

# **K.L.N. COLLEGE OF ENGINEERING**

**Pottapalayam-630612, Sivagangai District**

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



**Estd: 1994**

## **CURRICULA & SYLLABI**

**I to IV Semesters**

**REGULATIONS 2020**

**For Post Graduate Program**

**M.E. – POWER SYSTEMS ENGINEERING**

**CHOICE BASED CREDIT SYSTEM**

**(For the students admitted from the academic year 2020-2021 onwards)**



**K.L.N. COLLEGE OF ENGINEERING, POTTAPALAYAM**  
**(An Autonomous Institution, Affiliated to Anna University, Chennai)**



**VISION OF THE INSTITUTION**

To become a Centre of Excellence in Technical Education and Research in producing Competent and Ethical professionals to the society

**MISSION OF THE INSTITUTION**

To impart Value and Need based curriculum to the students with enriched skill development in the field of Engineering, Technology, Management and Entrepreneurship and to nurture their character with social concern and to pursue their career in the areas of Research and Industry.

**VISION OF THE DEPARTMENT**

To become a high standard of excellence in Education, Training and Research in the field of Electrical & Electronics Engineering and allied applications

**MISSION OF THE DEPARTMENT**

To produce excellent, innovative and Nationalistic Engineers with Ethical Values and to advance in the field of Electrical & Electronics Engineering and allied areas



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### **PROGRAM EDUCATIONAL OBJECTIVES (PEOs)**

**PEO 1:** Ability to engage in applications oriented work and management of the electrical power industry, including generation, transmission, distribution, electrical machines and machine control.

**PEO 2:** Ability to work as teaching faculty in reputed institutions and work as engineer in IT industries.

**PEO 3:** Ability to engage in research and development activities

### **PROGRAM SPECIFIC OUTCOMES (PSOs):**

**PSO1.** Ability to apply knowledge of Electrical Power System principles and techniques for power system operation, control and applications, economical operation and state of art techniques to protect Power System

**PSO2.** Ability to develop steady-state and dynamic models of various Power System components to perform system studies for generation and transmission system expansion planning.

**PSO3.** Ability to analyze various electricity market models with distributed energy resources and demand response management and to incorporate interdisciplinary knowledge to address the recent problems in the electrical power industry



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Chennai)

KLNCE PG EEE R2020



### PROGRAM OUTCOMES (POs):

The Graduate Attributes of PG programmes are as follows:

#### 1. Scholarship of Knowledge

Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyze and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.

#### 2. Critical Thinking

Analyze complex engineering problems critically, apply independent judgment for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.

#### 3. Problem Solving

Think laterally and originally, conceptualize and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.

#### 4. Research Skill

Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.

#### 5. Usage of modern tools

Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities with an understanding of the limitations.

**6. Collaborative and Multidisciplinary work**

Possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.

**7. Project Management and Finance**

Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economical and financial factors.

**8. Communication**

Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.

**9. Life-long Learning**

Recognize the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

**10. Ethical Practices and Social Responsibility**

Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.

**11. Independent and Reflective Learning**

Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.



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**REGULATIONS 2020**  
**For Post Graduate Program**  
**M.E. - POWER SYSTEMS ENGINEERING**  
**CHOICE BASED CREDIT SYSTEM**

**CATEGORY OF COURSES**

- i. **Professional Core (PC) Courses** include the core courses relevant to the chosen programme of study including Research methodology and IPR
- ii. **Professional Elective (PE) Courses** include the elective courses relevant to the chosen programme of study.
- iii. **Employability Enhancement Courses (EEC)** include Mini project, Project Work, and Technical seminar
- iv. **Audit Courses (AC)** include courses which develop desired attitudes.
- v. **Open Elective (OE)** courses include skill development courses.



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**REGULATIONS 2020**  
**CHOICE BASED CREDIT SYSTEM**  
**M.E. POWER SYSTEMS ENGINEERING (FULL TIME)**  
**CURRICULA AND SYLLABI**  
**I TO IV SEMESTERS**

**SEMESTER I**

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
<b>THEORY</b>								
1.	20PS101	<a href="#">Advanced Power System Analysis</a>	PC	4	3	1	0	4
2.	20PS102	<a href="#">Advanced Power System Operation and Control</a>	PC	3	3	0	0	3
3.	20PS103	<a href="#">Analysis and Computation of Electromagnetic Transients in Power Systems</a>	PC	3	3	0	0	3
4.	20PS104	<a href="#">System Theory</a>	PC	4	3	1	0	4
5.	20RM101	<a href="#">Research Methodology and IPR</a>	PC	2	2	0	0	2
6.		<a href="#">Professional Elective I</a>	PE	3	3	0	0	3
7.		Audit Course I	AC	2	2	0	0	0
<b>PRACTICAL</b>								
8.	20PS1L1	<a href="#">Power System Simulation Laboratory</a>	PC	4	0	0	4	2
<b>TOTAL</b>				<b>25</b>	<b>19</b>	<b>2</b>	<b>4</b>	<b>21</b>

**SEMESTER II**

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
<b>THEORY</b>								
1.	20PS201	<a href="#">Power System Dynamics</a>	PC	3	3	0	0	3
2.	20PS202	<a href="#">HVDC and FACTS</a>	PC	3	3	0	0	3
3.	20PS203	<a href="#">Advanced Power System Protection</a>	PC	3	3	0	0	3
4.	20PS204	<a href="#">Restructured Power System</a>	PC	3	3	0	0	3
5.		<a href="#">Professional Elective II</a>	PE	3	3	0	0	3
6.		<a href="#">Professional Elective III</a>	PE	3	3	0	0	3
7.		Audit Course II	AC	2	2	0	0	0
<b>PRACTICAL</b>								
8.	20PS2L1	<a href="#">Advanced Power System Simulation Laboratory</a>	PC	4	0	0	4	2
9.	20PS2L2	Technical Seminar	EEC	2	0	0	2	1
<b>TOTAL</b>				<b>26</b>	<b>20</b>	<b>0</b>	<b>6</b>	<b>21</b>

**SEMESTER III**

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
<b>THEORY</b>								
1.		<a href="#">Professional Elective IV</a>	PE	3	3	0	0	3
2.		<a href="#">Professional Elective V</a>	PE	3	3	0	0	3
3.		Open Elective	OE	3	3	0	0	3
<b>PRACTICAL</b>								
4.	20PS3L1	Project Work Phase I	EEC	12	0	0	12	6
<b>TOTAL</b>				<b>21</b>	<b>9</b>	<b>0</b>	<b>12</b>	<b>15</b>

**SEMESTER IV**

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
<b>PRACTICAL</b>								
1.	20PS4L1	Project Work Phase II	EEC	24	0	0	24	12
<b>TOTAL</b>				<b>24</b>	<b>0</b>	<b>0</b>	<b>24</b>	<b>12</b>

**TOTAL NO. OF CREDITS: 69**



**PROFESSIONAL CORE (PC)**

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	20PS101	Advanced Power System Analysis	PC	4	3	1	0	4
2.	20PS102	Advanced Power System Operation and Control	PC	3	3	0	0	3
3.	20PS103	Analysis and Computation of Electromagnetic Transients in Power Systems	PC	3	3	0	0	3
4.	20PS104	System Theory	PC	4	3	1	0	4
5.	20RM101	Research Methodology and IPR	PC	2	2	0	0	2
6.	20PS1L1	Power System Simulation Laboratory	PC	4	0	0	4	2
7.	20PS201	Power System Dynamics	PC	3	3	0	0	3
8.	20PS202	HVDC and FACTS	PC	3	3	0	0	3
9.	20PS203	Advanced Power System Protection	PC	3	3	0	0	3
10.	20PS204	Restructured Power System	PC	3	3	0	0	3
11.	20PS2L1	Advanced Power System Simulation Laboratory	PC	4	0	0	4	2
Total credits								32

**EMPLOYABILITY ENHANCEMENT COURSES (EEC)**

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	20PS2L2	Technical Seminar	EEC	2	0	0	2	1
2.	20PS3L1	Project Work Phase I	EEC	12	0	0	12	6
3.	20PS4L1	Project Work Phase II	EEC	24	0	0	24	12

**PROFESSIONAL ELECTIVES (PE)**

**PROFESSIONAL ELECTIVE I**

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	20PS1E1	<a href="#">Analysis of Electrical Machines</a>	PE	3	3	0	0	3
2.	20PS1E2	<a href="#">Analysis and Design of Power Converters</a>	PE	3	3	0	0	3
3.	20PS1E3	<a href="#">Industrial Power System Analysis and Design</a>	PE	3	3	0	0	3

**PROFESSIONAL ELECTIVE II**

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	20PS2A1	<a href="#">Smart Grid Technologies</a>	PE	3	3	0	0	3
2.	20PS2A2	<a href="#">Solar and Energy Storage Systems</a>	PE	3	3	0	0	3
3.	20PS2A3	<a href="#">Power System Reliability</a>	PE	3	3	0	0	3

**PROFESSIONAL ELECTIVE III**

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	20PS2B1	<a href="#">Advanced Digital Signal Processing</a>	PE	3	3	0	0	3
2.	20PS2B2	<a href="#">Distributed Generation and Microgrid</a>	PE	3	3	0	0	3
3.	20PS2B3	<a href="#">Soft Computing Techniques</a>	PE	3	3	0	0	3

**PROFESSIONAL ELECTIVE IV**

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	20PS3A1	<a href="#">Electrical Distribution System</a>	PE	3	3	0	0	3
2.	20PS3A2	<a href="#">Energy Management and Auditing</a>	PE	3	3	0	0	3
3.	20PS3A3	<a href="#">Wind Energy Conversion Systems</a>	PE	3	3	0	0	3
4.	20PS3A4	<a href="#">Design of Power Electronic Converters</a>	PE	3	3	0	0	3
5.	20PS3A5	<a href="#">Electromagnetic Interference and Compatibility</a>	PE	3	3	0	0	3

**PROFESSIONAL ELECTIVE V**

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	20PS3B1	<a href="#">Electric Vehicles and Energy Storage System</a>	PE	3	3	0	0	3
2.	20PS3B2	<a href="#">Principles of Electric Power Transmission</a>	PE	3	3	0	0	3
3.	20PS3B3	<a href="#">Advanced Power System Dynamics</a>	PE	3	3	0	0	3
4.	20PS3B4	<a href="#">Design of Substations</a>	PE	3	3	0	0	3

**AUDIT COURSES (AC)**

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	20AC101	<a href="#">English for Research Paper Writing</a>	AC	2	2	0	0	0
2.	20AC102	<a href="#">Disaster Management</a>	AC	2	2	0	0	0
3.	20AC103	<a href="#">Sanskrit for Technical Knowledge</a>	AC	2	2	0	0	0
4.	20AC104	<a href="#">Value Education</a>	AC	2	2	0	0	0
5.	20AC105	<a href="#">Constitution of India</a>	AC	2	2	0	0	0
6.	20AC106	<a href="#">Pedagogy Studies</a>	AC	2	2	0	0	0
7.	20AC107	<a href="#">Stress Management by Yoga</a>	AC	2	2	0	0	0
8.	20AC108	<a href="#">Personality Development through Life Enlightenment Skills</a>	AC	2	2	0	0	0

**OPEN ELECTIVES (OE)**

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	20OE301	<a href="#">Business Analytics</a>	OE	3	3	0	0	3
2.	20OE302	<a href="#">Industrial Safety</a>	OE	3	3	0	0	3
3.	20OE303	<a href="#">Operations Research</a>	OE	3	3	0	0	3
4.	20OE304	<a href="#">Cost Management of Engineering Projects</a>	OE	3	3	0	0	3
5.	20OE305	<a href="#">Composite Materials</a>	OE	3	3	0	0	3
6.	20OE306	<a href="#">Waste to Energy</a>	OE	3	3	0	0	3

**SUMMARY**

S.No	Category	Credits as per semester				Total Credits
		I	II	III	IV	
1.	PC	18	14	-	-	32
2.	PE	3	6	6	-	15
3.	EEC	-	1	6	12	19
4.	AC	0	0	-	-	0
5.	OE	-	-	3	-	3
<b>Total</b>		<b>21</b>	<b>21</b>	<b>15</b>	<b>12</b>	<b>69</b>

20PS101

**ADVANCED POWER SYSTEM  
ANALYSIS**

L	T	P	C
3	1	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

**PRE-REQUISITE: NIL**

**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**

**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- Apply the concepts of sparse matrix for large scale power system analysis
- Apply Newton Raphson and Fast Decoupled Load Flow methods for solving load flow problem
- Solve Optimal Power flow problem
- Analyze Symmetrical fault using Zbus algorithm
- Solve unsymmetrical faults
- Analyze Transient stability of power systems

**REFERENCES:**

1. M.A.Pai, "Computer Techniques in Power System Analysis", Tata McGraw-Hill Publishing Company Limited, New Delhi, 2014.
2. D.P.Kothari and I.J. Nagrath, "Modern Power System Analysis", Tata McGraw-Hill, 2011.
3. A.J.Wood and B.F.Wollenberg, "Power Generation Operation and Control", John Wiley and sons, 2013.
4. P.Kundur, "Power System Stability and Control", McGraw Hill, 2006.

20PS102

**ADVANCED POWER SYSTEM  
OPERATION AND CONTROL**

L	T	P	C
3	0	0	3

**OBJECTIVES:**

- To understand the fundamentals of speed governing system and the concept of control areas.
- To provide knowledge about Hydro thermal scheduling, Unit commitment and solution techniques.
- To impart knowledge on the need of state estimation and its role in the day- today operation of power system.

**PRE-REQUISITE:NIL**

**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.

**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  $\lambda$ -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**

**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- Apply electrical engineering knowledge to calculate the values of load distribution parameters.
- Analyze the static and dynamic model of Load Frequency Control in single and two area system
- Analyze the problems associated with hydro thermal Scheduling for feasible load management
- Solve unit commitment problems using various methods
- Solve economic dispatch problems using various methods
- Explain about the power system security factors and the algorithms used for optimal power flow

**REFERENCES:**

- 1 Olle. I. Elgerd, "Electric Energy Systems Theory – An Introduction", Tata McGraw Hill Publishing Company Ltd, New Delhi, Second Edition, 2003.
- 2 D.P. Kothari and I.J. Nagrath, "Modern Power System Analysis", Third Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2011.
- 3 L.L. Grigsby, "The Electric Power Engineering, Hand Book", CRC Press & IEEE Press, 2001.
- 4 Allen.J.Wood and Bruce F.Wollenberg, "Power Generation, Operation and Control", John Wiley & Sons, Inc., 2013.
- P. Kundur, "Power System Stability & Control", McGraw Hill Publications, USA, 2006.

20PS103

**ANALYSIS AND COMPUTATION OF  
ELECTROMAGNETIC TRANSIENTS IN  
POWER SYSTEMS**

L	T	P	C
3	0	0	3

**OBJECTIVES:**

- To understand the various types of transients and its analysis in power system.
- To learn about modeling and computational aspects transients computation

**PRE-REQUISITE:NIL**

**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 OVERVOLTAGES 9**

Lightning overvoltages: 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 overvoltages: 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,  $\alpha$ - $\beta$ -0 transformation and symmetrical components transformation, modal impedances; analysis of modes on untransposed 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: why 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

**TOTAL: 45 PERIODS**



**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- Demonstrate the travelling wave and Derive the travelling wave equation.
- Discuss the over voltages due to lightning, switching and temporary conditions and also categorize the methods to mitigate it.
- Analyze the various effects involving and methods to modeling of over head lines.
- Describe the features, parameters and methods to modeling of underground cables.
- Discuss the salient features of a line parameter evaluation program and compute the line parameters by digital methods.
- Demonstrate the case studies on simulation of various types of transients.

**REFERENCES:**

- 1 Allan Greenwood, "Electrical Transients in Power System", Wiley & Sons Inc. New York, 2010.
- 2 R. Ramanujam, "Computational Electromagnetic Transients: Modeling, Solution Methods and Simulation", I.K. International Publishing House Pvt. Ltd, New Delhi, 2014.
- 3 Naidu M S and Kamaraju V, "High Voltage Engineering", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2020.

20PS104

**SYSTEM THEORY**

L	T	P	C
3	1	0	4

**OBJECTIVES:**

- To understand the fundamentals of physical systems in terms of its linear and nonlinear models.
- To educate on representing systems in state variable form
- To educate on solving linear and non-linear state equations
- To exploit the properties of linear systems such as controllability and observability
- To educate on stability analysis of systems using Lyapunov's theory
- To educate on modal concepts and design of state and output feedback controllers and estimators

**PRE-REQUISITE:NIL**

**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.

**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 – Krasovski's and Variable-Gradient Method.

**TOTAL: 60 PERIODS**

**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- Derive state model for the given differential equation and basic Electrical and Mechanical circuits
- Solve the state equation of linear time invariant system
- Solve the state equation of linear time variant system
- Analyze the controllability and observability of the linear time variant and invariant system
- Design a state feedback controller and state observer for given problem
- Solve the stability problem of non-linear system using Lyapunov method

**TEXT BOOKS:**

1. M. Gopal, "Modern Control System Theory", New Age International, 2014.
2. K. Ogatta, "Modern Control Engineering", PHI, 2015.
3. John S. Bay, "Fundamentals of Linear State Space Systems", McGraw-Hill, 1999.
4. D. Roy Choudhury, "Modern Control Systems", New Age International, 2005.
5. John J. D'Azzo, C. H. Houpis and S. N. Sheldon, "Linear Control System Analysis and Design with MATLAB", Taylor Francis, 2013.
6. Z. Bubnicki, "Modern Control Theory", Springer, 2005.
7. C.T. Chen, "Linear Systems Theory and Design" Oxford University Press, 3rd Edition, 1999.
8. M. Vidyasagar, "Nonlinear Systems Analysis", 2nd edition, Prentice Hall, Englewood Cliffs, New Jersey.

<b>20RM101</b>	<b>RESEARCH METHODOLOGY AND IPR</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>2</b>	<b>0</b>	<b>0</b>	<b>2</b>

**OBJECTIVES:**

To give an overview of the research methodology and explain the technique of defining a research problem and to explain the functions of the literature review in research. This course can explain the art of interpretation and the art of writing research reports. Also it explains various forms of the intellectual property, its relevance and business impact in the changing global business environment.

**PRE-REQUISITE:NIL**

**UNIT-I INTRODUCTION TO RESEARCH METHODOLOGY 6**

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations. Effective literature studies approaches, analysis Plagiarism, Research ethics,

**UNIT-II EFFECTIVE TECHNICAL WRITING 6**

How to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

**UNIT - III INTELLECTUAL PROPERTY AND INTERNATIONAL SCENARIO 6**

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**UNIT - IV PATENT RIGHTS 6**

Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

**UNIT - V NEW DEVELOPMENTS IN IPR 6**

Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

**TOTAL: 30 PERIODS**

**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- Explain the meaning of research problem, Sources of research problem, Scope and objectives
- Analyze research related information.
- Summarize the research ethics to Effective literature studies approaches, analysis and Plagiarism
- Describe the Format of research proposal and presentation
- Describe the Nature of Intellectual Property and the process of Patents, Designs, Trade and Copyright.
- Discuss the Patent Rights, Scope of Patent Rights. Licensing and transfer of technology

**References:**

- Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students"
- Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
- Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
- Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.
- Mayall, "Industrial Design", McGraw Hill, 1992.
- Niebel, "Product Design", McGraw Hill, 1974.
- Asimov, "Introduction to Design", Prentice Hall, 1962.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", 2016.
- T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

20PS1L1

POWER SYSTEM SIMULATION LABORATORY

LT P C

0 0 4 2

**OBJECTIVES:**

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

**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**

**OUTCOMES:**

At the end of this course, students will be able to

- Solve the power flow problem using Newton-Raphson method and Fast decoupled method.
- Solve the contingency of power system and economic dispatch
- Demonstrate the switching surge using EMTP
- Demonstrate the Simulation and Implementation of Voltage Source Inverter
- Demonstrate the Digital Over Current Relay and Coordinate Relay
- Solve the unit commitment problem using MATLAB

**LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:**

S.No	Description of Equipment	Quantity Required
1.	Personal Computers (Intel Core i3, 250 GB, 1 GB RAM)	30
2.	Printer	1
3.	Server (Intel Core i3, 4 GB RAM) (High Speed Processor)	1
4.	Software: EMTP / ETAP / CYME / MIPOWER / Matlab/ any Power system simulation software	5 User Licenses
5.	Compilers: C / C++	30 users

20PS201

**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 stability of dynamic systems and its classification
- To understand and enhance small signal stability problem of power systems

**PRE-REQUISITE:NIL**

**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

**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**

**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- Describe the dynamic modeling of synchronous machine.
- Derive the voltage, current and flux linkage relationships in steady state analysis of synchronous machine
- Discuss the modeling of excitation and speed governing system for stability analysis
- Discuss about stability of dynamic systems.
- Describe the significance about small signal stability analysis with controllers.
- Discuss the different methods of 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, 2006.
- 3 P.M Anderson and A.A Fouad, "Power System Control and Stability", Iowa State University Press, Ames, Iowa, 2002.
- 4 R.Ramunujam," Power System Dynamics Analysis and Simulation, PHI Learning Private Limited, New Delhi, 2009



20PS202

**HVDC AND FACTS**

L	T	P	C
3	0	0	3

**OBJECTIVES:**

- To emphasize 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

**PRE-REQUISITE:NIL**

**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**

Simplified analysis of six pulse Graetz bridge – Characteristics - Analysis of converter operations – 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**

**OUTCOMES:**

At the end of this course, students will be able to

- Describe the basics of power transmission networks and FACTS controllers
- Illustrate the performance of SVC and STATCOM
- Illustrate the performance of TCSC and SSSC
- Explain the significance of HVDC converters.
- Explain the significance of HVDC system control.
- Develop the knowledge on 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.
2. K.R.Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age International(P) Ltd., Publishers, New Delhi, Reprint 2008.
3. K.R.Padiyar, "HVDC Power Transmission Systems", New Age International (P) Ltd., New Delhi, 2002.
4. J.Arrillaga, "High Voltage Direct Current Transmission", Peter Pregrinus, London, 1988.
5. V.K.Sood, "HVDC and FACTS controllers- Applications of Static Converters in Power System", Kluwer Academic Publishers 2004.

20PS203

**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 and Numerical protection

**PRE-REQUISITE:NIL**

**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 - 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 relayReactance 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.

**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**

**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- Explain over current and earth fault protection schemes using electro-magnetic relays
- Design differential protection for Transformer
- Design differential protection for busbar
- Explain the distance and carrier protection of transmission lines.
- Describe the various protection schemes of Alternator
- Discuss the digital over current, distance and differential protection of power system.

**REFERENCES:**

- 1 Y.G. Paithankar and S.R Bhide, “Fundamentals of Power System Protection”, Prentice-Hall of India, 2010
- 2 Badri Ram and D.N. Vishwakarma, “Power System Protection and Switchgear”, Tata McGraw- Hill Publishing Company, 2017.
- 3 T.S.M. Rao, “Digital Relay / Numerical relays”, Tata McGraw Hill, New Delhi, 2005.
- 4 P.Kundur, “Power System Stability and Control”, McGraw-Hill, 2006.

<b>20PS204</b>	<b>RESTRUCTURED POWER SYSTEM</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**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 Illustrate about various power sectors in India

**PRE-REQUISITE:NIL**

**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

**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 adequacy – FTR issuance process: FTR auction, FTR allocationTreatment 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****OUTCOMES:****AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- Explain the importance of restructuring of Power Systems, different market models and the function of ISO role in power market
- Apply the Concepts of Transmission Congestion and to calculate ATC.
- Analyze Locational marginal pricing and explain the significance of Financial Transmission rights.

Explain the financial transmission rights and pricing of transmission network

- Define Ancillary services management and analyze transmission pricing issues
- Outline the reform initiatives taken by Indian Government, Electricity act 2003 and open access issues.

**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. Bollen, "Operation of restructured power systems", Kluwer Academic Pub., 2001.
- 3 Paranjothi, S.R. , "Modern Power Systems" Paranjothi, S.R. , New Age International, 2017.
- 4 Sally Hunt," Making competition work in electricity", John Willey and Sons Inc. 2002.
5. Steven Stoft, "Power system economics: designing markets for electricity", John Wiley & Sons, 2002.

**OBJECTIVES:**

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

**LIST OF EXPERIMENTS**

1. Small-signal stability analysis of single machine-infinite bus system using classical machine model
2. Small-signal stability analysis of multi-machine configuration with classical machine model
3. Induction motor starting analysis
4. Load flow analysis of two-bus system with STATCOM
5. Transient analysis of two-bus system with STATCOM
6. Available Transfer Capability calculation using an existing load flow program
7. 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**

**OUTCOMES:**

At the end of this course, students will be able to

- Solve the Small-signal stability of Single machine-infinite bus system and Multi-Machine using classical machine model
- Solve the Load flow and transient of two-bus system with STATCOM
- Calculate the Available Transfer Capability of an existing load flow program
- Demonstrate the variable speed wind energy conversion system- DFIG and PMSG
- Compute the harmonic indices generated by a rectifier feeding a R-L load
- Design and demonstrate active filter for mitigating harmonics

**LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:**

Sl.No.	Description of Equipment	Quantity Required
1.	Personal Computers (Intel Core i3, 250 GB, 1 GB RAM)	30
2.	Laser Printer	1
3.	Dot matrix Printer	1
4.	Server (Intel Core i3, 4 GB RAM) (High Speed Processor)	1
5.	Software: EMTP / ETAP / CYME / MIPOWER / any Power system simulation software	5 User Licenses
6.	Compilers: C / C++ / Matlab	30 users

<b>20PS1E1</b>	<b>ANALYSIS OF ELECTRICAL MACHINES</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**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.

**PRE-REQUISITE:NIL**

**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**



**OUTCOMES:**

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

- Ability to understand the various electrical parameters in mathematical form.
- Ability to understand the different types of reference frame theories and transformation relationships.
- Ability to find the electrical machine equivalent circuit parameters and modeling of electrical machines.

**REFERENCES:**

1. Paul C.Krause, Oleg Wasyzcuk, 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, 2017
4. R. Krishnan, Electric Motor & Drives: Modeling, Analysis and Control, New Delhi, Prentice Hall of India, 2015

20PS1E2

**ANALYSIS AND DESIGN OF POWER CONVERTERS**

L	T	P	C
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

**PRE-REQUISITE:NIL**

**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.

**TOTAL: 45 PERIODS**

**OUTCOMES:**

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

- Analyze various single phase power converters.
- Analyze various three phase power converters
- Design dc-dc converter topologies for a broad range of power conversion applications.
- Design various power converter components
- Explain about resonant DC –DC converters
- Design ac-ac converters for variable frequency applications

**TEXT BOOKS:**

- 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 P.C. Sen, "Modern Power Electronics", Wheeler Publishing Co, First Edition, New Delhi, 2001.
- 4 P.S.Bimbra, "Power Electronics", Khanna Publishers, Eleventh Edition, 2003
- 5 Simon Ang, Alejandro Oliva, "Power-Switching Converters, Second Edition, CRC Press, Taylor & Francis Group, 2010
- 6 V.Ramanarayanan, "Course material on Switched mode power conversion", 2007
- 7 Alex Van den Bossche and VencislavCekovValchev, "Inductors andTransformers for PowerElectronics", CRC Press, Taylor & Francis Group, 2005
- 8 W. G. Hurley and W. H.Wolfle, "Transformers and Inductors for Power Electronics Theory, Design and Applications", 2013 John Wiley & Sons Ltd.
- 9 Marian.K.Kazimierczuk and DariuszCzarkowski, "Resonant Power Converters", John Wiley & Sons limited, 2011

<b>20PS1E3</b>	<b>INDUSTRIAL POWER SYSTEM ANALYSIS AND DESIGN</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**OBJECTIVES:**

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

**PRE-REQUISITE:NIL**

**UNIT-I MOTOR STARTING STUDIES 9**

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

**UNIT-II POWER FACTOR CORRECTION STUDIES 9**

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

**UNIT - III HARMONIC ANALYSIS 9**

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

**UNIT - IV FLICKER ANALYSIS 9**

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

**UNIT - V INSULATION AND COORDINATION 9**

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

**TOTAL: 45 PERIODS**

**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- Learners will have knowledge on motor starting and power factor correction.
- Learners will perform computer-aided harmonic and flicker analysis and to design filters.
- Learners will have knowledge on various grid grounding methodologies

**REFERENCES:**

- 1 Ramasamy Natarajan, “Computer-Aided Power System Analysis”, Marcel Dekker Inc.,2002.
- 2 EMTP literature from [www.microtran.cm](http://www.microtran.cm)
- 3 IEEE papers on bus transfer.

<b>20PS2A1</b>	<b>SMART GRID TECHNOLOGIES</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**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

**PRE-REQUISITE:NIL**

**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, 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**

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**

**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- 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.

<b>20PS2A2</b>	<b>SOLAR AND ENERGY STORAGE SYSTEMS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**OBJECTIVES:**

- To Study about solar modules and PV system design and their applications
- To Deal with grid connected PV systems
- To Discuss about different energy storage systems

**PRE-REQUISITE:NIL**

**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**

**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- Explain the basic characteristics and properties of solar cells
- Develop basic knowledge on Power conditioning units
- Analyze MPPT algorithms for PV system.
- Discuss the design issues for central power stations and grid connected PV systems
- Explain the various types of energy storage systems used in solar PV system
- Classify different applications of solar energy systems

**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.





**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.

<b>20PS2B1</b>	<b>ADVANCED DIGITAL SIGNAL PROCESSING</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		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
- To compare Architectures & features of Programmable DSP Processors & develop logical functions of DSP Processors
- To discuss on Application development with commercial family of DS Processors
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

**PRE-REQUISITE: NIL**

**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 and TMS 320 C6xxx 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**

**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- Students will learn the essential advanced topics in DSP that are necessary for successful Postgraduate level research.
- Students will have the ability to solve various types of practical problems in DSP
- Comprehend the DFTs and FFTs, design and Analyze the digital filters, comprehend the Finite word length effects in Fixed point DSP Systems.
- The conceptual aspects of Signal processing Transforms are introduced.
- The comparison on commercial available DSPProcessors 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. Ifeachor E. C., Jervis B. W , "Digital Signal Processing: A practical approach, Pearson-Education, PHI/ 2002
4. Shaila D. Apte, " Digital Signal Processing", Second Edition, Wiley, 2016.
5. Robert J.Schilling,Sandra L.Harris,"Intro. To Digital Signal Processing with Matlab",Cengage,2014.
6. Steven A. Tretter, "Communication System Design Using DSP Algorithms with Laboratory Experiments for the TMS320C6713™ DSK", Springer, 2008.
7. RulphChassaing and Donald Reay, "Digital Signal Processing and Applications with the TMS320C6713 and TMS320C6416 DSK", John Wiley & Sons, Inc., Hoboken, New Jersey, 2008.
8. K.P. Soman and K.L. Ramchandran,Insight into WAVELETS from theory to practice, Eastern Economy Edition, 2008
9. B Venkataramani and M Bhaskar "Digital Signal Processors", TMH, 2<sup>nd</sup>, 2010
10. Vinay K.Ingle,John G.Proakis,"DSP-A Matlab Based Approach",Cengage Learning,2010
11. Taan S.Elali,"Discrete Systems and Digital Signal Processing with Matlab",CRC Press2009.
12. Monson H. Hayes, "Statistical Digital signal processing and modelling", John Wiley & Sons, 2008.
13. Avatar Sing, S. Srinivasan, "Digital Signal Processing- Implementation using DSP Microprocessors with Examples from TMS320C54xx", Thomson India,2004.

<b>20PS2B2</b>	<b>DISTRIBUTED GENERATION AND MICROGRID</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**OBJECTIVES:**

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

**PRE-REQUISITE:NIL**

**UNIT-I INTRODUCTION 9**

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

**UNIT-II DISTRIBUTED GENERATIONS (DG) 9**

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

**UNIT - III IMPACT OF GRID INTEGRATION 9**

Requirements for grid 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**

**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- Learners will attain knowledge on the various schemes of conventional and nonconventional 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.

**REFERENCES:**

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

20PS2B3

**SOFT COMPUTING TECHNIQUES**

L	T	P	C
3	0	0	3

**OBJECTIVES:**

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

**PRE-REQUISITE:NIL**

**UNIT-I INTRODUCTION AND ARTIFICIAL NEURAL NETWORKS 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 -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- effect of learning rule coefficient -back propogation algorithm- factors affecting back propogation training- applications-machine learning.

**UNIT-II ARTIFICIAL NEURAL NETWORKS AND ASSOCIATIVE MEMORY 9**

Counter propogation network- architecture- functioning & characteristics of counter Propagation network- Hopfield/ Recurrent network configuration - stability constraints associative memory and characteristics- limitations and applications- Hopfield v/s Boltzman machine- Adaptive Resonance Theory- Architecture- classifications- Implementation and training - Associative Memory.

**UNIT - III FUZZY LOGIC SYSTEM 9**

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

**UNIT - IV GENETIC ALGORITHM 9**

Evolutionary programs – Genetic algorithms, genetic programming and evolutionary programming - Genetic Algorithm versus Conventional Optimization Techniques - Genetic representations and selection mechanisms; Genetic operators- different types of crossover and mutation operators - Optimization problems using GA-discrete and continuous - Single objective and multi-objective problems - Procedures in evolutionary programming.

**UNIT - V 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 –Introduction to Support Vector Machine- Evolutionary Programming-Particle Swarm Optimization - Case study – Familiarization of NN, FLC and ANFIS Tool Box.

**TOTAL: 45 PERIODS**

**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- Explain the basics of ANN architectures, algorithms and their limitations
- Explain the different types of Associative memories
- Apply the knowledge of Fuzzy logic for modeling and control of non-linear systems.
- Explain the basics of Genetic Algorithms
- Apply the knowledge of Genetic Algorithms to optimize the power system parameters
- Explain the use of hybrid control schemes for power system

**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, 2008.
3. Zimmermann H.J. "Fuzzy set theory and its Applications" Springer international edition, 2011.
4. David E.Goldberg, "Genetic Algorithms in Search, Optimization, and Machine Learning", Pearson Education, 2009.
5. W.T.Miller, R.S.Sutton and P.J.Webrose, "Neural Networks for Control" MIT Press", 1996.
6. T. Ross, "Fuzzy Logic with Engineering Applications", Tata McGraw Hill, New Delhi, 1995.
7. Ethem Alpaydin, "Introduction to Machine Learning (Adaptive Computation and Machine Learning Series)", MIT Press, 2004.
8. Corinna Cortes and V. Vapnik, " Support - Vector Networks, Machine Learning " 1995



<b>20PS3A1</b>	<b>ELECTRICAL DISTRIBUTION SYSTEM</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**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
- To analyze the power flow in balanced and unbalanced system

**PRE-REQUISITE:NIL**

**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.

**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**

**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- Ability to apply the concepts of planning and design of distribution system for utility systems
- Ability to implement the concepts of voltage control in distribution system.
- Ability to analyze the power flow in balanced and unbalanced system

**REFERENCES**

1. William H. Kersting," Distribution System Modeling and Analysis " CRC press3<sup>rd</sup> edition,2012.
2. Turan Gonen, “Electric Power Distribution System Engineering”, McGrawHill Company.1986
3. James Northcote – Green, Robert Wilson, “Control and Automation of Electrical Power Distribution Systems”, CRC Press, New York,2007.
4. Pabla H S, “Electrical Power Distribution Systems”, Tata McGraw Hill.2004.

<b>20PS3A2</b>	<b>ENERGY MANAGEMENT AND AUDITING</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**OBJECTIVES:**

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

**PRE-REQUISITE:NIL**

**UNIT-I INTRODUCTION** **9**

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

**UNIT-II ENERGY COST AND LOAD MANAGEMENT** **9**

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

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

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

**UNIT - IV METERING FOR ENERGY MANAGEMENT** **9**

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

**UNIT - V LIGHTING SYSTEMS & COGENERATION** **9**

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

**TOTAL: 45 PERIODS**

**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- Select the parameters based on location for energy audit process
- Analyze the load curve and load duration curve for energy management and cost reduction
- Calculate the energy consumption of equipments
- Measure and Analyze the energy consumption of equipments with suitable meters to identify energy loss and theft
- Design lighting system to utilize optimum energy
- Analyze the cogeneration for energy management and cost reduction

**REFERENCES:**

- 1 Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, "Guide to Energy Management", Fifth Edition, The Fairmont Press, Inc.,2006
- 2 Eastop T.D & Croft D.R, "Energy Efficiency for Engineers and Technologists",Logman Scientific & Technical, 1990.
- 3 Reay D.A, "Industrial Energy Conservation", 1<sup>st</sup> edition, Pergamon Press,1977.
- 4 "IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities", IEEE,1996
- 5 Amit K. Tyagi, "Handbook on Energy Audits and Management", TERI,2003.

<b>20PS3A3</b>	<b>WIND ENERGY CONVERSION SYSTEMS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**OBJECTIVES:**

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

**PRE-REQUISITE:NIL**

**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 FIXEDSPEED SYSTEMS 9**

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

**UNIT - IV VARIABLE SPEED SYSTEMS 9**

Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency system-synchronous generator-DFIG-PMSG-Variables 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**

**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- 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.,Trowbridge,1976.
5. N. Jenkins," Wind Energy Technology" John Wiley &Sons,1997
6. S.Heir "Grid Integration of WECS", Wiley1998.



**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- Ability to understand an overview on modern linear and nonlinear control strategies for power electronics devices
- Ability to model modern power electronic converters for industrial applications
- Ability to design appropriate controllers for modern power electronics devices.

**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 Chakraborty, Marija, "Control and Optimization Methods for Electric Smart Grids", Springer, 2012.

<b>20PS3A5</b>	<b>ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**OBJECTIVES:**

- To provide fundamental knowledge on electromagnetic interference and electromagnetic compatibility.
- To study the important techniques to control EMI and EMC.
- To expose the knowledge on testing techniques as per Indian and international standards in EMI measurement.

**PRE-REQUISITE:NIL**

**UNIT-I INTRODUCTION 9**

Definitions of EMI/EMC -Sources of EMI- Intersystems and Intrasystem- 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 field 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**



**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- Recognize the sources of Conducted and radiated EMI in Power Electronic Converters and consumer appliances and suggest remedial measures to mitigate the problems
- Assess the insertion loss and design EMI filters to reduce the loss
- Design EMI filters, common-mode chokes and RC-snubber circuits measures to keep the interference within tolerable limits

**REFERENCES:**

1. V.P. Kodali, "Engineering Electromagnetic Compatibility", S. Chand, 1996
2. Henry W. Ott, "Noise reduction techniques in electronic systems", John Wiley & Sons, 1989
3. Bernhard Keiser, "Principles of Electro-magnetic Compatibility", Artech House, Inc. (685 Canton Street, Norwood, MA 02062 USA) 1987
4. Bridges, J.E. Millea J. and Ricketts L.W., "EMP Radiation and Protective techniques", John Wiley and sons, USA 1976
5. William Duff G., & Donald White R. J., "Series on Electromagnetic Interference and Compatibility", Vol.
6. Weston David A., "Electromagnetic Compatibility, Principles and Applications", 1991.

<b>20PS3B1</b>	<b>ELECTRIC VEHICLES AND ENERGY STORAGE SYSTEM</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**OBJECTIVES:**

- To understand the concept of electrical vehicles and its operations
- To understand the need for energy storage in hybrid vehicles
- To provide knowledge about various possible energy storage technologies that can be used in electric vehicles

**PRE-REQUISITE:NIL**

<b>UNIT-I</b>	<b>ELECTRIC VEHICLES ANDVEHICLE MECHANICS</b>				<b>9</b>
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Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings, Comparisons of EV with internal combustion Engine vehicles, Fundamentals of vehicle mechanics

<b>UNIT-II</b>	<b>ARCHITECTURE OF EV's AND POWERTRAINCOMPONENTS</b>				<b>9</b>
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Architecture of EV's and HEV's – Plug-n Hybrid Electric Vehicles (PHEV)- Power train components and sizing, Gears, Clutches, Transmission and Brakes

<b>UNIT - III</b>	<b>CONTROL OF DC ANDAC DRIVES</b>				<b>9</b>
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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

<b>UNIT - IV</b>	<b>BATTERY ENERGY STORAGE SYSTEM</b>				<b>9</b>
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Battery Basics, Different types, Battery Parameters, Battery modeling, Traction Batteries

<b>UNIT - V</b>	<b>ALTERNATIVE ENERGY STORAGE SYSTEMS</b>				<b>9</b>
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Fuel cell – Characteristics- Types – hydrogen Storage Systems and Fuel cell EV – Ultra capacitors

**TOTAL: 45 PERIODS**

**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

Explain the operation of Electric vehicles and various energy storage technologies for electrical vehicles

- Explain the Architecture of EVs and Power Train Components
- Explain the Control of DC drives
- Describe the Control of AC drives
- Explain about various types of Battery energy storage system
- Describe the Alternative energy storage system

**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, Inc2010.

<b>20PS3B2</b>	<b>PRINCIPLES OF ELECTRIC POWER TRANSMISSION</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**OBJECTIVES:**

To impart knowledge on,

- types of power transmission and configurations
- various parameters and voltage gradients of transmission line conductors.
- the design requirements of EHV AC and DC lines.

**PRE-REQUISITE:NIL**

**UNIT-I INTRODUCTION 9**

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

**UNIT-II CALCULATION OFLINEPARAMETERS 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 GRADIENTSOFCONDUCTORS 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-l<sup>2</sup>R loss and corona loss-RIV.

**UNIT - IV ELECTROSTATIC FIELD AND DESIGN OFEHVLINES 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 linedesign

**TOTAL: 45 PERIODS**

**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- Ability to model the transmission lines and estimate the voltage gradients and losses
- Ability to design EHV AC and DC transmission lines

**REFERENCES**

- 1 Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", Second Edition, New Age International Pvt. Ltd.,2006.
- 2 Pritindra Chowdhari, "Electromagnetic transients in Power System", John Wileyand Sons Inc.,2009.
- 3 Sunil S.Rao, "EHV-AC, HVDC Transmission & Distribution Engineering", Third Edition, Khanna Publishers,2008.
- 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.
- 6 "Power Engineer's Handbook", Revised and Enlarged 6th Edition, TNEB Engineers' Association, October2002

20PS3B3

**ADVANCED POWER SYSTEM  
DYNAMICS**

L	T	P	C
3	0	0	3

**OBJECTIVES:**

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

**PRE-REQUISITE:NIL**

**UNIT-I TRANSIENTSTABILITYANALYSIS**

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 OFPOWER 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 SUBSYNCHRONOUS RESONANCE (SSR)ANDOSCILLATIONS**

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 STABILITYANALYSIS**

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 SUBSYNCHRONOUS RESONANCE**

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

**TOTAL: 45 PERIODS**

**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- 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 P. Kundur, "Power System Stability and Control", McGraw-Hill, 1993.
- 4 H.W. Dommel and N.Sato, "Fast Transient Stability Solutions," IEEE Trans., Vol. PAS-91, pp, 1643-1650, July/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

20PS3B4

**DESIGN OF SUBSTATIONS**

L	T	P	C
3	0	0	3

**OBJECTIVES:**

- To provide in-depth knowledge on design criteria of Air Insulated Substation (AIS) and Gas Insulated Substation (GIS).
- To study the substation insulation co-ordination and protection scheme.
- To study the source and effect of fast transients in AIS and GIS.

**PRE-REQUISITE:NIL**

**UNIT-I INTRODUCTION TO AISAND 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 AISAND 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-ringbus

**UNIT - III INSULATION COORDINATION OF AISAND 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 GROUNDINGAND 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 AISAND GIS 9**

Introduction – Disconnecter switching in relation to very fast transients – origin of VFTO – propagation and mechanism of VFTO – VFTO characteristics – Effects of VFTO.

**TOTAL: 45 PERIODS**

**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- 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



**REFERENCES:**

- 1 Andrew R. Hileman, "Insulation coordination for power systems", Taylor and Francis, 1999.
- 2 M.S. Naidu, "Gas Insulation Substations", I.K. International Publishing House Private Limited, 2008.
- 3 Klaus Ragallar, "Surges in high voltage networks" Plenum Press, New York, 1980.
- 4 "Power Engineer's handbook", TNEB Association.
- 5 Pritindra Chowdhuri, "Electromagnetic transients in power systems", PHI Learning Private Limited, New Delhi, Second edition, 2004.
- 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.

<b>20AC101</b>	<b>ENGLISH FOR RESEARCH PAPER WRITING</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		2	0	0	0

**OBJECTIVES:**

This course is intended to provide an integrated framework for the students can able to:

- Understand that how to improve your writing skills and level of readability
- Learn about what to write in each section
- Understand the skills needed when writing a Title
- Ensure the good quality of paper at very first-time submission

<b>UNIT I</b>	Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness.	<b>4</b>
<b>UNIT II</b>	Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts and Introduction.	<b>4</b>
<b>UNIT III</b>	Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.	<b>4</b>
<b>UNIT IV</b>	Key skills are needed when writing a Title, Key skills are needed when writing an Abstract, Key skills are needed when writing an Introduction, Skills needed when writing a Review of the Literature.	<b>4</b>
<b>UNIT V</b>	Skills are needed when writing the Methods, Skills needed when writing the Results, Skills are needed when writing the Discussion, Skills are needed when writing the Conclusions.	<b>4</b>
<b>UNIT VI</b>	Useful phrases, How to ensure paper is as good as it could possibly be the first-time submission.	<b>4</b>

**TOTAL: 24 PERIODS**

**REFERENCES:**

1. Robert Goldbort, "Writing for Science", Yale University Press, 2006.
2. Robert A Day and Barbara Gastel, "How to Write and Publish a Scientific Paper", Seventh Edition, Greenwood Press, 2011.
3. Nicholas J Higham, "Handbook of Writing for the Mathematical Sciences", Society for Industrial and Applied Mathematics, 1998.
4. Adrian Wallwork, "English for Writing Research Papers", Springer, 2011.

20AC102

**DISASTER MANAGEMENT**

L	T	P	C
2	0	0	0

**OBJECTIVES:**

This course is intended to provide an integrated framework for the students can able to:

- Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in.

<b>UNIT I</b>	<b>Disaster:</b> Definition, Factors and Significance, Difference between Hazard and Disaster. <b>Natural and Manmade Disasters:</b> Difference, Nature, Types and Magnitude.	<b>4</b>
<b>UNIT II</b>	<b>Repercussions of Disasters and Hazards:</b> Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. <b>Natural Disasters:</b> Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts and Famines, Landslides and Avalanches. <b>Man-made Disaster:</b> Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks and Spills, Outbreaks of Disease and Epidemics, War and Conflicts.	<b>4</b>
<b>UNIT III</b>	<b>Disaster Prone areas in India:</b> Study of Seismic Zones, Areas Prone to Floods and Droughts, Landslides and Avalanches; Areas Prone to Cyclonic and Coastal Hazards with Special Reference to Tsunami; Post-Disaster Diseases and Epidemics.	<b>4</b>
<b>UNIT IV</b>	<b>Disaster Preparedness and Management Preparedness:</b> Monitoring of Phenomena Triggering a Disaster or Hazard. <b>Evaluation of Risk:</b> Application of Remote Sensing, Data from Meteorological and other Agencies. <b>Media Reports:</b> Governmental and Community Preparedness.	<b>4</b>
<b>UNIT V</b>	<b>Risk Assessment Disaster Risk:</b> Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation In Risk Assessment and Warning, People’s Participation in Risk Assessment. Strategies for Survival.	<b>4</b>

**UNIT VI** Disaster Mitigation Meaning, Concept and Strategies of Disaster Mitigation, Emerging Trends in Mitigation. Structural Mitigation and Non-Structural Mitigation, Programs of Disaster Mitigation in India. **4**

**TOTAL: 24 PERIODS**

**REFERENCES:**

1. Nishith Rai and A.K.Singh, "Disaster Management in India: Perspectives, Issues and Strategies", New Royal Book Company, 2007.
2. Pardeep Sahni, Alka Dhameja and Uma Medury, "Disaster Mitigation: Experiences and Reflections", Prentice Hall India Learning Private Limited, 2001.
3. S.L.Goel, "Disaster Administration and Management: Text and Case Studies", Deep & Deep Publication Pvt. Ltd., 2007.

<b>20AC103</b>	<b>SANSKRIT FOR TECHNICAL KNOWLEDGE</b>	L	T	P	C
		2	0	0	0

**OBJECTIVES:**

This course is intended to provide an integrated framework for the students can able to:

- Get a working knowledge in illustrious Sanskrit, the scientific language in the world.
- Learning of Sanskrit to improve brain functioning.
- Learning of Sanskrit to develop the logic in mathematics, science and other subjects enhancing the memory power.
- The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature.

<b>UNIT I</b>	➤ Alphabets in Sanskrit	<b>8</b>
	➤ Past/Present/Future Tense	
	➤ Simple Sentences	
<b>UNIT II</b>	➤ Order	<b>8</b>
	➤ Introduction of roots	
	➤ Technical information about Sanskrit Literature	
<b>UNIT III</b>	Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics	<b>8</b>

**TOTAL: 24 PERIODS**

**REFERENCES:**

1. H.R.Vishwas and Samskrita Bharati, "Abhyāsapustakam", Samskrita-Bharti Publication, New Delhi.
2. Vempati Kutumba Shastri, "Teach Yourself Sanskrit: Prathama Diksha (Sanskrit)", Rashtriya Sanskrit Samsthana, Delhi, 2012.
3. Suresh Soni, "Indias Glorious Scientific Tradition", Prabhat Prakashan, 2006.

20AC104

VALUE EDUCATION

L T P C  
2 0 0 0

**OBJECTIVES:**

This course is intended to provide an integrated framework for the students can able

to:

- Understand the value of education and self-development.
- Imbibe good values in students.
- Know about the importance of character.
- Learn the importance of Human values.
- Developing the overall personality.

<b>UNIT I</b>	<ul style="list-style-type: none"> <li>➤ Values and self-development – Social values and individual attitudes.</li> <li>➤ Work ethics, Indian vision of humanism.</li> <li>➤ Moral and non-moral Valuation.</li> <li>➤ Standards and Principles.</li> <li>➤ Value judgements.</li> </ul>	<b>6</b>
<b>UNIT II</b>	<ul style="list-style-type: none"> <li>➤ Importance of cultivation of values.</li> <li>➤ Sense of duty.</li> <li>➤ Devotion, Self-reliance.</li> <li>➤ Confidence, Concentration.</li> <li>➤ Truthfulness, Cleanliness.</li> <li>➤ Honesty, Humanity.</li> <li>➤ Power of faith, National Unity.</li> <li>➤ Patriotism.</li> <li>➤ Love for nature, Discipline.</li> </ul>	<b>6</b>
<b>UNIT III</b>	<ul style="list-style-type: none"> <li>➤ Personality and Behaviour Development - Soul and Scientific attitude.</li> <li>➤ Positive Thinking.</li> <li>➤ Integrity and Discipline.</li> <li>➤ Punctuality, Love and Kindness.</li> <li>➤ Avoid fault Thinking.</li> <li>➤ Free from anger, Dignity of Labour.</li> <li>➤ Universal brotherhood and religious tolerance.</li> <li>➤ True Friendship.</li> <li>➤ Happiness vs.Suffering, Love for Truth.</li> <li>➤ Aware of Self-Destructive habits.</li> </ul>	<b>6</b>

➤ Association and Cooperation.

➤ Doing best for saving nature.

**UNIT IV**

➤ Character and Competence – Holy books vs. Blind faith.

**6**

➤ Self-Management and Good health.

➤ Science of reincarnation.

➤ Equality, Non-violence, Humility, Role of Women.

➤ All religions and same message.

➤ Mind your Mind, Self-control.

➤ Honesty, Studying effectively.

**TOTAL: 24 PERIODS**

**REFERENCES:**

1. S.K. Chakraborty, "Values of Ethics for Organization: Theory and Practice", Oxford University Press, 1999.

20AC105

**CONSTITUTION OF INDIA**

L T P C  
2 0 0 0

**OBJECTIVES:**

This course is intended to provide an integrated framework for the students can able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- Address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
- Address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

**UNIT I History of Making of the Indian Constitution:** History, Drafting Committee (Composition and Working) **4**

**UNIT II Philosophy of the Indian Constitution:** Preamble, Salient Features **4**

**UNIT III Contours of Constitutional Rights and Duties:** **4**

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

**UNIT IV Organs of Governance:** **4**

- Parliament
- Composition
- Qualifications and Disqualifications
- Powers and Functions
- Executive
- President
- Governor
- Council of Ministers
- Judiciary, Appointment and Transfer of Judges, Qualifications
- Powers and Functions



**UNIT V Local Administration: 4**

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

**UNIT VI Election Commission: 4**

- Election Commission: Role and Functioning
- Chief Election Commissioner and Election Commissioners
- State Election Commission: Role and Functioning
- Institute and Bodies for the welfare of SC/ST/OBC and women

**TOTAL: 24 PERIODS**

**REFERENCES:**

1. The Constitution of India, January 1950 (Bare Act), Gazette of **India**.
2. S.N.Busi, "Dr. B.R. Ambedkar Framing of Indian Constitution", Vol. 1 to 6, First Edition, 2016.
3. M.P.Jain, Justice Jasti Chelameswar and Justice Dama Seshadri Naidu, "Indian Constitution Law", Lexis Nexis, 2018.
4. D.D.Basu, "Introduction to the Constitution of India", Lexis Nexis, 2011.

20AC106

PEDAGOGY STUDIES

L	T	P	C
2	0	0	0

**OBJECTIVES:**

This course is intended to provide an integrated framework for the students can able to:

- Review existing evidence on the review topic to inform programme design and policy making undertaken by the Department for International Development (DFID), other agencies and researchers.
- Identify critical evidence gaps to guide the development.
- What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
- What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
- How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

**UNIT I Introduction and Methodology: 5**

- Aims and rationale, Policy background, Conceptual framework and terminology.
- Theories of learning, Curriculum, Teacher education.
- Conceptual framework, Research questions.
- Overview of methodology and Searching.

**UNIT II Thematic Overview: 4**

- Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries.
- Curriculum, Teacher education.

**UNIT III Evidence on the effectiveness of pedagogical practices: 5**

- Methodology for the in depth stage: Quality assessment of included studies.
- How can teacher education (Curriculum and Practicum) and the school curriculum and guidance materials best support effective pedagogy?
- Theory of change.
- Strength and nature of the body of evidence for effective pedagogical practices.
- Pedagogic theory and pedagogical approaches.
- Teachers' attitudes and beliefs and Pedagogic strategies.

**UNIT IV Professional Development: 5**

- Alignment with classroom practices and follow-up support.
- Peer support.
- Support from the head teacher and the community.
- Curriculum and Assessment.
- Barriers to learning: Limited resources and large class sizes.

**UNIT V Research gaps and future directions: 5**

- Research design
- Contexts
- Pedagogy
- Teacher education
- Curriculum and assessment
- Dissemination and research impact

**TOTAL: 24 PERIODS**

**REFERENCES:**

1. Jim Ackers and Frank Hardman, "Classroom Interaction in Kenyan Primary Schools", *Compare*, Vol. 31, No. 2, 2001. pp. 245-261.
2. Mamta Agrawal, "Curricular reform in schools: The importance of evaluation", *Journal of Curriculum Studies*, Vol. 36, No. 3, 2004. pp. 361-379.
3. Kwame Akyeampong, "Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER), Country Report One, London, DFID, March 2003.
4. Kwame Akyeampong, Kattie Lussier, John Pryor and Jo Westbrook, "Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count?", *International Journal of Educational Development*, Vol. 33, No. 3, 2013. pp. 272-282.
5. Robin J Alexander, "Culture and Pedagogy: International Comparisons in Primary Education", Wiley-Blackwell, 2001.
6. [www.pratham.org/images/resource%20working%20paper%202.pdf](http://www.pratham.org/images/resource%20working%20paper%202.pdf).

<b>20AC107</b>	<b>STRESS MANAGEMENT BY YOGA</b>	L	T	P	C
		2	0	0	0

**OBJECTIVES:**

This course is intended to provide an integrated framework for the students can able to:

- Achieve overall health of body and mind
- Overcome stress
- Develop healthy mind in a healthy body thus improving social health also
- Improve efficiency

**UNIT I     Ashtanga:** **8**  
 Definitions of Eight parts of yoga.

**UNIT II     Yam and Niyam:** Do and Not Do in life **8**  
 ➤ Ahinsa, Satya, Astheya, Bramhacharya and Aparigraha  
 ➤ Shaucha, Santosh, Tapa, Swadhyay, Ishwarpranidhan

**UNIT III     Asan and Pranayam:** **8**  
 ➤ Various yoga poses and their benefits for mind and body  
 ➤ Regularization of breathing techniques and its effects - Types of Pranayam

**TOTAL: 24 PERIODS**

**REFERENCES:**

1. "Yogic Asanas for Group Training-Part-I", Janardan Swami Yogabhyasi Mandal, Nagpur.
2. Swami Vivekananda, "Raja-Yoga or Conquering the Internal Nature", Vedanta Press, 1998.

<b>20AC108 PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS</b>	L	T	P	C
	2	0	0	0

**OBJECTIVES:**

This course is intended to provide an integrated framework for the students can able to:

- Learn to achieve the highest goal happily
- Become a person with stable mind, pleasing personality and determination
- Awaken wisdom in students
- Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life.
- The person who has studied Geeta will lead the nation and mankind to peace and prosperity
- Study of Neetishatakam will help in developing versatile personality of students.

**UNIT I Neetisatakam - Holistic development of personality: 8**

- Verses - 19, 20, 21, 22 (Wisdom)
- Verses - 29, 31, 32 (Pride and Heroism)
- Verses - 26, 28, 63, 65 (Virtue)
- Verses - 52, 53, 59 (Don't's)
- Verses - 71, 73, 75, 78 (Do's)

**UNIT II Approach to day-to-day work and duties: Shrimad Bhagwad Geeta 8**

- Chapter 2 - Verses - 41, 47, 48
- Chapter 3 - Verses - 13, 21, 27, 35
- Chapter 6 - Verses - 5, 13, 17, 23, 35
- Chapter 18 - Verses - 45, 46, 48

**UNIT III Statements of basic knowledge: Shrimad Bhagwad Geeta 8**

- Chapter 2 - Verses - 56, 62, 68
- Chapter 12 - Verses - 13, 14, 15, 16, 17, 18

**Personality of role model: Shrimad Bhagwad Geeta**

- Chapter 2 - Verses - 17
- Chapter 3 - Verses - 36, 37, 42
- Chapter 4 - Verses - 18, 38, 39
- Chapter 18 - Verses - 37, 38, 63

**TOTAL: 24 PERIODS**

**REFERENCES:**

1. Swami Swarupananda, "Srimad Bhagavad Gita", by Advaita Ashram, Kolkata.
2. Pt. Gopinath, "Three Satakam of Bharatrhari (Niti, Srngara, Vairagya)", Rashtriya Sanskrit Sansthan, 2010.

20OE301

**BUSINESS ANALYTICS**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**OBJECTIVES:**

- Understand the role of business analytics within an organization.
- Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.
- To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.
- To become familiar with processes needed to develop, report, and analyze business data.
- Use decision-making tools/Operations research techniques.
- Mange business process using analytical and management tools.
- Analyze and solve problems from different industries such as manufacturing, service, retail,
- Software, banking and finance, sports, pharmaceutical, aerospace etc.

**PRE-REQUISITE:NIL**

**UNIT-I BUSINESS ANALYTICS 9**

Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.

Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

**UNIT-II TRENDINESS AND REGRESSION ANALYSIS 9**

Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

**UNIT - III ORGANIZATION STRUCTURES OF BUSINESS ANALYTICS 9**

Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.



<b>20OE302</b>	<b>INDUSTRIAL SAFETY</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**OBJECTIVES:**

- To familiarize students with basic safety practices in the Electronics industry and other common industrial settings
- To be aware of signage commonly used for Hazards and Warning in industrial workplace.
- To learn the prevention methodology for wear and corrosion
- To understand fault tracing mechanism.
- To understand the importance of periodic and preventive maintenance.

**UNIT-I** **9**

Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

**UNIT-II** **9**

Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**UNIT - III** **9**

Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**UNIT - IV** **9**

Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, i. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.



**UNIT - V****9**

Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: i. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

**TOTAL: 45 PERIODS****OUTCOMES:****AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- Understanding of the documentation used with hazardous materials, such as the MSDS.
- Describe the different levels of danger that exist with electrical shock.
- Describe several appropriate actions to take in the event of an electrical accident.
- Describe the situations under which static electricity may cause damage to electronic components (ESD - electrostatic discharge).
- Apply the methods of prevention of fire and explosions.
- Understand the industrial laws, regulations and source models.

**REFERENCES:**

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

20OE303

**OPERATIONS RESEARCH**

L	T	P	C
3	0	0	3

**OBJECTIVES:**

- To understand the need for optimization techniques
- To learn optimization tool for solving the problems.
- To learn and solve linear programming and non linear programming problems
- To apply the optimization techniques for solving the different types of problems
- To understand the network problems and game theory problems

**UNIT-I**

**9**

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

**UNIT-II**

**9**

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

**UNIT - III**

**9**

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

**UNIT - IV**

**9**

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

**UNIT - V**

**9**

Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

**TOTAL: 45 PERIODS**

**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- Apply the dynamic programming to solve problems of discrete and continuous variables.
- Apply the concept of non-linear programming
- Carry out sensitivity analysis
- Model the real world problem and simulate it.

**REFERENCES:**

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 20104. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

<b>20OE304</b>	<b>COST MANAGEMENT OF ENGINEERING PROJECTS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**OBJECTIVES:**

- To understand the different types cost estimation and its process
- To learn the methods for controlling the scope of project
- To understand the cost based decision making
- To identify the methods pricing strategy and practical cost management

<b>UNIT-I</b>	<b>INTRODUCTION TO STRATEGIC COST MANAGEMENT PROCESS</b>	<b>9</b>
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Introduction and Overview of the Strategic Cost Management Process Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

<b>UNIT-II</b>	<b>PROJECT MANAGEMENT</b>	<b>9</b>
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Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

<b>UNIT - III</b>	<b>COST BASED DECISION-MAKING</b>	<b>9</b>
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Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector.

<b>UNIT - IV</b>	<b>PRICING STRATEGIES</b>	<b>9</b>
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Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

<b>UNIT - V</b>	<b>PRACTICAL COST MANAGEMENT</b>	<b>9</b>
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Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

**TOTAL: 45 PERIODS**

**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- Creating the project requirements document and project scope statement.
- Identify ways to control the scope of the project.
- Create a work breakdown structure and develop work packages.
- Develop a critical path Schedule.
- Perform a cost and schedule analysis.
- Calculate planned and earned values to compare with actual cost

**REFERENCES:**

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

<b>20OE305</b>	<b>COMPOSITE MATERIALS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**OBJECTIVES:**

- To understand the basic characteristics of composite material
- To know how to apply the computational techniques to mechanical systems with composite materials
- To design the guidelines and drafting notations for composite components
- To understand manufacturing process of metal matrix
- To learn the manufacturing process polymer matrix components
- To understand occurrence of different failures at composite materials

**UNIT-I INTRODUCTION 9**

Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

**UNIT-II REINFORCEMENTS 9**

Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

**UNIT - III MANUFACTURING OF METAL MATRIX COMPOSITES 9**

Casting – Solid State diffusion technique, Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

**UNIT - IV MANUFACTURING OF POLYMER MATRIX COMPOSITES 9**

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

**UNIT - V STRENGTH 9**

Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first ply failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

**TOTAL: 45 PERIODS**

**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- Understand the fundamental properties of composite materials.
- Apply the fundamental principles and mechanics of composite materials.
- Apply modern analytical techniques to mechanical systems with composite materials.
- Apply computational techniques to mechanical systems with composite materials.
- Understand the manufacturing processes and cost analysis in composite materials.
- Demonstrate effective communication and teamwork skills through technical presentations and reports in term projects.

**TEXT BOOKS**

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

**REFERENCES:**

1. Hand Book of Composite Materials-ed-Lubin.
- 2 .Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
- 4 .Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W.Tasi.

20OE306

**WASTE TO ENERGY**

L	T	P	C
3	0	0	3

**OBJECTIVES:**

- To learn the different types of environmental wastages
- To understand the mechanism of generating energy from wastages
- To identify the energy sources from biomass
- To evaluate the cost estimation of bio energy generation
- To identify the challenges and risks involved in the waste disposal and identify appropriate waste management technique to handle and turn waste to energy.

**UNIT-I INTRODUCTION TO ENERGY FROM WASTE 9**

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

**UNIT-II BIOMASS PYROLYSIS 9**

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

**UNIT - III BIOMASS GASIFICATION 9**

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

**UNIT - IV BIOMASS COMBUSTION 9**

Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

**UNIT - V BIOGAS 9**

Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

**TOTAL: 45 PERIODS**



**OUTCOMES:**

**AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:**

- Discuss the different types of bio-mass resources.
- Describe the process of Pyrolysis for manufacturing of fuels in the form of solid, liquid and gases from the bio-mass.
- Compare different types of Gasifiers used to produce producer gas with its construction, advantages and disadvantages.
- Describe the construction, design and operation of various types of bio-mass combustors
- Analyze the cost-benefit of various biomass energy conversion processes.
- Describe the biochemical conversion process of bio-mass for producing bio-gas.

**REFERENCES:**

- 1.Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
- 2.Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, McGraw Hill Publishing Co. Ltd., 1983.
- 3.Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
- 4.Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & S 1996.