w.e.f. 2024-25

Ph.D SU-R24

Ph.D Courses & Syllabus

for

Department of Electrical and Electronics Engineering

VELAGAPUDI RAMAKRISHNA SIDDHARTHA ENGINEERING COLLEGE

DEEMED TO BE UNIVERSITY

(Under Section 3 of UGC Act, 1956)

Kanuru, Vijayawada - 520 007, AP. www.vrsiddhartha.ac.in

(Sponsored by Siddhartha Academy of General & Technical Education)

VELAGAPUDI RAMAKRISHNA
SIDDHARTHA ENGINEERING COLLEGE
DEEMED TO BE UNIVERSITY
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
SCHEME OF INSTRUCTION (SU24)

Part A (Minimum 12 Credits)

Sl. No.	Course Name	Semester	Credits	Hours
1.	Research Methodology (Common for all)	I	4	60
2.	Course 1: Suggested by Research Supervisor related to research work to be carried out from a pool of courses prescribed by respective department.	I	3	45
3.	Oral Presentation/Seminar: Technical Paper Writing relevant to research work / domain	II	2	--
4.	Course 2: Suggested by Research Supervisor related to research work to be carried out from a pool of courses prescribed by respective department.	II	3	45
		TOTAL	**12**	**150**

S.No	Course Code	Title of the Course	L	T	P	C	SE	Total
1.	24UC701	Research Methodology (Common for All)	4	**0**	**0**	**4**	100	100

S.No	Course Code	Title of the Course	L	T	P	C	SE	Total
1.	24UC702	Oral Presentation/Seminar	0	**0**	**0**	**2**	100	100

S.No	Course Code	Title of the Course	L	T	P	C	SE	Total
1.	24UC800	Ph.D Thesis	--	**--**	**--**	**--**	--	--

Ph.D. ELECTRICAL AND ELECTRONICS ENGINEERING

POOL I Courses:

S.No	Course Code	Title of the Course	L	T	P	C	SE	Total
1.	24EE710A	Deregulated Power System	3	0	0	3	100	100
2.	24EE710B	Smart Grid Design and Analysis	3	0	0	3	100	100
3.	24EE710C	Modern Control Theory	3	0	0	3	100	100
4.	24EE710D	Analysis and design of power converters	3	0	0	3	100	100
5.	24EE710E	Sustainable Power Generation Systems	3	0	0	3	100	100
6.	24EE710F	Optimization Theory and Algorithms (NPTEL)	-	-	-	3	100	100
7.	24EE710G	Design of Photovoltaic Systems (NPTEL)	-	-	-	3	100	100
8.	24EE710H	Power Electronics with Wide Band Gap Devices (NPTEL)	-	-	-	3	100	100
9.	24EE710I	Nonlinear Dynamical Systems and Control (NPTEL)	-	-	-	3	100	100
10.	24EE710J	Introduction to Electric and Hybrid Electric Vehicle (NPTEL)	-	-	-	3	100	100

POOL II Courses:

S.No	Course Code	Title of the Course	L	T	P	C	SE	Total
1.	24EE720A	Flexible AC Transmission Systems	3	0	0	3	100	100
2.	24EE720B	Advanced Power System Protection	3	0	0	3	100	100
3.	24EE720C	Battery Technology for Electrical Vehicles	3	0	0	3	100	100
4.	24EE720D	Power Electronics applications to renewable energy systems	3	0	0	3	100	100
5.	24EE720E	Analysis and design of Inverters	3	0	0	3	100	100
6.	24EE720F	Solar Energy Engineering and Technology (NPTEL)	-	-	-	3	100	100
7.	24EE720G	Distributed Optimization and Machine Learning (NPTEL)	-	-	-	3	100	100
8.	24EE720H	Power Electronics Applications in Power Systems (NPTEL)	-	-	-	3	100	100
9.	24EE720I	Hydrogen Energy: Production, Storage, Transportation and Safety (NPTEL)	-	-	-	3	100	100
10.	24EE720J	Machine Learning and Deep Learning - Fundamentals and Applications (NPTEL)	-	-	-	3	100	100

L – Lecture, T-Tutorial, P- Practical, SE-Semester End Exam, C – Credits, Total – Total Marks

24UC701 RESEARCH METHODOLOGY
(Common for all)

Course Category:		**Credits:**	4
Course Type:	Theory	**Lecture -Tutorial-Practice:**	4 - 0 - 0
		Semester End Evaluation: **Total Marks:**	100 100

COURSE CONTENT

Unit-I: Research Methodology – An Introduction (09 hours)

Function of Research - Meaning of Research - Motivation in Research - Significance of Research – Characteristics of Research – Steps involved in Research – Research in Pure and Applied Sciences - Inter Disciplinary Research.

Literature review, Surveying, Synthesizing, critical analysis, reading materials, reviewing, rethinking, critical evaluation, interpretation, Research Purposes, Ethics in research – APA Ethics code

Unit - II: Defining the Research Problem (09 hours)

Selecting the Research problem – Necessity of defining the problem – Goals and Criteria for identifying problems for research.

Perception of Research problem – Techniques involved in defining the problem – Source of problems – Personal consideration.

Unit- III: Research Design (15 hours)

Formulation of Research design – Need for Research design – Features of a good design – Important concepts related to Research design - Basic Principles of Experimental Designs

Methods of Data Collection: Collection of Primary Data, Observation Method, Interview Method, Collection of Data through Questionnaires, Collection of Data through Schedules, Difference between Questionnaires and Schedules, other methods - Warranty cards, Distributor or store audits, Pantry audits, Consumer panels, Use of mechanical devices, Projective techniques.

Unit – IV: Processing and Analysis of Data (15 hours)

Processing Operations, Some Problems in Processing, Elements/Types of Analysis, Statistics in Research, Measures of Central

Tendency, Measures of Dispersion, Measures of Asymmetry (Skewness), Measures of Relationship, Simple Regression Analysis, Multiple Correlation and Regression

Sampling Fundamentals: Need for Sampling, Some Fundamental Definitions, Important Sampling Distributions, Central Limit Theorem, Sampling Theory, Sandler's A-test, Chi-square Test, Analysis of Variance and Covariance, Multivariate Analysis Techniques, Time Series Analysis.

Unit-V: Interpretation and Report Writing (12 hours)

Meaning and Technique of interpretation – Precautions in interpretation – Significance of report writing – Different steps in writing a report – Layout of a Research report.

Types of report – Mechanics of writing a research report – Precautions for writing a research report – Conclusion.

TEXT BOOKS

[1] Research Methodology Methods & Techniques, C.R. Kothari – New Age international Publishers, Reprint 2008.
[2] A Hand Book of Methodology of Research, Rajammall, P. Devadoss and K. Kulandaivel, RMM Vidyalaya press, 1976.
[3] Montgomery, D.C., 2017. Design and analysis of experiments. John Wiley & sons

REFERENCE BOOKS

[1] Donald H. McBurney, Research Methods, 5th edition, Thomson Learning, ISBN: 81-315- 0047-0, 2006
[2] Thesis and Assignment Writing, J. Anderson, Wiley Eastern Ltd., 1997.
[3] Research Methodology, Mukul Gupta, Deepa Gupta – PHI Learning Private Ltd., New Delhi, 2011.
[4] Fundamentals of Mathematical statistics, S.C. Gupta and V.K. Kapoor, Sultan Chand & Sons, New Delhi, 1999.

POOL I

COURSES SYLLABUS

DEREGULATED POWER SYSTEM
24EE710A

Course Type:	**Theory**		**Pool 1**
Credits: 3	**Lecture-Tutorial-Practice: 3 - 0 - 0**		**Total Marks:100**
Course Outcomes	After completion of this course the student should be able to		
	CO1	Describe the operation of deregulated electricity market systems.	
	CO2	Analyze typical issues in electricity markets and how these are handled world-wide in various markets.	
	CO3	Analyze various types of electricity market operational and control issues using new mathematical models.	
	CO4	Illustrate about reforms in Indian power sector and Availability based tariff.	
	CO5	To analyze the advancement in the deregulated power system.	
Course Content	**UNIT- I** **Introduction:** Deregulation of electric utilities, competitive whole sale electricity market: transmission expansion in new environment, transmission open access, pricing electricity in deregulated environment.		
	UNIT- II **Fundamentals of Deregulation:** Privatization and deregulation, motivations for restructuring the power industry, restructuring models and trading arrangements: components of restructured systems, independent system operator (ISO): functions and responsibilities, trading arrangements (pool, bilateral & multilateral).		
	UNIT- III **Open Access Transmission Systems:** Different models of deregulation: UK model, California model, Australian and New Zealand models, Deregulation in Asia including India. Market mechanism: bidding strategies, forward and future market. Operation and control: Old vs. New, available transfer capability, congestion management, ancillary services. Wheeling charges and pricing: wheeling methodologies, pricing strategies.		
	UNIT- IV **Market Model in Indian Power Sector:** Reforms in Indian power sector, framework of Indian power sector, National and Transnational Grids, The Independent Power Plants: Orissa Reform Model, Accelerated Power Development and Reforms Program (APDRP), Public-Private Partnership, The Availability Based Tariff (ABT).		
	UNIT- V **Advanced Topics in Deregulated Power Systems:** Emerging challenges and opportunities in deregulated power systems, impact of deregulation on renewable energy integration. Role of advanced technologies in market operations: smart grid initiatives, demand response mechanisms, energy storage in competitive markets. Future trends in deregulated electricity markets: decentralized generation and micro-grids, blockchain and peer-to-peer energy trading, case studies and lessons from global deregulation experiences.		
Text books:	1. Yong-Hua song, Xi-Fan Wang, "Operation of Market oriented Power systems", Springer, 2003. 2. DanielnKirschen and GoranStrbac, "Fundamentals of Power System economics", John Wiley & Sons Ltd, 2004.		
Reference books:	3. Kankar Bhattacharya, Jaap E. Daadler, Math H.J Bollen, "Operation of restructured power systems", Kluwer Academic Pub., 2001.		

SMART GRID DESIGN AND ANALYSIS
24EE710B

Course Type:	**Theory**		**Pool 1**
Credits: 3	**Lecture-Tutorial-Practice: 3 - 0 - 0**		**Total Marks:100**
Course Outcomes	After completion of this course the student should be able to		
	CO1	Analyze the concepts and design of Smart grid.	
	CO2	Apply communication and measurement technologies in smart grid.	
	CO3	Analyze load flow studies in smart grid.	
	CO4	Analyze stability of smart grid.	
	CO5	To learn the renewable energy resources and storages integrated with smart grid.	
Course Content	**UNIT- I** **Smart grid concepts & architectural designs:** Evolution of electric grid, concept, definitions and need for smart grid, smart grid drivers, functions, opportunities, challenges and benefits, difference between conventional & smart grid, concept of resilient & self-healing grid, present development & international policies in smart grid, diverse perspectives from experts and global smart grid initiatives. General view of the smart grid market drivers - stakeholder roles and functions - measures - representative architecture - functions of smart grid components - wholesale energy market in smart grid - smart vehicles in smart grid.		
	UNIT- II **Smart grid communications and measurement technology**: Communication and standards - communication and measurement - monitoring, introduction to smart meters, Advanced Metering infrastructure (AMI)– (GIS and Google Mapping Tools) 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. Wide area monitoring systems (WAMS).		
	UNIT- III **Performance analysis tools for smart grid design**: Introduction to load flow studies - challenges to load flow in smart grid and weaknesses of the present load flow methods - load flow state of the art: classical, extended formulations, and algorithms –load flow for smart grid design-contingencies studies for smart grid.		
	UNIT- IV **Stability analysis tools for smart grid:** Voltage stability analysis tools - voltage stability assessment techniques - voltage stability indexing - application and implementation plan of voltage stability in smart grid - angle stability assessment in smart grid - approach of smart grid to state estimation - energy management in smart grid.		
	UNIT- V **Renewable energy integration, storage & monitoring technologies:** Renewable energy resources - sustainable energy options for the smart grid - demand response issues - electric vehicles and plug in hybrid electric vehicles -PHEV technology - environmental implications - storage technologies - grid integration issues of renewable energy sources (Power Quality & EMC)- web based power quality monitoring (Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols), power quality audit, basics of web service and CLOUD computing to make smart grids smarter, cyber security for smart grid.		
Text books:	1. James Momoh, "*Smart Grid: Fundamentals of design and analysis*", *John Wiley & sons Inc, IEEE press 2012*. 2. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "*Smart Grid: Technology and Applications*", *John Wiley & sons Inc, 2012.*		
Reference books:	*3.* Fereidoon P. Sioshansi, "*Smart Grid: Integrating Renewable, Distributed & Efficient Energy*", Academic Press, 2012. 4. Clark W. Gellings, "*The smart grid: Enabling energy efficiency and demand response*", Fairmont Press Inc, 2009.		

MODERN CONTROL THEORY 24EE710C		
Course Type:	**Theory**	**Pool 1**
Credits: 3	**Lecture-Tutorial-Practice: 3 - 0 - 0**	**Total Marks:100**
Course Outcomes	After completion of this course the student should be able to	
	CO1	Design a control system via pole assignment
	CO2	Design of state observers
	CO3	Perform the stability analysis of nonlinear systems using describing functions and phase plane methods
	CO4	Analyze linear and non-linear systems using Lyapunov theorems and Design Lyapunov function for stable systems
	CO5	Formulate an optimal control problem and design optimal controller using Hamiltonian and/or LQR methods
Course Content	**UNIT- I** **State Feedback Controllers and Observers:** Review of state space concepts, Controllabil and Observability, State space representations of transfer-function systems –controllab observable, diagonal (Jordan) canonical forms; State feedback controller design through Pc Assignment- Direct, Transformation Matrix, Ackermann's methods;	
	UNIT- II **State Observers Design:** State observers - Full order and Reduced order - Direct, Transformation Matrix, Ackermann's methods, Kalman filter design	
	UNIT- III **Nonlinear Systems:** Introduction –Properties of nonlinear systems - Types of Nonlinearities Singular Points – Introduction to linearization of nonlinear systems,– Describing functio describing function analysis of nonlinear systems – Stability analysis of Nonlinear systems describing function and phase plane methods	
	UNIT- IV **Lyapunov Stability Analysis:** Equilibrium state, Stability in the sense of Lyapunov, Sca functions-Sign definiteness, Lyapunov's stability and instability theorems - Stability analys of the linear continuous- time invariant systems by Lyapunov second method– Direct meth of Lyapunov – Generation of Lyapunov functions – Variable gradient and Krasoviski methods	
	UNIT- V **Optimal Control:** Introduction to optimal control - Formulation of optimal control problems calculus of variations –Minimization of functions - Minimization of functional – functior involving independent functions – constrained minimization – formulation using Hamiltoni method – Linear Quadratic regulator.	
Text books:	1. Ogata K. "*Modern Control Engineering*", PHI, 5/e 2. IJ Nagrath and M. Gopal, "*Control System Engineering*", New Age International, 5/e 3. M. Gopal, "*Modern Control System Theory*", New Age International, 3/e	
Reference books:	4. M.Gopal, "*Control Systems – Principles and Design*", TMH, 4/e	

ANALYSIS AND DESIGN OF POWER CONVERTERS
24EE710D

Course Type:	**Theory**		**Pool 1**
Credits: 3	**Lecture-Tutorial-Practice: 3 - 0 - 0**		**Total Marks:100**
Course Outcomes	After completion of this course the student should be able to		
	CO1	**Analyze** the operation of non-isolated/isolated DC-DC converters.	
	CO2	**Design** of components used in power converters	
	CO3	**Analyze** the advanced modulation schemes.	
	CO4	To comprehend the concepts of AC-AC power converters and their applications.	
	CO5	**Elucidate** the operation of resonant converters	
Course Content	**UNIT I** **Non-Isolated & Isolated DC-DC Converters:** Non-isolated DC-DC Converters-buck, boost, buck-boost, CUK, SEPIC converters under continuous and discontinuous conduction operation, Isolated DC-DCConverters-forward, fly-back, push-pull, half-bridge, and full-bridge converters,relationship between input and output voltages, expression for filter inductor andcapacitors.		
	UNIT II **Design of Power Converter Components:** Design of magnetic components, design of transformer, design of inductor and current transformer, selection of filter capacitors, selection of ratings for devices, filter design, thermal design.		
	UNIT III **Advanced Modulation Techniques:** Quasi square wave modulation, End pulse modulation, center pulse modulation, Sinusoidal pulse width modulation,Trapezoidal, Staircase, Stepped, Harmonic Injection and Delta modulation techniques – Space Vector Modulation (SVM) – Implementation issues involved in the modulation schemes		
	UNIT IV **AC-AC Converters:** Single phase AC-AC voltage regulator-analysis of Half controlled and fully controlled AC regulators, three Phase AC Voltage Controller: operation, - integral cycle controller. Cycloconverters -types-Output equation of cycloconverters, Matrix converters – Design, analysis, and application.		
	UNIT V **Resonant DC-DC Converters:** Introduction, basic resonant circuit concepts, classification-Load resonant converters, resonant switch converters, zero voltage switching, clamped voltage converters, resonant DC link inverters, high frequency link integral half cycle converters, phase modulated resonant converters.		
Text books:	1. L.Umanand, "Power Electronics: Essentials and Applications", chapter 1 to 7, John Wiley, India, 2009. 2. N.Mohan, T.M.Undeland, WP.Robbins, "Power Electronics: Converters and Applications", John Wiley and Sons, 3rd edition, 2009. 3. M.H.Rashid, "Power Electronics-circuits, Devices and Applications", Prentice Hall of India, 3rd edition, 2005		
Reference books:	4. E.W.Robert, M.Dragan,"Fundamentals of Power Electronics", Springer, 1997. 5. Marian. K.Kazimierczuk and DariuszCzarkowski, "Resonant Power Converters", John Wiley & Sons limited, 2011 6. P.C. Sen, "Modern Power Electronics", Wheeler Publishing Co, First Edition, New Delhi, 1998.		

SUSTAINABLE POWER GENERATION SYSTEMS

24EE710E

Course Type:	**Theory**		**Pool 1**
Credits: 3	**Lecture-Tutorial-Practice: 3 - 0 - 0**		**Total Marks:100**
Course Outcomes	After completion of this course the student should be able to		
	CO1	To understand the concept of Solar Energy Technology.	
	CO2	To analyze the concept of Wind Energy Conversion System	
	CO3	To analyze the concept of BIO-Mass Energy	
	CO4	To distinguish the functionality of Geothermal, OTEC And Hybrid Energy Systems	
	CO5	To understand the concept of Hydrogen energy and fuel cells	
Course Content	**UNIT- I** **Solar Energy Technology:** Recent trends in energy consumption –Energy sources and their availability – Need to develop new energy technologies – Solar radiation and measurement – Solar cells and their characteristics –Availability and limitations of solar energy – Solar thermal collectors, General description and characteristics – Flat plate collectors – Solar concentrators Design, analysis and performance evaluation. – Analysis of PV systems, Applications of solar energy.		
	UNIT- II **Wind Energy Conversion System:** Basic principle of wind energy conversion - nature of wind -Wind survey in India, Site selection considerations– Power in the wind –components of a wind energy conversion system -Types of wind power conversion systems – Wind data analysis, Wind resource estimation, Betz's Limit, Turbulence Analysis Performance of Induction Generators for WECS – Classification of WECS.		
	UNIT- III **Bio-Mass Energy**: Biomass: Generation and utilization, Properties of biomass, Agriculture Crop & Forestry residues used as fuels. Concept of Bio-energy**:** Photosynthesis process, Biomass resources Bio based chemicals and materials. Bio-Chemical Conversion: Aerobic and Anaerobic conversion, Fermentation etc. Types of Bio-fuels, Bio fuel applications, Ethanol as a fuel for I.C. engines, Importance of biogas technology, Different Types of Biogas Plants.		
	UNIT- IV **Geothermal, OTEC and Hybrid Energy Systems:** Availability of Geothermal Energy-size and Distribution, Recovery of Geothermal Energy, Various Types of Systems to use Geothermal Energy, Direct heat applications, Power Generation using Geothermal Heat, Sustainability of Geothermal Source. Ocean Thermal Electricity Conversion (OTEC), Electricity generation from Waves: Shoreline and Floating wave systems. Hybrid energy systems: wind-diesel system, wind-PV system, biomass-PV-diesel system, geothermal.		
	UNIT- V **Hydrogen energy and fuel cells:** Importance, various routes of hydrogen generation, basic principle and design of different types of fuel cells and their applications, future prospects, Integrated Gasification Fuel Cell (IGFC).		
Text books:	1. Rai G.D., "Non – Conventional Energy Sources", Khanna Publishers, 1993. 2. R.K. Rajput, "Non-Conventional Energy Sources and Utilisation", S. Chand & Company Pvt. Ltd., Second Revised Editon 2014 3. S.PSukhatme and J.K. Nayak, Solar Energy: Principles of Thermal Collection and Storage, Tata Mc-Graw Hill Education Private Limited, 3rd Edition, 2010.		
Reference books:	4. Rai G.D., "Solar Energy Utilisation", Khanna Publishers, 1993. 5. Gary L. Johnson, "Wind Energy Systems", Prentice Hall Inc., 1985. 6. Chakraverthy A, "Biotechnology and Alternative Technologies for Utilization of Biomass or Agricultural Wastes", Oxford & IBH publishing Co, 1989.		

POOL II

COURSES SYLLABUS

FLEXIBLE AC TRANSMISSION SYSTEMS
24EE720A

Course Type:	**Theory**		**Pool 2**
Credits: 3	**Lecture-Tutorial-Practice: 3 - 0 - 0**		**Total Marks:100**
Course Outcomes	After completion of this course the student should be able to		
	CO1	To understand the basic concepts of power flow in transmission lines and basic types of FACTS controllers.	
	CO2	To analyze the concept of shunt compensation and types of shunt compensators and their operation.	
	CO3	To analyze the concept of series compensation and classification of series compensators and their operation.	
	CO4	To distinguish the functionality of UPFC and IPFC;	
	CO5	To analyze the modeling of various types of FACTS devices	
Course Content	**UNIT- I** **Introduction:** Reactive power flow control in Power Systems – Power flow control and dynamic stability considerations of power system - Constraints of maximum transmission line loading – Basic types of FACTS controllers - Benefits of FACTS Transmission line compensation. Uncompensated line - shunt compensation - Series compensation – Phase angle control – Reactive compensation at distribution level.		
	UNIT- II **Shunt compensation**: Static versus passive VAR compensators, Static shunt compensators - SVC - Operation and control of TCR, TSC, FC-TCR; Switching converter type VAR generators - STATCOM – Operation and control; Comparison between SVC and STATCOM.		
	UNIT- III **Static series compensation**: Variable impedance type Series compensators - GCSC, TSSC and TCSC Operation and Control; Switching converter type series compensator – SSSC Operation and Control; Static voltage and phase angle regulators – TCVR and TCPAR Operation and Control – Applications; SSR and its damping.		
	UNIT- IV **Unified Power Flow Controller and Interline power flow controller:** Circuit arrangement, operation and control of UPFC; Independent real and reactive power flow control of UPFC; Interline power flow controller (IPFC) – Basic operating principle and characteristics; - Applications of UPFC and IPFC; operation and control of DSTATCOM and UPQC.		
	UNIT- V **Modeling and power flow analysis of FACTS Controllers:** STATCOM, TCSC, IPFC and UPFC		
Text books:	1. Narain G.Hingorani, Laszio. Gyugyl, "*Understanding FACTS Concepts and Technology of Flexible AC Transmission System*", Standard Publishers, Delhi. 2. K.R.Padiyar," *FACTS Controllers in Power Transmission and Distribution*", New Age International (P) Ltd., Publishers, New Delhi, Reprint.		
Reference books:	3. Mohan Mathur, R., Rajiv. K. Varma, "Thyristor – Based FACTS Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc.		

ADVANCED POWER SYSTEM PROTECTION
24EE720B

Course Type:	**Theory**		**Pool 2**
Credits: 3	**Lecture-Tutorial-Practice: 3 - 0 - 0**		**Total Marks:100**
Course Outcomes	After completion of this course the student should be able to		
	CO1	**Implement** various microprocessor based relays.	
	CO2	**Analyze** the operation of static relays.	
	CO3	**Analyze and design** Static relay schemes	
	CO4	**Develop** models of Digital relays	
	CO5	**Apply** AI methods to Power system protection.	
Course Content	**UNIT -I** **Microprocessor Base Relays**: Basics of Electromagnetic Relays, their disadvantages and advantages. Microprocessor Based Relays hardware and algorithms: Over Current relay, impedance relay, directional relay, reactance relay, Mho relay, offset Mho relay.		
	UNIT –II **Static Relays:** Basic Block diagram, advantages of static relays. Comparators: Phase and amplitude comparators, duality between phase and amplitude comparators, operating principles of Static over current relays, static differential relays		
	UNIT –III **Static distance relays and their protection schemes:** Static distance relays. Transmission line pilot relaying and carrier current protection schemes, transformer differential protection, static harmonic restraint relay.		
	UNIT – IV **Digital relays:** Developments in computer relaying, mathematical basis for protective relaying algorithms, differential equation based technique, Fourier analysis based algorithms, Wavelet transforms based technique, numerical over current Protection, numerical distance protection, numerical differential protection		
	UNIT – V **AI Based Numerical Protection**: Application of ANN to over current protection, Application of ANN to Transmission line protection, Neural Networks Based Directional Relay, ANN modular approach for fault detection, classification and location, ANN Fuzzy based approach for fault classification Power transformer protection based on ANN & Fuzzy logic.		
Text books:	1. T S MadhavaRao, "Power System Protection – Static relays", TMH. 2. Badri Ram and D Vishwakarma, "Power System Protection and Switchgear", second edition, TMH. 3. A.T.Johns and S.K.Salman, "Digital Protection for Power Systems", IEE power Sys.		
Reference books:	4. Waldemar Rebizant, Janusz Szafran, et al, "Digital Signal Processing in Power System Protection and Control", Springer.		

BATTERY TECHNOLOGY FOR ELECTRICAL VEHICLES
24EE720C

Course Type:	**Theory**		**Pool 2**
Credits: 3	**Lecture-Tutorial-Practice: 3 - 0 - 0**		**Total Marks:100**
Course Outcomes	After completion of this course the student should be able to		
	CO1	To understand the fundamentals of batteryand electrical vehicle operation	
	CO2	To study the electric vehicle battery modelingand characteristics	
	CO3	To study various SOx parameters of the batteries and design of BMS	
	CO4	To understand battery charging methods	
	CO5	To understand electric vehicle battery performance	
Course Content	**UNIT -I** **Fundamentals of batteries and classification:** Electric Vehicle Operation, Lithium-ion Battery Basics, Principles of Operation of Cell, Batteries; Electrochemical Principles and Reactions,Battery Parameters, Next Generation Batteries: Sodium based batteries and nickel-based batteries (construction and working), Comparison among Lithium-ion Battery, Sodium based batteries and nickel-based batteries		
	UNIT –II **Battery modeling and characteristics:** Testing the Characteristics of Lithium-ion Batteries, Battery Modeling Method, Simulation and Comparison of Equivalent Circuit Models, Battery Modeling Method Based on a Battery Discharging Curve, Battery Pack Modeling		
	UNIT –III **Battery State Estimation:** State of charge, Discussion on the Estimation of the SOC of a Battery, Battery SOC Estimation Algorithm, State of energy, Estimation of the Battery SOE, state of health, Estimation of the SOH. The Functions and Architectures of a Battery Management System, Design of the Battery Parameters Measurement Module, Data Communication		
	UNIT – IV **Battery charging techniques:** Overview of Lithium-ion Battery Charging Technologies, different types of charging profiles, Key Indicators for Measuring Charging Characteristics, Charging External Characteristic Parameters of the Lithium-ion Battery, Improvement of the Constant Current and Constant Voltage Charging Method, Cell balancing – passive and active.		
	UNIT – V **EV Battery Performance:** The Battery Performance Management System, BPMS Thermal Management System, the BPMS Charging Control, High-Voltage Cabling and Disconnects, Safety in Battery Design, Battery Pack Safety— Electrolyte Spillage and Electric Shock, Electrical Insulation Breakdown Detection, Electrical Vehicle Component Tests, Building Standards, Ventilation.		
Text books:	1. Jiang, Jiuchun, and Caiping Zhang. Fundamentals and applications of lithium-ion batteries in electric drive vehicles. John Wiley & Sons, 2015. 2. Electric vehicle battery systems by Sandeep Dhameja, Newnes Publishing, 2002 3. Larminie, James, and John Lowry. Electric vehicle technology explained. John Wiley & Sons, 2012.		
Reference books:	4. Chris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons Ltd. , 2011 5. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press , 2003		

POWER ELECTRONICS FOR RENEWABLE ENERGYSYSTEMS 24EE720D			
Course Type:	**Theory**		**Pool 2**
Credits: 3	**Lecture-Tutorial-Practice: 3 - 0 - 0**		**Total Marks:100**
Course Outcomes	After completion of this course the student should be able to		
	CO1	To provide knowledge about the stand alone and grid connected renewable energy systems.	
	CO2	To equip with required skills to derive the criteria for the design of power converters for renewable energy applications.	
	CO3	To analyse and comprehend the various operating modes of wind electrical generators and solar energy systems.	
	CO4	To design different power converters namely AC to DC, DC to DC and AC to AC converters for renewable energy systems.	
	CO5	To develop maximum power point tracking algorithms	
Course Content	**UNIT I** **Introduction:** Environmental aspects of electric energy conversion: impacts of renewable energy generationon environment (cost-GHG Emission) -Qualitative study of different renewable energy resources ocean, Biomass, Hydrogen energy systems: operating principles and characteristicsof: Solar PV, Fuel cells, wind electrical systems-control strategy, operating area.		
	UNIT II **Electrical Machines for Renewable Energy Conversion:** Review of reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIGand DFIG.		
	UNIT III **Power Electronics for Solar:** Block diagram of solar photo voltaic system: line commutated converters (inversion-mode) -Boost and buck-boost converters-selection of inverter, battery sizing, array sizing- standalonePV systems - Grid tied and grid interactive inverters- grid connection issues.		
	UNIT IV **Power Electronics for Wind:** Three phase AC voltage controllers-AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, matrix converters- Stand-alone operation of fixed and variable speed wind energy conversion systems- Grid connection Issues -Grid integrated PMSG and SCIG Based WECS.		
	UNIT V **Hybrid Renewable Energy Systems:** Need for Hybrid Systems-Range and type of Hybrid Systems- Case studies of Wind-PV- Maximum Power Point Tracking (MPPT).		
Text books:	1. Rashid .M. H "power electronics Hand book", Academic press, 2001. 2. P.S.Bimbhra,"Power Electronics",Khanna Publishers, 3rd Edition,2003. 3. Rai. G.D, "Non conventional energy sources", Khanna publishes, 1993. 4. Rai. G.D," Solar energy utilization", Khanna publishes, 1993. 5. R.Seyezhai and R.Ramaprabha, "Power Electronics for Renewable Energy Systems", Scitech Publications, 2015.		
Reference books:	6. Gray, L. Johnson, "Wind energy system", prentice hall linc, 1995. 7. B.H.Khan, "Non-conventional Energy sources", Tata McGraw-hill Publishing Company. 8. Fang Lin Luo Hong Ye, " Renewable Energy systems", Taylor & Francis Group,2013. 9. S.N.Bhadra, D. Kastha, & S. Banerjee "Wind Electrical Systems", Oxford University Press, 2009.		

ANALYSIS AND DESIGN OF INVERTERS
24EE720E

Course Type:	**Theory**		**Pool 2**
Credits: 3	**Lecture-Tutorial-Practice: 3 - 0 - 0**		**Total Marks:100**
Course Outcomes	After completion of this course the student should be able to		
	CO1	To design different single phase and three phase inverters.	
	CO2	Develop PWM schemes to balance the neutral point, eliminate common mode voltage and reduce the switching power loss in diode clamped multilevel inverter.	
	CO3	Implement level-shifted, phase-shifted, hybrid and Space Vector PWM schemes for Cascaded H-Bridge Multilevel Inverters.	
	CO4	Develop reduced switch count MLIs and PWM current source inverters	
	CO5	To equip with required skills to derive the criteria for the design of inverters for UPS, drives etc.,	
Course Content	**UNIT I** **Inverters:** Single-phase and three-phase inverters - Operating Principle and mathematical modelling, PWM techniques- sinusoidal PWM scheme for single and three phase inverter, Impact of harmonics-Harmonic elimination schemes, forced commutated thyristor inverters, Impedance source inverters.		
	UNIT II **Multilevel Inverters:** Multilevel concept – flying capacitor – diode clamped –3, 4 and 5 level DCMLIs, Neutral point voltage balance, Elimination of common mode voltage, Carrier-Based PWM Scheme and Neutral-Point Voltage Control, High-Level Diode-Clamped Inverters– Active Neutral-Point Clamped Inverter.		
	UNIT III **Cascade H-Bridge Inverters:** Symmetrical and asymmetrical topologies, cascade H-bridgeinverter with Equal DC Voltage, H-Bridges with Unequal DC Voltages, level-shifted PWM, phase-shifted PWM, hybrid PWM and SVM.Topologies of modular multilevel inverters (MMI).		
	UNIT IV **Reduced Switch Count MLIS:** Introduction, classification, operation of T-type, multilevel dc link, switched series parallel source and other topologies.PWM current source inverters: Trapezoidal modulation, selective harmonic elimination and SVM, Load-commutated inverters (LCI).		
	UNIT V **Resonant Inverters and Power Conditioners:** Series and parallel resonant inverters - voltage control of resonant inverters – Class Eresonant inverter – resonant DC - link inverters -power line disturbances-powerconditioners-UPS: offline UPS, online UPS.		
Text books:	1. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004. 2. P.S.Bimbra, "Power Electronics", Khanna Publishers, Eleventh Edition, 2003 3. Ned Mohan,T.MUndeland and W.P Robbin, "Power Electronics: converters, Application and design" John Wiley and sons.Wiley India edition, 2006 4. Bin Wu, High Power Converters and AC Drives, Wiley-Inter science, 2017, 2nd Edition. 5. BimalK.Bose "Modern Power Electronics and AC Drives", Pearson Education, Second Edition, 2003.		
Reference books:	6. Philip T. krein, "Elements of Power Electronics" Oxford University Press -1998 7. P.C. Sen, "Modern Power Electronics", Wheeler Publishing Co, First Edition,New Delhi, 1998 8. Jai P.Agrawal, "Power Electronics Systems", Pearson Education, Second Edition, 2002		