Semester I

118PST01	**SYSTEM THEORY**	**L**	**T**	**P**	**C**
		3	**1**	**0**	**4**

PREREQUISITE : Nil

COURSE OBJECTIVES

- To gain knowledge about state variable representation models.
- To understand reduction techniques and realization of transfer functions.
- To get exposed to state space design and analysis of non-linear systems..

UNIT I STATE SPACE ANALYSIS & CONTROLLABILITY, OBSERVABILITY 12

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

UNIT II TRANSFER FUNCTION AND STATE SPACE DESIGN 12

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

UNIT III NON LINEAR SYSTEMS 12

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

UNIT IV STABILITY CONCEPTS 12

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

UNIT V OPTIMAL CONTROL & ADAPTIVE CONTROL 12

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

TOTAL:60 PERIODS

COURSE OUTCOMES

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

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

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

CO3 Ability to anlayse the controllability and observability of a system.

CO4 Acquire detail knowledge on stability analysis of Linear & Non linear Continuous Time Autonomous Systems.

CO5 Acquire detail knowledge on Optimal and Adaptive Control.

TEXT BOOKS

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

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2. Gopal. M., “Modern control system Theory”, Wiley Eastern Ltd., 2nd Edition Reprint 1995.
3. Graham C., Goodwill, S.Graebe and M.Salgado, “Control System Design” Prentice Hall India, New Delhi, 2000.
4. Astrom K.J., and Wittenmark B., “Adaptive control”, Addison-Wesley Longma Publishing Co, Second Edition,1994.
5. K.Ogata, “Modern Control Engineering” Prentice Hall of India, Fifth edition, 2010

REFERENCE BOOKS

1 Brian D. O. Anderson, John Barratt Moore, “Optimal Control” Prentice Hall, 1990.
2 Stefani, Shahian, Savant &Hostetter, “Design of feedback control systems,” Oxford University Press, 2002.

COs	Programme Outcomes												Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO12	PSO1	PSO2	PSO3
CO1	2	2		2									2	2	
CO2	2	3		2									2	1	
CO3		3	2	2									1	2	1
CO4	2	2		3									2	2	
CO5	1	3	3	3	2	1	1					1	3	3	2

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118PST02	POWER SYSTEM OPTIMIZATION TECHNIQUES	L	T	P	C
		3	1	0	4

PREREQUISITE : Nil

COURSE OBJECTIVES

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

UNIT I FUNDAMENTALS OF OPTIMIZATION 12

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

UNIT II EVOLUTIONARY COMPUTATION TECHNIQUES 12

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

UNIT III PARTICLE SWARM OPTIMIZATION 12

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

UNIT IV ADVANCED OPTIMIZATION METHODS 12

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

UNIT V MULTI OBJECTIVE OPTIMIZATION 12

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

TOTAL:60 PERIODS

COURSE OUTCOMES

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

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

CO2 Will be able to know the different operation on the fuzzy sets.

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

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

CO5 Will be knowledgeable to Solve Multi Objective Optimization technique.

REFERENCE BOOKS:

1. D.P.Kothari and J.S.Dhillon, "Power System Optimization", 2nd Edition, PHI learning private limited, 2010.
2. SolimanAbdelHady,AbdelAal Hassan Mantawy, "Modern optimization techniques
3. with applications in Electric Power Systems", Springer,2012.
4. Kalyanmoy Deb, "Multi objective optimization using Evolutionary Algorithms", John Wiley and Sons, 2008.
5. Kalyanmoy Deb, "Optimization for Engineering Design",Prentice hall of India first

edition,1988.
6. Carlos A.CoelloCoello, Gary B.Lamont, David A.VanVeldhuizen, "Evolutionary Algorithms for solving Multi Objective Problems", 2nd Edition, Springer, 2007.
7. JizhongZhu,"Optimization of power system operation",John Wiley and sons Inc publication,2009.
8. KwangY.Lee,MohammedA.ElSharkawi, "Modern heuristic optimization techniques", John Wiley and Sons,2008

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

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118PST03 COMPUTER AIDED POWER SYSTEMS ANALYSIS

L	T	P	C
3	0	0	3

PREREQUISITE : Nil

COURSE OBJECTIVES

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

UNIT I INTRODUCTION 9

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

UNIT II SPARSITY ORIENTED NETWORK SOLUTION 9

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

UNIT III POWER FLOW STUDIES 9

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

UNIT IV SHORT CIRCUIT STUDIES 9

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

UNIT V STABILITY STUDIES 9

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

TOTAL:45 PERIODS

COURSE OUTCOMES

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

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

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

CO3 Learners will be able to understand the need for Power Flow Studies.

CO4 Learners will be able to understand the need for short circuit studies.

CO5 Learners will be able to explain the stability in multi machine.

REFERENCE BOOKS:

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

2 Pai M.A. Computer Techniques in Power System Analysis Tata McGrawHill,2006.
3 Brown. H.E Solution of Large Networks by Matrix Methods: John Wiley and Sons. 1975
4 Arrillaga .J and Arnold. C.P Computer Modelling of Electrical Power Systems: John Wiley and Sons,2006
5 Kusic.G.LComputer Aided Power System Analysis PHI,1989.
6 Heydt. T Computer Techniques in Power System Analysis 1996.

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

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118PST04	POWER SYSTEM ESTIMATION AND SECURITY	L	T	P	C
		3	0	0	3

PREREQUISITE : Nil

COURSE OBJECTIVES

- A review of SCADA, measurement techniques, concept of data transmission and telemetry is expected.
- An algorithm for state estimation and methods of computing the states of the system is to instilled in the needs of the students.
- The requirement of the system to be secure even during contingent condition is to be explained. Measures that the operator will have to imitate are to be highlighted. The student will be able to incorporate security procedures not only in the design of power systems but also when he attempts to build newer techniques.

UNIT I INTRODUCTION 9

Concept of power system security - factors affecting security - functions of security control - system monitoring, state estimation, security assessment and security enhancement. System Monitoring: Power system control centres: equipment and interfaces - dual computer configuration, organization and functions - SCADA system.

UNIT II DATA ACQUISITION TRANSMISSION AND TELEMETRY 9

Block diagram of a typical microprocessor based data acquisition system for power systems - analog and digital signal acquisition modules - interface -microprocessor system-software - display devices. Amplitude modulation - frequency modulation -frequency shift keying - modems - PLCC equipment.

UNIT III POWER SYSTEM STATE ESTIMATION 9

Static state estimation : Maximum likelihood weighted least squares estimation algorithm - active and reactive power bus measurements - active and reactive power line flow measurements - line current measurements - bus voltage measurements -measurement redundancy - accuracy and variance of measurements - variance of measurement residuals-detection, identification and suppression of bad measurements. Computational aspects - approximations to reduce computations - external system equivalencing -fast decoupled state estimation - state estimation using d.c. model of power system. Weighted least absolute value state estimation - comparison with WLSE. Network observability - psuedo measurements - virtual measurements. Stability and robustness of estimation algorithms- tracking state estimation : algorithm - computational aspects.

UNIT IV SECURITY ASSESSMENT 9

Classification of security states : Normal, alert, contingency, emergency and restorative modes. Network equivalent for external system. Contingency analysis :a.c., linearised a.c. and linearised d.c. models of power systems for security assessment - line outage distribution factors and generation shift factors for d.c. and linearised a.c. models - single contingency analysis using these factors - double line outage analysis techniques using bus impedance matrix and factors of bus admittance matrix. Fast contingency algorithms for nonlinear a.c. models.

UNIT V SECURITY ENHANCEMENT 9

Correcting the generator dispatch for security enhancement using linearised d.c. models - methods using sensitivity factors - compensated factors - optimisation methods-Emergency and restorative control procedures.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

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CO1 Learners will be able to understand system load variations and get an overview of power system operations.

CO2 This course gives knowledge about various system components and communication protocols of SCADA system and its applications.

CO3 Learners will be able to analyze power system security.

CO4 Learners will be exposed to power system state estimation.

CO5 Learners will be able to analyze the enhancement and assessment of power system security.

REFERENCE BOOKS

1 Wood and WollenbergPower generation, operation and control John Wiley and Sons,1996.

2 Mahalanabis, Kothari and AhsonComputer aided power system analysis and control Tata McGraw Hill,1991

3 Kusic .G.L Computer aided power system analysis Prentice Hall of India,1989.

4 Murty P.S.R Power system operation and control Tata McGraw Hill. 1984

Cos	Programme Outcomes												Programme Specific Outcomes		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	2	3	2	2	1		2					2	2	3	1
CO2	2	3	3	3	3	1	2					1	3	3	2
CO3	2	3	3	3	3	1	2					1	2	3	2
CO4	2	3	3	2	3	1	2					1	2	3	2
CO5	1	3	3	3	2	1	1					1	3	3	2

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118PST05	MATHEMATICS FOR ELECTRICAL ENGINEERS	L	T	P	C
		3	0	0	3

PREREQUISITE : Nil

COURSE OBJECTIVES

- To learn the application of linear algebra in electrical engineering problems.
- To introduce the concept of calculus of variations.
- To impart the knowledge of random variables and probability distributions occurring in natural phenomena.
- To formulate and solve the Linear Programming Problems
- To introduce Fourier Series Analysis which plays a vital role in many applications in engineering.

UNIT I MATRIX THEORY 9

The Cholesky decomposition - Generalized Eigen vectors, Canonical basis - QR factorization - Least squares method - Singular value decomposition.

UNIT II CALCULUS OF VARIATIONS 9

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

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

UNIT IV LINEAR PROGRAMMING 9

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

UNIT V FOURIER SERIES 9

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

TOTAL:45 PERIODS

COURSE OUTCOMES

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

CO1 Apply various methods in matrix theory to solve system of linear equations.

CO2 Compute maxima and minima of a functional that occur in various branches of engineering disciplines.

CO3 Imbibe the knowledge of random variables which helps to understand the various probability distributions.

CO4 Formulate and find optimal solution in the real life optimizing/allocation/assignment problems involving conditions and resource constraints.

CO5 Describe an oscillating function which appear in a veriety of physical problem by Fourier Series.

REFERENCE BOOKS

1. Richard Bronson, "Matrix Operation", Schaum"s outline series, 2nd Edition,McGraw Hill, 2011.
2. Gupta, A.S., Calculus of Variations with Applications, Prentice Hall of India Pvt. Ltd., New Delhi, 1997.

3. T.Veerarajan,"Probability, Statistics & Random Processes", Tata McGraw Hill.2013
4. Hamdy A Taha, "Operations Research – An Introduction", Pearson, 10th Edition, 2016.
5. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition Wiley India, 2016.

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

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118PSP07	COMPUTER AIDED POWER SYSTEM ANALYSIS LABORATORY –I	L	T	P	C
		0	0	4	2

PREREQUISITE : Nil

COURSE OBJECTIVES

- To have hands on experience on various system studies and different techniques used for system planning, Software Packages.
- To perform the dynamic analysis of power system.

LIST OF EXPERIMENTS

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

TOTAL:45 PERIODS

COURSE OUTCOMES

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

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

CO2 Learners will be able to perform contingency analysis & economic dispatch.

CO3 Learners will be able to simulate the variable speed wind energy system.

CO4 Learners will be able to simulate the transient stability.

CO5 Learners will be able to perform DC Load Flow Analysis.

Cos	Programme Outcomes											Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	2	1					2	3	3	2
CO2	3	3	2	3	3	2	1					2	3	3	2
CO3	2	3	3	2	2	1	1					1	2	3	1
CO4	2	3	3	2	2	1	1					1	2	3	1
CO5	1	3	3	3	2	1	1					1	3	3	2

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118PSE02	ENERGY AUDITING AND MANAGEMENT	L	T	P	C
		3	0	0	3

PREREQUISITE : Nil

COURSE OBJECTIVES

- To study the concepts behind economic analysis and load management.
- To emphasize the energy management on various electrical equipments.
- To illustrate the concept of lighting systems and cogeneration.

UNIT I ENERGY MANAGEMENT IN ELECTRIC DRIVE 9

Motors and Adjustable speed drives – high efficiency motors – rewinding electric motors – Motor drives and controls – other factors in motor system efficiency – Utility rebates for motor and drives.

UNIT II ENERGY MANAGEMENT IN ELECTRIC HEATING AND LIGHTING 9

Industrial heating – resistance heating, induction heating, arc heating, dielectric and micro wave heating – Radiant heating – cost of electrical energy – lighting – lamp life time – efficient lighting – motive power and power factor improvement – capacitor rating – siting of capacitors – effects of power factor improvement – temperature measurement – optimum start control – efficient use of electrical energy in air conditioning

UNIT III DISTRIBUTION AUTOMATION 9

Introduction – Need Based Energy Management (NBEM) – advantages – conversional distribution network – automated system – Distribution Automation System (DAS) – communication interface – PLCC – different data communication systems – distribution SCADA – distribution automation – load management in automated distribution system – RTU – substation automation – feeder automation – consumer side automation – energy audit concept – reduced line loss – power quality – differed capital expenses – energy cost reduction – optimal energy use – improved reliability.

UNIT IV DEMAND SIDE MANAGEMENT 9

Introduction – scope of demand side management (DSM) – evolution of DSM concepts – DSM planning and implementation – load management as DSM strategy – application of load control – end use of energy conversion – tariff options for DSM – customer acceptance – implementation issues – implementation strategies – DSM environment – international experience with DSM.

UNIT V ENERGY AUDIT 9

Basic principles of energy audit – definition of energy auditing – objectives – energy flow diagram – strategy of energy audit – comparison with standards – energy management team – considerations in implementing energy with conservation programmes – periodic progress review – instruments for energy audit – energy audit of electrical system – energy audit of heating, ventilation and air conditioning systems – energy audit of compressed air systems – energy audit of buildings - energy audit of steam generation, distribution and utilization systems – economic analysis - energy audit case studies.

TOTAL:45 PERIODS

COURSE OUTCOMES

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

CO1 Students will develop the ability to learn about the need for energy management and auditing process.

CO2 Students will have knowledge on the concepts of metering and factors influencing cost function. Students will understand the energy management on various electrical equipments.

CO3 Learners will learn about basic concepts of economic analysis and load management..

CO4 Students will be able to learn about the concept of lighting systems light sources and various forms of cogeneration.

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CO5 Students will be able to learn about the concept of energy Auditing.

TOTAL: 45 PERIODS

REFERENCE BOOKS

1 Gupta B.R., 'Generation of Electrical Energy', S.Chand& Co. Ltd, New Delhi, 2001.
2 Rai G.D, 'Non Conventional Energy Sources', Khanna Publishers, New Delhi, 2000.
3 Murphy W.R, McKay G., "Energy Management", Butterworths Publications, London,1982.
4 Trivedi P.R., Jolka B.R., "Energy Management", Common Wealth Publishers, New Delhi, 1997.

Cos	Programme Outcomes												Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO12	PSO1	PSO2	PSO3
CO1	2	3	3	3	2	2	2					2	3	3	2
CO2	2	3	3	3	2	2	2					2	3	3	2
CO3	2	3	3	3	2	2	2					2	3	3	2
CO4	2	2	3	3	2	2	2					2	3	3	3
CO5	1	3	3	3	2	1	1					1	3	3	2

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Semester II

		L	T	P	C
218PST01	POWER SYSTEM PLANNING AND RELIABILITY	3	0	0	3

PREREQUISITE :Transmission and Distribution & Power System Analysis and Stability

COURSE OBJECTIVES

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

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 ANLYSIS 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 placement 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 PERIODS

COURSE OUTCOMES

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

CO1 Students will develop the ability to learn about load forecasting, reliability analysis of ISO and interconnected systems.

CO2 Students will understand the concepts of Contingency analysis and Probabilistic Load flow analysis.

CO3 Students will be able to understand the concepts of Reliability analysis on Transmission system.

CO4 Students will be able to understand the concepts of Expansion planning.

CO5 Students will have knowledge on the fundamental concepts of the Distribution system planning.

REFERENCE BOOKS

1. J. Endrenyi, Reliability Modelling in Electric Power Systems, 1st edition, John Willey and Sons, US, 1978.
2. Roy Billinton and Ronald NAllen, Reliability Evaluation of Engineering Systems, 2nd edition, Springer, NewYork, 2013.
3. Charles Eebeling, An Introduction to Reliability and Maintainability Engineering,

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Tata McGraw Hill, India, 2004.

4. Generation of Electrical Energy – B.R. Gupta, S. Chand Publication.

Cos	Programme Outcomes												Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO12	PSO1	PSO2	PSO3
CO1	2	3	3	3	2	2	1					1	3	3	2
CO2	2	3	3	3	2	2	1					1	3	3	2
CO3	2	3	2	2	2	1	1					1	2	2	1
CO4	2	3	2	2	2	1	1					1	2	2	1
CO5	1	3	3	3	2	1	1					1	3	3	2

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218PST02	POWER SYSTEM DYNAMICS AND STABILITY	L	T	P	C
		3	1	0	4

PREREQUISITE : Nil

COURSE OBJECTIVES

- To impart knowledge on dynamic modeling of a synchronous machine in detail.
- To describe the modeling of excitation and speed governing system in detail.
- To understand the fundamental concepts of stability of dynamic systems and its classification.
- To understand and enhance small signal stability problem of power systems.

UNIT I SYNCHRONOUS MACHINE MODELLING 12

Synchronous Machine - Physical Description - Mathematical Description of a Synchronous Machine - Basic equations of a synchronous machine - stator circuit equations, stator self, stator mutual and stator to rotor mutual inductances -dq0 Transformation- Per Unit Representation - Equations of Motion - Swing Equation, H-constant calculation - Representation in system studies -Synchronous Machine Representation in Stability Studies - Simplified model with amortisseurs neglected: -classical model with amortisseur windings neglected

UNIT II MODELLING OF EXCITATION AND SPEED GOVERNING SYSTEMS 12

Excitation System Modeling - Excitation System Requirements - Types of Excitation System - Rotating Rectifier and Potential-source controlled-rectifier systems: hardware block diagram and IEEE(1992) Type ST1A block diagram-Turbine and Governing System Modeling: Functional Block Diagram of Power Generation and Control -Schematic of a hydroelectric plant -classical transfer function of a hydraulic turbine (no derivation) - special characteristic of hydraulic turbine - electrical analogue of hydraulic turbine-Governor for Hydraulic Turbine - Requirement for a transient droop, Block diagram of governor with transient droop compensation -Steam turbine modeling: Single reheat tandem compounded type only and IEEE block diagram for dynamic simulation; geneneric speed-governing system model for normal speed/load control function.

UNIT III SMALL SIGNAL STABILTY ANALYSIS WITH AND WITHOUT CONTROLLERS 12

Classification of Stability - Basic Concepts and Definitions: Rotor angle stability - Fundamental Concepts of Stability of Dynamic Systems: State-space representation - stability of dynamic system - Linearisation, Eigenproperties of the state matrix - eigenvalue and stability - Single-Machine Infinitie Bus (SMIB) Configuration: Classical Machine Model stability analysis with numerical example - Effect of field flux variation on system stability: analysis with numerical example-Effects Of Excitation System - analysis of effect of AVR on synchronizing and damping components using a numerical example - Multi-Machine Configuration - Equations in a common reference frame - Formation of system state matrix for a two- machine system with classical models for synchronous machines, illustration of stability analysis using a numerical example.

UNIT IV TRANSIENT STABILITY ANALYSIS 12

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

UNIT V INSTABILITY ANALYSIS 12

Small signal angle instability (sub-synchronous frequency oscillations): analysis and counter-

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measures. Transient Instability: Analysis using digital simulation and energy function method-Transient stability controller- Introduction to voltage Instability- Analysis of voltage Instability.

TOTAL:60 PERIODS

COURSE OUTCOMES

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

CO1 Learners about the modeling of Synchronous machines.

CO2 Learners about the modeling of Excitation and speed governing systems.

CO3 Analyzing the small signal stability with and without controllers.

CO4 Analyzing the transient stability of power system.

CO5 Understanding of small signal and transient instabilities.

REFERENCE BOOKS

1. P. S. Kundur, "Power System Stability and Control", McGraw-Hill, 2004.
2. K.R.Padiyar, "Power System Dynamics Stability & Control", BS Publications, Hyderabad, 2002.
3. Peter W.Sauer & M.A.Pai, "Power System Dynamics & Stability", Pearson Education, 2002.
4. P.M Anderson and A.A Fouad, "Power System Control and Stability", Iowa State University Press, Ames, Iowa, 1978
5. IEEE Committee Report, "Dynamic Models for Steam and Hydro Turbines in Power System Studies," IEEE Transactions, Vol.PAS-92, pp 1904-1915, November / December 1973.

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

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218PST03	ADVANCED POWER SYSTEM PROTECTION	L	T	P	C
		3	0	0	3

PREREQUISITE :Power System Protection

COURSE OBJECTIVES

- To illustrate concepts of static protection.
- To describe about the various schemes of static protection.
- To analyze distance and carrier protection.
- To familiarize the concepts of Busbar protection.

UNIT I INTRODUCTION TO STATIC RELAYS 9

Basic construction of static relays, Classification of protective schemes, Comparison of Static relays with electromagnetic relays, Amplitude comparator, Phase comparator, Principle of Duality. Amplitude and phase comparators (two-input): Rectifier bridge circulating and opposed Voltage type- Averaging -phase splitting type –Sampling type of amplitude Comparison. Block spike type- Phase splitting type- Transistor integrating type- Rectifier bridge type- Vector product type-Phase comparison.

UNIT II STATIC OVER CURRENT RELAYS 9

Instantaneous- Definite time – Inverse time- Directional- IDMT- Very inverse Time- Extremely inverse time over current relays. Time current characteristics of Over current relays- applications. Static Differential Relays: Differential relay scheme, single-phase static comparator, poly phase differential protection. Differential protection for generator and transformer.

UNIT III STATIC DISTANCE PROTECTION 9

Static Impedance Relay- Static reactance relay- static MHO relay-effect of arc resistance, effect of power surges, effect of line length and source impedance on performance of distance relays- selection of distance relays Pilot Relaying Schemes: Wire pilot protection - circulating current scheme- balanced voltage scheme - transley scheme-half wave comparison scheme- Carrier current protection: phase comparison type-carrier aided distance protection-operational comparison of transfer trip and blocking schemes

UNIT IV MICROPROCESSOR BASED PROTECTIVE RELAYS 9

Introduction-over current relays-Impedance relay-Directional relay-Reactance relay. Distance Relays- Mho relay – Offset Mho relay-Digital Relaying Algorithms: Various transform techniques - Discrete Fourier Transform, Walsh- Hadamard Transform, Haar Transform, microprocessor implementation of digital distance relaying algorithms – Hardware Description – Software Description

UNIT V BUSBAR PROTECTION 9

Introduction – Differential protection of busbars-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 busbar differential scheme - Supervisory relay-protection of three – Phase busbars- Numerical examples on design of high impedance busbar differential scheme.

TOTAL:45 PERIODS

COURSE OUTCOMES

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

CO1 Learners will be able to understand the various schemes available in Transformer protection.

CO2 Learners will attain basic knowledge on substation automation.

CO3 Learners will attain knowledge about Distance and Carrier protection in transmission lines.

CO4 Learners will understand the concepts of Microprocessor Based Protective Relays.

CO5 Learners will understand the concepts of Bus bar protection.

REFERENCE BOOKS

1. Y.G.Paithankar , S.R.Bhide, " Fundamentals of Power System Protection",PHI Learning Pvt. Ltd-New Delhi, 2nd Edition, 2010.
2. A.G.Phadke, J.S.Thorpe," Numerical relaying for Power Systems", John-Wiley and Sons, 1988
3. T.S.M.Rao, "Digital / Numerical Relays", Tata McGraw Hill Education,2005-
4. Badri Ram and D.N. Vishwakarma, Power system Protection and Switchgear, 2nd Edition, Tata McGraw Hill Publication Company Limited, 2013.
5. Ravindar P. Singh, "Digital Power System Protection", Prentice-Hall of Indi-a Pvt.Ltd, 2007.
6. L.P.Singh, " Digital protection, Protective Relaying from Electromechanical to Microprocessor", New Age International Publishers, Second Edition, 1997
7. T.S. Madhava Rao, Power system Protection Static Relays with Microprocessor Applications, 2nd Edition, TataMcGraw Hill Publishing Company Limited, 2001.

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

218PST04	DISTRIBUTED GENERATION AND MICROGRID	L	T	P	C
		3	0	0	3

PREREQUISITE : Nil

COURSE OBJECTIVES

- To illustrate the concept of distributed generation.
- To analyze the impact of grid integration.
- To study concept of Microgrid and its configuration.
- To analyze control and protection of microgird.

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** 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 interconnection, limits on operational parameters,: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with non conventional energy sources on existing power system: reliability, stability and power quality issues.

UNIT IV **BASICS OF MICROGRID** 9

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

UNIT V **CONTROL AND OPERATION OF MICROGRID** 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1 Attaining knowledge on the various scheme of conventional and non conventional power generation.

CO2 Learning about energy sources of distributed generation.

CO3 Learning about the fundamental concept of Microgrid and the requirements for grid interconnection.

CO4 Understanding protection issues and control schemes.

CO5 Understanding the operation of MicroGrid.

REFERENCE BOOKS

1. 2. John Twidell and Tony Weir, "Renewable Energy Resources" Tyalor and Francis Publications, Second edition 2006

3. 4. D. D. Hall and R. P. Grover, "Biomass Regenerable Energy", John Wiley, New York,1987.

5. 6. J.F. Manwell, J.G. McGowan "Wind Energy Explained, theory design and applications", Wiley publication 2010.

7. 8. DorinNeacsu, "Power Switching Converters: Medium and High Power", CRC Press,

9. 10. Taylor & Francis, 2006

11. 12. S. Chowdhury, S.P. Chowdhury and P. Crossley Microgrids and Active Distribution Networks,2009.

13. 14. Chetan Singh Solanki, "Solar Photo Voltaics", PHI learning Pvt. Ltd., New Delhi,2009

COs	Programme Outcomes												Programme Specific Outcomes		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	2	3	2	2	2	1	1					1	2	2	1
CO2	2	3	2	2	2	1	1					1	2	2	1
CO3	2	3	3	2	2	1	1					1	2	2	1
CO4	2	3	3	2	2	1	1					1	2	2	1
CO5	1	3	3	3	2	1	1					1	3	3	2

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218PSP07 SEMINAR

L	T	P	C
0	0	2	0

OBJECTIVES

To enable the students to do a project involving some design and fabrication work.

Every project work shall have a Guide who is a member of the faculty. Four periods per week shall be allotted in the time table for this important activity and this timeshall be utilized by the students to receive directions from the Guide, on library reading, laboratory work, computer analysis, or field work as assigned by the Guide and also to present in periodical seminars or viva to review the progress made in the mini project.

Each student shall finally produce a comprehensive report covering background information, literature– survey, problem statement, project work details, estimation of cost and conclusions. This final report shall be in type written form as specified in the guidelines.

The continuous assessment and semester evaluation is to be carried out as specified in theguidelines to be issued from time to time.

TOTAL:45 PERIODS

COURSE OUTCOMES

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

CO1 Identify real time problems.

CO2 Aware of design methodologies & its implementation.

CO3 Implement advance simulation software techniques.

CO4 Produce a comprehensive report covering background information, literature survey.

CO5 Produce a comprehensive report covering problem statement, project work details and conclusion.

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218PSP08	ADVANCED POWER SYSTEM SIMULATION LABORATORY	L	T	P	C
		0	0	4	2

PREREQUISITE : Power System Simulation Lab

COURSE OBJECTIVES

- To analyze the effect of FACTS controller by performing steady state analysis.
- To have hands on experience on different wind energy conversion technologies.

LIST OF EXPERIMENTS

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. Simulation of variable speed wind energy conversion system- DFIG
8. Simulation 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:60 PERIODS

COURSE OUTCOMES

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

CO1 Students are able to gain Hands on experience on various power systems dynamic studies using own program and validation of results using software packages.

CO2 Learners will be able to perform load flow analysis and transient analysis

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

CO4 Learners will be able to design the filter for mitigating harmonics.

CO5 Learners will be able to Calculate the Transfer Capability of Transmission line using Load Flow Program.

Cos	Programme Outcomes												Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO12	PSO1	PSO2	PSO3
CO1	2	3	3	3	3	2	2					2	3	3	2
CO2	2	3	3	3	3	2	2					2	3	3	2
CO3	2	3	3	3	3	2	2					2	3	3	2
CO4	2	3	3	2	2	2	2					2	3	3	1
CO5	1	3	3	3	2	1	1					1	3	3	2

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PROFESSIONAL ELECTIVE-II

218PSE01	POWER QUALITY MANAGEMENT	L	T	P	C
		3	0	0	3

PREREQUISITE : Nil

COURSE OBJECTIVES

- To understand the various power quality issues.
- To understand the concept of power and power factor in single phase and three phase systems supplying non linear loads.
- To understand the conventional compensation techniques used for power factor correction and load voltage regulation.
- To understand the active compensation techniques used for power factor correction.
- To understand the active compensation techniques used for load voltage regulation.

UNIT I INTRODUCTION 9

Definitions – Power quality, Voltage quality – Power quality issues : Short duration voltage variations, Long duration voltage variations, Transients, Waveform distortion, Voltage imbalance, Voltage fluctuation, Power frequency variations, low power factor – Sources and Effects of power quality problems – Power quality terms – Power quality and Electro Magnetic Compatibility (EMC) Standards.

UNIT II SHORT INTERRUPTIONS & LONG INTERRUPTIONS 9

Introduction – Origin of short interruptions : Voltage magnitude events due to re-closing Voltage during the interruption – Monitoring of short interruptions –Influence on inductio motors, Synchronous motors, Adjustable speed drives, Electronic equipments – Single phas tripping : Voltage during fault and post fault period, Current during fault period – Prediction o short Interruptions. Definition – Failure, Outage, Interruption – Origin of interruptions – Cause of long interruptions – Principles of regulating the voltage – Voltage regulating devices, Applications Utility side, End-User side –Reliability evaluation – Cost of interruptions.

UNIT III VOLTAGE SAG & TRANSIENTS 9

Introduction – Definition – Magnitude, Duration – Causes of Voltage Sag – Three Phase Unbalance – Phase angle jumps – Load influence on voltage sags on Adjustable speed drives, Power electronics loads, Sensitive loads - Stochastic assessment of voltage sags - Overview of mitigation methods. Definition – Power system transient model – Principles of over voltage protection - Types and causes of transients – Devices for over voltage protection - Capacitor switching transients –Lightning transients – Transients from load switching.

UNIT IV WAVEFORM DISTORTION WIRING AND GROUNDING 9

Introduction – Definition and terms – Harmonics, Harmonics indices, Inter harmonics, Notching – Voltage Vs Current distortion – Harmonics Vs Transients – Sources and effects of harmonic distortion – System response characteristics – Principles of controlling harmonics – Standards and limitation - Definitions and terms – Reasons for grounding –National Electrical Code (NEC) grounding requirements – Utility Power system grounding –End-User power system grounding – Wiring and grounding problems.

UNIT V POWER QUALITY SOLUTIONS 9

Introduction – Power quality monitoring : Need for power quality monitoring, Evolution of power quality monitoring, Deregulation effect on power quality monitoring – Power factor improvement – Brief introduction to power quality measurement equipments and power conditioning equipments – Planning, Conducting and Analyzing power quality survey – Mitigation and control techniques - Active Filters for Harmonic Reduction

TOTAL:45 PERIODS

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COURSE OUTCOMES

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

CO1 To study various methods of power quality monitoring and the production of voltages sags.

CO2 To study the interruptions types and its influence in various components.

CO3 To study the effects of harmonics on various equipments.

CO4 Understand power quality monitoring and classification techniques.

CO5 Understanding the concepts of Waveform Distortion in Wiring and grounding.

REFERENCE BOOKS

1 Roger C.Dugan, Mark F. McGranaghan andH.WayneBeaty, "Electrical Power Systems Quality", McGraw-Hill, New York, 2nd Edition, 2002.

2 Barry W.Kennedy, "Power Quality Primer", McGraw-Hill, New York, 2000.

3 Sankaran.C, "Power Quality", CRC Press, Washington, D.C., 2002

4 Math H.J.Bollen, "Understanding Power Quality Problems: Voltage Sags and Interruptions", IEEE Press, New York, 2000.

5 Arrillaga.J, Watson.N.R and Chen.S, "Power System Quality Assessment", John Wiley & Sons Ltd., England, 2000

6 Short.T.A., "Distribution Reliability and Power Quality", CRC Press Taylor and Francis Group, 2006.

Cos	Programme Outcomes											Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO12	PSO1	PSO2	PSO3
CO1	1	3	2	2	1	1	1					1	2	2	1
CO2	1	3	3	3	2	1	1					1	3	3	2
CO3	1	3	3	3	2	1	1					1	3	3	2
CO4	1	3	2	2	1	1	1					1	2	2	1
CO5	1	3	3	3	2	1	1					1	3	3	2

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218PSE08	POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS	L	T	P	C
		3	0	0	3

PREREQUISITE :Power Electronics

COURSE OBJECTIVES

- To provide knowledge about the stand alone and grid connected renewable energy systems.
- To equip with required skills to derive the criteria for the design of power converters for renewable energy applications.
- To design different power converters namely AC to DC, DC to DC and AC to AC converters for renewable energy systems.
- To analyze and comprehend the various operating modes of wind electrical generators and solar energy systems.
- To develop maximum power point tracking algorithms.

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: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems.

UNIT II ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION 9

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

UNIT III POWER CONVERTERS 9

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

UNIT IV ANALYSIS OF WIND AND PV SYSTEMS 9

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

UNIT V HYBRID RENEWABLE ENERGY SYSTEMS 9

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

TOTAL:45 PERIODS

COURSE OUTCOMES

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

CO1	Knowledge about the stand alone and grid connected renewable energy systems.
CO2	Equip with required skills to derive the criteria for the design of power converters for renewable energy applications.
CO3	Design different power converters namely AC to DC, DC to DC and AC to AC converters for renewable energy systems.
CO4	Analyze and comprehend the various operating modes of wind electrical generators and solar energy systems.
CO5	Develop maximum power point tracking algorithms.

REFERENCES BOOKS

1. S. N. Bhadra, D.Kastha, S.Banerjee, "Wind Electrical Systems", Oxford UniversityPress, 2005.

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

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

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Semester III

		L	T	P	C
318PST01	**EHV POWER TRANSMISSIONS**	3	1	0	4

PREREQUISITE :Nil

COURSE OBJECTIVES

- To learn the basic knowledge of Transmission Lines and Equipment.
- To understand the line parameters calculation.
- To learn the voltage gradients of conductors.
- Analyzed the corona effects and design the filters.
- To understand the electrostatic field of EHV lines.

UNIT I INTRODUCTION **12**

Standard Transmission Voltages – Average Values of Line Parameters – Power Handling Capacity and Line Loss – Costs of Transmission Lines and Equipment – Mechanical Considerations in Line Performance.

UNIT II CALCULATION OF LINE PARAMETERS **12**

Calculation of Resistance, Inductance and Capacitance – Calculation of sequence inductances and capacitances – Line parameters for Modes of propagation.

UNIT III VOLTAGE GRADIENTS OF CONDUCTORS **12**

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

UNIT IV CORONA EFFECTS **12**

Power losses and audible losses : I^2R Loss and Corona Loss -Attenuation of Traveling Waves Due to Corona Loss - Audible Noise Generation and Characteristics - Limits for Audible Noise - Day-Night Equivalent Noise Level. Radio Interference : corona pulse generation and properties - Limits for Radio Interference Fields - The CIGRE Formula - The RI Excitation Function -Measurement of RI, RIV and Excitation Function - Design of Filter.

UNIT V ELECTROSTATIC FIELD OF EHV LINES **12**

Capacitance of Long Object - Calculation of Electrostatic Field of AC Lines Effect of High Field on Humans, Animals, and Plants - Meters and Measurement of Electrostatic Fields - Electrostatic Induction in Unenergised Circuit of a D/C Line - Induced Voltages in Insulated Ground Wires - Electromagnetic Interference.

TOTAL:60 PERIODS

COURSE OUTCOMES

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

CO1 Gain knowledge in the fundamental concept of transmission line and its parameters.
CO2 Extrapolate the knowledge of calculate the line parameters of RLC.
CO3 Familiar in voltage gradients of conductors in high voltage engineering.
CO4 Gain the knowledge of corona effects in power systems.
CO5 Gain the knowledge of electrostatic field of EHV lines.

REFERENCE BOOKS

1. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", New Age International Pvt. Ltd., 1990, Second Edition.
2. TuranGonen: Electric Power Transmission System Engineering Analysis and Design, McGraw Hill.
3. A Chakraborti, D.P. Kothari and A.K. Mukhopadyay: Performance, Operation and Control of EHV Power Transmission Systems, T.M.H, 1999.

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COs	Programme Outcomes												Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO12	PSO1	PSO2	PSO3
CO1	2	3	3	3	3	2	2					2	3	3	2
CO2	2	3	3	3	3	2	2					2	3	3	2
CO3	2	3	3	3	3	2	2					2	3	3	2
CO4	2	3	3	2	2	2	2					2	3	3	1
CO5	2	3	3	2	2	2	2					2	3	3	1

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318PSP01	PROJECT WORK (PHASE I)	L	T	P	C
		0	0	12	6

OBJECTIVES

To enable the students to do a project involving some design and fabrication work.

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The continuous assessment and semester evaluation is to be carried out as specified in theguidelines to be issued from time to time.

TOTAL:45 PERIODS

COURSE OUTCOMES

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

CO1 Identification of real time problems.
CO2 Knowledge about new technologies.
CO3 Awareness of design methodologies and its implementation.
CO4 Implementing advanced simulation software techniques.
CO5 Able to produce a comprehensive report covering background information, literature survey,problem statement, project work details and conclusion.

COs	Programme Outcomes												Programme Specific Outcomes		
	PO1	PO 2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO1 0	PO 11	PO1 2	PSO1	PSO2	PSO3
CO1							2								
CO2										2		2	3	2	
CO3						3									
CO4								2							2
CO5								2							2

PROFESSIONAL ELECTIVE-IV

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318PSE03	SMART GRID DESIGN AND ANALYSIS	L	T	P	C
		3	0	0	3

PREREQUISITE : Power system analysis and design, Renewable energy sources

COURSE OBJECTIVES

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

UNIT I INTRODUCTION 9

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

UNIT II DC DISTRIBUTIONAND SMART GRID 9

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

UNIT III DYNAMIC ENERGY SYSTEMS CONCEPT 9

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

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

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

UNIT V EFFICIENT ELECTRIC END- USE TECHNOLOGY ALTERNATIVES 9

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

TOTAL:45 PERIODS

COURSE OUTCOMES

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

CO1 Acquired the knowledge about the basis of smart grid.
CO2 Attained the idea about working of DC distribution.
CO3 Gained the acquaintance of energy system dynamics.
CO4 Gained the knowledge about the real time implementation of smart grid.

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CO5 Gained the innovative idea about end use technologies of electric end.

TOTAL: 45 PERIODS

REFERENCE BOOKS

1 Clark W Gellings, "The Smart Grid, Enabling Energy Efficiency and Demand Side Response"- CRC Press, 2009.

2 Janaka Ekanayake, Kithsiri Liyanage, Jianzhong.Wu, Akihiko Yokoyama, Nick Jenkins, "Smart Grid: Technology and Applications"- Wiley, 2012.

3 James Momoh, "Smart Grid: Fundamentals of Design and Analysis"- Wiley, IEEE Press, 2012

4 Jhon wiley & Sons Inc, Hoboken, New Jersey "Energy Processing in Smart Grid" IEEE Press, 2018.

COs	Programme Outcomes												Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO12	PSO1	PSO2	PSO3
CO1	1	3	3	3	3	2	2					2	2	2	2
CO2	1	2	2	2	2	1	1					1	2	2	1
CO3	1	3	3	3	3	2	2					2	2	2	2
CO4	1	3	3	3	3	2	2					2	2	2	2
CO5	1	3	3	3	3	2	2					2	2	2	2

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PROFESSIONAL ELECTIVE V

318PSE05	POWER SYSTEM INSTRUMENTATION	L	T	P	C
		3	0	0	3

PREREQUISITE :Nil

COURSE OBJECTIVES

- To study about power system instrumentation, different meters and advanced energy storage methods.
- To study about fiber optics transmission lines and instrumentation scheme used for high power transmissions.
- To familiarize the power measurement techniques in different ways.
- To analyze the functions of SCADA system.
- To familiarize the high performance computing in power measurements.

UNIT I POWER GENERATION INSTURMENTS 9

Review of Mechanical, Electrical, Electronics, Thermal, Optical, Pneumatic, fluidics Instruments-Power generating Station – Thermal, Hydel, Nuclear, Wind – Their functional characteristics as processes, Components of power Grid – interdependency between different blocks

UNIT II TRANSMISSION LINES 9

Fibre optics metering measurement: Fiber optics high voltage measurement - Fiber optics high current measurement- Transmission line sag measurement ordinary method, Transmission line sag measurement using triangulation technique.

UNIT III POWER TARIFF 9

Different tariff principles, Consumer tariff structures and considerations, different consumer categories, telescopic tariff, fixed and variable charges, time of day, interruptible tariff, different tariff based penalties and incentivessingle phase energy meter, three phase energy meter, Digital energy meter. Remote terminal unit (RTU).

UNIT IV LOCAL DISPATCH CENTRE 9

Data handling – Processing, Logging, Acquisition, A counting, Display and Storage, SCADA, Techniques of Data acquisition at Central Load Dispatch Centers for coordinated control of the grid

UNIT V COMPUTER CONTROL IN POWER PLANT 9

Introduction, load dispatching computer, generation station computer, mini computers, and supervisory control Application and Relevancy of IS specification in perspective of power system instrumentation

TOTAL:45 PERIODS

COURSE OUTCOMES

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

CO1 Use power system instrument for automatic generation and voltage control in power generation station.

CO2 Able to use signal transmission techniques for specific power system purposes.

CO3 Identify instrumentation schemes for monitoring and control.

CO4 Apply signal transmission techniques for sharing process information.

CO5 Understand the concepts of standard soft control techniques in power system.

REFERENCES BOOKS

1. Jarvis, E.W., "Modern Power Station Practice: Control and Instrumentation (Vol. F)", British Electricity International (1980).
2. Principles of Industrial Instrumentation - D Patranabish, TMH, New Delhi
3. Chakrabarti, A., Soni, M.L., Gupta, P.V. and Bhavnagar , U.S., A Text Book on Power

System Engineering, Dhanpat Rai and Co. (P) Ltd. (2008).
4. Lindsley, D.M. , Power Plant Control and Instrumentation, IEE Press (2000).
5. Liptak, B.G., Instrument Engineers Handbook, Butterworth, Heinemann (2002) 3rd ed.

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

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Semester IV

418PSP01 PROJECT WORK (PHASE II)

L	T	P	C
0	0	12	10

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CO1	2	3	3	3	3	2	3	1	1	1	2	2	3	3	2
CO2	2	3	3	3	3	2	3	1	1	1	2	2	3	3	2
CO3	2	3	3	3	3	2	3	1	1	1	2	2	3	3	2
CO4	2	3	3	3	3	2	3	1	2	2	3	2	3	3	2
CO5	2	3	3	3	3	2	3	1	1	1	2	2	3	3	2

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