K L E F
DEPARTMENT OF ELECTRICAL ENGINEERING
PROGRAM DEVELOPMENT DOCUMENT
M.Tech in Power Electronics& Drives
2021

Vision of the University

To be a globally renowned university.

Mission of the university:

To impart quality higher education and to undertake research and extension with emphasis on application and innovation that cater to the emerging societal needs through all-round development of students of all sections enabling them to be globally competitive and socially responsible citizens with intrinsic values.

VISION of the Department

To Produce globally renowned leader in education, extension activities and Carrying out research and technology development in frontier areas of electronics and electrical engineering and allied fields

MISSION of the Department

To produce quality electrical and electronics engineers having strong theoretical foundation, innovative, good design experience , exposure to research and development and responsible for social needs.

Program Educational Objectives

Programme Educational Objectives:
1.To produce well trained post graduates in the domain of power electronics and electrical drives, and ensure that at least 50 % of those are employable in the diversified sectors of industry, public sector or multinational corporations.
2. To produce some of these (15-20 %) post graduates will pursue Ph.D.
3. To produce some of these will demonstrate the academic leadership in engineering institutions and serve the education.
4. To inculcate research attitude and lifelong learning among postgraduates

Dr. JARUPULA SOMLAL
Professor & HOD
Department of EEE
KLEF Deemed to be University
Green Fields, Vaddeswaram,
Guntur Dt., A.P.-522 502.

Program Outcomes

a. apply the knowledge of science and mathematics in designing, analyzing and using the power converters and drives for various applications and problem solving
b. design the modern electric machines, drives, power converters, and control circuits for specific application
c. use modern tools, professional software platforms, embedded systems for the diversified applications
d. Function as a member of a multidisciplinary team and correlate the domain knowledge with global problems.
e. sense and demonstrates the communication at different levels effectively
f. explore ideas for inculcating research skills and appreciate, critical and independent thinking and engage in lifelong learning

MAPPING OF PEOs with MISSION OF THE DEPARTMENT:

S. No.	**Program Educational Objectives(PEOs)**	M1 Training the leaders of tomorrow	M2 Training the innovators of tomorrow	M3 Training the outstanding career professionals of tomorrow	M4 Conducting fundamental research
1	To produce well trained post graduates in the domain of power electronics drives, and ensure that at least 50 % of those are employable in the diversified sectors of industry, public sector or multinational corporations.	√	√	√	
2	To produce some of these (15-20 %) post graduates will pursue Ph.D.		√	√	√
3	. To produce some of these will demonstrate the academic leadership in engineering institutions and serve the education.	√	√	√	
4	To inculcate research attitude and lifelong learning among postgraduates		√	√	√

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MAPPING OF POs/PSOs with PEOs:

Mapping of POs to PEOs					
S.No.	Program Objectives(POs)	Program Educational Objectives(PEOs)			
		1	2	3	4
a	apply the knowledge of science and mathematics in designing, analyzing and using the power converters and drives for various applications and problem solving	√	√	√	√
b	.design the modern electric machines, drives, power converters, and control circuits for specific application	√	√		√
c	use modern tools, professional software platforms, embedded systems for the diversified applications	√	√		√
d	Function as a member of a multidisciplinary team and correlate the domain knowledge with global problems.	√	√	√	√
e	sense and demonstrates the communication at different levels effectively	√		√	√
f	.explore ideas for inculcating research skills and appreciate, critical and independent thinking and engage in lifelong learning	√	√		√

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES (POs) and PROGRAM SPECIFIC OUTCOMES (PSOs)

S No	Course Code	Course Title	CO NO	Description of the Course Outcome	PO						PSO	
					1	2	3	4	5	6	1	2
1	21EE5112	Analysis Of Power Converters	CO1	Analyze the various 3-phase controlled rectifiers and power factor correction converters with different load and	2	2					1	
			CO2	Analyze the performance of Switch-Mode PWM and different control techniques for Inverters	2	2					1	
			CO3	Analyze the performance of dc-dc switch regulators with CCM and DCM operation.	2				2		1	

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			CO4	Understand the operations and performance of various ac-ac regulators with different loads and its.	1	1					1	
			CO5	Demonstrate and test basic power electronic converters by hardware realization and MATLAB software.			2				1	
2	21EE5111	Modeling and Analysis of Electrical Machines	CO1	Apply the basic concepts of Electromagnetic Energy Conversion Principles to DC Machines	2							2
			CO2	Understand the performance of electrical machines through mathematical modeling		1					1	
			CO3	Illustrate the dynamic behaviour of electrical machines under different operating conditions	2							2
			CO4	Analysis of special machines		2					1	
3	21EE5113	Power Electronic Control of Drives	CO1	Analyze ac-dc and dc-dc converter fed DC motor drives	2						1	
			CO2	Understand converter fed stator side control of Induction Motor drives.			1				1	
			CO3	Analyze rotor side control and slip power recovery scheme of 3-phase Induction Motor drives		2					1	
			CO4	Analyze frequency control of Synchronous Motor drives for variable speed operation		2					1	
4	18EE5104	Modern Control Theory	CO1	Understand the basics of Z-Transforms and Digital control systems DCS components	1				1		1	
			CO2	Apply various stability analysis technics to digital control systems	2				2			2
			CO3	Apply various stability analysis technics to non-linear control systems	2				2			2
			CO4	Apply the basics of optimal control problem to state feedback controller design	2				2			2
5	21EE5114	Digital Simulation of Power Electronic Systems	CO1	Understand Pspice modeling of power semiconductor devices and passive components behavior with protection circuits.		2			2			2
			CO2	Analyze performance of AC-DC controlled, uncontrolled converters and DC-DC converters using Pspice and Matlab Simulink model.		2			2			2
			CO3	Evaluate DC-AC converters performance using modern simulation tools.		2			2			2

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			CO4	Analyze AC voltage controller and cyclo-converter performance with programming and simulation tools.		2			2			2
6	21EE51A1	Soft Computing Techniques	CO1	Demonstrate model, learning and training methods of Artificial Neural networks		1					1	
			CO2	Apply Genetic algorithms to engineering problems		2			2			2
			CO3	Demonstrate characteristics of Fuzzy systems		1					1	
			CO4	Apply Neual netwotks and fuzzy logic to motor controls		2			2			2
7	21EE5211	Switched Mode Power Supplies	CO1	Analyze the concepts of Resonant switch Converters, L-type, M-type, Load resonant converters	2	2					1	
			CO2	Analyze the operation of soft switched isolated converter and Quasi resonant inverter	2	2					1	
			CO3	Analyze the concept of Z-source to inverter and analyze the concept of multi-level to inverters, Analysis and comparison of Multi level Inverters	2	2					1	
			CO4	Apply different PWM techniques for Multi-level inverters, Apply the Concept of Matrix converter for direct AC-AC conversion	2	2						2
			CO5	Analyze the concepts of Advanced power converters through Lab experiments	2	2					1	
8	21EE5212	Advanced Electrical Drives	CO1	Understand the modeling of AC machines	1	1					1	
			CO2	Contrast the speed control performance of 3-Phase induction and synchronous motor drive using vector control methods	2	2					1	
			CO3	Analyze the dynamic behavior of SRM motor drives under various control methods	2	2					1	
			CO4	Distinguish the performance of BLDC Motor drive using various control techniques	2	2					1	
9	21EE5214	Smart Grids Technologies	CO1	Understand the basic concepts of smart grid, terminology, challenges and initiatives.	1						1	
			CO2	Identify various smart operations of power system structure, components, and monitoring techniques.		2		2				2

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			CO3	Apply smart metering and advanced metering infrastructure with monitoring, protection and measuring units.		2		2				2
			CO4	Illustrate various communication protocols and cyber-security importance in smart grid.				1			1	
10	21EE51B2	Digital Signal Processors and Applications	CO1	Apply basic digital program logics for programming CPLD and FPGA	2							2
			CO2	Understanding ASIC physical design flow	1						1	
			CO3	Understanding Analog VLSI design	2							2
			CO4	Analyse the control logics for motor application using VHDL program		2					1	
11	21EE52E2	Battery Management Systems for Electric Vehicle	CO1	Demonstrate Mechanics of Electric vehicle		1					1	
			CO2	Demonstrate Power train components of Electric vehicle		1					1	
			CO3	Apply controllers to electric vehicle drive system		2			2			2
			CO4	Outline energy storage systems for Electric vehicles		1					1	
12	21EE51B3	OPTIMIZATION TECHNIQUES	CO1	Understand classical optimization techniques, describe clearly the problems with and without constraints, identify its parts and analyze the individual functions, Feasibility study for solving an optimization problem.				1		1	1	
			CO2	Design and apply mathematical translation of the verbal formulation of an optimization problem and design algorithms of linear programming problems, the repetitive use of which will lead reliably to finding an approximate solution.				2		2		2
			CO3	Evaluate and measure the performance of an algorithm of different methods to solve non-linear programming problems, study and solve optimization problems.							1	
			CO4	Analyze optimization techniques using algorithms. Investigate, study, develop, organize and promote innovative solutions for various applications.							1	
13	21EE52C1	FACTS DEVICES	CO 1	Interpret the significance of FACTS devices in power system	1						1	

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			CO 2	Demonstrate the operation and control of shunt compensation devices	1						1	
			CO 3	Demonstrate the operation and control of series compensation devices	1						1	
			CO 4	Demonstratetheoperation and applications of special FACTS devices like UPFC and IPFC	1						1	
14	21EE52D2	POWER QUALITY	CO1	Outline basic power quality issues		1					1	
			CO2	Demonstrate conventional loop control for voltage and current balance		1					1	
			CO3	Demonstrate DSTATCOM for power quality restoration		1					1	
			CO4	Apply combined compensation techniques for power quality restoration		2			2			2

Program Articulation Matrix (Mapping of Courses with POs)

Course Code	Course Name	Course Category	L	T	P	S	CR	Prerequisite	PO						PSO	
									1	2	3	4	5	6	1	2
21EE5111	Modeling and Analysis of Electrical Machines	PC	3	1	0	0	4	Nil	2	2			2		1	
21EE5112	Analysis of Power Converters	PC	3	1	2	0	5	Nil	2	2					2	
21EE5113	Power Electronic Control Of Drives	PC	3	1	0	0	4	Nil		2	2					1
21EE5114	Modern Control Theory	PC	3	1	0	0	4	Nil		2		3				2
21EE5111	Advanced Power Converters	PC	3	1	2	0	5	Nil		3	2				1	
21EE5112	Advanced Electrical Drives	PC	3	1	0	0	4	Nil		3	2				2	
21EE5113	Electric Vehicle Technology	PC	3	1	0	0	4	Nil	3	2					1	
21EE5114	Smart Grids Technologies	PC	3	1	0	0	4	Nil	3	2						1
21EE51A1	Soft Computing Techniques	PE	3	0	0	0	3	Nil		2		3				
21EE51A2	Distributed generation systems	PE	3	0	0	0	3	Nil			3	2				
21EE51S3	Floating Solar and off shore wind technologies	PE	3	0	0	0	3	Nil		2		2				

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21EE51B1	Green Building and Energy systems	PE	3	0	0	0	3	Nil		2			3			
21EE51B2	Digital Signal Processors and Applications	PE	3	0	0	0	3	Nil		2		3				
21EE51B3	Optimization Techniques	PE	3	0	0	0	3	Nil		2		3				
19EE52D1	Floating Solar and off shore wind technologies	PE	3	0	0	0	3	Nil			3					
21EE52C1	FACTS	PE	3	0	0	0	3	Nil			2	3				
21EE52N2	Energy Storage Systems	PE	3	0	0	0	3	Nil		2		3				
21IE5149	Seminar	Project	0	0	4	0	2	Nil	2			2		3		
18IE5250	Term Paper	Project	0	0	4	0	2	Nil	2			2	2	3		
18IE6050	Dissertation	Project	0	0	72	0	36	Nil	2			2	2	3		

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21EE5111: MODELING AND ANALYSIS OF ELECTRICAL MACHINES

L-T-P-S: 3-1-0-0 **Credits: 4** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Apply the basic concepts of Electromagnetic Energy Conversion Principles to DC Machines	PO1	3
CO2	Understand the performance of electrical machines through mathematical modeling	PO2	2
CO3	Illustrate the dynamic behaviour of electrical machines under different operating conditions	PSO2	3
CO4	Analysis of special machines	PO2	4

Basic Concepts and Dc machine: Principles of Electromagnetic Energy Conversion, General expression of stored magnetic energy, co-energy and force/torque, example using single and doubly excited system. The Primitive Machine Equations. Mathematical model of a separately excited DC motor, DC series motor and DC Shunt motor- Voltage and torque equation of dc machine.

Basic Concepts of Rotating Machines: Calculation of air gap mmf and per phase machine inductance using physical machine data; Induction machine: Three phase symmetrical induction machine in phase variable form; Application of reference frame theory to three phase symmetrical induction Machine. Dynamic direct and quadrature axis model in arbitrarily rotating reference frames.

Synchronous Machine: Three phase salient pole synchronous machines in phase variable form. Voltage and torque equation of salient pole synchronous machine including damper winding in stator reference frame.Voltage and torque equation of salient pole synchronous machine including damper winding in rotor reference frame. Determination of Synchronous Machine Dynamic Equivalent Circuit Parameters.

Special Machines: Permanent magnet synchronous machine: Surface permanent magnet (square and sinusoidal back emf type) and interior permanent magnet machines. Construction and operating principle, dynamic modeling and self controlled operation; Analysis of Switch Reluctance Motors.

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Analysis and dynamic modeling of two phase asymmetrical induction machine and single phase induction machine.

Text Books:

1. Charles Kingsley, Jr., A.E. Fitzgerald, Stephen D.Umans, 'Electric Machinery', Tata McgrawHill, 5th Edition, 1992.

2. Generalized Theory of Electrical Machines – P.S.Bimbra- Khanna publications-5th edition 1995

Reference Books:

1. R. Krishnan, 'Electric Motor & Drives: Modeling, Analysis and Control', Prentice Hall of India, 2nd Edition, 2001.

2. Miller, T.J.E., 'Brushless Permanent Magnet and Reluctance Motor Drives', Clarendon Press, 1st Edition, 1989

Dr. JARUPULA SOMLAL
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21EE5112: ANALYSIS OF POWER CONVERTERS

L-T-P-S: 3-1-2-0 **Credits: 5** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No:	CO	PO/PSO	BLOOMS TAXANOMY LEVEL-BTL
1	Analyze the various high power controller converters and power factor correction.	PO2	4
2	Analyze the performance of Switch-Mode PWM and different control techniques for Inverters	PSO1	4
3	Analyze the operation of multi-level to inverters and Z-source inverter.	PO-5	3
4	Understand the various applications of power converters with solar systems	PO-2	2
5	Demonstrate and test basic power electronic converters by hardware realization and MATLAB software.	PO-3	4

LTPC -3-1-2-5

HIGH POWER ELECTRONIC CONVERTERS : Multi-pulse SCR Rectifiers, Performance parameters - Six-pulse, 12-pulse and 24- pulse SCR rectifier, Effect of line and leakage inductances, Power factor control. Pulse Width Modulated Rectifiers: Properties of ideal rectifier, realization of near ideal rectifier, control of the current waveform PWM, single phase and three-phase converter systems.

SWITCH-MODE DC-AC INVERTERS: Basic Concepts- PWM Principles- Sinusoidal Pulse Width Modulation in Single Phase Inverters-Choice of carrier frequency in SPWM- Bipolar and Unipolar Switching - Blanking Time -Maximum Attainable DC Voltage - Switch Utilization. Six step inverters, voltage control & PWM strategies, and implementation aspects, Modification of power circuit for Four quadrant operation,Pulse width modulation techniques (hysteresis, SVM), Selective Harmonic Reduction Techniques.

MULTILEVEL INVERTERS AND IMPEDANCE SOURCE INVERTERS: Multilevel concept – Classification of multilevel inverters – Diode clamped multilevel inverter –improved diode Clamped inverter –Flying capacitors multilevel inverter - Cascaded multilevel inverter -Multilevel inverter -features of multilevel inverters – comparisons of multilevel converters. – PWM techniques for MLI.- Quasi –Z source Inverters, control methods,

POWER CONVERTERS APPLICATIONS: Lighting, pumping and refrigeration Systems: Electronic ballast, LED power drivers for indoor and outdoor applications. PFC based grid fed LED drivers, PV /

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battery fed LED drivers. PV fed power supplies for pumping and refrigeration Applications.

Text books:

1. M.H. Rashid **:** Power Electronics Handbook, Butterworth-Heinemann, 4th edition, 2017.
2. N. Mohan, T.M. Undeland, W.P. Robbins**:** Power Electronics: Converters, Applications**,** John Wiley & Sons, 3rd edition, 2003.

References:

1. Umanand, L.: Power Electronics: Essentials and Applications, John Wiley India, 1st Edition, 2009.
2. Jayant Baliga B: Fundamentals of Power Semiconductor Devices, Springer, 1st Edition 2008.
3. Bin Wu: High Power Converters and AC Drives, Wiley-Interscience, 2nd Edition, 2017.
4. Derek A Paice: Power Electronic Converter Harmonics Multipulse Method for Clean Power, IEEE Press, 1995

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21EE5113: POWER ELECTRONIC CONTROL OF DRIVES

21EE5212: ADVANCED ELECTRICAL DRIVES

L-T-P-S: 3-1-0-0 **Credits: 4** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No:	Course Outcomes(CO)	PO/PSO	Blooms Taxonomy Level (BTL)
1.	Understand the modeling of AC machines	PO2	2
2.	Contrast the speed control performance of 3-Phase induction and synchronous motor drive using vector control methods	PO2	4
3.	Analyze the dynamic behavior of SRM motor drives under various control methods	PSO1	4
4.	Distinguish the performance of BLDC Motor drive using various control techniques	PO2	4

FIELD ORIENTED CONTROL OF INDUCTION MOTOR DRIVES - Field oriented control of induction machines – Theory – DC drive analogy – Direct and Indirect methods – Flux vector estimation - Direct torque control of Induction Machines – Torque expression with stator and rotor fluxes, DTC control strategy.

SENSORLESS VECTOR CONTROL OF INDUCTION MOTOR: Slip and Speed Estimation at Low performance, Rotor Angle and Flux-linkage Estimation at high performance -rotor Speed Estimation Scheme- estimators using rotor slot harmonics, Model Reference adaptive systems, Extended Kalman Filter.

CONTROL OF SYNCHRONOUS MOTOR DRIVES: Self control-margin angle control-torque control-power factor control-Brushless excitation systems - SRM Structure-Stator Excitation-techniques of sensor less operation-convertor topologies-SRM Waveforms-SRM drive design factors-Torque controlled SRM-Torque Ripple-Instantaneous Torque control -using current controllers-flux controllers.

CONTROL OF BLDC MOTOR DRIVES: principle of operation of BLDC Machine, Sensing and logic switching scheme, BLDM as Variable Speed Synchronous motor-methods of reducing Torque pulsations -Three-phase full wave Brushless dc motor -Sinusoidal type of Brushless dc motor - current controlled Brushless dc motor Servo drive.

TEXT BOOKS

1. Electric Motor Drives Modeling, Analysis & control -R. Krishnan- Pearson Education

2. Modern Power Electronics and AC Drives –B. K. Bose-Pearson Publications

Dr. JARUPULA SOMLAL
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3. Sensorless Vector Direct Torque control –Peter Vas, Oxford University Press

REFERENCES BOOKS

1. Modern Power Electronics and AC Drives –B. K. Bose-Pearson Publications-

2. Power Electronics control of AC motors – MD Murphy & FG Turn Bull Pergman Press -1st edition-1998
3. W.Leonhard, “Control of Electrical Drives”, Narosa Publishing House, 1992
4. VedamSubramanyam, “Electric Drives – Concepts and Applications”, Tata McGraw-Hill publishing company Ltd., New Delhi, 2002

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21EE5213: ELECTRIC VEHICLE TECHNOLOGY

L-T-P-S: 3-1-0-0 **Credits: 4** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	Blooms Taxonomy Level (BTL)BTL
CO1	Understand the History, Economics, Environmental issues and power train of Electric Vehicles	PO5	**2**
CO2	Analyze the dynamics of EV	PO7	4
CO3	Select and size the power train for 2W	PO7	3
CO4	Select and size the power train for 4W	PSO2	3

HISTORY, ECONOMIC & ENVIRONMENTAL IMPACT OF ELECTRIC VEHICLE: History of EV, Case studies on Economic and Environment aspects of EV, EV markets – Supply and demand, Economical analysis with case study, Environmental impact analysis with case study. Various Govt. policies, Impact of different transportation technologies on environment and energy supply. Power train components: BEV, HEV, PHEV and FCEV including working of Fuel cell

INTRODUCTION TO EV DYNAMICS: Motion and dynamic equations of electric vehicles, General description of vehicle movement, Vehicle resistance, Dynamic equation, Tire Ground Adhesion and maximum tractive effort, different drive cycles for, Drive cycles for vehicle emission, fuel consumption and performance testing.

2W POWER TRAIN SIZING: Chassis, differential and transmission selection for different drive trains, Battery, converter and motor drive sizing for different 2W drive trains. Analysis on the effect of sizing of different components for different drive cycles

4W POWER TRAIN SIZING: Chassis, differential and transmission selection for different drive trains, Battery, converter and motor drive sizing for different 4W drive trains. Analysis on the effect of sizing of different components for different drive cycles

Text books:

1. "A History of Electric Vehicles" by Nigel Burton, Edition -1, Crowood Publisher.
2. "Electric and Hybrid Vehicles Design Fundamentals, by Iqbal Hussain, CRC Press2nd edition, 2010
3. "*Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*" by M. Ehsani, Second edition, CRC Press, 2009.

Reference books:

1. "Electric Vehicle Technology Explained" by James Larminie and John Lowry.

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21EE5214: SMART GRIDTECHNOLOGIES

L-T-P-S: 3-1-0-0 **Credits: 4** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand the basic concepts of smart grid, terminology, challenges and initiatives.	PO-1	2
CO2	Understand various smart operations of power system structure, components, and monitoring techniques.	PO-4	2
CO3	Apply smart metering and advanced metering infrastructure with monitoring, protection and measuring units.	PSO-2	3
CO4	Apply various communication protocols and cyber-security importance in smart grid.	PO-4	2

INTRODUCTION TO SMART GRID - Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers,functions, opportunities, challenges and benefits, Difference between conventional & SmartGrid, National and International Initiatives in Smart Grid.**SMART GRID TECHNOLOGIES** 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 - service restoration, Outage management, High-Efficiency Distribution Transformers,Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV).**SMART METERS AND ADVANCED METERING INFRASTRUCTURE -**

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits,AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor MeasurementUnit (PMU), Intelligent Electronic Devices (IED) & their application for monitoring & protection.High Performance Computing for Smart Grid Applications**COMMUNICATION SYSTEMS-**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 CLOUDcomputing to make Smart Grids smarter, Cyber Security for Smart Grid.

TEXT BOOKS

1. Stuart Borlase “Smart Grid: Infrastructure, Technology and Solutions”, CRC Press 2017.
2. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, Wiley 2012.

REFERENCES BOOKS

1. Control and Optimization Methods for Electric Smart Grids, AranyaChakraborthy, Marija D llic Editor, Springer Publications.
2. Smart Grid Fundamentals of Design and Analysis, James Momoh, Wiley IEEE Press, Ed 2012.

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21EE51A1: SOFT COMPUTING TECHNIQUES

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand the model, learning and training methods of Artificial Neural networks	PO2	**2**
CO2	Apply Genetic algorithms to engineering problems	PO5	**3**
CO3	Understand the characteristics of Fuzzy systems	PSO1	**2**
CO4	Apply Neural networks and fuzzy logic to motor control	PO2	**3**

INTRODUCTION: Introduction and motivation. Approaches to intelligent control. Architecture for intelligent control. Symbolic reasoning system, rule-based systems, the AI approaches Knowledge representation. **ARTIFICIAL NEURAL NETWORKS:** Concept of Artificial Neural Networks and its basic mathematical model, McCulloch-Pitts neuron model, simple perceptron, Adaline and Madaline, Feed-forward Multilayer Perceptron. Learning and Training the neural network. Networks: Hopfield network, Self-organizing network and Recurrent network.

GENETIC ALGORITHM: Genetic Algorithm: Basic concept of Genetic algorithm: Mutation, Reproduction and cross over and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm, genetic algorithm as classifier and engineering applications.

FUZZY SYSTEMS: Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning. Introduction to Fuzzy logic modeling and control of a system.Fuzzification, inference and defuzzification.Fuzzy knowledge and rule bases. Fuzzy modeling and control schemes for nonlinear systems. Self-organizing fuzzy logic control.

FUZZY LOGIC & NEURAL NETWORK APPLICATIONS TO DRIVES: Fuzzy logic applications: Design of Fuzzy PI controller for speed control of DC motor- Flux programming efficiency improvement of three phase induction motor-Induction motor speed control. **Neural network applications:-**PWM Controller-Selected harmonic elimination PWM-Space vector PWM.

TEXT BOOKS

1. Neural Networks: A comprehensive Foundation – Simon Haykins, Pearson Edition, 2003.
2. Fuzzy logic with Fuzzy Applications – T.J.Ross – Mc Graw Hill Inc, 1997.
3. Genetic Algorithms- David E Goldberg.
4. Modern Power Electronics and AC Drives –B.K.Bose-Pearson Publications
5. Artificial Intelligent based Electrical Machines and Drives- Peter Vas, Oxford University Press

Dr. JARUPULA SOMLAL
Professor & HOD
Department of EEE
KLEF Deemed to be University
Green Fields, Vaddeswaram,
Guntur Dt., A.P.-522 502.

REFERENCE BOOKS

1. Neural Network Fundamentals with Graphs, Algorithms and Applications, N.K. Bose and P.Liang, Mc-Graw Hill, Inc. 1996.
2. Intelligent System- Modeling, Optimization and Control- Yung C. Shin and ChengyingXu,CRC Press, 2009.
3. Soft computing & Intelligent Systems- Theory & Applications – N.K.Sinha and ModanM Gupta. Indian Edition, Elsevier, 2007.
4. Fuzzy logic Intelligence, Control, and Information- John Yen and Reza Langari, Pearson Education, Indian Edition, 2003.

Dr. JARUPULA SOMLAL
Professor & HOD
Department of EEE
KLEF Deemed to be University
Green Fields, Vaddeswaram,
Guntur Dt., A.P.-522 502.

21EE51A2: DISTRIBUTED GENERATION SYSTEMS

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO NO	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understandthe significance of distributed generations and standards.	PO5	2
CO2	Apply various interface system for grid integration with Distributed energy system.	PSO1	3
CO3	Understand technical impacts of DGs integration to ensure power quality issues.	PSO1	2
CO4	Understand economical improvement and control strategyof DG integration.	PO7	2

Need for Distributed Generation– Renewable sources in distributed generation – Current scenario in distributed generation – Planning of DGs – Siting and sizing of DGs – Optimal placement of DG sources in distribution systems. Standards for interconnecting Distributed resources to electric power systems: IEEE 1547.

Grid integration of DG– Different types of interfaces – Inverter based DG and rotating machine based interfaces – Aggregation of multiple DG units – Energy storage elements – Batteries, ultra capacitors, flywheels. Requirements for grid interconnection, limits on operational parameters: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues.

Technical impacts of DGs –Transmission systems, Distribution systems, De-regulation – Impact of DGs upon protective relaying – Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.

Economic and control aspects of DGs– Market facts, issues and challenges – Limitations of DGs – Voltage control techniques, Reactive power control, Harmonics, Power quality issues – Reliability of DG based systems – Steady state and Dynamic analysis. DG installation classes, security issues in DG implementations.

TEXT BOOKS:

1. H. Lee Willis, Walter G. Scott , 'Distributed Power Generation – Planning and Evaluation', Marcel Decker Press, 2000.
2. M.GodoySimoes, Felix A.Farret, 'Renewable Energy Systems – Design and Analysis with Induction Generators', CRC press.

REF BOOKS:

1. F. Katiraei, M.R. Iravani, 'Transients of a Micro-Grid System with Multiple Distributed Energy Resources', International Conference on Power Systems Transients (IPST'05) in Montreal, Canada on June 19-23, 2005.
2. John Twidell and Tony Weir, "Renewable Energy Resources", Taylor and Francis Publications, Second Edition, 2006.

Dr. JARUPULA SOMLAL
Professor & HOD
Department of EEE
KLEF Deemed to be University
Green Fields, Vaddeswaram,
Guntur Dt., A.P.-522 502.

21EE51S3: FLOATING SOLAR & OFF- SHORE WIND TECHNOLOGIES

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO. No	Course Outcome	PO	BTL
1	understand the selection of floating solar power plant	PO-3	2
2	understand different layouts and selection of converters	PO-4	2
3	understand the operation of off shore wind power plants	PO-4	2
4	Analyze the operation of floating solar and off shore power system	PO-3	4

Concept of Floating Solar PV System – **Selection of Floating Solar PV Plant**: Site Survey of Floating Solar PV Plant, Dam Dimension calculations, Environment factor assessment, Power evacuation level, pontoon angle, Magnetic North & True North with variation of azimuth angle, Temperature factor - **Selection of floating pontoon:** Types of Pontoon**,** Specification of main Pontoons**,** Selection criteria for PV module pontoons, etc,. – **Preparation of Floating Solar PV Plant**: Overall plant layout, DC blocking layout, Earthing Layout for Floating solar Power Plant, Connection of Leap frog method for string connection – PV Modules & Sizing – Inverter Selection & Sizing – HT Switch & Sizing.

Overview of offshore wind technology - Energy Conversion Systems for Offshore Wind Turbines - Modelling and Analysis of Drivetrains in Offshore Wind Turbines - Fixed and Floating Offshore Wind Turbine Support Structures – **Offshore Wind Turbine Controls** - Operation and Maintenance Modelling - Supervisory Wind Farm Control - Offshore Transmission Technology - Grid Integration and Control for Power System Operation Support.

Text Books:

1. Marco Rosa-Clot Giuseppe Marco Tina, “Submerged and Floating Photovoltaic Systems”, Springer Publishers, ISBN: 9780128121498
2. Olimpo Anaya-Lara, John Olav Tande, KjetilUhlen, Karl Merz, “Offshore Wind Energy Technology”, Wiley Publishers, ISBN: 978-1-119-09780-8
3.

Dr. JARUPULA SOMLAL
Professor & HOD
Department of EEE
KLEF Deemed to be University
Green Fields, Vaddeswaram,
Guntur Dt., A.P.-522 502.

21EE51B1: GREEN BUILDING AND ENERGY SYSTEMS

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Apply energy audit for energy management in buildings	PO5	3
CO2	Understand energy conservation opportunities in electrical systems	PO7	2
CO3	Apply energy management strategies for energy efficiency	PSO1	3
CO4	Apply practices for energy efficiency green buildings	PO2	3

Syllabus

Energy Management: Definition and Objective of Energy Management, General Principles, Energy Management Strategy, Energy Balance sheet and Management Information System (MIS), Energy Modelling and Optimization, Demand Side management (DSM), Peak Demand control-Methodologies

Green Building Practices: Energy efficiency-life cycle perspective, Environmental product declaration, Building information model, choice of heat insulation materials, high thermal mass materials, phase change materials, Green building certifications

Energy Audit: Need, types, methodology and approach, Instruments for energy audit, Energy Management Approach, Understanding Energy Costs, Bench marking, Energy performance, matching energy usage to requirements, maximizing system efficiency, Return of Investment

Energy conservation opportunities: Energy conservation in HVAC, Refrigeration and Air Conditioning, Pumping Systems, lighting control, lighting control, Energy Conservation Building Code, Energy Conservation opportunities in Transformers and cables, Transmission lines

Text books

1. Industrial Energy Management: Principles and Applications by Giovanni and Petrecca, The Kluwer international series-207 (1999)
2. Guide to Electric Load Management by Anthony J.Pansini, Kenneth D.Smalling, Pennwell pub (1988)
3. Energy Management: W.R.Murphy, G.Mckay (Butterworths)

Reference books

1. Energy Management Hand book by Turner, Wayne C, Lilburn, The Fairmont press, 2001
2. Handbook of Energy Audits by Albert Thumann, Fairmont Pr; 5th edition (1998).
3. Recommended practice for Energy Conservation and cost effective planning in Industrial facilities by IEEE Bronze book, IEEE Inc, USA.
4. Energy Management Principles: C.B. Smith (Pergamon Press)
5. Bureau of Energy Efficiency Publications-Rating System, Teri Publications – Griha Rating System, Leeds Publications.

Dr. JARUPULA SOMLAL
Professor & HOD
Department of EEE
KLEF Deemed to be University
Green Fields, Vaddeswaram,
Guntur Dt., A.P.-522 502.

21EE51B2: DIGITAL SIGNAL PROCESSORS AND APPLICATIONS

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand components of digital signal processing	PO-2	**2**
CO2	Understand Architecture of TMS320C5X, TMS320C6X and ADSP-21XXprocessors	PSO-1	**2**
CO3	Understand programming of functional units of TMS320C5X, TMS320C6X and ADSP-21XX	PO-2	**2**
CO4	Apply Signal conditioning and PWM applications with TMS320C5X, TMS320C6X and ADSP-21XX processors	PSO-2	**3**

FUNDAMENTALS OF DIGITAL SIGNAL PROCESSING: Review of DSP fundamentals. Issues involved in DSP processor design - speed, cost, accuracy, pipelining, parallelism, quantization error, etc. Key DSP hardware elements - Multiplier, ALU, Shifter, Address Generator, etc.**TMS320C5X PROCESSOR 9 Architecture**: Assembly language syntax - Addressing modes – Assembly language Instructions - Pipeline structure, Operation – Block Diagram of DSP starter kit – Application Programs for processing real time signals.**TMS320C6X PROCESSOR 9 Architecture:** of the C6x Processor - Instruction Set - DSP Development System: Introduction– DSP Starter Kit Support Tools- Code Composer Studio - Support Files - Programming Examples to Test the DSK Tools – Application Programs for processing real time signals. **ADSP PROCESSORS 9 Architecture of ADSP-21XX:** and ADSP-210XX series of DSP processors- Addressing modes and assembly language instructions – **Software development tools:** assembler, linker and simulator. Applications using DSP Processor - spectral analysis, FIR/IIR filter, linear-predictive coding, etc.

TEXT BOOKS:

1. Avtar Singh and S. Srinivasan, Digital Signal Processing – Implementations using DSP Microprocessors with Examples from TMS320C54xx, cengage Learning India PrivateLimited, Delhi 2012

2. B.Venkataramani and M.Bhaskar, “Digital Signal Processors – Architecture”, TATA McGraw-Hill Education, 2002.

REFERENCES:1. Programming and Applications” – Tata McGraw – Hill Publishing Company Limited. NewDelhi, 2003.

2. RulphChassaing, Digital Signal Processing and Applications with the C6713 and C6416DSK, A JOHN WILEY & SONS, INC., PUBLICATION, 2005 5. User guides Texas Instrumentation, Analog Devices, Motorola.

Dr. JARUPULA SOMLAL
Professor & HOD
Department of EEE
KLEF Deemed to be University
Green Fields, Vaddeswaram,
Guntur Dt., A.P.-522 502.

21EE51B3: OPTIMIZATION TECHNIQUES

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No:	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand classical optimization techniques, describe clearly the problems with and without constraints, identify its parts and analyze the individual functions, Feasibility study for solving an optimization problem.	PO-6	2
CO2	Apply mathematical translation of the verbal formulation of an optimization problem and design algorithms of linear programming problems, the repetitive use of which will lead reliably to finding an approximate solution.	PSO-2	3
CO3	Analyze and measure the performance of an algorithm of different methods to solve non-linear programming problems, study and solve optimization problems.	P-11	4
CO4	Analyze optimization techniques using algorithms. Investigate study, develop, organize and promote innovative solutions for various applications.	PO-12	4

Classical Optimization Techniques: Single variable optimization, multi-variable optimization with no constraints, with equality and inequality constraints, Karush- Kuhn- Tucker constraints.

Linear Programming (LP): Geometry of LP problem, graphical solution, simplex algorithm, two-phases of simplex algorithm, duality, dual simplex method, quadratic programming.

Non-Linear Programming: One-dimensional optimization – Fibonacci method, golden section method, quadratic and cubic interpolation methods, Newton's method.Unconstrained optimization - Steepest descent method, conjugate gradient method, Davidon-Fletcher-Powell method.Constrained Optimization - Augmented Legrangian multiplier method, Branch and bound method

Non-traditional Optimization Methods and Applications: Genetic algorithms (G A), G A Operators, G A for constrained optimization.Particle swarm optimization (PSO).

Text Books:

1. S.S. Rao, 'Engineering Optimization : Theory andPractice.III Edition, New Age International (p) Limited Publications
2. Kalyanmoy Deb, 'Optimization for Engineering Design', PHI Learning Private Limited.

Reference Books:

1. PurnachandraBiswal, ' Optimization in Engineering', Scitech Publications (India) PVT Ltd.

Dr. JARUPULA SOMLAL
Professor & HOD
Department of EEE
KLEF Deemed to be University
Green Fields, Vaddeswaram,
Guntur Dt., A.P.-522 502.

21EE52C1: FACTS

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

Co.No:	Course Outcomes	PO/PSO	BTL
CO 1	Understand theimportance of FACTS devices and their applications to the Power Systems.	PO-8	2
CO 2	Analyzethe static shunt compensation and operation of devices under this category.	PO-9	4
CO 3	Analyze thestatic series compensation and operation of devices under this category.	PO-8	4
CO 4	Analyze the operation and applications of devices like UPFC and IPFC.	PO-9	4

FACTS CONCEPT AND GENERAL SYSTEM CONSIDERATIONS: Transmission interconnections, Power Flow in AC system, Dynamic stability Considerations and the importance of the controllable parameters, Introduction to Facts devices, Basic types of FACTS Controllers, benefits from FACTS controllers.**STATIC SHUNT COMPENSATION:** Objectives of shunt compensation, Methods of controllable VAR generation, variable impedance type static VAR generators (SVC): TCR, TSR, TSC, FC-TCR, TSC-TCR, switching converter type VAR generators: STATCOM, Comparison between SVC and STATCOM, STATCOM for transient and dynamic stability enhancement.**STATIC SERIES COMPENSATION: Objectives** of series compensation, variable impedance type static series controllers: GCSC, TSSC, TCSC, switching converter type controller: SSSC, Operation and Control External system Control for series Compensator SSR and its damping – Static Voltage and Phase angle Regulators - TCVR and TCPAR – Operation and Control.**UPFC AND IPFC:**The unified power flow Controller – Operation –Comparison with other FACTS devices – control of P and Q – dynamic performance – special Purpose FACTS controllers – Interline Power flow Controller – Operation and Control- Application and HVDC controlled link.

TEXT BOOKS:

1. FACTS: Modelling and Simulation in Power Networks, By Enrique Acha, Claudio R. Fuerte-Esquivel, Hugo Ambriz-Pérez, César Angeles-Camacho WILEY
2. K.R.Padiyar “FACTS Controller in power Transmission and Distribution” New Age Int Publisher,2007
3. Flexible AC Transmission Systems: Modelling and Control, By Xiao-Ping Zhang, Christian Rehtanz, Bikash Pal

REFERENCE BOOKS:

1. N.G Hingorani&L.Gyugyi “ Understanding FACTS: Concepts and Technology of Flexible AC Transmission System” , IEEE Press,2000
2. Ned Mohan et.al “Power Electronics” John wiley& Sons,2 nd edition ,2002
3. T.J.E Miller, “Reactive power control in electric Systems” John willey& sons,1982.

Dr. JARUPULA SOMLAL
Professor & HOD
Department of EEE
KLEF Deemed to be University
Green Fields, Vaddeswaram,
Guntur Dt., A.P.-522 502.

21EE52N2: ENERGY STORAGE SYSTEMS

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO NO	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand different energy storage system conversions.	PO5	2
CO2	Illustrate various electrochemical storage system operations.	PSO1	2
CO3	Understand electrode properties and energy conversion of super capacitor.	PSO1	2
CO4	Outline fuel cell energy conversion concepts and different type's chemistries.	PO7	2

Need of Energy Storage; Different Modes of Energy Storage: Potential energy: Pumped hydro storage; KE and Compressed gas system: Flywheel storage, compressed air energy storage; Electrical and magnetic energy storage: Capacitors, electromagnets; Chemical Energy storage: Thermo-chemical, photo-chemical, bio-chemical, electro-chemical, fossil fuels and synthetic fuels.

Electrochemical Energy Storage Systems: Batteries: Primary, Secondary batteries; chemistries of primary batteries such as Zinc-Carbon, Alkaline and secondary batteries such as Lead acid, Nickel Cadmium, Metal hydrides, lithium ion, lithium phosphate and high temperature batteries-sodium-sulphur. Advantages, disadvantages, limitations and application each above mentioned batteries.

Super capacitors: Types of electrodes and some electrolytes, Electrode materials - high surface area activated carbons, metal oxide, and conducting polymers, Electrolyte - aqueous or organic,

Disadvantages and advantages of super capacitors - compared to battery systems, applications -

transport vehicles, private vehicles, and consumer electronics - energy density, power density, price, and market.

Fuel Cell Basics: Fuel cell definition, Difference between batteries and fuel cells, fuel cell history, components - principle of working -Fuel cell thermodynamics -efficiency, Electrochemical kinetics, Butler-Volmer equation-Types of fuel cells and its chemistries – AFC, PAFC, PEMFC,MCFC and SOFC – merits and demerits.

References:

J Larminie and A Dicks, Fuel Cell Systems Explained", 2nd Edition, Wiley, 2003

Johannes Jensen Bent Squrensen, Fundamentals of Energy Storage, John Wiley, NY, 1984.

Dr. JARUPULA SOMLAL
Professor & HOD
Department of EEE
KLEF Deemed to be University
Green Fields, Vaddeswaram,
Guntur Dt., A.P.-522 502.

P.D.Dunn, Renewable Energies. First Edition, Peter Peregrinus Ltd, London, United Kingdom, 1986

S Srinivasan, Fuel Cells: From Fundamentals to Applications, Springer 2006

R. M. Dell, D.A.J. Rand, ‘Understanding Batteries’, RSC Publications, 2001.

James Larminie, Andrew Dick, ‘Fuel Cell System Explained’, J. Wiley, 2003.

Dr. JARUPULA SOMLAL
Professor & HOD
Department of EEE
KLEF Deemed to be University
Green Fields, Vaddeswaram,
Guntur Dt., A.P.-522 502.

21EE52N3: GRID INTEGRATION OF RENEWABLE ENERGY SYSTEMS

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO NO	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand Control Algorithms of Various Electric Vehicle Charging Modes	PO5	2
CO2	Apply Power Electronic Converters for Electric Vehicle Charging	PSO1	3
CO3	Apply Charging Station Infrastructure	PSO1	3
CO4	Understand Installation and site assessment of Charging Station	PO7	2

Introduction to renewable energy systems, environmental aspects of electric energy

conversion, impacts of renewable energy generation on environment, Need of integrating large renewable energy sources, issues related to integration of large renewable energy sources.

Power Electronic Converters: need of power electronic equipment's in grid integration, converter, inverter, chopper, ac regulator and cycloconverters for AC/DC conversion.

Solar-Photovoltaic (PV) cells-characteristics, variability, energy conversion principles, electrical modelling, optimal power extraction, shading effect, Stand-alone PV system, Grid connected PV system, Design of PV system-load calculation, array sizing, selection of converter/inverter, battery sizing.

Wind: variability, principles of wind energy extraction, electromechanical energy conversion, characteristics of wind turbines, voltage regulation

Grid operation and Control :Scheduling and dispatch, Forecasting, reactive power and voltage control, frequency control, operating reserve, storage systems, electric vehicles, CERC and CEA orders (technical and safety standards)

Text Books

1. Integration of Alternative sources of Energy, Felix A. Farret and M. Godoy Simoes, IEEE Press – Wiley-Interscience publication, 2006.
2. Grid integration of solar photovoltaic systems, Majid Jamil, M. Rizwan, D.P.Kothari, CRC Press (Taylor & Francis group), 2017

Dr. JARUPULA SOMLAL
Professor & HOD
Department of EEE
KLEF Deemed to be University
Green Fields, Vaddeswaram,
Guntur Dt., A.P.-522 502.

Reference Books

1. Renewable Energy Grid Integration, Marco H. Balderas, Nova Science Publishers, New York, 2009.
2. Wind Power Integration connection and system operational aspects, B. Fox, D. Flynn L. Bryans, N. Jenkins, M. O' Malley, R. Watson and D. Milborrow, IET Power and Energy Series 50 (IET digital library), 2007
3. Power Generation, Operation, and Control, Allen J. Wood, Bruce F. Wollenberg, Gerald B. Sheblé, John Wiley & Sons, New York, 2013 (3rd edition)

Dr. JARUPULA SOMLAL
Professor & HOD
Department of EEE
KLEF Deemed to be University
Green Fields, Vaddeswaram,
Guntur Dt., A.P.-522 502.

21EE52E1: CHARGING TECHNOLOGY FOR ELECTRIC VEHICLES

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO NO	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand Control Algorithms for Various Electric Vehicle Charging Modes	PO5	2
CO2	Apply Power Electronic Converters for Electric Vehicle Charging	PSO1	3
CO3	Apply Charging Station Infrastructure	PSO1	3
CO4	Understand Installation and site assessment of Charging Station	PO7	2

Charger Topologies : Charging time and charging speed, Defining power levels- Normal charging, Semi-fast charging, Overview of power levels ,DC conductive charging, AC conductive charging, Low power Charger, Automotive standard charger, High power topologies, Multi-port Charger.

Power Electronics for EV Battery Charging: Forward/ Flyback Converters, Half-Bridge DC–DC Converter, Full-Bridge DC–DC Converter, Power Factor Correction, Bidirectional Battery Chargers, Dual active bridge dc-dc converter. Charging Modes: Constant-current charging, Constant-voltage charging, Pulse Charging, Reflex charging, Float charge, Trickle Charge.

Charging Infrastructure: Charger - Existing National & International Charger Architecture Standards - SAE J1773, VDE-AR-E 2623-2-2, JEVS G105-1993 (CHAdeMO), CCS, Type-1 AC, Type-2 AC, Bharat DC-001, Bharat AC-001, Cords and Cables, Earthing, Fault Protection, Testing, Charging Safety, Protection against electric shock Digital Communication between EV and Charging Station.

Installation: Govt. of India guideline on Public Charging Stations, IEC Standards- 60068-2(1, 2, 14, 30), 61683, 60227, 60502, 60947 part I,II, III and 61215 Site assessment, EVSE Typical Site Plans, Design Guidelines and Site Drawings, Planning Considerations, Station Configuration, Selection and erection of electrical equipment - Isolation, switching and control, Load management at charging station and peak load management.

Text Books:

1.Power Electronics by Daniel W.Hart.

Dr. JARUPULA SOMLAL
Professor & HOD
Department of EEE
KLEF Deemed to be University
Green Fields, Vaddeswaram,
Guntur Dt., A.P.-522 502.

2.Power Electronics for Renewable Energy Systems, Transportation and industrial Applications by Haitham Abu-Rub, Mariusz Malinwoski, Kamal Al-Haddad.

Reference Books :1. AIS-138 Part 1 and Part2

1. Electric Vehicle Charging Stations Technical Installation Guide, 2 nd Edition, Hydro Quebec.

Dr. JARUPULA SOMLAL
Professor & HOD
Department of EEE
KLEF Deemed to be University
Green Fields, Vaddeswaram,
Guntur Dt., A.P.-522 502.

21EE52E2: BATTERY MANAGEMENT SYSTEMS FOR ELECTRIC VEHICLE

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO#	Course Outcome	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand the specifications and Li-ion chemistry	PO1	2
CO2	Understand the key functions of Battery management systems	PO5	2
CO3	Develop Enhanced Self Correcting (ESC) Model of battery	PO7	4
CO4	Develop Algorithms for SOC estimation of battery	PSO2	4

Syllabus:

Battery specifications and Li-on chemistry

Battery specifications, cell-module-pack formation and specification calculation, working principle of Li-ion cell, materials used for various components of Li-ion cell, different li-ion chemistries and there specification comparison

Functions of battery-management systems

BMS architecture, BMS functionality: Sensing and High Voltage Control, Protection-isolation,overvoltage, overcurrent protection, Performance-Battery pack energy and power calculations using HPPC, Balancing- passive and active cell balancing, Interface, and Diagnostics

Battery Modelling

Simple OCV model, Rint model, Thevinenins model, Hysteresis effect and ESC model of battery cell.Charge, discharge tests to determine battery cell parameters,

SOC estimation

Stoichiometry for SOC estimation, Look-table method and Coulomb counting methods and their limitation for accurate state estimation. Linear and nonlinear Kalman filter based estimation techniques

Text books:

1. Battery management systems: Battery Modeling, Gregory L.Plett, Artech house, 2015.
2. Battery management systems: Equivalent circuit methods, Gregory L.Plett, Artech house, 2015.

Reference books:

1. Hybrid Electric vehicles-Principles and Applications with practical perspectives, Chris Mi, M.

Dr. JARUPULA SOMLAL
Professor & HOD
Department of EEE
KLEF Deemed to be University
Green Fields, Vaddeswaram,
Guntur Dt., A.P.-522 502.

AbdulMasrur and David Wenzhong Gao, Wiley Publications,*1* edition 2011

2. Electric and Hybrid Vehicles power sources, models, sustainability, infrastructure and the market, Edited by Gianfranco Pistoia, Elsevier 1 edition 2010.

3. Electric and Hybrid Vehicles Design Fundamentals, by Iqbal Hussain, CRC Press2nd edition, 2010.

Dr. JARUPULA SOMLAL
Professor & HOD
Department of EEE
KLEF Deemed to be University
Green Fields, Vaddeswaram,
Guntur Dt., A.P.-522 502.

21EE52D2: POWER QUALITY

L-T-P-S: 3-0-0-0 **Credits: 3** **Pre-Requisite: NIL**

Mapping of Course Outcomes with PO/PSO:

CO No	Course Outcome (CO)	PO/PSO	Blooms Taxonomy Level (BTL)
CO1	Understand basic power quality issues	PO-1	**2**
CO2	Understand conventional loop control for voltage and current balance	PSO-1	**2**
CO3	Apply DSTATCOM for power quality restoration	PO-2	**3**
CO4	Apply combined compensation techniques for power quality restoration and fault ride through.	PSO-2	**3**

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

Disturbance in supply voltage – Power quality standards**.** Low Voltage Ride Through, High Voltage Ride Through.

CONVENTIONAL LOAD COMPENSATION METHODS -Principle of Load compensation and Voltage regulation – Classical load balancing problem: Open loop balancing – Closed loop balancing, Current balancing – Harmonic reduction andvoltage sag reduction – Analysis of unbalance – instantaneous real and reactive powers –Extraction of fundamental sequence component.

LOAD COMPENSATION USING DSTATCOM - Compensating single phase loads – Ideal three phase shunt compensator structure –Generating reference currents using instantaneous PQ theory – Instantaneous symmetricalcomponents theory – Generating reference currents when the source is unbalanced –Realization and control of DSTATCOM – DSTATCOM in Voltage control mode.SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEM**-**Rectifier supported Dynamic Voltage Restorer – DC Capacitor supported DVR – DVRStructure – voltage Restoration – Series Active Filter – Unified Power Quality Conditioner- Wind power interconnection requirement - Fault ride through techniques.

TEXT BOOKS:

1. ArindamGhosh “Power Quality Enhancement Using Custom Power Devices”, Kluwer Academic Publishers, 2002

Dr. JARUPULA SOMLAL
Professor & HOD
Department of EEE
KLEF Deemed to be University
Green Fields, Vaddeswaram,
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Dr. JARUPULA SOMLAL
Professor & HOD
Department of EEE
KLEF Deemed to be University
Green Fields, Vaddeswaram,
Guntur Dt., A.P.-522 502.