MUTHAYAMMAL ENGINEERING COLLEGE

(An Autonomous Institution)

(Approved by AICTE, New Delhi, Accredited by NAAC NBA & Affiliated to Anna University)

Rasipuram - 637 408, Namakkal Dist., Tamil Nadu.

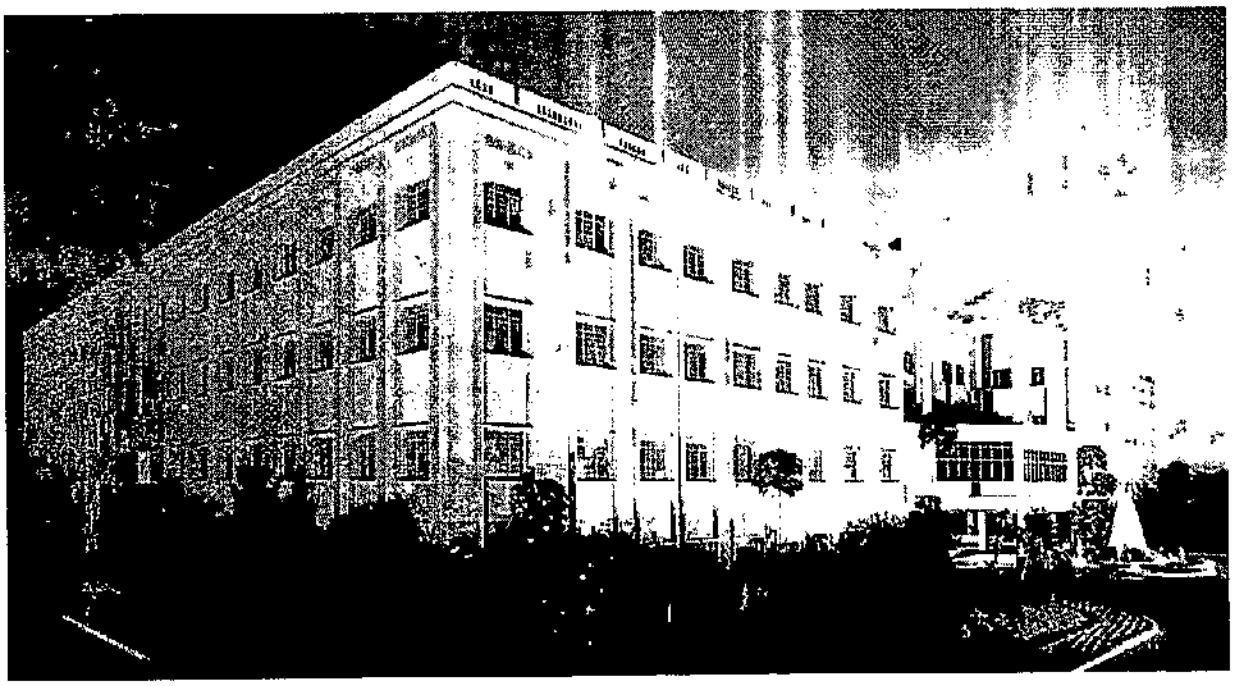
Estd. 2000

Curriculum/Syllabus

Programme Code : PSE

Programme Name : M.E – Power Systems Engineering

Regulation : R-2021



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INSTUTION VISION &MISSION

INSTUTION VISION

To be a Centre of Excellence in Engineering, Technology and Management on par with International Standards.

INSTUTION MISSION

- To prepare the students with high professional skills and ethical values
- To impart knowledge through best practices
- To instill a spirit of innovation through Training, Research and Development
- To undertake continuous assessment and remedial measures
- To achieve academic excellence through intellectual, emotional and social stimulation

INSTUTION MOTTO

Rural upliftment through Technical Education.

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DEPARTMENT VISION & MISSION

DEPARTMENT VISION

To produce competent Electrical and Electronics Engineers with advanced skills and knowledge to contribute the society.

DEPARTMENT MISSION

- To establish the advance laboratories to enable the students to face the challenges in Electrical and Electronics industries
- To enable collaborative research in contemporary and sustainable technologies in Electrical and Electronics Engineering
- To produce Electrical and Electronics Engineering graduates with quest for excellence, enthusiasm for continuous learning, ethical behavior, integrity and exceptional leadership

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DEPARTMENT PROGRAM EDUCATIONAL OBJECTIVES, PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES

PROGRAM EDUCATIONAL OBJECTIVES

The Electrical and Electronics Engineering Graduates should be able to

PEO1: Practice as an Engineer in the Electrical and Electronics industries and become an entrepreneur

PEO2: Pursue higher education and research for professional development

PEO3: Exhibit the leadership skills and ethical value for society

PROGRAM OUTCOMES

1. **Engineering Knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
2. **Problem Analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and Engineering sciences.
3. **Design/Development solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Lifelong learning:** Recognize the need for and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES

PSO1: Apply mathematical and engineering knowledge for designing Electrical and Electronics systems

PSO2: Derive sustainable solutions for complex Electrical and Electronics Engineering problems

PSO3: Use modern software tools and techniques related to Electrical and Electronics Engineering industry

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

GROUPING OF COURSES

1. Foundation Course (FC)

Sl. No.	Course Code	Course Name	Category	Contact Hrs	Hours/ Week			Credit
					L	T	P	C
1.	21PSA01	Advanced Numerical Methods	FC	4	3	1	0	4
2.	21PSA02	Applied Mathematics	FC	4	3	1	0	4
3.	21PSA03	Applied Probability and Statistics	FC	4	3	1	0	4

2. Professional Core (PC)

Sl. No.	Course Code	Course Name	Category	Contact Hrs	Hours/ Week			Credit
					L	T	P	C
1.	21PSB01	Linear and Non-Linear Systems Theory	PC	3	3	0	0	3
2.	21PSB02	Electrical Transients in Power Systems	PC	3	3	0	0	3
3.	21PSB03	Advanced Power System Analysis	PC	5	3	1	0	3
4.	21PSB04	Advanced Power System Operation and Control	PC	5	3	0	0	3
5.	21PSB05	Advanced Power System Operation and Control Laboratory	PC	3	0	0	3	1
6.	21PSB06	Advanced Power System Dynamics	PC	3	3	0	0	3
7.	21PSB07	Substation Equipment & Design	PC	3	3	0	0	3
8.	21PSB08	Advanced Power System Protection	PC	3	3	0	0	3
9.	21PSB09	Restructured Power System	PC	3	3	0	0	3
10.	21PSB10	Restructured Power System Laboratory	PC	3	0	0	3	1
11.	21PSB11	Solar and Energy Storage Systems	PC	3	3	0	0	3
12.	21PSB12	Power System Security	PC	3	3	0	0	3

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13.	21PSB13	Industrial Power System Analysis and Design	PC	3	3	0	0	3
14.	21PSB14	Power System Planning and Reliability	PC	3	3	0	0	3

3. Professional Elective (PE)

Sl. No.	Course Code	Course Name	Category	Contact Hrs	Hours/ Week			Credit
					L	T	P	C
1.	21PSC01	Flexible AC Transmission Systems	PE	3	3	0	0	3
2.	21PSC02	Microcontroller Based System Design	PE	3	3	0	0	3
3.	21PSC03	Design and Analysis of Inverters	PE	3	3	0	0	3
4.	21PSC04	Power Quality	PE	3	3	0	0	3
5.	21PSC05	Advanced Digital Signal Processing	PE	3	3	0	0	3
6.	21PSC06	Energy Management and Auditing	PE	3	3	0	0	3
7.	21PSC07	High Voltage Direct Current Transmission	PE	3	3	0	0	3
8.	21PSC08	Application of MEMS Technology	PE	3	3	0	0	3
9.	21PSC09	Distributed Generation and Micro Grid	PE	3	3	0	0	3
10.	21PSC10	Wind Energy Conversion Systems	PE	3	3	0	0	3
11.	21PSC11	Power Plant Instrumentation and Control	PE	3	3	0	0	3
12.	21PSC12	Smart Grid	PE	3	3	0	0	3
13.	21PSC13	Power Electronics for Renewable Energy Systems	PE	3	3	0	0	3
14.	21PSC14	Real time operating systems	PE	3	3	0	0	3
15.	21PSC15	Soft Computing Techniques	PE	3	3	0	0	3

4. Employability Enhancement Courses (EEC)

Sl. No.	Course Code	Course Name	Category	Contact Hrs	Hours/ Week			Credit
					L	T	P	C
1.	21PSD01	Project Work-Phase I	EEC	12	0	0	12	6
2.	21PSD02	Project Work-Phase II	EEC	24	0	0	24	12

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Department	Electrical and Electronics Engineering	
Programme	Power Systems Engineering	

SEMESTER – I

Sl. No.	Course Code	Course Name	Category	Hours /Week L	T	P	Contact Hours	Credits
THEORY								
1.	21PSA02	Applied Mathematics	FC	3	1	0	4	4
2.	21PSB01	Linear and Non Linear Systems Theory	PC	3	0	0	3	3
3.	21PSB02	Electrical Transients in Power Systems	PC	3	0	0	3	3
4.	21PSB03	Advanced Power System Analysis	PC	3	1	0	4	4
5.	21PSB04	Advanced Power System Operation and Control	PC	3	0	0	3	3
6.	21PSB11	Solar and Energy Storage Systems	PC	3	0	0	3	3
PRACTICAL								
7.	21PSB05	Advanced Power System Operation and Control Laboratory	PC	0	0	3	3	1
		TOTAL						**21**

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Department	Electrical and Electronics Engineering	
Programme	Power Systems Engineering	

SEMESTER – II

Sl. No.	Course Code	Course Name	Category	Hours /Week L	T	P	Contact Hours	Credits
THEORY								
1.	21PSB06	Advanced Power System Dynamics	PC	3	0	0	3	3
2.	21PSB08	Advanced Power System Protection	PC	3	0	0	3	3
3.	21PSB09	Restructured Power System	PC	3	0	0	3	3
4.		Elective-I	PE	3	0	0	3	3
5.		Elective-II	PE	3	0	0	3	3
		TOTAL						**15**

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Department	Electrical and Electronics Engineering
Programme	Power Systems Engineering

SEMESTER – III

Sl. No.	Course Code	Course Name	Category	Hours /Week			Contact Hours	Credits
				L	T	P		
1.		Elective- IV	PE	3	0	0	3	3
2.		Elective-V	PE	3	0	0	3	3
3.		Elective-VI	PE	3	0	0	3	3
4.	21PSD01	Project Work - Phase I	EEC	0	0	12	12	6
6.		Elective-III	PE	3	0	0	3	3
PRACTICAL								
7.	21PSB10	Restructured Power SystemLaboratory	PC	0	0	3	3	1
		TOTAL						21

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Department	Electrical and Electronics Engineering
Programme	Power Systems Engineering

SEMESTER – IV

Sl. No.	Course Code	Course Name	Category	Hours /Week			Contact Hours	Credits
				L	T	P		
1.	21PSD02	Project Work - Phase II	EEC	0	0	24	24	12
		TOTAL						12

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21PSA01 **ADVANCED NUMERICAL METHODS**

COURSE OBJECTIVES:

- To learn the algebraic equations which finds applications in many engineering branches.
- To make the student acquire sound knowledge of computational techniques in solving ordinary differential equations that model engineering.
- To solve Elliptic equations by using computational techniques
- To introduce numerical tools for the solutions of partial differential equations that model several physical processes
- To deal with interpolation and approximation for the application of finite element analysis

COURSE OUTCOMES:

- Demonstrate understanding and implementation of numerical solution algorithms applied to solve algebraic equations
- Be familiar with numerical solutions of ordinary differential equation and partial differential equations.
- Be competent with finite difference method and finite element method.
- Understanding the theoretical and practical aspects of the use of numerical methods. Implementing numerical methods for a variety of multidisciplinary applications. Establishing the limitations, advantages, and disadvantages of numerical methods
- The students will have a clear perception of the power of numerical Techniques. This will also serve as a precursor for future research.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSA01.CO1	x	x	-	-	-	-	-	-	-	x	-	x	x	-	-
21PSA01.CO2	x	x	x	x	-	-	-	-	-	x	-	x	x	x	-
21PSA01.CO3	x	x	x	x	-	-	-	-	-	x	-	x	x	x	-
21PSA01.CO4	-	x	x	x	-	-	-	-	-	x	-	x	-	x	-
21PSA01.CO5	x	x	x	x	-	-	-	-	-	x	-	x	x	2	-

L	T	P	C
3	1	0	3

UNIT - I ALGEBRAIC EQUATIONS 9+3

Systems of linear equations: Gauss Elimination method, pivoting techniques, Thomas algorithm for tridiagonal system – Jacobi, Gauss Seidel, SOR iteration methods - Systems of nonlinear equations: Fixed point iterations, Newton Method, Eigenvalue problems: power method, inverse power method, Faddeev – Leverrier Method.

UNIT – II ORDINARY DIFFERENTIAL EQUATIONS 9+3

Runge Kutta Meth ods for system of IVPs, numerical stability, Adams - Bashforth multistep method, solution of stiff ODEs, shooting method, BVP: Finite difference method, orthogonal collocation method, orthogonal collocation with finite element method, galerkin finite element method

UNIT – III FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATIONS 9+3

Parabolic equations: explicit and implicit finite difference methods, weighted average approximation - Dirichlet and Neumann conditions – Two dimensional parabolic equations – ADI method; First order hyperbolic equations – method of characteristics, different explicit and implicit methods; numerical stability analysis, method of lines – Wave equation: Explicit scheme - Stability of above schemes.

UNIT – IV FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS 9+3

Laplace and Poisson's equations in a rectangular region: Five point finite difference schemes, Leibmann's iterative methods, Dirichlet and Neumann conditions – Laplace equation in polar coordinates: finite difference schemes – approximation of derivatives near a curved boundary while using a square mesh.

UNIT – V FINITE ELEMENT METHOD 9+3

Partial differential equations – Finite element method – orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method.

TOTAL: 45 + 15

REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	M.K. Jain , S.R.K. Iyengar, R.K. Jain	Computational Methods for Partial Differential Equations, 2nd Edition	New Age Publishers	2021
2.	S. K. Gupta	Numerical Methods for Engineers, 3rd Edition	New Age International Pvt Ltd Publishers	2015
3.	Saumyen Guha and Rajesh Srivastava	Numerical methods for Engineering and Science	Oxford Higher Education, New Delhi	2010
4.	M.K. Jain	Numerical Methods for Scientific & Engineering Computation, 6th Edition	New Age International Publishers	2010
5.	Burden, R.L., and Faires, J.D.	Numerical Analysis –Theory and Applications	Cengage Learning, India Edition, New Delhi	2009

21PSA02 APPLIED MATHEMATICS

COURSE OBJECTIVES

- To realize the use of matrix theory techniques in engineering applications and to develop for future applications.
- To analyze and solve the fundamental problem with prescribed or free boundary conditions in simple cases
- Demonstrate knowledge of mathematics and mechanics to construct, analyze and interpret real world problems
- Provide a foundation and motivation for exposure to statistical ideas subsequent to the course.
- To formulate and construct a mathematical model for a linear programming problem in real life situation

COURSE OUTCOMES

- Explain geometrical concepts related to orthogonality and least squares solutions and perform calculations related to orthogonality.
- The variational calculus makes access to mastering in a wide range of classical results of variational calculus. Students get up apply results in technical problem solutions
- The students will have a basic knowledge of the main fields of mathematics and mechanics, including differential equations, elasticity theory, fluid mechanics.
- The students will have an exposure of various distribution functions and help in acquiring skills in handling situations involving more than one variable
- The knowledge gained on this course helps the students to do engineering optimization.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSA02.CO1	x	x	x	x	x	-	-	-	x	-	-	x	-	x	-
21PSA02.CO2	x	x	x	x	x	-	-	-	x	-	-	x	-	x	-
21PSA02.CO3	-	-	x	x	x	-	-	-	-	-	-	x	-	x	-
21PSA02.CO4	-	-	x	x	x	-	-	-	-	-	-	x	-	x	-
21PSA02.CO5	-	-	x	x	x	-	-	-	-	-	-	x	-	x	-

L	T	P	C
3	2	0	4

UNIT - I MATRIX THEORY 9+3

The Cholesky decomposition - Generalized Eigen vectors, 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 – Functional 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: Ritz and Kantorovich methods.

UNIT – III ONE DIMENSIONAL RANDOM VARIABLES 9+3

Random variables - Probability function – moments – moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Function of a Random Variable.

UNIT – IV LINEAR PROGRAMMING 9+3

Formulation – Graphical solution – Simplex method – Two phase method - Transportation and Assignment Models

UNIT – V FOURIER SERIES AND EIGEN VALUE PROBLEMS 9+3

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

TOTAL: 45 + 15

REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	Mital.K.V. Mohan and Chander	Optimization Methods in Operations Research and Systems Analysis, 4th Edition	New Age International Publishers	2021
2.	Stark. H., and Woods. J.W.	Probability and Random Processes with Applications to Signal Processing, 4th Edition	Pearson Education, Asia	2014
3.	Hamdy ATaha	Operations Research, 9th Edition (Asia)	Pearson Education, Asia	2014
4.	Gupta, A.S.	Calculus of Variations with Applications	Prentice Hall of India Pvt. Ltd., New Delhi	2011
5.	Richard Bronson	Matrix Operation, Schaum's outline series, 2nd Edition	McGraw Hill	2011

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21PSA03 APPLIED PROBABILITY AND STATISTICS

COURSE OBJECTIVES:

- To introduce the basic concepts of one dimensional and two dimensional Random Variables.
- To gain knowledge in the application of family of random variables in real life situations
- To provide information about Correlation and Regression
- Learn about maximum likelihood estimation, unbiased estimation and least square methods.
- To understand concepts of testing of hypothesis
- To enable the students to use the concepts of multivariate normal distribution and principle components analysis.

COURSE OUTCOMES:

- Analyze random or unpredictable experiments and investigate important features of random experiments. Construct probabilistic models for observed phenomena through distributions which play an important role in many engineering applications.
- Associate random variables by designing joint distributions and correlate the random variables
- Perform and interpret correlation and regression analysis and develop correlation models to predict changes in processes and products for linear and non-linear relationships
- Provides knowledge to apply testing of hypothesis to real life problems.
- Be familiar with multivariate analysis.
- The student will able to acquire the basic concepts of Probability and Statistical techniques for solving mathematical problems which will be useful in solving Engineering problems

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSA03.CO1	x	-	x	-	x	-	-	-	x	x	x	x	-	-	x
21PSA03.CO2	x	-	x	-	x	-	-	-	x	x	x	x	-	-	x
21PSA03.CO3	x	x	x	-	x	-	-	-	x	x	x	x	-	-	x
21PSA03.CO4	x	x	x	-	x	-	-	-	x	x	x	x	-	-	x
21PSA03.CO5	x	x	x	-	x	-	-	-	x	x	x	x	-	-	x

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3 2 0 4

UNIT - I ONE DIMENSIONAL RANDOM VARIABLES 9+3

Random variables - Probability function – Moments – Moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Functions of a Random Variable.

UNIT – II TWO DIMENSIONAL RANDOM VARIABLES 9+3

Joint distributions – Marginal and Conditional distributions – Functions of two dimensional random variables – Regression Curve – Correlation.

UNIT – III ESTIMATION THEORY 9+3

Unbiased Estimators – Method of Moments – Maximum Likelihood Estimation - Curve fitting by Principle of least squares – Regression Lines.

UNIT – IV TESTING OF HYPOTHESES 9+3

Sampling distributions - Type I and Type II errors - Tests based on Normal, t, Chi-Square and F distributions for testing of mean, variance and proportions – Tests for Independence of attributes and Goodness of fit.

UNIT – V MULTIVARIATE ANALYSIS 9+3

Random Vectors and Matrices - Mean vectors and Covariance matrices - Multivariate Normal density and its properties - Principal components Population principal components – Principal components from standardized variables.

TOTAL: 45 + 15

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REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	Douglas C. Montgomery, George C. Runger	Applied Statistics and Probability for Engineers (International Student Version), 6th Edition	John Wiley & Sons, Inc.	2021
2.	Richard A. Johnson and Dean W. Wichern,	Applied Multivariate Statistical Analysis, 6th Edition	Pearson Education, Asia	2015
3.	Gupta S.C. and Kapoor V.K	Fundamentals of Mathematical Statistics	Sultan Chand & Sons	2014
4.	HweiP.Hsu,	Schaum"s Outline of Theory and Problems of Probability, Random Variables and Random Processes	Tata Mc Graw Hill Edition, New Delhi	2014
5.	Walpole. R.E., Myers. R.H., Myers. S.L., and Ye. K., ,	Probability and Statistics for Engineers and Scientists, 8th Edition	Pearson Education, Asia	2013

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21PSB01 LINEAR AND NON LINEAR SYSTEMS THEORY

COURSE OBJECTIVES

- To educate on modeling and representing systems in state variable form.
- To educate on solving linear state equations.
- To educate on solving non-linear state equations.
- To illustrate the role of controllability and observability.
- To educate on stability analysis of systems using Lyapunov"s theory.
- To educate on modal concepts and design of state and output feedback controllers and estimators.

COURSE OUTCOMES

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

- Identify the stability of the given linear system
- Design pole placement controller and/or observer for the given system to achieve desired specifications.
- Identify the existence of limit cycle(s) for the given nonlinear system using describing function method.
- Explain the concept of Lyapunov stability.
- Explain optimal state regulator and stochastic optimal regulator.
- Explain the concept of adaptive control and fuzzy logic.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSB01.CO1	x	-	x	-	x	-	-	-	x	x	x	x	-	-	x
21PSB01.CO2	x	-	x	-	x	-	-	-	x	x	x	x	-	-	x
21PSB01.CO3	x	x	x	-	x	-	-	-	x	x	x	x	-	-	x
21PSB01.CO4	x	x	x	-	x	-	-	-	x	x	x	x	-	-	x
21PSB01.CO5	x	x	x	-	x	-	-	-	x	x	x	x	-	-	x

L	T	P	C
3	1	0	3

UNIT I LINEAR SYSTEMS 9

Concepts of state, state variables and state model - State model for linear time invariant continuous systems. Diagonalization – Solution of state equations – Concepts of Controllability and Observability- Pole placement by state feedback – Observer systems.

UNIT II NON-LINEAR SYSTEMS 9

Types of non-linearity – Typical examples – Phase plane analysis – Singular points – Limit cycles –Construction of phase trajectories – Describing function method – Derivation of describing functions.

UNIT III LIAPUNOV STABILITY 9

Liapunov stability analysis – Stability in the sense of Liapunov – Definiteness of scalar Functions – Quadratic forms – Second method of Liapunov – Liapunov stability analysis of linear time invariant systems and nonlinear systems.

UNIT IV OPTIMAL CONTROL SYSTEMS 9

Parameter Optimization: Servomechanisms – Optimal Control Problems: Transfer function Approach – State variable approach – the state regulator problem – The Infinite-time regulator problem – Output regulator and the tracking Problems – Parameter Optimization: Regulators.

UNIT V ADVANCED CONTROL SYSTEMS 9

Adaptive Control: Model-Reference Adaptive Control fundamental concepts - Self tuning control – Robust Control: Parameter perturbations - Design of robust control system – PID controllers – Fuzzy Logic Control –Neural Network Controller.

TOTAL: 45

REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	M. Gopal	Modern Control System Theory	New Age International	2005
2.	K. Ogatta	Modern Control Engineering	PHI	2002
3.	John S. Bay	Fundamentals of Linear State Space Systems	McGraw-Hill	2199
4	D.Roy Choudhury	Modern Control Systems	New Age International	2005
5	John J.D.Azzo, C.H.Houpis and S.N.Sheldon	Linear Control System Analysis and Design with MATLAB	Taylor Francis	2003

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21PSB02 ELECTRICAL TRANSIENTS IN POWER SYSTEMS

COURSE OBJECTIVES

- To gain knowledge in the sources and effects of lightning.
- To gain knowledge in switching and temporary over voltages.
- Ability to model and estimate the over voltages in power system.
- To coordinate the insulation of power system and protective devices.
- To gain knowledge about the effects of travelling waves on transmission lines.
- Ability to model and analyze power system and equipment for transient over voltages using Electromagnetic Transient Program (EMTP).

COURSE OUTCOMES

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

- Know the effects of lightning.
- Know the effects of switching and temporary over voltages.
- Model and estimate the over voltages in power system.
- Know about the effects of travelling waves on transmission lines.
- Apply insulation coordination principles for power system protective devices.
- To model and analyze power system equipment for transient over voltages using Electromagnetic Transient Program (EMTP).

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSB02.CO1	X	X	X	-	-	-	-	-	-	X	-	X	X	-	-
21PSB02.CO2	X	X	X	X	-	-	-	-	-	X	-	X	X	X	-
21PSB02.CO3	X	X	X	X	-	-	-	-	-	X	-	X	X	X	-
21PSB02.CO4	X	X	X	X	-	-	-	-	-	X	-	X	X	X	-
21PSB02.CO5	-	X	X	-	-	-	-	-	-	X	-	X	X	-	-

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UNIT I LIGHTNING OVERVOLTAGES 9

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

UNIT II SWITCHING AND TEMPORARY OVERVOLTAGES 9

Switching transients – concept – phenomenon – system performance under switching surges, 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

Classification of over voltages and insulations for insulation co-ordination – Characteristics of protective devices, applications, location of arresters – insulation coordination in AIS and GIS

UNIT V COMPUTATION OF POWER SYSTEM TRANSIENTS 9

Modeling of power apparatus for transient studies – principles of digital computation – transmission lines, cables, transformer and rotating machines – Electromagnetic Transient program – case studies: line with short and open end, line terminated with R,L, C, transformer, and typical power system case study: simulation of possible over voltages in a high voltage substation.

TOTAL: 45

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REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	Pritindra Chowdhari	Electromagnetic transients in Power System	John Wiley and Sons Inc.	2009
2.	Allan Greenwood	Electrical Transients in Power System	Wiley &Sons Inc. New York	2012
3.	Klaus Ragaller	Surges in High Voltage Networks	Plenum Press, New York	2180
4.	Rakosh Das Begamudre	Extra High Voltage AC Transmission Engineering	New age International (P) Ltd.	2006
5.	Juan.A Martinez velasco	Power System Transients Parameter Determination	CRC Press	2009

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21PSB03 ADVANCED POWER SYSTEM ANALYSIS

COURSE OBJECTIVES

- To introduce the different power system components.
- To introduce different techniques of dealing with sparse matrix for large scale power systems.
- To impart in-depth knowledge on different methods of power flow solutions.
- To perform optimal power flow solutions in detail.
- To perform short circuit fault analysis and understand the consequence of different type of faults.

COURSE OUTCOMES

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

- Model various power system components that are adequate for the basic system studies of load flow.
- Model various power system components that are adequate for the basic system studies of short-circuit.
- Facilitate the modification of the Bus admittance matrix to reflect the network changes.
- Perform power flow analysis using NR, FDLF methods.
- Perform short circuit fault analysis and understand the consequence of different type of faults.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSB03.CO1	x	-	x	x	x	x	-	-	-	x	x	x	x	x	-
21PSB03.CO2	x	x	-	x	x	x	-	-	x	x	-	x	x	-	-
21PSB03.CO3	x	x	x	x	x	x	-	-	x	x	x	x	x	x	-
21PSB03.CO4	x	x	x	x	x	x	-	-	x	x	x	x	x	x	-
21PSB03.CO5	x	x	x	x	x	x	-	-	x	x	x	x	x	x	-

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UNIT I POWER SYSTEM COMPONENTS AND ADMITTANCE MODEL 9+3

Classical Model of Synchronous machine – Modeling of transmission Network consisting of Transmission lines (long, medium and short lines) – Transformers (two winding, ULTC, phase shifting and three winding) –Branch and Node Admittances - Mutually Coupled Branches in Ybus - An Equivalent Admittance Network - Modification of Ybus - The Network Incidence Matrix and Ybus.

UNIT II THE IMPEDANCE MODEL AND NETWORK CALCULATIONS 9+3

The Method of Successive Elimination - Node Elimination (Kron Reduction) - Triangular Factorization - Sparsity and Near-Optimal Ordering. The Bus Admittance and Impedance Matrices - Thevenin's Theorem and Zbus - Modification of an Existing Zbus - Direct Determination of Zbus - Calculation of Zbus Elements from Ybus - Mutually Coupled Branches in Zbus.

UNIT III POWER-FLOW SOLUTIONS 9+3

The Power-flow Problem - Review of Newton-Raphson Power-flow Solution - Power-flow Studies in System Design and Operation - Fast Decoupled Power Flow method; Sensitivity factors for P-V bus adjustment - solution of optimal power flow (OPF) - Gradient method, newton's method.

UNIT IV SHORTCIRCUITANALYSIS 9+3

Formation of bus impedance matrix with mutual coupling (single phase basis and three phase basis) - Computer method for fault analysis using ZBUS and sequence components. Derivation of equations for bus voltages, fault current and line currents, both in sequence and phase – symmetrical and un symmetrical faults.

UNIT V TRANSIENTSTABILITYANALYSIS 9+3

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

TOTAL: 60

REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	John J. Grainger and Stevenson	Power System Analysis	TATA McGraw Hill	2194
2.	A.Pai	Computer techniques in power system analysis	TATA McGraw Hill	2006
3.	G.W.Stagg & A.H.EL-Abaid	Computer methods in power system analysis	TATA McGraw Hill	2187
4.	L.P.Singh	Advanced power system analysis and dynamics	Wiley Eastern Ltd	2009
5.	Nagrath.I.J and Kothari.D.P.	Modern power system analysis	TATA McGraw Hill	2006

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21PSB04 ADVANCED POWER SYSTEM OPERATION AND CONTROL

COURSE OBJECTIVES

- To understand the various load forecasting techniques.
- To understand the fundamentals of speed governing system and the concept of control areas.
- To provide knowledge about Hydro thermal scheduling and Unit commitment techniques
- To understand the role of energy control center, SCADA and EMS functions.
- To have hands on experience on various system studies and different techniques used for system planning.

COURSE OUTCOMES

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

- Explain the concept of load forecasting techniques.
- Explain the concept of AGC and analysis of multi-area system.
- Acquire knowledge about Hydrothermal scheduling
- Understand Unit commitment techniques.
- Illustrate various operating states of power system and control actions.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSB04.CO1	x	x	-	-	-	-	-	-	-	x	-	x	x	-	-
21PSB04.CO2	x	x	x	x	-	-	-	-	-	x	-	x	x	x	-
21PSB04.CO3	x	x	x	x	-	-	-	-	-	x	-	x	x	x	-
21PSB04.CO4	-	x	x	x	-	-	-	-	-	x	-	x	-	x	-
21PSB04.CO5	x	x	x	x	-	-	-	-	-	x	-	x	x	x	-

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UNIT I INTRODUCTION 9

System load variation: System load characteristics, load curves-daily, weekly and annual, load-duration curve, load factor, diversity actor. Reserve requirements: Installed reserves, spinning reserves, cold reserves, hot reserves. Overview of system operation: Load forecasting, techniques of forecasting, basics of power system operation and control.

UNIT II REAL POWER-FREQUENCY CONTROL 9

Fundamentals of speed governing mechanism and modeling: Speed-load characteristics – Load sharing between two synchronous machines in parallel; concept of control area. LFC control of a single-area system: Static and dynamic analysis of uncontrolled and controlled cases. Economic Dispatch Control. Multi-area systems:

UNIT III HYDROTHERMAL SCHEDULING PROBLEM 9

Hydrothermal scheduling problem: short term and long term-mathematical model, algorithm. Dynamic programming solution methodology for Hydro-thermal scheduling with pumped hydro plant: Optimization with pumped hydro plant-.

UNITIV UNITCOMMITMENT AND ECONOMIC DISPATCH 9

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

UNIT V COMPUTER CONTROL OF POWER SYSTEMS 9

Energy control Centre: Functions–Monitoring, data acquisition and control. System hardware configuration–SCADA and EMS functions: Network topology determination, state estimation, security analysis and control. Various operating states:

TOTAL: 45

REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	Olle. I. Elgerd	Electric Energy Systems Theory – An Introduction	Tata McGraw Hill Publishing Company Ltd	2003
2.	L.L. Grigsby	The Electric Power Engineering, Hand Book	CRC Press & IEEE	-
3.	D.P. Kothari and I.J. Nagrath	Modern Power System Analysis	Tata McGraw Hill Publishing Company Limited	2003
4.	Allen.J.Wood and Bruce F.Wollenberg	Power Generation, Operation and Control	John Wiley & Sons, Inc	2003
5.	P.Kundur	Power System Stability & Control	McGraw Hill Publications	2194

21PSB05 ADVANCED POWER SYSTEM OPERATION AND CONTROL LABORATORY

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COURSE OBJECTIVES

- To understand the various load forecasting techniques.
- To understand the fundamentals of speed governing system and the concept of control areas.
- To provide knowledge about Hydro thermal scheduling and Unit commitment techniques
- To understand the role of energy control center, SCADA and EMS functions.
- To have hands on experience on various system studies and different techniques used for system planning.

COURSE OUTCOMES

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

- Explain the concept of load forecasting techniques.
- Explain the concept of AGC and analysis of multi-area system.
- Acquire knowledge about Hydrothermal scheduling
- Understand Unit commitment techniques.
- Illustrate various operating states of power system and control actions.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSB05.CO1	x	x	-	-	-	-	-	-	-	x	-	x	x	-	-
21PSB05.CO2	x	x	x	x	-	-	-	-	-	x	-	x	x	x	-
21PSB05.CO3	x	x	x	x	-	-	-	-	-	x	-	x	x	x	-
21PSB05.CO4	-	x	x	x	-	-	-	-	-	x	-	x	-	x	-
21PSB05.CO5	x	x	x	x	-	-	-	-	-	x	-	x	x	x	-

LIST OF EXPERIMENTS:

1. Power flow analysis by Newton-Raphson method and Fast decoupled method.
2. Transient stability analysis of single machine-infinite bus system using classical machine model.
3. Contingency analysis: Generator shift factors and line outage distribution factors.
4. Economic dispatch using lambda-iteration method.
5. Unit commitment: Priority-list schemes and dynamic programming.
6. Analysis of switching surge using EMTP: Energisation of a long distributed- parameter line.
7. Analysis of switching surge using EMTP: Computation of transient recovery voltage.
8. Familiarization of Relay Test Kit.
9. Simulation and Implementation of Voltage Source Inverter.
10. Digital Over Current Relay Setting and Relay Coordination.
11. Co-ordination of over-current and distance relays for radial line protection.

TOTAL: 60

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21PSB06 ADVANCED POWER SYSTEM DYNAMICS

COURSE OBJECTIVES

- To perform transient stability analysis.
- To impart knowledge on unified algorithm.
- To impart knowledge on subsysnchronous resonance and oscillations
- To impart knowledge on EMTP.
- To analyze voltage stability problem in power system.

COURSE OUTCOMES

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

- Model the power system components in stability studies and explain the concept of Park's transformation and synchronous machine equations.
- Describe the concept of transient, steady state and dynamic stability.
- Describe the concept of EMTP with detailed synchronous model
- Analyze the stability of power system by point-by point method. Modified Euler's and Runge-Kutta method.
- Determine the critical clearing angle and clearing time for power system using equal area criterion.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSB06.CO1	x	x	x	-	-	-	-	-	-	x	-	x	x	-	-
21PSB06.CO2	x	x	x	-	-	-	-	-	-	x	-	x	x	-	-
21PSB06.CO3	x	x	x	-	-	-	-	-	-	x	-	x	x	-	-
21PSB06.CO4	x	x	x	-	-	-	-	-	-	x	-	x	x	-	-
21PSB06.CO5	x	x	x	-	-	-	-	-	-	x	-	x	x	-	-

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UNIT I TRANSIENT STABILITY ANALYSIS 9

Review of numerical integration methods: Euler and Fourth Order Runge-Kutta methods, Numerical stability and implicit methods, Interfacing of Synchronous machine (variable voltage) model to the transient stability algorithm (TSA) with partitioned – explicit and implicit approaches – Interfacing SVC with TSA-methods to enhance transient stability

UNIT II UNIFIED ALGORITHM FOR DYNAMIC ANALYSIS OF POWER SYSTEMS 9

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

UNIT III SUBSYSNCHRONOUS RESONANCE (SSR) AND OSCILLATIONS 9

Sub synchronous Resonance (SSR) – Types of SSR - Characteristics of series – Compensated transmission systems –Modeling of turbine-generator-transmission network- Self-excitation due to induction generator effect – Torsional interaction resulting in SSR –Methods of analyzing SSR

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

Review of transmission aspects – Generation Aspects: Review of synchronous machine theory – Voltage and frequency controllers – Limiting devices affecting voltage stability – Voltage-reactive power characteristics of synchronous generators – Capability curves – Effect of machine limitation on deliverable power – Load Aspects – Voltage dependence of loads

UNIT V ENHANCEMENT OF TRANSIENT STABILITY AND COUNTER MEASURES FOR SUB SYNCHRONOUS RESONANCE 9

Principle behind transient stability enhancement methods: high-speed fault clearing, reduction of transmission system reactance, regulated shunt compensation, dynamic braking, reactor switching, independent pole-operation of circuit-breakers, single-pole switching, fast-valving, high-speed excitation systems; NGH damper scheme.

TOTAL: 45

REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	R.Ramnujam	Power System Dynamics Analysis and Simulation	PHI Learning Private Limited	2009
2.	M T.V.Cutsem and C.Vournas	Voltage Stability of Electric Power Systems	Kluwer publishers	2198
3.	P. Kundur	Power System Stability and Control	TATA McGraw Hill	2193
4.	H.W. Dommel and N.Sato	Fast Transient Stability Solutions	IEEE Trans., Vol. PAS-91, pp. 2143-2150	2172.
5.	Roderick J.Frowd and J.C.Giri	Transient stability and Long term dynamics unified	IEEE Trans.	2182

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21PSB07 SUBSTATION EQUIPMENT & DESIGN

COURSE OBJECTIVES

- Identify the functions of various operating components of an electric power substation, and recognize them by their appearance.
- Discuss about Substation earthing.
- Discuss about power cables and control cables.
- Define the various terms and applications involved with substations and the distribution of electric power.
- Discuss the factors that go into planning a substation, such as location, environmental concerns, and electrical system diagraming.

COURSE OUTCOMES

- Explain about various operating components of an electric power substation, and recognize them by their appearance.
- Maintain Substation earthing.
- Explain about power cables and control cables.
- Explain the various terms and applications involved with substations and the distribution of electric power.
- Explain the factors that go into planning a substation, such as location, environmental concerns, and electrical system diagraming.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSB07.CO1	X	X	-	-	X	-	-	-	-	-	-	-	X	X	X
21PSB07.CO2	X	X	-	-	-	-	-	-	-	-	-	X	X	X	-
21PSB07.CO3	X	X	-	-	X	-	-	-	X	-	-	-	X	X	X
21PSB07.CO4	X	X	-	-	-	-	-	-	-	-	-	X	X	X	-
21PSB07.CO5	X	X	X	-	-	-	-	-	-	-	-	-	X	X	-

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UNIT I SUBSTATION EARTHING SYSTEMS 9

Functional Requiements of Earthing System, Equipment Earthing, Neutral Point Earthing, Substation Earthing System, Dimensioning of Earth Conductors, Step Potential and Touch Potential, Earth Mat, Resistance of Earthing System, Values of Soil Resistivity, Fencing, Procedure of Laying Earthing –Mat, Measurement of Earthing Resistance.

UNIT II POWER CABLES AND CONTROL CABLES 9

Power Cables, Types of Conventional Power Cables, Laying of Power Cables, Control Cables, Principles of Control Cable Installation, Sensitivity of Various Loads to interference , Measuring Cables , Grounding of Cable.

UNIT III PROTECTION, CONTROL AND AUTOMATION IN SUBSTATIONS 9

Control Panels, Protective Relaying in Substations, Power Transformer Protection, Bus Zone Protection, Protection of Transmission Lines, Carrier Assisted Distance Protection, Control and Automation, Fault Diagnostics.

UNIT IV HVDC AND EHVAC SUBSTATIONS 9

Layout of a HVDC Substation, A.C. Switchyard, A.C. Harmonic Filter Area, Convertor- transformers, Valve Hall and Control Room, HVDC Yard, D.C. Smoothing Reactors, Earth Return, D.C. Breaker and Load break switches

UNIT V INSTALLATION, COMMISSIONING AND SAFETY PROCEDURES 9

Installation safety procedures, Installation of Earthing System, Installation of Yard equipment, Drying of Electrical Equipment, Measurement of Insulation Resistance and Polarization Index of transformers.

TOTAL: 45

REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	John D. McDonald	Electric Power Substations Engineering	CRC Press	2007
2.	A.S. Pabla	Electric Power Distribution	Tata McGraw Hill	2011
3.	Paul Gill	Electrical Power Equipment Maintenance and Testing	CRC press	2008
4.	Juergan Schlabbach Karl Heinz Rofalski	Power system engineering planning design & operation of power systems.	Wiley	2008
5.	Evelio Padilla	Substation automation systems design and implementation	John Wiley	2021

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21PSB08 ADVANCED POWER SYSTEM PROTECTION

COURSE OBJECTIVES

- To emphasis the need for overcurrent protection.
- To learn about various protections of Transformers.
- To learn about various protections of generators.
- To emphasis the need for distance and carrier protection of transmission system.
- To learn about different protection schemes for busbar.

COURSE OUTCOMES

- Understand the basic principles of overcurrent protection.
- Understand the different types of protection for Transformers.
- Understand the different types of protection for generators.
- Understand the different types of protection schemes for distance and carrier protection of transmission system
- Understand the different protection schemes for busbar.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSB08.CO1	x	x	x	-	-	-	-	-	-	x	-	x	x	-	-
21PSB08.CO2	x	x	x	-	-	x	-	-	x	x	-	x	x	-	-
21PSB08.CO3	x	x	x	-	-	x	-	-	x	x	-	x	x	-	-
21PSB08.CO4	x	x	x	-	-	x	-	-	x	x	-	x	x	-	-
21PSB08.CO5	x	x	x	-	-	x	-	-	x	x	-	x	x	-	-

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UNIT I OVER CURRENT PROTECTION 9

Zones of protection – Primary and Backup protection operating principles and Relay Construction - Time – Current characteristics-Current setting – Time setting-Over current protective schemes - Reverse power or directional relay - Protection of parallel feeders

UNIT II EQUIPMENT PROTECTION 9

Types of transformers – Phasor diagram for a three – Phase transformer-Equivalent circuit of transformer – Types of faults in transformers- Over – current protection Percentage Differential Protection of Transformers - Inrush phenomenon-High resistance Ground Faults in Transformers - Inter-turn faults in transformers - Incipient faults in transformers

UNIT III DISTANCE AND CARRIER PROTECTION OF TRANSMISSION LINES 9

Drawback of over – Current protection – Introduction to distance relay - Simple impedance relay Reactance relay – mho relays comparison of distance relay – Distance protection of a three – Phase line-reasons for inaccuracy of distance relay reach - Three stepped distance protection - Trip contact configuration for the three - Stepped distance protection

UNIT IV BUSBAR PROTECTION 9

Introduction – Differential protection of bus bars-external and internal fault - Actual behaviors of a protective CT - Circuit model of a saturated CT - External fault with one CT saturation need for high impedance Minimum internal fault that can be detected by the high – Stability ratio of high impedance bus bar differential scheme

UNIT V NUMERICAL PROTECTION 9

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

TOTAL: 45

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REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	P.Kundur	Power System Stability and Control	TATA McGraw Hill	2193
2.	Stanley Horowitz	Protective Relaying for Power System	IEEE press	2008
3.	T.S.M. Rao	Digital Relay / Numerical relays	Tata McGraw Hill	2189
4.	Y.G. Paithankar and S.R Bhide	Fundamentals of Power System Protection	Prentice-Hall of India	2003
5.	C/Christo Polous , A.Wright	Electrical Power system Protection	Kluwer Academic Publisher	2199

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21PSB09 RESTRUCTURED POWER SYSTEM

COURSE OBJECTIVES

- To introduce the restructuring of power industry and market models.
- To impart knowledge on fundamental concepts of congestion management.
- To analyze the concepts of locational marginal pricing and financial transmission rights.
- To analyze ancillary service management.
- To analyze pricing of transmission network.

COURSE OUTCOMES

- Explain the restructuring process, new entities in power market and benefits.
- Apply the concepts and terminologies used in interchange evaluation, power pools and transaction issues.
- Explain the Indian power system, issues, regulatory and policy developments and acts.
- Determine available transfer capability in restructured environment.
- Analyze ancillary service management and pricing of transmission network.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSB09.CO1	x	x	x	-	-	-	-	-	x	x	-	x	x	-	-
21PSB09.CO2	x	x	x	-	-	-	-	-	x	x	-	x	x	-	-
21PSB09.CO3	x	x	x	-	-	-	-	-	x	x	-	x	x	-	-
21PSB09.CO4	x	x	x	-	-	-	-	-	x	x	-	x	x	-	-
21PSB09.CO5	x	x	x	-	-	-	-	-	x	x	-	x	x	-	-

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UNIT I INTRODUCTION TO RESTRUCTURING OF POWER INDUSTRY 9

Introduction: Deregulation of power industry, Restructuring process, Issues involved in deregulation, Deregulation of various power systems – Fundamentals of Economics: Consumer behavior, Supplier behavior, Market equilibrium, Short and long run costs, Various costs of production – Market models: Market models based on Contractual arrangements, Comparison of various market models, Electricity vis – a – vis other commodities, Market architecture, Case study.

UNIT II TRANSMISSION CONGESTION MANAGEMENT 9

Introduction: Definition of Congestion, reasons for transfer capability limitation, Importance of congestion management, Features of congestion management – Classification of congestion management methods – Calculation of ATC - Non – market methods – Market methods.

UNIT III LOCATIONAL MARGINAL PRICES AND FINANCIAL TRANSMISSION RIGHTS 9

Mathematical preliminaries: - Locational marginal pricing - Lossless DCOPF model for LMP calculation – Loss compensated DCOPF model for LMP calculation – ACOPF model for LMP calculation – Financial Transmission rights – Risk hedging functionality.

UNIT IV ANCILLARY SERVICE 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 - How to obtain ancillary service –Co-optimization of energy and reserve services - International comparison Transmission pricing – Principles.

UNIT V REFORMS IN INDIAN POWER SECTOR 9

Introduction – Framework of Indian power sector – Reform initiatives - Availability based tariff – Electricity act 2003 – Open access issues – Power exchange – Reforms in the near future

TOTAL: 45

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REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	Sally Hunt	Making competition work in electricity	John Willey and Sons Inc	2002
2.	Steven Stoft	Power system economics: designing markets for electricity	John Wiley & Sons	2002
3.	Mohammad Shahidehpour, Muwaffaq Alomoush and Marcel Dekker,	Restructured electrical power systems: operation, trading and volatility	Kluwer Academic Pub	2001
4.	Kankar Bhattacharya, Jaap E. Daadler and Math H.J. Boolen,	Operation of restructured power systems	Kluwer Academic Pub	2001
5.	S.A.Khaparde and A.R.Abhyankar	Restructured power systems	Alpha Science	2011

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21PSB10 RESTRUCTURED POWER SYSTEM LABORATORY

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COURSE OBJECTIVES

- To introduce the restructuring of power industry and market models.
- To impart knowledge on fundamental concepts of congestion management.
- To analyze the concepts of locational marginal pricing and financial transmission rights.
- To analyze ancillary service management.
- To analyze pricing of transmission network.

COURSE OUTCOMES

- Explain the restructuring process, new entities in power market and benefits.
- Apply the concepts and terminologies used in interchange evaluation, power pools and transaction issues.
- Explain the Indian power system, issues, regulatory and policy developments and acts.
- Determine available transfer capability in restructured environment.
- Analyze ancillary service management and pricing of transmission network.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSB10.CO1	x	x	x	-	-	-	-	-	x	x	-	x	x	-	-
21PSB10.CO2	x	x	x	-	-	-	-	-	x	x	-	x	x	-	-
21PSB10.CO3	x	x	x	-	-	-	-	-	x	x	-	x	x	-	-
21PSB10.CO4	x	x	x	-	-	-	-	-	x	x	-	x	x	-	-
21PSB10.CO5	x	x	x	-	-	-	-	-	x	x	-	x	x	-	-

1. Small-signal stability analysis of single machine-infinite bus system using classical machine model
2. Small-signal stability analysis of multi-machine configuration with classical machine model
3. Induction motor starting analysis
4. Load flow analysis of two-bus system with STATCOM
5. Transient analysis of two-bus system with STATCOM
6. Available Transfer Capability calculation using an existing load flow program
7. Study of variable speed wind energy conversion system- DFIG
8. Study of variable speed wind energy conversion system- PMSG
9. Computation of harmonic indices generated by a rectifier feeding a R-L load
10. Design of active filter for mitigating harmonics.

TOTAL: 45

21PSB11 SOLAR AND ENERGY STORAGE SYSTEMS

COURSE OBJECTIVES

- To Study about solar modules.
- To Deal with stand-alone PV systems.
- To Deal with grid connected PV systems.
- To Discuss about different energy storage systems.
- To study about various PV system design.

COURSE OUTCOMES

- Demonstrate the knowledge of the physics of solar power generation.
- Demonstrate the knowledge of stand-alone PV systems.
- Learning advanced techniques of grid connectivity and optimization non-conventional sources power.
- Simulation and modeling of solar photovoltaic systems.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSB11.CO1	-	x	x	x	-	-	-	-	-	x	-	x	-	x	-
21PSB11.CO2	x	x	x	x	-	-	-	-	-	x	-	x	-	x	-
21PSB11.CO3	-	x	x	x	-	-	-	-	-	x	-	x	-	x	-
21PSB11.CO4	x	x	x	x	-	-	-	-	-	x	-	x	-	x	-
21PSB11.CO5	-	x	x	x	-	-	-	-	-	x	-	x	-	x	-

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UNIT I INTRODUCTION 9

Characteristics of sunlight – semiconductors and P-N junctions – behavior of solar cells – cell properties – PV cell interconnection

UNIT II STAND ALONE PV SYSTEM 9

Solar modules – storage systems – power conditioning and regulation - protection – standalone PV systems design – sizing

UNIT III GRID CONNECTED PV SYSTEMS 9

PV systems in buildings – design issues for central power stations – safety – Economic aspect – Efficiency and performance - International PV programs

UNIT IV ENERGY STORAGE SYSTEMS 9

Impact of intermittent generation – Battery energy storage – solar thermal energy storage – pumped hydroelectric energy storage

UNIT V APPLICATIONS 9

Water pumping – battery chargers – solar car – direct-drive applications –Space -Telecommunications

TOTAL: 45

REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	Eduardo Lorenzo G. Araujo	Solar electricity engineering of photovoltaic systems	Progensa	2194
2.	Stuart R.Wenham, Martin A.Green, Muriel E. Watt and Richard Corkish	Applied Photovoltaic	Earth scan	2006
3.	S.P. Sukhatme	Solar Energy	Tata McGraw Hill	2187
4.	Frank S. Barnes & Jonah G. Levine	Large Energy storage Systems Handbook,	CRC Press	2011
5.	McNeils, Frenkel, Desai	Solar & Wind Energy Technologies	Wiley Eastern	2190

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21PSB12 POWER SYSTEM SECURITY

COURSE OBJECTIVES

- To understand the need for power system security.
- To analyze state estimation in power system.
- To study the security assessment of power system.
- To study the techniques for security enhancement.
- To study the recent techniques in voltage security assessment.

COURSE OUTCOMES

- Assess the security level status of the large power system, if n-1 contingency takes place in the system.
- Analyze the large power system in terms of real power performance index (PI) or other PIs.
- Estimate the state of the power system in terms of its measured values.
- Optimize the power flow in terms of real and reactive power with the possible various objectives and constraints involved in energy management system.
- Use appropriate OPF technique depending on the formulation of optimization which involves non-linear objective and constraints.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSB12.CO1	-	x	x	x	-	-	-	-	-	x	-	x	-	x	-
21PSB12.CO2	x	x	x	x	-	-	-	-	-	x	-	x	-	x	-
21PSB12.CO3	-	x	x	x	-	-	-	-	-	x	-	x	-	x	-
21PSB12.CO4	x	x	x	x	-	-	-	-	-	x	-	x	-	x	-
21PSB12.CO5	-	x	x	x	-	-	-	-	-	x	-	x	-	x	-

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UNIT I BASICS OF POWER SYSTEM SECURITY 9

Factors affecting power system security- decomposition and multilevel approach- state estimation- system monitoring- security assessment and security enhancement.

UNIT II POWER SYSTEM STATE ESTIMATION 9

Maximum likelihood weighted least-square estimation- state estimation- detection and identification of bad measurements- estimation of quantities not being measure- network observability and pseudo measurements.

UNIT III SECURITY ASSESSMENT 9

Detection of network problems- network equivalent for external system- network sensitivity methods- calculation of network sensitivity factors- fast contingency algorithms- contingency ranking- dynamic security indices.

UNIT IV SECURITY ENHANCEMENT 9

Correcting the generator dispatch by sensitivity methods- compensated factors- security constrained optimization- preventive- emergency and restorative control through NLP and LP methods.

UNIT V RECENT TECHNIQUES 9

Voltage security assessment-Transient Security assessment-methods-Comparison.

TOTAL: 45

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REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	John J.Graignaer and William D. Stevenson	Power system analysis	Tata McGraw Hill	2003
2.	P.Venkatesh, B.V.Manikandan, S.Charles raja and A.Srinivasan	Electrical power systems analysis. Security and Deregulation	PHI	2012
3.	A.J.Wood and B.F.Wollenberg	Power generation, operation and control	John Wiley and sons	2196
4.	Miceaeremia, Mohammed Shahidhpour	Handbook of Electrical Power system Dynamics, Modeling, Stablity	Jhon wiley and Sons	2013
5.	Hyungchulkim	Evaluation of Power system security and development of transmission pricing methods	Texas A&H University	2003

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21PSB13 INDUSTRIAL POWER SYSTEM ANALYSIS AND DESIGN

COURSE OBJECTIVES

- To analyze the motor starting.
- To expose various computer aided analysis.
- To study about power factor correction.
- To perform computer-aided harmonic analysis and to design filters.
- To perform the flicker analysis.

COURSE OUTCOMES

Upon completion of the course, students will be able to

- Understand the various types of motor starting.
- Understand the various computer aided analysis.
- Understand the power factor correction.
- Know the severity of power quality problems in distribution system.
- Understand the concept of voltage sag transformation from up-stream (higher voltages) to down-stream (lower voltage).

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSB13.CO1	x	x	-	-	-	-	-	-	-	x	-	x	x	-	-
21PSB13.CO2	x	x	x	x	-	-	-	-	-	x	-	x	x	x	-
21PSB13.CO3	x	x	x	x	-	-	-	-	-	x	-	x	x	x	-
21PSB13.CO4	x	x	x	x	-	-	-	-	-	x	-	x	x	x	-
21PSB13.CO5	x	x	x	x	-	-	-	-	-	x	-	x	x	x	-

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UNIT I MOTOR STARTING STUDIES 9

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

UNIT II POWER FACTOR CORRECTION STUDIES 9

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

UNIT III HARMONIC ANALYSIS 9

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

UNIT IV FLICKE ANALYSIS 9

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

UNIT V GROUND GRID ANALYSIS 9

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

TOTAL: 45

REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	RamasamyNatarajan	Computer-Aided Power System Analysis	Marcel Dekker Inc	2002
2.	ArindamGhosh	Power Quality Enhancement Using Custom Power Devices	Springer International Edition	2002
3.	G.T.Heydt	Electric Power Quality	Stars in a Circle Publications	2nd edition 2194
4.	Steven.J.Marrano and Craig Di Louie	Electrical system design and specification Handbook for industrial facilities	The Fairmont press	2198
5.	J.Duncun Glover Thomous Overbye and Mulukutla S.Sarma	Power system analysis and design	Cengage Learning	2021

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21PSB14 POWER SYSTEM PLANNING AND RELIABILITY

COURSE OBJECTIVES

- To introduces the objectives of Load forecasting.
- To study the fundamentals of Generation system reliability analysis.
- To study the fundamentals of transmission system reliability analysis.
- To illustrate the basic concepts of Expansion planning.
- To study the fundamentals of and Distribution system reliability analysis.

COURSE OUTCOMES

- Understand how the Power Market operates in a deregulated Electrical Power Industry.
- Know the significance of generation planning and transmission planning for power system reliability and security assessment.
- Understand the concept of probability theory, distribution, network modelling and reliability analysis.
- Describe the reliability functions with their relationships and Markov modeling.
- Evaluate reliability models using frequency and duration techniques and generate various reliability models.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSB14.CO1	-	x	x	-	-	x	x	-	-	x	-	x	-	-	-
21PSB14.CO2	x	x	x	-	-	x	-	-	-	x	-	x	x	-	-
21PSB14.CO3	x	x	x	-	-	x	-	-	-	x	-	x	x	-	-
21PSB14.CO4	x	x	x	-	-	x	x	-	-	x	-	x	x	-	-
21PSB14.CO5	x	x	x	-	-	x	-	-	-	x	-	x	x	-	-

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UNIT I LOAD FORECASTING 9

Objectives of 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 II GENERATION SYSTEM RELIABILITY ANALYSIS 9

Probabilistic generation and load models- Determination of LOLP and expected value of demand not served – Determination of reliability of iso and interconnected generation systems.

UNIT III TRANSMISSION SYSTEM RELIABILITY ANALYSIS 9

Deterministic contingency analysis-probabilistic load flow-Fuzzy load flow probabilistic transmission system reliability analysis-Determination of reliability indices like LOLP and expected value of demand not served.

UNIT IV EXPANSION PLANNING 9

Basic concepts on expansion planning-procedure followed for integrate transmission system planning, current practice in India-Capacitor placer problem in transmission system and radial distributions system.

UNIT V DISTRIBUTION SYSTEM PLANNING OVERVIEW 9

Introduction- Sub transmission lines and distribution substations- Design primary and secondary systems-distribution system protection and coordination of protective devices.

TOTAL: 45

REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	Roy Billinton & Ronald N. Allan	Reliability Evaluation of Power System	Springer Publication.	-
2.	R.L. Sullivan	Power System Planning	Tata McGraw Hill Publishing Company Ltd	-
3.	X. Wang & J.R. McDonald	Modern Power System Planning	McGraw Hill Book Company	-
4.	T. Gönen,	Electrical Power Distribution Engineering	McGraw Hill Book Company	-
5.	B.R. Gupta	Generation of Electrical Energy	S. Chand Publications	-

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21PSC01 FLEXIBLE AC TRANSMISSION SYSTEMS

COURSE OBJECTIVES

- To emphasis the need for FACTS controllers.
- To learn the characteristics, applications and modeling of series FACTS controllers.
- To learn the characteristics, applications and modeling of shunt FACTS controllers.
- To learn the characteristics of phase angle regulators.
- To learn the characteristics of UPFC.

COURSE OUTCOMES

- Understand the basic principles, characteristics of different types of series FACTS controllers.
- Understand the basic principles, characteristics of different types of shunt FACTS controllers
- Compare the performance of various FACTS controllers.
- Model FACTS controller for power flow and stability applications.
- Understand the concepts of phase angle regulators and UPFC

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSC01.CO1	X	X	-	-	-	-	-	-	-	X	-	X	X	-	-
21PSC01.CO2	X	X	X	X	-	-	-	-	-	X	-	X	X	X	-
21PSC01.CO3	X	X	X	X	-	-	-	-	-	X	-	X	X	X	-
21PSC01.CO4	X	X	X	X	-	-	-	-	-	X	-	X	X	X	-
21PSC01.CO5	X	X	X	X	-	-	-	-	-	X	-	X	X	X	-

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INTRODUCTION 9

Reactive power control in electrical power transmission lines -Uncompensated transmission line – Fixed series and shunt compensation – Basic types of FACTS controllers – Brief description and definitions of FACTS controllers.

UNIT II STATIC SHUNT COMPENSATORS 9

Objective of Shunt Compensation - Variable Impedance Type Static VAR Generators – Switching Converter Type VAR Generators - Basic operating principle and V-I Characteristics and Control Schemes – Comparison between thyristor based VSC and STATCOM. Applications: Enhancement of transient stability – Steady state power transfer – Enhancement of Power system damping – Prevention of voltage instability.

UNIT III STATIC SERIES COMPENSATORS 9

Objective of Series Compensation - Variable Impedance Type Static Series Compensator -TCSC,TSSC – Switching Converter Type Series Converters - Operation, Characteristics and Control Schemes – Modeling of TCSC – Variable reactance model- Applications: Improvement of the system stability limit- Enhancement of system damping – SSR Mitigation

UNIT IV PHASE ANGLE REGULATORS AND UPFC 9

Power Flow Control using TCPAR – UPFC – Operation – Transmission Control Capabilities – Real and Reactive Power Control Scheme – Applications-UPQC & IPFC.

UNIT V MODELING OF FACTS CONTROLLERS 9

Modeling of Shunt and Series Controllers for Power Flow and Transient stability. Modeling of UPFC.

TOTAL: 45

REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	K.R.Padiyar	FACTS Controllers in Power Transmission and Distribution	New Age International (P)Ltd. ,Publishers New Delhi	Reprint 2008
2.	MohanMathur,R. , Rajiv.K.Varma.	Thyristor–Based Facts Controllers for Electrical Transmission Systems	IEEE press and John Wiley & Sons, Inc	2009
3	A.T.John	Flexible AC Transmission System	Institution of Electrical and Electronic Engineers (IEEE)	2199
4	Narain G.Hingorani, Laszio. Gyugyl	Understanding FACTS Concepts and Technology of Flexible AC Transmission System	Standard Publishers, Delhi	2001
5	V. K.Sood	HVDC and FACTS controllers Applications of Static Converters in Power System	Kluwer Academic Publishers	2004

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21PSC02 MICROCONTROLLER BASED SYSTEM DESIGN

COURSE OBJECTIVES

- To expose the students to the fundamentals of microcontroller based system design.
- To expose the students to different microcontroller architecture.
- To teach I/O and RTOS role on microcontroller.
- To impart knowledge on PIC Microcontroller based system design.
- To introduce Microchip PIC 8 bit peripheral system Design

COURSE OUTCOMES

- Describe the fundamentals of microcontroller based system design.
- Describe the architecture of different microcontrollers.
- Depict the basics of I/O and RTOS role in microcontroller.
- Explain the concept of PIC Microcontroller based system design.
- Explain the concept of Microchip PIC 8 bit peripheral system Design.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSC02.CO1	x	x	x	x	-	-	-	-	-	x	-	x	x	x	x
21PSC02.CO2	x	x	x	x	-	-	-	-	-	x	-	x	x	x	x
21PSC02.CO3	x	x	x	x	-	-	-	-	-	x	-	x	x	x	x
21PSC02.CO4	x	x	x	x	-	-	-	-	-	x	-	x	x	x	x
21PSC02.CO5	x	x	x	x	-	-	-	-	-	x	-	x	x	x	x

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UNIT I 8051 ARCHITECTURE 9

Hardware Architecture ,pin and signal diagram–Functional Building Blocks of Controller–Memory organization–I/O ports and data transfer concepts– Timing Diagram – Interrupts

UNIT II 8051 MICRO CONTROLLER PROGRAMMING & APPLICATIONS 9

Data Transfer, Manipulation, Control Algorithms& I/O instructions – Simple programming exercises- key board and display interface – Closed loop control of servo motor- stepper motor control – Washing Machine Control.

UNIT III PIC MICROCONTROLLER 9

Introduction to PIC Microcontroller–PIC21C6x and PIC21C7x Architecture – PIC21cxx — Pipelining- Program Memory considerations–Register File Structure-Instruction Set-Addressing modes – Simple Operations.

UNIT IV PERIPHERAL OF PIC MICROCONTROLLER 9

Timers – Programming Timers 0 and 1, PIC Microcontroller Interrupts, I2C bus for peripheral chip access- Serial EEPROM-Analog to Digital converter- UART - ADC, DAC and Sensor Interfacing.

UNIT V ARM PROCESSOR AND ATMEGA CONTROLLER 9

ARM Architecture - ARM programmer's model - ARM Development tools - Memory Hierarchy – 3 Stage ARM Pipeline Organization- 5 Stage ARM Pipeline organization - ATMEGA architecture - Pin Configurations - Arduino Technology and Software - Simple programmes.

TOTAL: 45

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REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	Muhammad Ali Mazidi, Rolin D. Mckinlay, Danny Causey	PIC Microcontroller and Embedded Systems using Assembly and C for PIC18	Pearson Education	2008
2.	John Iovine	PIC Microcontroller Project Book	McGraw Hill	2000
3.	Myke Predko	Programming and customizing the 8051 microcontroller	Tata McGraw Hill	2001
4	Muhammad Ali Mazidi, Janice G. Mazidi and Rolin D. McKinlay	The 8051 Microcontroller and Embedded Systems	Prentice Hall	2005
5	I Scott Mackenzie and Raphael C.W. Phan	The Micro controller	Pearson, Fourth edition	2012

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21PSC03 DESIGN AND ANALYSIS OF INVERTERS

COURSE OBJECTIVES

- To provide the electrical circuit concepts behind the different working modes of inverters so as to enable deep understanding of their operation.
- To equip with required skills to derive the criteria for the design of power converters for UPS, Drives etc.,
- Ability to analyze and comprehend the various operating modes of different configurations of power converters.
- Ability to design VSI and CSI inverters.
- Ability to design multilevel inverters.

COURSE OUTCOMES

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

- Suggest the application of single phase inverters
- Demonstrate the operation of three phase inverters.
- Analyze the operation of various operating modes of different configurations of power converters.
- Analyze the operation of CSI inverter.
- Evaluate the performance of multilevel inverter.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSC03.CO1	X	-	X	X	-	-	-	-	-	X	-	X	X	X	-
21PSC03.CO2	X	X	-	-	-	X	-	-	X	X	-	X	X	X	-
21PSC03.CO3	X	X	X	X	-	X	-	-	X	X	X	X	X	X	-
21PSC03.CO4	X	X	X	X	-	X	-	-	X	X	X	X	X	X	-
21PSC03.CO5	X	X	X	X	-	X	-	-	X	X	X	X	X	X	-

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UNIT I BASIC INVERTERS 9

Basic series inverter – Modified series inverter- High frequency series inverter- Design of L and C – Parallel inverter- Design of parallel inverter- Line commutated inverter – Concepts of PWM techniques- SPWM , Multi-PWM , Carrier based PWM , Space vector PWM.

UNIT II VOLTAGE SOURCE INVERTERS 9

Principle of operation of half and full bridge inverters – Three phase inverters with 180 degree and 120 degree conduction mode with star and delta connected loads- Performance parameters – Voltage control of single phase and three phase inverters -- Various harmonic elimination techniques.

UNIT III CURRENT SOURCE AND IMPEDANCE SOURCE INVERTERS 9

Load commutated current source inverter- Single phase and three phase Auto Sequential Current Source Inverter (ASCI) – Principle of operation of impedance source inverter- Shoot through zero state – Comparison of current source inverter, Voltage source inverters and impedance source inverter.

UNIT IV MULTILEVEL INVERTERS 9

Multilevel concept – Diode clamped – Flying capacitor – Cascade type multilevel inverters – Hybrid multi-level inverter- FFT analysis- Comparison of multilevel inverters – Applications of multilevel inverters.

UNIT V RESONANT INVERTERS 9

Concept of Zero Voltage Switching and Zero Current Switching - Series and parallel resonant inverters- Voltage control of resonant inverters – Class E resonant inverter – Resonant DC Link inverters.

TOTAL: 45

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REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	Rashid M.H	Power Electronics Circuits, Devices and Applications, Third Edition	Prentice Hall India, New Delhi	2007
2.	Jai P.Agrawal	Power Electronics Systems	Pearson Education	2002
3.	Bimal K.Bose	Modern Power Electronics and AC Drives	Pearson Education	2009
4.	P.C. Sen	Modern Power Electronics	Wheeler Publishing Co, New Delhi	2005
5.	P.S.Bimbra	Power Electronics	Khanna Publishers	2003

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21PSC04 POWER QUALITY

COURSE OBJECTIVES

- The concept of the Power Quality Issues.
- The concept of the Power Quality standards.
- The concept of the Single phase linear and nonlinear loads.
- The concept of load compensation methods
- The concept of voltage regulation using DVR and analysis of classical load balancing problem.

COURSE OUTCOMES

- Explain the various power quality issues.
- Explain the various power quality issues.
- Elucidate the concept of power and power factor in single phase and three phase systems supplying non-linear loads.
- Explicate the conventional compensation techniques used for power factor correction.
- Explicate the load voltage regulation using DVR and analysis of classical load balancing problem.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSC04.CO1	-	X	X	-	-	X	X	-	-	X	-	X	-	-	-
21PSC04.CO2	X	X	X	-	-	X	-	-	-	X	-	X	X	-	-
21PSC04.CO3	X	X	X	-	-	X	-	-	-	X	-	X	X	-	-
21PSC04.CO4	X	X	X	-	-	X	X	-	-	X	-	X	X	-	-
21PSC04.CO5	X	X	X	-	-	X	-	-	-	X	-	X	X	-	-

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UNIT I INTRODUCTION 9

Introduction – Characterization of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves .

UNIT II ANALYSIS OF LINEAR AND NON-LINEAR SYSTEMS 9

Single phase static and rotating AC/DC converters, Three phase static AC/DC converters, Battery chargers, Arc furnaces, Fluorescent lighting, pulse modulated devices, Adjustable speed drives.

UNIT III CONVENTIONAL LOAD COMPENSATION METHODS 9

Principle of load compensation and voltage regulation – Classical load balancing problem: open loop balancing – Closed loop balancing, current balancing – Harmonic reduction and voltage sag reduction – Analysis of unbalance – Instantaneous real and reactive powers – Extraction of fundamental sequence component. Voltage Sag Lost Energy Index (VSLEI) - Analysis of voltage flicker, Reduced duration and customer impact of outages.

UNIT IV LOAD COMPENSATION USING DSTATCOM 9

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

UNIT V SERIES COMPENSATION AND POWER DISTRIBUTION SYSTEM 9

Rectifier supported DVR – DC Capacitor supported DVR – DVR Structure – Voltage Restoration – Series Active Filter – Unified power quality conditioner Utility-Customer interface –Harmonic filters: passive, Active and hybrid filters.

TOTAL: 45

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REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	Arindam Ghosh	Power Quality Enhancement Using Custom Power Devices	Springer International Edition	2002
2.	G.T.Heydt	Electric Power Quality, 2nd edition	Stars in a Circle Publications	2194
3.	Roger.C.Dugan, Mark.F.McGranagham, Surya Santoso, H.Wayne Beaty	Electrical Power Systems Quality	McGraw Hill	2004
4	Derek A. Paice	Power electronic converter harmonics: Multi pulse Method for Clean Power	Wiley-IEEE Press	2199
5.	Jos Arrillaga, Neville R. Watson	Power system harmonics, 2nd Edition	Wiley	2003

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21PSC05 ADVANCED DIGITAL SIGNAL PROCESSING

COURSE OBJECTIVES

- To expose the students to the fundamentals of digital signal processing in frequency domain& its application.
- To teach the fundamentals of digital signal processing in time-frequency domain& its application.
- To compare Architectures & features of Programmable DSP processors.
- To discuss on Application development with commercial family of DS Processors.
- To design & develop logical functions of DSP Processors with Re- Programmable logics &Devices.

COURSE OUTCOMES

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

- Comprehend the DFTs and FFTs.
- Design and analyze the digital filters.
- Acquire the basics of multi rate digital signal processing.
- Analyze the power spectrum estimation (4 or 5 methods).
- Comprehend the Finite word length effects in Fixed point DSP Systems.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSC05.CO1	x	x	-	-	x	-	-	-	-	x	-	x	x	-	-
21PSC05.CO2	x	x	-	x	x	-	-	-	-	x	-	x	x	x	-
21PSC05.CO3	x	x	x	x	x	-	-	-	-	x	-	x	x	x	
21PSC05.CO4	x	x	x	x	x	-	-	-	-	x	-	-	-	x	
21PSC05.CO5	x	x	x	x	x	-	-	-	-	x	-	x	x	x	

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UNIT I INTRODUCTION TO DIGITAL SIGNAL PROCESSING 9

Introduction, A Digital Signal-Processing System, The Sampling Process, Discrete Time Sequences, Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT), Linear Time-Invariant Systems, Decimation and Interpolation, Digital Filters, FIR Filters, IIR Filters.

UNIT II WAVELET TRANSFORM 9

Wavelets – Wavelet Analysis – The Continuous Wavelet Transform – scaling – shifting – scale and frequency – The Discrete Wavelet Transform – One Stage filtering – Approximation and Details – Filter bank analysis – Multilevel Decomposition – Number of levels – Wavelet reconstruction – Reconstruction filter- Reconstructing Approximations and details- Multilevel Reconstruction – Wavelet packet synthesis- Typical Applications. Recursive multi-resolution decomposition – Haar Wavelet – Daubechies Wavelet.

UNIT III ARCHITECTURES OF COMMERCIAL DIGITAL SIGNAL PROCESSORS 9

Introduction, categorization of DSP Processors, Fixed Point (Black fin), Floating Point (SHARC), TI TMS 320c6xxx & OMAP processors TMS320C54X & 54xx on Basic Architecture – comparison : of functional variations of Computational building blocks, MAC, Bus Architecture and memory, Data Addressing, Parallelism and pipelining, Parallel I/O interface, Memory Interface, Interrupt, DMA (one example Architecture in each of these case studies).

UNIT IV INTERFACING I/O PERIPHERALS FOR DSP BASED APPLICATIONS 9

Introduction, External Bus Interfacing Signals, Memory Interface, Parallel I/O Interface, Programmed I/O, Interrupts and I/O Direct Memory Access (DMA) -Introduction, Design of Decimation and Interpolation Filter, FFT Algorithm, PID Controller, Application for Serial Interfacing, DSP based Power Meter, Position control, CODEC Interface.

UNIT V VLSI IMPLEMENTATION 9

Low power Design - need for Low power VLSI chips - Basics of DSP system architecture design using VHDL programming, Mapping of DSP algorithm onto hardware, Realization of MAC & Filter structure.

TOTAL: 45

REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	John G.Proaks, Dimitris G.Manolakis	Digital Signal Processing	Pearson Education	2002
2.	Avatar Sing, S. Srinivasan	Digital Signal Processing-Implementation using DSP Microprocessors with Examples from TMS320C54xx	Thomson India	2004
3.	Lars Wanhammer	DSP Integrated Circuits	Academic press	2199
4	Lyla B Das	Embedded Systems-An Integrated Approach	Pearson Education	2013
5	Ashok Ambardar	Digital Signal Processing: A Modern Introduction	Thomson India edition	2007

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21PSC06 ENERGY MANAGEMENT AND AUDITING

COURSE OBJECTIVES

- To study about energy management and auditing.
- To study the concepts behind economic analysis and Load management.
- To emphasize the energy management on various electrical equipment.
- To emphasize the various metering for energy management.
- To illustrate the concept of lighting systems..

COURSE OUTCOMES

- Learn the concepts of energy management and auditing.
- Learn the concepts of economic analysis and load management.
- Learn the the energy management on various electrical equipment.
- Gain knowledge regarding the various metering for energy management.
- Gain knowledge regarding the lighting systems.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSC06.CO1	-	X	X	X	-	-	-	-	-	X	-	X	-	X	-
21PSC06.CO2	X	X	X	X	-	-	-	-	-	X	-	X	-	X	-
21PSC06.CO3	-	X	X	X	-	-	-	-	-	X	-	X	-	X	-
21PSC06.CO4	X	X	X	X	-	-	-	-	-	X	-	X	-	X	-
21PSC06.CO5	-	X	X	X	-	-	-	-	-	X	-	X	-	X	-

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UNIT I INTRODUCTION 9

Need for energy management - energy basics- designing and starting an energy management program – energy accounting -energy monitoring, targeting and reporting- energy audit process

UNIT II ENERGY COST AND LOAD MANAGEMENT 9

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

UNIT III ENERGY MANAGEMENT FOR MOTORS, SYSTEMS, AND ELECTRICAL EQUIPMENT 9

Systems and equipment- Electric motors-Transformers and reactors-Capacitors and synchronous machines.

UNIT IV METERING FOR ENERGY MANAGEMENT 9

Relationships between parameters-Units of measure-Typical cost factors- Utility meters - Timing of meter disc for kilowatt measurement - Demand meters - Paralleling of current transformers - Instrument transformer burdens-Multitasking solid-state meters - Metering location vs. requirements- Metering techniques and practical examples.

UNIT V LIGHTING SYSTEMS & COGENERATION 9

Concept of lighting systems - The task and the working space -Light sources - Ballasts - Luminaries - Lighting controls-Optimizing lighting energy - Power factor and effect of harmonics on power quality - Cost analysis techniques-Lighting and energy standards. Cogeneration: Forms of cogeneration - feasibility of cogeneration-Electrical interconnection.

TOTAL: 45

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REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	Reay D.A	Industrial Energy Conservation	Pergamon Press	2177
2.	Amit K. Tyagi	Handbook on Energy Audits and Management	-	2006
3.	-	IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities.	IEEE, 216	-
4	Barney L. Capehart, Wayne C. Turner, and William J. Kennedy	Guide to Energy Management	Fifth Edition, The Fairmont Press	2006
5	Eastop T.D & Croft D.R	Energy Efficiency for Engineers and Technologists	Logman Scientific & Technical, ISBN-0-582-03184	2190

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21PSC07 HIGH VOLTAGE DIRECT CURRENT TRANSMISSION

COURSE OBJECTIVES

- To impart knowledge on operation and Modeling.
- To impart knowledge on control of HVDC link.
- To impart knowledge on thyristors converters.
- To perform steady state analysis of AC/DC system.
- To analyze protection of hvdc systems, harmonics, filters and ground return.

COURSE OUTCOMES

After Completion of this course students will be able to,

- Identify driving factors behind the resurgence of HVDC.
- Examine how to control HVDC link.
- Recognize the best strategies for stakeholder engagement, communication, and
- Outreach programs for HVDC projects.
- Examine how an actual utility operates its existing, successful HVDC system.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSC07.CO1	X	X	-	-	-	-	-	-	-	X	-	X	X	-	-
21PSC07.CO2	X	X	X	X	-	-	-	-	-	X	-	X	X	X	-
21PSC07.CO3	X	X	X	X	-	-	-	-	-	X	-	X	X	X	-
21PSC07.CO4	X	X	X	X	-	-	-	-	-	X	-	X	X	X	-
21PSC07.CO5	X	X	X	X	-	-	-	-	-	X	-	X	X	X	-

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UNIT I GENERAL ASPECTS 9

Historical development of HVAC and DC links – kinds of DC links-HVDC projects in India and abroad – advantages and disadvantages of HVDC transmission - Applications of DC transmission – economic factors – development of power devices for HVDC transmission.

UNIT II THYRISTOR CONVERTERS 9

Three phase fully controlled thyristor bridge converters – operation as rectifiers and line commutated inverters – converter equivalent circuits – parameters and characteristics of rectifiers and inverters – series and parallel arrangement of thyristors – multibridge converters

UNIT III CONTROL OF CONVERTERS AND REACTIVE POWER CONTROL 9

Gate control – basic means of control and modes of operation – power reversal – desired features of control – control characteristics – constant current control – constant extinction angle control – stability of control – tap changer control – power control and current limits. Reactive Power Requirements – Reactive Power Control during Steady State and Transients

UNIT IV PROTECTION OF HVDC SYSTEMS, HARMONICS, FILTERS AND GROUND RETURN 9

Basics of protection of HVDC systems – DC reactors – voltage and current oscillations – DC line oscillations – clearing line faults and re-energizing the line – circuit breakers – over voltage protection -Characteristics and uncharacteristic harmonics – troubles caused by harmonics – means of reducing harmonics — harmonic filters – Corona and Radio interference- ground return and ground Electrodes.

UNIT V SIMULATION OF HVDC SYSTEMS 9

Introduction – System Simulation: Philosophy and Tools – HVDC System Simulation – Modeling of HVDC Systems for Digital Dynamic Simulation – Digital Dynamic Simulation of Converters and DC Systems.

TOTAL: 45

REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	P.Kundur	Power System Stability and Control	McGraw-Hill	2193
2.	K.R.Padiyar	HVDC Power Transmission Systems	New Age International (P) Ltd	2002
3	V.K.Sood	HVDC and FACTS controllers – Applications of Static Converters in Power System	Kluwer Academic Publishers	2004
4	J.Arrillaga	High Voltage Direct Current Transmission	Peter Pregrinus	2183
5	Erich Uhlmann	Power Transmission by Direct Current	BS Publications	2004

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21PSC08 APPLICATION OF MEMS TECHNOLOGY

COURSE OBJECTIVES

- To teach the design and modeling of Electrostatic sensors and actuators.
- To teach the characterizing thermal sensors through design and modeling.
- To teach the characterizing actuators through design and modeling.
- To teach the fundamentals of piezoelectric sensors and actuators
- To give exposure to different MEMS and NEMS devices.

COURSE OUTCOMES.

- Develop models and simulate electrostatic and electromagnetic sensors and actuators
- Understand material properties important for MEMS system performance
- Analyze dynamics of resonant micromechanical structures.
- Understand the design process and validation for MEMS devices and systems.
- Learn the state of the art in optical micro systems.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSC08.CO1	X	X	-	-	X	-	-	-	-	X	-	X	X	-	-
21PSC08.CO2	X	X	-	X	X	-	-	-	-	X	-	X	X	X	-
21PSC08.CO3	X	X	X	X	X	-	-	-	-	X	-	X	X	X	-
21PSC08.CO4	X	X	X	X	X	-	-	-	-	X	-	-	-	X	-
21PSC08.CO5	X	X	X	X	X	-	-	-	-	X	-	X	X	X	-

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UNIT I MEMS: MICROFABRICATION, MATERIALS AND ELECTRO MECHANICAL CONEPTS 9

Overview of micro fabrication–Silicon and other material based fabrication processes– Concepts: Conductivity of semiconductors-Crystal planes and orientation-stress and strain- flexural beam bending analysis-tensional deflections-Intrinsic stress-resonant frequency and quality factor.

UNIT II ELECTROSTATIC SENSORS AND ACTUATION 9

Principle, material, design and fabrication of parallel plate capacitors as electrostatic sensors and actuators-Applications.

UNIT III THERMAL SENSING AND ACTUATION 9

Principle, material, design and fabrication of thermal couples, thermal bimorph sensors, thermal resistor sensors-Applications.

UNIT IV PIEZOELECTRIC SENSING AND ACTUATION 9

Piezoelectric effect- cantilever piezoelectric actuator model-properties of piezoelectric materials- Applications.

UNIT V CASE STUDIES 9

Piezo resistive sensors – Magnetic actuation- Micro fluidics applications- Medical applications - Optical MEMS - NEMS Devices.

TOTAL: 45

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REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	Chang Liu Robbin	Foundations of MEMS	Pearson International Edition	2006
2.	Marc Madou	Fundamentals of micro fabrication	CRC Press	2197
3.	Boston	Micro machined Transducers Source book	WCB McGraw Hill	2198
4.	M.H.Bao	Micromechanical transducers: Pressure sensors, accelerometers and gyroscopes	Elsevier , New york	2000
5.	P.Rai Choudry	MEMS and MOEMS Technology and Applications	PHI	2012

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21PSC09 DISTRIBUTED GENERATION AND MICRO GRID

COURSE OBJECTIVES

- To study various non-conventional energy resources.
- To study about various standards.
- To illustrate the concept of distributed generation.
- To analyze the impact of grid integration.
- To study concept of Micro grid and its configuration.

COURSE OUTCOMES

- Review the distributed generation and installation.
- Know about various standards.
- Design the grid integration system with conventional and non-conventional energy sources.
- Analyze the stability and power quality issues in micro grid.
- Design the dc micro grid.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSC09.CO1	-	x	x	x	-	-	-	-	-	x	-	x	-	x	-
21PSC09.CO2	x	x	x	x	-	-	-	-	-	x	-	x	-	x	-
21PSC09.CO3	-	x	x	x	-	-	-	-	-	x	-	x	-	x	-
21PSC09.CO4	x	x	x	x	-	-	-	-	-	x	-	x	-	x	-
21PSC09.CO5	-	x	x	x	-	-	-	-	-	x	-	x	-	x	-

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UNIT I INTRODUCTION 9

Conventional power generation: advantages and disadvantages-Energy crises-Non- Conventional Energy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines, biomass, and tidal sources.

UNIT II DISTRIBUTED GENERATIONS (DG) 9

Concept of distributed generations: Topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting distributed resources to electric power systems- IEEE 1547, DG installation classes-security issues in DG implementations-Energy storage elements: Batteries, ultra-capacitors-flywheels-Captive power plants.

UNIT III IMPACT OF GRID INTEGRATION 9

Requirements for grid inter connection, limits on operational parameters: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues-Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.

UNIT IV BASICS OF A MICROGRID 9

Concept and definition of micro grid, micro grid drivers and benefits, review of sources of micro grids, typical structure and configuration of a micro grid, AC and DC micro grids, Power Electronics interfaces in DC and AC micro grids.

UNIT V CONTROL AND OPERATION OF MICROGRID 9

Modes of operation and control of micro grid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques, micro grid communication infrastructure, Power quality issues in micro grids, regulatory standards, Micro grid economics, Introduction to smart micro grids

TOTAL: 45

REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	Amir Naser Yezdani and Reza Iravani	Voltage Source Converters in Power Systems: Modeling, Control and Applications	John Wiley Publications	2004
2.	Dorin Neacsu	Power Switching Converters: Medium and High Power	CRC Press	2006
3.	Chetan Singh Solanki	Solar PhotoVoltaics	PHI learning Pvt. Ltd.	2009
4.	J.F. Manwell	Wind Energy Explained, theory design and applications	PHI learning Pvt. Ltd.	2006
5.	Magdi.s , Mahmoud, Fouad M, AC.sunni	Control and optimization of distributed generation system	Springer	2015

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21PSC10 WIND ENERGY CONVERSION SYSTEMS

COURSE OBJECTIVES

- To learn about components of wind energy conversion systems.
- To design Wind turbine.
- To control Wind turbine.
- To understand the concepts of fixed speed wind energy conversion systems.
- To understand the concepts of variable speed wind energy conversion systems.

COURSE OUTCOMES

Upon completion of the course, students will be able to.

- Express the fundamentals of wind energy
- Design and control wind turbine.
- Illustrate the concepts of fixed speed wind energy conversion systems.
- Illustrate the concepts of variable speed wind energy conversion systems
- Illustrate the aerodynamics of wind turbines' energy conservation techniques.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSC10.CO1	x	x	-	-	-	-	-	-	-	x	-	x	x	-	-
21PSC10.CO2	x	x	x	x	-	-	-	-	-	x	-	x	x	x	-
21PSC10.CO3	x	x	x	x	-	-	-	-	-	x	-	x	x	x	-
21PSC10.CO4	x	x	x	x	-	-	-	-	-	x	-	x	x	x	-
21PSC10.CO5	x	x	x	x	-	-	-	-	-	x	-	x	x	x	-

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UNIT I INTRODUCTION 9

Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory- Power coefficient-Sabinin's theory-Aerodynamics of Wind turbine

UNIT II WIND TURBINES 9

HAWT-VAWT-Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations- Tip speed ratio-No. of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control- stall control-Schemes for maximum power extraction.

UNIT III FIXED SPEED SYSTEMS 9

Generating Systems- Constant speed constant frequency systems -Choice of Generators- Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model of Wind Speed- Model wind turbine rotor - Drive Train model-Generator model for Steady state and Transient stability analysis.

UNIT IV VARIABLE SPEED SYSTEMS 9

Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG- PMSG -Variable speed generators modeling- Variable speed variable frequency schemes

UNIT V GRID CONNECTED SYSTEMS 9

Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, and supply of ancillary services for frequency and voltage control, current practices and industry trends wind interconnection impact on steady-state and dynamic performance of the power system including modeling issue.

TOTAL: 45

REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	L.L.Freris	Wind Energy conversion Systems	Prentice Hall	2190
2.	S.N.Bhadra, D.Kastha, S.Banerjee	Wind Electrical Systems	Oxford University Press	2010
3.	Ion Boldea	Variable speed generators	Taylor & Francis group	2006
4.	E.W.Golding	The generation of Electricity by wind power	Redwood burn Ltd., Trowbridge	2176
5.	N. Jenkins	Wind Energy Technology	John Wiley & Sons	2197

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REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	David Lindsley	Power Plant Control & Instrumentation	IEE Publications UK	(2001)
2.	Sam G.Dukelow	The control of Boilers	Instrument Society of America	2191
3.	Elonka S.M. and Kohal A.L	Standard Boiler Operators	McGraw Hill, New Delhi	2194
4.	Doebelin	Measurement Systems	5th edition, Tata McGraw-Hill	2007
5.	P.K.Nag	Power Plant Engineering	", Tata McGraw-Hill, New Delhi	2005

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21PSC12 SMART GRID

COURSE OBJECTIVES

- To Study about Present development in Smart Grid .
- To Study about International policies in Smart Grid.
- To Study about Smart Grid technologies.
- To Study about different smart meters and advanced metering infrastructure.
- To familiarize the power quality management issues in Smart Grid.

COURSE OUTCOMES

- Review the distributed generation and installation.
- Design the grid integration system with conventional and non-conventional energy sources.
- Analyze the stability and power quality issues in microgrid.
- Design the dc micro grid.
- Review the power quality management in smart grid.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSC12.CO1	X	X	-	-	-	-	-	-	-	X	-	X	X	-	-
21PSC12.CO2	X	X	X	X	-	-	-	-	-	X	-	X	X	X	-
21PSC12.CO3	X	X	X	X	-	-	-	-	-	X	-	X	X	X	-
21PSC12.CO4	X	X	X	X	-	-	-	-	-	X	-	X	X	X	-
21PSC12.CO5	X	X	X	X	-	-	-	-	-	X	-	X	X	X	-

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION TO SMARTGRID 9

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, Concept of Resilient & Self-Healing Grid, Present development & International policies in Smart Grid, Diverse perspectives from experts and global Smart Grid initiatives.

UNIT II SMART GRID TECHNOLOGIES 9

Technology Drivers, Smart energy resources,Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/VAr control,Fault Detection, isolation and service restoration, Outage management,High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV).

UNIT III SMART METERS AND ADVANCED METERING INFRASTRUCTURE 9

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit(PMU), Intelligent Electronic Devices(IED) & their application for monitoring & protection.

UNIT IV POWER QUALITY MANAGEMENT IN SMART GRID 9

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit

UNIT V HIGH PERFORMANCE COMPUTING FOR SMART GRID 9

Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid.

TOTAL: 45

21PSC11 POWER PLANT INSTRUMENTATION AND CONTROL

COURSE OBJECTIVES

- To study the power generating stations.
- To study the basic principles of power system instrumentation and control.
- To understand the boiler operation and its control in a thermal power plant.
- To study about various power flow circuits in boiler.
- To study about setting the demand for the steam generator.

COURSE OUTCOMES

- Explain various power generating stations.
- Explain the basic principles of power system instrumentation and control.
- Illustrate the boiler operation.
- Illustrate the control of boiler in a thermal power plant.
- Determine the performance of various power plant instrumentation and control systems.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSC11.CO1	-	X	X	-	-	X	X	-	-	X	-	X	-	-	-
21PSC11.CO2	X	X	X	-	-	X	-	-	-	X	-	X	X	-	-
21PSC11.CO3	X	X	X	-	-	X	-	-	-	X	-	X	X	-	-
21PSC11.CO4	X	X	X	-	-	X	X	-	-	X	-	X	X	-	-
21PSC11.CO5	X	X	X	-	-	X	-	-	-	X	-	X	X	-	-

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UNIT I OVERVIEW OF POWER GENERATING STATIONS 9

Brief survey of different methods of conventional power generation (hydro, thermal and nuclear)-Importance of instrumentation in power generating stations.

UNIT II BASICS OF STEAM GENERATION IN THERMAL POWER PLANTS 9

Process of power generation in coal-fired and oil fired in thermal power plants-Nature of steam-Thermal efficiency-Gas turbine and combined cycle plants-Steam turbine and use-Steam turbine.

UNIT III WATER, FUEL, AIR AND FLUE GAS CIRCUITS 9

The condensate and feed water system Feed pumps and valves-The water and steam circuits in HRSC plant.

UNIT IV SETTING THE DEMAND FOR THE STEAM GENERATOR 9

Nature of the demand-Setting the demand in power stations applications-Master demand in power station applications-Load demand in combined heat and power plants-Waste to energy plants.

UNIT V BOILER CONTROL 9

The principles of compression control-Draught control-The principles of feed water control-One, two and three elements feed water control-Drum level control-Steam temperature control-Spray-water at temperature-Temperature control with tilting burners-controlling temperature of reheated steam-Gas Recycling.

TOTAL: 45

REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	Vehbi C. Güngör, DilanSahin, TaskinKocak, Salih Ergüt, Concettina Buccella, Carlo Cecati, and Gerhard P. Hancke	Smart Grid Technologies: Communication Technologies and Standards	IEEE Transactions On Industrial Informatics	2011
2.	Xi Fang, Satyajayant Misra, Guoliang Xue, and Dejun Yang	Smart Grid – The New and Improved Power Grid: A Survey	IEEE Transaction on Smart Grids	2011
3.	Stuart Borlase	Smart Grid: Infrastructure, Technology and Solutions	CRC Press	2012
4.	Janaka Ekana yake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama	Smart Grid: Technology and Applications	Wiley	2013
5.	Bernad.M.Buchholz Zbigniewnstyczynski	Smart Grid fundamentals & Technologies in Electricity networks.	Springer	2014

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21PSC13 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

COURSE OBJECTIVES

- To provide knowledge about the stand alone and grid connected renewable energy systems.
- 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 converters for renewable energy systems.
- To design different power converters namely AC to AC converters for renewable energy systems.
- To develop maximum power point tracking algorithms.

COURSE OUTCOMES

- Comprehend the world energy situation, to understand the bad effects of the present concentration use of energy
- Compute the solar radiation on the earth's surface
- Understand the concept of photovoltaic cells
- Understand the concept of cyclo converters.
- Understand the various types of wind turbines. To be able to model, analyze and design wind energy systems

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSC13.CO1	X	X	X	X	-	-	-	-	-	X	-	X	X	X	X
21PSC13.CO2	X	X	X	X	-	-	-	-	-	X	-	X	X	X	X
21PSC13.CO3	X	X	X	X	-	-	-	-	-	X	-	X	X	X	X
21PSC13.CO4	X	X	X	X	-	-	-	-	-	X	-	X	X	X	X
21PSC13.CO5	X	X	X	X	-	-	-	-	-	X	-	X	X	X	X

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UNIT I 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 ocean, Biomass, Hydrogen energy systems : operating principles and characteristics of: Solar PV, Fuel cells, wind electrical systems-control Strategy, operating area.

UNIT II ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION 9

Review of 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: 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

Standalone operation of fixed and variable speed wind energy conversion systems and solar system-Grid connection Issues -Grid integrated PMSG and 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)

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REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	S.N.Bhadra, D. Kastha, & S. Banerjee	Wind Electrical Systems	Oxford University Press	2009
2.	Rashid .M. H	power electronics Hand book	Academic press	2007
3.	Rai. G.D	Non-conventional energy sources	Khanna publishes	2193
4.	Rai. G.D	Solar energy utilization	Khanna publishes	2193
5.	Gray, L. Johnson	Wind energy system	prentice hall linc	2195

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21PSC14 REAL TIME OPERATING SYSTEM

COURSE OBJECTIVES

- To study about the different program models for embedded system programming
- To study about the inter-process communication and synchronization in embedded system
- To study about the RTOS Programming concepts
- To study about the an Embedded System by programming using RTOS µCOS-II
- To design various applications using RTOS.

COURSE OUTCOMES

- Explain the different program models for embedded system programming.
- Explain inter-process communication and synchronization in embedded System
- Explain the RTOS Programming concepts
- Design an Embedded System by programming using RTOS µCOS-II
- Design various applications using RTOS.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSC14.CO1	X	-	X	X	-	-	-	-	-	X	-	X	X	X	-
21PSC14.CO2	X	X	-	-	-	X	-	-	X	X	-	X	X	X	-
21PSC14.CO3	X	X	X	X	-	X	-	-	X	X	X	X	X	X	-
21PSC14.CO4	X	X	X	X	-	X	-	-	X	X	X	X	X	X	-
21PSC14.CO5	X	X	X	X	-	X	-	-	X	X	X	X	X	X	-

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UNIT I INTRODUCTION AND PROGRAMMING OF EMBEDDED SYSTEMS 9

Embedded system, Overview and Design process, Program modeling concepts, Polling for events model, Concurrent process model, DFG models, State machine programming model, UML modeling.

UNIT II INTER-PROCESS COMMUNICATION AND SYNCHRONIZATION 9

Multiple processes, Multiple threads, Tasks, Task state and Task data, Semaphores, Shared data, Inter-process communication, Signal, message queue and mailbox functions, Pipe, socket and RPC functions.

UNIT III REAL TIME OPERATING SYSTEMS 9

OS services- process management, Timer and event functions, Memory, device, file and I/O subsystem management, Interrupt routine in RTOS environment, Basic design using an RTOS, RTOS task scheduling models, Interrupt latency and response of tasks, OS security issues.

UNIT IV RTOS PROGRAMMING 9

Basic functions and types of RTOSes, RTOS µCOS-II- basics, Functions in µCOS-II, Embedded linux system architecture.

UNIT V DESIGN EXAMPLES WITH µcos-II 9

Automatic chocolate vending machine, Digital Camera.

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REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	Raj kamal	Embedded Systems Architecture, Programming and Design'	Tata McGraw-Hill, second edition	2010
2.	David E.Simon	An Embedded Software Primer	Pearson Education	2006
3.	C.M. Krishna, Kang, G.Shin	Real Time Systems	McGraw Hill	2197
4.	Phillip A. Laplante	Real Time Systems Design and Analysis	An Engineer's Handbook, Second Edition, PHI India	2197
5.	Jane.W.S.Liu	Real Time Systems	Prentice Hall	2000

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21PSC15 SOFT COMPUTING TECHNIQUES

COURSE OBJECTIVES

- To expose the concepts of feed forward neural networks.
- To provide adequate knowledge about feedback neural networks.
- To teach about the concept of fuzziness involved in various systems.
- To expose the ideas about genetic algorithm
- To provide adequate knowledge about FLC toolbox

COURSE OUTCOMES

- Know about soft computing techniques and their applications.
- Analyze various neural network architecture.
- Define the fuzzy systems
- Analyze the genetic algorithm and their applications.
- Get adequate knowledge about FLC toolbox.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
21PSC15.CO1	-	X	X	-	-	X	X	-	-	X	-	X	-	-	-
21PSC15.CO2	X	X	X	-	-	X	-	-	-	X	-	X	X	-	-
21PSC15.CO3	X	X	X	-	-	X	-	-	-	X	-	X	X	-	-
21PSC15.CO4	X	X	X	-	-	X	X	-	-	X	-	X	X	-	-
21PSC15.CO5	X	X	X	-	-	X	-	-	-	X	-	X	X	-	-

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UNIT I INTRODUCTION AND ARTIFICIAL NEURAL NETWORKS 9

Introduction of soft computing - soft computing vs hard computing- various types of soft computing techniques- applications of soft computing-Neuron- Nerve structure and synapse- Artificial Neuron and its model- activation functions- Neural network architecture- single layer and multilayer feed forward networks- McCulloch Pitts neuron model.

UNIT II ARTIFICIAL NEURAL NETWORKS 9

Counter propagation network- architecture- functioning & characteristics of counter- Propagation network- Hopfield/ Recurrent network- configuration- stability constraints-associative memory- and characteristics- limitations and applications

UNIT III FUZZY LOGIC SYSTEM 9

Introduction to crisp sets and fuzzy sets- basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control- Fuzzification- inferencing and defuzzification- Fuzzy knowledge and rule bases-Fuzzy modeling and control schemes for nonlinear system

UNIT IV GENETIC ALGORITHM 9

Basic concept of Genetic algorithm and detail algorithmic steps-adjustment of free Parameters- Solution of typical control problems using genetic algorithm- Concept on some other search techniques like tabu search and ant colony search techniques for solving optimization problems.

UNIT V APPLICATIONS 9

GA application to power system optimization problem- Case studies: Identification and control of linear and nonlinear dynamic systems using MATLAB

TOTAL: 45

REFERENCE BOOKS:

Sl.No	Author(s)	Title of the Book	Publisher	Year of Publication
1.	Laurene V. Fausett,	Fundamentals of Neural Networks: Architectures, Algorithms And Applications.	Pearson Education	2010
2.	Timothy J. Ross	Fuzzy Logic with Engineering Applications	Wiley	2006
3.	Zimmermann H.J	Fuzzy set theory and its Applications	Springer international edition	2011
4.	David E.Goldberg	Genetic Algorithms in Search, Optimization, and Machine Learning	Pearson Education	2009
5.	W.T.Miller, R.S.Sutton and P.J.Webrose	Real Time Systems Design and Analysis	MIT Press	2196

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