Course Code	Course Title	Hours/week			Credits
		L	T	P	C
122PST01	APPLIED MATHEMATICS FOR POWER SYSTEM ENGINEERS	3	1	0	4

Prerequisite: Nil

Course Objectives

- To learn the application of linear algebra in electrical engineering problems.
- To introduce the concept of calculus of variations.
- To learn Laplace transform techniques to find the solutions of initial and boundary value problems involved in heat and wave equations.
- To introduce Fourier series analysis which plays a vital role in many applications in engineering.
- To formulate and solve the Linear Programming problems

UNIT – I MATRIX THEORY 9 + 3

The Cholesky decomposition – Generalized Eigenvectors, Canonical basis – QR factorization – Least squares method – Singular value decomposition.

UNIT - II CALCULUS OF VARIATIONS 9 + 3

Concept of variation and its properties – Euler's equation – Functionals dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables –Variational problems with moving boundaries – problems with constraints – Direct methods: Rayleigh Ritz and Kantorovich methods.

UNIT III LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 9 + 3

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 -- IV FOURIER SERIES 9 + 3

Dirichlet's conditions – General Fourier series – Change of scale - Odd and even functions – Half-range Sine and Cosine series – Parseval's identity – Harmonic Analysis – Complex form of Fourier series- Regular Strum-Liouville systems- Generalised Fourier series.

UNIT – V LINEAR PROGRAMMING 9 + 3

Formulation – Graphical solution - Simplex algorithm – Two phase method – Dual simplex method - Transportation and Assignment models.

TOTAL: 45 + 15 = 60 periods

Course Outcomes

After completing this course, the student will be able to

CO 1: Apply various methods in matrix theory to solve system of linear equations.

CO 2: Compute maxima and minima of a functional dependent of functions using different methods.

CO 3: Solve the initial and boundary value problems using Laplace Transform techniques.

CO 4: Able to solve problems using Fourier series associated with engineering applications.

CO 5: Formulate and find optimal solution in the real life optimizing/allocation/assignment problems involving conditions.

Reference Books

1. Richard Bronson,"Theory and Problems of Matrix Theory", Schaum's Outline Series, McGraw Hill, 1989.
2. Gupta, A.S., "Calculus of Variations with Applications", Prentice Hall of India Pvt. Ltd., New Delhi, 2010.
3. Sankar Rao. K, Introduction to Partial Differential Equations, Prentice Hall of India Pvt . Ltd, New Delhi,1997.
4. Hamdy A Taha, "Operations Research – An Introduction", Pearson, 10th Edition, 2016.
5. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition Wiley India, 2016.
6. Richard Bronson , Matrix Operation, Schaum's outline series, Second Edition, McGraw Hill, New Delhi , 2011.
7. Andrews .L.C, and Phillips. R.L, Mathematical Techniques for Engineers and Scientists, Prentice Hall , New Delhi , 2005.

Course Code	Course Title	Hours/week			Credits
		L	T	P	C
122PST02	COMPUTER AIDED POWER SYSTEMANALYSIS	3	1	0	4

Prerequisite: Power System Analysis

Objectives:

- A review of the basic studies in the area of power systems is expected.
- Improvements that enable the effective use of computers for large power networks is to be highlighted.
- An emphasis of how the power system models are built for different types of studies is to be laid.
- The course will pave the way for a student to incorporate the use of intelligent techniques in the area of power system analysis.
- To Illustrate different numerical integration methods and factors influencing transient stability.

UNIT – I INTRODUCTION 12

Importance of basic power system studies (power flow, short circuit and stability) in the planning and operation of power system - distinction between steady state, quasi steady state and transient modelling of power system.

UNIT - II SPARSITY ORIENTED NETWORK SOLUTION 12

Solution of network equation - Exploiting sparsity of bus admittance matrix - compact storage, optimal ordering, triangular factorization and solution using the factors - Solution using Gaussian elimination.

UNIT - III POWER FLOW ANALYSIS 12

Power flow model using bus admittance matrix - Fast decoupled power flow method (FDPF) - with voltage controlled buses using sparsity technique - Load flow based on sparsity oriented solution of I = YV - AC/DC power flow analysis using sequential FDPF method - Radial System power flow –Current injection based techniques – Multi-area power flow analysis with tie-line control - Special Purpose Power Flow Studies - Harmonic power flow - three phase load flow – distribution power flow - interactive load flows - contingency analysis - sensitivity analysis.

UNIT - IV SHORT CIRCUIT ANALYSIS 12

Short circuit analysis of a multi-node power system using bus impedance matrix ZBUS - Building algorithm for ZBUS - Algorithm for symmetrical fault analysis using ZBUS - Development of voltage and current equations under unsymmetrical faults using symmetrical components and algorithm for unsymmetrical fault analysis using ZBUS - Use of sparse factors of YBUS for obtaining the columns of ZBUS.

UNIT - V STABILITY STUDIES 12

Mathematical model for stability analysis of a multi-machines system with exciters and governors - solution of state equation by modified Euler method/4th order R.K. method

Lecture: 45, Tutorial: 15 TOTAL: 60

COURSE OUTCOMES(COS)

CO1: Learners are equipped with the power system studies that needed for the transmission system planning.

CO2: Learners will be able to analyse the impact of distributed generators on the performance of distribution system.

CO3: Learners will be able to understand the need for short circuit studies.

CO4: Learners will be able to explain the stability in multi machine.

CO5: Ability to do stability studies under various disturbances using numerical integration methods.

	Programme Outcomes												Programme Specific Outcomes		
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**PSO1**	**PSO2**	**PSO3**
CO1	**2**	**3**	**3**	**3**	**2**		**2**					**1**	**3**	**3**	**2**
CO2	**2**	**3**	**3**	**3**	**2**		**2**					**1**	**3**	**3**	**2**
CO3	**2**	**3**	**2**	**3**	**2**		**2**					**1**	**3**	**3**	**2**
CO4	**2**	**3**	**3**	**3**	**2**		**2**					**1**	**3**	**3**	**2**
CO5	**2**	**3**	**2**	**3**	**2**		**2**					**1**	**3**	**3**	**2**

REFERENCE BOOK(s) :

1 Stagg G.Wand El- Abiad .A.H, "Computer Methods in Power System Analysis",McGraw Hill Book Co,1987.

2 Pai M.A., "Computer Techniques in Power System Analysis", TataMcGrawHill, 2006.

3 Brown. H.E Solution of Large Networks by Matrix Methods: John Wiley and Sons. 1975.

4 Arrillaga .J and Arnold. C.P, "Computer Modelling of Electrical Power Systems", John Wiley and Sons,2006.

5 Kusic.G.L, "Computer Aided Power System Analysis", PHI,1989.

6 Heydt. T, "Computer Techniques in Power System Analysis", Macmillan USA,1996.

Course Code	Course Title	Hours/week			Credits
		L	T	P	C
122PST03	POWER SYSTEM OPERATION ANDCONTROL	3	0	0	3

Prerequisite: Nil

Objectives:

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

UNIT – I INTRODUCTION 9

System load variation: System load characteristics, load curves - daily, weekly and annual, load duration curve, load factor, diversity factor. Reserve requirements: Installed reserves, spinning reserves, cold reserves, hot reserves. 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, thermal unit constraints, hydro constraints, fuel constraints and other constraints; UC solution methods: Priority-list methods, forward dynamic programming approach, numerical problems. Incremental cost curve, 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 Hours: 45

Course Outcomes:

After Completion of the course, Students are 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 Analyze the problems associated with hydro thermal Scheduling and to construct thealgorithm for feasible load management.

CO4 Distinguish between various methods involved in unit commitment and economic dispatch problems.

CO5 Define about the power system security factors and analyze the algorithms used for optimal power flow.

	Programme Outcomes												Programme Specific Outcomes		
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**PSO1**	**PSO2**	**PSO3**
CO1	**2**	**3**	**3**	**2**	**3**				**1**				**2**	**3**	**2**
CO2	**2**	**3**	**3**	**2**	**3**				**1**				**2**	**3**	**2**
CO3	**2**	**3**	**3**	**2**	**3**				**1**				**2**	**3**	**2**
CO4	**2**	**3**	**3**	**2**	**3**				**1**				**2**	**3**	**2**
CO5	**2**	**3**	**3**	**2**	**3**				**1**				**2**	**3**	**2**

REFERENCE BOOKS:

1. D.P. Kothari and I.J. Nagrath, "Modern Power System Analysis", 5th Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2022.
2. Allen J. Wood, Bruce F. Wollenberg,Gerald B.Sheble „Power Generation, Operation and Control", Wiley India Edition, 3rd Edition, 2013.
3. Robert H. Miller, James H. Malinowski, „Power system operation", Tata McGraw-Hill, 3rd Edition 2009.
4. Olle. I. Elgerd, "Electric Energy Systems Theory – An Introduction", Tata McGraw Hill Publishing Company Ltd, New Delhi, 2nd Edition, 2003.

Course Code	Course Title	Hours/week			Credits
122PST04	SYSTEM THEORY	L	T	P	C
		3	0	0	3

Prerequisite: Nil

Objectives:

- To gain knowledge about state variable representation models.
- To understand reduction techniques and realization of transfer functions.
- To get exposed to state space design and analysis of non-linear systems**.**
- 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 SPACE ANALYSIS & CONTROLLABILITY, OBSERVABILITY 9

Introduction to state variable representation models of linear continuous time system solution of state equation by various methods. Diagonalization of matrices. Calculation of generalized Eigen vectors. Reduction to canonical and Jordan‟s canonical form. Gilberts and Kalman‟s test for controllability and observability.

UNIT - II TRANSFER FUNCTION AND STATE SPACE DESIGN 9

Impulse response and transfer function matrices. Properties of transfer functions, reducibility, Realization of transfer functions. State space design. Design by state feedback and pole placements.

UNIT - III NONLINEAR SYSTEMS 9

Types of non-linear phenomena- singular points- phase plane method- construction of phase trajectories- Derivation of describing functions. Need for model reduction-dominant pole concept-model reduction via partial realization-time moment matching and Pade Approximation-Hankel norm model reduction.

UNIT - IV STABILITY CONCEPTS 9

Stability concepts – Equilibrium points –BIBO and asymptotic stability, isoclines equilibrium points stability concepts- Lyaponouv‟s stability criteria- Stability of non- linear systems by describing function method- jump resonance. Frequency domain stability criteria- Popov‟s criterion.

UNIT - V OPTIMAL CONTROL & ADAPTIVE CONTROL 9

Formulation of optimal control problems- solving of optimal control problems – Hamiltonian formulation- linear regulator problem- solution of Richatti equation- Pontryagin‟s minimum principle- time optimal control. Classification of adaptive control systems-MRAC systems-different configuration- classification- Mathematical description.

Lecture: 45, TOTAL: 45

COURSE OUTCOMES (COS)

CO1: Acquire the concept of State-State equation for Dynamic Systems and understand the uniqueness of state model.

CO2: Ability to differentiate the existence and uniqueness of Continuous time state equations.

CO3: Ability to analyze the controllability and observability of a system.

CO4: Acquire detail knowledge on stability analysis of Linear & Nonlinear Continuous Time Autonomous Systems.

CO5: Perform Modal analysis and design controller and observer in state space form

	Programme Outcomes												Programme Specific Outcomes		
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	**2**	**2**		**2**									**2**	**2**	
CO2	**2**	**3**		**2**									**2**	**1**	
CO3		**3**	**2**	**2**									**1**	**2**	**1**
CO4	**2**	**2**		**3**									**2**	**2**	
CO5	**2**	**3**		**2**									**2**	**1**	

REFERENCE BOOK(s) :

1 Nagrath I.J., and Gopal, M., "Control Systems Engineering" New Age International (P) Limited, 2010.

2 Gopal. M., "Modern control system Theory", Wiley Eastern Ltd., 2nd Edition Reprint 1995.

3 Graham C., Goodwill, S.Graebe and M.Salgado, "Control System Design" Prentice Hall India, New Delhi, 2000.

4 Astrom K.J., and Wittenmark B., "Adaptive control", Addison-Wesley Longman Publishing Co, Second Edition,1994.

5 K.Ogata, "Modern Control Engineering" Prentice Hall of India, Fifth edition, 2010.

6 Brian D. O. Anderson, John Barratt Moore, "Optimal Control" Prentice Hall, 1990.

7 Stefani, Shahian, Savant &Hostetter, "Design of feedback control systems," Oxford University Press, 2002.

Course Code	Course Title	Hours/week			Credits
122PST05	ANALYSIS OF POWER CONVERTERS	L	T	P	C
		3	0	0	3

Prerequisite: Power Electronics and Electric drives and control

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 PHASEAC-DC CONVERTER 9

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 PHASEAC-DC CONVERTER 9

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

UNIT – III SINGLE PHASE INVERTERS 9

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 9

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

UNIT – V MODERN INVERTERS 9

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.

Lecture: 45, TOTAL: 45

Course Outcomes:

The students will be able to

CO1 Acquire and apply knowledge of mathematics in power converter analysis

CO2 Demonstrate the Converter fed DC drives and Chopper fed DC drives.

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

	Programme Outcomes												**Programme Specific Outcomes**		
	a	**b**	**c**	**d**	**E**	**f**	**g**	**h**	**i**	**j**	**k**	**L**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**													**1**	
CO2	**3**	**2**	**1**										**1**		
CO3	**3**	**2**	**2**										**2**	**2**	**1**
CO4	**3**	**2**	**1**										**2**	**2**	**1**
CO5	**2**	**1**			**2**								**2**	**1**	

TEXT BOOKS

1 Ned Mohan, T.M.Undeland and W.P.Robbins, "Power Electronics:converters, Application and design", 3rd edition Wiley,2007.

2 Bimal.K.Bose "Modern Power Electronics and AC Drives", Pearson Education, Second Edition,2003

3 Bin Wu, Mehdi Narimani, "High-Power Converters and AC Drives", Wiley, 2nd Edition, 2017.

4 VedamSubramanyam, "Electric Drives: Concepts and Applications", Second Edition, Tata McGraw hill Pvt. Ltd, New Delhi, 2011.

5. Gopal K Dubey., "Fundamentals of Electrical Drives", Second Edition, Narosa Publishing House, New Delhi, Reprint 2020.

REFERENCE BOOKS

1 Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Pearson, fourth Edition, 10th Impression2021

2 Jai P. Agrawal, "Power Electronics System Theory and Design", Pearson Education, First Edition,2015

3 Philip T. Krein, "Elements of Power Electronics" Indian edition Oxford UniversityPress-2017

4. P.C.Sen, "Modern Power Electronics", S.Chand Publishing2005.

5. P.S.Bimbra, "Power Electronics", Khanna Publishers, Eleventh Edition,2003

Course Code	Course Title	Hours /Weeks			Credits
		L	T	P	C
122MCT06	RESEARCH METHODOLOGY AND IPR	3	0	0	3

OBJECTIVE(S):

To impart knowledge and skills required for research and IPR:

- Problem formulation, analysis and solutions.
- Technical paper writing / presentation without violating professional ethics
- Patent drafting and filing patents.

UNIT - I RESEARCH METHODOLOGY: 9

Objectives and motivation of research - Types of research - Research approaches - Significance of research - Research methods verses methodology - Research and scientific method - Importance of research methodology - Research process - Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations- Criteria of good research. Defining the research problem: Definition of research problem - Problem formulation - Necessity of defining the problem - Technique involved in defining a problem.

UNIT–II LITERATURE SURVEY AND DATA COLLECTION: 9

Importance of literature survey - Sources of information - Assessment of quality of journals and articles - Information through internet. Effective literature studies approaches, analysis, plagiarism, and research ethics. Data - Preparing, Exploring, examining and displaying.

UNIT – III RESEARCH DESIGN AND ANALYSIS 9

Meaning of research design - Need of research design - Different research designs - Basic principles of experimental design - Developing a research plan - Design of experimental set-up - Use of standards and codes. 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 (IPR) 9

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. 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 PATENT RIGHTS (PR) **9**

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System, IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs. Licences, Licensing of related patents, patent agents, Registration of patent agents.

TOTAL:45

COURSEOUTCOMES:

CO1: Ability to formulate research problem

CO2: Ability to carry out research analysis

CO3: Ability to follow research ethics

CO4: Ability to understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity

CO5: Ability to understand about IPR and filing patents in R & D.

	Programme Outcomes												Programme Specific Outcomes		
	a	**b**	**c**	**d**	**e**	**f**	**g**	**H**	**i**	**j**	**k**	**l**	**PSO1**	**PSO2**	**PSO3**
CO1		3	1	2	3							1	**3**	**2**	**2**
CO2		1	1	2	3							1	**2**	**3**	**2**
CO3		1	1	2	1							1	**2**	**3**	**2**
CO4		1	1	2	3							1	**2**	**3**	**3**
CO5		1	1	2	3							1	**3**	**2**	**2**

REFERENCES:

1. Peter S. Menell ,Mark A. Lemley, Robert P. Merges, "Intellectual Property in the New Technological "Vol. I Perspectives, 2021.
2. Laura R. Ford,"The Intellectual Property of Nations: Sociological and Historical Perspectives on a Modern Legal Institution Paperback –2021.
3. 1. R. Ganesan, "Research Methodology for Engineers", MJP Publishers, Chennai, 2011.
4. Ratan Khananabis and Suvasis Saha, "Research Methodology", Universities Press, Hyderabad, 2015.
5. Cooper Donald R, Schindler Pamela S and Sharma JK, "Business Research Methods", Tata McGraw Hill Education, 11e (2012).
6. Catherine J. Holland, "Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets", Entrepreneur Press, 2007.
7. David Hunt, Long Nguyen, Matthew Rodgers, "Patent searching: tools & techniques", Wiley, 2007.
8. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, "Professional Programme Intellectual Property Rights, Law and practice", September 2013.
9. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners" 2010

Course Code	Course Title	Hours/week			Credits
		L	T	P	C
122PSA01	ENGLISH FOR RESEARCH PAPER WRITING	2	0	0	0

OBJECTIVES

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

UNIT I INTRODUCTION TO RESEARCH PAPER WRITING 6

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

UNIT II PRESENTATION SKILLS 6

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

UNIT III TITLE WRITING SKILLS 6

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check**.**

UNIT IV RESULT WRITING SKILLS 6

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

UNIT V VERIFICATION SKILLS 6

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

TOTAL: 30 PERIODS

COURSE OUTCOMES

CO1 –Understand that how to improve your writing skills and level of readability
CO2 –Learn about what to write in each section
CO3 –Understand the skills needed when writing a Title
CO4 – Understand the skills needed when writing the Conclusion
CO5 – Ensure the good quality of paper at very first-time submission

REFERENCES

1. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
2. Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006
3. Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006
4. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman‟s book 1998.

Course Code	Course Title	Hours/week			Credits	Maximum Marks		
		L	T	P	C	CA	EA	Total
122PSP07	POWER SYSTEM LABORATORY –I	0	0	4	2	50	50	100

Prerequisite: Power System Analysis

Objectives:

- To have hands on experience on various system studies and different techniques used for system planning. Software packages.
- To perform the dynamic analysis of power system.
- Evaluate the existing system and system under smart environment

List of Experiments:

1. Develop a program for Power flow analysis by Newton-Raphson method
2. Develop a program for load flow by Fast Decoupled method.
3. Economic load dispatch using lambda-iteration method.
4. Contingency analysis: Generator shift factors and line outage distribution factors Develop
5. Transient stability analysis of single machine-infinite bus system using classical machine model
6. Contingency analysis: Generator shift factors and line outage distribution factors
7. Develop a program for solving Unit commitment problem: Priority-list schemes and dynamic programming
8. Fault analysis in power system using matrix method
9. Simulation of variable speed wind energy conversion system- DFIG
10. Simulation of variable speed wind energy conversion system- PMSG

Course Outcomes:

Practical: 60, TOTAL:60

CO1: Learners will be able to analyze the power flow using Newton-Raphson method and Fast decoupled method

CO2: Learners will be able to perform counting encyanalysis & economic dispatch

CO3: Learners will be able to simulate the variable speed wind energy System

CO4: Learners will be able to simulate the transient stability.

CO5 : Learners will be able to perform Shift factors and outage factors

	Programme Outcomes												Programme Specific Outcomes		
	a	b	c	d	e	f	g	h	i	j	k	l	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	2	1					2	3	3	2
CO2	3	3	2	3	3	2	1					2	3	3	2
CO3	2	3	3	2	2	1	1					1	2	3	1
CO4	2	3	3	2	2	1	1					1	2	3	1
CO 5	2	3	3	2	2	1	1					1	2	3	1

Course Code	Course Title	Hours/week			Credits
122PSP08	POWER CONVERTERS LABORATORY	L	T	P	C
		0	0	4	2

Prerequisite: Power Electronics and Electric drives and control

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 EXPERIMENTS:

1. Study of switching characteristics of Power MOSFET &IGBT.
2. Circuit Simulation of Three-phase semi-converter with R, RL& Reload.
3. Circuit Simulation of Three-phase fully controlled converter with R, RL&RLE load.
4. Circuit Simulation of Three-phase Voltage Source Inverter in 180and 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/Microcontroller/PIC microcontroller for a DC-DC converter and single-phase voltage source inverter.
8. Simulation of a single-phase Z-source inverter with R load.
9. Simulation of three-phase AC voltage Controller with R load.
10. Simulation of a five-level cascaded multilevel inverter with R load.
11. Simulation of a Fly back DC-DC converter

PRACTICAL: 45, TOTAL: 45

Course Outcomes:

CO1-Comprehensive understanding on the switching behavior 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

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 three-phase controlled rectifiers and isolated DC-DC converters for designing the power supplies

	Programme Outcomes												**Programme Specific Outcomes**		
	a	**B**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**			**3**			**3**		**2**	**1**			**2**	**2**	
CO2	**3**			**3**			**3**		**2**	**1**			**2**	**2**	**1**
CO3	**3**			**3**	**2**		**3**		**2**	**1**				**2**	
CO4	**3**	**2**												**1**	**1**
CO5	**3**	**2**											**2**	**2**	

Course Code	Course Title	L	T	P	C
222PST01	POWER SYSTEM DYNAMICS AND STABILITY	3	1	0	4

Prerequisite:NIL

Course Objectives

1. To impart knowledge on dynamic modeling of asynchronous machine in detail
2. To describe the modeling of excitation and speed governing system in detail.
3. To understand and enhance small signal stability analysis with and without controllers
4. To understand and enhance the transient stability analysis of power systems.
5. To understand and enhance the instability analysis of power systems.

UNITI SYNCHRONOUS MACHINEMODELLING 12

Synchronous Machine-Physical Description: armature and field structure-direct and quadrature axes Mathematical Description of a Synchronous Machine-Basic equations of asynchronous machine- stator circuit equations, stator self, stator mutual and stator rotor mutual inductances-dq_0 Transformation :flux linkage and voltage equations for stator and rotor in dq0 coordinates, Physical interpretation of dq0 transformation, Per Unit Representation: 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.

UNITII MODELLING OF EXCITATION AND SPEED GOVERNINGSYSTEMS 12

Excitation System Modeling – Excitation System Requirements-Types of Excitation System-Control and protective functions; Modeling of Excitation system components: Modeling of IEEE type ST1A (1992) excitation model-classical transfer function of a hydraulic turbine (no derivation)-special characteristic of hydraulic turbine-electrical analogue of hydraulic turbine. Governor for Hydraulic Turbine- Requirement for a transient droop, Block diagram of governor with transient droop compensation-Steam turbine modelling: Single reheat and compounded type only and IEEE block diagram for dynamic simulation; generic speed-governing system model for normal speed/load control function.

UNIT III SMALL-SIGNAL STABILITY ANALYSISWITH AND WITHOUTCONTROLLERS 12

Classification of Stability – Basic Concepts and Definitions: Rotor angle stability-Fundamental Concepts of Stability of Dynamic Systems: State-space representation- stability of dynamic system-Linearization, Eigen properties of the state matrix-Eigen value and eigen vectors for stability- Participation factor, Single-Machine Infinite Bus(SMIB) Configuration : Classical Machine Model stability analysis with numerical example-Effect of field flux variation on system stability: analysis with numerical example Effects of Excitation System-analysis of effect of AVR on synchronizing and damping components using a numerical example - Multi-Machine Configuration –Equations in a common reference frame- Block diagram representation with K-constants; expression for K-constants (no derivation), effect of field flux variation on system stability.

UNIT IV TRANSIENTSTABILITYANALYSIS 12

Introduction-Factors influencing transient stability–Review of Numerical Integration Methods – Simulation of Power System Dynamic response : Structure of Power system Model, Synchronous machine representation-Thevenin's and Norton's equivalent circuits, Excitation system representation, Transmission network and load representation, Overall system equations and their solution: Partitioned-explicit and Simultaneous-implicit approaches, treatment of discontinuities, Simplified Transient Stability Simulation using simultaneous- implicit

UNIT V INSTABILITY ANALYSIS 12

Small signal angle instability (sub-synchronous frequency oscillations): analysis and counter-measures. Transient Instability: Analysis using digital simulation and energy function method-Transient stability controller-Introduction to voltage Instability-Analysis of voltage Instability.

TOTAL:60 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, the students should have the:

CO1 Learning about the modelling of Synchronous machines

CO2 Learning about the modelling of excitation and speed governing systems

CO3 Analyzing the small signal stability with and without controllers

CO4 Analyzing the transient stability of power system

CO5 Understanding of small signal and transient in stabilities.

REFERENCE BOOKS

1 John machowski, James R .Bumby "PowerSystem Dynamics Stability and Control", John Wiley & sons, 2020..

2 Prabha S.Kundur, "Power System Stability and Control", McGraw-Hill, 2022.

3 K.R.Padiyar," Power System Dynamics Stability & Control", BS Publications, Hyderabad,2018.

4 P.M Andersonand A.A Fouad, "Power System Control and Stability", Iowa State University Press, Ames, Iowa, Wiley 2023

5 Peter W.Sauer & M.A.Pai, "Power System Dynamics& Stability", Pearson Education,2007.

6 IEEE Committee Report, "Dynamic Models for Steam and Hydro Turbines in Power System Studies," IEEE Transactions,Vol.PAS-92,pp1904-1915, November/December1973

	Programme Outcomes												Programme Specific Outcomes		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	3				2	1					1	2	2	1
CO2	2	3					1						2		1
CO3	2	3	2	2	2	2						1	2	2	
CO4	2				2	2								2	
CO5	2	3				2	1					1	2	2	1

Course Code	Course Title	L	T	P	C
222PST02	ADVANCED POWER SYSTEM PROTECTION	3	0	0	3

Prerequisite: NIL

Course Objectives

1. To demonstrate the basic concepts and recent trends in power system protection
2. To design and work with the concepts of digital and numerical relaying ofvarious power apparatuses
3. To train up with the relay coordination for the transmission line protection scheme
4. To expose PC applications for designing protective relaying schemes.
5. To compare different protection schemes of a power apparatus through performanceanalysis.

UNITI NUMERICAL PROTECTION 12

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.

UNITII DIGITAL PROTECTION OF TRANSMISSION LINE 12

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 12

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 12

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 12

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:60 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, the students should have the:

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 Able to understand different protection schemes of a power apparatus through performance analysis.

REFERENCE BOOKS

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

	Programme Outcomes												**Programme Specific Outcomes**		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	**2**	**3**				**2**	**1**	**2**			**3**	**1**	**2**	**2**	**1**
CO2		**3**					**1**		**2**				**2**		**1**
CO3		**3**	**2**	**2**	**2**	**2**		**2**	**2**		**3**	**1**	**2**	**2**	
CO4	**2**				**2**	**2**				**3**				**2**	
CO5	**2**	**3**				**2**	**1**					**1**	**2**	**2**	**1**

Course Code	Course Title	L	T	P	C
222PST03	RESTRUCTURED POWER SYSTEM	3	0	0	3

Prerequisite: NIL

Course Objectives

1. Describe the behavior of deregulated markets in power system.
2. Describe the technical and non-technical issues in deregulated power industry.
3. Identify the methods of Local Marginal prices calculation in transmission and the function of financial transmission rights.
4. Analyze the energy and ancillary services management in deregulated power industry.
5. Discriminate the restructuring frame work US and Indian power sectors.

UNITI INTRODUCTION 12

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.

UNITII TRANSMISSION CONGESTION MANAGEMEN 12

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 all eviation method.

UNIT III LOCATIONAL MARGINAL PRICES AND FINANCIAL 12

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 is suance process – Treatment of revenue short fall-Secondary trading of FTRs**-** Flow Gate rights –FTR and market power.

UNIT IV ANCILLARY SERVICE MANAGEMENT AND PRICING OF TRANSMISSION NETWORK 12

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 location methods.

UNIT V MARKET EVOLUTION 12

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 Act2012-OpenAccessissues –Power exchange.

TOTAL:60 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, the students should have the:

CO1 Describe the requirement for deregulation of the electricity market and the principles of market models in power systems.

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.

REFERENCE BOOKS

1. Mohammad Shahidehpour, Muwaffaq Alomoush, "Restructured electrical power systems: operation, trading and volatility" Marcel Dekker Pub,2001.
2. Kankar Bhattacharya, Math H.J.Boolen, and Jaap E.Daadler, "Operation of restructuredpower systems", Kluwer Academic Pub.,2001
3. Paran jothi, S.R., "Modern Power Systems The Economics of Restructuring", New AgeInternationalPublishers,FirstEdition:2017
4. Sally Hunt, "Making competition work In electricity", John Willey and SonsInc.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/.

	Programme Outcomes												**Programme Specific Outcomes**		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	**2**					**2**	**1**					**1**	**2**	**2**	**1**
CO2	**2**						**1**	**2**		**3**					**1**
CO3		**3**	**2**	**2**	**2**	**2**			**2**	**3**		**1**	**2**	**2**	**2**
CO4	**2**				**2**				**2**					**2**	
CO5	**2**	**3**				**2**	**1**					**1**	**2**	**2**	**1**

Course Code	Course Title	L	T	P	C
222PSE01	POWER SYSTEM ECONOMICS AND CONTROL	3	0	0	3

PREREQUISITE: Power System Operation and Control

COURSE OBJECTIVES

- To gain knowledge in Economic Dispatch using various methods
- To learn about the Economic Emission Dispatch
- To impart the role of Unit commitment problems in power system Economics
- To impart the role of Hydrothermal Scheduling for different power system model
- To gain knowledge on Load Frequency Control and computer control of power systems.

UNIT I OPTIMUM DISPATCH 9

Economic Dispatch problem with and without losses - Analysis of two bus and „N‟ bus systems-Incremental transmission loss – Lambda iteration method – base point and participation factors - Optimal dispatch for cost and loss minimization – Security constrained economic dispatch–Solution algorithms – Kuhn Tucker conditions – Inequality constraint on control and dependent variables –Penalty function approach for constraint violations - Gradient search and Dynamic programming methods

UNIT II OPTIMAL DISPATCH WITH CONSTRAINTS 9

Environmental constraints – Clean Air Act – Emission function – Emission Dispatch – Combined Economic Emission Dispatch – Economic dispatch with multiple fuels – Ramp rate limits – Dynamic economic dispatch – Valve Point Effects.

UNIT III UNIT COMMITMENT 9

Unit commitment problem – spinning reserve – thermal unit constraints –other constraints – solution methods – priority List method – dynamic programming method – Lagrangian Relaxation method

UNIT IV HYDRO THERMAL SCHEDULING 9

Hydrothermal systems – Hydroelectric plant models – Glimn – Kirchmayer‟s model – Hildebrand‟s model – Arivanitidis Rosing model – Short range fixed and variable head scheduling – lambda –gamma iteration algorithm – gradient approach – hydro units in series – pumped storage hydro scheduling – hydro plant modeling for long term operation – long range generation scheduling of hydrothermal systems.

UNIT V LOAD FREQUENCY CONTROL 9

Control area – Automatic generation Control – Area control error – Transfer function model for single area and two area power systems – PID controllers – steady state error in two area system–Implementation of Load Frequency control (LFC) – Power/Frequency characteristic in an interconnected power system – Flat frequency control – Parallel Frequency control– Tie-line biased control – Selective frequency control – State variable models: Single and Two- Area Systems –Digital Load Frequency Control – Decentralized Control – Biased Control -Optimal Load-Frequency control -Computer control of power systems - Concept of energy control centre (or) load dispatch centre.

TOTAL:45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, the students should have the:

- **CO1** Ability to understand the system load variations and get an overview of power system operations.
- **CO2** Ability to analyze power system economics.
- **CO3** Ability to understand the significance of unit commitment and different solution methods.
- **CO4** Ability to gain knowledge on concepts of hydrothermal scheduling.
- **CO5** Ability to obtain the knowledge on Load Frequency Control and computer control of power systems.

REFERENCE BOOKS

1. Elgerd.O.I, "Electric Energy Systems: Theory – An Introduction", Tata Mc Graw Hill, NewDelhi, 1999.
2. Murthy P.S.R, "Power System Operation and Control", Tat McGraw Hill, 1984.
3. Kothari D.P and Dhillon J.S, "Power System Optimization", Prentice Hall of India, NewDelhi, 2004.
4. Ji Zhong Zhu, "Optimization of Power System Operation", Wiley IEEE Press, New Jersey, 2009.
5. Nagrath and Kothari, "Modern Power System Analysis", Tata Mc Graw Hill, New Delhi 2005.
6. Wood and Wollenberg, "Power Generation, Operation and Control", John Wiley and Sons, 1996.
7. Mahalanabis, Kothari and Ahson, "Computer Aided Power System Analysis and Control", Tata Mc Graw Hill, 1991.

COs	Programme Outcomes												Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	1	3	2	2	1	1	1					1	2	2	1
CO2	1	3	3	3	2	1	1					1	3	3	2
CO3	1	3	3	3	2	1	1					1	3	3	2
CO4	1	3	2	2	1	1	1					1	2	2	1
CO5	1	3	3	3	2	1	1					1	3	3	2

Course Code	Course Title	L	T	P	C
222PSE02	ELECTRICAL TRANSIENTS IN POWER SYSTEM	3	0	0	3

PREREQUISITE :NIL

COURSE OBJECTIVES

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

UNITI 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, Resonance Grounding – Steady state and dynamic tower- footing resistance, substation grounding Grid, Direct lightning strokes to overhead lines, without and with shield Wires

UNITII 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 – behavior of travelling waves at the line terminations – Lattice Diagrams – attenuation and distortion – multi conductor system and multi velocity waves

UNIT IV INSULATION CO-ORDINATION 9

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

UNIT V COMPUTATION OF POWER SYSTEM TRANSIENTS 9

Modelling of power system apparatus for transient studies – principles of digital computation – transmission lines, cables, transformer and rotating machines – Electromagnetic Transient program (EMTP) – case studies: line with short and open end, line terminated with R, L, C, transformer-Application of simplified method: single line station, two line station, Gas insulated substations-simulation of possible over voltages in a high voltage substation.

TOTAL:45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, the students should have the:

CO1 Ability to evaluate various sources of transients

CO2 Ability to compute possible over voltages in power systems

CO3 Ability to predict over voltages in power system using travelling wave theory

CO4 Ability to coordinate the insulation level of the power system

CO5 Ability to compute over voltages using EMTP with multiple sources

REFERENCE BOOKS

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. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", Second edition New age International (P) Ltd., New Delhi, 2006.
6. Naidu M S and Kamaraju V, "High Voltage Engineering", Tata McGraw-Hill PublishingCompany Ltd., New Delhi, 2004.
7. R. Ramanujam, "Computational Electromagnetic Transients: Modeling, Solution Methods and Simulation", I.K. International Publishing House Pvt. Ltd, New Delhi - 110016, 2014

COs	**Programme Outcomes**												**Programme Specific Outcomes**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	3	3			2	2					1	2	3	2
CO2	2	3	3			2	2					1	3	3	2
CO3	2	3	3			2	1					1	3	2	2
CO4	2	3	3			2	1					1	3	2	2
CO5	2	3	3			2	2					1	3	3	2

Course Code	Course Title	L	T	P	C
222PSE03	POWER SYSTEM OPTIMIZATION TECHNIQUES	3	0	0	3

Prerequisite: Nil

Objectives:

- To have knowledge on optimization techniques applied to power systems.
- To understand the different evolutionary computation techniques and multi objectiveoptimization and their applications in power systems.

UNIT – I FUNDAMENTALS OF OPTIMIZATION 9

Definition-Classification of optimization problems-Unconstrained and Constrained optimization-Optimality conditions-Classical Optimization techniques (Linear and non linear programming, Quadratic programming, Mixed integer programming)-Intelligent Search methods (Optimization neural network, Evolutionary algorithms, Tabu search, Particle swarm optimization, Application offuzzy set theory).

UNIT - II EVOLUTIONARY COMPUTATION TECHNIQUES 9

Evolution in nature-Fundamentals of Evolutionary algorithms-Working Principles of Genetic Algorithm-Evolutionary Strategy and Evolutionary Programming-Genetic Operators-Selection, Crossover and Mutation-Issues in GA implementation- GA based Economic Dispatch solution- Fuzzy Economic Dispatch including losses- Tabu search algorithm for unit commitment problem- GA for unit commitment-GA based Optimal power flow- GA based state estimation.

UNIT - III PARTICLE SWARM OPTIMIZATION 9

Fundamental principle-Velocity Updating-Advanced operators-Parameter selection- Hybrid approaches (Hybrid of GA and PSO, Hybrid of EP and PSO) -Binary, discrete and combinatorial PSO-Implementation issues-Convergence issues- PSO based OPF problem and unit commitment- PSO for reactive power and voltage control-PSO for power system reliability and security.

UNIT - IV ADVANCED OPTIMIZATION METHODS 9

Simulated annealing algorithm-Tabu search algorithm-SA and TS for unit commitment-Ant colony optimization- Bacteria Foraging optimization.

UNIT - V MULTI OBJECTIVE OPTIMIZATION 9

Concept of pareto optimality-Conventional approaches for MOOP-Multi objective GA-Fitness assignment-Sharing function-Economic Emission dispatch using MOGA-Multi objective PSO (Dynamic neighbor hood PSO, Vector evaluated PSO) –Multi objective OPF problem.

Lecture: 45, TOTAL: 45

COURSE OUTCOMES(COS)

CO1: Will be able to know the basic ANN architectures, algorithms and their limitations.

CO2: Also will be able to know the different operations on the fuzzy sets.

CO3: Will be competent to use hybrid control schemes and P.S.O.

CO4: Will be knowledgeable to use Fuzzy logic for modeling and control of non-linear systems.

CO5: Will be knowledgeable to solve Multi objective optimization technique

REFERENCE BOOK(s) :

1 D.P.Kothari and J.S.Dhillon, "Power System Optimization", 2nd Edition, PHI learning private limited, 2010.

2 Kalyanmoy Deb, "Multi objective optimization using Evolutionary Algorithms", John Wiley and Sons, 2008.

3 Kalyanmoy Deb, "Optimization for Engineering Design",Prentice hall of India first edition,1988.

4 Carlos A.CoelloCoello, Gary B.Lamont, David A.VanVeldhuizen, "Evolutionary Algorithms for solving Multi Objective Problems", 2nd Edition, Springer, 2007.

5 SolimanAbdelHady,AbdelAal Hassan Mantawy, "Modern optimization techniques with applications in Electric Power Systems", Springer,2012.

6 JizhongZhu,"Optimization of power system operation",John Wiley and sons Inc publication,2009.

7 Kwang Y.Lee,MohammedA.ElSharkawi, "Modern heuristic optimization techniques", John Wiley and Sons,2008.

	ProgrammeOutcomes												**ProgrammeSpecific Outcomes**		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**3**	**3**	**3**	**2**		**2**					**1**	**3**	**3**	**2**
CO2	**3**	**3**	**2**	**3**	**2**							**1**	**3**	**3**	**2**
CO3	**3**	**3**	**2**	**3**	**2**							**1**	**3**	**3**	**2**
CO4	**2**	**3**	**3**	**3**	**3**							**1**	**3**	**3**	**2**
CO5	**1**	**3**	**3**	**3**	**2**	1	**1**					**1**	**3**	**3**	**2**

Course Code	Course Title	Hours/week			Credits
222PSE04	COMPUTATIONAL INTELLIGENCE TECHNIQUES TO POWER SYSTEMS	L	T	P	C
		3	0	0	3

UNITI: INTRODUCTION (09 Periods)

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

UNITII: LINEAR QUADRATIC TRACKING PROBLEMS ANDNUMERICAL TECHNIQUES FOR OPTIMAL CONTROL (09 Periods)

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.

UNITIII: MODEL DECOMPOSITION AND CONVOLUTIONAL NEURAL NETWORK (09 Periods)

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: UNIT IV FILTERING AND ESTIMATION (09 Periods)

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

UNIT V: KALMAN FILTER (09 Periods)

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 Periods: *45*

COURSE OUTCOMES:

Ability to:

CO1: Understand the concept of Optimum Optimization Technique 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

REFERENCES:

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

2. Yong Hua Song, Johns Allen, Aggarwal Raj, 'Computational Intelligence Application to Power System', Springer Netherlands. 1997.

	ProgrammeOutcomes												**ProgrammeSpecific Outcomes**		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**3**	**3**	**3**	**2**		**2**					**1**	**3**	**3**	**2**
CO2	**3**	**3**	**2**	**3**	**2**				3	2		**1**	**3**	**3**	**2**
CO3	**3**	**3**	**2**	**3**	**2**							**1**	**3**	**3**	**2**
CO4	**2**	**3**	**3**	**3**	**3**							**1**	**3**	**3**	**2**
CO5	**1**	**3**	**3**	**3**	**2**	1	**1**		1	1		**1**	**3**	**3**	**2**

222PSE05	IoT FOR SMART SYSTEMS	L	T	P	C
		3	0	0	3

PREREQUISITE : Nil

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 RASPERRYPI 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:45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, the students should have the:

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.

TEXT BOOKS

1. ArshdeepBahga and VijaiMadisetti : A Hands-on Approach "Internet of Things",UniversitiesPress 2015.
2. Oliver Hersent , David Boswarthick and Omar Elloumi " The Internet of Things", Wiley,2016.
3. Lars T.Berger and Krzysztof Iniewski, "Smart Grid applications, communications and security",Wiley, 2015
4. Adrian McEwen and Hakim Cassimally"Designing the Internet of Things "Wiley,2014.
5. Adrian McEwen and Hakim Cassimally, "Designing the Internet of Things", John Wiley and sons,2014.

REFERENCE BOOKS

1. Janaka Ekanayake, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama and Nick Jenkins, "Smart Grid Technology and Applications", Wiley, 2015
2. Vijay Madisetti , ArshdeepBahga, "Internet of Things (A Hands on-Approach)", 2014.

COs	**ProgrammeOutcomes**												**Programme Specific Outcomes**		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2											2		
CO2	3	2	2		2							2	2		
CO3		3	2	2										3	2
CO4			3	3	3				2		2	2	2	1	
CO5			3	3	3				2		2	2	2	1	

Course Code	Course Title	Hours/week			Credits
222PSE06	RENEWABLE ENERGY AND GRIDINTEGRATION	L	T	P	C
		3	0	0	3

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 analyze 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.

UNITI: INTRODUCTION (09)

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.

UNITII: PHOTO VOLTAIC ENERGY CONVERSION SYSTEMS (09)

Introduction, Photo Voltaic (PV) effect, Solar Cell, Types, Equivalent circuit of PV cell, PV cell characteristics (I/V and P/V) for variation of insulation , 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.

UNITIII: WIND ENERGY CONVERSION SYSTEMS (09)

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 (09)

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

UNIT V: HYBRID STORAGE SYSTEMS AND GRID MANAGEMENT (09)

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 Periods: 45

COURSE OUTCOMES:

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

REFERENCES:

1. S.N.Bhadra, D. Kastha, & S. Banerjee "Wind Electrical Systems", Oxford University Press, 2009.
2. Haitham Abu-Rub, Mariusz Malinowski and Kamal Al-Haddad, "Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications", IEEE Press and John Wiley & Sons Ltd Press, 2014.
3. Rashid .M. H "power electronics Hand book", Academic press, 2001.
4. Rai. G.D, "Non-conventional energy sources", Khanna publishes, 1993
5. Gray, L. Johnson, "Wind energy system", prentice hall linc, 1995
6. Non-conventional Energy sources B.H.Khan Tata McGraw-Hill Publishing Company, New Delhi.

	ProgrammeOutcomes												**ProgrammeSpecific Outcomes**		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	**2**	**3**		**3**	**2**	2	**2**					**2**	**3**		**2**
CO2	**2**	**3**		**3**	**2**	2	**2**					**2**	**3**	**3**	**2**
CO3	**2**	**3**	**3**	**3**	**2**	2	**2**					**2**		**3**	
CO4	**2**	**2**	**3**	**3**			**2**					**2**	**3**	**3**	
CO5	**2**	**2**	**3**	**3**	**2**	2	**2**					**2**	**2**	**1**	**3**

Course code	Course Title	Hours/week			Credits
222PSE07	Demand Side Energy Management	L	T	P	C
		3	0	0	3

Objectives:

- Improving the efficiency with which energy is used to provide economic services meets the dual objectives of promoting sustainable development and of making the economy competitive.
- Energy Efficiency & Conservation has also assumed enhanced importance with a view to conserve depleting energy resources.

UNIT – I ENERGY AUDIT **9**

Definitions-Need-concepts-Types of energy audit; Energy index – cost index – pie charts – Sankey diagrams**. Energy Economics**: Introduction-Cost benefit risk analysis-Payback period-Straight line depreciation-Sinking fund depreciation—Reducing balance depreciation-Net present value method-Internal rate of return method-Profitability index for benefit cost ratio.

UNIT – II ENERGY CONSERVATION IN ELECTRIC UTILITIES AND INDUSTRY **9**

Electrical load management: Energy and load management devices-Conservation strategies; conservation in electric utilities and industry: Introduction-Energy conservation in utilities by improving load factor-Utility voltage regulation-Energy conservation in Industries-Power factor improvement**.**

UNIT - III ENERGY EFFICIENT ELECTRIC MOTORS (EEMS) **9**

Energy–efficient electric motors (EEMs): Energy efficient motors-construction and technical features-case studies of EEMs with respect to cost effectiveness-performance characteristics; Economics of EEMs and system life cycle-direct savings and payback analysis-efficiency factor or efficiency evaluation factor.

UNIT - IV ELECTRIC LIGHTING **9**

Introduction-Need for an energy management program-Building analysis-Modification of existing systems-Replacement of existing systems-priorities:

Illumination requirement: Task lighting requirements-lighting levels-system modifications-non illumination modifications-lighting for non task areas-reflectance's-space geometry; System elements.

UNIT - V SPACE HEATING ,VENTILATION **9**

Air-Conditioning(HVAC) and Water Heating: Introduction-Heating of buildings-Transfer of Heat-Space heating methods-Ventilation and air-conditioning-Insulation-Cooling load-Electric water heating systems-Energy conservation methods.

Co-generation and storage: Combined cycle cogeneration-energy storage: pumped hydro schemes-compressed air energy storage (CAES)-storage batteries-superconducting magnetic energy storage (SMES)

Lecture: 45, TOTAL: 45

Course Outcomes:

CO1: Able to explain about the energy auditing.
CO2: Knowledge about the energy conservation in electrical utilities
CO3: Able to describe about the electric lighting
CO4: Able to explain about the working methodology of air conditioning, co -generation and storage
CO5:Able to explain about the space heating and ventilation

REFERENCE BOOK(s) :

1 Wayne C.Turner'' Energy management Hand book,Johnwiley and sons Publications 2007.
2 S C Tripathy 'Electric Energy Utilization and Conservation,Tata McGraw Hill publishing company ltd.New Delhi 1991.
3 John C.Andreas 'Energy efficient electric motors selection and application.2006
4 Amit kumar Tyagi 'Hand book on Energy Audit and Management,published by TERI(Tata energy research Institute).2000.
5 Paul W.O' Callaghan 'Energy management McGraw hill book company 1993.
6 Rakosh Das Begamudre 'Energy conversion systems New age international publishers 2007.
7 W.R.Murphy&G.Mckey 'Energy Management 'Butterworth Heinemann, 2007.

	ProgrammeOutcomes												**ProgrammeSpecific Outcomes**		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	**2**	**3**	**3**	**3**	**2**	2	**2**					**2**	**3**	**3**	**2**
CO2	**2**	**3**	**3**	**3**	**2**	2	**2**					**2**	**3**	**3**	**2**
CO3	**2**	**3**	**3**	**3**	**2**	2	**2**					**2**	**3**	**3**	**2**
CO4	**2**	**2**	**3**	**3**	**2**	2	**2**					**2**	**3**	**3**	**3**
CO5	**2**	**2**	**3**	**3**	**2**	2	**2**					**2**	**2**	**1**	**3**

Course code	Course Title	L	T	P	C
222PSE08	ENERGY STORAGE TECHNOLOGIES	3	0	0	3

COURSEOBJECTIVES:

1. To understand the various types of energy storage Technologies
2. To analyze thermal storage system
3. To analyze different battery storage technologies
4. To analyze the thermodynamics of Fuel Cell
5. To study the various applications of energy storage systems

UNITI INTRODUCTION **9**

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

UNITII THERMALSTORAGESYSTEM **9**

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

UNITIII ELECTRICALENERGYSTORAGE **9**

Fundamental concept of batteries – Measuring of battery performance, charging and dis charging of abattery,storagedensity,energydensity,andsafetyissues-Typesofbatteries:– Lead Acid, Nickel-Cadmium,Zinc-Manganese dioxide- Mathematical Modelling for Lead Acid Batteries–Flow Batteries.

UNIT IV FUELCELL **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.

UNITV ALTERNATEENERGYSTORAGETECHNOLOGIES **9**

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

TOTAL: 45PERIODS

COURSEOUTCOMES:

Upon Completion of this course, the students will be able to

CO1: Understand the physics of energy storage
CO2: Model the different energy technologies.
CO3: Recognize the applications of various techniques.
CO4: Design and analyze the energy storage technologies.
CO5: Select and apply the appropriate technique based on the application.

REFERENCES

1. James Larminie and Andrew Dicks,,, Fuel cell systems Explained ",Wiley publications,2003.
2. Lunardini V.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,Wileypublications,2012
4. Schmidt. F.W.and Willmott. A.J., "Thermal Storage and Regeneration", Hemisphere PublishingCorporation,1981
5. Luisa F.Cabeza(Editor),"AdvancesinThermalEnergyStorageSystems:Methodsand Applications",WoodheadPublishers,2020.
6. IbrahimDinçerandMarcA.Rosen,"ThermalEnergyStorageSystemsandApplications ",WileyPublishers,2021.

MAPPING OF CO'S WITH PO'S

	ProgrammeOutcomes												**ProgrammeSpecific Outcomes**		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**3**	**3**	**3**	**2**		**2**					**1**	**3**	**3**	**2**
CO2	**3**	**3**		**3**	**2**							**1**	**3**	**3**	**2**
CO3	**3**	**3**		**3**	**2**							**1**		**3**	**2**
CO4	**2**	**3**	**3**									**1**			**2**
CO5	**1**	**3**	**3**	**3**	**2**	1	**1**					**1**	**3**		**2**

Course code	Course Title	L	T	P	C
222PSE09	ELECTROMAGNETICINTERFERENCE ANDCOMPATIBILITY	3	0	0	3

PREREQUISITE : Nil

COURSE OBJECTIVES

- To tutor the basics of EMI,EMC
- Toin still knowledge on the EMI coupling mechanism and its mitigation techniques
- Toimpart comprehensive insight about the current EMC standards and about various measurement techniques.
- To understand susceptibility standards and specifications.
- To impart comprehensive insight about various measurement techniques.

UNITI BASICTHEORY 9

Introduction to EMI and EMC, Intra and inter system EMI, Elements of Interference, SourcesandVictimsofEMI,ConductedandRadiatedEMIemissionandsusceptibility,CaseHistories,Radiation hazards to humans, Various issues of EMC, EMC Testing categories, EMC Engineering Application.

UNITII COUPLINGMECHANISM 9

ElectromagneticfieldsourcesandCouplingpaths,Couplingviathesupplynetwork,Commonmode coupling, Differential mode coupling, Impedance coupling, Inductive and Capacitivecoupling,Radioactivecoupling,Groundloopcoupling,Cablerelated emissions and coupling, Transient sources, Automotive transients.

UNIT III EMIMITIGATION TECHNIQUES 9

Working principle of Shielding and Murphy's Law, LF Magnetic shielding, Apertures and shielding effectiveness, Choice of Materials for H, E, and free space fields, Gasket ting and sealing, PCB Level shielding, Principle of Grounding, Isolated grounds, Grounding strategies for Large systems ,Grounding formixed signal systems, Filter types and operation ,Surge protection devices, Transient protection.

UNIT IV STANDARDS AND REGULATION 9

Need for Standards, Generic/General Standards for Residential and Industrial environment ,Basic Standards, Product Standards, National and International EMI Standardizing Organizations ;IEC, ANSI, FCC ,AS/NZS, CISPR, BSI, CENELEC, ACEC. Electro Magnetic Emission and susceptibility standards and specifications, MIL461E Standards.

UNIT V EMITESTMETHODSAND INSTRUMENTATION 9

Fundamental considerations, EMI Shielding effectiveness tests, Open field test, TEM cell for immunity test, Shielded chamber , Shielded anechoic chamber, EMI test receivers, Spectrum analyzer, EMI test wave simulators, EMI coupling networks, Line impedance stabilizationnetworks,Feedthroughcapacitors,Antennas,Currentprobes,MIL-

STD test methods, Civilian STD test methods.

TOTAL:45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, the students should have the:

CO1 Find solution to EMI Sources, EMI problems in PCB level/Subsystem and system level design.

CO2 Able to explain about coupling mechanisms.

CO3 Usage of modern technology and tools in risk reduction.

CO4 Develop the ability of Planning in emergency situations

CO5 Extrapolate the EMI test methods and instrumentations.

REFERENCE BOOKS

1 ClaytonPaul,"IntroductiontoElectromagneticCompatibility",WileyInterscience,2006.

2 VPrasadKodali,"EngineeringElectromagneticCompatibility",IEEEPress,Newyork,2001.

3 Henry W.Ott,"Electro magnetic Compatibility Engineering", John Wiley &SonsInc,Newyork,2009

4 DarylGerkeandWilliamKimmel,"EDN"sDesigner"sGuidetoElectromagneticCompatibility",ElsevierScience&TechnologyBooks,2002

	ProgrammeOutcomes												**Programme SpecificOutcomes**		
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**PSO1**	**PSO2**	**PSO3**
CO1	**1**	**3**	**3**	**3**	**3**	**2**	**2**					**1**	**3**	**3**	**2**
CO2	**1**	**3**	**3**	**2**	**2**	**1**	**1**					**1**	**2**	**3**	**1**
CO3	**1**	**3**	**3**	**2**	**2**	**1**	**1**					**2**	**2**	**3**	**1**
CO4	**1**	**3**	**3**	**2**	**3**	**2**	**2**					**1**	**3**	**3**	**2**
CO5	**1**	**3**	**3**	**2**	**3**	**2**	**2**					**1**	**3**	**3**	**2**

222PSE10	POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS	L	T	P	C
		3	0	0	3

PREREQUISITE : Power Electronics

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 analyze 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.

UNITI INTRODUCTION 9

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

UNITII ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION 9

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

UNIT III POWER CONVERTERS 9

Solar: Block diagram of solar photo voltaic system -Principle of operation: line commutated converters (inversion-mode) - Boost and buck-boost converters- selection of inverter, battery sizing, array sizing Wind: Three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters-matrix converters.

UNIT IV ANALYSIS OF WIND AND PV SYSTEMS 9

Stand alone operation of fixed and variable speed wind energy conversion systems and solar system- Grid connection Issues -Grid integrated PMSG, SCIG Based WECS, grid Integrated solar system

UNIT V HYBRID RENEWABLE ENERGY SYSTEMS 9

Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Wind-PV Maximum Power Point Tracking (MPPT).

TOTAL:45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, the students should have the:

CO1 Ability to handle the engineering aspects of electrical energy generation and utilization.

CO2 Ability to understand the operation of electrical machines for renewable energy conversion.

CO3 Ability to understand the power converters for renewable energy systems.

CO4 Able to analyze wind and PV systems.

CO5 Able to develop strategies for hybrid renewable energy systems.

REFERENCE BOOKS

1. Rashid .M. H "power electronics Hand book", Academic press, 2001.
2. Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006.
3. Rai. G.D, "Non conventional energy sources", Khanna publishes, 1993.
4. Gray, L. Johnson, "Wind energy system", prentice hall linc, 1995.
5. Andrzej M. Trzynnadlowski, „Introduction to Modern Power Electronics", Second edition, wiley India Pvt. Ltd, 2012.
6. S. N. Bhadra, D.Kastha, S.Banerjee, "Wind Electrical Systems", Oxford University Press, 2005.
7. B.H.Khan Non-conventional Energy sources Tata McGraw-hill Publishing Company, New Delhi,2009.

	ProgrammeOutcomes												**ProgrammeSpecific Outcomes**		
	PO 1	**PO 2**	**PO3**	**PO 4**	**PO 5**	**PO 6**	**PO7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**3**	**3**	**3**	**2**		**2**					**1**	**3**	**3**	**2**
CO2	**3**				**2**							**1**	**3**	**3**	**2**
CO3	**3**				**2**										**2**
CO4	**2**	**3**			**3**							**1**			**2**
CO5	**1**	**3**	**3**	**3**	**2**	1	**1**					**1**	**3**	**3**	**2**

222PSE11	ELECTRICAL POWER DISTRIBUTION SYSTEM	L	T	P	C
		3	0	0	3

PREREQUISITE :Transmission and Distribution systems

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

UNITI DISTRIBUTION SYSTEMS 9

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

UNITII CONTROL AND PROTECTION 9

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

UNIT III RELIABILITY ANALYSIS 9

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

UNIT IV DISTRIBUTION AUTOMATION 9

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

UNIT V EXPANSION PLANNING 9

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

TOTAL:45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, the students should have the:

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.

REFERENCE BOOKS

1. C.L. Wadhwa, "Electrical Power Systems", New Age International Publishers, Sixth Edition, 2014.
2. A.S. Pabla, "Electrical Power Distribution Systems", Tata McGraw Hill Books Company, Sixth
3. Edition, 2011.
4. V. Kamaraju, "Electrical Power Distribution Systems", Tata McGraw Hill Books Company, Sixth Edition, 2009.
5. Anthony J. Pansini, "Electrical Distribution Engineering", CRC Press, 2005.
6. H Lee Willis, "Distributed Power Generation Planning and Evaluation", CRC Press, 2000.
7. James A Momoh, "Electric Power Distribution Automation Protection and Control" CRC Press,2007.

	ProgrammeOutcomes												**ProgrammeSpecific Outcomes**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**3**	**3**	**3**	**2**		**2**					**1**	**3**	**3**	**2**
CO2	**3**			**3**	**2**							**1**	**3**	**3**	**2**
CO3	**3**			**3**	**2**							**1**	**3**		
CO4	**2**			**3**	**3**							**1**	**3**		
CO5	**1**	**3**	**3**	**3**	**2**	1	**1**					**1**	**3**	**3**	**2**

222PSE12	MACHINE LEARNING AND DEEP LEARNING	L	T	P	C
		3	0	0	3

PREREQUISITE : Nil

COURSE OBJECTIVES

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

UNIT I LEARNING PROBLEMS AND ALGORITHMS 9

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

UNIT II NEURAL NETWORKS 9

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

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

Classifying Samples: The confusion matrix, Accuracy, Precision, Recall, F1- Score, the curse of dimensionality, training, testing, validation, cross validation, 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, Auto encoders: Convolutional Auto encoders, Denoising auto encoders, Variational auto encoders ,GANs: The discriminator, generator, DCGANs.

TOTAL:45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, the students should have the:

CO1 Illustrate the categorization of machine learning algorithms.

CO2 Compare and contrast the types of neural network architectures, activation functions.

CO3 Acquaint with the pattern association using neural networks.

CO4 Elaborate various terminologies related with pattern recognition and architectures of convolutional neural networks.

CO5 Construct different feature selection and classification techniques and advancedneural network architectures such as RNN, Auto encoders, and GANs
Implement IoT solutions for smart applications.

TEXT BOOKS

1. J. S. R. Jang, C. T. Sun, E. Mizutani, Neuro Fuzzy and Soft Computing - A Computational Approach to Learning and Machine Intelligence, 2012, PHI learning
2. The Elements of Statistical Learning. Trevor Hastie, Robert Tibshirani and Jerome Friedman.Second Edition. 2009

REFERENCE BOOKS

1. Deep Learning, Ian Good fellow, YoshuaBengio and Aaron Courville, MIT Press, ISBN:9780262035613, 2016
2. Vijay Madisetti , ArshdeepBahga, "Internet of Things (A Hands on-Approach)", 2014.

COs	**Programme Outcomes**												**Programme Specific Outcomes**		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**					**2**		**3**					**2**	**3**	
CO2	**3**	**2**	**2**		**2**			**3**				**2**	**2**	**2**	
CO3		**3**	**2**	**2**		**2**		**3**					**2**	**1**	**2**
CO4		**3**				**2**			**2**		**2**	**2**			**2**
CO5	**3**					**2**			**2**		**2**	**2**			**2**

222PSO01/ 122EDT03	COMPUTER APPLICATIONS IN DESIGN	L	T	P	C
		3	0	0	3

OBJECTIVES:

1. To understand fundamental concepts of computer graphics and its tools in a generic framework.
2. To impart the parametric fundamentals to create and manipulate geometric models using curves, surfaces and solids.
3. To impart the parametric fundamentals to create and manipulate geometric models using NURBS and solids.
4. To provide clear understanding of CAD systems for 3D modeling and viewing.
5. To create strong skills of assembly modeling and prepare the student to be an effective user of a standards in CAD system.

PREREQUISITE: Fundamentals of Computer and Programming, Design of Machine Elements, Design of Transmission Systems.

UNIT I INTRODUCTION TO COMPUTER GRAPHICS FUNDAMENTALS 9

Overview of Graphics systems: Video Display Devices, Raster-Scan System, Random-Scan Systems, Graphics Monitors and Workstations, Input Devices, Hard-Copy Devices, Graphics Software.

Output primitives: Line Drawing Algorithm - DDA, Bresenham's and Parallel Line Algorithm. Circle generating algorithm – Midpoint Circle Algorithm.

Geometric Transformations: Coordinate Transformations, Windowing and Clipping, 2D Geometric transformations -Translation, Scaling, Shearing, Rotation and Reflection, Composite transformation, 3D transformations.

UNIT IICURVES AND SURFACES MODELLING 9

Introduction to curves - Analytical curves: line, circle and conics – synthetic curves: Hermite cubic spline- Bezier curve and B-Spline curve – curve manipulations.

Introduction to surfaces - Analytical surfaces: Plane surface, ruled surface, surface of revolution and tabulated cylinder – synthetic surfaces: Hermitebicubic surface- Bezier surface and B-Spline surface-surface manipulations.

UNIT IIINURBS AND SOLID MODELING 9

NURBS- Basics- curves, lines, arcs, circle and bi linear surface. Regularized Boolean set operations - primitive instancing - sweep representations - boundary representations - constructive solid Geometry- comparison of representations - user interface for solid modeling.

UNIT IVVISUAL REALISM 9

Hidden Line removal, Hidden Surface removal, – Hidden Solid Removal algorithms - Shading – Coloring.

Animation - Conventional, Computer animation, Engineering animation - types and techniques.

UNITVASSEMBLYOFPARTSANDPRODUCTLIFECYCLEMANAGEMENT 9

Assembly modeling – Design for manufacture – Design for assembly – computer aided DFMA - inferences of positions and orientation - tolerances analysis –Center of Gravity and mass property calculations - mechanism simulation. Graphics and computing standards – Data Exchange standards. Product development and management – new product development – models utilized in various phases of new product development – managing product life cycle.

TOTAL : 45 Hours

COURSE OUTCOMES:

Students will be able to

- Solve 2D and 3D transformations for the basic entities like line and circle.
- Formulate the basic mathematics fundamental to CAD system.
- Use the different geometric modeling techniques like feature based modeling, surface modeling and solid modeling.
- Create geometric models through animation and transform them into real world systems
- Simulate assembly of parts using Computer-Aided Design software.

TEXT BOOKS:

1. Ibrahim Zeid, "Mastering CAD/CAM", McGraw Hill, 2nd Edition, 2006.
2. William M Newman and Robert F.Sproull "Principles of Interactive Computer Graphics",McGraw Hill Book Co. 1st Edition, 2001.

REFERENCE BOOKS:

1. Boothroyd, G, "Assembly Automation and Product Design", Marcel Dekker, New York, 1997.
2. Chitale A.K and Gupta R.C, "Product design and manufacturing", PHI learning private limited, 6th Edition, 2015.
3. David Rogers, James Alan Adams, "Mathematical Elements for Computer Graphics" 2nd Edition, Tata McGraw-Hill edition, 2003.
4. Donald D Hearn and M. Pauline Baker "Computer Graphics C Version", Prentice Hall, Inc., 2nd Edition, 1996.

	ProgrammeOutcomes												**ProgrammeSpecific Outcomes**		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	**2**	**3**	**3**	**3**	**2**	2	**2**					**2**	**3**	**3**	**2**
CO2	**2**				**2**	2	**2**					**2**	**3**		
CO3	**2**				**2**	2	**2**					**2**	**3**	**3**	**2**
CO4	**2**	**2**	**3**	**3**	**2**	2	**2**					**2**			**3**
CO5	**2**	**2**	**3**	**3**			**2**					**2**			**3**

222PSO02/122MCE21	CYBER SECURITY	L	T	P	C
		3	0	0	3

Students should be able to understand.

- The difference between threat, risk, attack and vulnerability.
- How threats materialize into attacks.
- Where to find information about threats, vulnerabilities and attacks.
- Typical threats, attacks and exploits and the motivations behind them.

UNIT I INTRODUCTION TO CYBER SECURITY 9

Introduction,Cyber Security- Layers of security, Vulnerability, Assets and Threat, Challenges and Constraints - Computer Security - Threats -Harm - Vulnerabilities - Controls - Authentication -Access Control and Cryptography - Web—User Side - Browser Attacks - Web AttacksTargeting Users - Obtaining User or Website Data - Email Attacks

UNIT II SECURITY IN OPERATING SYSTEM & NETWORKS 9

Security in Operating Systems - Security in the Design of Operating Systems -Rootkit -Network security attack- Threats to Network Communications - Wireless Network Security - Denial of Service - Distributed Denial-of-Service.

UNIT III DEFENCES: SECURITY COUNTERMEASURES 9

Cryptography in Network Security - Firewalls - Intrusion Detection and Prevention Systems - Network Management - Databases - Security Requirements of Databases -Reliability and Integrity - Database Disclosure - Data Mining and Big Data**.**

UNIT IV PRIVACY IN CYBERSPACE 9

Privacy Concepts -Privacy Principles and Policies -Authentication and Privacy –Data Mining - Privacy on the Web - Email Security - Privacy Impacts of Emerging Technologies- Where the Field Is Headed.

UNIT V MANAGEMENT AND INCIDENTS 9

Security Planning - Business Continuity Planning - Handling Incidents - Risk Analysis -Dealing with Disaster - Emerging Technologies - The Internet of Things - Economics -Electronic Voting - Cyber Warfare- Cyberspace and the Law - International Laws –Cyber-crime - Cyber Warfare and Home Land Security.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

At the end of this course, the students will be able to:

CO1: Understand the broad set of technical, social & political aspects of Cyber Security

CO2: Describe the operational and organizational Cyber Security Aspects

CO3: Identify and assess different types of Cyber security breaches and possible solutions for a robust system

CO4: understand cyber-attacks, and also how to protect the entire Internet community from such attacks

CO5: Demonstrate the ability to select and design among available security solutions based on different domains of cyber systems

REFERENCES:

1. Charles P. Pfleeger Shari Lawrence Pfleeger Jonathan Margulies, Security in Computing, 5th Edition , Pearson Education , 2018

2. Nina Godbole, SunitBelapure, –Cyber Security: Understanding Cyber Crimes, Computer Forensics and Legal Perspectives‖, Wiley India Pvt. Ltd. , 2011

3. B. B. Gupta, D. P. Agrawal, Haoxiang Wang, Computer and Cyber Security: Principles, Algorithms, Applications, and Perspectives, CRC Press, 2018.

4. George K.Kostopoulos, Cyber Space and Cyber Security, CRC Press, 2013.

5. MarttiLehto, PekkaNeittaanmäki, Cyber Security: Analytics, Technology and Automation, Springer International Publishing Switzerland 2015

6. Chwan-Hwa (John) Wu, J. David Irwin, Introduction to Computer Networks and Cyber security,CRC Press T&F Group, 2013.

7. James Graham, Richard Howard and Ryan Otson, Cyber Security Essentials, CRC Press T&F Group, 2011

	Programme Outcomes												**Programme Specific Outcomes**		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	**2**	**3**		**3**	**2**	2	**2**					**2**	**3**		**2**
CO2	**2**	**3**		**3**	**2**	2	**2**			**2**	**2**	**2**	**3**	**3**	**2**
CO3	**2**	**3**	**3**	**3**	**2**	2	**2**					**2**		**3**	
CO4	**2**	**2**	**3**	**3**			**2**			**2**		**2**	**3**	**3**	
CO5	**2**	**2**	**3**	**3**	**2**	2	**2**				**2**	**2**	**2**	**1**	**3**

CourseCode	CourseTitle	L	T	P	C
222PSO03/122COT05	ADVANCED RADIATION SYSTEMS	3	0	0	3

COURSE OBJECTIVES:

- Understand the concept of Retarded vector potential with Heuristic and Maxwell's equation approach.
- Describe the concept of Antenna Arrays with different types and their pattern multiplication
- Examine the different Antenna synthesis method
- Design different types of Antennas with their characteristic
- Compare all the special antennas with their applications.

UNIT I ANTENNA FUNDAMENTALS 9

Antenna fundamental parameters, Radiation integrals, Radiation from surface and line current distributions -Introduction to numerical techniques- FEM, FDTD, MoM. Linear array -uniform array, end fire and broad side array, gain, beam width, side lobe level- Two dimensional uniform array- Phased array, beam scanning, grating lobe, feed network

UNIT II RADIATION FROM APERTURES 9

Field equivalence principle, Radiation from Rectangular and Circular apertures, Uniform aperture distribution on an infinite ground plane; Slot antenna; Horn antenna-Reflector antenna, aperture blockage, and design consideration.

UNIT III ANTENNA SYNTHESIS 9

Synthesis problem-Line source based beam synthesis methods - Fourier transform and Woodward-Lawson sampling method – Linear array shaped beam synthesis method – Low side lobe, narrow main beam synthesis methods - discretization of continuous sources. Schelkunoff polynomial method

UNIT IV MICRO STRIP ANTENNA 9

Radiation Mechanism from patch - Excitation techniques; Micro strip dipole; Rectangular patch, Circular patch, and Ring antenna - radiation analysis from cavity model - input impedance of rectangular and circular patch antenna – Micro strip array and feed network - Application of microstrip array antenna.

UNIT V SPECIAL ANTENNAS 9

Need of meta material structures, Advantages of meta material structures. Design of the meta material antennas, Fractal antennas, polarization sensitive antenna design, sinuous antennas, EBG structure, PBG structures. CNT antennas.

TOTAL HOURS:45 PERIODS

COURSE OUTCOMES

CO1: Calculate the Power radiated in far field and also familiar with Polarization concept.
CO2: Apply Antenna Arrays with N elements for specified Application
CO3: Summarize the Antenna based on their Specification and Performance, for various Applications
CO4: Categorize the micro strip antennas for different applications.
CO5: Understand about Special antennas

REFERENCE BOOKS

1. Balanis, C.A., "Antenna Theory" Wiley,2003
2. Warren L. Stutzman and Gary A. Thiele," Antenna theory and design"John Wiley and sons 1998
3. Jordan, E.C., " Electromagnetic waves and Radiating systems". PHI 2003
4. Krauss, J.D., " Radio Astronomy" McGraw-Hill 1966, for the last unit (reprints available)
5. Krauss, J.D.,, Fleisch,D.A., "Electromagnetics" McGraw-Hill,1999

	ProgrammeOutcomes												**ProgrammeSpecific Outcomes**		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	**2**			**3**	**2**	2	**2**					**2**			**2**
CO2	**2**	**3**	**3**		**2**	2	**2**					**2**	**3**	**3**	**2**
CO3	**2**		**3**		**2**	2	**2**		**2**			**2**	**3**	**3**	**2**
CO4	**2**	**3**		**3**	**2**	2	**2**		**2**			**2**	**3**		
CO5	**2**	**2**	**3**	**3**	**2**	2	**2**					**2**	**2**	**1**	**3**

CourseCode	CourseTitle	L	T	P	C
222PSO04/122COT03	ADVANCED DIGITAL COMMUNICATION TECHNIQUE	3	0	0	3

COURSE OBJECTIVES

- To extend the theory of Constant envelope modulation to Mary schemes and to familiarize the concept of Spread Spectrum.
- To develop the mathematical and algorithmic foundations of the error detecting and error correcting codes used in modern communications systems.

UNIT I DETECTION AND ESTIMATION 9

Pass band Transmission model - Gram Schmidt orthogonalization procedure, Geometric Interpretation of signals, Response of bank of correlators to a noisy input-Coherent detection of signals in noise, Probability of error - Correlation Receiver - Matched Filter - Detection of signals with unknown phase.

UNIT II EQUALIZATION TECHNIQUES 9

Band Limited Channels- ISI – Nyquist Criterion- Controlled ISI-Partial Response signals Equalization algorithms– Linear equalizer – Decision feedback equalization – Adaptive Equalization algorithms.

UNIT III CONVOLUTIONAL CODING 9

Representation of codes using Polynomial - State diagram - Tree diagram - and Trellis diagram, Decoding techniques: Maximum likelihood decoding - Viterbi algorithm- Sequential decoding Coded modulation for bandwidth constrained channels.

Trellis coded modulation : Set Partitioning - Four state trellis - coded modulation with 8-PSK signal

constellation - Eight state trellis code for coded 8-PSK modulation - Eight state trellis for rectangular QAM signal constellations.

UNIT IV TURBO CODING 9

Introduction - Turbo Encoder -Turbo Decoder-Iterative Turbo Decoding Principles- Modifications of the MAP Algorithm - The Soft-Output Viterbi Algorithm (SOVA) -Turbo Coded BPSK Performance over Gaussian channels -Turbo Coding Performance over Rayleigh Channels.

UNIT VMULTICARRIER AND MULTIUSER COMMUNICATIONS 9

Single Vs multicarrier modulation, orthogonal frequency division multiplexing (OFDM), Modulation and demodulation in an OFDM system, An FFT algorithmic implementation of an OFDM system, Bit and power allocation in multicarrier modulation, Peak-to-average ratio in multicarrier modulation. Introduction to CDMA systems, multiuser detection in CDMA systems–optimum multiuser receiver, suboptimum detectors**,successive interference cancellation.**

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon Completion of this course, students will be able to :

CO1: Apply Digital communication technologies in a variety of engineering applications
CO2: Gain knowledge in equalization techniques
CO3: Implement Error control coding and Digital modulation techniques in MATLAB
CO4: Learn turbo coding and its comparison with Rayleigh channels
CO5: Learn about multicarrier and multiuser communication.

REFERENCE BOOKS

1. Simon Haykin, "Digital Communications", John Wiley and sons, Reprint 2009
2. L. Hanzo, T.H. Liew & B.L. Yeap, "Turbo Coding, Turbo Equalization & Space-Time Coding", Wiley, First Edition, 2002
3. Theodore S.Rappaport, "Wireless Communications", Pearson Education, Second Edition 2002.
4. Stephen G. Wilson, "Digital Modulation and Coding", Pearson Education, First Indian Reprint, 2003.
5. Rodger E. Ziemer, Roger L. Peterson, David E. Borth, "Introduction to Spread Spectrum Communications", Prentice Hall, First Edition, 1995.
6. Lathi B P and Zhi Ding, "Modern Digital and Analog communication Systems", Oxford University Press, 2011.
7. Richard Van Nee &Ramjee Prasad, "OFDM for Multimedia Communications" Artech House Publication, 2001.
8. Nptel Lecture: http://aicte-stream/

	ProgrammeOutcomes												**ProgrammeSpecific Outcomes**		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	**2**				**2**	2	**2**					**2**	**3**	**3**	**2**
CO2	**2**				**2**	2	**2**					**2**	**3**	**3**	**2**
CO3	**2**				**2**	2	**2**					**2**	**3**	**3**	**2**
CO4	**2**	**2**	**3**				**2**					**2**			**3**
CO5	**2**	**2**	**3**				**2**					**2**			**3**

222PSO05/ 122MCT04	SOFTWARE REQUIREMENT ENGINEERING	L	T	P	C
		3	0	0	3

PREREQUISITE: Fundamentals of Software Engineering

COURSE OBJECTIVES:

1. Understand the basics of requirements engineering.
2. Learn different techniques used for requirements elicitation.
3. Know the role played by requirements analysis in requirement integration.
4. Appreciate the use of various methodologies for requirement development.
5. Study the current trends in requirements prioritization and validation.

UNIT I REQUIREMENTS ENGINEERING OVERVIEW 9

Software Requirement Overview – Software Development Roles –Software Development Process Kernels – Commercial Life Cycle Model – Vision Development – Stakeholders Needs & Analysis – Stakeholder needs –Stakeholder activities–**Requirement Capture and Modelling– Requirement Analysis.**

UNIT II REQUIREMENTS ELICITATION 9

The Process of Requirements Elicitation – Requirements Elicitation Problems – Current Elicitation Techniques – Information Gathering – Requirements Expression and Analysis – Validation – An Elicitation Methodology Framework – A Requirements Elicitation Process Model – Methodology over Method – Integration of Techniques – Fact-Finding – Requirements Gathering – Evaluation and Rationalization – Prioritization– Integration and Validation – Risk Assessment and Risk Treatment (RART).

UNIT III REQUIREMENTS ANALYSIS 9

Identification of Functional and Non Functional Requirements **– Requirement Engineering – Requirement Elicitation and Analysis – Requirements Management –** Identification of Quality Requirements – Six Quality Attributes– Analysis – Feasibility and Internal Compatibility of System Requirements –Human Requirements Baseline.

UNIT IV REQUIREMENTS DEVELOPMENT 9

Requirements analysis – Requirements Documentation – Requirements Development Workflow –Fundamentals of Requirements Development – Requirements Attributes Guidelines Document –Supplementary Specification Document – Use Case Specification Document – Methods for Software Prototyping – Evolutionary prototyping –Throwaway prototyping.

UNIT V REQUIREMENTS VALIDATION AND VERIFICATION 9

Validation objectives – Analysis of requirements validation – Activities – Properties Requirement reviews – Requirements testing – ISO 31000 – **Testing Fundamentals Test Plan– Test Design– Test Execution– Reviews– Inspection Auditing**– Case tools for requirements engineering.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, the student will be able to
CO1: Prepare SRS including the details of requirements engineering.
CO2: Describe the stages of requirement elicitation.
CO3: Analyze software requirements gathering.
CO4: Integrate the requirements well during requirements analysis.
CO5: Use various methodologies for requirements validation and verification

REFERENCES:

1. Phillip A.Laplante, Mohamad H.Kassab ,"Requirement Engineering for Software and Systems"Fourth Edition, 2022
2. Wiegers, Karl,Joy Beatty, "Software Requirements", Pearson Education,2013.
3. Ian Sommerville, Pete Sawyer," Requirements Engineering: A Good Practice Guide", Sixth Edition, Pearson Education, 2004.
4. Dean Leffingwe, DonWidrig, "Managing Software Requirements AUseCaseApproach", Second Edition, Addison Wesley,2003.
5. Karl Eugene Wiegers, "Software Requirements", Word Power Publishers, 2000.
6. Ian Graham, "Requirements Engineering and Rapid Development", AddisonWesley,1998.

	CO-PO MAPPING											
		Program outcomes (Washington Accord Attributes)											
Course Name	**CO'S**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
SOFTWARE REQUIREMENTS ENGINEERING	**CO1**	2	1	-	-	1	2	-	-	-	-	1	-
	CO2	2	1	-	1	-	2	-	-	-	-	1	-
	CO3	2	-	-	1	1	-	-	-	-	-	1	-
	CO4	1	2	-	1	1	-	-	-	-	-	2	-
	CO5	-	1	-	2	2	1	-	-	-	-	-	-
AVERAGE		**1.00**	**1.00**	**-**	**1.00**	**1.00**	**1.00**	**-**	**-**	**-**	**-**	**1.00**	**-**

CourseCode	CourseTitle	Hours/week			Credits
222PSP07	POWER SYSTEM LABORATORY–II	L	T	P	C
		0	0	4	2

Prerequisite: PowerSystem Analysis

Objectives:

1. Solve the power system problems using computational intelligent techniques

2.Analyze the solution obtained for power system under normal and abnormal Conditions using simulation software

3. Expose with real time monitoring of power system

4. Evaluate the new techniques used for power system problems with the conventional one.

5. Educate to integrate renewable energy sources

LIST OF 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

COURSE OUTCOMES:

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

	Programme Outcomes												**Programme Specific Outcomes**		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**				**3**	**2**	**1**					**2**	**3**	**3**	**2**
CO2	**3**	**3**	**2**			**2**	**1**					**2**			**2**
CO3	**2**	**3**		**2**	**2**	**1**	**1**					**1**	**2**	**3**	**1**
CO4	**2**	**3**	**3**	**2**	**2**	**1**	**1**					**1**			**1**
CO5	**2**	**3**				**1**	**1**					**1**	**2**	**3**	**1**

CourseCode	CourseTitle	Hours/week			Credits
222PSP08	Technical Seminar	L	T	P	C
		0	0	2	1

OBJECTIVE:

To motivate the students to attain the confidence and competence.

The students are asked to give a seminar on the recent trends in the field of electrical engineering on an individual basis and evaluation will be done by a panel of faculty Members.

322PST01	POWER SYSTEM PLANNING AND RELIABILITY	L	T	P	C
		3	0	0	3

Prerequisite: Power System Operation and Control

Objectives:

To introduce the basic concepts of reliability engineering
To understand the objectives of Load forecasting
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 LOAD FORECASTING **9**

Objectives of forecasting -Load Forecasting Categories-Long term, Medium term, short term, very short-term Applications of Load Forecasting- Load growth patterns and their importance in planning - Load Forecasting Based on discounted multiple regression technique-Weather sensitive load forecasting-Determination of annual forecasting-Use of AI in load forecasting.

UNIT - III 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 - IV COMPOSITE GENERATION AND TRANSMISSION SYSTEM **9**

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

UNIT - V DISTRIBUTION SYSTEM **9**

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

Total: 45 Hours

Course Outcomes:

The students will be able to

- **CO1** Acquire design knowledge of system components in reliability point of view.
- **CO2** Understand the objectives of Load forecasting.
- **CO3** Understand the importance of customer oriented and system oriented indices.
- **CO4** Familiarize with reliability evaluation methodologies.
- **CO5** Analyse the system performance with proper remedial strategies.

TEXT BOOKS

1. Dr. K. Uma Rao, "Power system operation & control", Wiley-India, First edition, 2013.
2. Ali Chowdhury, Don Koval, "Power Distribution System Reliability: Practical Methods and Applications", Wiley-IEEE Press, 2009.
3. Cepin, Marko, "Assessment of Power System Reliability", Springer, 2011.
4. Roy Billinton, R.N. Allan, "Reliability Evaluation of Power Systems", Springer, 2013.
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.

REFERENCE BOOKS :

1. J. Endrenyi, Reliability Modelling in Electric Power Systems, 1st edition, John Willey and Sons, US, 1978..
2. Charles Eebeling, An Introduction to Reliability and Maintainability Engineering, Tata McGraw Hill, India, 2004.
3. Generation of Electrical Energy – B.R. Gupta, S. Chand Publication.

COs	**Programme Outcomes**												**Programme SpecificOutcomes**		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	**2**	**3**	**3**	**3**	**2**	**2**	**1**					**1**	**3**	**3**	**2**
CO2	**2**	**3**	**3**	**3**	**2**	**2**	**1**					**1**	**3**	**3**	**2**
CO3	**2**	**3**	**2**	**2**	**2**	**1**	**1**					**1**	**2**	**2**	**1**
CO4	**2**	**3**	**2**	**2**	**2**	**1**	**1**					**1**	**2**	**2**	**1**
CO5	**2**	**3**	**2**	**2**	**2**	**1**	**1**					**1**	**2**	**2**	**1**

322PST02	HVDC and FACTS	L	T	P	C
		3	0	0	3

Prerequisite: Power Electronics

Objectives:

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

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 system - Review of basics of LCC and VSC HVDC system. Configurations-Monopolar Asymmetric and Symmetric MMC-HVDC Scheme- Bipolar and Homopolar HVDC Scheme- Multi-Terminal HVDC Configuration- Layout of HVDC system (LCC, VSC)

UNIT - II 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, Concepts of Power Oscillation Damping Controller, Frequency Controller and Sub synchronous Damping controller in LCC HVDC.

UNIT - III THYRISTOR BASED FACTS CONTROLLERS **9**

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

UNIT - IV VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS **9**

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

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(MMC) 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.

Total Hours: 45

Course Outcomes:

The students will be able to

- **CO1** Understand the basics of power transmission networks and need for HVDC and FACTS controllers
- **CO2** Attain knowledge in HVDC Converters and system control
- **CO3** Design series and shunt compensating devices for power transfer enhancement
- **CO4** Understand the significance about different voltage source converter-based FACTS controllers
- **CO5** Understand the system operation, modelling and control of HVDC link.

TEXT BOOKS

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, Milti colour edition 2016.
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.
6. Narain G. Hingorani, Laszlo Gyugyi, "Understanding FACTS – Concepts and Technology of Flexible AC Transmission Systems" Wiley India publications 2011.

COs	Programme Outcomes												Programme SpecificOutcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	3	3	3	2	2					1	3	3	2
CO2	2	3	3	2	2	1	1					1	2	3	1
CO3	2	3	3	2	2	1	1					1	2	3	1
CO4	2	3	3	2	3	2	2					1	3	3	2
CO5	2	3	3	2	2	1	1					1	2	3	2

322PSE01	WIND AND SOLAR ENERGY SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

1. To understand the construction of wind energy system.
2. To understand the design of wind turbine.
3. To understand the construction of solar Photo Voltaic panel.
4. To understand the design of solar Photo Voltaic panel.
5. To understand the battery storage and economics of wind and solar energy system.

PRE REQUISITE: Power Generation Systems.

UNIT I INTRODUCTION TO WIND ENERGY 9

Types and classification of WECS; Power, torque and speed characteristics, Aerodynamic design principles; Aerodynamic theories; Axial momentum, blade element and combine theory; Rotor characteristics; Maximum power coefficient; Prandltís tip loss correction- Power extracted from ideal and practical wind turbine - Efficiency limit for wind energy conversion.

UNIT II DESIGN OF WIND TURBINE 9

Wind turbine design considerations- Design of wind turbine rotor: Diameter of the rotor - Choice of number of blades - The tower- Transmission system and Gear box - Power speed characteristics - Torque speed characteristics. Wind turbine control systems - Pitch angle control, Stall control, Yaw control, Control strategy.; Horizontal axis machines, vertical axis machines, Advantages and Diadvantages

UNIT III INTRODUCTION TO SOLAR PV PANEL 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- Basic photo voltaic system for power generation – Advantages and disadvantages of photo voltaic solar energy conversion –Components of PV systems.-Application of solar photo voltaic system

UNIT IV DESIGN OF SOLAR PV PANEL 9

Solar PV system design and grid integration-Charge controllers-PV-MPPT techniques--Power conditioning and storage arrangement – Maximum power point tracking (MPPT) - Introduction to string inverters-Design of solar power plant

UNIT V BATTERY STORAGE AND ECONOMICS OF WIND AND SOLAR ENERGY SYSTEM 9

Types of Batteries- Performance Characteristics- battery design- battery management- overview of economic assessment, capital, operation and maintenance costs of wind and solar energy systems, comparison of alternative energy systems using life cycle cost analysis.

TOTAL : 45 Hours

COURSE OUTCOMES:

CO 1 Students will able to understand the wind energy system.

CO 2 Students will able to understand the design of wind turbine.

CO 3 Students will able to understand the Solar Photovoltaic System.

CO 4 Students will able to understand the design of Solar Photovoltaic System.

CO 5 Students will able to understand the battery storage and economics of Wind and Solar energy system.

REFERENCES:

1. Suneel, Deambi, 'Photovoltaic System Design: Procedures, Tools and Application', First Edition, 2016.
2. MuyiwaAdaramola,'Wind Turbine Technology, Principles and Design', First Edition, 2021.
3. European Wind Energy European Wind Energy Association, 'Wind Energy- The Facts: A Guide to the Technology, Economics and Future of Wind Power', First Edition 2009.
4. Adel A. Elbaset, Adel Z. El Dein, Ibrahim Moukhtar,'Solar Energy: Technologies, Design, Modeling, and Economics (Power Systems), First Edition, 2021.
5. Solar photovoltaic technology and systems, manual for technicians, trainers and engineers, PHI learning private ltd delhi-2013

	Programme Outcomes												**Programme Specific Outcomes**		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**2**	**2**	**2**	**2**	**1**	**1**					**2**	**2**	**2**	**2**
CO2	**3**	**2**	**2**	**2**	**2**	**1**	**1**					**2**	**2**	**2**	**2**
CO3	**3**	**2**	**2**	**2**	**2**	**1**	**1**					**2**	**2**	**2**	**2**
CO4	**3**	**2**	**2**	**2**	**2**	**1**	**1**					**2**	**2**	**2**	**2**
CO5	**3**	**3**	**3**	**3**	**3**	**2**	**2**					**2**	**2**	**2**	**2**

322PSE02	POWER SYSTEM DEREGULATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To provide in-depth understanding of operation of deregulated electricity market systems.
- To examine topical issues in electricity markets and how these are handled in various markets.
- To enable students to analyze various types of electricity market operational and control issues using new mathematical models.
- To understand the capability of congestion management in transmission side.
- To understand the Indian power market challenges and Indian power sector in past and present.

PRE REQUISITE: Nil

UNIT I INTRODUCTION 9

Introduction to deregulation - Basic Terminologies - Reconfiguring Power systems-unbundling of electric utilities-Background to deregulation and the current situation around the world, -benefits from a competitive electricity market after effects of deregulation - Issues involved in deregulation.

UNIT II POWER SYSTEM OPERATION IN COMPETITIVE ENVIRONMENT 9

Introduction-Role of Independent system operator- power pools – single auction power pool & double auction power pool with supply bid and demand - Operational planning activities of a GENCO-Genco in Pool and Bilateral markets-market participation issues- competitive bidding Transmission networks and bilateral Electricity markets- bilateral trading in a two-bus power system.

UNIT III TRANSMISSION OPEN ACCESS AND PRICING ISSUES 9

Introduction-power wheeling -Transmission open access- Types of Transmission services in open access – cost components in transmission – Pricing of power transactions – Embedded cost-based Transmission pricing - Postage stamp method - contract path method-MW Mile method – Marginal participation method – Incremental cost based transmission pricing –SRMC and LRMC based pricing.

UNIT IV AVAILABLE TRANSFER CAPABILITY & CONGESTION MANAGEMENT 9

Introduction of ancillary services–Types of Ancillary services–Classification of Ancillary services–Load generation balancing related services–Voltage control and reactive power support devices–Black start capability service-ancillary service–Co-optimization of energy and reserve services-International comparison-Transmission pricing–Principles–Classification–Role in transmission pricing methods–Marginal transmission pricing paradigm–Composite pricing paradigm–Merits and demerits of different paradigm.

UNIT V INDIAN POWER MARKET 9

Introduction –Indian power sector past and present status-growth of power sector in India – Electricity Act, 2003 - Key issues and solution; Developing power exchanges suited to the Indian market - Challenges and synergies in the use of IT in power- Competition-in Indian power market- Indian energy exchange- Indian power exchange Infrastructure model for power exchanges.

TOTAL: 45 Hours

COURSE OUTCOMES:

CO 1 Ability to understand the basic of power system deregulation.

CO 2 Able to understand the power system operation in electricity market.

CO 3 Able to understand the marginal pricing and transmission pricing in transmission side.

CO 4 Able to understand the capability of congestion management in transmission side.

CO 5 Understand the Indian power market challenges and Indian power sector in past and present.

REFERENCES:

1. Kankar Bhattacharya Maath H.J. Bollen and Jaap E.Daalder,-Operation of restructured power systems, Kluwer academic publishers, USA , first edition, 2011.
2. Daniel Kirschen and Goran Strbac ,-Fundamentals of power system economics‖, John Wiley sons, 2014.
3. M.Shahidepour, Hatim Tamin and Zuyi Li, ―Market operations in electric power system forecasting, scheduling and risk management‖, John Wiley sons, 2012.

	Programme Outcomes												**Programme Specific Outcomes**		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1			**3**	**1**					**3**	**3**			**3**		**3**
CO2	**3**		**3**				**2**			**2**		**3**			
CO3	**3**						**3**								**2**
CO4		**2**			**3**				**2**			**3**	**3**	**3**	
CO5	**3**				**1**	**3**		**3**							**3**

322PSE03	SMART GRID DESIGN AND ANALYSIS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure.
- To familiarize the DC distribution side in Smart Grid.
- To study about the concept of energy system dynamics.
- To study about the concept of energy port in multinational levels.
- To analyze various types of technologies in smart grid design.

PRE-REQUISITE: Nil

UNIT I INTRODUCTION 9

Introduction to smart grid- Electricity Network-Local energy networks- Electric transportation- Low carbon central generation-Attributes of the smart grid- Alternate views of a smart grid-- Overview of the perfect power system configurations- Device level power system- Building integrated power systems- Distributed power systems- Fully integrated power system-Nodes of innovation.

UNIT II DC DISTRIBUTION AND SMART GRID 9

AC vs DC sources-Benefits of and drives of DC power delivery systems-Powering equipment and appliances with DC-Data centers and information technology loads-Future Neighbourhood-Potential future work and research—Launching intelligrid- Intelligrid today-Smart grid vision based on the intelligrid architecture-Barriers and enabling technologies.

UNIT III DYNAMIC ENERGY SYSTEMS CONCEPT 9

Smart energy efficient end use devices-Smart distributed energy resources-Advanced whole building control systems- Integrated communications architecture-Energy management-Role of technology in demand response- Current limitations to dynamic energy management-Distributed energy resources-Overview of a dynamic energy management-Key characteristics of smart devices- Key characteristics of advanced whole building control systems-Key characteristics of dynamic energy management system.

UNIT IV ENERGY PORT AS PART OF THE SMART GRID: MANAGEMENT 9

Concept of energy -Port, generic features of the energy port-policies and programs to encourage end – use energy efficiency-Policies and programs in action -multinational - national-state-city and corporate levels- Framework-factors influencing customer acceptance and response - program planning-monitoring.

UNIT V EFFICIENT ELECTRIC END – USE TECHNOLOGY ALTERNATIVES 9

Existing technologies – lighting - Space conditioning - Indoor air quality - Domestic water heating - hyper efficient appliances - Ductless residential heat pumps and air conditioners – Variable refrigerant flow air conditioning-Heat pump water heating - Hyper efficient residential appliances -Data centre energy efficiency- LED street and area lighting - Industrial motors and drives -Equipment retrofit and replacement - Process heating - Cogeneration, Thermal energy storage -Industrial energy management programs - Manufacturing process-Electro-technologies, Residential, Commercial and industrial sectors.

TOTAL: 45 Hours

COURSE OUTCOMES:

CO 1 Acquired the knowledge about the basis of smart grid.

CO 2 Attained the idea about working of DC distribution.

CO 3 Gained the acquaintance of energy system dynamics.

CO 4 Gained the knowledge about the real time implementation of smart grid.

CO 5 Gained the innovative idea about end use technologies of electric end.

REFERENCES:

1. Kenneth C.Budka, Jayant G. Deshpande, Marina Thottan, 'Communication Networks for Smart Grids', Springer, 2014.
2. Janaka Ekanayake, Kithsiri Liyanage,Jianzhong.Wu, Akihiko Yokoyama, Nick Jenkins, "Smart Grid: Technology and Applications"- Wiley, 2012.
3. Clark W Gellings, "The Smart Grid, Enabling Energy Efficiency and Demand Side Response"- CRC Press, 2009.

	Programme Outcomes												**Programme Specific Outcomes**		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**		**2**	**1**		**3**			**3**	**3**			**3**		**3**
CO2	**3**		**3**				**2**		**3**	**2**		**3**	**3**	**2**	
CO3	**2**						**3**						**2**		**2**
CO4		**2**			**2**			**2**	**2**			**3**	**3**	**3**	
CO5	**3**				**1**	**3**		**3**							**3**

322PSE04	INSULATION TECHNOLOGY AND HIGH VOLTAGE ENGINEERING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To learn various Insulating Materials, Properties and Breakdown Mechanisms of Insulating Materials.
- To learn about the Nature of Breakdown Mechanism in Solid, Liquid and Gaseous Dielectrics.
- To know about Breakdown in Vacuum Insulation.
- To know about the Dielectric breakdown in Solid and Liquid Dielectrics.
- To learn about the Applications of Insulating materials in transforms and other electrical equipments.

PRE REQUISITE: Nil

UNIT I GENERAL PROPERITIES OF INSULATING MATERIALS 9

Requirements of Insulating Materials – Electrical Properties – Molecular Properties of dielectrics – Dependence of permittivity on temperature, pressure, humidity and voltage, permittivity of mixtures, practical importance of permittivity – Behaviour of dielectric under alternating fields – Complex dielectric constants –Bipolar relaxation and dielectric loss, dielectric strength.

UNIT II BREAKDOWN MECHANISMS IN GASEOUS DIELECTRICS 9

Behaviour of gaseous dielectrics in electric fields– Gaseous discharges – Different ionization processes – Effect of electrodes on gaseous discharge – Townsend's theory, Streamer theory – electronegative gases and their influence on gaseous discharge – Townsend's criterion for spark breakdown, gaseous discharges in non-uniform fields - Breakdown in vacuum insulation.

UNIT III BREAKDOWN MECHANISMS IN SOLID DIELECTRICS 9

Intrinsic breakdown of solid dielectrics – Electromechanical Breakdown-Streamer breakdown, thermal breakdown and partial discharges in solid dielectrics - Electrochemical breakdown – Tracking and Treeing – Classification of solid dielectrics, composite insulation and its mechanism of failure.

UNIT IV BREAKDOWN MECHANISMS IN LIQUID DIELECTRICS 9

Liquid as insulators, conduction and breakdown in pure and commercial liquids - Electronic breakdown, suspended solid particle mechanism, cavity breakdown, examples - Static electrification in power transformers transformer oil filtration, transformer oil test, alternative liquid insulations like vegetable oils, esters and silicon oils.

UNIT V APPLICATION OF INSULATING MATERIALS 9

Application of insulating materials in Transformers, Rotating Machines, Circuit Breakers, Cables, Power Capacitors and Bushings.

TOTAL: 45 Hours

COURSE OUTCOMES:

CO 1 Learning about the various Insulating Materials, Properties and Breakdown Mechanisms.

CO 2 Learning about the Breakdown Mechanism of Gaseous Dielectrics.

CO 3 Learning about the Breakdown mechanism of Solid Dielectrics.

CO 4 Learning about the Breakdown mechanism of Liquid Dielectrics.

CO 5 Analyzing various applications of Insulating Materials in Electrical Equipments.

REFERENCES:

1. Naidu M. S. and Kamaraju V., "High Voltage Engineering", fourth Edition, Tata McGraw- Hill Publishing Company Limited, New Delhi, 2019.
2. Rakosh Das Begamudre, "High Voltage Engineering, Problems and Solutions", New Age International Publishers, New Delhi, 2020.
3. Wadhwa C.L., "High Voltage Engineering", Third Edition, New Age publishers, New Delhi, 2012.

	Programme Outcomes												**Programme Specific Outcomes**		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**		**2**	**1**		**3**			**3**	**3**			**3**		**3**
CO2		**3**	**3**		**2**		**2**	**3**	**3**	**3**	**2**	**3**	**3**	**2**	
CO3	**2**			**3**			**3**			**3**			**2**	**3**	**2**
CO4		**2**	**2**		**2**	**3**		**2**	**2**		**3**	**3**	**3**	**3**	
CO5	**3**				**1**	**3**		**3**							**3**

322PSE05	EHV POWER TRANSMISSION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

To learn the basic knowledge of Transmission Lines and Equipment.
To understand the line parameters calculation.
To learn the voltage gradients of conductors.
To understand the electrostatic field of EHV lines.
To analyze the Design and control issues 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 with single & bundled conductors– Calculation of sequence inductances and capacitances – Line parameters for Modes of propagation- effect of ground return.

UNIT III VOLTAGE GRADIENTS OF CONDUCTORS 9

Charge-Potential Relations for Multi-conductor lines – Surface Voltage Gradient on Conductors – Gradient Factors and their use – Distribution of Voltage Gradient on Sub conductors of Bundle - Voltage Gradients on Conductors in the Presence of Ground Wires on Towers- I^2R Loss and Corona Loss-RIV.

UNIT IV ELECTROSTATIC FIELD AND DESIGN OF EHV LINES 9

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

UNIT V HVDC LINES 9

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

TOTAL: 45 Hours

COURSE OUTCOMES

At the end of the course the student will be

CO1 Gaining the knowledge to identify voltage level and line configurations.

CO2 Able to Extrapolate the knowledge of calculate the line parameters of R,L,C.

CO3 Familiar in computing the voltage gradients of transmission line conductors.

CO4 Able to analyze the effects of electrostatic field on living and nonliving beings.

CO5 Able to analyze the design, control and protection aspects of HVDC lines.

REFERENCE BOOKS

1. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", 5th Edition, New Age International Pvt. Ltd., 2023.
2. TuranGonen, 'Electric Power Transmission System Engineering: Analysis and Design' 3rd Edition, CRC Press, 2015.
3. A Chakraborti, D.P. Kothari and A.K. Mukhopadyay, 'Performance, Operation and Control of EHV Power Transmission Systems' , A. H. Wheeler Publishing Company Limited, 1999.
4. K R Padiyar, 'HVDC Power Transmission Systems' 3rd Edition, New Age International Pvt. Ltd., 2017.
5. Sunil S.Rao, "EHV-AC, HVDC Transmission & Distribution Engineering", 3rd Edition, Khanna Publishers, 2008.
6. William H. Bailey, Deborah E. Weil and James R. Stewart . "A Review on HVDC Power Transmission Environmental Issues", Oak Ridge National Laboratory, Oak Ridge National Lab. (ORNL), Oak Ridge, TN (United States), 1997.
7. Pritindra Chowdhuri, "Electromagnetic transients in Power System", 2nd Edition, Research Studies Press, 2004.

COs	Programme Outcomes												Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	2	3	3	3	3	2	2					2	3	3	2
CO2	2	3	3	3	3	2	2					2	3	3	2
CO3	2	3	3	3	3	2	2					2	3	3	2
CO4	2	3	3	2	2	2	2					2	3	3	1
CO5	2	3	3	2	2	2	2					2	3	3	1

322PSE06	MACHINE LEARNING TECHNIQUES	L	T	P	C
		3	0	0	3

OBJECTIVE(S):

- To understand the concepts and mathematical foundations of machine learning and types of problems tackled by machine learning
- To explore the different supervised learning techniques including ensemble methods
- To learn different aspects of unsupervised learning and reinforcement learning
- To learn the role of probabilistic methods for machine learning
- To understand the applications of Machine Learning

UNIT–I INTRODUCTIONAND MATHEMATICAL FOUNDATIONS 9

What is Machine Learning? Need –History – Definitions – Applications - Advantages, Disadvantages& Challenges -Types of Machine Learning Problems – Mathematical Foundations - Linear Algebra &Analytical Geometry -Probability and Statistics- Bayesian Conditional Probability -Vector Calculus &Optimization - Decision Theory - Information theory

UNIT–II SUPERVISED LEARNING 9

Introduction-Discriminative and Generative Models -Linear Regression - Least Squares -Under-fitting/Overfitting -Cross-Validation – Lasso Regression- Classification - Logistic Regression- GradientLinear Models -Support Vector Machines –Kernel Methods -Instance based Methods - K-NearestNeighbors - Tree based Methods –Decision Trees –ID3 – CART - Ensemble Methods – RandomForest - Evaluation of Classification Algorithms

UNIT– IIIUNSUPERVISED LEARNING AND REINFORCEMENT LEARNING 9

Introduction - Clustering Algorithms -K – Means – Hierarchical Clustering - Cluster Validity - Dimensionality Reduction –Principal Component Analysis – Recommendation Systems – EMalgorithm. Reinforcement Learning – Elements -Model based Learning – Temporal DifferenceLearning

UNIT–IV PROBABILISTIC METHODS FOR LEARNING 9

Introduction -Naïve Bayes Algorithm -Maximum Likelihood -Maximum Apriori -Bayesian BeliefNetworks -Probabilistic Modelling of Problems -Inference in Bayesian Belief Networks – ProbabilityDensity Estimation - Sequence Models – Markov Models – Hidden Markov Models

UNIT–V APPLICATIONS OF MACHINE LEARNING 9

Recommendation Systems – Model for Recommendation Systems, Utility Matrix, Content-Based Recommendations, Discovering Features of Documents, Collaborative Filtering.Advertising on the Web: Issues in Online Advertising, Online and offline algorithms, The matchingProblem, The AdWords Problem, The Balance Algorithm.Application of dimensionality reduction-SVD for Latent Semantic Indexing

TOTAL: 45Hours

COURSEOUTCOMES:

Attheendofthecoursestudent shouldbeableto

CO1: Understand and outline problems for each type of machine learning

CO2: Design a Decision tree and Random forest for an application

CO3: Implement Probabilistic Discriminative and Generative algorithms for an application and analyze the results.

CO4: Use a tool to implement typical Clustering algorithms for different types of applications.

CO5: Understand how Machine learning is applied tosolve problems in various applications like gameplaying, recommendation systems, high dimensional analysis

REFERENCES:

1. Stephen Marsland, "Machine Learning: An Algorithmic Perspective", Chapman & Hall/CRC, 2nd Edition, 2014.
2. Tom M Mitchell, "Machine Learning", McGraw Hill Education, 2013.
3. Kevin Murphy, "Machine Learning: A Probabilistic Perspective", MIT Press, 2012
4. Peter Flach, "Machine Learning: The Art and Science of Algorithms that Make Sense of Data", First Edition, Cambridge University Press, 2012.
5. ShaiShalev-Shwartz and Shai Ben-David, "Understanding Machine Learning: From Theory to Algorithms", Cambridge University Press, 2015
6. AnandRajaRaman, Jure Leskovec and J.D. Ullman, "Mining of Massive Data sets", e-book,Publisher, 2014

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1		2	1							2
CO2	1	1		2	1							2
CO3	1	1		2	1							2
CO4	1	1		2	1							2
CO5	1	1		2	1					1		2

322PSE07	Design of Controllers in Power Applications	L	T	P	C
		3	0	0	3

Prerequisite: NIL

Objectives:

To introduce the mathematical representation of controller components and solution techniques

To impart in-depth knowledge on different methods of modern controllers.

To gain knowledge on current controller design

To get insight of contingency analysis problem and the solution methods.

To gain knowledge on transient stability analysis and the associated solution techniques

UNIT – I CLASSICAL CONTROLLER DESIGN 9

Introduction of controller design – Proportional (P)-Integral (I)-Derivative (D)-PI-PD -PID controllers-Characteristics-Design of controller- Tuning- Ziegler-Nichol's method, Cohen coon method and damped oscillation method

UNIT - II SLIDING MODE CONTROL & VARIABLE STRUCTURE CONTROLLER 9

Dynamics in the sliding mode – linear system, non-linear system, chattering phenomenon – sliding mode control design – reachability condition, robustness properties –application Sliding surfaces- Continuous approximations of Switching control laws- Modeling / Performance trade-Variable structure controller-Adaptive variable structure controller bang-bang control theory-trajectory planning-Case Studies

UNIT - III CURRENT CONTROLLER DESIGN 9

Hysteresis current control (HCC) – Design of HCC with PWM schemes-Case Studies Predictive current controller (PCC) –Model predictive control (MPC)-PWM predictive control (PPC)

UNIT - IV H-INFINITY CONTROL & ROBUST CONTROL THEORY 9

Introduction of H-infinity methods in control theory-Elements of robust control theory – Design objectives – Shaping the loop gain –Signal spaces – Computation of H∞ norm- All pass systems-- Linear-quadratic-Gaussian control (LQG)-Robust control theory- Robust controller design- Robust decision methods- Analytic tools for robust decision making-Case Studies

UNIT - V CONTROLLER DESIGN 9

Controller synthesis and tuning, Linear Matrix inequalities, LMI solvers, control system analysis and design with LMIs using MATLAB/Simulink Uncertain system analysis -Statistical and worst-case analysis of stability and performance Analysis

Total: 45 Hours

COURSE OUTCOMES:

CO1 Learned the significance of classical Controller Design and its solution techniques

CO2 Understand the sliding mode control & variable structure controller

CO3 Understand the current controller design and its solution techniques

CO4 Acquired the knowledge in H-infinity control & robust control theory

CO5 Able to understand the concept of Controller Design.

	Programme Outcomes												**Programme Specific Outcomes**		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PO1 2**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**2**	**3**	**2**	**2**	**2**							**2**	**3**	**3**
CO2	**3**	**2**	**2**	**3**	**3**	**3**							**2**	**3**	**3**
CO3	**3**	**2**	**2**	**3**	**3**	**3**							**2**	**3**	**3**
CO4	**3**	**2**	**2**	**2**	**2**	**2**							**2**	**3**	**3**
CO5	**3**	**3**	**3**	**3**	**3**	**3**							**2**	**3**	**3**

TEXT BOOKS:

1. Jean Pierre Barbot., “Sliding Mode Control in Engineering” Marcel Bekker, 2002.

2. Green M. and Limebeer /D.J.N., “Linear Robust Control”, Englewood cliffs, NJ: Prentice Hall, 1995.

3. Ramya K Yedavalli, Robust Control of Linear Dynamical Systems”, a linear state space approach AcademicPress Limited,New York .2014

3. P.C.Charndrasekharan., “Robust Control of Linear Dynamical Systems”, AcademicPress Limited, San Diego.1996.

4. Zinober, Alan S.I., ed. “Variable Structure and Lyapunov Control” , London: Springer-Verlag. doi:10.1007/BFb0033675. ISBN 978-3-540-19869-7, 1994.

REFERENCES

1. Bryson, A.E and Ho, Y., "Applied Optimal Control: Optimization, Estimation and Control (Revised Printing)", John Wiley and Sons, New York, 1975.

2. SomanathMajhi., “Advanced Control Theory A relay Feedback Approach”, Cengage Learning, 2009.

3. www.Mathworks,com/Matlab-2012b,2013a/Simulnik.

322PSE08	ELECTRIC POWER DISTRIBUTION SYSTEM	L	T	P	C
		3	0	0	3

Pre-Requisite:Transmission and Distribution

OBJECTIVES:

1. To understand the fundamentals of distribution system.
2. To understand design and operation of distribution system.
3. To understand system planning of distribution system.
4. To understand the Load forecasting of distribution system.
5. To understand the distribution system tariff and protection methods.

UNIT I FUNDAMENTALS OF DISTRIBUTION SYSTEM 9

General Concept- Distribution of Power, Quality of Supply- System Study- Benchmarking Electricity Reforms- Primary Distribution Configurations- Urban Networks- Primary Voltages Levels- Distribution Substations- Sub transmission systems- Loads.

UNIT II DESIGN AND OPERATION OF DISTRIBUTION SYSTEMS 9

Engineering Design-Operation Criteria and Standards- Sub transmission-Sub - station and Feeder-Low Voltage- Three phase or Single Phase- Practices- Location of Sectionalizer-Voltage Control- Harmonics- Load Variations- Impact Loading of Transformer- System Losses- Energy Management- Model Distribution System.

UNIT III SYSTEM PLANNING OF DISTRIBUTION SYSTEMS 9

Planning Process- Planning Criteria and Standards- System Development- Distributed Generation- Distribution System Economics and Finance- Mapping- Enterprise Resource Planning (ERP)- Modelling System Calculations- Introductory Methods- Network Elements-Load Flow- Automated Planning- Fault Studies- Effect of Abnormal Loads- Line Circuits-Urban Distribution- Outsourcing.

UNIT IV ELECTRICITY FORECASTING OF DISTRIBUTION SYSTEMS 9

Power Loads- Connected Load- Load Forecasting- Definitions of Some Basic Concepts in Statistics- Regression Analysis- Correlation Theory- Analysis of Time Series- Factors in Power System Loading-Unloading the system- Forecast of System Peak, Strategic Forecasting- Spatial Load Forecasting- Technological Forecasting- Scenario Planning-Sources of Error- Regulating the Model.

UNIT V TARIFF AND PROTECTION OF DISTRIBUTION SYSTEM 9

Objectives- Costing- Pricing Approach- Classifications- Economically Efficient Tariff Structure- National Tariff Policy- Rational Tariffs- Tariff Applications- Electricity Market. System protection Time Current Characteristics-Fuses- Switching Devices- Circuit Breakers-Protective Relaying Instrument Transformers- Overcurrent Scheme- Unit Protection.

TOTAL:45 Hours

COURSE OUTCOMES:

CO 1 Students will be able to understand the features of power distribution systems.

CO 2 Students will be able to understand the basic principles of design and operation of distribution systems.

CO 3 Students will be able to know the approaches of planning and expansion of distribution system.

CO 4 Students will get an exposure on electricity market, tariff mechanism and demand management.

CO 5 Students will be able to design the protection schemes for distribution system.

REFERENCES:

1. William H. Kersting, Distribution System Modeling and Analysis, CRC Press, Fourth edition, Sep 2017.
2. Amarjit Singh Pabla, Electric Power Distribution, McGraw-Hill Education, 2010.
3. Thomas Allen Short, Electric Power Distribution Handbook, CRC Press, Second edition, Oct 2018.
4. Anthony J. Pansini, 'Guide to Electrical Power Distribution Systems', The Fairmont Press, Sixth edition, 2023.

	Programme Outcomes												**Programme Specific Outcomes**		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	**1**	**2**	**2**	**2**	**2**	**1**	**1**					**1**	**2**	**2**	**1**
CO2	**1**	**2**	**2**	**2**	**2**	**1**	**1**					**1**	**2**	**2**	**1**
CO3	**1**	**2**	**2**	**2**	**2**	**1**	**1**					**1**	**2**	**2**	**1**
CO4	**1**	**2**	**2**	**2**	**2**	**1**	**1**					**1**	**2**	**2**	**1**
CO5	**1**	**3**	**3**	**3**	**3**	**2**	**2**					**2**	**2**	**2**	**2**

322PSE09	COMPUTER RELAYING AND WIDE AREA MEASUREMENT SYSTEMS	L	T	P	C
		3	0	0	3

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.

PRE REQUISITE: Nil

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

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

UNIT V PHASOR MEASUREMENT APPLICATIONS 9

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

TOTAL: 45 Hours

COURSE OUTCOMES:

CO 1 Demonstrate knowledge of fundamental theories, principles and practice of computer relaying, Wide area measurement system.

CO 2 Analyze the power system with computer relaying and Wide area measurement system.

CO 3 Validate the recent relaying technologies which work towards smart grid.

CO 4 Design wide area measurement systems for Smart grid.

CO 5 Compare the performance of modern relaying schemes and measurement techniques with the conventional one.

REFERENCES:

1. AntonelloMonti, Carlo Muscas, FerdinandaPonci,"Phasor Measurement Units and Wide Area Monitoring Systems" Academic Press, 09-Jun-2016.
2. Stanley H. Horowitz, Arun G. Phadke, "Power System Relaying", John Wiley & Sons, 25-Oct- 2013.
3. A.G. Phadke, J.S. Thorp, "Computer Relaying for Power Systems", John Wiley and Sons Ltd., Research Studies Press Limited, 2nd Edition, 2009.

	Programme Outcomes												**Programme Specific Outcomes**		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**			**1**		**3**				**3**			**3**		**3**
CO2	**3**		**3**		**2**		**2**		**3**	**2**		**3**	**3**	**2**	
CO3	**3**		**2**				**2**								
CO4					**2**				**2**			**3**	**3**	**3**	
CO5	**3**				**1**	**3**		**3**							**3**

		L	T	P	C
322PSE10	**APPLICATION OF DSP TO POWER SYSTEM PROTECTION**	**3**	**0**	**0**	**3**

OBJECTIVES:

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

PRE-REQUISITE: POWER SYSTEM PROTECTION

UNIT I DIGITAL SIGNAL PROCESSING TECHNIQUES 9

Sampling-Principle of scaling-aliasing-Decimation, Interpolation. Fourier and discrete Fourier transform - 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, bus bar protection.

UNIT III ALGORITHMIC TECHNIQUES 9

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

UNIT IV DIGITAL PROTECTION TECHNIQUES 9

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

UNIT V DIGITAL PROTECTIVE RELAYS 9

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

TOTAL:45 Hours

COURSE OUTCOMES:

CO 1 The students will be able to apply DSP techniques for digital protection.

CO 2 The students will be capable of decision-making algorithm suitable for digital relayingapplications.

CO 3 The students will be able to employ FIR based algorithms for digital relaying.

CO 4 The students will be able to do transformer protection using digital techniques.

CO 5 The students will be able to perform coordinated operation of relays for specific purposes.

REFERENCES:

1. J.L. Blackburn, Protective Relaying: Principles and Applications, J. Lewis Blackburn,Third Edition, 2007.
2. A.G. Phadke and J.S. Thorp, Computer Relaying for Power Systems, John Wiley & Sons, Second Edition, Sep 2012.
3. John Proakis and Dimitris Manolakis, 'Digital Signal Processing Principles, Algorithms, Fourth Edition, 2013.
4. Y.G. Paithankar and S.R Bhide, "Fundamentals of Power System Protection", PHI Learning;2nd edition edition , July, 2013.

	Programme Outcomes												**Programme Specific Outcomes**		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO 3**
CO1	**1**	**2**	**2**	**2**	**2**	**1**	**1**					**1**	**2**	**2**	**1**
CO2	**1**	**2**	**2**	**2**	**2**	**1**	**1**					**1**	**2**	**2**	**1**
CO3	**1**	**2**	**2**	**2**	**2**	**1**	**1**					**1**	**2**	**2**	**1**
CO4	**1**	**2**	**2**	**2**	**2**	**1**	**1**					**1**	**2**	**2**	**1**
CO5	**1**	**3**	**3**	**3**	**3**	**2**	**2**					**2**	**2**	**2**	**2**

322PSE11	ELECTRIC VEHICLES AND POWER MANAGEMENT	L	T	P	C
		3	0	0	3

Prerequisite: NIL

Objectives:

To familiarize about the significance of EV than conventional vehicles.
To understand the concept of hybrid electric vehicles and its types with their Performance To understand the need for energy storage in hybrid vehicles.
To understand the EV transmission and electric propulsion using various drives.
To understand the various converter topologies for EV vehicle.
To understand the different strategies related to battery technology and energy storage systems.

UNIT – I INTRODUCTION TO CONVENTIONAL AND ELECTRIC VEHICLES 9

Conventional Vehicles: Internal combustion Engines – Working principle, Engine Operation Characteristics, Emission Control. EV vehicles: EV system – Configurations of EVs – Components of EV – Recent EVs and HEVs – EVs advantages – EVs market – Environmental Impact

UNIT - II HYBRID ELECTRIC VEHICLES 9

Concept of Hybrid Electric drive, Types of Hybrids, Architectures of Hybrid Electric Drive Trains, Design of HEV, Plug–in Hybrid Electric Vehicles (PHEVs), Fuel Cell Electric Vehicles (FCEVs), Comparison of Different Vehicle Specifications

UNIT - III ELECTRIC TRAINS AND PROPULSION 9

EV Transmission configurations, Transmission components, Ideal Gearbox: Steady State Model, EV Motor Sizing. Electric Propulsion: DC motor drives, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, Configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives.

UNIT - IV POWER CONVERTER TOPOLOGIES FOR EV/PHEV CHARGING 9

Power converter topology, Grid and Photovoltaic (PV) System for EV/PHEV Charging, Design of DC/DC Converters and DC/AC Inverters for Grid/PV, Integrated converter, With and without Transformer Based Isolated Charger topology-charging station AC &DC

UNIT - V ENERGY STORAGE AND BATTERY MANAGEMENT SYSTEMS FOR EV 9

Battery Technologies – Analysis: Lead–Acid Battery, Nickel–Based Batteries, Lithium – Based Batteries – Battery parameters, Fuel cell – types and characteristics, Ultra capacitors–based energy storage and its analysis, ultra–high–speed flywheels–based energy storage and its analysis, Hybridization of energy storage devices, Battery management systems – SOC Estimation, SOH Estimation.

Total: 45 Hours

Course Outcomes:

CO1	Learned the significance of Electric Vehicle compared to conventional vehicles.
CO2	Able to understand the concept of hybrid electric vehicles architecture with their performance.
CO3	Acquired the knowledge in EV transmission and electric propulsion using various drives train.
CO4	Ability to design the various converter topologies for EV vehicle.
CO5	Concept of different strategies related to battery technology and energy storage systems are analysed.

	Programme Outcomes												Programme Specific Outcomes		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO1	PSO2	PSO3
CO1	3	2	3	1	3	2	2				1	3	3	3	3
CO2	3	2	3	3	3	2	2				1	2	3	3	3
CO3	3	3	3	3	2	2	3				2	3	3	3	2
CO4	3	2	2	3	3	3	3				2	3	3	3	1
CO5	3	2	2	2	3	3	3				2	3	3	3	1

TEXT BOOKS:

1. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, 'Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design', CRC Press, 2004
2. Iqbal Husain, 'Electric and Hybrid vehicles: Design fundamentals', CRC PRESS, Boca Raton London, New York Washington, D.C, 2005.

REFERENCES:

1. C. Mi, M. A. Masrur and D. W. Gao, 'Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives', John Wiley & Sons, 2011. Ali Emadi, Mehrdad Ehsani, John M.Miller, "Vehicular Electric Power Systems", Special Indian Edition, Marcel dekker, Inc 2010.
2. S. Onori, L. Serrao and G. Rizzoni, 'Hybrid Electric Vehicles: Energy Management Strategies', Springer, 2015..
3. Tariq Muneer and Irene Illescas García, 'The automobile, In Electric Vehicles: Prospects and Challenges', Elsevier, 2017.
4. Link – Sheldon S.Williamson " Energy Magement strategies for Electrical Plug In Hybrid Vehicles" Springer Concordia University Canada 2013 https://www.google.co.in/books/edition/Energy_Management_Strategies_for_Electri/voe4BAAAQBAJ?hl=en&gbpv=1&printsec=frontcover.

322PSE12	HIGH VOLTAGE TECHNOLOGY	L	T	P	C
		3	0	0	3

Prerequisite: Nil

Objectives:

- To study the various types of over voltages in power system and protection methods
- To understand Generation of over voltages in laboratories
- To study Measurement of over voltages
- To learn Nature of Breakdown mechanism in solid, liquid and gaseous dielectrics.
- To know Testing of power apparatus and insulation coordination

UNIT – I **OVER VOLTAGES IN ELECTRICAL POWER SYSTEMS** **9**

Causes of over voltages and its effect on power system-Lightning ,Switching surges and temporary over voltages –Reflection and Refraction of Travelling waves-protection against over voltages –Insulation Coordination

UNIT - II **DIELECTRIC BREAKDOWN** **9**

Properties of Dielectric Materials-Gaseous breakdown in uniform and non-uniform fields-Corona discharges-Vacuum breakdown –Conduction and breakdown in pure and commercial liquids, Maintenance of oil quality –Breakdown mechanisms in solid and composite dielectrics – Applications of insulating materials in electrical equipment.

UNIT - III **GENERATION AND MEASUREMENTS OF HIGH VOLTAGES AND HIGH CURRENTS** **9**

Generation of High DC,AC,Impulse voltages and currents – Analysis of DC/AC and Impulse generator circuits-Tripping and control of impulse generators , Measurement of High voltages and High currents –High resistance with series ammeter-Dividers-Resistance ,Capacitance and Mixed dividers-Peak Voltmeter , Generating Voltmeters ,Electostatic Voltmeters-Sphere Gaps, High current shunts –Digital techniques in high voltage measurement .

UNIT - IV **HIGH VOLTAGE TESTING & INSULATION COORDINATION** **9**

High voltage testing of electrical power apparatus – International and Indian standards – Power frequency ,impulse voltage and DC testing of Insulators ,circuit breakers ,bushings ,isolators and transformers-Insulation Coordination.

UNIT - V APPLICATION OF INDUSTRY **9**

Introduction –electrostatic applications –electrostatic precipitation , separation , painting/coating ,spraying,imaging,printing,Transport of materials –manufacturing of sand paper –Smoke particle detector-Electrostatic spinning,pumping,propulsion-Ozone generation-Biomedical Applications

Total: 45 Hours

Course Outcomes:

CO1	Explain various overvoltage's and its effects on power system
CO2	Understand the breakdown phenomena in different medium under uniform and non-uniform fields.
CO3	Explain the methods of generating and measuring High DC,AC,Impulse voltage and currents
CO4	Suggest and Conduct suitable HV testing of Electrical power apparatus as per Standards
CO5	Explain the Industrial Applications of Electrostatic Fields

TEXT BOOKS:

1. M.S.Naidu and V.Kamaraju,'High Voltage Engineering ',Tata Mc Graw Hill,Fifth Edition ,2013
2. E.Kuffel and W.S.Zaengl, J.Kuffel,'High voltage Engineering fundamentals'.Newnes Second Edition,Elsevier,New Delhi ,2005
3. C.L Wadhwa ,'High voltage Engineering ', New Age International Publishers ,Fourth Edition ,2020

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1. L.L.Alston, High voltage Technology ,Oxford University Press,First Indian Edition - 2006
2. Mazen Abdel –Salam,Hussein Anis,Ahdab A-Morshedy,Roshday Radwan , High Voltage Engineering –Theory & Practice, Second Edition , Taylor & Francis Group,2019
3. Subir Ray ,"An Introduction to High Voltage Engineering " PHI Learning Private Limited , New Delhi , Second Edition -2011

	Programme Outcomes												Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2											3	2	
CO2	3	2		1									3		
CO3	2	2	3	1							2	3	3	2	
CO4	1	2	3	1				1	1			3	3	2	
CO5	2	2	1			2					2		3		2