SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur-603203.

DEPARTMENT OF

ELECTRICAL AND ELECTRONICS ENGINEERING

Post Graduate

CURRICULA AND SYLLABI

(Regulations 2019)

Programme: M.E. Power Systems Engineering

SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

PROGRAMME: M.E-POWER SYSTEMS ENGINEERING

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

1. To prepare the students to have career in the electrical power industry/research organization/teaching.
2. To provide good foundation in mathematics and computational technology to analyze and solve problems encountered in electrical power industry.
3. Pursue lifelong learning and continuous improvement of their knowledge in the electrical power industry.
4. To understand the national and global issues related to the electrical power industry and to be considerate of the impact of these issues on the environment and within different cultures.
5. Apply the highest professional and ethical standards to their activities in the electrical power industry.
6. To provide the students with knowledge to be involved with the technology advancements and future developments in power generation, control and management as well as with alternate and new energy resources.

PROGRAM OUTCOMES (PO):

On successful completion of the programme Graduates will be able to

1. Demonstrate the principles and practices of the electrical power industry regarding generation, transmission, distribution and electrical machines and their controls.
2. Apply their knowledge of electrical power principles, as well as mathematics and scientific principles to new applications in electrical power.
3. Perform, analyze, and apply the results of experiments to electrical power application improvements.
4. Look at all options in design and development projects and creativity and choose the most appropriate option for the current project.
5. Function effectively as a member of a project team.
6. Identify problems in electrical power systems, analyze the problems and solve them using all of the required and available resources.
7. Effectively communicate technical project information in writing or in personal presentation and conversation.
8. Engaged in continuously learning the new practices, principles, and techniques of the electrical power industry.
9. Work on application software packages for power system analysis and design.
10. Develop indigenous software packages for power system planning and operational problems of utilities

PROGRAM SPECIFIC OUTCOMES (PSOs):

1. Ability to apply the knowledge of Advanced Power System Analysis, Power System Protection, Restructured Power Systems, Electromagnetic Transients, HVDC, FACTS and System Theory to Power System Engineering Problems.
2. Ability to design, analyze and investigate the power system components using the modern engineering tools and Economic Operation of Power System

PEO/PO Mapping

PEO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
1	3	3	3	3	3	3	3	3	3	3	3	3
2	3	3	3	3	3			3	3	3	3	3
3								3				
4	2		3	3		3			3	3	2	3
5					3		3	3	3	3	3	3
6	3	3	3	3		3		3	3	3	3	3

Contribution 1:Reasonable 2:Significant 3:Strong

MAPPING – PG POWER SYSTEMS ENGINEERING

Year	Sem	Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
Year I	Sem I	Applied Mathematics for Electrical Engineers	3	2	2	1								
		Advanced Power System Analysis	2	1	2	1		2		1	2	1	2	2
		Power System Operation and Control	2	2	1	2	1	2	3	2	2	1	3	2
		Analysis and Computation of Electromagnetic Transients in Power Systems	3	2	2	1	1	1			1	1	1	1
		System Theory	2	3	2	2		1		2	2		3	3
		Professional Elective I												
		Power System Simulation Laboratory	3	3	3			3		3	3	2	3	3
Year I	Sem II	Power System Dynamics	2	2	2					1	1	2	2	2
		HVDC and FACTS	2	1	2	2	2	1	1	1	1	1	1	1
		Advanced Power System Protection	3	2	2	1	1	2	1	2	2	2	2	2
		Restructured Power System	2	3	2	1	1	1		1	1	2	3	
		Professional Elective II												
		Professional Elective III												
		Advanced Power System Simulation Laboratory	3	3	3			3		3	3	3	3	3
		Technical Seminar					3		3					1
Year II	Sem III	Professional Elective IV												
		Professional Elective V												
		Professional Elective VI												
		Project Work Phase I	2	2	2	3	1	1	1	1	2	2	3	3
Year II	Sem IV	Project Work Phase II	2	2	2	3	1	1	1	1	2	2	3	3

SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution, Affiliated to Anna University, Chennai)

M.E. POWER SYSTEMS ENGINEERING

REGULATIONS – 2019
CHOICE BASED CREDIT SYSTEM
CURRICULA & SYLLABI (I TO IV SEMESTERS)

SEMESTER I

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	1918106	Applied Mathematics for Electrical Engineers	FC	4	4	0	0	4
2.	1916101	Advanced Power System Analysis	PC	4	4	0	0	4
3.	1916102	Power System Operation and Control	PC	3	3	0	0	3
4.	1916103	Analysis and Computation of Electromagnetic Transients in Power Systems	PC	3	3	0	0	3
5.	1916104	System Theory	PC	4	3	1	0	4
6.		Professional Elective I	PE	3	3	0	0	3
PRACTICALS								
7.	1916108	Power System Simulation Laboratory	PC	4	0	0	4	2
		TOTAL		**25**	**20**	**1**	**4**	**23**

SEMESTER II

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	1916201	Power System Dynamics	PC	3	3	0	0	3
2.	1916202	HVDC and FACTS	PC	3	3	0	0	3
3.	1916203	Advanced Power System Protection	PC	3	3	0	0	3
4.	1916204	Restructured Power System	PC	3	3	0	0	3
5.		Professional Elective II	PE	3	3	0	0	3
6.		Professional Elective III	PE	3	3	0	0	3
PRACTICALS								
7.	1916211	Advanced Power System Simulation Laboratory	PC	4	0	0	4	2
8.	1916212	Technical Seminar	EEC	2	0	0	2	1
		TOTAL		**24**	**18**	**0**	**6**	**21**

SEMESTER III

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Professional Elective IV	PE	3	3	0	0	3
2.		Professional Elective V	PE	3	3	0	0	3
3.		Professional Elective VI	PE	3	3	0	0	3
PRACTICALS								
4.	1916310	Project Work Phase I	EEC	12	0	0	12	6
TOTAL				**21**	**9**	**0**	**12**	**15**

SEMESTER IV

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICALS								
1.	1916401	Project Work Phase II	EEC	24	0	0	24	12
TOTAL				**24**	**0**	**0**	**24**	**12**

SUMMARY

SL NO.	SUBJECT AREA	CREDIT AS PER SEMESTER				CREDITS TOTAL	%
		I	II	III	IV		
1	FC	4	-	-	-	4	6
2	PC	16	14	-	-	30	42
3	PE	3	6	9	-	18	25
4	EEC	-	1	6	12	19	27
	Total	**23**	**21**	**15**	**12**	**71**	**100**

TOTAL NO. OF CREDITS: 71

PROFESSIONAL ELECTIVES (PE)
SEMESTER I

ELECTIVE I

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	1916105	Analysis of Electrical Machines	PE	3	3	0	0	3
2.	1916106	Analysis and Design of Power Converters	PE	3	3	0	0	3
3.	1916107	Industrial Power System Analysis and Design	PE	3	3	0	0	3

SEMESTER II
ELECTIVE II and III

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	1916205	Smart Grid	PE	3	3	0	0	3
2.	1916206	Solar and Energy Storage Systems	PE	3	3	0	0	3
3.	1916207	Power System Reliability	PE	3	3	0	0	3
4.	1916208	Advanced Digital Signal Processing	PE	3	3	0	0	3
5.	1916209	Distributed Generation and Microgrid	PE	3	3	0	0	3
6.	1916210	Soft Computing Techniques	PE	3	3	0	0	3

SEMESTER III
ELECTIVE IV, V and VI

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	1916301	Electrical Distribution System	PE	3	3	0	0	3
2.	1916302	Energy Management and Auditing	PE	3	3	0	0	3
3.	1916303	Wind Energy Conversion Systems	PE	3	3	0	0	3
4.	1916304	Electric Vehicles and Power Management	PE	3	3	0	0	3
5.	1916305	Electromagnetic Interference and Compatibility	PE	3	3	0	0	3
6.	1916306	Control System Design for Power Electronics	PE	3	3	0	0	3
7.	1916307	Principles of Electric Power Transmission	PE	3	3	0	0	3
8.	1916308	Advanced Power System Dynamics	PE	3	3	0	0	3
9.	1916309	Design of Substations	PE	3	3	0	0	3

FOUNDATION COURSES (FC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	1918106	Applied Mathematics for Electrical Engineers	FC	4	4	0	0	4

PROFESSIONAL CORE (PC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	1916101	Advanced Power System Analysis	PC	4	4	0	0	4
2.	1916102	Power System Operation and Control	PC	3	3	0	0	3
3.	1916103	Analysis and Computation of Electromagnetic Transients in Power Systems	PC	3	3	0	0	3
4.	1916104	System Theory	PC	4	3	1	0	4
5.	1916108	Power System Simulation Laboratory	PC	4	4	0	0	2
6.	1916201	Power System Dynamics	PC	3	3	0	0	3
7.	1916202	HVDC and FACTS	PC	3	3	0	0	3
8.	1916203	Advanced Power System Protection	PC	3	3	0	0	3
9.	1916204	Restructured Power System	PC	3	3	0	0	3
10.	1916211	Advanced Power System Simulation Laboratory	PC	4	4	0	0	2

EMPLOYMENT ENHANCEMENT COURSES (EEC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	1916212	Technical Seminar	EEC	2	0	0	2	1
2.	1916310	Project Work Phase I	EEC	12	0	0	12	6
3.	1916401	Project Work Phase II	EEC	24	0	0	24	12

1918106 APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS **L T P C**

4 0 0 4

OBJECTIVES:

- The primary objective of this course is to demonstrate various analytical skills in applied mathematics
- The students to identify, formulate, abstract, and solve problems in Calculus of Variations
- The extensive experience with the tactics of linear programming problem solving and logical thinking applicable in Electrical engineering.
- This course also will help study the decomposition of matrices and Matrix Theory.
- This gives application of Probability and random variables with its distributions.

UNIT-I: MATRIX THEORY **12**

Cholesky decomposition - Generalized Eigenvectors - QR Factorization-Least squares method - Singular value decomposition.

UNIT-II: CALCULUS OF VARIATIONS **12**

Concept of variation and its properties – Euler's equation – Functional dependent on first and higher order derivatives – Functionals dependent on functions of several independent variables – Variational problems with moving boundaries – Isoperimetric problems - Direct methods : Ritz methods.

UNIT-III: PROBABILITY AND RANDOM VARIABLES **12**

Probability – Axioms of probability – Conditional probability – Random variables- Probability function–Moments– Moment generating functions and their properties–Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions–Function of random variable.

UNIT-IV: LINEAR PROGRAMMING **12**

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

UNIT-V: FOURIER SERIES **12**

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

TOTAL: 60 PERIODS

COURSE OUTCOMES:

After completing this course, students should demonstrate competency in the following skills:

- Apply various methods in matrix theory to solve system of linear equations.
- Maximizing and minimizing the functional that occur in electrical engineering discipline.
- Computation of probability and moments, standard distributions of discrete and

continuous random variables and functions of a random variable.

- Could develop a fundamental understanding of linear programming models, able to develop a linear programming model from problem description, apply the simplex method for solving linear programming problems.
- Fourier series analysis and its uses in representing the power signals.

REFERENCES :

1. Andrews L.C. and Phillips R.L., "Mathematical Techniques for Engineers and Scientists", Prentice Hall of India Pvt. Ltd., New Delhi,2005.
2. Bronson, R. "Matrix Operation", Schaum's outline series, 2nd Edition, McGraw Hill,2011.
3. Elsgolc, L. D. "Calculus of Variations", Dover Publications, New York,2007.
4. Johnson, R.A., Miller, I and Freund J., "Miller and Freund's Probability and Statistics for Engineers", Pearson Education, Asia, 8th Edition,2015.
5. O'Neil, P.V., "Advanced Engineering Mathematics", Thomson Asia Pvt. Ltd., Singapore,2003.
6. Taha, H.A., "Operations Research, An Introduction", 9th Edition, Pearson education, New Delhi, 2016

CO / PO & PSO Mapping :

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	3	2	2	1								
CO2	3	2	2	1								
CO3	3	2	2	1								
CO4	3	2	2	1								
CO5	3	2	2	1								

1916101	ADVANCED POWER SYSTEM ANALYSIS	L	T	P	C
		4	0	0	4

OBJECTIVES:

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

- To illustrate different numerical integration methods and factors influencing transient stability.

UNIT-I: SOLUTION TECHNIQUE 12

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 Bifactorization and Gauss elimination methods; Repeat solution using Left and Right factors and L and U matrices.

UNIT-II: POWER FLOW ANALYSIS 12

Power flow equation in real and polar forms; Review of Newton's 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 12

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 12

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

UNIT-V: TRANSIENT STABILITY ANALYSIS 12

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

TOTAL:60 PERIODS

COURSE OUTCOMES:

- Ability to apply the concepts of sparse matrix for large scale power system analysis.
- Ability to analyze power system studies that needed for the transmission system planning.
- Ability to apply the optimal power flow solutions to power system.
- Ability to apply the concept of Z-Bus building algorithm for large scale power system for obtaining protection system parameter calculation.
- Ability to understand transient stability analysis of power system.

REFERENCES:

1. A.J.Wood and B.F.Wollenberg, "Power Generation Operation and Control", Wiley; Second edition 2006.
2. M.A.Pai," Computer Techniques in Power System Analysis", McGraw Hill Education; 3rd edition 2017.
3. G W Stagg, A.H El. Abiad, "Computer Methods in Power System Analysis", Medtech, 2019.
4. P.Kundur, "Power System Stability and Control", McGraw Hill, first edition 2006.
5. W.F.Tinney and W.S.Meyer, "Solution of Large Sparse System by Ordered Triangular Factorization" IEEE Trans. on Automatic Control, Vol : AC-18, pp:333- 346, Aug 1973.
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 & PSO Mapping :

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	3					1		1	3	2	3	3
CO2	2	1	3			2		1	3	1	1	
CO3	2	2	3			3			3	1	3	2
CO4	1	1	3	3		1			1	1	1	1
CO5	1	2	2	1		1			1	2	2	2

1916102 POWER SYSTEM OPERATION AND CONTROL

L	T	P	C
3	0	0	3

OBJECTIVES:

- To understand the fundamentals of load characteristics, load forecasting and operation of load dispatch centre.
- To understand the fundamentals of speed governing system and the concept of control areas.
- To provide knowledge about Hydrothermal scheduling.
- To provide knowledge about Unit commitment and economic dispatch.
- To impart knowledge on the need of state estimation and its role in the day- today operation of power system

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: Load forecasting, techniques of forecasting, basics of power system operation and control. Operation of load dispatch centre.

UNIT-II: REAL POWER - FREQUENCY CONTROL 9

Fundamentals of speed governing mechanism and modelling: Speed-load characteristics – Load sharing between two synchronous machines in parallel; concept of control area, LFC control of a single-area system: Static and dynamic analysis of uncontrolled and controlled cases, Economic Dispatch Control. Multi-area systems: Two-area system modelling; static analysis, uncontrolled case; tie line with frequency bias control of two-area system derivation, state variable model.

UNIT-III: HYDROTHERMAL SCHEDULING PROBLEM 9

Hydrothermal scheduling problem: short term and long term-mathematical model, algorithm. Dynamic programming solution methodology for Hydro-thermal scheduling with pumped hydro plant: Optimization with pumped hydro plant-Scheduling of systems with pumped hydro plant during off-peak seasons: algorithm. Selection of initial feasible trajectory for pumped hydro plant- Pumped hydro plant as spinning reserve unit-generation of outage induced constraint- Pumped hydro plant as Load management plant.

UNIT-IV: UNIT COMMITMENT AND ECONOMIC DISPATCH 9

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

UNIT-V: STATE ESTIMATION 9

Need for power system state estimation- Network observability – DC state estimation model- State estimation of power system – Methods of state estimation: Least square state estimation, Weighted least square state estimation, Maximum likelihood- Bad data detection and identification.

TOTAL :45 PERIODS

COURSE OUTCOMES:

- Learners will be able to understand system load variations and get an overview of power system operations.
- Learners will understand the real power frequency control on single and multi area power system.
- Learners will attain knowledge about hydrothermal scheduling.
- Learners will understand the significance of unit commitment and different solution methods.
- Learners will understand the need for state estimation in real time operation.

REFERENCES::

1. Allen.J.Wood and Bruce F.Wollenberg, “Power Generation, Operation and Control”, John Wiley & Sons, Inc., 2003.
2. Olle. I. Elgerd, “Electric Energy Systems Theory – An Introduction”, Tata McGraw Hill Publishing Company Ltd, New Delhi, Second Edition, 2003.
3. L.L. Grigsby, “The Electric Power Engineering, Hand Book”, CRC Press & IEEE Press, 2001.
4. D.P. Kothari and I.J. Nagrath, “Modern Power System Analysis”, Third Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2003.
5. P. Kundur, “Power System Stability & Control”, McGraw Hill Publications, USA, 1994.
6. John D.grainger,William D,”Power System Analysis”, International edition, McGraw Hill Publications, USA, 1994

CO / PO & PSO Mapping :

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	3	2	2	1	2	2	3	2	2	1	3	2
CO2	3		2	2		3	2		3		3	3
CO3	2	2	1	3			3	1	3	3	1	3
CO4	3	2		3	3	2	3	2	1		3	2
CO5	1	3	1	2	2	1	2	3	2	2	3	2

1916103	ANALYSIS AND COMPUTATION OF ELECTROMAGNETIC TRANSIENTS IN POWER SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the various parameters of travelling waves.
- To understand the Lightning, Switching and temporary over voltages.
- To understand the OH lines parameters.
- To understand the modeling and function of cables.
- To understand the concept of EMTP in power system.

UNIT-I: REVIEW OF TRAVELLING WAVE PHENOMENA 9

Lumped and Distributed Parameters – Wave Equation – Reflection, Refraction, Behaviour of Travelling waves at the line terminations – Lattice Diagrams – Attenuation and Distortion.

UNIT-II: LIGHTNING, SWITCHING AND TEMPORARY OVER VOLTAGES 9

Lightning over voltages: interaction between lightning and power system- ground wire voltage and voltage across insulator; switching overvoltage: Short line or kilometric fault, energizing transients - closing and re-closing of lines, methods of control; temporary over voltages: line dropping, load rejection; voltage induced by fault; Very Fast Transient Overvoltage (VFTO).

UNIT-III: PARAMETERS AND MODELING OF OVERHEAD LINES 9

Review of line parameters for simple configurations: series resistance, inductance and shunt capacitance; bundle conductors : equivalent GMR and equivalent radius; modal propagation in transmission lines: modes on multi-phase transposed transmission lines, α-β-0 transformation and symmetrical components transformation, modal impedances; analysis of modes on un-transposed lines; effect of ground return and skin effect; transposition schemes; introduction to frequency-dependent line modeling.

UNIT-IV: PARAMETERS AND MODELING OF UNDERGROUND CABLES 9

Distinguishing features of underground cables: technical features, electrical parameters, overhead lines versus underground cables; cable types; series impedance and shunt admittance of single-core self-contained cables, impedance and admittance matrices for three phase system formed by three single-core self-contained cables; approximate formulas for cable parameters.

UNIT-V: COMPUTATION OF POWER SYSTEM TRANSIENTS 9

Digital computation of line parameters: Necessity of line parameter evaluation programs. Salient features of a typical line parameter evaluation program; constructional features of that affect transmission line parameters; line parameters for physical and equivalent phase conductors elimination of ground wires bundling of conductors; principle of digital computation of transients: features and capabilities of electromagnetic transients program; steady state and time step solution modules: basic solution methods; case studies on simulation of various types of transients using EUROSTAG and PSCAD.

TOTAL :45 PERIODS

COURSE OUTCOMES:

- Learners will be able to understand the concept of travelling waves.
- Learners will be able to understand various types of over voltages.
- Learners will be able to model overhead lines.
- Learners will be able to model cables and transformers.
- Learners will be able to understand the EMTP program.

REFERENCES:

1. Allan Greenwood “Electrical Transients in Power System”, Wiley and sons, Inc., New york, Second Edition, 1991.
2. R. Ramanujam, “Computational Electromagnetic Transients: Modeling, Solution Methods and simulation, I.K.International Publishing House Pvt limited, New delhi 2014.
3. Naidu M S and Kamaraju V, “High Voltage Engineering”, Tata McGraw-Hill Publishing company Ltd, New Delhi, Third Edition, 2005.

CO / PO & PSO Mapping :

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	3	1	2									
CO2	3	2	2									
CO3	3	3	2	1		1			1			
CO4	3	3	2	1		1			1	2	3	3
CO5	3	3	2	1	2	1			3	3	3	3

1916104	SYSTEM THEORY	L	T	P	C
		3	1	0	4

OBJECTIVES:

- Fundamentals of physical systems in terms of its linear and nonlinear models in the state variable form.
- Solving linear and non-linear state equations by different techniques.
- Exploit the properties of linear systems such as controllability and observability for Stability analysis.
- Educate on model concepts and design of state and output feedback controllers and estimators.
- Educate on stability analysis of systems using Lyapunov's theory for Linear and Non Linear Systems

UNIT-I: STATE VARIABLE REPRESENTATION **12**

Introduction - Concept of State - State 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 **12**

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 - Cayley Hamilton's Theorem – Canonical form.

UNIT-III: STABILITY ANALYSIS OF LINEAR SYSTEMS **12**

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

UNIT-IV: STATE FEEDBACK CONTROL AND STATE ESTIMATOR **12**

Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems- The 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.

UNIT-V: LYAPUNOV STABILTY ANALYSIS **12**

Introduction-Equilibrium Points- BIBO Stability-Stability of LTI Systems- Stability in the sense of Lyapunov - Equilibrium Stability of Nonlinear Continuous-Time Autonomous Systems-The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous-Time Autonomous Systems – Krasovskil's and Variable-Gradiant Method.

TOTAL :60 PERIODS

COURSE OUTCOMES:

- Ability to acquire the knowledge on Physical Systems representation in the State Variable form.
- Ability to acquire the knowledge on the solution of state transition matrix by different techniques.
- Ability to represent the time-invariant systems in state space form as well as analyze, whether the system is stabilizable, controllable, observable and detectable.

- Ability to assess the stability of certain class of non-linear system.
- Ability to apply the techniques such as describing function, Lyapunov Stability, Popov's Stability Criterion and Circle Criterion to assess the stability of certain class of non-linear system. Ability to design state feedback controller and state observers.

REFERENCES:

1. M. Gopal, "Modern Control System Theory", New Age International, 2005.
2. K. Ogatta, "Modern Control Engineering", Prentice Hall India Pvt. Ltd., 2010.
3. C.T. Chen, "Linear Systems Theory and Design'' Oxford University Press, 3rd Edition,1999
4. John S. Bay, "Fundamentals of Linear State Space Systems", McGraw-Hill, 1999.
5. D. Roy Choudhury, "Modern Control Systems", New Age International, 2015.
6. John J. D'Azzo, C. H. Houpis and S. N. Sheldon, "Linear Control System Analysis and Design with MATLAB", Taylor Francis, 2003.
7. Z. Bubnicki, "Modern Control Theory", Springer, 2005.
8. M. Vidyasagar, "Nonlinear Systems Analysis", 2nd edition, Prentice Hall, Englewood Cliffs, New Jersey,2002.

CO / PO & PSO Mapping :

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	2	3	2	2		2		2	2		3	2
CO2	2	3	2	2		2		2	2		3	2
CO3	2	3	3	3		2		2	2		3	3
CO4	2	3	2	2		2		2	2		3	3
CO5	2	3	3	2		3		2	3		3	3

1916108	**POWER SYSTEM SIMULATION LABORATORY**	**L**	**T**	**P**	**C**
		0	**0**	**4**	**2**

OBJECTIVES:

- To have hands on experience on various system studies and different techniques used for system planning, software packages.
- To apply iterative techniques for power flow analysis
- To analyse power system security using shift factors.
- To analyse the overcurrent relay settings and their coordination.
- To study the characteristics of PV cell, Wind Energy Conversion System and Fuel Cell.

LIST OF EXPERIMENTS

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

TOTAL: 60 PERIODS

COURSE OUTCOMES:

- Ability to analyze the power flow using Newton-Raphson method, Fast decoupled method and Ladder Iterative Technique.
- Able to perform contingency analysis & state estimation.
- Ability to select and coordinate over current relay.
- Acquired knowledge in steady state voltage stability.
- Able to analyze the characteristics of PV system, Wind Energy Conversion System & hybrid power system.

LIST OF EQUIPMENTS FOR A BATCH OF 18 STUDENTS:

1	Computers (Intel Core i3, 250 GB, 2 GB RAM)	18
2	Printer	1
3	Server (Intel Core i3, 4 GB RAM) (High Speed Processor)	1
4	Software: MATLAB / PSCAD / EUROSTAG / MIPOWER any Power system simulation software	5 Users license

.

CO / PO & PSO Mapping :

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	3	3	3			3		3	3	3	3	3
CO2	3	3	3			3		3	3	2	3	3
CO3	3	3	3			3		3	3	2	3	3
CO4	3	3	3			3		3	3	2	3	3
CO5	3	3	3			3		3	3	2	3	3

1916201	POWER SYSTEM DYNAMICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart knowledge on dynamic modeling of a synchronous machine in detail.
- To describe the modeling of excitation and speed governing system in detail.
- To understand the fundamental concepts of Small signal stability without controller.
- To understand the fundamental concepts of Small signal stability with controller.
- To understand and enhance small signal stability problem of power systems.

UNIT-I: SYNCHRONOUS MACHINE MODELLING 9

Schematic Diagram, Physical Description: armature and field structure, machines with multiple pole pairs, mmf waveforms, direct and quadrature axes, Mathematical Description of a Synchronous Machine: Basic equations of a synchronous machine: stator circuit equations, stator self, stator mutual and stator to rotor mutual inductances, dq0 Transformation: flux linkage and voltage equations for stator and rotor in dq0 coordinates, electrical power and torque, 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 relationships, Phasor representation, Rotor angle, Steady-state equivalent circuit, Computation of steady-state values, Equations of Motion: Swing Equation, calculation of inertia constant, Representation in system studies, Synchronous Machine Representation in Stability Studies: Simplifications for large-scale studies : Neglect of stator transients, Simplified model with amortisseurs neglected: two-axis model with amortisseur windings neglected, classical model.

UNIT-II: MODELLING OF EXCITATION AND SPEED GOVERNING SYSTEMS 9

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

UNIT-III: SMALL-SIGNAL STABILITY ANALYSIS WITHOUT CONTROLLERS 9

Classification of Stability, Basic Concepts and Definitions: Rotor angle stability, The Stability Phenomena. Fundamental Concepts of Stability of Dynamic Systems: State-space representation, stability of dynamic system, Linearization, Eigen properties of the state matrix: Eigen values and eigenvectors, modal matrices, Eigen value and stability, mode shape and participation factor. Single-Machine Infinite Bus (SMIB) Configuration: Classical Machine Model stability analysis with numerical example, Effects of Field Circuit Dynamics: synchronous machine, network and linearised system equations, block diagram representation with K- constants; expression for K-constants (no derivation), effect of field flux variation on system stability: analysis with numerical example.

UNIT-IV: SMALL-SIGNAL STABILITY ANALYSIS WITH CONTROLLERS 9

Effects Of Excitation System: Equations with definitions of appropriate K-constants and simple thyristor excitation system and AVR, block diagram with the excitation system, analysis of effect of AVR on synchronizing and damping components using a numerical example, 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 a example. Multi-Machine Configuration: Equations in a common reference frame, equations in individual machine rotor coordinates, illustration of formation of system state matrix for a two-machine system with classical models for synchronous machines, illustration of stability analysis using a numerical example. Principle behind small- signal stability improvement methods: delta-omega and delta P-omega stabilizers. Metheds of improving stability.

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 stabilizer gain – Stabilizer limits

TOTAL:45 PERIODS

COURSE OUTCOMES:

- Learners will be able to understand on dynamic modelling of synchronous machine.
- Learners will be able to understand the modeling of excitation and speed governing system for stability analysis.
- Learners will attain knowledge about stability of dynamic systems.
- Learners will understand the significance about small signal stability analysis with controllers
- Learners will understand the enhancement of small signal stability.

REFERENCES:

1. P. W. Sauer and M. A. Pai, “Power System Dynamics and Stability”, Stipes Publishing Co, 2007.
2. P. Kundur, “Power System Stability and Control”, McGraw-Hill, 1993.
3. P.M Anderson and A.A Fouad, “Power System Control and Stability”, Iowa State University Press, Ames, Iowa, 1978.
4. R.Ramunujam,” Power System Dynamics Analysis and Simulation, PHI Learning Private Limited, New Delhi, 2009

CO / PO & PSO Mapping :

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	2	3	1						1	1	3	3
CO2	1	2	1						1	2	2	1
CO3	2	1	3						1	3	1	1
CO4	2	1	2					1	1	1	1	2
CO5	3	1	2					1	2	1	1	1

1916202	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. Comparison of AC & DC Transmission, Applications of DC Transmission Topologies.

UNIT II SVC & STATCOM **9**

Configuration of SVC- voltage regulation by SVC- Modelling of SVC for load flow analysis- Design of SVC to regulate the mid-point voltage of a SMIB system- Applications Static synchronous compensator (STATCOM) - Operation of STATCOM – Voltage regulation -Power flow control with STATCOM.

UNIT-III: TCSC and SSSC **9**

Concepts of Controlled Series Compensation- Operation of TCSC - Analysis of TCSC operation - Modelling of TCSC for load flow studies - Static synchronous series compensator(SSSC) - Operation of SSSC - Modelling of SSSC for power flow – operation of Unified power flow controllers(UPFC).

UNIT-IV: ANALYSIS OF HVDC LINK **9**

Evolution of HVDC Transmission - Simplified analysis of six pulse Graetz bridge – Charecteristics - Analysis of converter operations – Different modes of converter operation - Commutation overlap – Equivalence circuit of bipolar DC transmission link – Modes of operation – Mode ambiguity – Different firing angle controllers – Power flow control.

UNIT-V: POWER FLOW ANALYSIS IN AC/DC SYSTEMS **9**

Per unit system for DC Quantities - Modelling of DC links - Solution of DC load flow - Solution of AC-DC power flow – Unified and Sequential methods.

TOTAL:45 PERIODS

COURSE OUTCOMES:

- Learners will be able to refresh on basics of power transmission networks and need for FACTS controllers.
- Learners will understand the significance about different voltage source converter based FACTS controllers.
- Learners will be able to understand the mathematical model of various FACTS devices and its power flow control in power system
- Learners will understand the significance of HVDC converters and HVDC system control.
- Learners will attain knowledge on various methods of AC/DC power flow analysis.

REFERENCES:

1. Mohan Mathur, R., Rajiv. K. Varma, "Thyristor – Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc. 2012.
2. Kalyan K. Sen, Mey Ling Sen, "Introduction to FACTS Controllers: Theory, Modeling, and Applications", IEEE Press Series on Power Engineering, Wiley-IEEE Press, Year: 2016.
3. K.R.Padiyar, "HVDC Power Transmission Systems", third edition New Age International (P) Ltd., New Delhi, 2017.
4. V.K.Sood, "HVDC and FACTS controllers- Applications of Static Converters in Power System", Kluwer Academic Publishers, 2013.
5. K.R.Padiyar, "FACTS Controllers in Power Transmission and Distribution", second edition,New Age International(P) Ltd., Publishers, New Delhi, 2016.
6. J.Arrillaga, "High Voltage Direct Current Transmission", Peter Pregrinus, London, 1998.
7. S Kamakshaiah, V. Kamaraju "HVDC Transmission" McGraw Hill Education, 2017.
8. EW Kimbark, "Direct Current Transmission" Wiley-Blackwell; Volume 1 edition (1 January 1971)

CO / PO & PSO Mapping :

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	1	1	2	2	3						3	
CO2	2	1	3	1	2	1			1			2
CO3	2	2	3	1	3			3		1		1
CO4	3	1	2	3	1		1					2
CO5	1	1	2	2	3	1			1		2	

1916203	ADVANCED POWER SYSTEM PROTECTION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To illustrate concepts of transformer protection.
- To describe about the various schemes of over current protection.
- To analyze distance and carrier protection.
- To familiarize the concepts of Generator protection.
- To familiarize the concepts of Numerical protection.

UNIT-I: OVER CURRENT & EARTH FAULT PROTECTION 9

Zones of protection – Primary and Backup protection – operating principles and Relay Construction - Time – Current characteristics-Current setting – Time setting-Over current protective schemes – Concept of Coordination - Protection of parallel / ring feeders - Reverse power or directional relay– Polarisation Techniques – Cross Polarisation – Quadrature Connection -Earth fault and phase fault protection - Combined Earth fault and phase fault protection scheme - Phase fault protective - scheme directional earth fault relay - Static over current relays – Numerical over – current protection; numerical coordination example for a radial feeder

UNIT-II: TRANSFORMER & BUSBAR PROTECTION 9

Types of transformers –Types of faults in transformers- Types of Differential Protection – High Impedance – External fault with one CT saturation – Actual behaviors of a protective CT – Circuit model of a saturated CT - Need for high impedance – Disadvantages - Percentage Differential Bias Characteristics – Vector group & its impact on differential protection - Inrush phenomenon – Zero Sequence filtering – High resistance Ground Faults in Transformers – Restricted Earth fault Protection - Inter-turn faults in transformers – Incipient faults in transformers –DGA for transformer monitoring, Phenomenon of overfluxing in transformers – Transformer protection application chart. Differential protection of busbars external and internal fault - Supervisory relay-protection of three – Phase busbars – Numerical examples on design of high impedance busbar differential scheme – Biased Differential Characteristics – Comparison between Transformer differential & Busbar differential.

UNIT-III: DISTANCE AND CARRIER PROTECTION OF TRANSMISSION LINES 9

Drawback of over – Current protection – Introduction to distance relay – Simple impedance relay Reactance relay – mho relays comparison of distance relay – Distance protection of a three – Phase line-reasons for inaccuracy of distance relay reach - Three stepped distance protection - Trip contact configuration for the three - Stepped distance protection - Three- stepped protection of three-phase line against all ten shunt faults - Impedance seen from relay side - Three-stepped protection of double end fed lines-need for carrier – Aided protection – Various options for a carrier –Coupling and trapping the carrier into the desired line section - Unit type carrier aided directional comparison relaying – Carrier aided distance schemes for acceleration of zone II; numerical example for a typical distance protection scheme for a transmission line. Protection schemes for FACTS devices.

UNIT-IV: GENERATOR PROTECTION 9

Electrical circuit of the generator –Various faults and abnormal operating conditions – Stator Winding Faults – Protection against Stator (earth) faults – third harmonic voltage protection – Rotor fault – Abnormal operating conditions - Protection against Rotor faults – Potentiometer Method – injection method – Pole slipping – Loss of excitation – Protection against Mechanical faults; Numerical examples for typical generator protection schemes.

UNIT-V: NUMERICAL PROTECTION 9

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

TOTAL :45 PERIODS

COURSE OUTCOMES:

- Learners will be able to understand the various schemes available in Transformer protection
- Learners will have knowledge on Overcurrent protection
- Learners will attain knowledge about Distance and Carrier protection in transmission lines
- Learners will understand the concepts of Generator protection
- Learners will attain knowledge on numerical protection schemes

REFERENCES:

1. Y.G. Paithankar and S.R Bhide, "Fundamentals of Power System Protection", Prentice Hall of India, Second Edition, 2010.
2. Badri Ram and D.N. Vishwakarma, "Power System Protection and Switchgear", Tata McGraw- Hill Publishing Company, Second Edition, 2011.
3. S.M. Rao, "Digital Relay / Numerical relays", Tata McGraw Hill, New Delhi, 2005.
4. P.Kundur, "Power System Stability and Control", McGraw-Hill, 1993.

CO / PO & PSO Mapping:

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	3	3	2	2		2		2	2	2	2	3
CO2	2	2	2			3		3	2		2	2
CO3	3	2	2		2	2	3	2	2	2	3	2
CO4	3	2	2	2		2		2	2	2	3	3
CO5	3	2	2			2	2	2	2	2		2

1916204 RESTRUCTURED POWER SYSTEM

L	T	P	C
3	0	0	3

OBJECTIVES:

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

UNIT-I: INTRODUCTION TO RESTRUCTURING OF POWER INDUSTRY 9

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

UNIT-II: TRANSMISSION CONGESTION MANAGEMENT 9

Introduction: Definition of Congestion, reasons for transfer capability limitation, Importance of congestion management, Features of congestion management – Classification of congestion management methods – Calculation of ATC - Non – market methods – Market methods – Nodal pricing – Inter zonal and Intra zonal congestion management – Price area congestion management – Capacity alleviation method – Congestion management using evolutionary approach.

UNIT-III: LOCATIONAL MARGINAL PRICES AND FINANCIAL TRANSMISSION RIGHTS 9

Mathematical preliminaries: - Locational marginal pricing– Lossless DCOPF model for LMP calculation – Loss compensated DCOPF model for LMP calculation – ACOPF model for LMP calculation – Financial Transmission rights – Risk hedging functionality -Simultaneous feasibility test and revenue adequency – FTR issuance process: FTR auction, FTR allocation Treatment of revenue shortfall – Secondary trading of FTRs – Flow gate rights – FTR and market power - FTR and merchant transmission investment.

UNIT-IV: ANCILLARY SERVICE MANAGEMENT AND PRICING OF TRANSMISSION NETWORK 9

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

UNIT-V: REFORMS IN INDIAN POWER SECTOR 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- Ability and attain knowledge on restructuring of power industry.
- Ability and understand basics of congestion management
- Ability and attain knowledge about locational margin prices and financial transmission rights.
- Ability and understand the significance ancillary services and pricing of transmission network.
- Ability and attain knowledge on the various power sectors in India.

REFERENCES:

1. Mohammad Shahidehpour, Muwaffaq Alomoush, Marcel Dekker, "Restructured electrical power systems: operation, trading and volatility" Pub., 2001.
2. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, "Operation of restructured power systems", Kluwer Academic Pub., 2001.
3. Steven Stoft, "Power system economics: designing markets for electricity", John Wiley & Sons, 2002.
4. Paranjothi, S.R., "Modern Power Systems" Paranjothi, S.R., New Age International, 2017.
5. Sally Hunt," Making competition work in electricity", John Willey and Sons Inc. 2002.
6. Loi Lei Lai,"Power System Restructuring and Deregulation: Trading, Performance and Information Technology" John Wiley & Sons, 2001.

CO / PO & PSO Mapping:

CO	**PO**										**PSO**	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	3	2						2		2	3	
CO2	2	3	2			2					3	
CO3	2	3	2	1	1	2		2	2	3	3	
CO4	2	3	2	1	1	1		1	2	2	3	
CO5	3	2	2					2	2	3	3	

1916211 **ADVANCED POWER SYSTEM SIMULATION LABORATORY**

L	T	P	C
0	0	4	2

OBJECTIVES:

- To analyze the small signal stability for SMIB and multi machine system.
- To apply iterative technique for power flow analysis with STATCOM.
- To calculate Available Transfer Capability in power system network.
- To study the characteristics of variable speed wind energy conversion system.
- To analysis harmonics and design the filters for mitigation of harmonics.

LIST OF EXPERIMENTS

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

TOTAL: 60 PERIODS

COURSE OUTCOMES:

- Ability to analyze the small signal stability of SMIB and Multi machine system.
- Ability to analyze load flow and transient analysis of power system with STATCOM.
- Ability to calculate Availability Transfer Capability in power system network.
- Ability to analyze characteristics of variable speed wind energy conversion system.
- Ability to analyze harmonics and design the filters for mitigation of harmonics.

LIST OF EQUIPMENTS FOR A BATCH OF 18 STUDENTS:

1	Computer (Intel core i3,320GB,2GB RAM)	18
2	Printer	01
3	Server (Intel Core,i3,320GB,4GB RAM)	01
4	Matlab/PSCAD Software	0 5 User
5	EUROSTAG Software/any Power System Simulation Software	01 Use

CO / PO & PSO Mapping:

CO	**PO**										**PSO**	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	3	3	3			3		3	3	3	3	3
CO2	3	3	3			3		3	3	3	3	3
CO3	3	3	3			3		3	3	3	3	3
CO4	3	2	3			3		2	3	3	3	3
CO5	3	3	3			3		3	3	3	3	3

1916105 ANALYSIS OF ELECTRICAL MACHINES

L	T	P	C
3	0	0	3

OBJECTIVES:

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

UNIT-I: PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION 9

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

UNIT-II: DC MACHINES 9

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

UNIT-III: REFERENCE FRAME THEORY 9

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

UNIT-IV: INDUCTION MACHINES 9

Three phase induction machine, equivalent circuit and analysis of steady state operation – free acceleration characteristics – voltage and torque equations in machine variables and arbitrary reference frame variables – analysis of dynamic performance for load torque variations – digital computer simulation.

UNIT-V: SYNCHRONOUS MACHINES 9

Three phase synchronous machine and analysis of steady state operation - voltage and torque equations in machine variables and rotor reference frame variables (Park's equations) – analysis of dynamic performance for load torque variations – Generalized theory of rotating electrical machine and Krons primitive machine.

TOTAL :45 PERIODS

COURSE OUTCOMES:

- Ability to understand the various electrical parameters in mathematical form.
- Ability to acquire the knowledge on construction, operation of DC Machines and dynamic characteristics of permanent magnet and shunt DC motors.

- Ability to understand the different types of reference frame theories and transformation relationships.
- Ability to acquire the knowledge on dynamic performance for load torque and operation of Three phase induction machine
- Ability to find the electrical machine equivalent circuit parameters and modeling of electrical machines.

REFERENCES:

1. Paul C.Krause, Oleg Wasyzczuk, Scott S, Sudhoff, “Analysis of Electric Machinery and Drive Systems”, John Wiley, Second Edition, 2010.
2. P S Bimbhra, “Generalized Theory of Electrical Machines”, Khanna Publishers, 2008.
3. A.E, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, “ Electric Machinery”, Tata McGraw Hill, 5th Edition, 1992.
4. R. Krishnan, Electric Motor & Drives: Modeling, Analysis and Control, New Delhi, Prentice Hall of India, 2001.

CO / PO & PSO Mapping :

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	2	3	1									2
CO2	3		2	2								2
CO3	2	3	2	2		2			1		2	2
CO4	3	2	2	2		2						2
CO5	2	3	2	2		2			2		2	3

		L	T	P	C
1916106	**ANALYSIS AND DESIGN OF POWER CONVERTERS**	**3**	**0**	**0**	**3**

OBJECTIVES:

- To determine the operation and characteristics of controlled rectifiers.
- To apply switching techniques and basic topologies of DC-DC switching regulators.
- To introduce the design of power converter components.
- To provide an in depth knowledge about resonant converters.
- To comprehend the concepts of AC-AC power converters and their applications.

UNIT-I: SINGLE PHASE & THREE PHASE CONVERTERS 9

Principle of phase controlled converter operation – single-phase full converter and semi- converter (RL,RLE load)- single phase dual converter – Three phase operation full converter and semi-converter (R,RL,RLE load) – reactive power – power factor improvement techniques – PWM rectifiers.

UNIT-II: DC-DC CONVERTERS 9

Limitations of linear power supplies, switched mode power conversion, Non-isolated DC-DC converters: operation and analysis of Buck, Boost, Buck-Boost, Cuk& SEPIC – under continuous and discontinuous operation – Isolated converters: basic operation of Flyback, Forward and Push-pull topologies.

UNIT-III: DESIGN OF POWER CONVERTER COMPONENTS 9

Introduction to magnetic materials- hard and soft magnetic materials –types of cores , copper windings – Design of transformer –Inductor design equations –Examples of inductor design for buck/flyback converter-selection of output filter capacitors – selection of ratings for devices – input filter design.

UNIT-IV: RESONANT DC-DC CONVERTERS 9

Switching loss, hard switching, and basic principles of soft switching- classification of resonant converters- load resonant converters – series and parallel – resonant switch converters – operation and analysis of ZVS, ZCS converters comparison of ZCS/ZVS- Introduction to ZVT/ZCT PWM converters.

UNIT-V: AC-AC CONVERTERS 9

Principle of on-off and phase angle control – single phase ac voltage controller – analysis with R & RL load – Three phase ac voltage controller – principle of operation of cyclo converter – single phase /and three phase cyclo converters – Introduction to matrix converters-Working principles of matrix converter.

TOTAL :45 PERIODS

COURSE OUTCOMES:

- Ability to acquire the knowledge on Analyze various single phase and three phase power converters.
- Ability to acquire the knowledge on design dc-dc converter topologies for a broad range of power conversion applications
- Ability to understand the Develop improved power converters for any stringent application requirements.
- Ability to acquire the knowledge Analyze of Resonant switch dc-dc converters.
- Ability to understand the Design ac-ac converters for variable frequency applications.

REFERENCES:

1. Ned Mohan,T.M.Undeland and W.P Robbin, "Power Electronics: converters, Application and design" John Wiley and sons.Wiley India edition, 2006.
2. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.
3. Simon Ang, Alejandro Oliva, "Power-Switching Converters, Second Edition, CRC Press, Taylor & Francis Group, 2010.
4. W. G. Hurley and W. H.Wolfle, "Transformers and Inductors for Power Electronics Theory, Design and Applications", 2013 John Wiley & Sons Ltd.
5. P.C. Sen, "Modern Power Electronics", Wheeler Publishing Co, First Edition, New Delhi,1998.
6. P.S.Bimbra, "Power Electronics", Khanna Publishers, Eleventh Edition, 2003.
7. Simon Ang, Alejandro Oliva, "Power-Switching Converters, Second Edition, CRC Press, Taylor & Francis Group, 2010.
8. V.Ramanarayanan, "Course material on Switched mode power conversion", 2007.
9. Alex Van den Bossche and Vencislav CekovValchev, "Inductors and Transformers for

Power Electronics", CRC Press, Taylor & Francis Group, 2005.
10. Marian.K.Kazimierczuk and DariuszCzarkowski, "Resonant Power Converters", John Wiley & Sons Limited,2011.

CO / PO & PSO Mapping :

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1		1	3	1		1		2		1		1
CO2	1		2		3	1	1	1	1			
CO3		2		1		1	1		3	1	1	
CO4		3	1	1	1			3		2		3
CO5	1	2			3	2	3		1		2	1

1916107	INDUSTRIAL POWER SYSTEM ANALYSIS AND DESIGN	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To analyze the starting methods of motors.
- To study the methods of power factor correction and analysis of switching surge.
- To perform computer-aided harmonic analysis and to design filters.
- To analyze the various sources of Flicker and its minimizing techniques.
- To expose various grid grounding methodologies.

UNIT-I: STUDIES ON MOTORS 9

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

UNIT-II: POWER FACTOR CORRECTION STUDIES 9

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

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: Harmonic analysis for 33kV distribution network.

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.

UNIT-V: INSULATION AND COORDINATION 9

Modeling of system; simulation of switching surges; description of EMTP – capabilities; voltage acceptance criteria; insulation coordination case study: High voltage substation; methods of minimizing switching transients.

TOTAL:45 PERIODS

COURSE OUTCOMES:

- Learners will have knowledge on starting methods of motors.
- Learners will study the methods of power factor correction and analysis of switching surge.
- Learners will perform computer-aided harmonic and flicker analysis and to design filters.
- Learners will develop more understanding on the various sources of Flicker and its minimizing techniques.
- Learners will have knowledge on various grid grounding methodologies.

REFERENCES:

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

2. J.C.Das, “ Short- Circuit Load Flow and Harmonics, Second Edition, 2017..

CO / PO & PSO Mapping :

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	3	2	2	1	2		3	2	2	1	3	2
CO2	1	3	2		1	3	2	1	3		3	1
CO3	2	2	1	3	1	3	3	1		3	3	2
CO4	1	2	2	1	3	2	3	2	3		2	3
CO5	1	3	1	1		1	2	3		2	3	1

1916205	SMART GRID	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure.
- To familiarize the power quality management issues in Smart Grid.
- To familiarize the high performance computing for Smart Grid applications
- To illustrate the basic concepts of Expansion planning.
- To impart knowledge on the fundamental concepts of the Distribution system planning.

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, Concept of Resilient & Self Healing Grid, Present development & International policies in Smart Grid, National and International Initiatives in Smart Grid.

UNIT-II: SMART GRID TECHNOLOGIES 9

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

UNIT-III: SMART METERS AND ADVANCED METERING INFRASTRUCTURE 9

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

UNIT-IV: POWER QUALITY MANAGEMENT IN SMART GRID 9

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

UNIT-V: HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS 9

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

TOTAL :45 PERIODS

COURSE OUTCOMES

- Learners will develop more understanding on the concepts of Smart Grid and its present developments.
- Learners will study about different Smart Grid technologies.
- Learners will acquire knowledge about different smart meters and advanced metering infrastructure.
- Learners will have knowledge on power quality management in Smart Grids
- Learners will develop more understanding on LAN, WAN and Cloud Computing for Smart Grid applications.

REFERENCES:

1. Stuart Borlase "Smart Grid :Infrastructure, Technology and Solutions", CRC Press 2012.
2. Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley 2012.
3. Vehbi C. Güngör, DilanSahin, TaskinKocak, Salih Ergüt, Concettina Buccella, Carlo Cecati, and Gerhard P. Hancke, "Smart Grid Technologies: Communication Technologies and Standards" IEEE Transactions On Industrial Informatics, Vol. 7, No. 4, November 2011.
4. Xi Fang, Satyajayant Misra, Guoliang Xue, and Dejun Yang "Smart Grid – The New and Improved Power Grid: A Survey", IEEE Transaction on Smart Grids, vol. 14, 2012

CO / PO & PSO Mapping :

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	1	1	1			1	1	2				1
CO2	1	1	1			1	1	2				2
CO3	1	1	2			1	1	2				2
CO4	1	1	1			1	1	2				2
CO5	1	1	1			1	1	2				1

1916206	SOLAR AND ENERGY STORAGE SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To discuss about basics of PV system.
- To study about solar modules and PV system design.
- To deal with grid connected PV systems.
- To discuss about different energy storage systems.
- To illustrate the applications of PV systems.

UNIT-I: INTRODUCTION 9

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

UNIT-II: STAND ALONE PV SYSTEM 9

Solar modules – storage systems – power conditioning and regulation - MPPT- protection – stand alone PV systems design – sizing.

UNIT-III: GRID CONNECTED PV SYSTEMS 9

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

UNIT-IV: ENERGY STORAGE SYSTEMS 9

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

UNIT-V: APPLICATIONS 9

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

TOTAL:45 PERIODS

COURSE OUTCOMES

- Students will develop more understanding on solar energy storage systems.
- Students will develop basic knowledge on standalone PV system.
- Students will understand the issues in grid connected PV systems.
- Students will know about the modeling of different energy storage systems and their performances.
- Students will attain knowledge on different applications of solar energy.

REFERENCES:

1. Solanki C.S., “Solar Photovoltaics: Fundamentals, Technologies And Applications”, PHI Learning Pvt. Ltd., 2015.
2. Stuart R.Wenham, Martin A.Green, Muriel E. Watt and Richard Corkish, “Applied Photovoltaics”, 2007, Earthscan, UK.
3. Eduardo Lorenzo G. Araujo, “Solar electricity engineering of photovoltaic systems”, Progensa, 1994.
4. Frank S. Barnes & Jonah G. Levine, “Large Energy storage Systems Handbook”, CRC Press, 2011.
5. McNeils, Frenkel, Desai, “Solar & Wind Energy Technologies”, Wiley Eastern, 1990
6. S.P. Sukhatme , “Solar Energy”, Tata McGraw Hill,1987.

CO / PO & PSO Mapping :

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	3	2	1			1		1	2	1	3	2
CO2	3	2	1			1		1	2	1	3	2
CO3	3	2	1			2		1	2	1	3	2
CO4	3	2	1			1		2	1		3	3
CO5	3	3	2			1		2	1		3	2

1916207 **POWER SYSTEM RELIABILITY**

L	T	P	C
3	0	0	3

OBJECTIVES:

- To introduce the objectives of Load forecasting.
- To study the fundamentals of Generation system, Transmission system and Distribution.
- To study the transmission system reliability analysis.
- To illustrate the basic concepts of Expansion planning.
- To impart knowledge on the fundamental concepts of the Distribution system planning.

UNIT-I: LOAD FORECASTING 9

Objectives of forecasting - Load growth patterns and their importance in planning - Load forecasting Based on discounted multiple regression technique-Weather sensitive load forecasting-Determination of annual forecasting-Use of AI in load forecasting.

UNIT-II: GENERATION SYSTEM RELIABILITY ANALYSIS 9

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

UNIT-III: TRANSMISSION SYSTEM RELIABILITY ANALYSIS 9

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

UNIT-IV: EXPANSION PLANNING 9

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

UNIT-V: DISTRIBUTION SYSTEM PLANNING OVERVIEW 9

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

TOTAL:45 PERIODS

COURSE OUTCOMES

- Students will develop the ability to learn about load forecasting.
- Students will learn about reliability analysis of ISO and interconnected systems.
- Students will understand the concepts ot Contingency analysis and Probabilistic Load flow Analysis.
- Students will be able to understand the concepts of Expansion planning.
- Students will have knowledge on the fundamental concepts of the Distribution system planning.

REFERENCES:

1. Roy Billinton & Ronald N. Allan, “Reliability Evaluation of Power Systems” Springer Publication.
2. R.L. Sullivan, “Power System Planning”, Tata McGraw Hill Publishing Company Ltd,1977.
3. X. Wang & J.R. McDonald, “Modern Power System Planning”, McGraw Hill Book

Company, 1994.
4. T. Gonen, “Electrical Power Distribution Engineering”, McGraw Hill Book Company, 1986.
5. B.R. Gupta, “Generation of Electrical Energy”, S.Chand Publications 1983

CO / PO & PSO Mapping :

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	3	3						3				
CO2	3											
CO3	2	2	3		2							
CO4	2				2							
CO5	3							3				

1916208	ADVANCED DIGITAL SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To expose the students to the fundamentals of digital signal processing in frequency domain & its application.
- To teach the fundamentals of digital signal processing in time-frequency domain & its application.
- The student is familiar with estimation, prediction and filtering concepts and techniques.
- To compare Architectures & features of Programmable DS Processors & develop logical functions of DS Processors.
- To discuss on Application development with commercial family of DS Processors.

UNIT-I: FUNDAMENTALS OF DSP 9

Frequency interpretation, sampling theorem, aliasing, discrete-time systems, constant- coefficient difference equation. Digital filters: FIR filter design – rectangular,Hamming,Hanning windowing technique. IIR filter design – Butterworth filter, bilinear transformation method, frequency transformation. Fundamentals of multirate processing – decimation and interpolation.

UNIT-II: TRANSFORMS AND PROPERTIES 9

Discrete Fourier transform (DFT): - properties, Fast Fourier transform (FFT), DIT-FFT, and DIF- FFT. Wavelet transforms:Introduction, wavelet coefficients – orthonormal wavelets and their relationship to filter banks, multi-resolution analysis, and Haar and Daubechies wavelet.

UNIT-III: ADAPTIVE FILTERS 9

Wiener filters – an introduction. Adaptive filters: Fundamentals of adaptive filters, FIR adaptive filter – steepest descent algorithm, LMS algorithm, NLMS, applications – channel equalization. Adaptive recursive filters – exponentially weighted RLS algorithm.

UNIT-IV: ARCHITECTURE OF COMMERCIAL DIGITAL SIGNAL PROCESSORS 9

Introduction to commercial digital signal processors, Categorization of DSP processor – Fixed point and floating point, Architecture and instruction set of the TI TMS 320 C54xx, TMS 320 C6xxx and TMS 320 C55XX DSP processors, On-chip and On-board peripherals – memory (Cache, Flash, SDRAM), codec, multichannel buffered I/O serial ports (McBSPs), interrupts, direct memory access (DMA), timers and general purpose I/Os.

UNIT-V: INTERFACING I/O PERIPHERALS FOR DSP BASED APPLICATIONS 9

Introduction, External Bus Interfacing Signals, Memory Interface, I/O Interface, Programmed I/O, Interrupts, Design of Filter, FFT Algorithm, ,Application for Serial Interfacing, DSP based Power Meter, Position control , CODEC Interface .

TOTAL:45 PERIODS

COURSE OUTCOMES:

- Students will learn the essential advanced topics in DSP that are necessary for successful Postgraduate level research.
- The conceptual aspects of Signal processing Transforms are introduced.
- Design AR, MA, ARMA models, Weiner filter, anti-aliasing filters, and develop FIR adaptive filter and polyphase filter structures.
- The comparison on commercial available DSP Processors helps to understand system design through processor interface.
- Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design

REFERENCES:

1. John. G. Proakis, Dimitris G. Manolakis, “Digital signal processing”, Pearson Edu, 2002.
2. Sen M.Kuo,Woon-Seng S.Gan, “Digital Signal Processors- Pearson Edu, 2012.
3. Monson H. Hayes, “Statistical Digital signal processing and modelling”, John Wiley & Sons, 2008.
4. RulphChassaing and Donald Reay, “Digital Signal Processing and Applications with the TMS320C6713 and TMS320C6416 DSK”, John Wiley & Sons, Inc., Hoboken, New Jersey, 2008.
5. Steven A. Tretter, “Communication System Design Using DSP Algorithms with Laboratory Experiments for the TMS320C6713™ DSK”, Springer, 2008.
6. RulphChassaing and Donald Reay, “Digital Signal Processing and Applications with the TMS320C6713 and TMS320C6416 DSK”, John Wiley & Sons, Inc., Hoboken, New Jersey, 2008.
7. K.P. Soman and K.L. Ramchandran, “Insight into Wavelets from theory to practice”, Eastern Economy Edition, 2008.
8. Vinay K.Ingle, John G.Proakis,”DSP-A Matlab Based Approach”, Cengage Learning,2010.
9. Avatar Sing, S.Srinivasan, “Digital Signal Processing-Implementation using DSP Microprocessors with Examples from TMS320C54xx”, Thomson India, 2004.
10. TI, ATMS320C55x, Technical Overview

CO / PO & PSO Mapping :

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	2	1		2							1	1
CO2		3	1		2		3	2		2		2
CO3	3			1		2			3		1	
CO4		2	2		3						3	2
CO5	3	2		3		2			2	3	2	3

1916209	DISTRIBUTED GENERATION AND MICROGRID	L	T	P	C
		3	0	0	3

OBJECTIVES:
- To provide basic knowledge on various Non –conventional energy sources.
- To illustrate the concept of distributed generation.
- To analyze the impact of grid integration.
- To study concept of microgrid and its configuration.
- To acquire the adequate knowledge on control of microgrid.

UNIT-I: INTRODUCTION 9

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

UNIT-II: DISTRIBUTED GENERATIONS (DG) 9

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

UNIT-III: IMPACT OF GRID INTEGRATION 9

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

UNIT-IV: BASICS OF A MICROGRID 9

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

UNIT-V: CONTROL AND OPERATION OF MICROGRID 9

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

TOTAL:45 PERIODS

COURSE OUTCOMES:

- Learners will attain knowledge on the various schemes of conventional and non- conventional power generation.
- Learners will have knowledge on the topologies and energy sources of distributed generation.
- Learners will learn about the requirements for grid interconnection and its impact with NCE sources.
- Learners will understand the fundamental concept of microgrid.
- Learners will develop adequate knowledge on control of microgrid.

REFERENCES:

1. Amirnaser Yezdani, and Reza Iravani, “Voltage Source Converters in Power Systems: Modeling, Control and Applications”, IEEE John Wiley Publications, 2010.
2. D. D. Hall and R. P. Grover, “Biomass Regenerable Energy”, John Wiley, New York, 1987.
3. John Twidell and Tony Weir, “Renewable Energy Resources” Tyalor and Francis Publications, Second edition 2006.
4. Dorin Neacsu, “Power Switching Converters: Medium and High Power”, CRC Press, Taylor & Francis, 2006.
5. Chetan Singh Solanki, “Solar Photo Voltaics”, PHI learning Pvt. Ltd., New Delhi, 2009.
6. J.F. Manwell, J.G. McGowan “Wind Energy Explained, theory design and applications”, Wiley publication 2010.

CO / PO & PSO Mapping :

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	3		2			2		1			3	
CO2	3		3	1	2	2	2	1	1		2	
CO3	2	1	3	1	2	1	2	1	2			3
CO4	1		2	2	1	3	2	1	1		3	
CO5	2	1	2	2	2	3	2	2	2			2

1916210 SOFT COMPUTING TECHNIQUES

	L	T	P	C
	3	0	0	3

OBJECTIVES:

- To expose the concepts of Evolutionary Programming and Optimization.
- To teach about the concept of fuzziness involved in various systems.
- To provide knowledge about feedback neural networks.
- To provide adequate knowledge about of ANFIS.
- To expose the concepts of machine learning, focusing on regression, SVM, decision trees and neural networks.

UNIT-I: INTRODUCTION AND EVOLUTIONARY PROGRAMMING 9

Introduction to intelligent systems- Soft computing techniques- Conventional Computing versus Swarm Computing - Classification of meta-heuristic techniques - Properties of Swarm intelligent Systems - Application domain - Discrete and continuous problems - Single objective and multi-objective problems. Evolutionary programming – Genetic algorithms & Genetic programming - Particle Swarm Optimization- Ant colony Optimization

UNIT-II: FUZZY LOGIC SYSTEM 9

Introduction to crisp sets and fuzzy sets- basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control- Fuzzification inferencing and defuzzification- Fuzzy knowledge and rule bases-Fuzzy modeling and control schemes for nonlinear systems. Self-organizing fuzzy logic control- Fuzzy logic control for nonlinear time delay system. Case study – Familiarization of FLC Tool Box.

UNIT-III: ARTIFICIAL NEURAL NETWORKS 9

Neuron- Nerve structure and synapse- Artificial Neuron and its model- activation functions- Neural network architecture- single layer and multilayer feed forward networks- Mc Culloch Pitts neuron model- perceptron model- Adaline and Madaline- multilayer perception model- back propogation learning methods. Counter propagation network- architecture- functioning & characteristics of counter Propagation network- Hopfield/ Recurrent network configuration- Adaptive Resonance Theory. Case study – Familiarization of NN Tool Box.

UNIT-IV: HYBRID CONTROL SCHEMES 9

Fuzzification and rule base using ANN – Neuro fuzzy systems-ANFIS – Fuzzy Neuron - Optimization of membership function and rule base using Genetic Algorithm. Familiarization of ANFIS Tool Box.

UNIT-V: INTRODUCTION TO MACHINE LEARNING AND DEEP LEARNING 9

Linear Regression, Logistic Regression, Naive Bayes Classifier, kNN algorithm, Support Vector Machines (SVMs) and Decision Trees, Random Forest Classifier, Deep Learning-Recurrent Neural Networks and Convolutional Neural Networks and Reinforcement Learning: Markov Decision processes (MDPs) and Q-learning

TOTAL :45 PERIODS

COURSE OUTCOMES:

- Ability to acquire the knowledge on Evolutionary Programming
- Will be able to know the different operations on the fuzzy sets and knowledgeable to use Fuzzy logic for modeling and control of non-linear systems.
- Will be able to know the basic ANN architectures, algorithms and their limitations.
- Will be competent to use hybrid control schemes

- Will be able to know the concepts of machine learning, focusing on regression, SVM, decision trees and deep neural networks

REFERENCES:

1. Laurene V. Fausett, “Fundamentals of Neural Networks: Architectures, Algorithms And Applications”, Pearson Education, 2004.
2. Timothy J. Ross, “Fuzzy Logic with Engineering Applications” Wiley India, 2016.
3. David E.Goldberg, “Genetic Algorithms in Search, Optimization, and Machine Learning”, Pearson Education, 2009.
4. Kalyanmoy Deb, “Multi-objective optimization using evolutionary algorithms”, John Wiley & Sons, Ltd.
5. Machine Learning. Tom Mitchell. First Edition, McGraw- Hill, 1997.
6. X. Yao, “Evolutionary Computation: Theory and Applications”, World Scientific Publ. Co., Singapore, 1999.
7. Zimmermann H.J. "Fuzzy set theory and its Applications" Springer international edition, 2011.
8. Machine Learning. Tom Mitchell. First Edition, McGraw- Hill, 1997.
9. Ethem Alpaydin, “Introduction to Machine Learning (Adaptive Computation and Machine Learning Series)”, MIT Press, 2004.
10. Corinna Cortes and V. Vapnik, " Support - Vector Networks, Machine Learning” 1995.
11. J.S.R.Jang, C.T.Sun and E.Mizutani, “Neuro-Fuzzy & Soft Computing – A Computational Approach to Learning and Machine Intelligence”, Pearson, 2016.

CO / PO & PSO Mapping :

CO	**PO**										**PSO**	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1		2	1	2	3			2	2	1	3	
CO2	1	2	3	2	1	1	2	3	3			2
CO3			2	3	1	2	1	1	2	1	2	
CO4	1		2	2	1	1	2	2			1	
CO5		2	2	1	2	3	1	1	1	2		3

1916301	ELECTRICAL DISTRIBUTION SYSTEM	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To provide knowledge about the distribution system electrical characteristics.
- To gain knowledge about planning and designing of distribution system
- To analyze power quality in distribution system and modeling.
- To analyze the voltage regulation and methods of controlling.
- To analyze the power flow in balanced and unbalanced system.

UNIT-I: INTRODUCTION 9

Distribution System-Distribution Feeder Electrical Characteristics-Nature of Loads: Individual Customer Load, Distribution Transformer Loading and Feeder Load-Approximate Method of Analysis: Voltage Drop, Line Impedance, "K" Factors, Uniformly Distributed Loads and Lumping Loads in Geometric Configurations.

UNIT-II: DISTRIBUTION SYSTEM PLANNING 9

Factors effecting planning, present techniques, planning models(Short term planning, long term planning and dynamic planning), planning in the future, future nature of distribution planning, Role of computer in Distribution planning. Load forecast, Load characteristics and Load models.

UNIT-III: DISTRIBUTION SYSTEM LINE MODEL 9

Exact Line Segment Model-Modified Line Model-Approximate Line Segment Model-Modified "Ladder" Iterative Technique-General Matrices for Parallel Lines.

UNIT-IV: VOLTAGE REGULATION 9

Standard Voltage Ratings-Two-Winding Transformer Theory-Two-Winding Autotransformer Step-Voltage Regulators: Single-Phase Step-Voltage Regulators-Three-Phase Step-Voltage Regulators- Application of capacitors in Distribution system – Application of Distribution Transformers.

UNIT-V: DISTRIBUTION FEEDER ANALYSIS 9

Power-Flow Analysis- Ladder Iterative Technique -Unbalanced Three-Phase Distribution Feeder- Modified Ladder Iterative Technique- Load Allocation- Short-Circuit Studies.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

- Ability to understand the distribution system electrical characteristics.
- Ability to apply the concepts of planning and design of distribution system for utility Systems
- Ability to model the distribution system for steady steady state and transient analysis.
- Ability to implement the concepts of voltage control in distribution system.
- Ability to analyze the power flow in balanced and unbalanced system.

REFERENCES:

1. Pabla H S, "Electrical Power Distribution Systems", Tata McGraw Hill. 6th edition 2019
2. V. Kamaraju, "Electrical Power Distribution Systems", Tata McGraw Hill. 1st edition 2017
3. William H. Kersting," Distribution System Modeling and Analysis" CRC press 3rd edition, 2012.
4. Turan Gonen, "Electric Power Distribution System Engineering", McGraw Hill Company. 3rd edition 2014.
5. James Northcote – Green, Robert Wilson, "Control and Automation of Electrical Power Distribution Systems", CRC Press, New York, 2007.
6. T.A.Short, "Electric Power Distribution Handbook", CRC Press, 2nd edition, 2003

CO / PO & PSO Mapping:

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	2	1				1		2	1	1	2	1
CO2	2	2				2		2	1	1	1	3
CO3	2	1				1		2	1	2	1	2
CO4	2	1				1		2	1	2	1	3
CO5	2	1				1		2	1	1	1	2

1916302	ENERGY MANAGEMENT AND AUDITING	L	T	P	C
		3	0	0	3

OBJECTIVES:

To impart knowledge on the following Topics

- To acquaint and equip the students in energy auditing in industries and house hold sectors for increasing energy efficiency.
- To impart knowledge on energy management and facilitate application of energy conservation techniques in process industries.
- To impart knowledge on thermal and electrical utilities for evaluating energy saving potential.
- To familiarize on the trends in economics of energy use in various sectors and facilitate energy modeling to make policy decisions.
- To identify sources of energy loss and target savings.

UNIT-I: ENERGY CONSERVATION CONCEPTS 9

Energy – classification – scenario – energy pricing – energy and environment – energy conservation and its importance – energy strategy for the future – energy conservation act and its features

UNIT-II: ENERGY AUDITING AND ECONOMICS 9

Scope of energy audit-– principles – energy audit strategy - types – detailed energy audit steps. Role of energy managers in industries; Energy performance - bench marking – fuel substitutions – energy audit instruments – material and energy balance – energy conversion – energy index – cost index – financial management – financing options.

UNIT-III: THERMAL ENERGY AUDIT 9

Energy efficiency in thermal utilities – methodology – stoichiometric analysis of combustion in a boiler – performance evaluation – boiler losses - analysis – feed water treatment – energy conservation opportunities in boilers and steam system – furnaces – insulation and refractories – cogeneration – principles of operation - waste heat recovery systems – case study – analysis.

UNIT-IV: ELECTRICAL ENERGY AUDIT – I 9

Electrical systems – introduction – electricity billing – load management – power factor – improvements and benefits – transformers – distribution losses – analysis – energy audit in electrical utilities methodology – energy conservation opportunities in motors – efficiency – energy efficient motors – motor losses – analysis – energy efficiency in compressed air system

UNIT-V: ELECTRICAL ENERGY AUDIT - II 9

HVAC and refrigeration system – fans and blowers – fan performance – pumps – lighting system - energy auditing and reporting in industries – replacement of renewable energy technology option – case study in agro-industries

TOTAL : 45 PERIODS

COURSE OUTCOMES:

- Acquire the knowledge on fundamentals of economic operation of an electrical system and understand the basic principles of energy auditing, types and objectives, instruments used.
- Develop procedures for conducting energy audit in different utilities in accordance with national and international energy regulations.
- Evaluate the performance of thermal utilities like furnace, boilers and steam distribution systems to improve efficiency
- Evaluate the performance of a electrical utilities like pumps, fans blowers to improve efficiency.
- Carryout performance assessment and suggest methods to improve the overall efficiency for different energy intensive industries.

REFERENCES:

1. Guide books for National Certification Examination for Energy Managers and Energy Auditors, Book 1, 2, 3 & 4. Bureau Energy Efficiency, New Delhi. 2005.
2. Murphy, W.R. and McKay, G. Energy Management. Butterworth & Co., Publishers Ltd., London. 1982.
3. Craig B. Smith. Energy Management Principles, Applications, benefits & savings. Pergamon Press Inc. 1981
4. Murgai, M.P. and Ram Chandra. Progress in Energy Auditing and Conservation – Boiler Operations, Wiley Eastern Ltd. 1990.
5. Victor B.Ottaviano,Energy Management. An OTIS Publication. Ottaviano Technical Service Inc. 150. Broad Hollow Road, Melville, New York. 11747.

6. Richard Porter and Tim Roberts, 1985. Energy saving by Waste recycling. Elsevier applied science publishers
7. Energy Management - Bi-monthly journal published by National Productivity Council,New Delhi.

CO / PO & PSO Mapping :

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	1		3	1	1	1			1		2	
CO2	2	2	2	1	3			1		2		1
CO3	3	1	1		1				2		3	
CO4	2	1	1	1	3		1				1	
CO5	2	3	2	1	3							3

.

1916303 WIND ENERGY CONVERSION SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To learn the design of Wind turbine.
- To learn about the concept of control principles of Wind turbine.
- To understand the concepts of fixed speed wind energy conversion systems.
- To understand the concepts of variable speed wind energy conversion systems.
- To analyze the grid integration issues.

UNIT -I: INTRODUCTION 9

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

UNIT- II: WIND TURBINES 9

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

UNIT -III: FIXED SPEED SYSTEMS 9

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

UNIT -IV: VARIABLE SPEED SYSTEMS 9

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

UNIT -V: GRID CONNECTED SYSTEMS 9

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

TOTAL:45 PERIODS

COURSE OUTCOMES:

- Acquire knowledge on the basic concepts of Wind energy conversion system.
- Understand the mathematical modeling and control of the Wind turbine.
- Develop more understanding on the design of fixed speed system.
- Study about the need of Variable speed system and its modeling.
- Able to learn about Grid integration issues and current practices of wind interconnections with power system.

REFERENCES:

1. L.L.Freris "Wind Energy conversion Systems", Prentice Hall, 1990.
2. S.N .Bhadra, D.Kastha, S.Banerjee,"Wind Electrical Sytems",Oxford University Press,2010.
3. Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006.
4. E.W.Golding "The generation of Electricity by wind power", Redwood burn Ltd., Trowbridg 1976.
5. N. Jenkins," Wind Energy Technology" John Wiley & Sons,1997
6. S.Heir "Grid Integration of WECS", Wiley 1998

CO / PO & PSO Mapping :

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	3	2	2			1	3	1	2	1	2	1
CO2	3	3	1	3		1	2	1	2	1	3	
CO3	3	2	1			2		1	2	1		2
CO4	3	2	2			1		2	1	3	3	3
CO5	3	3			3	3		2			3	2

.

1916304	ELECTRIC VEHICLES AND POWER MANAGEMENT	L	T	P	C
		3	0	0	3

OBJECTIVES:

To impart knowledge on the following Topics

- To understand the concept of electrical vehicles and its operations.
- To provide knowledge about Power train components.
- To understand the various Control strategies in AC and DC drives.
- To understand the need for energy storage in hybrid vehicles.
- To provide knowledge about alternative energy storage technologies that can be used in electric vehicles.

UNIT-I: ELECTRIC VEHICLES AND VEHICLE MECHANICS 9

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

UNIT-II: ARCHITECTURE OF EV's AND POWER TRAIN COMPONENTS 9

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

UNIT-III: CONTROL OF DC AND AC DRIVES 9

DC/DC chopper based four quadrant operations of DC drives – Inverter based V/f Operation (motoring and braking) of induction motor drive system – Induction motor and permanent motor-based vector control operation – Switched reluctance motor (SRM) drives.

UNIT-IV: BATTERY ENERGY STORAGE SYSTEM 9

Battery Basics, Different types, Battery Parameters, Battery modeling, Traction Batteries, Energy management system in Electric vehicle – Battery Management Systems.

UNIT-V: ALTERNATIVE ENERGY STORAGE SYSTEMS 9

Fuel cell – Characteristics- Types – hydrogen Storage Systems and Fuel cell EV – Ultra Capacitors

TOTAL : 45 PERIODS

COURSE OUTCOMES:

- Learners will understand the operation of Electric vehicles and Hybrid Electric vehicles.
- Learners will gain knowledge on Power train components.
- Learners can analyze the control strategies in AC and DC drives.
- Learners will gain knowledge on various energy storage technologies for electrical vehicles.
- Learners know about alternative energy storage technologies for electric vehicles.

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. James Larminie and John Loury, "Electric Vehicle Technology – Explained", John Wiley & Sons Ltd, 2003.
4. Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric and Fuel cell

Vehicles” CRC Press, Taylor & Francis Group, Second Edition (2010).
5. Emanuele Crisostomi, Robert Shorten, SonjaStudli & Fabian Wirth “Electric and Plug-in Hybrid Vehicle Networks” Taylor & Francis group 2018.
6. Ronald K Jurgen, “Electric and Hybrid – Electric Vehicles”, SAE, 2002.

CO / PO & PSO Mapping :

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1			3	2	1	1	2	2			3	
CO2			2	2	2	1		2				1
CO3			1	3	2	2		1			2	
CO4			2	2	1	2		1			2	
CO5			2	2	3	1		2			3	

		L	T	P	C
1916305	**ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY**				
		3	**0**	**0**	**3**

OBJECTIVES:
- To provide fundamental knowledge on electromagnetic interference and electromagnetic compatibility.
- To study the important techniques to control EMI.
- To study the important techniques to control EMC.
- To impart knowledge on EMI in elements and circuits
- 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 regulation typical noise path- EMI predictions and modeling, Cross talk - Methods of eliminating interferences.

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 equipments- 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:

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

REFERENCES:

1. V.P. Kodali, “Engineering Electromagnetic Compatibility”, S. Chand, 2001
2. Weston David A., “Electromagnetic Compatibility, Principles and Applications”, 2001
3. Henry W.Ott, “Electromagnetic Compatibility Engineering”, John Wiley & Sons, 2011
4. Henry W.Ott, “ Noise reduction techniques in electronic systems”, John Wiley & Sons, 2009
5. Bernhard Keiser, “Principles of Electro-magnetic Compatibility”, Artech House, Inc. (685 canton street, Norwood, MA 020062 USA) 1987.
6. Bridges, J.E Milleta J. and Ricketts.L.W., “EMP Radiation and Protective techniques”, John Wiley and sons, USA 1976

CO / PO & PSO Mapping :

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	2											
CO2	2				1							
CO3	3				2		2					
CO4	3	2	2	3			2					
CO5	2		3		3							

		L	T	P	C
1916306	**CONTROL SYSTEM DESIGN FOR POWER ELECTRONICS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

- To understand the modeling of various power converters.
- To know the design of feedback controllers in Power Electronics.
- To Study the linear control theories and techniques relevant to the controllers.
- To Study the non- linear control theories and techniques relevant to the controllers.
- To acquire the knowledge of predictive control and fault analysis.

UNIT-I: MODELLING OF DC-TO-DC POWER CONVERTERS 9

Modelling of Buck Converter , Boost Converter ,Buck-Boost Converter, Cuk Converter ,Sepic Converter, Zeta Converter, Quadratic Buck Converter ,Double Buck-Boost Converter, Boost- Boost Converter General Mathematical Model for Power Electronics Devices.

UNIT -II: SLIDING MODE CONTROLLER DESIGN 9

Variable Structure Systems. Single Switch Regulated Systems Sliding Surfaces, Accessibility of the Sliding Surface Sliding Mode Control Implementation of Boost Converter, Buck-Boost Converter, Cuk Converter ,Sepic Converter, Zeta Converter, Quadratic Buck Converter, Double Buck-Boost Converter, Boost-Boost Converter.

UNIT-III: APPROXIMATE LINEARIZATION CONTROLLER DESIGN 9

Linear Feedback Control, Pole Placement by Full State Feedback , Pole Placement Based on Observer Design ,Reduced Order Observers , Generalized Proportional Integral Controllers, Passivity Based Control , Sliding Mode Control Implementation of Buck Converter , Boost Converter, Buck-Boost Converter.

UNIT –IV: NONLINEAR CONTROLLER DESIGN **9**

Feedback Linearization Isidori's Canonical Form, Input-Output Feedback Linearization, State Feedback Linearization, Passivity Based Control , Full Order Observers , Reduced Order Observers, Minimum order observer.

UNIT –V: PREDICTIVE CONTROL OF POWER CONVERTERS **9**

Basic Concepts, Theory, and Methods, Application of Predictive Control in Power Electronics, AC-DC-AC Converter System, Faults and Diagnosis Systems in Power Converters.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

- Ability to acquire the knowledge of modeling various modern power electronic converters.
- Ability to design controllers for industrial applications
- Ability to have an overview on modern linear control strategies for power electronics devices
- Ability to have an overview on modern nonlinear control strategies for power electronics devices
- Ability to apply the predictive control of power converters.

REFERENCES:

1. Hebertt Sira-Ramírez, Ramón Silva-Ortigoza, "Control Design Techniques in Power Electronics Devices", Springer 2012
2. Mahesh Patil, Pankaj Rodey, "Control Systems for Power Electronics: A Practical Guide", Springer India, 2015.
3. Blaabjerg José Rodríguez, "Advanced and Intelligent Control in Power Electronics and Drives" , Springer, 2014.
4. Enrique Acha, Vassilios Agelidis, Olimpo Anaya, TJE Miller, "Power Electronic Control in Electrical Systems", Newnes, 2002.
5. Marija D. Aranya Chakrabortty, Marija , "Control and Optimization Methods for Electric Smart Grids", Springer, 2012.

CO / PO & PSO Mapping :

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	2	3	2	2		2		2	2		2	2
CO2	2	2	2	3		2		2	2		2	3
CO3	3	2	2	2		2		2	2		2	2
CO4	3	2	2	2		2		2	2		2	2
CO5	2	3	3	2		2		2	2		3	3

1916307	PRINCIPLES OF ELECTRIC POWER TRANSMISSION	L	T	P	C
		3	0	0	3

OBJECTIVES:

To impart knowledge on

- Types of power transmission and configurations.
- Various line parameters and its calculation.
- Voltage gradients of transmission line conductors.
- The design requirements of EHV AC and DC lines.
- The design aspects of HVDC lines and its protection.

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 – electrical and mechanical considerations in line performance.

UNIT-II: CALCULATION OF LINE PARAMETERS 9

Calculation of resistance, inductance and capacitance for multi-conductor lines – calculation of sequence 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 corona loss - RIV.

UNIT-IV: ELECTROSTATIC FIELD AND DESIGN OF EHV LINES 9

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

UNIT-V: HVDC LINES 9

Introduction - Reliability and failure issues - Design-tower, ROW, clearances, insulators, electrical and mechanical protection – Maintenance - Control and protection - D.C Electric field and Magnetic field - Regulations and guide lines -underground line design - Introduction to UHVDC.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

- Ability to understand the basic knowledge on line transmission and considerations for line performance.
- Ability to model the transmission lines using the line parameters.
- Ability to estimate the voltage gradients and losses.
- Ability to design EHV AC and DC transmission lines.
- Ability to analyze the various aspects in the design of HVDC lines.

REFERENCES:

1. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", Second Edition, New Age International Pvt. Ltd., 2006.
2. Sunil S.Rao, "EHV-AC, HVDC Transmission & Distribution Engineering", Third Edition, Khanna Publishers, 2008.
3. Pritindra Chowdhari, "Electromagnetic transients in Power System", John Wiley and Sons Inc., 2009.
4. William H. Bailey, Deborah E. Weil and James R. Stewart, "A Review on HVDC Power Transmission Environmental Issues", Oak Ridge National Laboratory.
5. 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), 2007

CO / PO & PSO Mapping :

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	3	2	2	1	2	2	3	1	3	3	3	2
CO2	2	1	2	2	1		2		3	3	2	2
CO3	2			3	3	3	3	1	1	1	2	3
CO4	1	2	1	3		2	3	2	3	2	3	3
CO5	1	3	1	2	1	2	2	3	1	2	3	3

.

		L	T	P	C
1916308	**ADVANCED POWER SYSTEM DYNAMICS**	**3**	**0**	**0**	**3**

OBJECTIVES:

- To perform transient stability analysis using unified algorithm.
- To perform transient stability analysis interaction with SVC
- To impart knowledge on sub-synchronous resonance and oscillations
- To analyze voltage stability problem in power system.
- To f102amiliarize the methods of transient stability enhancement.

UNIT-I: TRANSIENT STABILITY ANALYSIS 9

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

UNIT-II: UNIFIED ALGORITHM FOR DYNAMIC ANALYSIS OF POWER SYSTEMS 9

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

UNIT-III: SUBSYSNCHRONOUS RESONANCE (SSR) AND OSCILLATIONS 9

Subsynchronous Resonance (SSR) – Types of SSR - Characteristics of series- Compensated transmission systems – Modeling of turbine-generator-transmission network - Self-excitation due to induction generator effect **–** Torsional interaction resulting in SSR **–** Methods of analyzing SSR **–** Numerical examples illustrating instability of subsynchronous oscillations **–** time-domain simulation of subsynchronous 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-IV: TRANSMISSION, GENERATION AND LOAD ASPECTS OF VOLTAGE STABILITY ANALYSIS 9

Review of transmission aspects – Generation Aspects: Review of synchronous machine theory – Voltage and frequency controllers – Limiting devices affecting voltage stability Voltage reactive power characteristics of synchronous generators – Capability curves – Effect of machine limitation on deliverable power – Load Aspects – Voltage dependence of loads – Load restoration dynamics – Induction motors – Load tap changers – Thermostatic load recovery – General aggregate load models.

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

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

- Learners will be able to understand the various schemes available in Transformer protection.
- Learners will have knowledge on over current protection.
- Learners will attain knowledge about Distance and Carrier protection in transmission lines.
- Learners will understand the concepts of Busbar protection.
- Learners will attain basic knowledge on numerical protection techniques.

REFERENCES:

1 R. Ramnujam,” 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 Kundur P., Power System Stability and Control, McGraw Hill Education Pvt. Ltd., New Delhi, 10th reprint, 2010.
4. H.W. Dommel and N. Sato, "Fast Transient Stability Solutions," IEEE Trans., Vol. PAS-91, pp, 1643-1650, July/August 1972.
5. Roderick J. Frowd and J. C. Giri, “Transient stability and Long term dynamics unified”, IEEE Trans., Vol.101, No.10, October 1982.
6. M. Stubbe, A. Bihain, J. Deuse, J.C. Baader, “A New Unified software program for the study of the dynamic behaviour of electrical power system” IEEE Transaction, Power Systems, Vol.4, No.1, Feb:1989, Pg.129 to 138.

CO / PO & PSO Mapping :

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	1	3	3					2	1	1	2	1
CO2	2	2	2						1	3	1	1
CO3	3	1	3						1	3	2	1
CO4	1	3	2					3	2	1	1	2
CO5	3	1	2					1	2	3	3	1

1916309	DESIGN OF SUBSTATIONS	L	T	P	C
		3	0	0	3

OBJECTIVES:

1 To provide in-depth knowledge on design criteria of Air Insulated Substation (AIS) and Gas Insulated Substation (GIS).
2 To study the substation insulation co-ordination and protection scheme.
3 To study the source and effect of fast transients in AIS and GIS.
4 To study design of substation grounding and shielding of substations.
5 To study disconnector switching during VFTO.

UNIT-I: INTRODUCTION TO AIS AND GIS 9

Introduction – characteristics – comparison of Air Insulated Substation (AIS) and Gas Insulated Substation (GIS) – main features of substations, Environmental considerations, Planning and installation - GIB / GIL.

UNIT-II: MAJOR EQUIPMENT AND LAYOUT OF AIS AND GIS 9

Major equipment – design features – equipment specification, types of electrical stresses, mechanical aspects of substation design - substation switching schemes - single feeder circuits; single or main bus and sectionalized single bus - double main bus - main and transfer bus - main, reserve and transfer bus - breaker-and-a- half scheme - ring bus.

UNIT-III: INSULATION COORDINATION OF AIS AND GIS 9

Introduction – stress at the equipment – insulation strength and its selection – standard BILs – Application of simplified method – Comparison with IEEE and IEC guides.

UNIT-IV: GROUNDING AND SHIELDING 9

Definitions – soil resistivity measurement – ground fault currents – ground conductor – design of substation grounding system – shielding of substations – Shielding by wires and masts.

UNIT-V: FAST TRANSIENTS PHENOMENON IN AIS AND GIS 9

Introduction – selection and sizing of Disconnector switches - Disconnector switching in relation to very fast transients – origin of VFTO – propagation and mechanism of VFTO – VFTO characteristics – Effects of VFTO.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

- Ability to apply Awareness towards substation equipment and their arrangements.
- Ability to design the substation for present requirement with proper insulation coordination and protection against fast transients.
- Ability to design insulation strength with IEEE and IEC standards.
- Ability to design substation grounding system and shielding.
- Ability to design disconnector switching for VFTO.

REFERENCES:

1 Andrew R. Hileman, “Insulation coordination for power systems”, Taylor and Francis, 1999.

2 Klaus Ragallar, “Surges in high voltage networks” Plenum Press, New York, 1980.

3 “Power Engineer’s handbook”, TNEB Association.

4 Pritindra Chowdhuri, “Electromagnetic transients in power systems”, PHI Learning Private Limited, New Delhi, Second edition, 2008.

5 Klaus Ragallar, “Surges in high voltage networks” Plenum Press, New York, 1980.

6. “Design guide for rural substation”, United States Department of Agriculture, RUS Bulletin, 1724E-300, June 2001.

7. AIEE Committee Report, “Substation One-line Diagrams,” AIEE Trans. On Power Apparatus and Systems, August 1953.

8. Hermann Koch, “Gas Insulated Substations”, Wiley-IEEE Press, 2014.

CO / PO & PSO Mapping :

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	3	2	3			2					2	3
CO2	2		1	3			2		3	2	3	2
CO3		3	3		1	3		3	2		2	3
CO4	2	1	1	2		2	1			1	2	2
CO5	1	3	3		2	3		2	1		3	2

1916212	TECHNICAL SEMINAR	L	T	P	C
		0	0	2	1

OBJECTIVES:

- To encourage the students to study advanced engineering developments.
- To prepare and present technical reports.
- To encourage the students to use various teaching aids such as power point presentation and demonstrative models.
- To prepare the students in preparing project reports and to face an interview.
- To encourage the students to present the technical topics.

METHOD OF EVALUATION:

During the seminar session each student is expected to prepare and present a topic on engineering/ technology, for duration of about 8 to 10 minutes. In a session of three periods per week, 15 students are expected to present the seminar. Each student is expected to present at least twice during the semester and the student is evaluated based on that. At the end of the semester, he / she can submit a report on his / her topic of seminar and marks are given based on the report. A Faculty guide is to be allotted and he / she will guide and monitor the progress of the student and maintain attendance also. Evaluation is 100% internal.

TOTAL :30 PERIODS

COURSE OUTCOMES:

- Ability to study advanced engineering developments
- Ability to prepare and present technical reports.
- Ability to use various teaching aids such as power point presentation and demonstrative models.
- Ability to prepare project reports and to face an interview
- Ability to prepare the students to present the technical topics

CO / PO & PSO Mapping:

CO	PO										PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1					3		3					1
CO2					3		3					1
CO3					3		3					1
CO4					3		3					1
CO5					3		3					1

1916310	PROJECT WORK – I	L	T	P	C
		0	0	12	6

OBJECTIVES:

- To enable a student to do an individual project work which may involve design, modelling, simulation and/or fabrication.
- To analyze a problem both theoretically and practically.
- To motivate the students to involve in research activities leading to innovative solutions for industrial and societal problem
- To train the students in preparing project reports and to face reviews and viva voce examination.
- To present the work in International/National conference or reputed journals

The student works on a topic approved by the head of the department under the guidance of a faculty member and prepares a comprehensive project report after completing the work to the satisfaction of the supervisor. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department.

TOTAL:180 PERIODS

COURSE OUTCOMES:

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

- Comprehend a problem thoroughly and provide an appropriate solution.
- Do a systematic literature survey.
- Derive a mathematical model for the system under study.
- Get proficiency over the software used for simulation and analysis.
- Present the findings of a research work in conferences and publish in journals

CO / PO & PSO Mapping :

CO	**PO**										**PSO**	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	2	3	3	3	3	3	2	2	3	3	3	3
CO2	3	3	3	3					2	2	3	3
CO3	1	3	3	3							3	3
CO4				3				3	3	3	3	3
CO5	2	2	3	3	3	3	3	2	3	3	3	3

1916401	**PROJECT WORK – II**	**L**	**T**	**P**	**C**
		0	**0**	**24**	**12**

OBJECTIVES:

- To enable a student to do an individual project work which may involve design, modelling, simulation and/or fabrication.
- To analyze a problem both theoretically and practically.
- To motivate the students to involve in research activities leading to innovative solutions for industrial and societal problem
- To train the students in preparing project reports and to face reviews and viva voce examination.
- To present the work in International/National conference or reputed journals

The student works on a topic approved by the head of the department under the guidance of a faculty member and prepares a comprehensive project report after completing the work to the satisfaction of the supervisor. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department.

TOTAL:360 PERIODS

COURSE OUTCOMES:

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

- Comprehend a problem thoroughly and provide an appropriate solution.
- Do a systematic literature survey.
- Derive a mathematical model for the system under study.
- Get proficiency over the software used for simulation and analysis.
- Present the findings of a research work in conferences and publish in journals

CO / PO & PSO Mapping :

CO	**PO**										**PSO**	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2
CO1	2	3	3	3	3	3	2	2	3	3	3	3
CO2	3	3	3	3					2	2	3	3
CO3	1	3	3	3							3	3
CO4				3				3	3	3	3	3
CO5	2	2	3	3	3	3	3	2	3	3	3	3