ANNA UNIVERSITY: CHENNAI 600 025
NON AUTONOMOUS COLLEGES AFFILIATED TO ANNA UNIVERSITY
REGULATIONS – 2021
CHOICE BASED CREDIT SYSTEM
M.E. POWER SYSTEMS ENGINEERING

1. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

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

2. PROGRAMME OUTCOMES (POs):

PO#	Programme Outcomes
1	An ability to independently carry out research/investigation and development work to solve practical problems
2	An ability to write and present a substantial technical report/document
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
4	Ability to attain professional ethics and intellectual integrity to contribute to the community for sustainable development of society
5	Apply knowledge of basic science and engineering in analysis and modeling of the power system components
6	Implement cost effective and cutting edge technologies in Power System

4. PEO/PO Mapping:

PEO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
I.	3		3		2	2
II.	2	3	2	2	3	3
III.	2				2	
IV.			2		1	3
V.	2		2	1	1	3

1,2,3,-, scale against the correlation PO’s with PEO’s

PROGRAM ARTICULATION MATRIX OF PG - POWER SYSTEMS ENGINEERING

		COURSE NAME	PO1	PO2	PO3	PO4	PO5	PO6
YEAR I	SEMESTER I	Applied Mathematics For Power Systems Engineers						
		Research Methodology and IPR						
		Computer Aided Power System Analysis	1.8	2	2.7	-	2.3	2
		Power System Operation and Control	1.34	2	-	1.67	2.2	2.75
		System Theory	2.8	2	2.8	3	2.5	2.5
		Analysis and Design of Power Converters						
		Audit Course I*						
		Power system Lab - 1	3	2	3	3	3	2.5
		Power Converters Lab						
	SEMESTER II	Advanced Power system Protection	2.8	1	3	2.5	2.75	2.5
		Power System Dynamics	2.8	1.5	2.2	1.7	1.75	2.7
		Power System Transients						
		Restructured Power System	2.4	2.33	2.33	2.5	2	2.2
		PE – I						
		PE – II						
		Audit Course I*						
		Power System Lab – 2	3	2	3	2	2.4	2.6
		Technical Seminar / Mini Project						
YEAR II	SEMESTER III	HVDC and FACTS	2.2	2	1.8	1.5	2.33	1.5
		PE – III						
		PE – IV						
		Open Elective						
		Project Work I						

	SEMESTER IV	Project Phase II						

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M.E. POWER SYSTEMS ENGINEERING

I TO IV SEMESTERS CURRICULUM AND SYLLABUS

SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA4107	Applied Mathematics for Power Systems Engineers	FC	3	1	0	4	4
2.	RM4151	Research Methodology and IPR	RMC	2	0	0	2	2
3.	PS4101	Computer Aided Power System Analysis	PCC	3	1	0	4	4
4.	PS4102	Power System Operation and Control	PCC	3	0	0	3	3
5.	PS4151	System Theory	PCC	3	0	0	3	3
6.	PX4151	Analysis of Power Converters	PCC	3	1	0	4	4
7.		Audit Course I*	AC	2	0	0	2	0
PRACTICALS								
8.	PS4111	Power System Laboratory - I	PCC	0	0	3	3	1.5
9.	PX4161	Power Converters Laboratory	PCC	0	0	3	3	1.5
			TOTAL	**19**	**3**	**6**	**28**	**23**

*** Audit Course is optional**

SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	PS4201	Advanced Power System Protection	PCC	3	0	0	3	3
2.	PS4202	Power System Dynamics	PCC	3	0	0	3	3
3.	PS4203	Power System Transients	PCC	3	0	0	3	3
4.	PS4204	Restructured Power System	PCC	3	0	0	3	3
5.		Professional Elective I	PEC	3	0	0	3	3
6.		Professional Elective II	PEC	3	0	0	3	3
7.		Audit Course II*	AC	2	0	0	2	0
PRACTICALS								
8.	PS4211	Power System Laboratory – II	PCC	0	0	4	4	2
9.	PS4212	Technical Seminar / Mini Project	EEC	0	0	4	4	2
			TOTAL	**20**	**0**	**8**	**28**	**22**

*** Audit Course is optional**

SEMESTER III

S.NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	PS4351	HVDC and FACTS	PCC	3	0	0	3	3
2.		Professional Elective III	PEC	3	0	0	3	3
3.		Professional Elective IV	PEC	3	0	0	3	3
4.		Open Elective	OEC	3	0	0	3	3
PRACTICALS								
5.	PS4311	Project Work I	EEC	0	0	12	12	6
			TOTAL	**12**	**0**	**12**	**24**	**18**

SEMESTER IV

S.NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	PS4411	Project Work II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL NO. OF CREDITS: 75

FOUNDATION COURSES (FC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CRE DITS	SEME STER
			LECTURE	TUTORIAL	PRACTICAL		
1.	MA4107	Applied Mathematics for Power Systems Engineers	3	1	0	4	I

PROFESSIONAL CORE COURSES (PCC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CRE DITS	SEME STER
			LECTURE	TUTORIAL	PRACTICAL		
1	PS4101	Computer Aided Power System Analysis	3	1	0	4	I
2	PS4102	Power System Operation and Control	3	0	0	3	I
3	PS4151	System Theory	3	0	0	3	I
4	PX4151	Analysis of Power Converters	3	1	0	4	I
5	PS4111	Power System Laboratory-I	0	0	3	1.5	I
6	PX4161	Power Converters Laboratory	0	0	3	1.5	I
7	PS4201	Advanced Power System Protection	3	0	0	3	II

8	PS4202	Power System Dynamics	3	0	0	3	II
9	PS4203	Power System Transients	3	0	0	3	II
10	PS4204	Restructured Power System	3	0	0	3	II
11	PS4211	Power System Laboratory- II	0	0	4	2	II
12	PS4351	HVDC and FACTS	3	0	0	3	III
					TOTAL CREDITS	**34**	

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			LECTURE	TUTORIAL	PRACTICAL		
1.	RM4151	Research Methodology and IPR	2	0	0	2	I
					TOTAL CREDITS	**2**	

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			LECTURE	TUTORIAL	PRACTICAL		
1.	PS4212	Technical Seminar / Mini Project	0	0	4	2	II
2.	PS4311	Project Work I	0	0	12	6	III
3.	PS4411	Project Work II	0	0	24	12	IV
					TOTAL CREDITS	**20**	

PROFESSIONAL ELECTIVES

SEMESTER II

ELECTIVE I

S. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1	PS4001	Power System State Estimation and Security Assessment	PEC	3	0	0	3	3
2	PS4002	Optimization Techniques to Power System Engineering	PEC	3	0	0	3	3
3	PS4003	Computational Intelligence Techniques to Power Systems	PEC	3	0	0	3	3

4	ET4251	IoT for Smart Systems	PEC	3	0	0	3	3
5	PS4092	Renewable Energy and Grid Integration	PEC	3	0	0	3	3
6	PS4093	Smart Grid	PEC	3	0	0	3	3

SEMESTER II

ELECTIVE II

S. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1	PS4004	Electrical Power Distribution System	PEC	3	0	0	3	3
2	PS4005	Wind and Solar Energy Systems	PEC	3	0	0	3	3
3	PS4091	Distributed Generation and Micro Grid	PEC	3	0	0	3	3
4	PS4072	Energy Storage Technologies	PEC	3	0	0	3	3
5	PX4071	Power Quality	PEC	3	0	0	3	3
6	ET4072	Machine Learning and Deep Learning	PEC	3	0	0	3	3

SEMESTER III

ELECTIVE III

S. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1	PS4006	Power System Reliability	PEC	3	0	0	3	3
2	PS4007	EHV AC Transmission	PEC	3	0	0	3	3
3	PS4008	Electromagnetic Interference and Compatibility in System Design	PEC	3	0	0	3	3
4	PS4009	Industrial Power System Analysis and Design	PEC	3	0	0	3	3
5	PS4010	Advanced Power System Dynamics	PEC	3	0	0	3	3
6	ET4073	Python Programming for Machine Learning	PEC	3	0	0	3	3

SEMESTER III

ELECTIVE IV

S. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1	PS4011	Computer Relaying and Wide Area Measurement Systems	PEC	3	0	0	3	3
2	PS4012	Application of DSP To Power System Protection	PEC	3	0	0	3	3
3	PS4013	Power System Instrumentation	PEC	3	0	0	3	3
4	PS4014	High Voltage Technology	PEC	3	0	0	3	3
5	PX4291	Electric Vehicles and Power Management	PEC	3	1	0	4	4
6	PS4071	Energy Management and Auditing	PEC	3	0	0	3	3

AUDIT COURSES - I

REGISTRATION FOR ANY OF THESE COURSES IS OPTIONAL TO STUDENTS

SL. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS
			L	T	P	
1.	AX4091	English for Research Paper Writing	2	0	0	0
2.	AX4092	Disaster Management	2	0	0	0
3.	AX4093	Constitution of India	2	0	0	0
4.	AX4094	நற்றமிழ் இலக்கியம்	2	0	0	0

SUMMARY

	Name of the Programme: M.E.POWER SYSTEMS ENGINEERING					
	SUBJECT AREA	CREDITS PER SEMESTER				CREDITS TOTAL
		I	II	III	IV	
1.	FC	4				4
2.	PCC	17	14	3		34
3.	PEC	-	6	6		12
4.	RMC	2				2
5.	OEC			3		3
6.	EEC		2	6	12	20
7.	Non Credit/Audit Course	0	0			0
8.	**TOTAL CREDIT**	**23**	**22**	**18**	**12**	**75**

MA4107 APPLIED MATHEMATICS FOR POWER SYSTEMS ENGINEERS

L	T	P	C
3	1	0	4

OBJECTIVES :

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

UNIT I MATRIX THEORY 9

The Cholesky decomposition - Generalized Eigenvectors - Canonical basis - QR factorization - Singular value decomposition - Pseudo inverses - Least square approximation.

UNIT II LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 9

Definitions - Properties - Transform error function - Bessel's function - Dirac Delta function - Unit step function - Convolution theorem - Inverse Laplace transform - Complex inversion formula - Solutions to partial differential equations : Heat and Wave equations.

UNIT III FOURIER SERIES 9

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

UNIT IV LINEAR PROGRAMMING PROBLEMS 9

Formulation - Graphical solution - Simplex method - Big M method - Two phase method - Transportation and Assignment models.

UNIT V NON – LINEAR PROGRAMMING PROBLEMS 9

Lagrange multipliers – Equality constraints – Inequality constraints – Kuhn – Tucker Conditions – Quadratic programming.

L - 45; T - 15; TOTAL – 60 PERIODS

OUTCOMES :

- Student can able to apply the concepts of matrix theory in Electrical Engineeringproblems.
- Students can be easily understood to solve boundary value problems associatedwith engineering applications.
- Able to solve problems using Fourier series associated with engineering applications.
- Able to understood the basic concepts and also to solve complicated problems using linear programming.
- Student have capability of solving problems using non - linear programming techniques.

REFERENCES:

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

MAPPING OF CO'S WITH PO'S

CO	PO					
	1	2	3	4	5	6
1	3	2	2	1	3	1
2	3	2	2	1	3	1
3	3	2	2	1	3	1
4	3	2	2	1	3	1
5	3	2	2	1	3	1
AVG	3	2	2	1	3	1

RM4151 RESEARCH METHODOLOGY AND IPR **L T P C**
2 0 0 2

UNIT I RESEARCH DESIGN **6**

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

UNIT II DATA COLLECTION AND SOURCES **6**

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

UNIT III DATA ANALYSIS AND REPORTING **6**

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

UNIT IV INTELLECTUAL PROPERTY RIGHTS **6**

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

UNIT V PATENTS **6**

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

TOTAL : 30 PERIODS

REFERENCES

1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
3. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.
4. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

PS4101 COMPUTER AIDED POWER SYSTEM ANALYSIS **L T P C**
3 1 0 4

OBJECTIVES:

- To introduce various solution techniques to solve the large scale power systems.
- To impart in-depth knowledge on different power flow solution methods for large power system networks.
- To perform various optimal power flow methods involving operating and security constraints.
- To perform short circuit fault analysis for various fault conditions on three phase basis.
- To Illustrate different numerical integration methods and factors influencing transient stability

UNIT I SOLUTION TECHNIQUE 9

Sparse Matrix techniques for large scale power systems - Optimal ordering schemes for preserving sparsity - Flexible packed storage scheme for storing matrix as compact arrays - Factorization by Bi-factorization and Gauss elimination methods - Repeat solution using Left and Right factors and L and U matrices.

UNIT II POWER FLOW ANALYSIS 9

Power flow equation in real and polar forms - Review of Newton Raphson method for solution; Adjustment of P-V buses - Review of Fast Decoupled Power Flow method - Sensitivity factors for P-V bus adjustment.

UNIT III OPTIMAL POWER FLOW 9

Problem statement - Solution of Optimal Power Flow (OPF) - The gradient method - Newton's method - Linear Sensitivity Analysis - LP methods - With real power variables only - LP method with AC power flow variables and detailed cost functions - Security constrained Optimal Power Flow - Interior point algorithm - Bus Incremental costs.

UNIT IV SHORT CIRCUIT ANALYSIS 9

Formation of bus impedance matrix with mutual coupling (single phase basis and three phase basis) - Computer method for fault analysis using Z_{BUS} and sequence components - Derivation of equations for bus voltages -fault current and line currents - both in sequence and phase - symmetrical and unsymmetrical faults.

UNIT V TRANSIENT STABILITY ANALYSIS 9

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

L - 45; T - 15; Total – 60 PERIODS

OUTCOMES:

CO1 Ability to solve large scale simultaneous linear equations and the ordering schemes for preserving sparsity.

CO2 Ability to solve large scale power flow problems

CO3 Ability to solve optimal power flow problem using various solution methods

CO4 Ability to do fault calculations for various fault conditions on three phase basis

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

REFERENCES:

1. A. J. Wood and B. F. Wollenberg, "Power Generation Operation and Control", John Wiley and sons, New York, 2016.
2. M. A. Pai," Computer Techniques in Power System Analysis",Tata McGraw Hill Publishing Company Limited, New Delhi, 2006.
3. G W Stagg, A.H El. Abiad, "Computer Methods in Power System Analysis", McGraw Hill,1968.
4. P. Kundur, "Power System Stability and Control", McGraw Hill, 1994.
5. D. P. Kothari and I. J. Nagrath, 'Modern Power System Analysis', Fourth Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2011.
6. K. Zollenkopf, "Bi-Factorization: Basic Computational Algorithm and Programming Techniques ; pp:75-96 ; Book on "Large Sparse Set of Linear Systems" Editor:J.K.Rerd, Academic Press, 1971.

CO-PO MAPPING

CO	PO					
	1	2	3	4	5	6
1	2	-	-	-	3	1
2	3	3	3	-	3	3
3	2	2	3	-	-	2
4	1	1	2	-	-	-
5	1	2	-	-	1	-
AVg.	1.8	2	2.7	-	2.3	2

1 - low, 2-medium, 3-high, '-"- no correlation

PS4102 POWER SYSTEM OPERATION AND CONTROL

L	T	P	C
3	0	0	3

OBJECTIVES

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

UNIT I INTRODUCTION 9

System load variation: System load characteristics, load curves - daily, weekly and annual, load-duration curve, load factor, diversity factor. Reserve requirements: Installed reserves, spinning reserves, cold reserves, hot reserves. Overview of system operation and Control: Load forecasting, techniques of forecasting, Indian power sector – Past and present status: Recent growth of power sector in India – An overview, A time line of the Indian power sector, Players in the Indian power sector, basics of power system operation and control.

UNIT II LOAD FREQUENCY CONTROL 9

Need for frequency and voltage control - Plant and system level control - modeling of LFC of single area system - static and dynamic analysis - LFC of two area system - static and dynamic analysis - Tie line bias control - development of state variable model of single and two area system.

UNIT III HYDROTHERMAL SCHEDULING PROBLEM 9

Hydrothermal coordination – hydro electric plant models - short term and long term scheduling problem – gradient approach – Hydro units in series - Hydro-thermal scheduling with pumped hydro plant: Scheduling of systems using Dynamic programming and linear programming.

UNIT IV UNIT COMMITMENT AND ECONOMIC DISPATCH 9

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

UNIT V POWER SYSTEM SECURITY 9

Need for power system Security- - Contingency analysis – linear sensitivity factors – AC power flow methods – contingency selection – concentric relaxation – bounding-security constrained optimal power flow-Interior point algorithm-Bus incremental costs.

TOTAL 45 PERIODS

OUTCOMES:

Students able to

CO1: Explain about the operation and control of power system and List the past and present status of Indian power sector

CO2: Develop the static and dynamic model of Load Frequency Control in single and two area system

CO3: Analyse the problems associated with hydro thermal Scheduling and to construct the algorithm for feasible load management

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

CO5: Define about the power system security factors and analyse the algorithms used for optimal power flow

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

MAPPING O CO’S WITH PO’S

CO	PO					
	1	2	3	4	5	6
1	-	3	-	2	2	-
2	-	-	-	-	3	2
3	1	2	-	1	2	3
4	2	1	-	2	2	3
5	1	2	-	-	2	3
AVG	1.34	2	-	1.67	2.2	2.75

PS4151 SYSTEM THEORY L T P C
3 0 0 3

OBJECTIVES:
1. To educate on modeling and representing systems in state variable form.
2. To train on solving linear and non-linear state equations.
3. To illustrate the properties of control system.
4. To classifynon–linearitiesand examine stability of systems in the sense of Lyapunov’s theory.
5. To educate on modal concepts, design of state, output feedback controllers and estimators.

UNIT I STATE VARIABLE REPRESENTATION 9

Introduction-Concept of State-Space equations for Dynamic Systems -Time invariance and linearity-Non uniqueness of state model- Physical Systems and State Assignment - free and forced responses-State Diagrams.

UNIT II SOLUTION OF STATE EQUATIONS 9

Existence and uniqueness of solutions to Continuous-time state equations - Solution of Nonlinear and Linear Time Varying State equations - State transition matrix and its properties – Evaluation of matrix exponential- System modes- Role of Eigen values and Eigen vectors.

UNIT III PROPERTIES OF THE CONTROL SYSTEM 9

Controllability and Observability-Stabilizability and Detectability-Test for Continuous time Systems-Time varying and Time invariant case-Output Controllability-Reducibility-System Realizations.

UNIT IV NON-LINEARITIES AND STABILITY ANALYSIS 9

Equilibrium Points-Stability in the sense of Lyapunov-BIBO Stability-Stability of LTI Systems-Types of nonlinearity – Phase plane analysis – Singular points – Limit cycles – Construction of phase trajectories – Describing function method – Derivation of describing functions. Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems - Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems- Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems-Krasovskii and Variable-Gradiant Method

UNIT IV MODAL ANALYSIS 9

Controllable and Observable Companion Forms - SISO and MIMO Systems – Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

TOTAL: 45 PERIODS

OUTCOMES:

Students able to

CO1 Understand the concept of State-State representation for Dynamic Systems

CO2 Explain the solution techniques of state equations

CO3 Realize the properties of control systems in state space form

CO4 Identify non-linearities and evaluate the stability of the system using Lyapnov notion

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

REFERENCES:

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

MAPPING OF CO’S WITH PO’S

CO	PO					
	1	2	3	4	5	6
1	3	-	2	2	3	-
2	2	2	3	-	2	3
3	3	-	3	-	-	-
4	3	-	3	2	2	-
5	3	-	3	2	3	2
AVG	2.8	2	2.8	3	2.5	2.5

PX4151 ANALYSIS OF POWER CONVERTERS **L T P C**
3 1 0 4

OBJECTIVES:

- To provide the mathematical fundamentals necessary for deep understanding of power converter operating modes.
- To introduce the electrical circuit concepts behind the different working modes of power converters so as to enable deep understanding of their operation.
- To impart required skills to formulate and design inverters for generic load and for machine loads.
- To equip with required skills to derive the criteria for the design of power converters starting from basic fundamentals.
- To inculcate knowledge to perform analysis and comprehend the various operating modes of different configurations of power converters.

UNIT I SINGLE PHASE AC-DC CONVERTER 12

Static Characteristics of power diode, SCR and GTO, half controlled and fully controlled converters with R-L, R-L-E loads and freewheeling diodes – continuous and discontinuous modes of operation - inverter operation and its limit –Sequence control of converters – performance parameters – effect of source impedance and overlap-reactive power and power balance in converter circuit.

UNIT II THREE PHASE AC-DC CONVERTER 12

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

UNIT III SINGLE PHASE INVERTERS 12

Introduction to self-commutated switches : MOSFET and IGBT - Principle of operation of half and full bridge inverters – Performance parameters – Voltage control of single phase inverters using various PWM techniques – various harmonic elimination techniques – Design of UPS - VSR operation

UNIT IV THREE PHASE INVERTERS 12

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

UNIT V MODERN INVERTERS 12

Multilevel concept – diode clamped – flying capacitor – cascaded type multilevel inverters - Comparison of multilevel inverters - application of multilevel inverters – PWM techniques for MLI – Single phase &Three phase Impedance source inverters – Filters.

TOTAL : 60 PERIODS

OUTCOMES:

After completing the above course, students will be able to

CO1 : Acquire and apply knowledge of mathematics in power converter analysis

CO2: Model, analyze and understand power electronic systems and equipments.

CO3 :Formulate, design and simulate phase controlled rectifiers for generic load and for machine loads

CO4 : Design and simulate switched mode inverters for generic load and for machine loads

CO5 : Select device and calculate performance parameters of power converters under various operating modes

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CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		3	3	2	2
CO2	3		3	3	2	2
CO3	3		3	3	2	2
CO4	3		3	3	2	2
CO5	3		3	3	2	2

PS4111 POWER SYSTEM LABORATORY- I **L T P C**
0 0 3 1.5

OBJECTIVES:

1. Illustrate the power system issues under normal and abnormal conditions
2. Analyze the performance of power system under normal and abnormal conditions using simulation software
3. Evaluate the existing system and system under smart environment

LIST OF EXERCISES:

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

10. Demand Side Management in Smart Power Grid environment
11. Determination of Sequence Impedances of Power Network

(Any 10 for Conduct of end semester examination)

TOTAL : 45 PERIODS

OUTCOMES:

CO1: Acquire expertise in usage of simulation software as applied to power system
CO2: Apply tools to simulate the mathematical model of power network for power system Analysis
CO3:Analyze the power system through various numerical methods under normal and Abnormal conditions

MAPPING O CO'S WITH PO'S

CO	PO					
	1	2	3	4	5	6
1	3	-	3	-	-	3
2	3	2	3	-	3	2
3	3	-	3	3	3	-
AVG	3	2	3	3	3	2.5

PX4161 POWER CONVERTERS LABORATORY

L T P C
0 0 3 1.5

OBJECTIVES:

- To provide the basic understanding of the dynamic behavior of the power electronic switches
- To make the students familiar with the digital processors used in generation of gate pulses for the power electronic switches
- To make the students acquire knowledge on the design of power electronic circuits and implementing the same using simulation tools
- To facilitate the students to design gate drive circuits for power converters
- To provide the fundamentals of DC-AC power converter topologies and analyze the harmonics.

LIST OF EXPERIMENTS:

1. Study of switching characteristics of Power MOSFET & IGBT.
2. Circuit Simulation of Three-phase semi-converter with R,RL& RLE load.
3. Circuit Simulation of Three-phase fully controlled converter with R, RL & RLE load.
4. Circuit Simulation of Three-phase Voltage Source Inverter in 180 and 120 degree mode of conduction
5. Circuit simulation of Three-phase PWM inverter and study of spectrum analysis for various modulation indices.
6. Simulation of Four quadrant operation of DC Chopper.
7. Generation of Gating pulse using Arduino/Micro Controller/PIC microcontroller for a DC-DC converter and single-phase voltage source inverter.
8. Simulation of a single-phase Z-source inverter with R load.
9. Simulation of three-phase AC voltage Controller with R load.

10. Simulation of a five-level cascaded multilevel inverter with R load.
11. Simulation of a Flyback DC-DC converter

TOTAL : 45 PERIODS

OUTCOMES:

- Comprehensive understanding on the switching behaviour of Power Electronic Switches
- Comprehensive understanding on mathematical modeling of power electronic system and ability to implement the same using simulation tools
- Ability of the student to use arduino/microcontroller for power electronic applications
- Ability of the student to design and simulate various topologies of inverters and analyze their harmonic spectrum
- Ability to design and fabricate the gate drive power converter circuits. Analyze the three-phase controlled rectifiers and isolated DC-DC converters for designing the power supplies

CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	1	2	
CO2	2		3	1	2	3
CO3	2		3			
CO4	2		3		2	
CO5	2		3			3

PS4201 **ADVANCED POWER SYSTEM PROTECTION** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

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

UNIT I NUMERICAL PROTECTION 9

Introduction - Block diagram of numerical relay - Sampling theorem - Correlation with a reference wave - Least Error Squared (LES) technique - Digital filtering and numerical over- Current protection.

UNIT II DIGITAL PROTECTION OF TRANSMISSION LINE 9

Introduction - Protection scheme of transmission line – Distance relays - Traveling wave relays - Digital protection scheme based upon fundamental signal - Hardware design - Software design - Digital protection of EHV/UHV transmission line based upon traveling wave phenomenon - New relaying scheme using amplitude comparison.

UNIT III DIGITAL PROTECTION OF SYNCHRONOUS GENERATOR & TRANSFORMER 9

Introduction - Faults in synchronous generator - Protection schemes for Synchronous Generator - Digital protection of Synchronous Generator - Faults in a Transformer - Schemes used for Transformer Protection - Digital Protection of Transformer.

UNITIV DISTANCE AND OVERCURRENT RELAY SETTING AND CO-ORDINATION 9

Directional instantaneous IDMT over current relay - Directional multi-Zone distance relay - Distance relay setting - Co-ordination of distance relays - Co-ordination of over current relays - Computer graphics display - Man-machine interface subsystem - Integrated operation of national power system - Application of computer graphics.

UNIT V PC APPLICATIONS FOR DESIGNING PROTECTIVE RELAYING SCHEME 9

Types of faults – Assumptions - Development of algorithm for SC studies - PC based integrated software for SC studies - Transformation to component quantities - SC studies of multiphase systems - Ultra high speed protective relays for high voltage long transmission line.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Students able to

CO1 Familiarize the underlying principle of digital techniques for power system protection
CO2 Design the relaying scheme for protection of power apparatus using digital techniques
CO3 Evaluate and interpret relay coordination
CO4 Develop PC based algorithm for short circuit studies

CO5 Compare the performance of modern protection schemes with the conventional schemes

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2. S. R. Bhide, “Digital Power System Protection”, Prentice Hall of India Pvt. Ltd., New Delhi, 2014
3. Paithankar and Bhide, “Fundamentals of Power System Protection”, Prentice Hall of India Pvt. Ltd., New Delhi, second edition, 2010.
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6. T. S. M. Rao, “Digital / Numerical relays”, Tata McGraw Hill, New Delhi, 2005.

MAPPING OF CO’S WITH PO’S

CO	PO					
	1	2	3	4	5	6
1	2	-	3	-	3	-
2	3	-	3	-	3	3
3	3	1	3	2	2	2
4	3	-	3	-	-	3
5	3	1	3	3	3	2
AVG	2.8	1	3	2.5	2.75	2.5

PS4202 POWER SYSTEM DYNAMICS **L T P C**
3 0 0 3

COURSE OBJECTIVES:

- To impart knowledge on mathematical modeling of a synchronous machine in detail.
- To enable the students to develop the transfer function model for excitation and speed governing systems.
- To offer an opportunity to innovate newer procedures and better methods for effective design.
- To enable the students to model the single and multi-machine power systems with controllers for stability analysis
- To provide knowledge on enhancing small signal stability concepts in power system

UNIT I SYNCHRONOUS MACHINE MODELLING 9

Physical description of a synchronous machine: armature and field structure - direct and quadrature axes- Mathematical Description: Basic equations of a synchronous machine: stator circuit equations, stator self, stator mutual and stator to rotor mutual inductances, dq0 Transformation: flux linkage and voltage equations for stator and rotor in dq0 coordinates, Physical interpretation of dq0 transformation, Per Unit Representations: power invariant form of Park‟s transformation; Equivalent Circuits for direct and quadrature axes, Steady-state Analysis: Voltage, current and flux-linkage phasor relationships, Computation of steady-state values.

UNIT II MODELLING OF EXCITATION AND SPEED GOVERNING SYSTEMS 9

Elements of an Excitation System: Types of Excitation System; Control and protective functions; Modeling of Excitation system components: Modeling of IEEE type ST1A (1992) excitation model, Turbine and Governing System Modeling: Classical transfer function of a hydraulic turbine (no derivation), Special characteristics of a hydraulic turbine, Electrical analogue of a hydraulic turbine, Governor for Hydraulic Turbine: Requirement for a transient droop, Block diagram of governor with transient droop compensation, Modeling of Single reheat tandem compounded type Steam Turbine.

UNIT III SMALL-SIGNAL STABILITY ANALYSIS WITHOUT CONTROLLERS 9

Classification of Stability, Concepts of Stability of Dynamic Systems: State-space representation, Eigen properties of the state matrix: Eigen values and eigenvectors for stability, Participation factor, Single-Machine Infinite Bus (SMIB) Configuration: Classical Machine Model stability analysis with numerical example, Effects of Field Circuit Dynamics: Block diagram representation with K-constants; expression for K-constants (no derivation), effect of field flux variation on system stability

UNIT VI SMALL-SIGNAL STABILITY ANALYSIS WITH CONTROLLERS 9

Effects of Excitation System: Thyristor Excitation System with AVR, Block diagram representation with Exciter and AVR, Effect of AVR on Synchronizing and Damping torque components, Power System Stabilizer: Block diagram representation with AVR and PSS, System state matrix including PSS-Illustration of principle of PSS application with numerical example -Small Signal Stability of Multi machine systems: illustration of formation of system state matrix for a two-machine system with classical models for synchronous machines

UNIT V ENHANCEMENT OF SMALL SIGNAL STABILITY 9

Power System Stabilizer – Stabilizer based on shaft speed signal (delta omega) – Delta P-Omega stabilizer-Frequency-based stabilizers – Digital Stabilizer – Excitation control design – Exciter gain – Phase lead compensation – Stabilizing signal washout and stabilizer gain – Stabilizer limits, Selection of PSS location

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students will be able to

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

REFERENCES:

1. PrabhaKundur, "Power System Stability and Control", Tata McGraw-Hill, 2014.
2. R.Ramanujam," Power System Dynamics: Analysis and Simulation, PHI Learning Private Limited, Second print, New Delhi, 2013.
3. J.Machowski, Bialek, Bumby, "Power System Dynamics and Stability", John wiley and sons, 3rd edition, 2020.
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System Control and Stability", Iowa State University Press, Ames, Iowa, 3rd edition, 2019.
5 P. W. Sauer and M. A. Pai," Power System Dynamics and Stability", Stipes Publishing Co, 2007.

MAPPING OF CO'S WITH PO'S

CO	PO					
	1	2	3	4	5	6
1	3	-	2	--	2	--
2	3	-	2	1	2	--
3	3	1	2	-	1	2
4	3	-	3	2	2	3
5	2	2	2	2	--	3
AVg.	**2.8**	**1.5**	**2.2**	**1.7**	**1.75**	**2.7**

1- low, 2-medium, 3-high, '-"- no correlation

PS4203 POWER SYSTEM TRANSIENTS LT P C
3 0 0 3

COURSEOBJECTIVES:

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

UNIT I LIGHTNING OVERVOLTAGES 9

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

UNIT II SWITCHING AND TEMPORARY OVERVOLTAGES 9

Switching transients – concept – phenomenon – system performance under switching surges- Ferranti Effect, Temporary overvoltages – load rejection – line faults – ferroresonance, VFTO

UNIT III TRAVELLING WAVES ON TRANSMISSION LINE 9

Circuits and distributed constants, wave equation, reflection and refraction – behaviour of travelling waves at the line terminations – Lattice Diagrams – attenuation and distortion – multiconductor system and multivelocity waves

UNIT IV INSULATION CO-ORDINATION 9

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

UNIT V COMPUTATION OF POWER SYSTEM TRANSIENTS 9

Computation of transients using electromagnetic transient program-Modelling of power system components- Simple case studies - Application of simplified method: single line station, two line station, gas insulated substations, comparison with IEEE and IEC guides

TOTAL : 45 PERIODS

COURSEOUTCOMES:

CO1: Ability to analyse various sources of transients

CO2: Ability to compute possible overvoltages in power systems

CO3: Ability to predict overvoltages in power system using travelling wave theory

CO4: Ability to compute overvoltages using EMTP with multiple sources

CO5: Ability to coordinate the insulation level of the power system

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	1				
CO2	3	3			3		
CO3	3	3	2	3	3		
CO4	3	3	2	3	3		
CO5	3	3	3	3	3		2
AVG.	3	3	1.6	1.8	2.4		0.4

REFERENCES

1. Pritindra Chowdhari, "Electromagnetic transients in Power System", John Wiley and Sons Inc.,Second Edition, 2009.
2. Allan Greenwood, "Electrical Transients in Power System", Wiley & Sons Inc. New York,2012.
3. Andrew R. Hileman, "Insulation Coordination for Power Systems", CRC press, Taylor &Francis Group, New York, 1999.
4. Klaus Ragaller, "Surges in High Voltage Networks", Plenum Press, New York, 1980.
5. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", (Secondedition) Newage International (P) Ltd., New Delhi, 2006.
6. Naidu M S and Kamaraju V, "High Voltage Engineering", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.
7. IEEE Guide for safety in AC substation grounding IEEE Standard 80-2000.
8. Working Group 33/13-09 (1988), 'Very fast transient phenomena associated with Gas Insulated System', CIGRE, 33-13, pp. 1-20.
9. R. Ramanujam, "Computational Electromagnetic Transients: Modeling, Solution Methods and Simulation", I.K. International Publishing House Pvt. Ltd, New Delhi -110 016, 2014

PS4204 RESTRUCTURED POWER SYSTEM **L T P C**
3 0 0 3

COURSE OBJECTIVES;

Students will be able to:

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

UNIT I INTRODUCTION 9

Reasons for restructuring - Understanding the restructuring process - objectives of deregulation of various power systems across the world - Consumer behavior - Supplier behavior - Market equilibrium - Short-run and Long-run costs - Various costs of production. The Philosophy of Market Models: Market models based on contractual arrangements - Market architecture - .

UNIT II TRANSMISSION CONGESTION MANAGEMENT 9

Importance of congestion management in deregulated environment - Classification of congestion management methods - Calculation of ATC - Non-market methods - Market based methods - Nodal pricing - Inter-zonal Intra-zonal congestion management - Price area congestion management - Capacity alleviation method.

UNIT III LOCATIONAL MARGINAL PRICES AND FINANCIAL TRANSMISSION RIGHTS 9

Fundamentals of locational marginal pricing - Lossless DCOPF model for LMP calculation - Loss compensated DCOPF model for LMP calculation - ACOPF model for LMP calculation - Risk Hedging Functionality Of financial Transmission Rights - FTR issuance process - Treatment of revenue shortfall - Secondary trading of FTRs - Flow Gate rights - FTR and market power

UNIT IV ANCILLARY SERVICE MANAGEMENT AND PRICING OF TRANSMISSION NETWORK 9

Types of ancillary services -Load-generation balancing related services - Voltage control and reactive power support services - Black start capability service - Mandatory provision of ancillary services - Markets for ancillary services - Co-optimization of energy and reserve services - International comparison. Pricing of transmission network: wheeling - principles of transmission pricing - transmission pricing methods - Marginal transmission pricing paradigm - Composite pricing paradigm - loss allocation methods.

UNIT V MARKET EVOLUTION 9

US markets: PJM market - The Nordic power market - Reforms in Indian power sector: Framework of Indian power sector - Reform initiatives - availability based tariff (ABT) - The Electricity Act 2012 - Open Access issues - Power exchange

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students will be able to:

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

CO2: Analyze the methods of congestion management in deregulated power system

CO3: Analyze the locational marginal pricing and financial transmission rights

CO4: Analyze the ancillary services management

CO5: Differentiate the framework of US and Indian power sectors

REFERENCES

1. Mohammad Shahidehpour, MuwaffaqAlomoush, “Restructured electrical power systems: operation, trading and volatility” Marcel Dekker Pub.,2001.
2. Kankar Bhattacharya, Math H.J.Boolen, and JaapE. Daadler, "Operationofrestructured power systems”, Kluwer AcademicPub.,2001.
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4. Sally Hunt, "MakingcompetitionworkInelectricity”,JohnWilleyandSonsInc.2002.
5. Steven Stoft," Power System Economics: Designing Markets for Electricity”,Wiley-IEEE Press, 2002.
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MAPPING OF CO’S WITH PO’S

CO	PO					
	1	2	3	4	5	6
1	3			3		2
2	2	3	2			3
3	2	2	2			3
4	2	2	3			2
5	3			2	2	1
AVG	2.4	2.33	2.33	2.5	2	2.2

PS4211 POWER SYSTEM LABORATORY - II

L	T	P	C
0	0	4	2

OBJECTIVES:

1. Solve the power system problems using computational intelligent techniques
2. Analyze the solution obtained for power system under normal and abnormal conditions using simulation software
3. Expose with real time monitoring of power system
4. Evaluate the new techniques used for power system problems with the conventional one.
5. Educate to integrate renewable energy sources

LIST OF EXERCISES

1. AC-DC power flow analysis
2. Application of neural networks to load forecasting and contingency analysis
3. Solution of Unit commitment Problem through Evolutionary algorithm
4. Solution of Economic Dispatch using Evolutionary algorithm
5. Automatic Voltage Regulator with Power System Stabilizer
6. Study of Relay Coordination
7. Simulation of Solar PV & Wind Energy Conversion System
8. Intelligent control techniques for Automatic Generation Control
9. Soft Computing Techniques for Power System Problems
10. State Estimation of Power System
11. Analysis of Power grid in presence of Renewable Energy Sources

(Any 10 for Conduct of end semester examination)

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

MAPPING OF CO'S WITH PO'S

CO	PO					
	1	2	3	4	5	6
1	3	-	3	-	3	3
2	3	2	3	2	2	3
3	3	-	3	-	3	3
4	3	-	3	-	2	1
5	3	-	3	2	2	3
AVG	3	2	3	2	2.4	2.6

PS4351 **HVDC AND FACTS** **L T P C**
3 0 0 3

OBJECTIVES:

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

UNIT I INTRODUCTION 9

Review of basics of power transmission networks-control of power flow in AC transmission line- Analysis of uncompensated AC Transmission line- Passive reactive power compensation: Effect of series and shunt compensation at the mid-point of the line on power transfer- Need for FACTS controllers- types of FACTS controllers-Need for HVDC system-MTDC system-Review of basics of LCC and VSC HVDC system.Configurations-Monopolar Asymmetric and Symmetric MMC-HVDC Scheme- Bipolar and Homopolar HVDC Scheme- Multi-Terminal HVDC Configuration- Layout of HVDC system (LCC, VSC)

UNIT II THYRISTOR BASED FACTS CONTROLLERS 9

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

UNIT III ANALYSIS OF LCC HVDC CONVERTERS AND HVDC SYSTEM CONTROL 9

Choice of converter configuration – Simplified analysis of Graetz circuit Converter bridge characteristics – characteristics of a twelve pulse converter- detailed analysis of converters. General principles of DC link control – Converter control characteristics – System control hierarchy - Firing angle control – Current and extinction angle control – Generation of harmonics and filtering - power control – Higher level controllers. Modelling of LCC HVDC system and controllers, transformer derating and core saturation instability,Concepts of Power Oscillation Damping Controller, Frequency Controller and Sub synchronous Damping controller in LCC HVDC.

UNIT IV VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS 9

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

UNIT V VOLTAGE SOURCE CONVERTER BASED HVDC SYSTEM AND CONTROLS 9

Applications VSC based HVDC: Operation, Modelling for steady state and dynamic studies, .Introduction to Modular Multilevel converters- Main circuit design-Converter Operating

Principle and Averaged Dynamic Model- Per-Phase Output-Current Control - Arm-Balancing (Internal) Control- Vector Output-Current Control-Higher-Level Control-Modulation and Submodule Energy Balancing- Offshore HVDC integration System Studies -Control and Protection of MMC-HVDC under AC and DC Network Fault Contingencies- Modeling and Simulation of MMC based MTDC Simulation exercises, Steady state, Fault recovery characteristics - Solution of DC load flow-Solution of AC-DC power flow: Sequential and Simultaneous methods.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

REFERENCES

1. Mohan Mathur, R., Rajiv. K. Varma, "Thyristor – Based Facts Controllers forElectrical Transmission Systems", IEEE press and John Wiley & Sons, Inc.

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MAPPING OF CO'S WITH PO'S

CO	PO					
	1	2	3	4	5	6
CO1	3	2	1	-	1	-
CO2	1	1	2	-	3	-
CO3	2	-	3	1	1	2
CO4	3	3	1	2	-	1
CO5	2	2	2	-	3	-
AVG	2.2	2	1.8	1.5	2.33	1.5

PS4001 POWER SYSTEM STATE ESTIMATION AND SECURITY ASSESSMENT **L T P C**
3 0 0 3

COURSE OBJECTIVES:

- To introduce the state estimation on DC network.
- To impart in-depth knowledge on power system state estimation.
- To study alternative formulations of WLS state estimation.
- To get insight of network observability and bad data identification.
- To gain knowledge on Power System Security Assessment.

UNIT I INTRODUCTION TO STATE ESTIMATION 9

Need for state estimation – Measurements – Noise - Measurement functions – Measurement Jacobian – Weights - Gain matrix - State estimation as applied to DC networks - Comparison of Power flow and State Estimation problems - Energy Management System.

UNIT II WEIGHTED LEAST SQUARE ESTIMATION 9

Modeling of transmission lines - Shunt capacitors and reactors - Tap changing and phase shifting transformers - loads and generators - Building network models - Maximum likelihood estimation - Measurement model and assumptions - WLS State Estimation Algorithm - Measurement functions - Measurement Jacobian matrix - Gain matrix - Cholesky decomposition and performing forward and backward substitutions - Decoupled formulation of WLS State estimation - DC State estimation model - Role of Phasor Measurement Units (PMU) in state estimation.

UNIT III ALTERNATIVE FORMULATION OF WLS STATE ESTIMATION 9

Weakness of normal equation formulation, Orthogonal factorization, Hybrid method, Method of Peters and Wilkinsons, Equality constraints WLS State estimation, Augmented matrix approach, Blocked formulation and comparison of techniques.

UNIT IV NETWORK OBSERVABILITY AND BAD DATA DETECTION IDENTIFICATION 9

Network and graphs, Network matrices, loop equations, Methods Observability analysis, Numerical Method based on Nodal Variable formulation and branch variable formulation, Topological Observability analysis, Determination of critical measurements – Role of PMU in network observability. Properties of measurement residuals - Classification of measurements - Bad data detection and identification using Chi-squares distribution and normalized residuals - Bad data identification - Largest normalized residual test and Hypothesis testing identification. bad data detection using PMU

UNIT V POWER SYSTEM SECURITY ASSESSMENT 9

Introduction to Security Assessment -Static Security Assessment-Summary of Different Types of Static SecurityIndices-Methods for Assessing Power System Security-Methods for Assessing Power System Security-Dynamic Security Assessment-Future Trends to Assessing Dynamic Security-Issues Related to Integration of Renewable Energies-Security Enhancement-Issues and Methods to Solve SCOPF Problem-Deal with the Challenges for Enhancing Dynamic Security.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students able to

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

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

MAPPING OF CO'S WITH PO'S

CO	PO					
	1	2	3	4	5	6
1	2	3	-	-	2	-
2	2	2	-	-	3	-
3	2	3	-	-	-	-
4	1	3	2	-	2	-
5	3	2	-	-	-	3
AVG	2	2.6	2	-	2.3	3

PS4002 OPTIMIZATION TECHNIQUES TO POWER SYSTEM ENGINEERING **L T P C**
3 0 0 3

COURSE OBJECTIVES:

- Discriminate the capabilities of bio-inspired system and conventional methods in solving optimization problems
- Examine the importance of exploration and exploitation swarm intelligent system to attain near global optimal solution
- Distinguish the functioning of various swarm intelligent systems
- Employ various bio-inspired algorithms for Power systems engineering applications

UNIT I FUNDAMENTALS OF SOFT COMPUTING TECHNIQUES 9
Definition-Classification of optimization problems - Unconstrained and Constrained optimization Optimality conditions - Introduction to intelligent systems - Soft computing techniques - Conventional Computing versus Swarm Computing - Classification of meta-heuristic techniques - Single solution based and population based algorithms – Exploitation and exploration in population based algorithms - Properties of Swarm intelligent Systems - Application domain - Discrete and continuous problems - Single objective and multi-objective problems.

UNIT II GENETIC ALGORITHM AND PARTICLE SWARM OPTIMIZATION 9
Genetic algorithms - Genetic Algorithm versus Conventional Optimization Techniques - Genetic representations and selection mechanisms; Genetic operators - different types of crossover and mutation operators - Bird flocking and Fish Schooling – anatomy of a particle - equations based on velocity and positions - PSO topologies - control parameters – GA and PSO algorithms for solving ELD problem.

UNIT III ANT COLONY OPTIMIZATION and ARTIFICIAL BEE COLONY ALGORITHMS 9
Biological ant colony system - Artificial ants and assumptions - Stigmergic communications - Pheromone updating - local-global - Pheromone evaporation - ant colony system- ACO Models - Touring ant colony system -max min ant system - Concept of elistic Ants - Task partitioning in honey bees - Balancing foragers and receivers - Artificial bee colony (ABC) algorithms - binary ABC algorithms – ACO and ABC algorithms for solving Economic Dispatch of thermal units.

UNIT IV SHUFFLED FROG-LEAPING ALGORITHM and BAT OPTIMIZATION ALGORITHM 9
Bat Algorithm - Echolocation of bats - Behaviour of microbats - Acoustics of Echolocation - Movement of Virtual Bats - Loudness and Pulse Emission - Shuffled frog algorithm - virtual population of frogs - comparison of memes and genes - memeplex formation - memeplexupdation - BA and SFLA algorithms for solving ELD and optimal placement and sizing of the DG problem.

UNIT V MULTI OBJECTIVE OPTIMIZATION 9
Multi-Objective Optimization Introduction - Concept of Pareto optimality - Non-dominant sorting Technique - Pareto fronts-best compromise solution - min-max method-NSGA-II algorithm and applications to power systems.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
Students able to

CO1 understand the capabilities of bio-inspired system and conventional methods in solving optimization problems

CO2 implement the genetic algorithm and particle swarm optimization technique to solve the ED problems

CO3 understand and implement the ant colony algorithm and artificial bee colony algorithms to PS problems

CO4 implement the shuffled frog-leaping algorithm and bat optimization algorithm for solving ELD and optimal placement and sizing of the DG problem

CO5 understand and implement the multi-objective optimization techniques to implement in power system problems

REFERENCES:

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

CO-PO MAPPING

CO	PO					
	1	2	3	4	5	6
1	2	2	3	-	2	2
2	3	3	2	-	2	3
3	3	3	3	-	2	3
4	3	3	2	-	2	3
5	3	3	2	-	2	3
AVg.	2.8	2.8	2.4	-	2	2.8

1 - low, 2-medium, 3-high, '-"- no correlation

PS4003 COMPUTATIONAL INTELLIGENCE TECHNIQUES TO POWER SYSTEMS LT P C
3 0 0 3

UNIT I INTRODUCTION 9

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

UNIT II LINEAR QUADRATIC TRACKING PROBLEMS ANDNUMERICAL TECHNIQUES FOR OPTIMAL CONTROL 9

Linear tracking problem – LQG problem – Computational procedure for solving optimal control problems – Characteristics of dynamic programming solution – Dynamic programming application to discrete and continuous systems – Hamilton Jacobi Bellman equation.Numerical solution of 2-point boundary value problem by steepest descent and Fletcher Powell method - solution of Ricatti equation by negative exponential and interactive Methods.

UNIT III MODEL DECOMPOSITION AND CONVOLUTIONAL NEURAL NETWORK 9

CNN Classification, CNN Algorithm ,model decomposition techniques, application of model decomposition and CNN based techniques for various power system fault digonesis problems, model predictive controllers for power system for power system stabilizers

UNIT IV FILTERING AND ESTIMATION 9

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

UNIT V KALMAN FILTER 9

Filter problem and properties – Linear estimator property of Kalman Filter – Time invariance and asymptotic stability of filters – Time filtered estimates and signal to noise ratio improvement – Extended Kalman filter,. Application of Kalman filter for power system protection applications

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Ability to:

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

REFERENCES:

1. Ajith Abraham and Swagatham Das.,"Computaional Intelligence in Power Engineering", 2010 Springer Verlag.
2. Yong Hua Song, Johns Allen, Aggarwal Raj, 'Computational Intelligence Application to Power System', Springer Netherlands., 1997.

CO-PO MAPPING

CO	PO					
	1	2	3	4	5	6
CO1	1	2	1	-	1	-
CO2	2	3	3		2	
CO3	2	-	3	1	3	2
CO4	3	2	1	2		1
CO5	2	2	2	-	3	-
AVG	2	2.25	2	1.5	2.66	1.5

ET4251 IoT FOR SMART SYSTEMS LT P C
3 0 0 3

COURSE OBJECTIVES:

1. To study about **Internet of Things** technologies and its role in real time applications.
2. To introduce the infrastructure required for IoT
3. To familiarize the accessories and communication techniques for IoT.
4. To provide insight about the embedded processor and sensors required for IoT
5. To familiarize the different platforms and Attributes for IoT

UNIT I INTRODUCTION TO INTERNET OF THINGS 9

Overview, Hardware and software requirements for IOT, Sensor and actuators, Technology drivers, Business drivers, Typical IoT applications, Trends and implications.

UNIT II IOT ARCHITECTURE 9

IoT reference model and architecture -Node Structure - Sensing, Processing, Communication, Powering, Networking - Topologies, Layer/Stack architecture, IoT standards, Cloud computing for IoT, Bluetooth, Bluetooth Low Energy beacons.

UNIT III PROTOCOLS AND WIRELESS TECHNOLOGIES FOR IOT 9
PROTOCOLS:

NFC, SCADA and RFID, Zigbee MIPI, M-PHY, UniPro, SPMI, SPI, M-PCIe GSM, CDMA, LTE, GPRS, small cell.

Wireless technologies for IoT: WiFi (IEEE 802.11), Bluetooth/Bluetooth Smart, ZigBee/ZigBee Smart, UWB (IEEE 802.15.4), 6LoWPAN, Proprietary systems-Recent trends.

UNIT IV IOT PROCESSORS **9**

Services/Attributes: Big-Data Analytics for IOT, Dependability,Interoperability, Security, Maintainability.

Embedded processors for IOT :Introduction to Python programming -Building IOT with RASPERRY PI and Arduino.

UNIT V CASE STUDIES **9**

Industrial IoT, Home Automation, smart cities, Smart Grid, connected vehicles, electric vehicle charging, Environment, Agriculture, Productivity Applications, IOT Defense

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, the students will have the ability to

CO1: Analyze the concepts of IoT and its present developments.

CO2: Compare and contrast different platforms and infrastructures available for IoT

CO3: Explain different protocols and communication technologies used in IoT

CO4: Analyze the big data analytic and programming of IoT

CO5: Implement IoT solutions for smart applications

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	**1**	**2**	**1**	-	-	-
2	-	**2**	-	-	-	-
3	**1**	**2**	-	**1**	**3**	-
4	**2**		**3**	**3**	**3**	**3**
5	**3**	**2**	**3**	**3**	**3**	**3**
Avg.	1.75	2	2.33	2.33	3	2

REFERENCES:

1. ArshdeepBahga and VijaiMadisetti : A Hands-on Approach “Internet of Things”,Universities Press 2015.
2. Oliver Hersent , David Boswarthick and Omar Elloumi “ The Internet of Things”, Wiley,2016.
3. Samuel Greengard, “ The Internet of Things”, The MIT press, 2015.
4. Adrian McEwen and Hakim Cassimally“Designing the Internet of Things “Wiley,2014.
5. Jean- Philippe Vasseur, Adam Dunkels, “Interconnecting Smart Objects with IP: The Next Internet” Morgan Kuffmann Publishers, 2010.
6. Adrian McEwen and Hakim Cassimally, “Designing the Internet of Things”, John Wiley and sons, 2014.
7. Lingyang Song/DusitNiyato/ Zhu Han/ Ekram Hossain,” Wireless Device-to-Device Communications and Networks, CAMBRIDGE UNIVERSITY PRESS,2015.
8. OvidiuVermesan and Peter Friess (Editors), “Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems”, River Publishers Series in Communication, 2013.
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10. Zach Shelby, Carsten Bormann, “6LoWPAN: The Wireless Embedded Internet”, John Wiley and sons, 2009.

11. Lars T.Berger and Krzysztof Iniewski, “Smart Grid applications, communications and security”, Wiley, 2015.
12. JanakaEkanayake, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama and Nick Jenkins, “ Smart Grid Technology and Applications”, Wiley, 2015.
13. UpenaDalal,”Wireless Communications & Networks,Oxford,2015.

PS4092 RENEWABLE ENERGY AND GRID INTEGRATION L T P C
3 0 0 3

COURSE OBJECTIVES:

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

UNIT I INTRODUCTION 9

Introduction to renewable energy systems, environmental aspects of electric energy conversion, impacts of renewable energy penetration to grid. Grid Codes in India and other countries . Basic power electronic converters for renewable energy integration to grid-Qualitative analysis -Boost and buck-boost converters, three phase AC voltage controllers- AC-DC-AC converters, PWM Inverters, Grid Interactive Inverters-matrix converters.

UNIT II PHOTO VOLTAIC ENERGY CONVERSION SYSTEMS 9

Introduction, Photo Voltaic (PV) effect, Solar Cell, Types, Equivalent circuit of PV cell, PV cell characteristics (I/V and P/V) for variation of insolation, temperature and shading effect,Stand-alone PV system, Grid connected PV system, Design of PV system-load calculation, array sizing, selection of converter/inverter, battery sizing.

UNIT III WIND ENERGY CONVERSION SYSTEMS 9

Introduction, Power contained in wind, Efficiency limit in wind, types of wind turbines, Wind control strategies, Power curve and Operating area, Types of wind generators system based on Electrical machines-Induction Generator and Permanent Magnet Synchronous Generator(PMSG), Grid Connected-Single and Double output system, Self-excited operation of Induction Generator and Variable Speed PMSG.

UNIT IV MPPT TECHNIQUES IN SOLAR AND WIND SYSTEMS 9

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

UNIT V HYBRID STORAGE SYSTEMS AND GRID MANAGEMENT 9

Energy Storage systems, Need for Hybrid Systems, Features of Hybrid Systems, Range and types of Hybrid systems (Wind-Diesel, PV-Diesel and Wind-PV),

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1 Relate the power generation of different renewable energy sources to grid impact and grid codes
CO2 Explain the design principles of solar energy management systems
CO3 Understand the power conversion system of wind generators
CO4 Analyze the different Maximum Power Point tracking Techniques
CO5 Build grid connected and stand alone renewable energy management system

REFERENCES:

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

CO-PO MAPPING

CO	PO					
	1	2	3	4	5	6
CO1	1	2	1	-	1	-
CO2	1	1	2	-	1	-
CO3	2	-	1	1	1	2
CO4	1	2	1	2	-	2
CO5	3	3	2	-	2	-
AVG	1.6	2	1.4	1.5	1.25	2

PS4093 **SMART GRID** **L T P C**
3 0 0 3

COURSE OBJECTIVES

- To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure.
- To know about the function of smart grid.
- To familiarize the power quality management issues in Smart Grid.
- To familiarize the high performance computing for Smart Grid applications
- To get familiarized with the communication networks for Smart Grid applications

UNIT I INTRODUCTION TO SMART GRID 9
Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, Comparison of Micro grid and Smart grid, Present development & International policies in Smart Grid, Smart Grid Initiative for Power Distribution Utility in India – Case Study.

UNIT II SMART GRID TECHNOLOGIES 9
Technology Drivers, Smart Integration of energy resources, Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/Var control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV) – Grid to Vehicle and Vehicle to Grid charging concepts.

UNIT III SMART METERS AND ADVANCED METERING INFRASTRUCTURE 9
Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit(PMU) & their application for monitoring & protection. Demand side management and demand response programs, Demand pricing and Time of Use, Real Time Pricing, Peak Time Pricing.

UNIT IV POWER QUALITY MANAGEMENT IN SMART GRID 9
Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

Unit V HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS 9
Architecture and Standards -Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), PLC, Zigbee, GSM, IP based Protocols, Basics of Web Service and CLOUD Computing, Cyber Security for Smart Grid.

TOTAL : 45 PERIODS

COURSE OUTCOME:
Students able to
CO1: Relate with the smart resources, smart meters and other smart devices.
CO2: Explain the function of Smart Grid.
CO3: Experiment the issues of Power Quality in Smart Grid.

CO4: Analyze the performance of Smart Grid.
CO5: Recommend suitable communication networks for smart grid applications

REFERENCES

1. Stuart Borlase 'Smart Grid: Infrastructure, Technology and Solutions', CRC Press 2012.
2. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, 'Smart Grid: Technology and Applications', Wiley, 2012.
3. Mini S. Thomas, John D McDonald, 'Power System SCADA and Smart Grids', CRC Press, 2015
4. Kenneth C.Budka, Jayant G. Deshpande, Marina Thottan, 'Communication Networks for Smart Grids', Springer, 2014
5. SMART GRID Fundamentals of Design and Analysis, James Momoh, IEEE press, A John Wiley & Sons, Inc., Publication.

MAPPING OF CO'S WITH PO'S

CO	PO					
	1	2	3	4	5	6
1	3	2	-	2	2	2
2	3	-	2	2	-	2
3	2	-	1	-	-	-
4	1	-	-	3	3	1
5	-	2	2	2	2	3
AVG	2.25	2	1.66	2.25	2.3	2

PS4004 ELECTRICAL POWER DISTRIBUTION SYSTEM **L T P C**
3 0 0 3

COURSE OBJECTIVES:

- To detail the function of electric power distribution network.
- To derive the voltage profile enhancement and protection schemes.
- To evaluate the reliability of the electrical distribution system.
- To detail the automation schemes in various sections like substation, feeder, etc.,
- To derive the strategies for distribution system expansion.
- To acquire wide knowledge in distribution system operation, protection, control and expansion planning of distribution system architecture

UNIT I DISTRIBUTION SYSTEMS 9

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

UNIT II CONTROL AND PROTECTION 9

Voltage control: Application of shunt capacitance for loss reduction – Harmonics in the system – Static VAR systems – Voltage profile enhancement schemes.

System protection: Fuses and section analyzers - Over current protection - Under voltage and under frequency protection – Coordination of protective device.

UNIT III RELIABILITY ANALYSIS 9

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

UNIT VI DISTRIBUTION AUTOMATION 9

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

UNIT V EXPANSION PLANNING 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students able to

CO1: Obtain fundamental knowledge in electric power distribution system.

CO2: Be proficient in control and protection schemes for distribution systems.

CO3: Gain familiarity to evaluate reliability of distribution systems.

CO4: Demonstrate the methodologies for distribution automation.

CO5: Able to develop strategies for expanding the existing distribution systems.

REFERENCES:

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

7. James J. Burke, “Power distribution engineering: fundamentals and applications”, CRC Press, 2004.

MAPPING OF CO’S WITH PO’S

CO	PO					
	1	2	3	4	5	6
1	1	-	-	-	2	1
2	2	2	2	1	3	2
3	2	2	3	1	2	2
4	2	2	3	1	3	2
5	3	3	2	2	2	2
AVG	2	1.8	2	1	2.4	1.8

PS4005 WIND AND SOLAR ENERGY SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To study the concepts of wind energy system
- To understand the new developments in solar energy system
- To provide students with a solid foundation in mathematical, scientific and engineering fundamentals required to solve wind and solar energy problems

UNIT I WIND ENERGY CONVERSION 9

Wind resources – Nature and occurrence of wind – Power in the wind – Wind characteristics – Principles of wind energy conversions – Components of wind energy conversion system (WECS) – Classification of WECS – Advantages and disadvantages of WECS.

UNIT II WIND ELECTRIC GENERATORS 9

Characteristics of Induction generators – Permanent magnet generators – Single phase operation of induction generators – Doubly fed generators – Grid connected and standalone systems – Controllers for wind driven self-excited systems and capacitor excited isolated systems – Synchronized operation with grid supply – Real and reactive power control.

UNIT III PHOTO VOLTAIC MODELS 9

Solar cells and panels – Structure of PV cells – Semiconductor materials for PV cells – I-V characteristics of PV systems – PV models and equivalent circuits- Effects of irradiance and temperature on PV characteristics.

UNITIV PHOTO VOLTAIC ENERGY CONVERSION SYSTEM 9

Basic photo voltaic system for power generation – Advantages and disadvantages of photo voltaic solar energy conversion –Application of solar photo voltaic system – Components of PV systems- Design of PV systems- Power conditioning and storage arrangement – Maximum power point tracking (MPPT) - Introduction to string inverters.

UNIT V RECENT ADVANCEMENTS IN WIND AND PV SYSTEMS 9

Wind farms and grid connections – Grid related problems on absorption of wind – Grid interfacing arrangement – Operation, control and technical issues of wind generated electrical energy – Interconnected operation – Hybrid systems.
Recent Advances in PV Applications: Building Integrated PV systems, Grid Connected PV systems, Hybrid systems, Solar cars, Solar energy storage system and their economic aspects.

TOTAL: 45 PERIODS

OUTCOMES:

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

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

REFERENCES

1. G.N. Tiwari, "Solar Energy: Fundamentals, Design, Modeling & Application", Narosa Publishing House, 2013.
2. G.D. Rai, "Non-conventional Energy Resources", Sixth Ed., Khanna Publishers, 2018.
3. B.H. Khan, "Non-conventional Energy Resources", Tata McGraw Hill Education India Pvt. Ltd., Third Edition, 2017.
4. D.P.Kothari and K.C.Singhal,"RenewableEnergy Sources and Emerging Technologies", P.H.I. 2nd Ed., 2011.
5. D.S.Chauhan, S.K. Srivastava, "Non – Conventional Energy Resources", 3rd Ed.,New Age Publishers, 2012.
6. Ashish Chandra and Taru Chandra, Non-conventional Energy Resources, 2ndEdn., Khanna Publishers, 2021.

MAPPING OF CO'S WITH PO'S

CO	PO					
	1	2	3	4	5	6
1	1	1	-	-	2	-
2	3	1	3	-	2	3
3	3	2	2	2	3	2
4	2	2	2	1	2	2
5	3	2	3	-	3	2
AVG	2.4	1.6	2.5	1.5	2.4	2.25

PS4091 DISTRIBUTED GENERATION AND MICRO GRID

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

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

UNIT I INTRODUCTION TO DISTRIBUTED GENERATION 9

DG definition - Reasons for distributed generation-Benefits of integration - Distributed generation and the distribution system - Technical, Environmental and Economic impacts of distributed generation on the distribution system - Impact of distributed generation on the transmission system-Impact of distributed generation on central generation

UNIT II DISTRIBUTED ENERGY RESOURCES 9

Combined heat and power (CHP) systems-Wind energy conversion systems (WECS)- Solar photovoltaic (PV) systems-Small-scale hydroelectric power generation-Other renewable energy sources-Storage devices-Inverter interfaces

UNIT III DG PLANNING AND PROTECTION 9

Generation capacity adequacy in conventional thermal generation systems-Impact of distributed generation-Impact of distributed generation on network design-Protection of distributed generation-Protection of the generation equipment from internal Faults-Protection of the faulted distribution network from fault currents supplied by the distributed generator-Impact of distributed generation on existing distribution system protection.

UNIT IV CONCEPT OF MICROGRID 9

Microgrid Definition-A typical Microgrid configuration- Functions of Micro source controller and central controller- Energy Management Module (EMM) and Protection Co-ordination Module (PCM)- Modes of Operation- Grid connected and islanded modes- Modelling of Microgrid- Microturbine Model- PV Solar Cell Model- Wind Turbine Model-Role of Microgrid in power market competition.

UNIT V IMPACTS OF MICROGRID 9

Technical and economical advantages of Microgrid-Challenges and disadvantages of Microgrid development-Management and operational issues of a Microgrid- Impact on heat utilization-Impact on process optimization-Impact on market-Impact on environment-Impact on distribution system-Impact on communication standards and protocols.

Microgrid economics-Main issues of Microgrid economics-Microgrids and traditional power system economics-Emerging economic issues in Microgrids-Economic issues between Microgrids and bulk power systems-Potential benefits of Microgrid economics.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students able to

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

REFERENCES:

1. Nick Jenkins, JanakaEkanayake , GoranStrbac , "Distributed Generation", Institution of Engineering and Technology, London, UK,2010.
2. S. Chowdhury, S.P. Chowdhury and P. Crossley, "Microgrids and Active Distribution Networks", The Institution of Engineering and Technology, London, United Kingdom, 2009.
3. Math H. Bollen , Fainan Hassan, "Integration of Distributed Generation in the Power System", John Wiley &Sons, New Jersey, 2011.
4. Magdi S. Mahmoud, Fouad M. AL-Sunni, "Control and Optimization of Distributed Generation Systems", Springer International Publishing, Switzerland, 2015.
5. NadarajahMithulananthan, Duong Quoc Hung, Kwang Y. Lee, "Intelligent Network Integration of Distributed Renewable Generation", Springer International Publishing, Switzerland, 2017.
6. Ali K., M.N. Marwali, Min Dai, "Integration of Green and Renewable Energy in Electric Power Systems", Wiley and sons, New Jersey, 2010.

MAPPING OF CO'S WITH PO'S

CO	PO					
	1	2	3	4	5	6
1	1	1	2	1	2	1
2	2	2	2	1	3	2
3	2	2	2	1	3	2
4	1	1	2	1	2	1
5	2	2	2	2	3	2
AVG	1.6	1.6	2	1.2	2.4	1.6

PS4072 **ENERGY STORAGE TECHNOLOGIES** **LT P C**
3 0 0 3

COURSE OBJECTIVES:

- To understand the various types of energy storage Technologies
  - To analyze thermal storage system
  - To analyze different battery storage technologies
  - To analyze the thermodynamics of Fuel Cell
  - To study the various applications of energy storage systems

UNIT I INTRODUCTION 9

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

UNIT II THERMAL STORAGE SYSTEM 9

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

UNIT III ELECTRICAL ENERGY STORAGE 9

Fundamental concept of batteries – Measuring of battery performance, charging and dis charging of a battery, storage density, energy density, and safety issues - Types of batteries: – Lead Acid, Nickel-Cadmium, Zinc-Manganese dioxide - Mathematical Modelling for Lead Acid Batteries – Flow Batteries.

UNIT IV FUEL CELL 9

Fuel Cell – History of Fuel cell, Principles of Electrochemical storage – Types: Hydrogen oxygen cells, Hydrogen air cell, Hydrocarbon air cell, Alkaline fuel cell -Detailed analysis – Advantages and disadvantages –Fuel Cell Thermodynamics.

UNIT V ALTERNATE ENERGY STORAGE TECHNOLOGIES 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Understand the physics of energy storage

CO2: Model the different energy technologies.

CO3: Recognize the applications of various techniques.

CO4: Design and analyze the energy storage technologies.

CO5: Select and apply the appropriate technique based on the application.

REFERENCES

1. James Larminie and Andrew Dicks, ‘Fuel cell systems Explained’, Wiley publications, 2003.
2. LunardiniV.J, “Heat Transfer in Cold Climates”, John Wiley and Sons 1981.
3. Jiujun Zhang (Editor), Lei Zhang (Editor), Hansan Liu (Editor), Andy Sun (Editor), Ru-Shi Liu (Editor), “Electrochemical technologies for energy storage and conversion”, Two Volume Set, Wiley publications, 2012

4. Schmidt.F.W. and Willmott.A.J., "Thermal Storage and Regeneration", Hemisphere Publishing Corporation, 1981
5. Luisa F. Cabeza (Editor), "Advances in Thermal Energy Storage Systems: Methods and Applications", Woodhead Publishers, 2020.
6. Ibrahim Dinçer and Marc A. Rosen, "Thermal Energy Storage Systems and Applications", Wiley Publishers, 2021.

MAPPING OF CO'S WITH PO'S

CO	PO					
	1	2	3	4	5	6
1	-	1	-	-	2	-
2	2	1	2	-	3	-
3	2	2	2	-	3	-
4	3	2	3	-	3	3
5	2	2	2	2	2	3
AVG	2.25	1.6	2.25	1	2.6	3

PX4071 POWER QUALITY L T P C
3 0 0 3

OBJECTIVES:

- To provide knowledge about various power quality issues.
- To understand the concept of power and power factor in single phase and three phase systems supplying nonlinear loads.
- To equip with required skills to design conventional compensation techniques for power factor correction and load voltage regulation.
- To introduce the control techniques for the active compensation.
- To understand the mitigation techniques using custom power devices such as DSTATCOM, DVR & UPQC

UNIT I INTRODUCTION 9

Introduction – Characterization of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Non-linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality standards.

UNIT II ANALYSIS OF SINGLE PHASE AND THREE PHASE SYSTEM 9

Single phase linear and non-linear loads - single phase sinusoidal, non-sinusoidal source - supplying linear and nonlinear loads - three phase balanced system - three phase unbalanced system - three phase unbalanced and distorted source supplying non-linear loads - concept of power factor - three phase- three wire - three phase - four wire system.

UNIT III CONVENTIONAL LOAD COMPENSATION METHODS 9

Principle of load compensation and voltage regulation – classical load balancing problem : open loop balancing – closed loop balancing, current balancing – harmonic reduction and voltage sag reduction– analysis of unbalance – instantaneous of real and reactive powers – Extraction of fundamental sequence component from measured.

UNIT IV LOAD COMPENSATION USING DSTATCOM 9

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

UNIT V SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEM 9

Rectifier supported DVR – DC Capacitor supported DVR – DVR Structure – Voltage Restoration – Series Active Filter – Unified Power Quality Conditioner.

TOTAL : 45 PERIODS

OUTCOMES:

After completing the above course, students will be able to

CO1: comprehend the consequences of Power Quality issues.

CO2: conduct harmonic analysis of single phase and three phase systems supplying non-linear loads.

CO3: design passive filter for load compensation.

CO4: design active filters for load compensation.

CO5: understand the mitigation techniques using custom power devices such as distribution static compensator (DSTATCOM), dynamic voltage restorer (DVR) & UPQC.

TEXTBOOKS:

1.Arindam Ghosh and Gerad Ledwich “Power Quality Enhancement Using Custom Power Devices”,Kluwer Academic Publishers, First Edition,2002

2.G.T.Heydt, “Electric Power Quality”, Stars in a Circle Publications, Second Edition, 1994

REFERENCES:

1.R.C.Duggan “Electric Power Systems Quality”, Tata MC Graw Hill Publishers, Third Edition,2012

2.Arrillga “Power System Harmonics”, John Wiely and Sons,2003

3.Derek A.Paice “Power Electronic Converter Harmonics” IEEE Press, 1995

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	3	3	3	2
CO2	3	-	3	3	3	2
CO3	3	-	3	3	3	2
CO4	3	-	3	3	3	2
CO5	3	-	3	3	3	2
AVG	**3**	**-**	**3**	**3**	**3**	**2**

ET4072 MACHINE LEARNING AND DEEP LEARNING **L T P C**
3 0 0 3

COURSE OBJECTIVES:

The course is aimed at

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

UNIT I LEARNING PROBLEMS AND ALGORITHMS 9

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

UNIT II NEURAL NETWORKS 9

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

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

Classifying Samples: The confusion matrix, Accuracy, Precision, Recall, F1- Score, the curse of dimensionality, training, testing, validation, cross validation, overfitting, under-fitting the data, early stopping, regularization, bias and variance. Feature Selection, normalization, dimensionality reduction, Classifiers: KNN, SVM, Decision trees, Naïve Bayes, Binary classification, multi class classification, clustering.

UNIT IV DEEP LEARNING: CONVOLUTIONAL NEURAL NETWORKS 9

Feed forward networks, Activation functions, back propagation in CNN, optimizers, batch normalization, convolution layers, pooling layers, fully connected layers, dropout, Examples of CNNs.

UNIT V DEEP LEARNING: RNNS, AUTOENCODERS AND GANS 9

State, Structure of RNN Cell, LSTM and GRU, Time distributed layers, Generating Text, Autoencoders: Convolutional Autoencoders, Denoising autoencoders, Variational autoencoders, GANs: The discriminator, generator, DCGANs

TOTAL : 45 PERIODS

COURSE OUTCOMES (CO):

At the end of the course the student will be able to

CO1 : Illustrate the categorization of machine learning algorithms.

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

CO3: Acquaint with the pattern association using neural networks

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

CO5: Construct different feature selection and classification techniques and advanced neural network architectures such as RNN, Autoencoders, and GANs.

CO	PO					
	1	2	3	4	5	6
1	1	3	1	-	-	-
2	2	3	2	-	-	-
3	3	-	3	-	3	-
4	2	3	3	-	-	-
5	3	3	3	-	3	-
6	3	3	3	-	3	-
7	3	3	3	-	3	-
Avg.	2.42	3	2.57	-	3	-

REFERENCES:

1. J. S. R. Jang, C. T. Sun, E. Mizutani, Neuro Fuzzy and Soft Computing - A Computational Approach to Learning and Machine Intelligence, 2012, PHI learning
2. Deep Learning, Ian Good fellow, YoshuaBengio and Aaron Courville, MIT Press, ISBN: 9780262035613, 2016.
3. The Elements of Statistical Learning. Trevor Hastie, Robert Tibshirani and Jerome Friedman. Second Edition. 2009.
4. Pattern Recognition and Machine Learning. Christopher Bishop. Springer. 2006.
5. Understanding Machine Learning. Shai Shalev-Shwartz and Shai Ben-David. Cambridge University Press. 2017.

PS4006 POWER SYSTEM RELIABILITY

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To introduce the basic concepts of reliability engineering
- To understand hierarchical levels in power system reliability assessment
- To study the formation of system model
- To learn the importance of reliability indices in power system planning, expansion, operation and control

UNIT I INTRODUCTION 9

Definition of Reliability and Failure - Bathtub Curve - Concepts of Probability- Evaluation Techniques: Markov Process, Recursive Technique - Security levels of system – Reliability cost – Adequacy indices – Functions of system security – Contingency analysis – Linear sensitivity factors- Hierarchical Levels in Power System Reliability Assessment.

UNIT II GENERATING CAPACITY: BASIC PROBABILITY METHODS 9

Generation system models –Capacity outage probability tables – Loss of load indices – Equivalent forced outage rate – Capacity expansion analysis – Scheduled outages – Evaluation methods on period basis– Loss of energy indices.

UNIT III GENERATING CAPACITY: FREQUENCY AND DURATION METHOD 9

Introduction – Generation model with no derated states– System risk indices with individual and cumulative load model– Practical system studies.

UNIT VI COMPOSITE GENERATION AND TRANSMISSION SYSTEM 9

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

UNIT V DISTRIBUTION SYSTEM 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Students able to

CO1: Acquire design knowledge of system components in reliability point of view.

CO2: Understand the importance of customer oriented and system oriented indices.

CO3: Familiarize with reliability evaluation methodologies.

CO4: Analyse the system performance with proper remedial strategies.

CO5: Enrich the capability of analysing reliability design alternatives in engineering systems.

REFERENCES:

1. Dr. K. Uma Rao, “Power system operation & control”, Wiley-India, First edition, 2013.
2. Ali Chowdhury, Don Koval, “Power Distribution System Reliability: Practical Methods and Applications”, Wiley-IEEE Press, 2009.
3. Cepin, Marko, “Assessment of Power System Reliability”, Springer, 2011.
4. Roy Billinton, R.N. Allan, “Reliability Evaluation of Power Systems”, Springer, 1996.
5. M.V.F. Pereira, N.J. Balu, “Composite generation/transmission reliability evaluation”, Proceedings of the IEEE, Vol. 80, No. 4, pp. 470-491, 1992.

MAPPING OF CO’S WITH PO’S

CO	PO					
	1	2	3	4	5	6
1	2	1	2	-	3	2
2	1	1	2	1	2	2
3	3	2	2	-	2	3
4	3	2	3	-	3	2
5	3	2	3	1	3	2
AVG	2.4	1.6	2.4	0.4	2.6	2.2

PS4007 EHV AC TRANSMISSION LT P C
3 0 0 3

COURSEOBJECTIVES:

- To understand power system structure and line configurations
- To compute line parameters and understand effect of ground return
- To analyse voltage gradients of transmission line conductors.
- To compute electrostatic field and design of EHV AC
- To design and know basic concepts of HVDC lines.

UNIT I INTRODUCTION 9

Standard transmission voltages-AC and DC – different line configurations– average values of line parameters – power handling capacity and line loss – costs of transmission lines and equipment – mechanical considerations in line performance

UNIT II CALCULATION OF LINE PARAMETERS 9

Calculation of resistance, inductance and capacitance for multi-conductor lines – calculation ofsequence inductances and capacitances – line parameters for different modes of propagation –effect of ground return

UNIT III VOLTAGE GRADIENTS OF CONDUCTORS 9

Charge-potential relations for multi-conductor lines – surface voltage gradient on conductors – gradient factors and their use – distribution of voltage gradient on sub conductors of bundle - voltage gradients on conductors in the presence of ground wires on towers-I^2R loss and coronaloss-RIV

UNIT IV ELECTROSTATIC FIELD AND DESIGN OF EHV LINES 9

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

UNIT V HVDC LINES 9

Introduction- Reliability and failure issues-Design-tower, ROW, clearances, insulators, electrical and mechanical protection-Maintenance-Control and protection-D.C Electric field and Magneticfield -Regulations and guide lines-under ground line design.

TOTAL : 45 PERIODS

COURSEOUTCOMES:

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	3		3	
CO2	3	3	3	3	3		
CO3	3	3	3	3	3	3	
CO4	3	3	3	3		3	3
CO5	3	3	3	3	3	3	
AVG.	**3**	**3**	**3**	**3**	**1.8**	**2.4**	**0.6**

REFERENCES

1. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", SecondEdition, New Age International Pvt. Ltd., 2006.
2. Pritindra Chowdhari, "Electromagnetic transients in Power System", John Wiley and SonsInc., 2009.
3. Andrew R. Hileman, "Insulation Coordination for Power Systems", CRC press, Taylor &Francis Group, New York, 1999.
4. Power Engineer's Handbook, Revised and Enlarged 6th Edition, TNEB Engineers' Association, October 2002.
5. Sunil S.Rao, "EHV-AC, HVDC Transmission & Distribution Engineering", Third Edition,Khanna Publishers, 2008
6. Gas Insulated Transmission Lines (GIL) – by Hermann Koch, Oct 2011, John Wiley & Sons.

7. William H. Bailey, Deborah E. Weil and James R. Stewart . “A Review on ,”HVDC Power Transmission Environmental Issues”, Oak Ridge National Laboratory.
8. J.C Molburg, J.A. Kavicky, and K.C. Picel ,”A report on The design, Construction and operation of Long-distance High-Voltage Electricity Transmission Technologies” , Argonne (National Laboratory)
9. P.Kundur,“Power system stability and control”,McGraw-Hill,Inc.,1993
10. K.R.Padiyar, “HVDC Power Transmission Systems”, New Age International (P) Ltd.,New Delhi, 2002.

PS4008 ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY IN SYSTEM DESIGN **LT P C 3 0 0 3**

COURSE OBJECTIVES:

1. To provide fundamental knowledge on electromagnetic interference and electromagnetic compatibility.
2. To know about the importance of Grounding and shielding.
3. To study the important techniques to control EMI and EMC.
4. To expose the knowledge on testing techniques as per Indian and international standards in EMI measurement.

UNIT I INTRODUCTION **9**

Definitions of EMI/EMC –Sources of EMI- Inter systems and Intra system- Conducted and radiated interference- Characteristics – Designing for electromagnetic compatibility (EMC)- EMC regulationtypical noise path- EMI predictions and 67odeling, Methods of eliminating interferences and noise mitigation

UNIT II GROUNDING AND CABLING **9**

Cabling- types of cables, mechanism of EMI emission / coupling in cables –capacitive coupling, inductive coupling- shielding to prevent magnetic radiation- shield transfer impedance, Grounding – safety grounds – signal grounds- single point and multipoint ground systems –hybrid grounds- functional ground layout –grounding of cable shields- -guard shields- isolation, neutralizing transformers, shield grounding at high frequencies, digital grounding- Earth measurement Methods

UNIT III BALANCING, FILTERING AND SHIELDING **9**

Power supply decoupling- decoupling filters-amplifier filtering –high frequency filtering- EMI filters characteristics of LPF, HPF, BPF, BEF and power line filter design –Choice of capacitors, inductors, transformers and resistors, EMC design components –shielding – near and far fields shielding effectiveness- absorption and reflection loss- magnetic materials as a shield, shield discontinuities, slots and holes, seams and joints, conductive gaskets-windows and coatings – grounding of shields

UNIT IV EMI IN ELEMENTS AND CIRCUITS 9

Electromagnetic emissions, noise from relays and switches, non-linearities in circuits, passive inter modulation, transients in power supply lines, EMI from power electronic equipment, EMI as combination of radiation and conduction

UNIT V ELECTROSTATIC DISCHARGE, STANDARDS AND TESTING TECHNIQUES 9

Static Generation- human body model- static discharges- ESD versus EMC, ESD protection in equipment- standards – FCC requirements – EMI measurements – Open area test site measurements and precautions- Radiated and conducted interference measurements, Control requirements and testing methods

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1 Ability to understand the types and sources of EMI.
CO2 Ability to understand the needs of rounding and cabling.
CO3 Ability to understand the design concept of filtering and shielding.
CO4 Ability to study the effect of EMI in elements and circuits.
CO5 Ability to know about the effects of electrostatic discharge and testing techniques.

MAPPING OF CO'S WITH PO'S

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	3	3	1	
CO2	3	3	3	3	3		
CO3	3	3	3	3	3	1	2
CO4	3	3	3	3	3	1	2
CO5	3	3	3	3	3	1	2
AVG.	**3**	**3**	**3**	**3**	**3**	**0.8**	**1.2**

REFERENCES

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

PS4009 INDUSTRIAL POWER SYSTEM ANALYSIS AND DESIGN

L T P C
3 0 0 3

Students will be able to:

- To impart knowledge on Motor Starting Studies.
- To understand the need for power factor correction and analyse the various methods that are used in the Power Factor Correction studies.
- To learn about the sources of harmonics, evaluate the harmonics present in the power system and mitigate them by filters.
- To analyse the sources that can cause the voltage flicker and find solutions to minimize the flicker.
- To impart knowledge on the ground grid analysis.

UNIT I MOTOR STARTING STUDIES 9

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

UNIT II POWER FACTOR CORRECTION STUDIES 9

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

UNIT III HARMONIC ANALYSIS 9

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

UNIT IV FLICKER ANALYSIS 9

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

UNIT V GROUND GRID ANALYSIS 9

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

TOTAL: 45 PERIODS

Students will be able to:

CO1: perform motor starting studies.
CO2: To model and carry out power factor correction studies.
CO3: Perform harmonic analysis and reduce the harmonics by using filters.
CO4: Carry out the flicker analysis by proper modeling of the load and its minimization.
CO5: Design the appropriate ground grid for electrical safety.

MAPPING OF CO'S WITH PO'S

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	3	3	1	
CO2	3	3	3	3	3	1	
CO3	3	3	3	3	3	1	
CO4	3	3	3	3	3	1	
CO5	3	3	3	3	3	1	2
AVG.	**3**	**3**	**3**	**3**	**3**	**1**	**0.4**

REFERENCES

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

PS4010 ADVANCED POWER SYSTEM DYNAMICS **LT P C**
3 0 0 3

COURSE OBJECTIVES
- To perform transient stability analysis using unified algorithm.
- To impart knowledge on sub-synchronous resonance and oscillations.
- To analyze voltage stability problem in power system.
- To familiarize the methods of transient stability enhancement.

UNIT I SUBSYSNCHRONOUS RESONANCE (SSR) AND OSCILLATIONS 9
Subsysnchronous Resonance (SSR) – Types of SSR - Characteristics of series –Compensated transmission systems –Modelling of turbine-generator-transmission network- Self-excitation due to induction generator effect – Torsional interaction resulting in SSR – Methods of analyzing SSR – Numerical examples illustrating instability of sub synchronous oscillations –time-domain simulation of sub synchronous resonance – EMTP with detailed synchronous machine model- Turbine Generator Torsional Characteristics: Shaft system model – Examples of torsional characteristics – Torsional Interaction with Power System Controls: Interaction with generator excitation controls – Interaction with speed governors – Interaction with nearby DC converters.

UNIT II TRANSMISSION, GENERATION AND LOAD ASPECTS OF VOLTAGE STABILITY ANALYSIS 9
Review of transmission aspects – Generation Aspects: Review of synchronous machine theory – Voltage and frequency controllers – Limiting devices affecting voltage stability – Voltagereactive power characteristics of synchronous generators – Capability curves – Effect of machine limitation on deliverable power – Load Aspects – Voltage dependence of loads – Load restoration dynamics – Induction motors – Load tap changers – Thermostatic load recovery – General aggregate load models.

UNIT III SMALL SIGNAL STABILITY ANALYSIS AND ENHANCEMENT 9

Multi machine small signal stability analysis - Effects of Excitation System - Power System Stabilizer: Block diagram with AVR and PSS, Illustration of principle of PSS application with numerical example, Block diagram of PSS with description, system state matrix including PSS, analysis of stability with numerical example. Multi-Machine Configuration: Equations in a common reference frame, equations in individual machine rotor coordinates, illustration of formation of system state matrix with classical model and variable voltage behind transient reactant model of synchronous machines, illustration of stability analysis using a numerical example. Principle behind small-signal stability improvement methods: delta-omega and delta P-omega stabilizers.

UNIT IV UNIFIED ALGORITHM FOR DYNAMIC ANALYSIS OF POWERSYSTEMS 9

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

UNIT V INSTABILITY MECHANISM AND COUNTER MEASURES 9

Types of Counter measures – Classification of Instability Mechanisms – Examples of Short term Voltage Instability- Counter measures to Short – term Instability – Case studies of Long Term voltage Instability – Corrective Actions against Long-term Instability.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Students will be able to:

CO1: Understand the concepts behind sub-synchronous resonance and detect the SSR by suitable modeling

CO2: Analyze the effect of generation and transmission and load dynamics on voltage stability.

CO3: Analyze the effect of load dynamics on power system voltage stability.

CO3: analyze and enhance small signal stability of the power system.

CO4: Analyze the short-term and long-term stability of the power system using unified stability algorithm.

CO5: study and analyze the various instability mechanisms of voltage stability.

MAPPING OF CO'S WITH PO'S

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	1
CO2	3	3	3	3	3	1
CO3	3	3	3	3	3	1
CO4	3	3	3	3	3	1
CO5	3	3	3	3	3	1
AVG	**3**	**3**	**3**	**3**	**3**	**1**

REFERENCES

1. R.Ramanujam," Power System Dynamics Analysis and Simulation, PHI Learning Private Limited, New Delhi,2009
2. T.V. Cutsem and C.Vournas, "Voltage Stability of Electric Power Systems", Kluwer publishers,1998.
3. P. Kundur, Power System Stability and Control, McGraw-Hill,1993.

4. H.W. Dommel and N.Sato, "Fast Transient Stability Solutions," IEEE Trans., Vol. PAS- 91, pp, 1643-1650, July/August1972.
5. Roderick J.Frowd and J. C. Giri, “Transient stability and Long term dynamics unified”, IEEE Trans., Vol 101, No. 10, October1982.
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ET4073 PYTHON PROGRAMMING FOR MACHINE LEARNING **L T P C**
3 0 0 3

COURSE OBJECTIVES:

1. Students will understand and be able to use the basic programming principles such as data types, variable, conditionals, loops, recursion and function calls.
2. Students will learn how to use basic data structures such as List, Dictionary and be able to manipulate text files and images.
3. To make the students familiar with machine learning concepts & techniques.
4. Students will understand the process and will acquire skills necessary to effectively attempt a machine learning problem and implement it using Python.
5. To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved research/employability skills

UNIT I INTRODUCTION TO MACHINE LEARNING AND PYTHON 9

Introduction to Machine Learning: Significance, Advantage and Applications – Categories of Machine Learning – Basic Steps in Machine Learning: Raw Data Collection, Pre-processing, Training a Model, Evaluation of Model, Performance Improvement

Introduction to Python and its significance – Difference between C, C++ and Python Languages; Compiler and Interpreters – Python3 Installation & Running – Basics of Python Programming Syntax: Variable Types, Basic Operators, Reading Input from User – Arrays/List, Dictionary and Set – Conditional Statements – Control Flow and loop control statements

UNIT II PYTHON FUNCTIONS AND PACKAGES 9

File Handling: Reading and Writing Data – Errors and Exceptions Handling – Functions & Modules – Package Handling in Python – Pip Installation & Exploring Functions in python package – Installing the Numpy Library and exploring various operations on Arrays: Indexing, Slicing, Multi-Dimensional Arrays, Joining Numpy Arrays, Array intersection and Difference, Saving and Loading Numpy Arrays – Introduction to SciPy Package & its functions - Introduction to Object Oriented Programming with Python

UNIT III IMPLEMENTATION OF MACHINE LEARNING USING PYTHON 9

Description of Standard Datasets: Coco, ImageNet, MNIST (Handwritten Digits) Dataset, Boston Housing Dataset – Introducing the concepts of Regression – Linear, Polynomial & Logistic Regression with analytical understanding - Introduction to SciPy Package & its functions – Python Application of Linear Regression and Polynomial Regression using SciPy – Interpolation, Overfitting and Underfitting concepts & examples using SciPy

UNIT IV CLASSIFICATION AND CLUSTERING CONCEPTS OF ML 9

Introduction to ML Concepts of Clustering and Classification – Types of Classification Algorithms – Support Vector Machines (SVM) - Decision Tree - Random Forest – Introduction to ML using scikit-learn – Using scikit-learn, Loading a sample dataset, Learning & prediction, interpolation & fitting, Multiclass fitting - Implementation of SVM using Blood Cancer Dataset, Decision Tree using data from csv.

Types of Clustering Algorithms & Techniques – K-means Algorithm, Mean Shift Algorithm & Hierarchical Clustering Algorithm – Introduction to Python Visualization using Matplotlib: Plotting 2-dimensional, 3-dimensional graphs; formatting axis values; plotting multiple rows of data in same graph – Implementation of K-means Algorithm and Mean Shift Algorithm using Python

UNIT V INTRODUCTION TO NEURAL NETWORKS AND EMBEDDED MACHINE LEARNING 9

Introduction to Neural Networks & Significance – Neural Network Architecture – Single Layer Perceptron & Multi-Layer Perceptron (MLP) – Commonly Used Activation Functions - Forward Propagation, Back Propagation, and Epochs – Gradient Descent – Introduction to Tensorflow and Keras ML Python packages – Implementation of MLP Neural Network on Iris Dataset – Introduction to Convolution Neural Networks – Implementation of Digit Classification using MNIST Dataset

ML for Embedded Systems: Comparison with conventional ML – Challenges & Methods for Overcoming – TinyML and Tensorflow Lite for Microcontrollers – on-Board AI – ML Edge Devices: Arduino Nano BLE Sense, Google Edge TPU and Intel Movidius

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, the students will have the ability to

CO1: Develop skill in system administration and network programming by learning Python.

CO2: Demonstrating understanding in concepts of Machine Learning and its implementation using Python

CO3: Relate to use Python's highly powerful processing capabilities for primitives, modelling etc

CO4: Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design.

CO5: Apply the concepts acquired over the advanced research/employability skills

CO	PO					
	1	2	3	4	5	6
1	-	-	2	3	3	-
2	3	1	3	-	3	1
3	2	1	2	-	3	3
4	3	2	3	3	3	3
5	-	-	-		3	-
Avg.	2.66	1.33	2.5	3	3	2.33

REFERENCES:

1. Mark Lutz,"LearningPython,Powerful OOPs,O'reilly,2011

2. Zelle, John "M. Python Programming: An Introduction to Computer Science.", Franklin Beedle& Associates, 2003
3. Andreas C. Müller, Sarah Guido, "Introduction to Machine Learning with Python", O'Reilly,2016
4. Sebastian Raschka , VahidMirjalili, "Python Machine Learning - Third Edition", Packt, December 2019

PS4011 COMPUTER RELAYING AND WIDE AREA MEASUREMENT SYSTEMS **L T P C**
3 0 0 3

COURSE OBJECTIVES:

The goal of this course is

1. To discriminate conventional relays and computer relays
2. To comprehend the operating values of a computer relays
3. To provide exposure to wide area measurement systems through the computer hierarchy in the substation, system relaying and control
4. To inculcate knowledge on phasor measurement unit and its application to power system
5. To enhance the conventional power system studies with wide area measurement techniques

UNIT I INTRODUCTION 9

Historical background - Expected benefits - Computer relay architecture - Analog to digital converters - Anti-aliasing filters - Substation computer hierarchy - Fourier series Exponential fourier series - Sine and cosine fourier series – Phasor.

UNIT II FILTERS IN COMPUTER RELAYING 9

Walsh functions - Fourier transforms - Discrete fourier transform - Random processes - Filtering of random processes - Kalman filtering - Digital filters - Windows and windowing - Linear phase Approximation - Filter synthesis – Wavelets - Elements of artificial intelligence.

UNIT III COMPUTATION OF PHASORS 9

Introduction - Phasor representation of sinusoids - Fourier series and Fourier transform and DFT Phasor representation - Phasor Estimation of Nominal Frequency Signals - Formulas for updating phasors – Non-recursive updates - Recursive updates - Frequency Estimation.

UNIT IV PHASOR MEASUREMENT UNITS 9

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

UNIT V PHASOR MEASUREMENT APPLICATIONS 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students able to

- **CO1** Demonstrate knowledge of fundamental theories, principles and practice of computer relaying, Wide area measurement system
- **CO2** Analyze the power system with computer relaying and Wide area measurement system
- **CO3** Validate the recent relaying technologies which work towards smart grid
- **CO4** Design wide area measurement systems for Smart grid.
- **CO5** Compare the performance of modern relaying schemes and measurement techniques with the conventional one.

REFERENCES:

1. A.G. Phadke, J.S. Thorp, "Computer Relaying for Power Systems", John Wiley and Sons Ltd., Research Studies Press Limited, 2nd Edition, 2009.
2. A.G. Phadke, J.S. Thorp, "Synchronized Phasor Measurements and Their Applications", Springer, 2008
3. Antonello Monti, Carlo Muscas, FerdinandaPonci,"Phasor Measurement Units and Wide Area Monitoring Systems" Academic Press, 09-Jun-2016
4. Stanley H. Horowitz, Arun G. Phadke, "Power System Relaying", John Wiley & Sons, 25-Oct-2013.

MAPPING OF CO'S WITH PO'S

CO	PO					
	1	2	3	4	5	6
1	3	-	3	-	3	-
2	3	-	3	-	3	3
3	3	-	3	-	-	3
4	3	-	3	-	-	3
5	3	-	3	-	-	3
AVG	3	-	3	-	3	3

PS4012 APPLICATION OF DSP TO POWER SYSTEM PROTECTION L T P C
3 0 0 3

COURSE OBJECTIVES:

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

UNIT I DIGITAL SIGNAL PROCESSING TECHNIQUES 9

Sampling-Principle of scaling-aliasing-Decimation, Interpolation. Fourier and discrete Fourier transforms - Fast Fourier Transforms.-Wavelet transform -Numerical Algorithms

UNIT II DIGITAL PROTECTION 9

Digital Protection -performance and operational characteristics of digital protection. Basic components of digital relays -Signal conditioning systems -Conversion subsystem -digital relay subsystem- Numerical relay for generator, transformer, feeder, busbar protection

UNIT III ALGORITHMIC TECHNIQUES 9

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

UNIT IV DIGITAL PROTECTION TECHNIQUES 9

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

UNIT V DIGITAL PROTECTIVE RELAYS 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES

CO1: The students will be able to apply DSP techniques for digital protection.
CO2: The students will be capable of decision making algorithm suitable for digital relaying applications.
CO3: The students will be able to employ FIR based algorithms for digital relaying.
CO4: The students will be able to do transformer protection using digital techniques.
CO5: The students will be able to perform coordinated operation of relays for specific purposes.

REFERENCES

1. J.L. Blackburn, Protective Relaying: Principles and Applications, Marcel Dekker, New York, 1987.
2. A.G. Phadke and J.S. Thorp, Computer Relaying for Power Systems, John Wiley & Sons, New York, 1988.
3. J.G. Proakis and D.G. Manolakis, ‘Digital Signal Processing Principles, Algorithms
4. Y.G. Paithankar and S.R Bhide, “Fundamentals of Power System Protection”,PHI Learning; 2nd edition edition (July 30, 2013)

MAPPING OF CO’S WITH PO’S

CO	PO					
	1	2	3	4	5	6
CO1	1	2	1	-	1	-
CO2	1	1	2	-	3	1
CO3	2	-	3	1	1	1
CO4	1	2	1	2	-	1
CO5	2	2	2	-	3	1
AVG	1.4	1.75	1.8	1.5	2.33	1

PS4013 POWER SYSTEM INSTRUMENTATION **L T P C**
3 0 0 3

COURSE OBJECTIVES:

- To use the processors in the process and their relative merits to be brought out.
- To explain the algorithms used in the investigation procedure and error analysis.
- To offer an opportunity to innovate newer procedures and better methods for effective design of instrumentation systems for power networks.
- To provide the knowledge on various controls and measurements involved in power plant
- To import knowledge on distribution automation and substation controls

UNIT I MEASUREMENTS AND SCADA SYSTEMS 9

Measurement and error analysis. Object and philosophy of power system instrumentation to measure large currents, high voltages, Torque and Speed - Standard specifications - Data acquisition systems for Power System applications - Data Transmission and Telemetry - PLC equipment - computer control of power system - Man Machine Interface.

UNIT II POWER PLANT INSTRUMENTATION 9

Piping and Instrumentation diagram of thermal and nuclear power plants - Fuel measurement – gas analysis meters - smoke measurement - Monitoring systems – measurement and control of furnace draft – measurement and control of combustion – Turbine monitoring and control: speed, vibration, shell temperature monitoring – radiation detection instruments – process sensors for nuclear power plants – spectrum analyzers – nuclear reactor control systems and allied instrumentation.

UNIT III DISTRIBUTION AUTOMATION 9

Definitions – automation switching control – management information systems (MIS) – remote terminal units – communication method for data transfer – consumer information service (CIS) – graphical information systems (GIS) - automatic meter reading (AMR) – Remote control load management.

UNIT VI SUBSTATION INSTRUMENTATION 9

Sub-station automation – requirements – control aspects in substations – feeder automation – consumer side automation – reliability - GPIB programmable test instruments - microprocessor / microcontroller based GPIB controllers

UNIT V ENERGY MANAGEMENT TECHNIQUES AND INSTRUMENTS 9

Demand side management (DSM)– DSM planning – DSM Techniques – Load management as a DSM strategy – energy conservation – tariff options for DSM - Energy audit – instruments for energy audit – Energy audit for generation, distribution and utilization systems – economic analysis.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Students able to

CO1: understand the basics of instrumentation and SCADA system implementation in PS
CO2: understand and implement the controls involved in power plant instrumentation
CO3: understand the functioning of distribution automation in power system network
CO4: understand concepts of substation automation and to implement the controls
CO5: analyse the energy management techniques and energy audit

REFERENCES:

1. Liptak B.G, Instrumentation in Process Industries, Vol I and II, Chilton Book Co., 1973.
2. Sherry A., Modern Power Station Practice, Vol.6 (Instrumentation, controls and Testing), Pergamon Press,1971.
3. Pabla. A.S "Electric power distribution "- Tata McGraw Hill; New Delhi 2004
4. MahalanaBis A K, Kothari D P and Ahson S I " Computer aided Power System analysis and control" - Tata McGraw Hill; New Delhi 1988.
5. Murphy. W.R and McKay G "Energy Management" Butterworths Publications, London 1982

6. Wayne C Tuner “Energy Management Hand Book” John Wiley and Sons, 1982

MAPPING OF CO’S WITH PO’S

CO	PO					
	1	2	3	4	5	6
1	2	1	1	-	1	2
2	3	2	2	-	2	2
3	2	2	1	-	2	2
4	3	2	1	-	2	2
5	2	2	1	2	2	2
AVG	2.4	1.8	1.2	0.4	1.8	2

PS4014 HIGH VOLTAGE TECHNOLOGY LT P C
3 0 0 3

COURSE OBJECTIVES

- To provide strong knowledge on different types of electrical stresses on power system and equipment
- To impart knowledge on generation of high AC and DC voltages
- To provide adequate knowledge to simulate and generate impulse voltages and impulse currents.
- To expose the different techniques of measuring High voltages and high currents
- To provide awareness on electro-static hazards and safety measures

UNIT I GENERATION OF DIRECT VOLTAGES 9

Requirements of HV generation in Laboratory, voltage stress, testing voltages, generation of direct voltages – AC to DC conversion – single phase rectifier circuits – cascade circuits –Voltage multiplier circuits – Cockcroft-Walton circuit – voltage regulation –ripple-factor – Electrostatic generators.

UNIT II GENERATION OF ALTERNATING VOLTAGE 9

Testing transformer – single unit testing transformer, cascaded transformer – equivalent circuit of cascaded transformer –resonant circuits – resonant transformer – voltage regulation.

UNIT III GENERATION OF IMPULSE VOLTAGES AND CURRENTS 9

Impulse voltage, general shape and definition of lightning impulses, generator circuit – Marx generator –analysis of various impulse voltage generator circuits, controlled switching – multistage impulse generator circuits – Switching impulse generator circuits – Generation of impulse currents, generation of non- standard impulse voltages and very fast transient voltage (VFTO)- Relevant IS and IEC Standards

UNIT IV MEASURMENT OF HIGH VOLTAGES 9

Measurement of high AC, DC Impulse voltages - Peak voltage measurements by sphere gaps – Electrostatic voltmeter – generating voltmeters and field sensors – Chubb-Fortescue method – voltage dividers, types, dynamic response and impulse voltage measurements- Relevant IS and IEC Standards, measurement of high DC, AC and impulse currents – shunts, measurement using magnetic potentiometers and magnetic coupling - Fast digital transient recorders for impulse measurements

UNIT V SAFETY AND ELECTROSTATIC HAZARDS 9

Introduction – Nature of static electricity – Triboelectric series – Basic laws of Electrostatic electricity– materials and static electricity – Electrostatic discharges (ESD) – Static electricity problems – Hazards of Electrostatic electricity in industry – Hazards from electrical equipment and installations – Static eliminators and charge neutralizers – Lightning protection- safety measures and standards

TOTAL : 45 PERIODS

COURSEOUTCOMES:

CO1: Ability to design, simulate and generate HVDC
CO2: Ability to design, simulate and generate HVAC
CO3: Ability to design, simulate and generate impulse voltage and current
CO4: Ability to design and analyze the suitable measuring circuits for HV
CO5: Ability to provide safety measures against electrostatic hazards

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	-	3
CO2	3	3	3	2	-	3
CO3	3	3	3	2	-	3
CO4	3	3	-	1	-	-
CO5	-	-	-	-	-	-
AVG.	2.4	2.4	1.8	1.6	-	1.8

REFERENCES

1. Kuffel, E., Zaengl, W.S. and Kuffel J., “High Voltage Engineering Fundamentals”, Elsvier India Pvt. Ltd, Second edition, 2008
2. Naidu M S and Kamaraju V, “High Voltage Engineering”, Tata McGraw-hill Publishing Company Ltd., Fifth edition., New Delhi, 2017.
3. R.Mazen Abdel-Salam, Hussein Anis, Ahdab El-Morshedy, RoshdyRadwan, “High Voltage Engineering Theory and Practice” Second Edition, Revised and Expanded, Marcel Dekker,Inc., New York, 2000.
4. Adolf J. Schwab, “High Voltage Measurement Techniques”, M.I.T Press, 1972.
5. Indian Electricity Rules; IS-5216; Electrical Safety Handbook by John Cadick

PX4291 ELECTRIC VEHICLES AND POWER MANAGEMENT **L T P C 3 1 0 4**

OBJECTIVES:

- To understand the concept of electric vehicles and its operations
- To present an overview of Electric Vehicle (EV), Hybrid Electric vehicle (HEV) and their architecture
- To understand the need for energy storage in hybrid vehicles
- To provide knowledge about various possible energy storage technologies that can be used in electric vehicles

UNIT I ELECTRIC VEHICLES AND VEHICLE MECHANICS 12

Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings- Comparisons of EV with internal combustion Engine vehicles- Fundamentals of vehicle mechanics.

UNIT II ARCHITECTURE OF EV's AND POWER TRAIN COMPONENTS 12

Architecture of EV's and HEV's – Plug-n Hybrid Electric Vehicles (PHEV)- Power train components and sizing, Gears, Clutches, Transmission and Brakes.

UNIT III POWER ELECTRONICS AND MOTOR DRIVES 12

Electric drive components – Power electronic switches- four quadrant operation of DC drives – Induction motor and permanent magnet synchronous motor-based vector control operation – Switched reluctance motor (SRM) drives- EV motor sizing.

UNIT IV BATTERY ENERGY STORAGE SYSTEM 12

Battery Basics- Different types- Battery Parameters-Battery life & safety impacts -Battery modeling-Design of battery for large vehicles.

UNIT V ALTERNATIVE ENERGY STORAGE SYSTEMS 12

Introduction to fuel cell – Types, Operation and characteristics- proton exchange membrane (PEM) fuel cell for E-mobility– hydrogen storage systems –Super capacitors for transportation applications.

TOTAL : 60 PERIODS

OUTCOMES:

After the completion of this course, students will be able to

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

REFERENCES:

1. Iqbal Hussain, “Electric and Hybrid Vehicles: Design Fundamentals, Second Edition” CRC Press, Taylor & Francis Group, Second Edition (2011).
2. Ali Emadi, Mehrdad Ehsani, John M.Miller, “Vehicular Electric Power Systems”, Special Indian Edition, Marcel dekker, Inc 2010.
3. Mehrdad Ehsani, YiminGao, Sebastian E. Gay, Ali Emadi, 'Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design', CRC Press, 2004.
4. C.C. Chan and K.T. Chau, 'Modern Electric Vehicle Technology', OXFORD University Press, 2001.
5. Wie Liu, “Hybrid Electric Vehicle System Modeling and Control”,Second Edition, John Wiley & Sons, 2017.

CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	3	2
CO2	3	3	3	2	3	2
CO3	3	3	3	2	3	2
CO4	3	3	3	2	3	2
CO5	3	3	3	2	3	2
AVG.	**3**	**3**	**3**	**2**	**3**	**2**

PS4071 ENERGY MANAGEMENT AND AUDITING LT P C
3 0 0 3

OBJECTIVES:

- To study the concepts behind economic analysis and load management
- To emphasize the energy management of various electrical equipment and metering
- To illustrate the concept of energy management technologies

UNIT I ENERGY SCENARIO 9

Basics of Energy and its various forms - Conventional and non-conventional sources - Energy policy - Energy conservation act 2001, Amedments (India) in 2010 - Need for energy management- Designing and starting an energy management program - Energy managers and energy auditors - Roles and responsibilities of energy managers - Energy labelling and energy standards.

UNIT II ENERGY COST AND LOAD MANAGEMENT 9

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

UNIT III ENERGY MANAGEMENT 9

Demand side management (DSM)– DSM planning – DSM techniques – Load management as a DSM strategy – Energy conservation – Tariff options for DSM.

UNIT IV ENERGY AUDITING 9

Definition – Energy audit methodology: audit preparation, execution and reporting – Financial analysis – Sensitivity analysis – Project financing options - Instruments for energy audit – Energy audit for generation, distribution and utilization systems – Economic analysis.

UNIT V ENERGY EFFICIENT TECHNOLOGIES 9

Energy saving opportunities in electric motors - Power factor improvement benefit and techniques- Shunt capacitor, Synchronous Condenserand Phase Advancer - Energy conservation in industrial drives, electric furnaces, ovens and boilers - Lighting techniques: Natural,CFL, LED lighting sources and fittings.

TOTAL : 45 PERIODS

OUTCOMES:

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

CO1: Understand the present energy scenario and role of energy managers.

CO2: Comprehend the Economic Models for cost and load management.

CO3: Configure the Demand side energy management through its control techniques, strategy and planning.

CO4: Understand the process of energy auditing.

CO5: Implement energy conservation aspects in industries.

REFERENCES

1. Barney L. Capehart, Wayne C. Turner, William J. Kennedy, “Guide to Energy Management”, CRC press, Taylor & Francis group, Eighth Edition, 2016.
2. https://prsindia.org/files/bills_acts/bills_parliament/2010/The_Energy_Conservation_Amendment_Bill_2010.pdf
3. Eastop T.D and Croft D.R, “Energy Efficiency for Engineers and Technologists”, Logman Scientific & Technical, 1990.
4. IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities, IEEE, 1996.
5. Amit K. Tyagi, “Handbook on Energy Audits and Management”, TERI, 2003.
6. https://www.eeeguide.com/power-factor-improvement.
7. Anil Kumar, **,Om Prakash,Prashant Singh Chauhan**“Energy Management: Conservation and Audits, CRC Press, 2020.
8. Barney L. Capehart, Wayne C. Turner, William J. Kennedy, “Guide to Energy Management”, CRC press, Taylor & Francis group, Eighth Edition, 2016.
9. S.C. Bhatia and Sarvesh Devraj, “Energy Conservation”, Woodhead Publishing India Pvt. Ltd, 2016.

CO	PO					
	1	2	3	4	5	6
1	2	2	2	-	2	-
2	2	3	2	1	2	1
3	2	2	2	1	2	2
4	1	2	2	3	-	-
5	3	3	2	3	3	3
AVG	2	2.4	2	2	2.25	2

AX4091 ENGLISH FOR RESEARCH PAPER WRITING **L T P C**
2 0 0 0

OBJECTIVES

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

UNIT I INTRODUCTION TO RESEARCH PAPER WRITING **6**

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

UNIT II PRESENTATION SKILLS **6**

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

UNIT III TITLE WRITING SKILLS **6**

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

UNIT IV RESULT WRITING SKILLS **6**

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

UNIT V VERIFICATION SKILLS **6**

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

TOTAL: 30 PERIODS

OUTCOMES

CO1 –Understand that how to improve your writing skills and level of readability
CO2 –Learn about what to write in each section
CO3 –Understand the skills needed when writing a Title
CO4 – Understand the skills needed when writing the Conclusion

CO5 – Ensure the good quality of paper at very first-time submission

REFERENCES

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

AX4092 DISASTER MANAGEMENT **LT P C**
2 0 0 0

OBJECTIVES

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches

UNIT I INTRODUCTION 6

Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS 6

Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

UNIT III DISASTER PRONE AREAS IN INDIA 6

Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics

UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT 6

Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT V RISK ASSESSMENT 6

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival

TOTAL : 30 PERIODS

OUTCOMES

CO1: Ability to summarize basics of disaster

CO2: Ability to explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.

CO3: Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.

CO4: Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.

CO5: Ability to develop the strengths and weaknesses of disaster management approaches

REFERENCES

1. Goel S. L., Disaster Administration And Management Text And Case Studies",Deep& Deep Publication Pvt. Ltd., New Delhi,2009.
2. NishithaRai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'NewRoyal book Company,2007.
3. Sahni, PardeepEt.Al. ," Disaster Mitigation Experiences And Reflections", Prentice Hall OfIndia, New Delhi,2001.

AX4093 CONSTITUTION OF INDIA L T P C
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OBJECTIVES

Students will be able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional
- Role and entitlement to civil and economic rights as well as the emergencenation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

UNIT I HISTORY OF MAKING OF THE INDIAN CONSTITUTION

History, Drafting Committee, (Composition &Working)

UNIT II PHILOSOPHY OF THE INDIAN CONSTITUTION

Preamble, Salient Features

UNIT III CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES

Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

UNIT IV ORGANS OF GOVERNANCE
Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

UNIT V LOCAL ADMINISTRATION
District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: ZilaPachayat. Elected officials and their roles, CEO ZilaPachayat: Position and role.Block level: Organizational Hierarchy(Different departments), Village level:Roleof Elected and Appointed officials, Importance of grass root democracy.

UNIT VI ELECTION COMMISSION
Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.

TOTAL: 30 PERIODS

OUTCOMES
Students will be able to:
- Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
- Discuss the intellectual origins of the framework of argument that informed the conceptualization
- ofsocial reforms leading to revolution in India.
- Discuss the circumstances surrounding the foundation of the Congress Socialist Party[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- Discuss the passage of the Hindu Code Bill of 1956.

SUGGESTED READING

1. The Constitution of India,1950(Bare Act),Government Publication.
2. Dr.S.N.Busi, Dr.B.R.Ambedkarframing of Indian Constitution,1stEdition, 2015.
3. M.P. Jain, Indian Constitution Law, 7thEdn.,Lexis Nexis,2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

AX4094 **நற்றமிழ்இலக்கியம்** **LT P C 2 0 0 0**

UNIT I **சங்கஇலக்கியம்** **6**

1. தமிழின்துவக்கநூல்தொல்காப்பியம்

   – எழுத்து, சொல், பொருள்

2. அகநானூறு (82)

   - இயற்கைஇன்னிசைஅரங்கம்

3. குறிஞ்சிப்பாட்டின்மலர்க்காட்சி

4. புறநானூறு (95,195)

   - போரைநிறுத்தியஔவையார்

UNIT II **அறநெறித்தமிழ்** **6**

1. அறநெறிவகுத்ததிருவள்ளுவர்

   - அறம்வலியுறுத்தல், அன்புடைமை, ஒப்புரவறிதல், ஈகை, புகழ்

2. பிறஅறநூல்கள்- இலக்கியமருந்து

– ஏலாதி, சிறுபஞ்சமூலம், திரிகடுகம், ஆசாரக்கோவை (தூய்மையைவலியுறுத்தும்நூல்)

UNIT III **இரட்டைக்காப்பியங்கள்** **6**

1.கண்ணகியின்புரட்சி

- சிலப்பதிகாரவழக்குரைகாதை

2. சமூகசேவைஇலக்கியம்மணிமேகலை

- சிறைக்கோட்டம்அறக்கோட்டமாகியகாதை

UNIT IV அருள்நெறித்தமிழ் 6

1. சிறுபாணாற்றுப்படை

- பாரிமுல்லைக்குத்தேர்கொடுத்தது,

பேகன்மயிலுக்குப்போர்வைகொடுத்தது,

அதியமான்ஔவைக்குநெல்லிக்கனிகொடுத்தது, அரசர்பண்புகள்

2. நற்றிணை

- அன்னைக்குரியபுன்னைசிறப்பு

3. திருமந்திரம் (617, 618)

- இயமம்நியமம்விதிகள்

4. தர்மச்சாலையைநிறுவிய வள்ளலார்
5. புறநானூறு
   - சிறுவனேவள்ளலானான்

6. அகநானூறு (4) - வண்டு

நற்றிணை (11) - நண்டு

கலித்தொகை (11) - யானை, புறா

ஐந்திணை 50 (27) - மான்

ஆகியவைபற்றியசெய்திகள்

UNIT V நவீனதமிழ்இலக்கியம் 6

1. உரைநடைத்தமிழ்,

- தமிழின்முதல்புதினம்,
- தமிழின் முதல் சிறுகதை,
- கட்டுரை இலக்கியம்,

- பயணஇலக்கியம்,
- நாடகம்,

2. நாட்டுவிடுதலைபோராட்டமும்தமிழ்இலக்கியமும்,
3. சமுதாயவிடுதலையும்தமிழ்இலக்கியமும்,
4. பெண்விடுதலையும்விளிம்புநிலையினரின்மேம்பாட்டில்தமிழ்இலக்கியமும்,
5. அறிவியல்தமிழ்,
6. இணையத்தில்தமிழ்,
7. சுற்றுச்சூழல்மேம்பாட்டில்தமிழ்இலக்கியம்.

<u>தமிழ்இலக்கியவெளியீடுகள் / புத்தகங்கள்</u>

1. தமிழ்இணையகல்விக்கழகம் (Tamil Virtual University)

   - www.tamilvu.org

2. தமிழ்விக்கிப்பீடியா (Tamil Wikipedia)

-https://ta.wikipedia.org

3. தர்மபுர ஆதீன வெளியீடு

4. வாழ்வியல்களஞ்சியம்

   - தமிழ்ப்பல்கலைக்கழகம், தஞ்சாவூர்

5. தமிழ்கலைக்களஞ்சியம்

   - தமிழ்வளர்ச்சித்துறை (thamilvalarchithurai.com)

6. அறிவியல்களஞ்சியம்

   - தமிழ்ப்பல்கலைக்கழகம், தஞ்சாவூர்

TOTAL: 30 PERIODS