E.G.S. PILLAY ENGINEERING COLLEGE

(Autonomous)

NAGAPATTINAM – 611002

(Affiliated to Anna University, Chennai | Accredited by NAAC with 'A++' Grade|Accredited by NBA T1(B.E. – CSE, CIVIL, ECE, EEE, MECH& B.Tech – IT) | Approved by AICTE, New Delhi)

M.E. – POWER ELECTRONICS AND DRIVES R- 2024

SECOND YEAR

CURRICULUM AND SYLLABUS FOR THIRD SEMESTER

Course Code	Course Name	L	T	P	C	Maximum Marks			Category
						CA	ES	Total	
Theory Course									
	Program Elective–IV	3	0	0	3	40	60	100	PEC
	Program Elective–IV	3	0	0	3	40	60	100	PEC
	Open Elective	3	0	0	3	40	60	100	OEC
Laboratory Course									
2404PE301	Project Work–Phase I	0	0	20	10	50	50	100	EEC
Total		9	0	20	19	170	230	400	

L-Lecture |T –Tutorial |P- Practical |CA – Continuous Assessment |ES – End Semester

PROGRAM ELECTIVE - IV

Course Category	Course Name	L	T	P	C
2403PE013	IOT FOR POWER ELECTRONIC SYSTEM	3	0	0	3
2403PE014	NONLINEAR DYNAMICS FOR POWER ELECTRONIC CIRCUITS	3	0	0	3
2403PE015	ELECTRIC VEHICLES AND POWER MANAGEMENT	3	0	0	3
2403PE016	MICRO ELECTRO MECHANICAL SYSTEMS	3	0	0	3

PROGRAM ELECTIVE - V

Course Category	Course Name	L	T	P	C
2403PE017	DISTRIBUTED GENERATION AND MICRO GRIDS	3	0	0	3
2403PE018	POWER CONVERTERS FOR SOLAR AND WIND ENERGY CONVERSION SYSTEM	3	0	0	3
2403PE019	APPLICATIONS OF POWER ELECTRONICS IN UTILITY SYSTEMS	3	0	0	3
2403PE020	ENERGY MANAGEMENT AND AUDITING	3	0	0	3

OPEN ELECTIVE COURSES

Course Category	Course Name	L	T	P	C
2403PE021	SMART GRID	**3**	**0**	**0**	**3**
2403PE022	RENEWABLE ENERGY TECHNOLOGY	**3**	**0**	**0**	**3**
2403PE023	ELECTRIC AND HYBRID VEHICLES	**3**	**0**	**0**	**3**
2403PE024	INDUSTRIAL CONTROL ELECTRONICS	**3**	**0**	**0**	**3**

2403PE013	**IOT FOR POWERELECTRONIC SYSTEMS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

PREREQUISITE:

	Basics of Power Electronics and Electrical Machines
	Fundamentals of Microcontrollers and Embedded Systems
	Computer Programming (preferably Python or C)
	Basic Concepts of Communication Networks and Protocols

COURSE OBJECTIVES:

1	To introduce the fundamentals of IoT devices, platforms, and their integration with power electronics.
2	To analyze the role of IoT in industrial automation, smart grids, and renewable energy systems.
3	To evaluate IoT applications in modern electric vehicles and emerging power electronic systems

COURSE OUTCOMES:

After completion of the course, Student will be able to

CO1:	Explain the architecture, devices, and interfaces used in IoT systems.
CO2:	Demonstrate IoT applications in power electronics for monitoring and control.
CO3:	Analyze the integration of IoT with industrial systems for automation and productivity
CO4:	Evaluate IoT-enabled smart grid, renewable energy, and energy management applications.
CO5:	Apply IoT concepts in electric vehicle systems including charging, monitoring, and traffic management

COs Vs POs MAPPING:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	–	–	–	–	–	–	1	3	2	–
CO2	3	2	2	2	3	–	–	–	–	–	–	1	3	2	–
CO3	3	3	2	3	3	–	–	–	–	–	–	2	3	3	–
CO4	3	2	3	3	3	–	–	–	–	–	–	2	3	3	–
CO5	3	2	3	3	3	–	–	–	–	–	–	2	3	3	–

COURSE CONTENTS:

MODULE I	**BASIC CONCEPTS OF IoT**	**8 Hours**

Introduction and evolution of IoT from internet, IOT Physical Devices & Endpoints - Basic building blocks and Exemplary IOT Device: Raspberry Pi, Linux on Raspberry Pi, Raspberry Pi Interfaces - Serial, SPI, I2C, Programming Raspberry Pi with Python - Controlling LED with Raspberry Pi, Interfacing an LED and Switch with Raspberry Pi.

MODULE II	**IOT POWERELECTRONICS**	**9 Hours**

Power Electronics with IoT – Introduction, Power electronics 2.0: IoT-connected and Al-controlled powerelectronicsoperatingoptimallyforeachuser-IoTAssistedPowerElectronicsforModernPower Systems – Benefits and disadvantages of IoT Power Electronics – Applications of IoT Power Electronics

MODULE III	**INDUSTRIES**	**9 Hours**

Connecting sensors, actuators, control systems, and machines to optimize production and supply chain networks in manufacturing- automation of process controls in process industries- service information systems,andoperatortoolstoincreaseproductivityandsafety.ImpactofIoT:realtimemonitoringand controlling operations- deploying intelligent equipment, sensors, and controllers - Automation and control

MODULE IV	**ENERGY**	**9 Hours**

Smart grid - automation, distribution, and monitoring - Advanced Infrastructure for Measuring – SCADA - Smart Inverters - Remote operation of devices that use energy - connecting solar panels, rainwater harvesters, smartroof,and windows in one system -Observable, automated, and controllable green energy using IoT sensors - IoT solutions in renewable energy power production.

MODULE V	**ELECTRIC VEHICLE**	**9 Hours**

Intelligentsmartcontrollers-EVchargingstationlocator-Smartchargingstations-Batterymonitoring and management - Vehicular traffic and smart parking – case studies

TOTAL: 45 HOURS

FURTHER READING / CONTENT BEYOND SYLLABUS / SEMINAR

1. 1.Role of Artificial Intelligence and Machine Learning in IoT-enabled Power Electronics.

2.	2.Cybersecurity challenges and solutions in IoT-based energy and industrial systems.

REFERENCES:

1. ArshdeepBahga, Vijay Madisetti, *Internet of Things: A Hands-On Approach*, Universities Press.
2. RajkumarBuyya, Amir VahidDastjerdi, *Internet of Things: Principles and Paradigms*, Elsevier.
3. Jeeva Jose, *Internet of Things*, Khanna Publishing.
4. Oliver Hersent, David Boswarthick, Omar Elloumi, *The Internet of Things: Key Applications and Protocols*, Wiley.
5 SudipMisra, Anand Kumar, Anandarup Mukherjee, *Introduction to IoT*, Cambridge University Press

2403PE014	NON LINEAR DYNAMICS FOR POWER ELECTRONIC CIRCUITS	L	T	P	C
		3	0	0	3

PREREQUISITE:

1	Basics of Power Electronics (Converters and Inverters)
2	Control Systems Engineering (Stability and Feedback)
3	Differential Equations and Linear Algebra
4	Fundamentals of Electrical Machines and Drives

COURSE OBJECTIVES:

1	To introduce the fundamentals of nonlinear dynamics and chaos in electrical and power electronic systems.
2	To analyze nonlinear behavior in converters and drives using experimental and numerical techniques.
3	To explore control methods for chaos and apply them to stabilize power electronic systems

COURSE OUTCOMES:

CO1:	Explain the concepts of nonlinear dynamics, attractors, bifurcations, and chaos in dynamical systems.
CO2:	Apply analytical, numerical, and experimental techniques to investigate nonlinear phenomena.
CO3:	Analyze nonlinear behaviors such as bifurcation and chaos in various DC–DC converters and inverters.
CO4:	Evaluate nonlinear phenomena in electrical drives including DC and PMSM drives.
CO5:	Apply chaos control techniques (Hysteresis, Sliding Mode, OGY, Pyragas, etc.) in power electronic circuits and drives

COs Vs POs MAPPING:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	–	–	–	–	–	–	1	3	2	–
CO2	3	3	2	3	2	–	–	–	–	–	–	1	3	2	–
CO3	3	3	2	3	2	–	–	–	–	–	–	2	3	3	–
CO4	3	2	3	3	2	–	–	–	–	–	–	2	3	3	–

CO5	3	2	3	3	3	–	–	–	–	–	–	2	3	3	–

COURSE CONTENTS:

MODULE I	**BASICSOFNONLINEARDYNAMICS**	**9 Hours**

Basics of Nonlinear Dynamics: System, state and state space model, Vector field - Modeling of Linear, nonlinear and Linearized systems, Attractors, chaos, Poincare map, Dynamics of Discrete time system, LyapunovExponent, Bifurcations, Bifurcations of smooth map, Bifurcations in piecewise smooth maps, border crossing and border collision bifurcation.

MODULE II	**TECHNIQUES FOR INVESTIGATION OF NONLINEAR PHENOMENA**	**9 Hours**

Techniques for experimental investigation, Techniques for numerical investigation, Computation of averages under chaos, Computations of spectral peaks, Computation of the bifurcation and analyzing stability.

MODULE III	**NONLINEARPHENOMENAINDC-DCCONVERTERS**	**9 Hours**

Border collision in the Current Mode controlled Boost Converter, Bifurcation and chaos in the Voltage controlled Buck Converter with latch, Bifurcation and chaos in the Voltage controlled Buck Converter without latch, Bifurcation and chaos in Cuk Converter. Nonlinear phenomenon in the inverter under tolerance band control.

MODULE IV	**NONLINEARPHENOMENAINDRIVES**	**9 Hours**

Nonlinear Phenomenon in Current controlled and voltage-controlled DC Drives, Nonlinear Phenomenon in PMSM Drives.

MODULE V	**CONTROL OFCHAOS**	**9 Hours**

Hysteresis control, Sliding mode and switching surface control, OGY Method, Pyragas method, Time Delay control. Application of the techniques to the Power electronics circuit and drives.

TOTAL: 45 HOURS

FURTHER READING / CONTENT BEYOND SYLLABUS / SEMINAR

1. Application of Machine Learning in predicting and controlling chaotic behavior in power electronic systems.
2. Nonlinear phenomena in renewable energy converters (solar inverters, wind energy systems).

REFERENCES:

1. Steven H. Strogatz, **Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering**, Westview Press.
2. Leon O. Chua, **Nonlinear Circuits**, World Scientific.
3. Guanrong Chen &TetsushiUeta, **Chaos in Circuits and Systems**, World Scientific.
4. Banerjee, S., &Verghese, G.C., **Nonlinear Phenomena in Power Electronics: Attractors,**

Bifurcations, Chaos, and Nonlinear Control, IEEE Press.
1. Khalil, H.K., **Nonlinear Systems**, Prentice Hall

2403PE015	ELECTRIC VEHICLES AND POWER MANAGEMENT	L	T	P	C
		3	0	0	3

PREREQUISITE:

1	Fundamentals of Electrical Machines and Power Electronics
2	Basics of Control Systems and Drives
3	Energy Storage Technologies and Batteries
4	Fundamentals of Automotive Engineering and Vehicle Mechanics

COURSE OBJECTIVES:

1	To understand the fundamentals, architecture, and powertrain components of electric and hybrid vehicles.
2	To analyze the operation and control of various electric drives used in EV applications.
3	To explore different energy storage technologies including batteries, fuel cells, and ultracapacitors for EV power management

COURSE OUTCOMES:

CO1:	Explain the principles of EVs, HEVs, and fundamentals of vehicle mechanics..
CO2:	Analyze the architecture and powertrain components of EVs and HEVs
CO3:	Demonstrate control techniques for DC and AC drives used in EV propulsion.
CO4:	Evaluate the characteristics, modeling, and performance of battery energy storage systems
CO5:	Compare and assess alternative energy storage systems like fuel cells and ultracapacitors for EV applications.

COs Vs POs MAPPING:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	–	–	–	–	–	–	1	3	2	2
CO2	3	3	2	2	3	–	–	–	–	–	–	1	3	3	2
CO3	3	3	2	3	3	–	–	–	–	–	–	2	3	3	3
CO4	3	2	3	3	3	–	–	–	–	–	–	2	3	3	3
CO5	3	2	3	3	3	–	–	–	–	–	–	2	3	3	3

COURSE CONTENTS:		
MODULE I	**ELECTRIC VEHICLES AND VEHICLE MECHANICS**	**9 Hours**
Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings, Comparisons of EV with internal combustion engine vehicles, Fundamentals of vehicle mechanics.		
MODULE II	**ARCHITECTURE OF EV'S AND POWER TRAIN COMPONENTS**	**9 Hours**
Architecture of EV's and HEV's -Plug-in Hybrid Electric Vehicles (PHEV); Power train components and sizing, Gears, Clutches, Transmission and Brakes.		
MODULE III	**CONTROL OF DC AND AC DRIVES**	**9 Hours**
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.		
MODULE IV	**BATTERY ENERGY STORAGE SYSTEM**	**9 Hours**
Battery basics, Different types, Battery parameters, Battery modeling, Traction Batteries.		
MODULE V	**ALTERNATIVE ENERGY STORAGE SYSTEMS**	**9 Hours**
Fuelcell –Characteristics, types, hydrogen storage systems and fuelcellEV; Ultracapacitors.		
TOTAL: 45 HOURS		
FURTHER READING / CONTENT BEYOND SYLLABUS / SEMINAR		
1. Role of Artificial Intelligence and IoT in Smart EV Charging Infrastructure. 2. Wireless Power Transfer Technologies for Electric Vehicle Charging.		

REFERENCES:

1. MehrdadEhsani, YiminGao, Ali Emadi, **Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design**, CRC Press.
2. Husain, Iqbal, **Electric and Hybrid Vehicles: Design Fundamentals**, CRC Press.
3. James Larminie, John Lowry, **Electric Vehicle Technology Explained**, Wiley.
4. Chan, C.C., and Chau, K.T., **Modern Electric Vehicle Technology**, Oxford University Press.
5. Ali Emadi, **Advanced Electric Drive Vehicles**, CRC Press

2403PE016	MICRO ELECTRO MECHANICAL SYSTEMS	L	T	P	C
		3	0	0	3

PREREQUISITE:

1	Basics of Semiconductor Devices and Materials
2	Fundamentals of Solid Mechanics and Stress–Strain Analysis
3	Basics of Electrical Circuits and Sensors
4	Fundamentals of Control Systems and Instrumentation

COURSE OBJECTIVES:

1	To introduce the concepts of MEMS fabrication technologies, materials, and electro-mechanical behavior.
2	To study different sensing and actuation mechanisms including electrostatic, thermal, and piezoelectric principles.
3	To analyze case studies and real-world applications of MEMS in engineering and medical systems.

COURSE OUTCOMES:

CO1:	Explain the fundamentals of micro-fabrication processes, materials, and electro-mechanical concepts.
CO2:	Analyze the principle, design, and fabrication of electrostatic sensors and actuators
CO3:	Demonstrate the working principles of thermal sensors and actuators with applications.
CO4:	Evaluate piezoelectric sensing and actuation mechanisms for practical systems.
CO5:	Apply MEMS concepts in real-world case studies including medical, optical, and microfluidics applications

COs Vs POs MAPPING:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	–	–	–	–	–	–	1	3	2	2
CO2	3	3	2	2	3	–	–	–	–	–	–	1	3	3	2
CO3	3	3	2	3	3	–	–	–	–	–	–	2	3	3	3

CO4	3	2	3	3	3	–	–	–	–	–	–	2	3	3	3
CO5	3	2	3	3	3	–	–	–	–	–	–	2	3	3	3

COURSE CONTENTS:

MODULE I	**MICRO- FABRICATION, MATERIALS AND ELECTRO - MECHANICAL CONCEPTS**	**9 Hours**

Overview of micro fabrication; Silicon and other material based fabrication processes– Concepts, conductivity of semiconductors, crystal planes, orientation-stress and strain; Flexural beam bending analysis - Torsional deflections, intrinsic stress, resonant frequency and quality factor.

MODULE II	**ELECTRO STATIC SENSORS AND ACTUATION**	**9 Hours**

Principle, material, design and fabrication of parallel plate capacitors as electrostatic sensors and actuators; Applications.

MODULE III	**THERMAL SENSING AND ACTUATION**	**9 Hours**

Principle, material, design and fabrication of thermocouples, thermal bimorph sensors, thermal resistor sensors; Applications.

MODULE IV	**PIEZO ELECTRIC SENSING AND ACTUATION**	**9 Hours**

Piezoelectric effect-cantilever piezoelectric actuator model-properties of piezoelectric materials-Applications.

MODULE V	**CASE STUDIES**	**9 Hours**

Case study- Piezoresistivesensors, magnetic actuation, micro fluidics applications, medical applications, optical MEMS-NEMS devices.

TOTAL: 45 HOURS

FURTHER READING / CONTENT BEYOND SYLLABUS / SEMINAR

1. Nano-Electro-Mechanical Systems (NEMS) and their future applications in smart devices.
2. Integration of MEMS with IoT and Artificial Intelligence for biomedical and industrial applications

REFERENCES:

1. Chang Liu, **Foundations of MEMS**, Pearson Education.
2. NadimMaluf, Kirt Williams, **An Introduction to Microelectromechanical Systems Engineering**, Artech House.

3. Stephen D. Senturia, **Microsystem Design**, Springer.
4. Marc Madou, **Fundamentals of Microfabrication: The Science of Miniaturization**, CRC Press.
5.Tai-Ran Hsu, **MEMS and Microsystems: Design, Manufacture, and Nanoscale Engineering**, Wiley

PROGRAM ELECTIVE - V

2403PE017	**DISTRIBUTED GENERATION AND MICRO GRIDS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

PREREQUISITE:

1	Fundamentals of Electrical Engineering
2	Power Electronics and Drives
3	Power System Analysis
4	Renewable Energy Sources

COURSE OBJECTIVES:

1	To provide knowledge on conventional and non-conventional power generation systems and their challenges.
2	To analyze distributed generation concepts, optimization, and integration with utility grids.
3	To understand microgrid architecture, control strategies, and the role of smart grid technologies

COURSE OUTCOMES:

On successful completion of this course, the students will be able to:

CO1:	Explain conventional and non-conventional energy resources and their comparative advantages.
CO2:	Analyze the principles, regulation, and market aspects of distributed generation.
CO3:	Evaluate the impact of integrating distributed generation with the utility grid.
CO4:	Demonstrate knowledge of microgrid components, configurations, operation modes, and control methods.
CO5:	Assess the role of smart grid technologies and sustainable energy integration for future power systems

COs Vs POs AND PSO MAPPING:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	2	2	-	-	-	-	2	3	2	-
CO2	3	3	2	2	-	2	2	-	-	-	-	2	3	3	-
CO3	3	3	3	2	2	2	2	-	-	-	-	3	3	3	-
CO4	3	3	3	3	2	2	3	-	-	-	-	3	3	3	3
CO5	3	3	2	3	2	2	3	2	-	-	-	3	3	3	3

COURSE CONTENTS:

MODULE I	**INTRODUCTION**	**9 Hours**

Conventional power generation - Advantages and disadvantages; Energy crisis; Non - conventional energy (NCE) resources; Review of solar PV; Wind energy systems; Fuel cells; Micro turbines; Biomass; Tidal resources.

MODULE II	**DISTRIBUTED GENERATION**	**9 Hours**

Distributed generation – Description, Regulation; Compensation schemes of distributed generations; Market designs for distributed generations; Role of distributed generations in electricity market; Distributed generation optimization methods.

MODULE III	**GRID INTEGRATION**	**9 Hours**

Direct machine coupling with the grid; Distributed power electronics interface; Local control of distributed generation; Overloading of radial distribution networks; Losses &loadability; Impact of grid integration with non-conventional energy resources.

MODULE IV	**MICROGRID**	**9 Hours**

Micro grid- Components, review ,control; Control methods for a micro grid systems; Structure and configuration of micro grid; AC and DC microgrids; Power electronics interfaces in DC and AC micro grids; Modes of operation of micro grid; Communication infrastructure of micro grid; Power quality issues in micro grids; Micro grid economics.

MODULE V	**SMART GRID**	**9 Hours**

Introduction to smart grid; Functions of smart grid components; Communication measurement and monitoring technologies of smart grid; Stability analysis for smart grid; Sustainable energy options for the smart grid; Micro grid and smart grid comparison.

TOTAL: 45 HOURS

FURTHER READING / CONTENT BEYOND SYLLABUS / SEMINAR :

1. Hybrid Energy Storage Systems for Microgrids
2. Artificial Intelligence and Machine Learning Applications in Smart Grids

REFERENCES:

1. Hatziargyriou, N. *Microgrids: Architectures and Control*. Wiley-IEEE Press, 2014.
2. Ackermann, T. *Distributed Generation: A Definition*. Electric Power Systems Research, Elsevier.
3. Lasseter, R. H. *Microgrids and Distributed Generation*. IEEE Power Engineering Society.
4. Rashid, M. H. *Power Electronics: Circuits, Devices, and Applications*. Pearson, 2018.
5. Guerrero, J. M., Vasquez, J. C., and Loh, P. C. *Advanced Control Architectures for Intelligent Microgrids*. IEEE Transactions.

2403PE018	**POWER CONVERTERS FOR SOLAR AND WIND ENERGY CONVERSION SYSTEM**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
PREREQUISITE:					
1	Fundamentals of Electrical Engineering				
2	Power Electronics and Drives				
3	Renewable Energy Sources				
4	Power System Analysis				
COURSE OBJECTIVES:					
1	To understand the fundamentals of solar and wind energy systems with emphasis on Indian and global energy scenarios.				
2	To analyze the design, operation, and control of power converters used in solar PV and wind energy systems.				
3	To develop knowledge of grid integration, distributed generation, and optimization of hybrid renewable systems.				
COURSE OUTCOMES:					
CO1:	**CO1**: Explain the energy scenario, solar/wind survey, and the need for renewable energy technologies..				
CO2:	Analyze PV cell, module, array characteristics, and apply MPPT techniques for solar PV				

	systems.
CO3:	Evaluate wind energy conversion systems, their components, and associated power conditioning methods
CO4:	Examine grid integration issues, converter topologies, and control methods for solar and wind systems.
CO5:	Assess hybrid renewable energy systems, cogeneration processes, storage, and optimization strategies.

COs Vs POs MAPPING:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	2	3	-	-	-	-	2	3	2	-
CO2	3	3	2	2	-	2	2	-	-	-	-	2	3	3	-
CO3	3	3	3	2	2	2	2	-	-	-	-	3	3	3	-
CO4	3	3	3	3	2	2	3	-	-	-	-	3	3	3	3
CO5	3	3	2	3	2	2	3	2	-	-	-	3	3	3	3

COURSE CONTENTS:

MODULE I	**INTRODUCTION**	**9 Hours**

Energy consumption; World energy scenario - Energy source and their availability, Conventional and renewable source; Need to develop new energy technologies; MNRE Rules and Regulations; TEDA; Wind and solar survey in India and World.

MODULE II	**PHOTOVOLTAIC ENERGY CONVERSION**	**9 Hours**

Solar radiation and measurements - Solar cells, Panels and their characteristics , Influence of insulation and temperature ; PV arrays –Maximum power point tracking, Applications; Water pumping, Street lighting; DC-DC converters for solar PV systems.

MODULE III	**WIND ENERGY SYSTEMS**	**9 Hours**

Basic principle of Wind Energy Conversion System ; Nature of Wind ; Components of Wind Energy ;Conversion System; Generators for WECS ; Classifications of WECS; Self excited induction generator, synchronous generator, Power conditioning schemes.

MODULE IV	**GRID CONNECTED WECS AND SECS**	**9 Hours**
Grid connectors ; Wind farm and its accessories ; Grid related problems; Generator control; Performance improvements; Different schemes – Matrix converters, Line commutated inverters, Multilevel inverters, Power converters for Grid connected WECS; Grid connected solar energy converter systems.		
MODULE V	**DISTRIBUTED POWER GENERATION SYSTEMS**	**9 Hours**
Solar, PV, Hybrid Systems ; Selection of power conversion ratio; Optimization of System components ; Storage; Reliability evolution ; Types of Cogeneration processes ; Power converters for distributed power systems.		
TOTAL: 45 HOURS		

FURTHER READING / CONTENT BEYOND SYLLABUS / SEMINAR

1. Grid Integration of EV Charging with Solar and Wind Hybrid Systems
2. Blockchain Technology for Peer-to-Peer Renewable Energy Trading

REFERENCES:

1. Rashid, M. H. *Power Electronics: Circuits, Devices and Applications*, Pearson, 2018.
2. Rai, G. D. *Non-Conventional Energy Sources*, Khanna Publishers, 2011.
3. Godfrey Boyle, *Renewable Energy – Power for a Sustainable Future*, Oxford University Press, 2012.
4. Bimal K. Bose, *Power Electronics and Motor Drives – Advances and Trends*, Academic Press, 2006.
5. FredeBlaabjerg, *Power Electronics for Renewable Energy Systems, Transportation, and Industrial Applications*, IEEE Press, 2014.

2403PE020	ENERGY MANAGEMENT AND AUDITING	L	T	P	C
		3	0	0	3

PREREQUISITE:

1	Fundamentals of Electrical Engineering
2	Power Systems
3	Electrical Machines
4	Power Electronics

COURSE OBJECTIVES:

1	To impart knowledge on energy management principles, auditing procedures, and cost analysis.
2	To analyze energy efficiency opportunities in electrical equipment, systems, and utilities.
3	To develop skills in energy auditing, metering techniques, and cogeneration for sustainable energy utilization

COURSE OUTCOMES:

After completion of the course, Student will be able to

CO1:	Explain the need for energy management and auditing process.
CO2:	Analyze economic aspects of energy cost, load management, and utility monitoring.
CO3:	Evaluate energy conservation opportunities in motors, transformers, and electrical equipment
CO4:	Demonstrate knowledge of metering systems, techniques, and measurement practices for energy management.
CO5:	Assess lighting systems, cogeneration techniques, and perform cost-benefit analysis for energy optimization.

COs Vs POs MAPPING:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	3	2	-	-	-	-	2	3	2	-
CO2	3	3	2	2	-	3	2	-	-	-	-	2	3	3	-
CO3	3	3	3	2	2	3	3	-	-	-	-	3	3	3	-
CO4	3	3	3	3	2	2	3	-	-	-	-	3	3	3	3
CO5	3	3	2	3	2	2	3	2	-	-	-	3	3	3	3

COURSE CONTENTS:

MODULE I	**INTRODUCTION**	**9 Hours**

Need for energy management – Role of energy manager and auditor – energy basics- designing and starting an energy management program – energy accounting -energy monitoring, targeting and reporting- energy audit process

MODULE II	**ENERGYCOSTANDLOADMANAGEMENT**	**9 Hours**

Important concepts in an economic analysis - Economic models-Time value of money-Utility rate structures-costofelectricity-Lossevaluationfortransformerandmotors-Loadmanagement:Demand control techniques-Utility monitoring and control system-HVAC and energy management-Economic justification.

MODULE III	ENERGYMANAGEMENTFORMOTORS,SYSTEMS,ANDELECTRICAL EQUIPMENT	9 Hours

Systemsandequipment-Electricmotors-BasicsonDCandACmotors,Motorsizingfordifferentduty cycles,Energyefficientmotor,andpaybackanalysis.Transformers-Basicsandtransformerlosses,Loss ratio, energy saving recommendations, transformer sizing, and parallel operation. Reactors- energy saving opportunities. Quality of power and harmonics, Power factor improvement and benefits, AutomaticPowerfactorcontroller,sizingofacapacitor,capacitorandsynchronousmachinesforplant power factor improvement.

MODULE IV	METERINGFORENERGYMANAGEMENT	9 Hours

Relationships between parameters-Units of measure-Typical cost factors- Utility meters - Timing of meterdiscforkilowattmeasurement-Demandmeters-Parallelingofcurrenttransformers-Instrument transformer burdens-Multitasking solid-state meters - Metering location vs. requirements- Metering techniques and practical examples.

MODULE V	LIGHTINGSYSTEMS&COGENERATION	9 Hours

Concept of lighting systems - The task and the working space -Light sources - Ballasts - Luminaries - Lightingcontrols-Optimizinglightingenergy-Costanalysistechniques-Lightingandenergystandards Cogeneration: Forms of cogeneration - feasibility of cogeneration- Electrical interconnection.

Beyond the Syllabus / Seminar Topics (Any 2):

1. IoT and Smart Metering in Energy Auditing
2. Artificial Intelligence for Predictive Energy Management

TOTAL: 45 hours

REFERENCES:

1. W.R. Murphy and G. McKay, *Energy Management*, Butterworth-Heinemann, 2009.
2. Wayne C. Turner, *Energy Management Handbook*, CRC Press, 2007.
3. Steve Doty and Wayne C. Turner, *Energy Management Handbook*, Fairmont Press, 2012.
4. Paul O’Callaghan, *Energy Management*, McGraw Hill Book Company, 1993.
5. Albert Thumann, *Handbook of Energy Audits*, The Fairmont Press Inc., 2013.

2403PE019	APPLICATIONS OF POWER ELECTRONICS IN UTILITY SYSTEMS	L	T	P	C
		3	0	0	3

PREREQUISITE:

1	Fundamentals of Power Electronics (Converters, Inverters, and Control)
2	Power Systems Analysis (Transmission, Distribution, and Stability Concepts)
3	Electrical Machines and Drives (Synchronous and Induction machines)
4	Control Systems Engineering (Basic feedback and stability concepts)

COURSE OBJECTIVES:

1	To understand the role of power electronics in modern utility systems including HVDC and reactive power compensation.
2	To analyze the operation and control of power electronic converters in high-power applications.
3	To evaluate advanced FACTS controllers and their applications in improving power quality and system stability.

COURSE OUTCOMES:

After completion of the course, Student will be able to

CO1:	Explain the configurations and characteristics of converters used in utility applications.
CO2:	Analyze the performance of single-phase and three-phase converters with respect to harmonics, reactive power, and stability
CO3:	Demonstrate the principles, control, and limitations of HVDC transmission systems.
CO4:	Apply different reactive power compensation techniques for enhancing system performance
CO5:	Evaluate static applications of power electronics in utility systems such as excitation systems, UPS, and induction furnaces.

COs Vs POs MAPPING:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	–	–	–	–	–	–	1	3	2	–
CO2	3	3	2	2	2	–	–	–	–	–	–	1	3	2	2
CO3	3	2	2	3	2	–	–	–	–	–	–	2	3	3	2
CO4	3	2	3	2	2	–	–	–	–	–	–	2	3	3	3

CO5	3	2	3	2	2	–	–	–	–	–	–	2	3	2	–

COURSE CONTENTS:

MODULE I	**INTRODUCTION**	**9 Hours**

High Power drives for Power systems controllers –Characteristics– Converters Configuration for Large power control.

MODULE II	**SINGLE PHASE AND THREE PHASE CONVERTERS**	**9 Hours**

Properties–Current and voltage harmonics–Effect of source and load impendence – Choice of best circuit for power systems-Converter Control-Gate Control–Basic means of Control –Control characteristics–Stability of control–Reactive power control – Applications of converters in HVDC systems–Static VAR control- Source of reactive power–Harmonics and filters.

MODULE III	**HVDC**	**9 Hours**

HVDC configurations, components of HVDC system: Converter, transformer, smoothing reactor, harmonic filter. Reactive power support, operation of 6-pulsecontrolledrectifierininvertingmodeofoperation.Operation of12- pulse converter. Control of HVDC system, Rectifier and inverter characteristics, mode stabilization, current control, voltage dependent current order limit, combined rectifier-inverter characteristics, valve blocking and by- passing, limitations HVDC system using line commutated converters, modern HVDC system – HVDC light.

MODULE IV	**REACTIVE POWER COMPENSATION**	**9 Hours**

Introduction, methods of vargeneration, analysis of uncompensated AC line, Passive reactive power compensation, Compensationbya series capacitor connected at the midpoint of the line, Effect on Power Transfer capacity, Compensation by STATCOM and SSSC, Fixed capacitor-Thyristor controlled reactor(FC-TCR),Thyristor-switched capacitor- Thyristorcontrolled reactor(TSC-TCR), static varcompensators**.**

MODULE V	**STATIC APPLICATIONS**	**9 Hours**

Static excitation of synchronous generators-Solid state tap changers for transformer-UPS Systems-Induction furnace control.

TOTAL: 45 HOURS

Beyond the Syllabus / Seminar Topics (Any 2):

1. Role of Power Electronics in Smart Grid and Renewable Energy Integration.
2. Wide Bandgap (SiC and GaN) Devices for High Power Utility Applications.

REFERENCES:

1. Mohan, Ned, Undeland, T.M., and Robbins, W.P., *Power Electronics: Converters, Applications and Design*, John Wiley & Sons.
2. Rashid, M.H., *Power Electronics: Circuits, Devices, and Applications*, Pearson Education.
3. Arrillaga, J., *High Voltage Direct Current Transmission*, IET Power Engineering Series.
4. Hingorani, N.G., and Gyugyi, L., *Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems*, Wiley-IEEE Press.
5. Padiyar, K.R., *HVDC Power Transmission Systems*, New Age International Publishers

OPEN ELECTIVE COURSES

2403PE021	SMART GRID	L	T	P	C
		3	0	0	3

PREREQUISITE:

1	Fundamentals of Power Systems (Generation, Transmission & Distribution)
2	Basics of Power Electronics and FACTS Controllers
3	Communication Systems and Protocols
4	Control Systems and SCADA Basics

COURSE OBJECTIVES:

1	To understand the evolution, need, and attributes of Smart Grids along with global and Indian initiatives.
2	To study the infrastructure, technologies, and communication systems essential for Smart Grids.
3	To analyze the role of power electronics, automation, and information security in modern Smart Grid systems

COURSE OUTCOMES:

After completion of the course, Student will be able to

CO1:	Explain the evolution, need, challenges, and initiatives of Smart Grids at national and international levels.
CO2:	Analyze smart grid infrastructure components such as smart meters, AMI, IEDs, and SCADA systems.
CO3:	Evaluate distribution and transmission system management techniques with automation and modeling tools

CO4:	Assess the role of power electronics, energy storage, and renewable integration in Smart Grids. .
CO5:	Apply communication technologies, standards, and cybersecurity principles in Smart Grid applications

COs Vs POs MAPPING:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	–	–	–	–	–	–	1	3	2	2
CO2	3	3	2	2	3	–	–	–	–	–	–	1	3	3	2
CO3	3	3	2	3	3	–	–	–	–	–	–	2	3	3	3
CO4	3	2	3	3	3	–	–	–	–	–	–	2	3	3	3
CO5	3	2	3	3	3	–	–	–	–	–	–	2	3	3	3

COURSE CONTENTS:

MODULE I	**INTRODUCTION TO SMART GRID**	**9 Hours**

Evolution of Electric Grid, Need for Smart Grid, Smart grid attributes, challenges and benefits, Overview of technologies required for the smart grid- National and International Initiatives in Smart Grid- Smart grid projects in India

MODULE II	**SMART GRID INFRASTRUCTURE**	**9 Hours**

Introduction to Smart Meters- AMI Hardware components- communications infrastructure and protocols - Substation automation equipment: current transformer, voltage transformer, Intelligent ElectronicDevices(IED),Baycontrollers,RemoteTerminalUnit(RTU),Switchgears,RingMainUnit (RMU),RecloserandSectionalizer-Transmissionsystem:SCADA,PhasorMeasurementUnit(PMU), Visualization techniques.

MODULE III	**DISTRIBUTION AND TRANSMISSION SYSTEM MANAGEMENT**	**9 Hours**

Distribution Automation &Management : Smart energy resources - smart substations, Substation and Feeder Automation, Effect of Partial and full automation in Fault isolation & Restoration and Loss of supply–StructureandcomponentsofDistributionManagementSystem–Modelling&AnalysisTools – Applications: System operation & management – Outage Management System (OMS) Transmission systems: Energy Management System (EMS), Data sources, Wide area Monitoring, Protection and Control (WAMPAC).

MODULE IV	**POWER ELECTRONICS IN SMART GRID**	**9 Hours**

Voltage and Current source Inverters (Qualitative analysis) – Distributed Generators & Electric Vehicles– FaultCurrentlimiting-Shuntandseriescompensation–FACTS&HVDC–EnergyStorage Technologies- Power Quality issues of Grid connected Renewable Energy Sources- Power Quality Audit.		
MODULE V	**COMMUNICATION TECHNOLOGIES**	**9 Hours**
SwitchingTechniques-CommunicationChannels–Layeredarchitecture&Protocols–Communication technologies- Standards for information exchange – Information Security: Encryption, decryption, Authentication, Digital signatures- Cyber security standards - Basics of Web Service, CLOUD Computing andIoT to make Smart Grids smarter.		
TOTAL: 45 HOURS		
FURTHER READING / CONTENT BEYOND SYLLABUS / SEMINAR		
1. Artificial Intelligence and Machine Learning applications in Smart Grid operation and predictive maintenance. **2.** Blockchain technology for secure energy trading in peer-to-peer Smart Grid systems.		
REFERENCES:		

1. Ali Keyhani, Mohammad N. Marwali, Min Dai, *Integration of Green and Renewable Energy in Electric Power Systems*, Wiley, 2010.
2. James Momoh, *Smart Grid: Fundamentals of Design and Analysis*, Wiley-IEEE Press, 2012.
3. Stuart Borlase, *Smart Grids: Infrastructure, Technology, and Solutions*, CRC Press, 2013.
4. Jean-Claude Sabonnadiere, NouredineHadjsaid, *Smart Grids*, Wiley-ISTE, 2012.
5. Qiuwei Wu, Yonghua Song, *Smart Grid Technologies and Applications*, Wiley, 2015.

2403PE022	**RENEWABLE ENERGY TECHNOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

PREREQUISITE:

1	Fundamentals of Electrical and Electronics Engineering
2	Basics of Energy Conversion and Power Systems
3	Fundamentals of Power Electronics
4	Engineering Physics (Solar radiation, Wind mechanics basics)

COURSE OBJECTIVES:

1	To understand the fundamentals of solar and wind energy conversion systems.
2	To analyze the design, operation, and performance of photovoltaic, wind, and hybrid renewable energy systems.
3	To explore emerging renewable energy technologies for sustainable power generation

COURSE OUTCOMES:

CO1:	**CO1:** Explain the basic principles of solar radiation and photovoltaic energy conversion.
CO2:	Design standalone and grid-connected photovoltaic systems with appropriate storage and MPPT techniques.
CO3:	Analyze wind energy characteristics, turbine aerodynamics, and design considerations.
CO4:	Evaluate the performance of different wind turbine generator configurations for various applications
CO5:	Assess the feasibility and integration of hybrid energy systems including solar, wind, biomass, and ocean energy

Cos VsPos MAPPING:

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	–	2	–	2	–	–	–	–	1	3	2	2
CO2	3	3	2	2	3	–	2	–	–	–	–	2	3	3	2
CO3	3	3	2	2	3	–	2	–	–	–	–	2	3	3	3
CO4	3	2	3	3	3	–	2	–	–	–	–	2	3	3	3
CO5	3	2	3	3	3	–	3	–	–	–	–	3	3	3	3

COURSE CONTENTS:

MODULE I	**BASICSOFSOLAR ENERGY**	**9 Hours**

Sun and earth, Basic characteristics of solar radiation, Angle of sunrays on solar collector, Photovoltaic cell, Characteristics and equivalent circuit, Photovoltaic modules and arrays.

MODULE II	**PHOTOVOLTAIC SYSTEMS**	**9 Hours**

PV systems – Design of PV systems, Standalone system with DC/AC loads and with/without battery storage, Grid connected PV systems, Maximum Power Point Tracking.		
MODULE III	**WIND ENERGY SYSTEMS**	**9 Hours**
Wind energy – Energy in the wind, Aerodynamics, Rotor types, Forces developed by blades, Aerodynamic models, Braking systems, Tower, Control and monitoring system, Design considerations, Power curve, Power speed characteristics, Choice of electrical generators.		
MODULE IV	**WIND ENERGY CONVERSION SYSTEMS**	**9 Hours**
Wind turbine generator systems: Fixed speed induction generator – Performance analysis; Semi variable speed induction generator, Variable speed induction generators with full and partial rated power converter topologies, Isolated systems, Self-excited induction generator, Permanent magnet alternator, Performance analysis.		
MODULE V	**HYBRID ENERGY SYSTEMS**	**9 Hours**
Hybrid energy systems – Wind – Diesel system, Wind – PV system, Micro hydro – PV system, Biomass – PV – Diesel system, Geothermal-Tidal and OTEC systems.		

FURTHER READING / CONTENT BEYOND SYLLABUS / SEMINAR

1. Artificial Intelligence and IoT applications in smart renewable energy management.
2. Hydrogen fuel cells and green hydrogen technology for future sustainable power systems

REFERENCES:

1. Boyle, G., *Renewable Energy: Power for a Sustainable Future*, Oxford University Press, 2012.
2. Godfrey Boyle, *Renewable Energy Systems and Applications*, CRC Press, 2017.
3. B.H. Khan, *Non-Conventional Energy Resources*, McGraw Hill, 2017.
4. Eldon D. Hansen & S. Rahman, *Renewable and Efficient Electric Power Systems*, Wiley-IEEE, 2013.
5. .P. Kothari, K.C. Singal, RakeshRanjan, *Renewable Energy Sources and Emerging Technologies*, PHI Learning, 2019.

2403PE023	ELECTRIC AND HYBRID VEHICLES	L	T	P	C
		3	0	0	3

PREREQUISITE:

1	Fundamentals of Electrical Machines and Drives
2	Basics of Power Electronics and Energy Conversion
3	Fundamentals of Control Systems
4	Electrical Power Systems and Energy Storage Basics

COURSE OBJECTIVES:

1	To introduce the fundamentals, evolution, and importance of electric, hybrid, fuel-cell vehicles.
2	To analyze various energy storage technologies, charging systems, and propulsion drives used in EVs.
3	To explore emerging technologies in vehicle-to-grid integration, smart charging, and road safety ethics.

COURSE OUTCOMES:

CO1:	Explain the evolution, importance, and challenges of electric, hybrid, and solar-based vehicles.
CO2:	Analyze different battery technologies, charging requirements, and storage hybridization techniques.
CO3:	Evaluate charging and starting systems including diagnosis of faults and new advancements.
CO4:	Compare different electric propulsion systems and assess their performance characteristics.
CO5:	Assess the role of emerging EV technologies in smart grids, vehicle-to-grid integration, and road safety ethics.

COs V POs MAPPING:

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	–	2	–	3	–	–	–	–	1	3	2	2
CO2	3	3	2	2	3	–	2	–	–	–	–	2	3	3	2
CO3	3	3	2	2	3	–	2	–	–	–	–	2	3	3	3
CO4	3	2	3	3	3	–	2	–	–	–	–	2	3	3	3
CO5	3	2	3	3	3	–	3	–	–	–	–	3	3	3	3

COURSE CONTENTS:		
MODULE I	**ELECTRIC VEHICLES**	**9 Hours**
History of modern transportation; Introduction to electric vehicles; History of EVs, hybrid electric vehicles and fuel cell vehicles; Solar based EVs; Social, environmental importance and key challenges of hybrid and electric vehicles.		
MODULE II	**ENERGY STORAGE AND BATTERY TECHNOLOGY**	**9 Hours**
Introduction to energy storage system; Battery requirements for HEVs, PHEVs, and EVs; Types of batteries; Properties of batteries; Working principle and construction of lead-acid, nickel cadmium, nickel metal hydride, lithium ion Batteries; Maintenance and charging of batteries; Diagnosing lead-acid battery faults; Advanced battery technology; Developments in electrical storage; Flow batteries; Hybridization of energy storage systems; Case studies.		
MODULE III	**CHARGING AND STARTING SYSTEMS**	**9 Hours**
Requirements of the charging system; Charging system principles; Alternators and charging circuits; Diagnosing charging system faults; Advanced charging system technology; New developments in charging systems; Requirements of the starting system; Starter motors and circuits; Types of starter motor; Diagnosing starting system faults; Advanced starting system technology; New developments in starting systems; Case studies.		
MODULE IV	**ELECTRIC PROPULSION SYSTEMS**	**9 Hours**
Electric motors used in EVs; DC motor drives, Induction motor drives, PMBLDC motor drives, SRM drives – Principle and modes of operation, Speed control and performance characteristics.		
MODULE V	**EMERGING TECHNOLOGIES**	**9 Hours**
Introduction-Electric vehicle supply equipment, Smart vehicles in smart grid; Vehicle-to-grid technologies-Unidirectional and bidirectional; Need of charging station selection (CSS) server, Smart grid technologies-Applications / benefits, smart meter, smart charger; Purpose and benefits; Ethics in road safety.		
		TOTAL: 45 HOURS
FURTHER READING / CONTENT BEYOND SYLLABUS / SEMINAR		
1. Role of Artificial Intelligence and IoT in autonomous electric mobility. 2. Wireless power transfer technologies for EV charging.		
REFERENCES:		
1. Iqbal Husain, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, 2011.		

2. MehrdadEhsani, YiminGao, Sebastien E. Gay, Ali Emadi, *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design*, CRC Press, 2018.
3. James Larminie& John Lowry, *Electric Vehicle Technology Explained*, Wiley, 2012.
4. Chris Mi, M. AbulMasrur, David WenzhongGao, *Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives*, Wiley-IEEE Press, 2017.
5 . Ron Hodkinson& John Fenton, *Lightweight Electric/Hybrid Vehicle Design*, Butterworth-Heinemann, 2020

2403PE024	**INDUSTRIAL CONTROL ELECTRONICS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
PREREQUISITE:					
1.	Fundamentals of Power Electronics				
2.	Electrical Machines and Drives				
3.	Control Systems Engineering				
4.	Basics of Sensors and Instrumentation				
COURSE OBJECTIVES:					
1.	To impart knowledge on UPS topologies, advanced energy storage, and solid-state power controllers.				
2.	To understand the role of sensors, controllers, and signal conditioners in industrial control applications.				
3.	To familiarize students with PLC, SCADA systems, and their applications in industrial automation.				
COURSE OUTCOMES:					
CO1:	Explain the concepts of UPS topologies, solid-state power devices, and advanced energy storage technologies.				
CO2:	Analyze the role and operation of various industrial sensors for electrical and thermal measurements.				
CO3:	Apply concepts of analog controllers and signal conditioners in industrial control systems.				
CO4:	Evaluate solid-state control of welding and heating systems with suitable characteristics and techniques				
CO5:	Demonstrate the working of PLC and SCADA systems in automation and energy-saving				

	applications

COs Vs POs MAPPING:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	–	2	–	3	–	–	–	–	1	3	2	2
CO2	3	3	2	2	3	–	2	–	–	–	–	2	3	3	2
CO3	3	3	2	2	3	–	2	–	–	–	–	2	3	3	3
CO4	3	2	3	3	3	–	2	–	–	–	–	2	3	3	3
CO5	3	2	3	3	3	–	3	–	–	–	–	3	3	3	3

COURSE CONTENTS:

MODULE I	**UPS AND STORAGE SYSTEMS**	**9 Hours**

Review of uninterrupted power supplies, Offline and on-line topologies, Analysis of UPS topologies, Solid state circuit breakers and Solid-state tap changing of transformer; Advanced energy storage systems – Advanced chemistry batteries, Ultra-capacitors, Flywheel energy storage, Fuel cells characteristics and applications.

MODULE II	**SENSORS**	**9 Hours**

Overview of sensors in industrial applications, Current sensors, Current transformer, Hall effect sensors, Voltage sensors, Non-isolated measurement, Hall effect, Temperature sensors, Thermal protection of power components, Speed sensors, Position sensors.

MODULE III	**CONTROLLERS AND SIGNAL CONDITIONERS**	**9 Hours**

Analog controllers– P, PI and PID controllers, Derivative overrun, Integral windup, Cascaded control, Feed forward control.
Signal conditioners - Instrumentation amplifiers, Voltage to current, Current to voltage, Voltage to frequency, Frequency to voltage converters.

MODULE IV	**SOLID STATE CONTROL**	**9 Hours**

Solid state welding power source - Introduction, Classification, Basic characteristics, Volt ampere relationship and its measurements, Control of volt ampere characteristics, Volt control, Slope control and Dual control, Pulsing techniques, Testing of welding power source; Introduction to heating, Classification, Characteristics, Applications.

MODULE V	**PLC AND SCADA SYSTEMS**	**9 Hours**

Introduction to programmable logic controllers, Architecture, Programming. Supervisory Control and Data Acquisition (SCADA) systems, Components of SCADA systems, SCADA basic functions, SCADA application

functions in electrical engineering, Energy saving in electrical drive systems.
TOTAL: 45 HOURS
FURTHER READING / CONTENT BEYOND SYLLABUS / SEMINAR
1. Role of IoT-enabled industrial automation and smart manufacturing. 2. Cybersecurity challenges in SCADA and industrial control systems
REFERENCES:
1. Frank D. Petruzella, *Programmable Logic Controllers*, McGraw Hill, 2017.
2. W. Bolton, *Programmable Logic Controllers and SCADA Systems*, Newnes, 2015.
3. K. Ogata, *Modern Control Engineering*, Prentice Hall, 2010.
4. M. H. Rashid, *Power Electronics: Circuits, Devices, and Applications*, Pearson, 2014.
5. J. G. Grainger & W. D. Stevenson, *Power System Analysis*, McGraw Hill, 2016

2404PE301	PROJECTWORK-PHASEI	L	T	P	C
		0	0	20	16

COURSEOBJECTIVES

1 Todevelopskillstoformulateatechnicalproject.
2 Togiveguidanceonthevarioustasksoftheprojectandstandard procedures.
3 Toteachuseofnewtools,algorithmsandtechniquesrequiredtocarryoutthe projects.
4 Togiveguidanceonthevariousproceduresforvalidationoftheproductan danalysesthecost effectiveness.
5 Toprovideguidelinestopreparetechnicalreportoftheproject.

COURSEOUTCOMES(COS)

Aftercompletionofthecourse,studentswillbeableto

CO1 Formulatearealworldproblem,identifytherequirementanddevelopthed

esignsolutions

CO2 Identify technical ideas, strategies and methodologies

CO3 Utilizethenewtools,algorithms,techniquesthatcontributetoobtainthesolutionoftheproject CO4 Perform test and validate through conformance of the developed prototype

CO5 AnalysisthecostEffectivenessoftheproject

CO6 Explaintheacquiredknowledgethroughpreparationofreportandoralpresentations

GUIDELINEFORREVIEWANDEVALUATION

The student will be work under a project supervisor. The device/ system/component(s) to be fabricated may be decided in consultation with the supervisorand ifpossible with an industry. A projectreport hasto be submitted by the student with the fabricated model, which will be reviewed and evaluated for internal assessment by a committee constituted by the head of the department. At the end of the semester examination, the project workis evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the head of the department