ADHIYAMAAN COLLEGE OF ENGINEERING

[An Autonomous Institution Affiliated to Anna University, Chennai]
[Accredited by NAAC]
Dr.M.G.R NAGAR, HOSUR, KRISHNAGIRI (DT) – 635 130, TAMILNADU, INDIA

REGULATIONS 2018

CHOICE BASED CREDIT SYSTEM

M.E - POWER SYSTEMS ENGINEERING

VISION

The department of electrical and electronics engineering is focused to produce highly competent electrical engineers by imparting effective teaching learning process to meet the rapidly changing technical scenario.

MISSION

- To produce world class electrical engineers with advanced professional knowledge, critical problem solving and analytical skills through effective teaching, research and industrial collaboration.

- To equip students with skills in the areas of interpersonal communication, ethics, team work and project management.

The Programme defines Programme Educational Objectives, Programme Outcomes and Programme Specific Outcomes as follows:

I. PROGRAMME EDUCATIONAL OBJECTIVES [PEOs]

PEO 1 Our Post Graduates will excel in industry and in higher studies by learning the Engineering Sciences with more emphasis in Power Systems Engineering along with high moral values.

PEO 2 Our Post Graduates will have good scientific and engineering expertise so as to comprehend, to analyze, to design and to create innovative products and solutions for the challenges of multi-disciplinary fields.

PEO 3 Our Post Graduates will exhibit professional and ethical attitude, effective communication skills, teamwork skills, leadership skills, life-long learning, entrepreneurial thinking, global competency and an ability to transform engineering solutions into broader social context.

II. PROGRAMME OUTCOMES [POs]

PO1 An ability to exhibit the knowledge of science, mathematics, communication and programming skills.

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PO2	An ability to identify, formulate and analytically solve electrical engineering problems.
PO3	Demonstrate their ability in designing analog and digital systems and develop products and solutions.
PO4	An ability to investigate the complex problems in research and industry.
PO5	Build the capability to use all current and future modern tools to analyze problems in global contexts.
PO6	An ability to exhibit the knowledge to assess societal, health, safety, legal and cultural issues and the relevant responsibilities to the professional engineering practice.
PO7	An ability to design electrical systems those are efficient, within realistic context such as economic, environmental, social, political, manufacturability and sustainability.
PO8	Ability to impart holistic professional and ethical values.
PO9	To function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings.
PO10	An ability to listen and communicate effectively in verbal and written form.
PO11	Ability to exhibit quality managerial skills in finance, economics and project management.
PO12	Competent enough for self-study and for life-long learning in the broadest context of rapid technological changes.

III. PROGRAM SPECIFIC OUTCOMES [PSOs]

PSO1 **Skilled Professional in Power Systems Engineering:**
Ability to identify, formulate and solve real time problems by applying the knowledge acquired during the course of the program.

PSO2 **Problem Solving Skills:**
Ability to understand the recent technological developments in Power Systems Engineering and to develop products/software to cater the societal & Industrial needs.

PSO3 **Successful Career:**
Ability to utilize the modern technologies in building innovative career paths for being a thriving entrepreneur and to have a successful career.

Correlation of PEOs with POs and PSOs

Program Educational Objectives (PEOs)	Program Outcomes(POs)												Program Specific Outcomes (PSOs)		
	a	b	c	d	e	f	g	h	i	j	k	l	1	2	3
PEO I	√	√	√	√	√		√				√	√	√	√	√
PEO II	√	√	√	√	√	√	√		√	√		√	√		√
PEO III						√	√	√	√	√	√	√			√

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PROGRAM ARTICULATION MATRIX

M.E-POWER SYSTEMS ENGINEERING

YEAR	SEMESTER	COURSE NAME	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	System Theory	2	3	3	2	2	1	1					1	2	2	2
1	1	Power System Optimization Techniques	2	3	3	3	2	1	2					1	3	3	2
1	1	Computer Aided Power System Analysis	2	3	3	3	2	1	2					1	3	3	2
1	1	Power System Estimation and Security	2	3	3	3	2	1	2					1	2	3	2
1	1	Mathematics for Electrical Engineers	3	3	2	2	1							2	2	2	
1	1	Professional Elective I															
1	1	Computer Aided Power System Analysis	2	3	3	3	2	1	1					1	3	3	2

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		Laboratory															
1	**2**	Power System Planning and Reliability	2	3	3	3	2	1	1					1	3	3	2
1	**2**	Power System Dynamics and Stability	2	3	3	3	2	2	1					1	2	2	1
1	**2**	Advanced Power System Protection	1	3	3	3	3	2	1					1	3	3	2
1	**2**	Distributed Generation and Micro Grid	2	3	3	2	2	1	1					1	2	2	1
1	**2**	Professional Elective – II															
1	**2**	Professional Elective – III															
1	**2**	Advanced Power System Simulation Laboratory	2	3	3	3	3	2	2					2	3	3	2
1	**2**	Seminar															

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2	**3**	EHV Power Transmission	2	3	3	3	3	2	2					2	3	3	2
2	**3**	Professional Elective – IV															
2	**3**	Professional Elective – V															
2	**3**	Project Work Phase- I						3	2	2		2		2	3	2	2
2	**4**	Project Work Phase-II	2	3	3	3	3	2	3	1	1	1	2	2	3	3	2

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Semester I

S. NO	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	118PST01	System Theory	PC	3	1	0	4	4
2.	118PST02	Power System Optimization Techniques	PC	3	1	0	4	4
3.	118PST03	Computer Aided Power System Analysis	PC	3	0	0	3	3
4.	118PST04	Power System Estimation and Security	PC	3	0	0	3	3
5.	118PST05	Mathematics for Electrical Engineers	FC	3	0	0	3	3
6.	118PSEXX	PROFESSIONAL ELECTIVE-I	PE	3	0	0	3	3
PRACTICAL								
7.	118PSP01	Computer Aided Power System Analysis Laboratory	PC	0	0	4	4	2
			TOTAL	**18**	**2**	**4**	**24**	**22**

PROFESSIONAL ELECTIVE I

S. NO	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	118PSE01	Wind and Solar Energy Systems	PE	3	0	0	**3**	**3**
2.	118PSE02	Energy Auditing and Management	PE	3	0	0	**3**	**3**
3.	118PSE03	Industrial Power System Analysis and Design	PE	3	0	0	**3**	**3**
4.	118PSE04	Electric And Hybrid Vehicles	PE	3	0	0	**3**	**3**

Semester II

S. NO	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	218PST01	Power System Planning and Reliability	PC	3	0	0	3	3
2.	218PST02	Power System Dynamics and Stability	PC	3	1	0	4	4
3.	218PST03	Advanced Power System Protection	PC	3	0	0	3	3
4.	218PST04	Distributed Generation and Micro Grid	PC	3	0	0	3	3

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Adhiyamaan College of Engineering (Autonomous)
Dr. M.G.R. Nagar, HOSUR - 635130

5.	218PSEXX	Professional Elective-II	PE	3	0	0	3	3
6.	218PSEXX	Professional Elective-III	PE	3	0	0	3	3
PRACTICAL								
7.	218PSP07	Seminar	EEC	0	0	2	2	0
8.	218PSP08	Advanced Power System Simulation Laboratory	PC	0	0	4	4	2
			TOTAL	**18**	**1**	**6**	**25**	**21**

PROFESSIONAL ELECTIVE II

S. NO	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	118PSE01	Wind and Solar Energy Systems	PE	3	0	0	3	3
2.	118PSE02	Energy Auditing and Management	PE	3	0	0	3	3
3.	118PSE03	Industrial Power System Analysis and Design	PE	3	0	0	3	3
4.	118PSE04	Electric And Hybrid Vehicles	PE	3	0	0	3	3

PROFESSIONAL ELECTIVE III

S. NO	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	218PSE05	Demand Side Energy Management	PE	3	0	0	**3**	**3**
2.	218PSE06	HVDC and FACTS Controllers	PE	3	0	0	**3**	**3**
3.	218PSE07	Electromagnetic Interference and capability	PE	3	0	0	**3**	**3**
4.	218PSE08	Power Electronics for Renewable Energy Systems	PE	3	0	0	**3**	**3**

Semester III

S. NO	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								

PRINCIPAL
Adhiyamaan College of Engineering (Autonomous)
Dr. M.G.R. Nagar, HOSUR - 635130

1.	318PST01	EHV Power Transmission	PC	3	1	0	4	4
2.	318PSEXX	PROFESSIONAL ELECTIVE-IV	PE	3	0	0	3	3
3.	318PSEXX	PROFESSIONAL ELECTIVE-V	PE	3	0	0	3	3
PRACTICAL								
4.	318PSP01	Project Work (Phase –1)	EEC	0	0	12	12	6
			TOTAL	**9**	**1**	**12**	**22**	**16**

PROFESSIONAL ELECTIVE IV

S. NO	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	318PSE01	Restructured Power System	PE	3	0	0	**3**	**3**
2.	318PSE02	Power System Deregulation	PE	3	0	0	**3**	**3**
3.	318PSE03	Smart Grid Design and Analysis	PE	3	0	0	**3**	**3**
4.	318PSE04	Insulation Technology and High Voltage Engineering	PE	3	0	0	**3**	**3**

PROFESSIONAL ELECTIVE V

S. NO	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	318PSE05	Power System Instrumentation	PE	3	0	0	**3**	**3**
2.	318PSE06	Design of Controllers in Power Application	PE	3	0	0	**3**	**3**
3.	318PSE07	Artificial Neural Networks Applied to Power Systems	PE	3	0	0	**3**	**3**
4.	318PSE08	Analysis of Electrical Machines	PE	3	0	0	**3**	**3**

Semester IV

S. NO	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	418PSP01	Project Work (Phase –II)	EEC	0	0	20	**20**	10
			TOTAL	**0**	**0**	**20**	**20**	**10**

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Dr. M.G.R. Nagar, HOSUR - 635130

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CBCS – PG CURRICULUM

NAME OF THE PG PROGRAMME: POWER SYSTEMS ENGINEERING

FOUNDATION COURSES (FC)							
SL.No.	**Course Code**	**Course Title**	**Hrs / Wk& Credits**				**Preferred Semester**
			L	**T**	**P**	**C**	
1	118PST05	Mathematics for Electrical Engineers	3	0	0	3	1

PROFESSIONAL CORE (PC)							
SL.No.	**Course Code**	**Course Title**	**Hrs / Wk& Credits**				**Preferred Semester**
			L	**T**	**P**	**C**	
1.	118PST01	System Theory	3	1	0	4	1
2.	118PST02	Power System Optimization Techniques	3	1	0	4	1
3.	118PST03	Computer Aided Power System Analysis	3	0	0	3	1
4.	118PST04	Power System Estimation and Security	3	0	0	3	1
5.	118PSP01	Computer Aided Power System analysis Laboratory	0	0	4	2	1
6.	218PST01	Power System Planning and Reliability	3	0	0	3	2
7.	218PST02	Power System Dynamics and Stability	3	1	0	4	2
8.	218PST03	Advanced Power System Protection	3	0	0	3	2
9.	218PST04	Distributed Generation and Micro Grid	3	0	0	3	2
10.	218PSP02	Advanced Power System Simulation Laboratory	0	0	4	2	2
11.	318PST01	EHV Power Transmission	3	1	0	4	3

PROFESSIONAL ELECTIVES (PE)							
SL.No.	**Course Code**	**Course Title**	**Hrs / Wk& Credits**				**Preferred Semester**
			L	**T**	**P**	**C**	
1	118PSE01	Wind and Solar Energy Systems	3	0	0	3	1
2	118PSE02	Energy Auditing and Management	3	0	0	3	1
3	118PSE03	Industrial Power System Analysis and Design	3	0	0	3	1
4	118PSE04	Electric and Hybrid Vehicles	3	0	0	3	1
5	218PSE01	Power Quality Management	3	0	0	3	2
6	218PSE02	Reactive Power Compensation and Management	3	0	0	3	2
7	218PSE03	Power System Economics and Control	3	0	0	3	2
8	218PSE04	Electrical Transients in Power Systems	3	0	0	3	2
9	218PSE05	Demand Side Energy Management	3	0	0	3	2
10	218PSE06	HVDC and FACTS Controllers	3	0	0	3	2
11	218PSE07	Electromagnetic Interference and capability	3	0	0	3	2
12	218PSE08	Power Electronics for Renewable Energy Systems	3	0	0	3	2

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Dr. M.G.R. Nagar, HOSUR - 635130

13	318PSE01	Restructured Power System	3	0	0	3	3
14	318PSE02	Power System deregulation	3	0	0	3	3
15	318PSE03	Smart Grid Design and Analysis	3	0	0	3	3
16	318PSE04	Insulation Technology and High Voltage Engineering	3	0	0	3	3
17	318PSE05	Power System Instrumentation	3	0	0	3	3
18	318PSE06	Design of Controllers in Power Application	3	0	0	3	3
19	318PSE07	Artificial Neural Networks Applied to Power Systems	3	0	0	3	3
20	318PSE08	Analysis of Electrical Machines	3	0	0	3	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)							
SL.No.	**Course Code**	**Course Title**	**Hrs / Wk& Credits**				**Preferred Semester**
			L	**T**	**P**	**C**	
1	218PSP01	Seminar	0	0	2	0	2
2	318PSP01	Project Work (Phase – I)	0	0	12	6	3
3	418PSP01	Project Work (Phase - II)	0	0	20	10	4

SUMMARY

S.No.	**Subject Area**	**Credits as per Semester**				**Credits Total**
		I	**II**	**III**	**IV**	
1	**FC**	3	-	-	-	**3**
2	**PC**	16	15	4	-	**35**
3	**PE**	3	6	6	-	**15**
4	**EEC**	-	0	6	10	**16**
	Total	**22**	**21**	**16**	**10**	**69**

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Dr. M.G.R. Nagar, HOSUR - 635130

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.

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

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

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Dr. M.G.R. Nagar, HOSUR - 635130

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

118PST03	COMPUTER AIDED POWER SYSTEMS ANALYSIS	L	T	P	C
		3	0	0	3

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Dr. M.G.R. Nagar, HOSUR - 635130

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	PO 5	PO6	PO7	PO8	PO9	PO1 0	PO 11	PO1 2	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

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:

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

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

PREREQUISITE : Nil

COURSE OBJECTIVES

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- 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.

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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	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	

		L	T	P	C
118PSP07	**COMPUTER AIDED POWER SYSTEM ANALYSIS LABORATORY –I**	**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.

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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	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

PROFESSIONAL ELECTIVE I

		L	T	P	C
118PSE01	**WIND AND SOLAR ENERGY SYSTEMS**	**3**	**0**	**0**	**3**

PREREQUISITE : Nil

COURSE OBJECTIVES

- To educate the students scientifically the new developments in wind and solar energy systems.
- To emphasize the significant influence of wind and solar energy in power system.

UNIT I INTRODUCTION 9

Recent trends in energy consumption - World energy scenario - Energy sources and their availability - Qualitative study of different renewable energy resources: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems - need to develop new energy technologies.

UNIT II WIND ENERGY CONVERSION SYSTMES 9

Basic principle of wind energy conversion - nature of wind - Wind survey in India - Power in the wind - components of a wind energy - conversion system - Performance of induction generators for WECS - classification of WECS - Analysis of different wind power generators - IG - PMSG - DFIG – SEIG.

UNIT III GRID CONNECTED WIND ENERGY SYSTEMS 9

Grid Connected WECS: Grid connectors concepts - wind farm and its accessories - Systems for Feeding into the Grid - Induction Generators for Direct Grid Coupling - Asynchronous Generators in Static Cascades - Synchronous Generators Grid related problems - Generator control - Performance improvements - Different schemes - AC voltage controllers - Harmonics and PF improvement.

UNIT IV SOLAR ENERGY CONVERSION SYSTEMS 9

Photovoltaic Energy Conversion: Solar radiation and measurement - solar cells and their characteristics -PV arrays - Electrical storage with batteries - Switching devices for solar energy conversion Grid connection Issues - Principle of operation: line commutated converters (inversion-mode) - Boost and buck-boost converters- selection of inverter, battery sizing, array sizing.

PV Applications: Stand alone inverters - Charge controllers - Water pumping, audio visual equipments, street lighting - analysis of PV systems.

UNIT V OPERATION OF POWER SYSTEM WITH WIND AND SOLAR ENERGY SYSTEMS 9

Interface requirement – synchronizing with grid – operating limit – energy storage and load scheduling – utility resource planning – electrical performance – voltage, current and power efficiency – component design for maximum efficiency – static bus impedance and voltage regulation – quality of power – renewable capacity limit – Plant economy.

TOTAL:45 PERIODS

COURSE OUTCOMES

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

CO1 Ability to design grid connected/standalone renewable energy system employing embedded energy storage and MPPT strategy.

CO2 Students will develop more understanding on solar energy storage systems.

CO3 Students will develop basic knowledge on standalone PV system.

CO4 Students will attain knowledge on the basic concepts of wind energy conversion system.

CO5 Students will attain knowledge on Grid connected Solar and Wind energy system.

1. REFERENCE BOOKS

1 Thomas Ackermann, "Wind Power in Power Systems", John Wiley & Sons, Ltd, 2005.
2 Mukund R. Patel, "Wind and Solar Power Systems", CRC Press, 1999.
3 Muhammed H. Rashid, "Power Electronics Handbook", Academic Press, Second edition,2006.
4 Rao. S. &Parulekar, "Energy Technology", Khanna publishers, Fourth edition, 2005.
5 Rai ,G.D., "Non- conventional resources of energy", Khanna publishers ,Fourth edition , 2010.
6 Bansal N K, Kleeman and Meliss, "Renewable energy sources and conversion Techniques", Tata McGraw hill, 1990.
7 B.H.Khan, "Non-Conventional Energy Resources", Tata McGraw Hills, Second edition, 2009.

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

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.

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	PO1	PO	PO1	PSO1	PSO2	PSO3

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										0	**11**	**2**			
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

118PSE03	INDUSTRIAL POWER SYSTEM ANALYSIS AND DESIGN	L	T	P	C
		3	0	0	3

PREREQUISITE : Nil

COURSE OBJECTIVES

- To impart knowledge on Motor Starting Studies.
- To study about Power Factor Correction.
- To analyze Harmonic, Flicker, Ground Grid Analysis problem in power system.

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 Overvoltages-Switching Surge Analysis-Back-to-Back Switching-Summary and Conclusions.

UNIT III HARMONIC ANALYSIS 9

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

UNIT IV FLICKER ANALYSIS 9

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

UNIT V GROUND GRID ANALYSIS 9

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

TOTAL:45 PERIODS

COURSE OUTCOMES

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

CO1 Ability to conduct harmonic analysis on power supplies and drive systems.

CO2 Ability to conduct load tests on power supplies and drive systems.

CO3 Ability to conduct the Harmonic Analysis.

CO4 Ability to conduct the flicker analysis.

CO5 Ability to conduct the ground grid analysis in computer aided software.

TOTAL: 45 PERIODS

REFERENCE BOOKS

1 J. Duncan Glover, MulukutlaS.Sarma, Thomas Overbye, "Power System Analysis and Design", 2011.

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2 TuranGonen“ Electrical Power Transmission System Engineering: Analysis and Design”,Mcgraw Hill publishers,1986.
3 Ramasamy Natarajan, “Computer-Aided Power System Analysis”, Marcel Dekker Inc., 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	3	3	3	2	1	2					2	2	3	2
CO2	2	3	3	3	3	1	2					2	2	3	2
CO3	2	3	3	3	2	1	2					2	2	3	2
CO4	2	3	3	3	3	1	2					2	2	3	2
CO5	1	3	3	3	2	1	1					1	3	3	2

118PSE04	ELECTRIC AND HYBRID VEHICLES	L	T	P	C
		3	0	0	3

PREREQUISITE : Electric Drives and control, Electrical Machines

COURSE OBJECTIVES

- This course introduces the fundamental concepts, principles, analysis and design of hybrid and electric vehicles.

UNIT I HYBRID AND ELECTRIC VEHICLES 9

History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.

UNIT II CONCEPTS OF ELECTRIC TRACTION 9

Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. Basic concepts of electric traction, introduction to various electric drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

UNIT III CONFIGURATION AND CONTROL OF MOTOR DRIVES 9

Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Introduction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency

UNIT IV SELECTION OF THE ENERGY STORAGE TECHNOLOGY 9

Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems.

UNIT V ENERGY MANAGEMENT STRATEGIES 9

Introduction to energy management strategies used in hybrid and electric vehicle, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy strategies.

TOTAL:45 PERIODS

COURSE OUTCOMES

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

CO1 Understand mathematical models, performance and characteristics of hybrid and electric vehicles.

CO2 Analyze the concepts, topologies and power flow control of electric traction systems.

CO3 Appraise the configuration and control of various hybrid electric motor drives.

CO4 Plan and design appropriate vehicle management system.

CO5 Analyze the concepts of Energy Management Strategies.

TOTAL: 45 PERIODS

REFERENCE BOOKS

1. Sira -Ramirez, R. Silva Ortigoza, 'Control Design Techniques in Power Electronics Devices', Springer, 2006.
2. Siew-Chong Tan, Yuk-Ming Lai, Chi Kong Tse, 'Sliding mode control of switching Power Converters', CRCPress, 2011
3. Bimal Bose, 'Power electronics and motor drives', Elsevier, 2006
4. Ion Boldea and S.A Nasar, 'Electric drives', CRC Press, 2005

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

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-

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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, 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	PO11	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

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UNIT V INSTABILITY ANALYSIS 12

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

TOTAL:60 PERIODS

COURSE OUTCOMES

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

CO1 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

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

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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. John Twidell and Tony Weir, "Renewable Energy Resources" Tyalor and Francis Publications, Second edition 2006
2. D. D. Hall and R. P. Grover, "Biomass Regenerable Energy", John Wiley, New York,1987.
3. J.F. Manwell, J.G. McGowan "Wind Energy Explained, theory design and applications", Wiley publication 2010.
4. DorinNeacsu, "Power Switching Converters: Medium and High Power", CRC Press,
5. Taylor & Francis, 2006
6. S. Chowdhury, S.P. Chowdhury and P. Crossley Microgrids and Active Distribution Networks,2009.
7. 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

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

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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.

		L	T	P	C
218PSP08	**ADVANCED POWER SYSTEM SIMULATION LABORATORY**	**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

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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

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 inductioi 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

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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

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

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CO5	1	3	3	3	2	1	1					1	3	3	2

		L	T	P	C
218PSE02	**REACTIVE POWER COMPENSATION AND MANAGEMENT**	**3**	**0**	**0**	**3**

PREREQUISITE : Nil

COURSE OBJECTIVES

- To improve the knowledge in power system using Reactive Power Compensation.
- To describe the modeling of Line and Load compensation and compensating devices.
- To understand the fundamental concepts of Reactive power coordination, Power Quality, and reactive power management in Domestic and Industrial Sectors.

UNIT I THEORY OF LOAD COMPENSATION 9

Objectives and specifications – reactive power characteristics – inductive and capacitive approximate biasing – Load compensator as a voltage regulator – phase balancing and power factor correction of unsymmetrical loads- examples.

UNIT II STEADY- STATE REACIVE POWER COMPENSATION IN TRANSMISSION SYSTEMS 9

Uncompensated line – types of compensation – Passive shunt and series and dynamic shunt compensation –examples-Transient state reactive power compensation in transmission systems: Characteristic time periods – passive shunt compensation – static compensations- series capacitor compensation –compensation using synchronous condensers – examples.

UNIT III REACTIVE POWER COORDINATION 9

Objective – Mathematical modeling – Operation planning – transmission benefits – Basic concepts of quality of power supply – disturbances- steady –state variations – effects of under voltages – frequency –Harmonics, radio frequency and electromagnetic interferences.

UNIT IV DEMAND SIDE MANAGEMENT 9

Load patterns – basic methods load shaping – power tariffs- KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels-Distribution side Reactive power Management: System losses – loss reduction methods – examples – Reactive power planning – objectives – Economics Planning capacitor placement – retrofitting of capacitor banks.

UNIT V USER SIDE REACTIVE POWER MANAGEMENT 9

KVAR requirements for domestic appliances – Purpose of using capacitors – selection of capacitors – deciding factors – types of available capacitor, characteristics and Limitations-Reactive power management in electric traction systems and arc furnaces: Typical layout of traction systems – reactive power control requirements – distribution transformers- Electric arc furnaces – basic operations- furnaces transformer –filter requirements –remedial measures –power factor of an arc furnace.

TOTAL:45 PERIODS

COURSE OUTCOMES

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

CO1 Distinguish the importance of load compensation in symmetrical as well as un symmetrical loads.

CO2 Observe various compensation methods in transmission lines.

CO3 Construct model for reactive power coordination.

CO4 Distinguish demand side reactive power management & user side reactive power manangement.

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CO5 Understand the Concepts of Reactive Power Coordination.

REFERENCE BOOKS

1. T.J.E.Miller, Reactive power control in Electric power systems, John Wiley and Sons, 1982
2. D.M. Tagare, Reactive power Management, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.
3. Wolfgang Hofmann, JurgenSchlabbach, Wolfgang Just, Reactive Power Compensation: A Practical Guide, Wiley, April, 2012

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

218PSE03	POWER SYSTEM ECONOMICS AND CONTROL	L	T	P	C
		3	0	0	3

PREREQUISITE : Nil

COURSE OBJECTIVES

- A review of the dispatch studies in power system networks is expected.
- An emphasis on the development of algorithms suitable for efficient operation is to be laid.
- Techniques used to solve mathematical formulation are to be explained.
- The problems associated with interconnected networks, the need for maintaining co-coordinated actions and the use of controllers in augmenting these actions is to addressed.
- The students will derive the benefit of having understood the credentials of smooth and satisfactory operation of power systems.

UNIT I OPTIMUM DISPATCH 9

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

UNIT II OPTIMAL DISPATCH WITH CONSTRAINTS 9

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

UNIT III UNIT COMMITMENT 9

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

UNIT IV HYDRO THERMAL SCHEDULING 9

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

UNIT V LOAD FREQUENCY CONTROL 9

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

TOTAL:45 PERIODS

COURSE OUTCOMES

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

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

CO2 Learners will be able to analyze power system security.

CO3 Learners will understand the significance of unit commitment and different solution methods.

CO4 Learners will attain knowledge about hydrothermal scheduling.

CO5 Learners will attain knowledge about Load Frequency Control.

TOTAL: 45 PERIODS

REFERENCE BOOKS

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

Cos	Programme Outcomes												Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO1	PO	PO1	PSO1	PSO2	PSO3

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										0	**11**	**2**			
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

		L	T	P	C
218PSE04	**ELECTRICAL TRANSIENTS IN POWER SYSTEM**	**3**	**0**	**0**	**3**

PREREQUISITE : Nil

COURSE OBJECTIVES

- To gain knowledge in the sources and effects of lightning, 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.
- Ability to model and analyze power system and equipment for transient over voltages using Electromagnetic Transient Program (EMTP).

UNIT I LIGHTNING OVER VOLTAGES 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 OVER VOLTAGES 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 co-ordination in AIS and GIS.

UNIT V COMPUTATION OFPOWER 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 PERIODS

COURSE OUTCOMES

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

CO1 Ability to understand to explain the over voltages in lightning.

CO2 Ability to illustrate about the traveling wave i9n transmission lines.

CO3 Ability to illustrate about insulation coordination.

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CO4 Ability to describe about the computation of power systems transients.

CO5 Ability to describe about the Switching and Temporary Over Voltages.

REFERENCE BOOKS

1. Pritindra Chowdhari, "Electromagnetic transients in Power System", John Wiley and Sons Inc., Second Edition, 2009.
2. Allan Greenwood, "Electrical Transients in Power System", Wiley & Sons Inc. New York, 2012.
3. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering",(Second edition) Newage International (P) Ltd., New Delhi, 2006.
4. Naidu M S and Kamaraju V, "High Voltage Engineering", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.
5. Klaus Ragaller, "Surges in High Voltage Networks", Plenum Press, New York, 1980.

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

PROFESSIONAL ELECTIVE-III

218PSE05	DEMAND SIDE ENERGY MANAGEMENT	L	T	P	C
		3	0	0	3

PREREQUISITE :Nil

COURSE OBJECTIVES

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

UNIT I ENERGY AUDIT 9

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

UNIT II ENERGY CONSERVATION IN ELECTRIC UTILITIES AND INDUSTRY 9

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

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improvement.

UNIT III ENERGY EFFICIENT ELECTRIC MOTORSC(EEMS) 9

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

UNIT IV ELECTRIC LIGHTING 9

Introduction-Need for an energy management program-Building analysis-Modification of existing systems-Replacement of existing systems-priorities: Illumination requirement: Task lighting requirements-lighting levels-system modifications-non illumination modifications-lighting for non task areas-reflectance's-space geometry; System elements.

UNIT V SPACE HEATING, VENTILATION 9

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

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

TOTAL:45 PERIODS

COURSE OUTCOMES

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

CO1 Able to explain about the energy auditing.

CO2 Knowledge about the energy conservation in electrical utilities.

CO3 Able to describe about the electric lighting.

CO4 Able to explain about the working methodology of air conditioning, co-generation and storage.

CO5 Able to explain about the Space Heating and Ventilation.

REFERENCES BOOKS

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

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	2					2	3	3	2
CO2	2	3	3	3	2	2	2					2	3	3	2

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Dr. M.G.R. Nagar, HOSUR - 635130

CO3	2	3	3	3	2	2	2					2	3	3	2
CO4	2	2	3	3	2	2	2					2	3	3	3
CO5	2	2	3	3	2	2	2					2	2	1	3

		L	T	P	C
218PSE06	**HVDC AND FACTS CONTROLLERS**	**3**	**0**	**0**	**3**

PREREQUISITE :Power Electronics

COURSE OBJECTIVES

- To provide knowledge about the evolution of AC and DC transmission systems.
- To equip with required skills to derive the criteria for the design of power converters.
- To understand different Flexible AC Transmission Systems.
- To design different Static Var Compensation methods.

UNIT I INTRODUCTION TO HVDC 9

Need for power system interconnections – Evolution of AC and DC transmission systems – Comparison of HVDC and HVAC Transmission systems – Types of DC links – relative merits – Components of a HVDC system – Modern trends in DC Transmission systems – Pulse number – choice of converter

UNIT II ANALYSIS OF HVDC CONVERTERS 9

configurations – Analysis of Grates circuit with and without overlap – voltage waveforms – Analysis of two and three valve conduction mode – Converter Bridge characteristics – Inverter mode of operation – voltage waveforms – Principles of DC link control – Converter Control characteristics – system control – Constant current Control – CEA Control – firing angle control of valves – Starting and stopping of a dc link – Power control – Harmonics & Filters – Ill effects of Harmonics – sources of harmonic generation – Types of filters.

UNIT III INTRODUCTION FLEXIBLE AC TRANSMISSION SYSTEM 9

Flexible AC Transmission Systems (FACTS): Power flow in AC systems – Relative importance of controllable parameters – Basic types of FACTS controllers – shunt and series controllers – Current source and Voltage source

UNIT IV STATIC VAR COMPENSATION 9

converters – Objectives of shunt compensation – Methods of controllable VAR generation – Static Var Compensator – its characteristics – TCR – TSC – FC –TCR configurations – STATCOM – basic operating principle – control approaches and characteristics – Objectives of series compensator – variable impedance type of series compensators – TCSC – TSSC – operating principles and control schemes – SSSC

UNIT V UNIFIED POWER FLOW CONTROL 9

Power Angle characteristics – Control range and VAR rating – Capability to provide reactive power compensation – external control – Introduction to Unified Power Flow Controller – Basic operating principles – Conventional control capabilities – Independent control of real and reactive power

TOTAL:45 PERIODS

COURSE OUTCOMES

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

CO1 Ability to explain about the HVDC converters.

CO2 Ability to analysis about the HVDC Converters.

CO3 Ability to describe about the operation of facts.

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CO4 Able to describe about the static Var compensation.

CO5 Able to understand about the unified power flow control.

REFERENCES BOOKS

1. "HVDC Power Transmission Systems – Technology and System Interactions" .R.Padiyar – New Age International Publishers, 2012
2. "Understanding FACTS – Concepts and Technology of Flexible AC Transmission Systems" Narain G. Hingorani, Laszlo Gyugyi, Wiley India publications 2011

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

218PSE07	ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY	L	T	P	C
		3	0	0	3

PREREQUISITE :Nil

COURSE OBJECTIVES

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

UNIT I BASIC THEORY 9

Introduction to EMI and EMC, Intra and inter system EMI, Elements of Interference, Sources and Victims of EMI, Conducted and Radiated EMI emission and susceptibility, Case Histories, Radiation hazards to humans, Various issues of EMC, EMC Testing categories, EMC Engineering Application.

UNIT II COUPLING MECHANISM 9

Electromagnetic field sources and Coupling paths, Coupling via the supply network, Common mode coupling, Differential mode coupling, Impedance coupling, Inductive and Capacitive coupling, Radioactive coupling, Ground loop coupling, Cable related emissions and coupling, Transient sources, Automotive transients.

UNIT III EMI MITIGATION TECHNIQUES 9

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

UNIT IV STANDARDS AND REGULATION 9

Need for Standards, Generic/General Standards for Residential and Industrial environment, Basic

Standards, Product Standards, National and International EMI Standardizing Organizations; IEC, ANSI, FCC, AS/NZS, CISPR, BSI, CENELEC, ACEC. Electro Magnetic Emission and susceptibility standards and specifications, MIL461E Standards.

UNIT V EMI TEST METHODS AND INSTRUMENTATION 9

Fundamental considerations, EMI Shielding effectiveness tests, Open field test, TEM cell for immunity test, Shielded chamber , Shielded anechoic chamber, EMI test receivers, Spectrum analyzer, EMI test wave simulators, EMI coupling networks, Line impedance stabilization networks, Feed through capacitors, Antennas, Current probes, MIL -STD test methods, Civilian STD test methods.

TOTAL:45 PERIODS

COURSE OUTCOMES

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

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

CO2 To measure emission immunity level from different systems to couple with the prescribed EMC standards.

CO3 Usage of modern technology and tools in risk reduction.

CO4 Develop the ability of Planning in emergency situations.

CO5 Develop the ability to know about the EMI Test methods and Instrumentation.

REFERENCES BOOKS

1. Clayton Paul, "Introduction to Electromagnetic Compatibility", Wiley Interscience, 2006.
2. Henry W. Ott, "Electromagnetic Compatibility Engineering", John Wiley & Sons Inc, Newyork, 2009
3. V Prasad Kodali, "Engineering Electromagnetic Compatibility", IEEE Press, Newyork, 2001.
4. Daryl Gerke and William Kimmel, "EDN‟s Designer‟s Guide to Electromagnetic Compatibility", Elsevier Science & Technology Books, 2002

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

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

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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.

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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									

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

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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.

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

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.

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.

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Dr. M.G.R. Nagar, HOSUR - 635130

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

		L	T	P	C
318PSE01	**RESTRUCTURED POWER SYSTEM**	**3**	**0**	**0**	**3**

PREREQUISITE : Nil

COURSE OBJECTIVES

- To provide in depth understanding of operation of deregulated electricity market systems.
- To examine topical issues in electricity markets.
- To examine the electricity markets issues in worldwide various markets.
- To enable students to analyze various types of electricity market operation.
- To enable the control issues using new mathematical models.

UNIT I INTRODUCTION TO RESTRUCTURING OF POWER INDUSTRY 9

Introduction- Restructuring process,-Issues involved in restructuring- 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 – Nodal pricing – Inter zonal and Intra zonal congestion management – Price area congestion management – Capacity alleviation method.

UNIT III LOCATIONAL MARGINAL PRICES AND FINANCIAL TRANSMISSION RIGHTS 9

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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 - Simultaneous feasibility test and revenue adequency – FTR issuance process: FTR auction, FTR allocation – Treatment of revenue shortfall – Secondary trading of FTRs – Flow gate rights – FTR and market power - FTR and merchant transmission investment.

UNIT IV ANCILLARY SERVICE MANAGEMENT AND PRICING OF TRANSMISSION 9

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

UNIT V 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 PERIODS

COURSE OUTCOMES

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

CO1 Understand the need for restructuring of power systems, discuss different market models, different stakeholders and market power.

CO2 Understand and generalize the functioning and planning activities of ISO.

CO3 Understand transmission open access pricing issues and congestion management.

CO4 Define transfer capability and estimate the transfer capability of small power systems (Numerical examples).

CO5 Define ancillary services and understand reactive power as ancillary service and management through synchronous generator.

REFERENCE BOOKS

1. Mohammad Shahidehpour and Muwaffaq Almoush, “Restructured Electrical Power Systems Operation, Trading and Volatility,” Marcel Dekkar, Inc, 2001
2. Zaccour, “Deregulation of Electric Utilities”, Kluwer Academic Publishers 1998.
3. G. M.Illic, F.Galiana and L.Fink, “Power Systems Restructuring : Engineering and Economics”, Kluwer Academic Publishers, 2000.
4. Simon Haykin, “Neural Networks – A comprehensive foundation”, Pearson Education Asia, 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	3	2	2	1	1					1	2	2	1
CO2	2	2	3	2	2	1	1					1	2	2	1
CO3	2	2	3	2	2	1	1					1	2	2	1
CO4	2	3	3	2	2	1	1					1	2	2	1
CO5	2	3	3	2	2	1	1					1	2	2	1

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318PSE02	POWER SYSTEM DEREGULATION	L	T	P	C
		3	0	0	3

PREREQUISITE : Nil

COURSE OBJECTIVES

- To get an overview knowledge of power system quality and tariff details in electricity market.
- To provide in depth understanding of operation of deregulated electricity market systems.
- To understand the pricing issues and marginal in transmission side.
- To examine topical issues in electricity markets and how these are handled in various markets.
- To analyze various types of electricity market operational and control issues using new mathematical models.

UNIT I AN OVERVIEW 9

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

UNIT II POWER SYSTEM OPERATION IN COMPETITIVE ENVIRONMENT 9

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

UNIT III TRANSMISSION OPEN ACCESS AND PRICING ISSUES 9

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

UNIT IV AVAILABLE TRANSFER CAPABILITY & CONGESTION MANAGEMENT 9

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

UNIT V INDIAN POWER MARKET 9

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

TOTAL:45 PERIODS

COURSE OUTCOMES

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

CO1 Ability to understand the basic of power system deregulation.

CO2 Able to understand the power system operation in electricity market.

CO3 Able to understand the marginal pricing and transmission pricing in transmission side.

CO4 Able to understand the capability of congestion management in transmission side.

CO5 Understand the Indian power market challenges and Indian power sector in past and present

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status.

REFERENCE BOOKS

1 Kankar Bhattacharya Maath H.J. Bollen and Jaap E.Daalder,—Operation of restructured power systems, Kluwer academic publishers, USA ,first edition, 2001.

2 Daniel Kirschen and Goran Strbac ,‖Fundamentals of power system economics‖, John Wiley sons, 2004..

3 Loi Lei Lai, —Power system Restructuring and regulation‖ John Wiley sons, 2001.

4 M.Shahidepour, Hatim Tamin and Zuyi Li, —Market operations in electric power system forecasting, scheduling and risk management‖, John Wiley sons, 2002

5 Fred I Denny and David E. Dismukes "Power System Operations and Electricity Markets",CRC Press, LLC, 2002.

6 Mohammad Shahidehpour, Muwaffaq Alomoush, Marcel Dekker, "Restructured electrical power systems: operation, trading and volatility" Pub., 2001.

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

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

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Dr. M.G.R. Nagar, HOSUR - 635130

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.

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

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Dr. M.G.R. Nagar, HOSUR - 635130

CO4	1	3	3	3	3	2	2					2	2	2	2
CO5	1	3	3	3	3	2	2					2	2	2	2

		L	T	P	C
318PSE04	**INSULATION TECHNOLOGY AND HIGH VOLTAGE ENGINEERING**	**3**	**0**	**0**	**3**

PREREQUISITE : High Voltage Engineering

COURSE OBJECTIVES

- To learn various insulating materials, properties and breakdown mechanisms of insulating Materials.
- To learn about the Nature of Breakdown mechanism in solid, liquid and gaseous dielectrics.
- To know about breakdown in vacuum insulation.
- To know about the dielectric breakdown in solid and liquid dielectrics.
- To learn about the Applications of Insulating materials in transforms and other electrical equipments.

UNIT I GENERAL PROPERITIES OF INSULATING MATERIALS 9

Requirements of insulating materials – electrical properties – molecular properties of dielectrics – dependence of permittivity on temperature, pressure, humidity and voltage, permittivity of mixtures, practical importance of permittivity – behavior of dielectric under alternating fields – complex dielectric constants –bipolar relaxation and dielectric loss, dielectric strength.

UNIT II BREAKDOWN MECHANISMS IN GASEOUS DIELECTRICS 9

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

UNIT III BREAKDOWN MECHANISMS IN SOLID DIELECTRICS 9

Intrinsic breakdown of solid dielectrics – electromechanical breakdown-Streamer breakdown, thermal breakdown and partial discharges in solid dielectrics - electrochemical breakdown – tracking and treeing – classification of solid dielectrics, composite insulation and its mechanism of failure.

UNIT IV BREAKDOWN MECHANISMS IN LIQUID DIELECTRICS 9

Liquids as insulators, conduction and breakdown in pure and commercial liquids, Cryogenic insulation.

UNIT V APPLICATION OF INSULATING MATERIALS 9

Application of insulating materials in transformers. rotating machines, circuit breakers, cables, power capacitors and bushings

TOTAL:45 PERIODS

COURSE OUTCOMES

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

CO1 Learning about the various insulating materials, properties and breakdown mechanisms.
CO2 Learning about the Breakdown mechanism of Gaseous Dielectrics.
CO3 Learning about the Breakdown mechanism of Solid Dielectrics.
CO4 Learning about the Breakdown mechanism of Liquid Dielectrics.
CO5 Analyzing various applications of insulating materials in electrical equipments.

TOTAL: 45 PERIODS

REFERENCE BOOKS

1 M.S Naidu, V.Kamaraj, "High Voltage Engineering", Tata Mc Graw-Hill Publishing Company Ltd., New Delhi, Fifth Edition 2013.

2 Kuffel, E., Zaengl, W.S. and Kuffel J., "High Voltage Engineering Fundamentals", Elsvier India Pvt. Ltd, 2008.

3 Alston, L.L, "High Voltage Technology", Oxford University Press, London, 2006.

4 Dieter Kind and Hermann Karner, "High Voltage Insulation Technology", 1985. (Translated from German by Y. Narayana Rao, Friedr.Vieweg & Sohn,Braunschweig,).

5 Adrinaus, J.Dekker, "Electrical Engineering Materials", Prentice Hall of India Pvt. Ltd., New Delhi, 1979.

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

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

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Dr. M.G.R. Nagar, HOSUR - 635130

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

		L	T	P	C
318PSE06	**DESIGN OF CONTROLLERS IN POWER APPLICATIONS**	**3**	**0**	**0**	**3**

PREREQUISITE :Nil

COURSE OBJECTIVES

- To introduce the mathematical representation of controller components and solution techniques.

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- To know the background of controller designing properties and theory.
- To impart in-depth knowledge on different methods of modern controllers.
- To impart in depth knowledge in control theory.
- To get insight of contingency analysis problem and the solution methods.

UNIT I CLASSICAL CONTROLLER DESIGN 9

Introduction of Controller design – Proportional (P)-Integral (I)-Derivative (D)-PI-PD - PID Controllers-Characteristics-Design Controller Tuning- Ziegler-Nichol's method and Cohen coon method – Damped oscillation method.

UNIT II SLIDING MODE CONTROL & VARIABLE STRUCTURE CONTROLLER 9

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

UNIT III CURRENT CONTROLLER DESIGN 9

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

UNIT IV H- INFINTIY CONTROL & ROBUST CONTROL THEORY 9

Instruction of H-infinity methods in control theory-Elements of Robust Control Theory – Design Objectives – Shaping the Loop Gain –Signal Spaces – Computation of H∞ norm- All Pass Systems-- Linear-quadratic- Gaussian control (LQG)- -Case Studies Robust Control Theory- Robust Controller Design- Robust decision methods- Analytic tools for robust decision making- Case Studies.

UNIT V CONTROLLER DESIGN 9

Controller synthesis and tuning, Linear Matrix Inequalities, LMI solvers, control system analysis and design with LMIs using MATLAB/Simulink Uncertain System Analysis -Statistical and worst-case analysis of stability and performance Analysis. Survey and Review of different controller's used in power system and power electronics practices.

TOTAL:45 PERIODS

COURSE OUTCOMES

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

CO1 Understand the mathematical derivation behind the controller design.
CO2 Ability to know the properties and theory concept in controllers.
CO3 Ability to differentiate the different in controller design.
CO4 Able to know the robust control theory and robust controller design.
CO5 Able to analyze the uncertainties in system by using controller.

REFERENCES BOOKS

1 Ramon Vilanova Antonio Visioli, PID Control in the Third Millennium Lessons Learned and New Approaches Springer-Verlag London Limited, 2012.
2 Christopher Edward and Sarah K Spurgeon, "Sliding Mode Control: Theory And Applications" ,CRC Press, 1998.
3 Katsuhiko Ogata , "Modern Control Engineering", PHI, 2010
4 Guang-Ren Duan, Hai-Hua Yu , "LMIs in Control Systems: Analysis, Design and Applications", CRC Press, 2013

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

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Dr. M.G.R. Nagar, HOSUR - 635130

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

		L	T	P	C
318PSE07	**ARTIFICIAL NEURAL NETWORKS APPLIED TO POWER SYSTEMS**	**3**	**0**	**0**	**3**

PREREQUISITE :Artificial Neural Networks

COURSE OBJECTIVES

- To understand the fundamental concepts of ANN.
- To understand the different architectures and its learning methodologies.
- To gain knowledge about different network architectures.
- To learn the concepts of the various training/learning algorithms.
- To learn about the applications of artificial neural networks in power systems.

UNIT I INTRODUCTION 9

Artificial neural networks – definition and fundamental concepts –-biological -neural networks – Artificial neuron- activation functions – setting of weights -– typical architectures – biases and thresholds – learning/ training algorithms -Laws, Self adaptation Equations-Coincidence -performance, competitive, filter and spatiotemporal learning.

UNIT II FEED FORWARD NEURAL NETWORKS 9

Perception – architectures, algorithm and applications – linear reparability – ADALINE – feed forward networks – back propagation algorithm– alternate -activation functions-number of hidden layers – practical consideration – gradient decent algorithms- radial basis function networks [RBF].

UNIT III STATISTICAL METHODS BASED NEURAL NETWORKS 9

Associate memory-Auto associative-hetero associative – bidirectional -associative memory-Hopfield neural networks – discrete and continuous networks.

UNIT IV COMPETITIVE NETWORKS 9

Kohonen's self organizing maps[SOM]-learning vector quantization[LVQ] -and its types- Adaptive resonance theory – ART 1, ART2- architecture, algorithms.

UNIT V APPLICATION OF ANN 9

Applications of ANN in Power system s – load forecasting- unit commitment --load scheduling – Power flow studies- Control applications in FACTS and power quality applications-Fault Analysis and fault classification problems in Power systems.

TOTAL:45 PERIODS

COURSE OUTCOMES

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

CO1 Understand the basic concepts of Artificial Neural Networks.
CO2 Analyses the various types of Architectures that are used in Neural networks.
CO3 Learnt about the statistical methods in Neural Networks.
CO4 Gained knowledge about different types of Algorithms.
CO5 Analyzing various applications of Artificial Neural Networks in Power Systems.

REFERENCES BOOKS

1 Simon Haykin, "Neural Networks and learning machines" ,Prentice Hall,third edition 2016.
2 Robert J. Schalkoff, "Artificial Neural Networks", McGraw-Hill International Editions, first

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edition,2011.
3 Laurene fausett, “Fundamentals of Neural Network Architecture” algorithms and applications – pearsons education.2008
4 Yegnanarayana B., “Artificial Neural Networks”, Prentice Hall of India Private Ltd., New Delhi, 2004.

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

318PSE08	ANALYSIS OF ELECTRICAL MACHINES	L	T	P	C
		3	0	0	3

PREREQUISITE :Electrical Machines

COURSE OBJECTIVES

- To provide knowledge about the fundamentals of magnetic circuits, energy, force and torque of multi-excited systems.
- To analyze the steady state and dynamic state operation of DC machine through Mathematical modeling and simulation in digital computer.
- To provide the knowledge of theory of transformation of three phase variables to two phase variables.
- To provide the knowledge about the induction machine dynamics and digital computer simulation.
- To provide the knowledge about the synchronous machine dynamics and digital computer simulation.

UNIT I PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION 9

Magnetic circuits, permanent magnet, stored magnetic energy, co-energy - force and torque in singly and doubly excited systems – machine windings and air gap mmf - winding inductances and voltage equations.

UNIT II DC MACHINES 9

Elementary DC machine and analysis of steady state operation - Voltage and torque equations – dynamic characteristics of permanent magnet and shunt d.c. motors – Time domain block diagrams - solution of dynamic characteristic by Laplace transformation – digital computer simulation of permanent magnet and shunt D.C. machines

UNIT III REFERENCE FRAME THEORY 9

Historical background – phase transformation and commutator transformation – transformation of variables from stationary to arbitrary reference frame - variables observed from several frames of reference.

UNIT IV INDUCTION MACHINES 9

Three phase induction machine, equivalent circuit and analysis of steady state operation – free

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acceleration characteristics – voltage and torque equations in machine variables and arbitrary reference frame variables – analysis of dynamic performance for load torque variations – digital computer simulation.

UNIT V SYNCHRONOUS MACHINES 9

Three phase synchronous machine and analysis of steady state operation - voltage and torque equations in machine variables and rotor reference frame variables (Park‟s equations) – analysis of dynamic performance for load torque variations – digital computer simulation.

TOTAL:45 PERIODS

COURSE OUTCOMES

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

CO1 Understand the basic concepts of electro mechanical energy conversion.

CO2 Understand the digital computer simulation of permanent magnet D.C machine and shunt Motor.

CO3 Understand the phase transformation and commutator transformation.

CO4 Understand the digital computer simulation of induction machines.

CO5 Understand the digital computer simulation of synchronous machines.

REFERENCES BOOKS

1. Paul C.Krause, Oleg Wasyzczuk, Scott S, Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley, Second Edition, 2010.
2. P S Bimbhra, "Generalized Theory of Electrical Machines", Khanna Publishers, 2008.
3. A.E, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, " Electric Machinery", Tata McGraw Hill, 5th Edition, 1992

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	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	3	3	2	2					2	3	3	2
CO5	2	3	3	3	3	2	2					2	3	3	2

Semester IV

		L	T	P	C
418PSP01	**PROJECT WORK (PHASE II)**	**0**	**0**	**12**	**10**

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.

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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 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		
	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	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