PUNE VIDYARTHI GRIHA'S

COLLEGE OF ENGINEERING AND TECHNOLOGY, PUNE-9

(AFFILIATED TO SAVITRIBAI PHULE PUNE UNIVERSIT, PUNE)

DEPARTMENT OF ELECTRICAL ENGINEERING

CURRICULUM BOOK

ACADEMIC YEAR : 2021-22

FOR THE PROGRAMME

FOURTH YEAR – ELECTRICAL ENGINEERING

PUNE VIDYARTHI GRIHA'S

COLLEGE OF ENGINEERING AND TECHNOLOGY

VISION

TO ACHIEVE EXCELLENCE IN ENGINEERING EDUCATION

MISSION

- **To satisfy all stakeholders**
- **To develop ethical, highly motivated engineering professionals with good human values, requisite skills and competencies**
- **To adopt innovative teaching mechanisms**
- **To promote research culture**
- **To contribute to country's economic development**
- **To be responsive to changes in technology, socio-economic and environmental conditions**

DEPARTMENT OF ELECTRICAL ENGINEERING

VISION

To develop Electrical Engineering Department as one of the premier facility centre for disseminating the state of the art education.

MISSION

- **Providing Quality education in the field of Electrical Engineering.**
- **Developing State of the art facilities in the department.**
- **Creating platform Training, Research and Development**
- **Producing Sound electrical engineers catering need of industry and other stake holders.**

PROGRAM EDUCATIONAL OBJECTIVES

PEO1 To produce students with knowledge base of Electrical Engineering to excel in industry and higher studies.

PEO2 To produce competent students with analytical abilities and problem solving capabilities on the basis of strong fundamentals in Electrical Engineering.

PEO3 To produce responsible students developing sustainable solutions for society with ethics and professionalism.

PEO4 To produce students with professional qualities such as team work, leadership, entrepreneurial thinking and communication skills.

PEO5 To produce students habitual to lifelong learning abilities.

PROGRAMME OUTCOMES

Electrical Engineering Graduates will have:

PO1: Engineering Knowledge: An ability to apply knowledge of mathematics, science and Engineering fundamentals to analyze complex engineering problems.

PO2: Problem Analysis: An ability to identify, formulate and analyze complex engineering problems by reviewing research literature to arrive at substantiated conclusions.

PO3: Design/Development of Solutions: An ability to design solutions for complex engineering problems, system components or processes to meet the specified needs of the society, considering safety and environment.

PO4: Conduct Investigations of Complex problems: Ability to carry out experiments, simulations and apply research methodologies to investigate the data for providing valid conclusions.

PO5: Modern tool usage: An ability to select and apply appropriate techniques, resources and modern engineering tools such as advanced controllers and application softwares for engineering activities

PO6: The Engineer and society: An ability to assess and develop professional engineering practices catering the need of society considering safety, health, regulatory and other relevant issues.

PO7: Environment and sustainability: An ability to apply professional engineering knowledge to understand the impact on society and environment demonstrating the need for the sustainable development.

PO8: Ethics: An ability to adopt professional ethics while committing professional and social responsibilities.

PO9: Individual and Team work: An ability to develop multidisciplinary skills as an individual and as a member or leader in diverse teams.

PO10: Communication: An ability to communicate effectively with engineering community and society at large with effective documentation and presentation on engineering activities.

PO11: Project management and Finance: An ability to demonstrate knowledge of Engineering and Management principles as a member or a leader to manage project and multidisciplinary tasks.

PO12: Life-long Learning: An ability to understand need and develop the habit of being lifelong learner to adopt to technological changes.

PROGRAMME SPECIFIC OUTCOMES

PSO1: An ability to acquire adequate proficiency in the area of Energy Systems and Sustainability.

PSO2: An ability to acquire multidisciplinary skills in the area of Control and Drives.

PSO3 : An ability to acquire enhanced skills and core competency in the field of Electrical Engineering through hands on training.

INDEX

Fourth Year

Curriculum Book

Savitribai Phule Pune University

FACULTY OF ENGINEERING

B.E. Electrical Engineering (2015 Course)

(w.e.f. 2018-2019)

SEMESTER-I

Sr No	Subject Code	Subject Title	Teaching Scheme (Hrs/Week)			Examination Scheme (Marks)					Total Marks	Credit	
						PP							
			TH	PR	TU	In Sem	End Sem	TW	PR	OR		TH / TU	PR + OR
1	403141	Power System Operation and Control	03	02	--	30	70	25	--	25	150	03	01
2	403142	PLC and SCADA Applications	04	02	--	30	70	25	50	--	175	04	01
3	403143	Elective I	03	02	--	30	70	25	--	--	125	03	01
4	403144	Elective II	03	--	--	30	70	--	--	--	100	03	--
5	403145	Control System II	03	02	--	30	70	25	--	25	150	03	01
6	403146	Project I	--	--	02	--	--	--	--	50	50	02	-
	403152	Audit Course V											
TOTAL			16	08	02	150	350	100	50	100	750	18	04

SEMESTER-II

Sr No	Subject Code	Subject Title	Teaching Scheme (Hrs/Week)			Examination Scheme (Marks)					Total Marks	Credit	
						PP							
			TH	PR	TU	In Sem	End Sem	TW	PR	OR		TH / TU	PR + OR
1	403147	Switchgear and Protection	03	02	--	30	70	50	--	25	175	03	01
2	403148	Power Electronic Controlled Drives	04	02	--	30	70	25	50	--	175	04	01
3	403149	Elective III	03	02	--	30	70	25	--	25	150	03	01
4	403150	Elective IV	03	--	--	30	70	--	--	--	100	03	--
5	403151	Project II	--	--	06	--	--	50	--	100	150	06	--
	403153	Audit Course VI											
TOTAL			13	06	06	120	280	150	50	150	750	19	03

Elective I (403143) **A) Fundamentals of Microcontroller MSP430 and its Applications [Open Elective]** **B) Power Quality** **C) Renewable Energy Systems** **D) Digital Signal Processing**	**Elective II (403144)** **A) Restructuring and Deregulation** **B) Electromagnetic Fields** **C) EHV AC Transmission** **D) Electric and Hybrid Vehicles** **E) Special Purpose Machines**
Elective III (403149) **A) High Voltage Engineering** **B) HVDC and FACTS** **C) Digital Control System** **D) Intelligent Systems and Applications in Electrical Engineering** **E) Analog Electronics and Sensing Technology [Open Elective]**	**Elective IV (403150)** **A) Smart Grid** **B) Robotics and Automation** **C) Illumination Engineering** **D) VLSI Design [Open Elective]**

Audit Course

- Audit Course: Optional for 1st and 2nd term of BE Electrical Engineering
- 'Audit Courses' means a Course in which the student shall be awarded Pass or Fail only. It is left to the discretion of the respective affiliated institute to offer such courses to the students. Evaluation of audit course will be done at institute level itself.
- Teaching-learning process for these subjects is decided by concern faculty/industry experts appointed by the affiliated Engineering College based on the syllabus and guidelines given.
- Marks obtained by student for audit course will not be taken into consideration of SGPA or CGPA.

Audit Course V 403152	**(A) Hydro Energy Systems** **(B) Foreign Language – German**
Audit Course VI 403153	**Energy Storage Systems**

BE (ELECTRICAL)

Semester I&II

Power System Operation and Control

Course Name : Power System Operation and Control **Course Number : 403141**		
Teaching Scheme **Theory : 3 Hrs. / week** **Practical : 2 Hrs. / week**	**Credits** **Th : 03** **PR : 01**	**Examination Scheme [Marks]** **In Sem : 30 Marks** **End Sem : 70 Marks** **Practical : 25 Marks** **Term Work : 25 Marks**

Designation of the Course : Professional-Core

Prerequisites : Generation of power, Alternator, Power system single line diagram, types of faults etc

Course Objectives :

1.	To develop ability to analyze and use various methods to improve stability of power systems
2.	To understand the need for generation and control of reactive power.
3.	To impart knowledge about various advanced controllers such as FACTs controllers with its evolution, principle of operation, circuit diagram and applications
4.	To illustrate the automatic frequency and voltage control strategies for single and two area case and analyze the effects, knowing the necessity of generation control.
5.	To understand formulation of unit commitment and economic load dispatch tasks and solve it using optimization techniques.
6.	To illustrate various ways of interchange of power between interconnected utilities and define reliability aspects at all stages of power system

Course Outcomes :
At the end of the course, a graduate will be able to –

CO1.	Identify and analyze the dynamics of power system and suggest means to improve stability of system
CO2.	Suggest the appropriate method of reactive power generation and control
CO3.	Selection of appropriate FACTs devices
CO4.	Analyze the generation-load balance in real time operation and its effect on frequency and develop automatic control strategies with mathematical relations.
CO5.	Formulate objective functions for optimization tasks such as unit commitment and economic load dispatch and get solution using computational techniques
CO6.	Evaluate reliability indices of Power system , appreciate ways of power exchange

Course Contents :

Unit 1 :	**Power System Stability**	**[6 Hrs]**

Introduction to stability, dynamics of synchronous machine, swing equation, power angle equation and curve, types of power system stability (concepts of steady state, transient, dynamic stability), equal area criterion, applications of equal area criterion (sudden change in mechanical input, effect of clearing time on stability, critical clearing angle, short circuit at one end of line, short circuit away

from line ends and reclosure), solution of swing equation by point by point method, methods to improve steady state and transient stability, numerical based on equal area criteria.		
PR:	1. To determine Steady state Stability of synchronous motor (performance). 2. To plot swing curve by Point by Point method for transient stability analysis. 3. To apply equal area criteria for analysis stability under sudden rise in mechanical power input. 4. To apply equal area criteria for stability analysis under fault conditio	
Unit 2 :	**Reactive Power Management**	**[6 Hrs]**
Necessity of reactive power control, reactive power generation by a synchronous machine, effect of excitation, loading capability curve of a generator, compensation in power system: series and shunt compensation using capacitors and reactors, Problems with Series Compensation, synchronous condenser.		
Unit 3 :	**FACTs Technology**	**[6 Hrs]**
Programming languages for PLC, Ladder diagram fundamentals, Rules for proper construction of ladder diagram Timer and counter- types along with timing diagrams, Reset instruction, latch instruction MCR (master control relay) and control zones Developing ladder logic for Sequencing of motors, ON OFF Tank level control, ON OFF temperature control, elevator, bottle filling plant, car parking, traffic light controller.		
Unit 4 :	**Automatic Generation and Control (AGC)**	**[6 Hrs]**
Concept of AGC, complete block diagram representation of load-frequency control of an isolated power system, steady state and dynamic response, control area concept, two area load frequency control. Schematic and block diagram of alternator voltage regulator scheme.		
PR :	1. To study load frequency control using approximate and exact model. 2. To study load frequency control with integral control. 3. To study the two area load frequency control.	
4.		
Unit 5 :	**Economic Load Dispatch and Unit Commitment**	**[6 Hrs]**
A. Economic load dispatch: Introduction, revision of cost curve of thermal and hydropower plant, plant scheduling method, equal incremental cost method, method of Lagrange multiplier (neglecting transmission losses), Bmn coefficient, economic scheduling of thermal plant considering effect of transmission losses, penalty factor, procedure of load dispatch at state level load dispatch center, Regional Load Dispatch Center, numerical on penalty factor, exact coordination equation. B. Unit commitment: Concept of unit commitment, constraints on unit commitment – spinning reserve, thermal and hydro constraints, methods of unit commitment – priority list and dynamic programming, Numerical on priority list method..		
PR:	1. To study Lagrange multiplier technique for economic load dispatch	
Unit 6 :	**Energy Control and Planning and Reliability of Power Systems**	**[6 Hrs]**
A. Energy Control: Interchange of power between interconnected utilities, economy interchange evaluation, interchange evaluation with unit commitment, types of interchange, capacity and		

diversity interchange, energy banking, emergency power interchange, inadvertent power exchange, power pools.
B. Planning and Reliability of Power Systems: Need of short term planning and long term planning in generation, transmission, distribution expansion. Definition of reliability of power system, Hierarchical levels for reliability study, Reliability evaluation of generation system, loss of load probability (LOLP), loss of load expectation (LOLE), Expected Energy Not Supplied (EENS), generation model, load model, risk model, composite system reliability evaluation, Distribution system reliability evaluation for radial and parallel system, customer oriented and energy based reliability indices.

Text Books :

[T1]	I. J. Nagrath, D. P. Kothari, "Modern Power System Analysis", 4th Edition, Tata McGraw Hill Publishing Co. Ltd. (Edition 2)
[T2]	Hadi Saadat, "Power System Analysis", Tata McGraw Hill
[T3]	P. S. R. Murthy, "Power System Operation and Control", Tata McGraw Hill Publishing Co. Ltd.
[T4]	P. S. R. Murthy, "Operation and Control in Power System", B. S. Publication.
[T5]	R. Mohan Mathur, Rajiv K. Varma, "Thyristor based FACTs controller for Electrical transmission system", John Wiley and Sons Inc.
[T6]	Abhijit Chakrabarti, Sunita Halder, "Power System Analysis Operation and Control", Prentice Hall of India.
[T7]	Narain G. Hingorani and Laszlo Gyugyi, "Understanding FACTS", IEEE Press.

Reference Books :

[R1]	Allen J. Wood, Bruce F. Wollenberg, "Power Generation, Operation, and Control", Wiley India Edition.
[R2]	"Electrical Power System Handbook", IEEE Press.
[R3]	Narain G. Hingorani, Laszlo Gyugyi, "Understanding FACTs Concepts and Technology of Flexible AC Transmission Systems," IEEE Press.
[R4]	Olle I. Elgerd, "Electrical Energy System Theory", 2nd Edition, Tata McGraw Hill. Publishing Co. Ltd.
[R5]	Prabha Kundur, "Power System Stability and Control", Tata McGraw Hill

Extra Experiments :

1. Voltage Control Using Static VAR Compensation

Self-Learning Topics :

Functioning of SLDC, Working of NLDC

Contents beyond Syllabus :

1.Loading Capability Curve of Generator at Thermal Power Station
2.Functioning of Tap-Changing transformer for reactive power management

Bridging Courses :
1.Mathematics of Optimization Techniques
Assignment Topics :
1. Questions based on Power System Stability, Reactive Power Management, FACTs Devices
Presentations :
1. Automatic generation control 2. Energy Control

****

PLC and SCADA Applications

Course Name : PLC and SCADA Applications
Course Number : 403142

Teaching Scheme	Credits	Examination Scheme [Marks]
Theory : 4 Hrs. / week	**Th : 04**	**In Sem : 30 Marks**
Practical : 2 Hrs. / week	**PR : 01**	**End Sem : 70 Marks**
		Practical : 50 Marks
		Term Work : 25 Marks

Designation of the Course : Professional-Core

Prerequisites : Logic gates operations, Boolean algebra, Relay Logic

Course Objectives :

1.	To understand the generic architecture and constituent components of a Programmable Logic Controller.
2.	To develop architecture of SCADA explaining each unit in detail.
3.	To develop a software program using modern engineering tools and technique for PLC and SCADA.
4.	To apply knowledge gained about PLCs and SCADA systems to identify few real-life industrial applications.

Course Outcomes :
At the end of the course, a graduate will be able to –

CO1.	Develop block diagram and explain the working of PLC.
CO2.	Develop architecture of SCADA and explain the importance of SCADA in critical infrastructure.
CO3.	Execute, debug and test the programs developed for digital and analog operations.
CO4.	Describe various industrial applications using PLC and SCADA
CO5.	Classify input and output interfacing devices with PLC.
CO6.	Describe various SCADA protocols along with their architecture.

Course Contents :

Unit 1 :	**Introduction to PLC**	**[8 Hrs]**

Role of automation in Industries, benefits of automation, Necessity of PLC, History and evolution of PLC, Definition as per NEEMA (National Electrical Engineering Manufacturers' Association), types – fixed/modular/dedicated, Overall PLC system, PLC Input and output modules (along with Interfaces), CPU, programmers and monitors, power supplies, selection criterion, advantages and disadvantages, specifications, comparison of various PLCs manufactured by Allen Bradley, Siemens, ABB, Mitsubishi, GE, Fanuc and Schneider.

Unit 2 :	**Interfacing of PLC with I/O devices**	**[8 Hrs]**

Input ON/OFF switching devices, Input analog devices, Output ON/OFF devices, Output analog devices Sensors-temperature, pressure, flow, level Actuators-Electrical, pneumatic, hydraulic

Encoders-Incremental, Absolute Transducers, Limit switches, proximity sensors Control Elements-Mechanical, Electrical, Fluid valves		
PR :	1. Interfacing of lamp & button with PLC for ON & OFF operation. Verify all logic gates. 2. Performed delayed operation of lamp by using push button. 3. UP/DOWN counter with RESET instruction. 4. Combination of counter & timer for lamp ON/OFF operation. 5. Set / Reset operation: one push button for ON & other push button for OFF operation.	
Unit 3 :	**Programming of PLC**	**[9 Hrs]**
Programming languages for PLC, Ladder diagram fundamentals, Rules for proper construction of ladder diagram Timer and counter- types along with timing diagrams, Reset instruction, latch instruction MCR (master control relay) and control zones Developing ladder logic for Sequencing of motors, ON OFF Tank level control, ON OFF temperature control, elevator, bottle filling plant, car parking, traffic light controller.		
Unit 4 :	**Advance function and Applications of PLC**	**[8 Hrs]**
Analog PLC operation and PLC analog signal processing, PID principles, Typical continuous process control curves, simple closed loop systems, closed loop system using Proportional, Integral and Derivative (PID), PID modules, PID tuning, tuning methods including "Adjust and observe" method. Motors Controls: AC Motor starter, AC motor overload protection, DC motor controller, Variable speed (Variable Frequency) AC motor Drive. PLC Applications in developing systems- Tank level controller using analog signals, temperature controller using RTD, speed control of electric motor.		
PR :	5. PLC based temperature sensing using RTD. 6. PLC based thermal ON/OFF control.	
Unit 5 :	**SCADA Systems**	**[8 Hrs]**
Introduction, definitions and history of Supervisory Control and Data Acquisition, typical SCADA system Architecture, important definitions HMI, MTU, RTU, communication means, Desirable Properties of SCADA system, advantages, disadvantages and applications of SCADA. SCADA generations (First generation - Monolithic, Second generation - Distributed, Third generation – Networked Architecture), SCADA systems in operation and control of interconnected power system, Functions and features of SCADA systems, Automatic substation control, Energy management systems (EMS), System operating states, SCADA system in critical infrastructure: Petroleum Refining Process, Conventional electric power generation, Water Purification System, Chemical Plant.		
PR:	2. PLC interfaced with SCADA & status read/command transfer operation.	

	3. Parameter reading of PLC in SCADA. 4. Alarm annunciation using SCADA. 5. Reporting & trending in SCADA system 6. Temperature monitoring by using SCADA.

Unit 6 :	**SCADA Protocols**	**[7 Hrs]**

Open systems interconnection (OSI) Model, TCP/IP protocol, Modbus model, DNP3 protocol, IEC61850 layered architecture, Control and Information Protocol (CIP), Device Net, Control Net, Ether Net/IP, Flexible Function Block process (FFB), Process Field bus (Profibus).

Text Books :

[T1]	John W. Webb, Ronald A. Reis, "Programmable Logic Controllers: Principles and Application", PHI Learning, New Delhi, 5th Edition
[T2]	John R. Hackworth, Frederick D., Hackworth Jr., "Programmable Logic Controllers Programming Methods and Applications", PHI Publishers
[T3]	Ronald L. Krutz, "Securing SCADA System", Wiley Publishing
[T4]	Stuart A Boyer, "SCADA supervisory control and data acquisition", ISA, 4th Revised edition
[T5]	Sunil S. Rao, "Switchgear and Protections", Khanna Publication
[T6]	Gary Dunning, "Introduction to Programmable Logic Controllers", Thomson, 2nd Edition
[T7]	Curtis Johnson, "Process Control Instrumentation Technology", Prentice Hall of India

Reference Books :

[R1]	Gordan Clark, Deem Reynders, "Practical Modern SCADA Protocols", ELSEVIER
[R2]	Batten G. L., "Programmable Controllers", McGraw Hill Inc., Second Edition
[R3]	Bennett Stuart, "Real Time Computer Control", Prentice Hall, 1988
[R4]	Krishna Kant, "Computer Based Industrial Control", PHI
[R5]	P. K. Srivstava, "Programmable Logic Controllers with Applications", BPB Publications

Self-Learning Topics :

Programming with PICOSOFT

Contents beyond Syllabus :

Hysteresis control using PLC and SCADA.

Extra Experiments :

1. Traffic light controller, Pump controller
2. ON/OFF control using Hysteresis.

Bridging Courses :

1. Introduction to Micrologix 1400

2. Introduction to SCADA software Factory Talk View
Assignment Topics :
Sample question are included 1. Explain block diagram of PLC, Advantages & disadvantages, Applications 2. Draw and explain architecture of SCADA, Advantages & disadvantages, Applications
Presentations :
1. Logic gates, Boolean algebra 2. Types of PLC 3. Timers 3. Counters

****

Elective I - Power Quality

Course Name Elective I - Power Quality **Course Number : 403143 B**		
Teaching Scheme **Theory : 3 Hrs. / week** **Practical : 2 Hrs. / week**	**Credits** **Th : 03** **PR : 01**	**Examination Scheme [Marks]** **In Sem : 30 Marks** **End Sem : 70 Marks** **TW : 25 Marks**
Designation of the Course : Professional - Elective		

Prerequisites :

Fundamentals of Power system and Power electronics

Course Objectives :

1.	Develop ability to identify various power quality issues, its sources and effects on various equipments.
2.	Monitor and analyze various power quality problems
3.	Describe and selection of cost effective power quality mitigation solutions.
4.	Explain use of power quality standards

Course Outcomes :
At the end of the course, a graduate will be able to –

CO1.	Identify importance of various power quality issues
CO2.	Carry out power quality monitoring
CO3.	List and explain various causes and effects of power quality problems
CO4.	Analyze power quality parameters and carry out power quality analysis
CO5.	Select cost effective mitigation technique for various power quality problems
CO6.	Use IEEE 519-2014 power quality standard for harmonic compliance

Course Contents :

Unit 1 : Basics of Power Quality [06 Hrs]

Introduction and importance of power quality, symptoms of poor power quality. Classification of power quality events, power quality definition as per IEEE 1159.Grounding of sensitive electronic equipment's and guidelines of IEEE std .Long duration RMS voltage variations, its sources, effects and solutions.

Practical:

1. Study of power quality analyzer and measurement of voltage, current, power and power factor using it.

Unit 2 : Voltage Sag [06 Hrs]

Sources of voltage sags, classification of voltage sags, factors governing severity of voltage sag. Area of vulnerability, critical distance. Voltage sag characteristics. Classification of equipment's based on its sensitivity to various characteristics of voltage sag. Effect of voltage sag on various equipment's. Voltage tolerance curve, ITIC and SEMI F47 curve, investigation of sensitivity of equipment's to

voltage sags. Voltage sag mitigation techniques at equipment level, LT power entrance and medium voltage. Voltage sag indices. Study of important provisions in IEEE Std 1346.

Practical:-

1. Measurement of voltage sag magnitude and duration by using digital storage oscilloscope/ power quality analyzer.

Unit 3 :	**Transient Overvoltage and Flicker**	**[06 Hrs]**

Sources of transient over voltages, Impulsive and oscillatory transients. Magnification of capacitor switching transients, pre insertion reactors to control capacitor switching transients, Ferro resonance, principle of over voltage protection. Devices for over voltage protection. Voltage flicker, its sources. Factors governing severity of flicker. Flicker measurement, Pst and Plt. Flicker mitigation solutions.

Practical:

1. Simulation study of transient and/or flicker measurement

Unit 4 :	**Fundamentals of Harmonics**	**[06 Hrs]**

Waveform Distortion, Harmonics, Harmonic phase sequences. Classification of harmonics, Voltage Verses Current distortion, AC quantities under non-sinusoidal conditions, Voltage and current harmonic indices, Sources of harmonics, General and special Effects of Harmonics on Electrical Equipments, cables, switchgears, Meters and Communications.

Practicals:

1. Measurement of harmonic distortion of various Equipment's such as UPS /AC/DC drive
2. Harmonic analysis of transformer for various conditions (no load, inrush, full load etc.)
3. Analysis of performance of induction motor/transformer operated with sinusoidal supply and under distorted supply conditions supplied by 3 phase inverter.

Unit 5 :	**Harmonic Mitigation Techniques**	**[06 Hrs]**

System behavior to harmonics, location of harmonic sources, Series and parallel resonance, Harmonic mitigation, passive tuned and detuned filters, design of tuned filters, Active Filter, Sizing and location of active filters, Advantages of active filters over passive filters, Hybrid filters. IEEE 519-2014 standard.

Practicals:

1. Harmonic compliance of institute as per IEEE 519-2014 standard and sizing of active filter.
2. Simulation studies of harmonic generation sources and harmonic measurement (THD) by using professional software like MATLAB.

Unit 6 :	**Power Quality Monitoring**	**[06 Hrs]**

Objectives of Power quality monitoring. Types of power quality monitoring, Power quality monitoring equipments, Power quality analyser specification requirement as per EN50160 Standard. Selection of power quality equipments for cost effective power quality monitoring, selection of voltage and current transducers. Power quality indices. IEEE 1159 standard and important provision related with power quality monitoring. Computer Tools for analysis of power quality.

Practical:

1. Simulation studies of harmonic generation sources and harmonic measurement (THD) by using professional software like MATLAB.

Text Books :	
[T1]	R. C. Dugan, Mark F. McGranghan, Surya Santoso, H. Wayne Beaty, "Electrical Power System Quality", 2nd Edition, McGraw Hill Publication.
[T2]	M. H. J. Bollen, "Understanding Power Quality Problems, Voltage Sag and Interruptions", New York: IEEE Press, 2000, Series on Power Engineering.
[T3]	C.Sankaran "Power quality", CRC Press
[T4]	Arrillaga, M. R. Watson, S. Chan, "Power System Quality Assessment", John Wiley and Sons.
Reference Books :	
[R1]	Enriques Acha, Manuel Madrigal, "Power System Harmonics: Computer Modeling and Analysis", John Wiley and Sons Ltd.
[R2]	Ewald F. Fuchs, Mohammad A. S. Masoum, "Power Quality in Power Systems and Electrical Machines" Elsevier Publication.
[R3]	G. J. Heydt, "Electric Power Quality", Stars in Circle Publications
[R4]	EN50160and IEEE 1100, 1346,519 and 1159 standards
[R5]	Arrillaga, M. R. Watson, "Power System Harmonics", John Wiley and Sons

Self-Learning Topics :

Active Filter, Sizing and location of active filters, Advantages of active filters over passive filters, Hybrid filters, Selection of power quality equipments for cost effective power quality monitoring, selection of voltage and current transducers. Power quality indices

Contents beyond Syllabus :

- Introduction to Fourier series for harmonic analysis

Extra Experiments :

1. Harmonic analysis of discharge type of lamps

Assignment Topics :

1. Basics of power quality
2. Voltage sag
3. Transients, Flickers
4. Fundamentals of Harmonics and Harmonic mitigation techniques
5. Power quality monitoring

****

Elective- I: Renewable Energy Systems

Course Name : Elective- I: Renewable Energy Systems **Course Number : 403143 C**		
Teaching Scheme **Theory : 3Hrs. / week** **Practical : 2 Hrs. / week**	**Credits** **Th : 03** **PR : 01**	**Examination Scheme [Marks]** **In Sem: 30 Marks** **End Sem : 70 Marks** **Term Work : 25 Marks**
Designation of the Course : Professional -Elective		
Prerequisites : Fundamental Concept of power and energy conversions		
Course Objectives :		

1.	Understand the basics of thermal applications, solar radiation, concentrating solar power solar film technology, and concept related to PV.
2.	Understand the basics related to wind as power contained, thermodynamics, different characteristics, statistics and about offshore wind energy.
3.	Understand the classification of Biomass its conversion technologies and gasification technologies.
4.	Understand the different storage such as fuel cell, hydrogen storage, batteries and different storage technologies.

Course Outcomes :
At the end of the course, a graduate will be able to –

CO1.	Understand concept of solar radiation and concentrating solar power.
CO2.	Analyze PV system performance and design simple PV systems
CO3.	Draw stand alone and grid connected of renewable systems and Evaluate economical option
CO4.	Understand concepts in wind technology and its performance analysis
CO5.	Identify biomass classification, biomass conversion technologies, biomass gasification, biogas plants, power generation from municipal solid waste.
CO6.	Differentiate and use various Storage Systems for renewables

Course Contents :

Unit 1 :	**Solar Thermal**	**[6 Hrs]**

Solar radiation at the Earth's surface, solar constant, spectral distribution, Extra-terrestrial radiation, solar terrestrial radiation, solar radiation geometry, Introduction to the concept of monthly average daily and hourly global and diffuse radiation, beam and diffuse radiation under cloudless skies, solar radiation on tilted surfaces: a) beam radiation, b) diffuse radiation, c) reflected radiation, d) flux on tilted surface.

Instruments for measuring solar radiation, Basics of flat plate collector, concepts of solar water heating system and space heating system, solar dryer, introduction to Concentrating Solar Power (CSP) plants using technologies like a) parabolic troughs b) linear Fresnel reflector, c) paraboloid dish, etc		
Practical :	1. To evaluate performance of Solar flat plate collector.	
Unit 2 :	**Solar PV**	**[6 Hrs]**
Introduction to various solar PV technologies, Single c-Si, Poly c-Si, thin film PV Cell, Module and Array, factors influencing the electrical design of the solar system: a) Sun Intensity, b) Sun Angle, c) Shadow Effect, d) Temperature Effect, e) Effect of Climate, f) Electrical Load Matching, g) Sun Tracking; Peak Power Point Operation, Electrical characteristics of Silicon PV Cells and Modules, PV System Components, Efficiency of PV system, Design of typical solar PV system with and without battery backup for applications such as homes, commercial complex, agriculture etc.		
Practical :	1. To identify and measure the parameters of a Solar PV Module with Series and/or Parallel combination. 2. To plot I-V and P-V characteristics with series and parallel combination of Solar PV Modules for different Insolation and temperature effects. 3. To evaluate effect of Shading and Tilt Angle on I-V and PV characteristics of Solar Module. 4. To estimate effect of sun tracking on energy generation by Solar PV Module. 5. To estimate efficiency of standalone Solar PV Module.	
Unit 3 :	**Wind Energy System**	**[6 Hrs]**
Types of wind turbine, Site selection, Power Contained in Wind, Aerodynamics of Wind Energy, Efficiency Limit for Wind Energy Conversion, Maximum Energy obtained for a Thrust-operated converter (Efficiency limit), Introduction to the Design of Wind Turbine Rotor, Power-Speed Characteristics, Wind Turbine Control Systems: a) Pitch Angle Control, b) Stall Control, c) Power Electronics Control, d) Yaw Control; Control Strategy, Introduction to Offshore Wind Energy System and its comparison with on grid Wind Energy System		
Practical :	1. To analyze effect of blade angles on performance of wind turbine. 2. To evaluate performance of horizontal axis wind turbine. 3. To evaluate performance evolution of vertical axis wind turbine. 4. To study synchronization of wind electric generator. 5. Wind generation analysis using Matlab for variable wind speeds. 6. To evaluate efficiency of DFIG System (Hardware setup only).	
Unit 4 :	**Biomass Energy System**	**[6 Hrs]**
Biomass Classification, Biomass Resources and their Energy Potential, Biomass Conversion Technologies: Anaerobic Digestion, Ethanol Fermentation, Biomass Gasification: Gasifiers, Fluidized Bed Gasifier, Biogas Technologies and their factor affecting Biogas Production,Biogas Plants: Floating and Fixed Dome type, Introduction to other bio-reactors such as CSTR and UASB, designing of biogas plant. Power Generation from Municipal Solid Waste (MSW), Land Fill Gas, Liquid Waste. Introduction to organic fertilizers from digest state.		
Practical :	1. Field visit to Renewable Energy Sources locations or Manufacturing Industry.	

Unit 5 :	**Fuel cell and Storage Systems**	**[6 Hrs]**

a) Fuel Cells: Introduction to Fuel Cell Technology; type of fuel cells, Operating principles of Fuel Cell, Fuel and Oxidant Consumption, Fuel Cell System Characteristics, application and limits.
b) Energy Storage systems: Hydrogen storage: Hydrogen production, relevant properties, Hydrogen as an Engine Fuel, methods of Hydrogen storage.
Batteries: Introduction to Batteries, Elements of Electro Chemical Cell, Battery classification, Battery Parameters, Factors affecting battery performance.
Grid scale storage, various options available (pumped storage, SMES, compressed air storage, fly wheels, etc.), requirements, future trends, Introduction to the concepts of round trip efficiency and cost of storage.

Practical :	1. To plot characteristics of lead-acid battery for various source and load condition.

Unit 6 :	**Integration and Economics of Renewable Energy Systems**	**[6 Hrs]**

a) Integration of RES with grid, standards., Introduction to hybrid systems
b) Economics of RES: Simple payback, Internal Rate of Return (IRR), time value, Net present value (NPV), Life cycle costing, Effect of fuel cost Escalation, Annualized and levelized cost of energy

Text Books :

[T1]	S.P. Sukhatme, "Solar Energy," Tata McGraw Hill
[T2]	Mukund R. Patel, "Wind and Power Solar System", CRC Press
[T3]	Chetan Singh Solanki, "Solar Photovoltaics-Fundamentals, Technologies and Applications", PHI Second Edition
[T4]	H. P. Garg, J. Prakash, "Solar Energy-Fundamentals and Applications", Tata McGraw hill Publishing Co.ltd., First Revised Edition
[T5]	Tony Burton, Nick Jenkins, David Sharpe, "Wind Energy Hand Book-Second Edition", John Wiley & Sons, Ltd., Publication
[T6]	Godfrey Boyle, "Renewable Energy", Third edition, Oxford University Press
[T7]	S. Rao, Dr. B. B. Parulekar, "Energy Technology – Non Conventional, Renewable and Conventional,"Khanna Publication

Reference Books :

[R1]	D. P. Kothari, K. C. Singal, Rakesh Rajan, "Renewable Energy Sources and Emerging Technologies", PHI Second Edition
[R2]	Gilbert M. Masters, "Renewable and Efficient Electrical Power Systems", Wiley – IEEE Press, August 2004
[R3]	Donald L.Klass, "Biomass for Renewable Energy, Fuels, and Chemicals, Elsevier, Academic Press
[R4]	B T.Nijaguna, "Biogas Technology", New Age International Publishers Tapan Bhattacharya, "Terrestrial Solar Photovoltaics", Narosa Publishing House. Thomas Ackermann, "Wind Power in Power Systems", Wiley Publications

[R5]	D. P. Kothari, K. C. Singal, Rakesh Rajan, "Renewable Energy Sources and Emerging Technologies", PHI Second Edition
[R6]	Gilbert M. Masters, "Renewable and Efficient Electrical Power Systems", Wiley – IEEE Press, August 2004

****

Elective II - Electric and Hybrid Vehicles

Course Name: Electric and Hybrid Vehicles **Course number: 403144 D**		
Teaching Scheme **Theory : 3 Hrs. / week**	**Credits** **Th : 03**	**Examination Scheme [Marks]** **In Sem : 30 Marks** **End Sem : 70 Marks**
Designation of the Course : Profesional -Elective		
Prerequisites :		
Basic concept of Batteries, Electrical motors, Power electronic conversion		
Course Objectives : The course aims:-		
1.	To make students aware the need and importance of Electric, Hybrid Electric Vehicles and Fuel cell vehicle.	
2.	To differentiate and analyze the various energy storage devices and battery charging and management systems.	
3.	To impart knowledge about architecture and performance of Electric and Hybrid Vehicles	
4.	To classify the different drives and controls used in electric vehicles.	
Course Outcomes :At the end of the course, a graduate will be able to –		
CO1.	Review history, social and environmental importance of Hybrid and Electric vehicles.	
CO2.	Describe the performance and selection of energy storage systems and analyse battery management system.	
CO3.	Propose the architecture and modify the performance of Electric and Hybrid Vehicles.	
CO4.	Distinguish between the performance and architecture of various drive trains.	
CO5.	Describe the different Instrumentation and Control used for electric vehicles.	
CO6.	Differentiate between Vehicle to Home, Vehicle to Vehicle and Vehicle to Grid energy systems concepts.	
Course Contents :		
Unit 1 :	**Introduction**	**[5 Hrs]**
Conventional Vehicle: Basic of Vehicle performance, vehicle power source characterization, transmission characterization. Need and importance of transportation development. History of Electric Vehicle, Hybrid Electric Vehicle and Fuel cell Vehicle. Social and environmental importance of Hybrid and Electric vehicles. Impact of modern drive-trains on energy supplies.		
Unit 2 :	**Energy Storage Systems**	**[7 Hrs]**
Introduction to energy storage requirements in Hybrid and Electric vehicles, battery-based energy storage and its analysis, Fuel cell based energy storage and its analysis, Ultra capacitor based energy storage and its analysis, flywheel based energy storage and its analysis.Hybridization of energy sources for Hybrid and Electric vehicle: - Hybridization of drive trains in HEVs, Hybridization of energy storage in EVs. Selection of energy storage technology.		

Unit 3 :	**Battery charging and Management systems**	**[6 Hrs]**
Introduction, charging algorithm, balancing method for battery pack charging. Battery management system representation: - battery module, measurement unit block, battery equalization balancing unit, MCU estimation unit, display unit, fault warning block. SoC and SoH, estimation of SoC, battery balancing, Thermal monitoring of Battery unit.		
Unit 4 :	**Hybrid and Electric vehicles**	**[5 Hrs]**
Electric vehicles: - Components, configuration, performance, tractive efforts in normal driving, Advantages and challenges in EV design. Hybrid Electric vehicles: - Concept and architecture of HEV drive train (Series, parallel and series-parallel).Energy consumption of EV and HEV		
Unit 5 :	**Drives and control systems**	**[7 Hrs]**
Drives: - Application of BLDC drives and Switched reluctance motor drive for HEV and EV, performance characteristics of drives. Instrumentation and control system related to Hybrid and Electric vehicles, speed control, acceleration characteristics, Electric steering, motion control, braking mechanism, Vehicle tracking through GPS, over speed indicating systems, Auto-parking systems		
Unit 6 :	**Vehicle to Home, Vehicle to Vehicle and Vehicle to Grid energy systems**	**[6 Hrs]**
Vehicle to Home(V2H): PHEV control Strategies to V2H applications, V2H with demand response. Vehicle to Vehicle(V2V): - Concept and structure of EV aggregator, control method for EV aggregator for dispatching a fleet of EV. Vehicle to Grid(V2G): - planning of V2G infrastructure in the smart grid, ancillary services provided by V2G, cost emission optimization.		
Text Books :		
[T1]	James Larminie and John Lowry, "Electrical Vehicle", John Wiley and Sons, 2012.	
[T2]	Ronald K. Jurgen, "Electric and Hybrid-Electric Vehicles", SAE InternationalPublisher**.**	
[T3]	K T Chau, "Energy Systems for Electric and Hybrid Vehicles", The institution of Engineering and Technology Publication	
[T4]	D.A.J Rand, R Woods, R M Dell, "Batteries for Electric Vehicles", Research studies press Ltd, New York, John Willey and Sons	
[T5]	Electric and Hybrid Vehicles-Design Fundamentals, CRC press	
[T6]	Mark Warner, The Electric Vehicle Conversion handbook –HP Books, 2011.	
Reference Books :		
[R1]	Mehrdad Ehsani, Yimin Gao and Ali Emadi, "Modern Electrical Hybrid Electric and Fuel Cell Vehicles: Fundamental, Theory and design", CRC Press, 2009.	
[R2]	Junwei Lu, Jahangir Hossain,"Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid", IET Digital Library.	

[R3]	"Automobile Electrical and Electronic systems", Tom Denton, SAE International publications.
[R4]	"Automotive handbook 5th edition", Robert Bosch, SAE international publication.

Self-Learning Topics :

- History of Electric Vehicle, Hybrid Electric Vehicle and Fuel cell Vehicle.
- Vehicle tracking through GPS
- Over speed indicating systems
- Auto-parking systems

Contents beyond Syllabus :

- Various application of electric mobility such as electrical traction, hybrid electric and electric vehicles, elevators, personal mobility and special applications such as wheel chairs.
- Driverless vehicles, road safety and traffic control and monitoring.

Presentations:

- Social and environmental importance of Hybrid and Electric vehicles.
- Impact of modern drive-trains on energy supplies.
- Instrumentation and control system related to Hybrid and Electric vehicles, speed control, acceleration characteristics
- Auto-parking systems

Assignments:

- Unit wise assignments

****

Elective II Special Purpose Machines

Course Name : Special Purpose Machines **Course Number : 403144 E**		
Teaching Scheme **Theory : 3 Hrs. / week**	**Credits** **Th : 03**	**Examination Scheme [Marks]** **In Sem: 30 Marks** **End Sem : 70 Marks**
Designation of the Course : Professional-Core		

Prerequisites :

Fundamentals of Magnetic circuits, Principles of operation of synchronous, induction and dc machines, Knowhow of D-Q axis theory related to electrical machines

Course Objectives:

1.	To explain operation and performance of synchronous reluctance motors.
2.	To describe operation and performance of stepping motors.
3.	To elaborate operation and performance of switched reluctance motors.
4.	To familiarize with operation and performance of permanent magnet brushless D.C. motors.
5.	To illustrate operation and performance of permanent magnet synchronous motors.

Course Outcomes:

At the end of the course, a graduate will be able to –

CO1.	Reproduce fundamentals of magnetic circuits
CO2.	Reproduce principal of operation of PMSM, Stepper motor, SRM, Switch reluctance and linear motors.
CO3.	Derive basic transformations used in machine modeling and control
CO4.	Develop torque speed and performance characteristics of above motors
CO5.	Enlist application of above motors
CO6.	Demonstrate various control strategies.

Course Contents :

Unit 1 :	**Generalised Machine Theory**	**[6 Hrs]**

Energy in singly excited magnetic field systems, determination of magnetic force and torque from energy. Determination of magnetic force and torque from co-energy, Forces and torques in systems with permanent magnets. MMF of distributed winding, Magnetic fields production of EMFs in rotating machines.

Unit 2 :	**Permanent Magnet Synchronous and brushless D.C. Motor Drives**	**[6 Hrs]**

Synchronous machines with PMs, machine configurations. Types of PM synchronous machines Sinusoidal and Trapezoidal. EMF and torque equations Torque speed characteristics Concept of electronic commutation, Comparative analysis of sinusoidal and trapezoidal motor operations. Applications

Unit 3 :	**Control of PMSM Machine**	**[6 Hrs]**

abc-αβ and αβ-dq transformations, significance in machine modelling, Mathematical Model of PMSM (Sinusoidal), Basics of Field Oriented Control (FOC), Control Strategies: constant torque angle, unity power factor.

Unit 4 :	**Reluctance Motor**	**[6 Hrs]**

Principle of operation and construction of Switch Reluctance motor, Selection of poles and pole arcs, Static and dynamics Torque production, Power flow, effects of saturation, Performance, Torque speed characteristics, Synchronous Reluctance, Constructional features; axial and radial air gap motors; operating principle; reluctance torque; phasor diagram; motor characteristics Introduction to control of Reluctance Drive. Applications.

Unit 5 :	**Stepper Motor**	**[6 Hrs]**

Construction and operation of stepper motor, hybrid, Variable Reluctance and Permanent magnet, characteristics of stepper motor; Static and dynamics characteristics, theory of torque production, figures of merit; Concepts of lead angles , micro stepping , Applications selection of motor.

Unit 6 :	**Linear Electrical Machines**	**[6 Hrs]**

Introduction to linear electric machines. Types of linear induction motors, Constructional details of linear induction motor, Operation of linear induction motor. Performance specifications and characteristics Applications.

Text Books:

[T1]	K. Venkatratnam, 'Special Electrical Machines', University Press
[T2]	A.E. Fitzgerald Charles Kingsley, Stephen Umans, 'Electric Machinery', Tata McGraw Hill Publication
[T3]	T.J.E. Miller, 'Brushless Permanent magnet and Reluctance Motor Drives' Clarendon Press, Oxford 1989.
[T4]	V. V. Athani, 'Stepper Motors: Fundamentals, Applications and Design', New age International, 1997

Reference Books:

[R1]	R Krishnan, 'Permanent Magnet Synchronous and Brushless D.C. Motor Drives' CRC Press.
[R2]	Ion Boldea, 'Linear Electric Machines, Drives and maglevs' CRC press
[R3]	Ion Boldea S. Nasar, 'Linear Electrical Actuators and Generators', Cambridge University Press.

Self-Learning Topics :

- Applications of Linear induction machine
- Classification of PMSM

Contents beyond Syllabus :

Demagnetization of permanent magnets
Determination of energy, coenergy, force and torque in multiply excited systems
Brushless doubly fed reluctance machine

Assignment Topics :

Assignment 1 Singly excited system for force and torque calculation
Assignment 2 Multiply excited system
Assignment 3 Applications of LIM

****

Control Systems - II

Course Name : Control Systems – II **Course Number : 403145**		
Teaching Scheme **Theory : 3 Hrs. / week** **Practical : 2 Hrs. / week**	**Credits** **Th : 03** **PR : 01**	**Examination Scheme [Marks]** **In Sem: 30 Marks** **End Sem : 70 Marks** **Oral : 25 Marks** **Term Work : 25 Marks**
Designation of the Course : Professional-Core		
Prerequisites :		
Control System – I Course at TE Elect		
Course Objectives:		
1.	Explain the basic digital control system and the concept of sampling and reconstruction.	
2.	Elaborate the concept of state and to be able to represent a system in the state space format.	
3.	Solve the state equation and familiarize with STM and its properties.	
4.	Design a control system using state space techniques including state feedback control and full order observer.	
Course Outcomes: At the end of the course, a graduate will be able to –		
CO1.	Describe Analog to Digital conversion process and signal reconstruction.	
CO2.	Obtain Pulse Transfer Function and apply Z transform technique to solve difference equation.	
CO3.	Demonstrate stability analysis of closed loop system in z-plane and realize a digital controller by digital programming.	
CO4.	Define the terms related to state space and obtain state model in various forms.	
CO5.	Diagonalize system matrix and solve state equation by computing STM	
CO6.	Determine controllability and observability of the system and design state feedback gain controller and state observer.	
Course Contents :		
Unit 1 :	**Digital Control System**	**[6 Hrs]**
Introduction, Configuration of the basic digital control system. Advantages and limitations of digital control; data conversion and quantization, Sampling and Reconstruction processes, Shannon's Sampling theorem, practical aspects of choice of sampling rate. Zero order hold (ZOH) and it's transfer function, Basic concepts and transfer function of first order hold.		
Practical :	• Plotting of Discrete time waveforms. • Effect of sampling and verification of sampling theorem.	
Unit 2 :	**Z-Transform and Pulse Transfer Function**	**[6 Hrs]**

Unit 3 :	**Stability Analysis**	**[6 Hrs]**
Sampled data closed loop systems, characteristic equation, causality and physical realizability of discrete data system, realization of digital controller by digital programming, direct digital programming, cascade digital programming, and parallel digital programming. Mapping between S-plane and Z-plane, stability analysis of closed loop system in z-plane using Jury's test, Bilinear Transformation.		
Practical :	• Convert a continuous time system to digital control system and check response using software.	
Unit 4 :	**Introduction to State Space Analysis**	**[6 Hrs]**
Important definitions – state, state variable, state vector, state space, state equation, output equation. State space representation for electrical and mechanical system, nth order differential equation and transfer function. Conversion of transfer function to state model and vice versa. State model of armature control DC motor		
Practical :	• Software programming for determination of state space representation for given transfer function and vice-versa	
Unit 5 :	**Solution of State Equation**	**[6 Hrs]**
Concept of diagonalization, eigen values, eigenvectors, diagonalization of system matrices with distinct and repeated eigen values, Vandermonde matrix. Solution of homogeneous and non-homogeneous state equation in standard form, state transition matrix, its properties, Evaluation of STM using Laplace transform method and infinite series method Cayley Hamilton theorem.		
Practical :	• Software programming for determination of STM.	
Unit 6 :	**Design of Control System using State Space Technique**	**[6 Hrs]**
Concept of controllability and observability, controllability and observability Tests, condition for controllability and observability from the system matrices in Canonical form, Jordan canonical form, effect of pole zero cancellation on the controllability and observability of the system, duality property. Pole placement design by state variable feedback. Necessity of an observer, design of full order observer.		
Practical :	• Check for observability and Controllability in MATLAB. • Verify State feedback control using pole placement. • Design and validation of State Observer	

Text Books:

[T1]	K. Ogata, "Discrete Time Control System", 2nd Edition, PHI Learning Pvt. Ltd. 2009
[T2]	Benjamin C. Kuo "Digital Control System", Prentice Hall of India Pvt. Ltd.
[T3]	J. Nagrath, M. Gopal "Control System Engineering", 5th Edition. New Age International Publishers

[T4]	R.Anandanatarajan and P.Ramesh Babu "Control System Engineering",4th Edition, SCITECH Publications, India Pvt. Ltd.

Reference Books:

[R1]	K. Ogata, "Modern Control Engineering", Prentice Hall of India Pvt. Ltd.
[R2]	M. Gopal, "Digital Control and State Variable Methods", Tata McGraw-Hill.
[R3]	M. N. Bandyopadhyay, "Control Engineering – Theory and Practice", Prentice Hall of India Ltd. Delhi.

Self-Learning Topics :

- Properties and theorems related to Z Transform
- Properties of STM, Evaluation of STM using Infinite Power Series method.
- Observer Design using various methods.

Contents beyond Syllabus :

Design of a compensator using MATLAB SISO Design Tool.

Extra Experiments :

- Introduction to MATLAB and Control System Toolbox

Assignment Topics :

Assignment 1 on Analog to Digital Conversion and Z-Transform
Assignment 2 on physical realization of digital controllers
Assignment 3 on State Space Representation and solution of state equation

****

Project I

Course Name : Project I
Course Number : 403146

Teaching Scheme	Credits	Examination Scheme [Marks]
Tutorial : 2 Hrs. / week	**Th : 02**	**Oral : 50 Marks**

Designation of the Course : Professional-Core

Prerequisites : All subjects

Course Objectives :

1.	To develop skills for carrying literature survey and organize the material in proper manner.
2.	To provide opportunity of designing and building complete system/subsystem based on their knowledge acquired during graduation.
3.	To understand the needs of society and based on it to contribute towards its betterment and to learn to work in a team.
4.	To explore and to acquire specified skill in areas related to Electrical Engineering
5	To ensure the completion of given project such as fabrication, conducting experimentation, analysis, validation with optimized cost.
6	Collect the data in report form and represent and communicate findings of the completed work in written and verbal form.

Course Outcomes :

At the end of the course, a graduate will be able to –

CO1.	Design and develop complete system or subsystem using their technical skills.
CO2.	Work in team and ensure satisfactory completion of project in all respect.
CO3.	Handle different tools to complete the given task and to acquire specified knowledge in the area of interest.
CO4.	Provide solutions to the current issues faced by the society.
CO5.	Practice moral and ethical values while completing the given task.
CO6.	Communicate effectively findings in the verbal and written form.

Course Contents :

The student shall take up a project in the field closely related to Electrical Engineering. An individual can undertake project. Preferably, a group of 3 students should be formed for project work.
The project work should be based on the knowledge acquired by the student during the graduation and preferably it should meet and contribute towards the needs of the society. The project aims to provide an opportunity of designing and building complete system or subsystems based on area where the student likes to acquire specialized skills.
Project work in this semester is an integral part of the project work. In this, the student shall complete the partial work of the project which will consists of problem statement, literature review, project

overview and scheme of implementation. As a part of the progress report of project work, the candidate shall deliver a presentation on the advancement in Technology pertaining to the selected project topic.

Guidelines for VIIth Semester for Project work

1. To identify the problems in industry and society.
2. Perform Literature survey on the specific chosen topic through research papers, Journals, books etc. and market survey if required.
3. To narrow down the area taking into consideration his/her strength and interest. The nature of project can be analytical, simulation, experimental, design and validation.
4. To define problem, objectives, scope and it's outcomes.
5. To design scheme of implementation of project.
6. Data collection, simulation, design, hardware if any need to be completed.
7. Presentation based on partially completed work.
8. Submission of report based on the work carried out.

****

Switchgear & Protection

Course Name : Switchgear & Protection **Course Number : 403147**		
Teaching Scheme **Theory : 3Hrs. / week** **Practical : 2 Hrs. / week**	**Credits** **Th : 03** **PR : 01**	**Examination Scheme [Marks]** **In Sem: 30 Marks** **End Sem : 70 Marks** **Oral: 25 Marks** **Term Work : 50 Marks**

Type of the Course : Professional-Core

Prerequisites :

- Different type of faults in power system
- Various switchgears & their use in substation
- Principle and working of rotating machines and transformer with vector groups.

Course Objectives :

1.	Acquaint about construction and working principle of different types of HVCBs
2.	Elaborate the Need of protective Relaying and operating principles of different types of relays.
3.	Explain different type of faults in transformer, alternator and 3 phase Induction motor and various protective schemes related to them.
4.	Impart knowledge about transmission line protection schemes and characteristics of different types of distance relays

Course Outcomes :
At the end of the course, a graduate will be able to –

CO1.	Describe arc interruption methods in circuit breakers.
CO2.	Derive expression for restriking voltage & RRRV in circuit breakers.
CO3.	Explain construction & working of different high voltage circuit breakers.
CO4.	Classify & describe construction and working of different types of relays.
CO5.	Describe various protection schemes used for transformer, alternator, & induction motor.
CO6.	Demonstrate transmission line protection schemes and testing of LV switchgears.

Course Contents :

Unit 1 :	**Fundamentals of protective relaying**	**[8 Hrs]**

Need for protective system, nature & causes of fault, types of faults, effects of faults, evolution of protective relaying, classification of relays, zones of protection, primary & backup protection, essential qualities of protective relaying. Trip circuit of circuit breaker, zone of protection. Various basic operating principles of protection- over current, (current graded & time graded),directional over current, differential, distance, induction type relay, torque equation in induction type relay, current and time setting in induction relay, Numericals on TSM , PSM & operating time of relay

Unit 2 :	**Fundamentals of arc interruption:**	**[6 Hrs]**

Ionization of gases, deionization, Electric arc formation , Current interruption in AC circuit breaker, high & low resistance principles, arc interruption theories, arc voltage, recovery voltage, derivation and definition of restriking voltage and RRRV, current chopping, interruption of capacitive current, resistance switching, Numerical on RRRV, current chopping and resistance switching.		
Unit 3 :	**Circuit Breaker**	**[5 Hrs]**
Different ratings of circuit breaker (like rated voltage, rated current, rated frequency, rated breaking capacity – symmetrical and unsymmetrical breaking, making capacity, rated interrupting duties, rated operating sequence, short time rating). Classification of high voltage circuit breaker. Working and constructional features of ACB, SF6 VCB- advantages, disadvantages and applications. Auto reclosing.		
Practicals :	• Study of switchgear testing kit. • Study of Fuse, MCB & testing of MCB • Study & testing of contactors. • Study & testing of MCCB. • Study & testing of ACB.	
Unit 4 :	**A) Static & Digital Relaying :**	**[3 Hrs]**
Overview of Static relay, block diagram, operating principal, merits & demerits of static relay. Numerical Relays:-Introduction, Block diagram of numerical relay, Sampling theorem, Anti – Aliasing Filter, Block diagram of PMU.		
	B) Three Phase Induction Motor Protection	**[2Hrs]**
Abnormal conditions & causes of failures in 3 phase Induction motor, single phasing protection, Overload protection, Short circuit protection.		
Practical :	• Study & testing of thermal overload relay for Induction Motor protection.	
Unit 5 :	**A)Transformer Protection**	**[3 Hrs]**
Types of faults in transformer. Percentage differential protection in transformers, Restricted E/F protection. Incipient faults, buchholz relay, protection against over fluxing. Protection against inrush current.		
	B)Alternator Protection	**[3 Hrs]**
Various faults in Alternator, abnormal operating conditions- stator faults, longitudinal percentage differential scheme and transverse percentage differential scheme. Rotor faults- abnormal operating conditions, inter turn fault, unbalance loading, over speeding, loss of excitation, protection against loss of excitation using offset Mho relay, loss of prime mover.		
Unit 6 :	**Transmission line Protection:**	**[6 Hrs]**
Over current protection for feeder using directional & non directional overcurrent relays, Introduction to distance protection, impedance relay, reactance relay, mho relay & Quadrilateral Relays, Introduction to PLCC, block diagram, advantages, disadvantages, three stepped distance protection, Effect of arc resistance, and power swing on performance of distance relay. Realization of distance relays (impedance, reactance, & mho relay) using numerical relaying algorithm (flowchart, block diagram), Introduction to Wide Area Measurement (WAM) system.		
Practicals :	• Protection of Transmission line using Impedance relay • Study of bus-bar protection schemes.	

Text Books :	
[T1]	S. Rao, "Switchgear Protection and Power Systems", Khanna Publications
[T2]	Y. G. Paithankar, S. R. Bhide, "Fundamentals of Power System Protection", Prentice Hall of India
[T3]	Bhavesh Bhalja,R.P. Maheshwari, N.G. Chothani," Protection and Switchgear", Oxford University Press, 2011 Edition.
[T4]	J.B.Gupta "Switchgear and Protection", S.K. Kataria and Sons.
Reference Books :	
[R1]	Badri Ram, D. N. Vishwakarma, "Power System Protection and Switchgear", Tata McGraw Hill Publishing Co. Ltd.
[R2]	J Lewis Blackburn , "Protective Relaying- Principles and Applications", Dekker Publications.
[R3]	Prof. Dr S.A. Soman, IIT Mumbai, A Web course on "Digital Protection of power System" http://www.cdeep.iitb.ac.in/nptel/Electrical%20Engineering/Power%20System%20Protection/Course_home_L27.html
[R4]	A.G. Phadke, J.S. Thorp ,Computer relaying for Power System , Research Studies Press LTD, England.(John Willy and Sons Inc New York)
[R5]	Mason C.R., "Art and Science of Protective Relaying", Wiley Eastern Limited.
[R6]	Arun Ingole, "Switchgear and Protection", Pearson.

Extra Experiments :

- Study of different protection schemes for transformer.

Bridging Courses

Industrial Visit is arranged to 220 kV Parvati Substation to bridge the gap between theoretical knowledge and practical things.

Contents beyond Syllabus

- Study of Vacuum Circuit Breaker.
- Drawbacks of overcurrent protection

Assignment Topics :

- Numericals based on calculation of restriking voltage & RRRV, Explain the terms such as arc voltage, restriking voltage, recovery voltage , RRRV , Explain current chopping & resistance switching.
- Explain essential qualities of protective relaying, what is zone of protection , explain primary & back up protection, explain protection principles used in differential relay & distance relay
- Explain with neat diagram construction & working of ACB, SF6 & VCB, explain different rating of HV CB.
- Explain various protection schemes used for transformer (eg from inrush current, incipient faults), various faults in alternator and its protection schemes (failure of prime mover, failure of excitation, & over speed protection)

- Explain static relay & numerical relay with neat block diagram , state its advantages & disadvantages over electromagnetic relay, Explain three step distance protection scheme for transmission lines

****

Power Electronic Controlled Drives

Course Name : Power Electronic Controlled Drives **Course Number : 403148**		
Teaching Scheme **Theory : 4 Hrs. / week** **Practical : 2 Hrs. / week**	**Credits** **Th : 04** **PR : 01**	**Examination Scheme [Marks]** **In Sem: 30 Marks** **End Sem : 70 Marks** **Practical: 50Marks** **Term Work : 25Marks**
Type of the Course : Professional-Core		
Prerequisites :		
Construction, working and characteristic of different electrical motors and soft starting methods.		
Power Electronic Applications such as converter, inverter, chopper etc.		
Basic concept of control system		

Course Objectives :	
1.	To understand motor load dynamics.
2.	To analyze the operation of the converter fed and chopper fed dc drives.
3.	To elaborate braking methods of D.C. and Induction motor drive.
4.	To explain vector control of induction motor.
5.	To differentiate synchronous and BLDC motor drive.
6.	To identify classes and duty of motor.
7.	To describe the modes of operation of drive in various applications.

Course Outcomes : **At the end of the course, a graduate will be able to –**	
CO1.	Explain motor load dynamics and multi quadrant operation of drives
CO2.	Analyze operation of converter fed and chopper fed DC drives.
CO3.	Describe braking methods of D.C. and induction motor drive.
CO4.	Explain vector control for induction motor drives
CO5.	Describe synchronous motor drive
CO6.	Identify classes and duty cycles of motor and applications of drives in industries

Course Contents :		
Unit 1 :	**Electrical Drives**	**[8 Hrs]**

A. Definition, Advantages of electrical drives, Components of Electric drive system, Types of Electrical Drives (DC and AC). B. Motor-Load Dynamics, Speed Torque conventions and multi quadrant operation, Equivalent values of drive parameters. Load Torque Components, Nature and classification of Load. Constant Power operation of a Drive. Steady state stability, Numerical based on motor load dynamics.		
Unit 2 :	**D. C. Motor Drives**	**[8 Hrs]**
A. Braking methods: Rheostatic, Plugging, and Regenerative. Closed loop control of drives: current limit control, torque control and speed control. B. Single phase and three phase fully controlled converter drives and performance of converter fed separately excited DC Motor for speed control operations. Chopper controlled drives for separately excited and series DC Motor operations. Numerical based on above. Closed loop speed control of DC motor below and above base speed.		
Practical : 1. Rheostatic braking of separately excited D. C. Motor 2. Simulation of starting characetristics of D. C. Motor 3. Simulation of 1- phase converter fed D. C. Motor 4. Chopper controlled D. C. Motor		
Unit 3 :	**Induction Motor Drives-I**	**[8 Hrs]**
Braking methods: DC Dynamic Braking, AC Rheostatic braking, Plugging, Regenerative Braking, V/f control and comparison with stator voltage control, voltage source inverter (VSI) control, Steady State Analysis. Current source inverter (CSI) control-open and closed loop, Regenerative braking and multiquadrant operation of Induction motor drives, relative merits and demerits of VSI and CSI for induction motor drives, Numerical on VSI and CSI fed I.M. drives		
Practicals :	1. Braking of three phase induction motor by Plugging 2. VSI fed three phase induction motor 3. Simulation of 1- phase inverter fed Induction Motor	
Unit 4 :	**Induction Motor Drives-II**	**[8 Hrs]**
A. Principle of vector control, Block diagram of Vector control of induction motor. Servo mechanism in drives and block diagram for position control (Descriptive treatment only). B. Thermal model of motor for heating and cooling, classes of motor duty, types of enclosures for motor.		
Practical	Stator voltage control of three phase induction motor	
Unit 5 :	**Synchronous Motor Drives**	**[8 Hrs]**
Types of motor, cylindrical rotor wound field motor, equivalent circuit, speed torque characteristics and effect of power factor, salient pole wound field motor, phasor diagram, simple numerical based on above, closed loop speed control of self controlled synchronous motor drives fed from VSI and CSI. BLDC drives, block diagram and speed torque characteristics.		
Unit 6 :	**Industrial Applications**	**[8 Hrs]**
Specific requirement and choice of drives for following applications.		

1. Machine tools
2. Textile mills
3. Steel rolling mills
3. Sugar mills
4. Traction drives
5. Crane and hoist drives
6. Solar and battery powered drives

Text Books :

[T1]	G. K. Dubey, "Fundamentals of Electric Drives", 2nd Edition, Narosa Publishing House
[T2]	N. K. De, P. K. Sen, "Electric Drives", Prentice Hall of India Eastern Economy Edition
[T3]	S. K. Pillai, "Analysis of Thyristor Power Conditioned Motors", University Press
[T4]	R. Krishnan, "Electric Motor Drives – Modeling Analysis and Control", PHI India
[T5]	G.K. Dubey, "Power Semiconductor controlled drives", PHI publication

Reference Books :

[R1]	B. K. Bose, "Modern Power Electronics and AC Drives", Pearson Education
[R2]	Malcolm Barnes, "Practical Variable Speed Drives and Power Electronics", Elsevier Newnes Publications
[R3]	V. Subrahmanyam, "Electric Drives: Concepts and Application", Tata Mc-Graw Hill (An imprint of Elsevier)
[R4]	M.D. Singh and Khanchandani "Power Electronics", Tata Mc-Graw Hill
[R5]	Austin Huges, "Electrical motor and drives: Fundamental, types and applications", Heinemann Newnes, London
[R6]	Tyagi MATLAB for engineers oxford (Indian Edition)

Assignment Topics :

- Multi quadrant operation of drive
- Steady state performance of converter fed D. C. Motor
- Braking methods of D. C. Motor
- Vector control of Induction motor drives
- Synchronous motor drives
- Various applications of drives

****

Elective III - High Voltage Engineering

Course Name : Elective III High Voltage Engineering **Course Number : 403149 A**		
Teaching Scheme **Theory : 3Hrs. / week** **Practical : 2 Hrs. / week**	**Credits** **Th : 03** **PR : 01**	**Examination Scheme [Marks]** **In Sem: 30 Marks** **End Sem : 70 Marks** **Oral: 25 Marks** **Term Work : 25 Marks**
Type of the Course : Professional-Elective		

Prerequisites :

- Atomic and molecular structure of gaseous and solid materials, basic properties of conductors and insulators, knowledge of material science.

Course Objectives :

1.	To enable students to know and compare the various processes of breakdown in solid, liquid and gaseous dielectric materials
2.	To enable students understand and apply various methods of generation and measurement of DC, AC, impulse voltage and current.
3.	To enable students to know the charge formation and separation phenomenon in clouds, causes of overvoltage and lightening phenomenon
4.	To develop ability among learners to execute testing on various high voltage equipments as per standards
5.	To introduce students to the design, layout, safety precautions, earthing, and shielding of HV laboratory

Course Outcomes :
At the end of the course, a graduate will be able to –

CO1.	Describe and analyze the breakdown theories of gaseous dielectric materials.
CO2.	Describe and analyze the reasons of breakdown of solid and liquid dielectric materials
CO3.	Describe different circuits for generation of high AC voltage, impulse voltage and current.
CO4.	Describe different circuits of measurement of high AC voltage., impulse voltage and current
CO5.	Explain the occurrence of overvoltage and provide remedial solutions
CO6.	Demonstrate an ability to carry out different tests on high voltage equipment and design the high voltage laboratory

Course Contents :

Unit 1 :	**Breakdown in Gases**	**[6 Hrs]**

Ionization process in gas, Townsend's Theory, current growth equation in presence of primary and secondary ionization processes, Townsend's breakdown criterion, primary and secondary ionization coefficients, limitations of Townsend's theory, Streamer mechanism of breakdown, Paschen's Law and its limitations, Corona discharges for point plane electrode combination with positive and negative

pulse application, time lag and factors on which time lag depends. (Numerical on Townsend's theory and Paschen's law).		
Practical	1.To find out the breakdown of air in uniform and non-uniform field and compare it 2.To understand basic principle of corona and obtain audible and visible corona inception and extinction voltage under non uniform field	
Unit 2 :	**Breakdown in Liquid and Solid Dielectrics:**	**[6 Hrs]**
1. Breakdown in Liquid Dielectrics: Pure and commercial liquids, Different breakdown theories: Breakdown in Pure liquid and breakdown in commercial liquids: Suspended Particle theory, Cavitations and bubble theory, Thermal mechanism of breakdown and Stressed Oil volume theory 2. Breakdown in Solid Dielectrics: Intrinsic breakdown: electronic breakdown, avalanche or streamer breakdown, electro-mechanical breakdown, thermal breakdown, treeing and tracking phenomenon, Chemical and electrochemical breakdown, Partial discharge(Internal discharge),Composite dielectric material, Properties of composite dielectrics, breakdown in composite dielectrics. (Numerical on theories of liquid and solid dielectric materials)		
Practical	1. To find the constants of breakdown equation of transformer oil.(Analytical and graphical method) 2. To obtain breakdown strength of composite insulation system, and observe the effect of parameter like no. of layers, thickness of layer, effect of interfacing 3. To study surface flashover on corrugated porcelain/polymeric insulation system 4. To observe development of tracks and trees on polymeric insulation system	
Unit 3 :	**Generation of High Voltages and Current**	**[6 Hrs]**
a)Generation of high ac voltages-Cascading of transformers, series and parallel resonance system, Tesla coil b)Generation of impulse voltages and current-Impulse voltage definition, wave front and wave tail time, Multistage impulse generator, Modified Marx circuit, Tripping and control of impulse generators, Generation of high impulse current		
Unit 4 :	**Measurement of High Voltage and High Currents:**	**[6 Hrs]**
Sphere gap voltmeter, electrostatic volt meter, generating voltmeter, peak reading voltmeter, resistive, capacitive and mixed potential divider , capacitance voltage transformer, cathode ray oscilloscope for impulse voltage and current measurement, measurement of dielectric constant and loss factor, partial discharge measurements. Measurement of high power frequency a.c. using current transformer with electro-optical signal converter, Radio interference measurements		
Practical :	1. Measurement of unknown high a.c. voltage using sphere gap.	
Unit 5 :	**Lightning and Switching Over Voltages**	**[6 Hrs]**
Causes of over voltages, lightning phenomenon, Different types of lightening strokes and mechanisms of lightening strokes, Charge separation theories, Wilson theory, Simpson theory, Reynolds and Mason theory, Over voltage due to switching surges and methods to minimize switching surges. Statistical approach of insulation coordination		
Unit 6 :	**High Voltage Testing of Electrical Apparatus and H V Laboratories:**	**[6 Hrs]**

a)Testing of insulators and bushings, Power capacitors and cables testing, testing of surge arresters. b) Design, planning and layout of High Voltage laboratory:-Classification and layouts, earthing and shielding of H.V. laboratories.	
Text Books :	
[T1]	M. S. Naidu, V. Kamaraju, "High Voltage Engineering", Tata McGraw Hill Publication Co. Ltd. New Delhi
[T2]	C. L. Wadhwa, "High Voltage Engineering", New Age International Publishers Ltd.
Reference Books :	
[R1]	E. Kuffel, W. S. Zaengl, J. Kuffel, "High Voltage Engineering Fundamentals", Newnes Publication
[R2]	Prof. D. V. Razevig Translated from Russian by Dr. M. P. Chourasia, "High Voltage Engineering", Khanna Publishers, New Delhi
[R3]	Ravindra Arora, Wolf Gang Mosch, "High Voltage Insulation Engineering", New Age International
[R4]	High Voltage Engineering Theory and Practice by M. Khalifa Marcel Dekker Inc. New York and Basel
[R5]	Subir Ray, "An Introduction to High voltage Engineering" PHI Pvt. Ltd. New Delhi
Extra Experiments :	
• To perform experiment on horn gap arrestor and understand arc quenching phenomenon.	
Contents beyond Syllabus	
• Types of arresters	
Assignment Topics :	
• Theory questions as well as numerical on any of 6 units	

****

Elective IV- Smart Grid

Course Name : Elective IV - Smart Grid
Course Number : 403150 A

Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 3Hrs. / week	**Th : 03**	**[100 Marks]** **In Sem: 30 Marks** **End Sem : 70 Marks**

Type of the Course : Professional-Elective

Prerequisites :

- Power Electronics
- Analog And Digital Electronics

Course Objectives :

1.	To explain the concept of Smart Grid, compare with conventional grid, and identify its opportunities and barriers.
2.	To describe the concept of Smart Meter, Smart Appliances, Automatic Meter Reading, Outage Management System, Plug in Hybrid Electric Vehicles, Vehicle to Grid, Smart Sensors, Home and Building Automation, Phase Shifting Transformers.
3.	To elaborate the concept of Substation Automation, Feeder Automation.Intelligent Electronic Devices, Smart storage like Battery, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System, Phase Measurement Unit.
4.	To elaborate the concept of microgrid
5.	To acquaint Power Quality issues of Grid connected Renewable Energy Sources, Web based Power Quality monitoring, Power Quality Audit.

Course Outcomes :
At the end of the course, a graduate will be able to –

CO1.	Identify the need of Smart Grid and differentiate between Conventional and Smart Grid in India.
CO2.	Explain the application of Smart grid Technologies like RTU, IED, PMU, PHEV, V2G, G2V and Smart storage.
CO3.	Smart metering and advance metering infrastructure
CO4.	Comprehend the issues, solution and deployment of micro grid.
CO5.	Identify the Power Quality problems in smart grid.
CO6.	Apply the communication technology in smart grid.

Course Contents :

Unit 1 :	**Introduction to Smart Grid:**	**[8 Hrs]**

Concept of Smart Grid, Need of Smart Grid, Functions of Smart Grid, Opportunities and Barriers of Smart Grid, Drivers of SG in India, Functionalities and key components of smart grid, Difference between conventional and smart grid, Smart Grid Vision and Roadmap for India, Concept of Resilient

and Self-Healing Grid, Present development and International policies in Smart Grid, Smart Cities. Pilot projects in India.		
Unit 2 :	**Smart Grid Technologies**	**[6 Hrs]**
Remote Terminal Unit (RTU):Block diagram and function of each block, Intelligent Electronic Devices (IED), Phase Measurement Unit (PMU). Smart Substations, Substation and Feeder Automation, application for monitoring, protection and control, Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid(V2G), Grid to vehicles(G2V), Smart storage technologies and applications – Battery(flow and advanced), SMES, Super Capacitors, Compressed Air Energy Storage(CAES) and its comparison, Optimal location of PMUs for complete Observability.		
Unit 3 :	**Smart Meters and Advance Metering Infrastructure:**	**[6 Hrs]**
Introduction to Smart Meters, Advanced Metering Infrastructure (AMI), Real Time Prizing, Automatic Meter Reading (AMR), Outage Management System (OMS) Smart Sensors, Smart Appliances, Home and Building Automation, Geographic Information System (GIS).		
Unit 4 :	**Microgrid**	**[6 Hrs]**
Concept of Microgrid, need and applications of Microgrid, Microgrid Architecture, DC Microgrid, Formation of Microgrid, Issues of interconnection, protection and control of Microgrid, Integration of renewable energy sources, Smart Microgrid, Microgrid and Smart Grid Comparison, Smart Microgrid Renewable Green Energy System, Cyber Controlled Smart Grid.		
Unit 5 :	**Power Quality Management in Smart Grid**	**[6 Hrs]**
Power Quality and EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.		
Unit 6 :	**Communication Technology for Smart Grid**	**[6 Hrs]**
Communication Architecture of SG, Wide Area Measurement System (WAMS), Home Area Network (HAN), Neighbourhood Area Network (NAN), Wide Area Network (WAN)., ZigBee, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network, Basics of CLOUD Computing and Cyber Security for Smart Grid, Broadband over Power line (BPL).		
Text Books :		
[T1]	Ali Keyhani, Mohammad N. Marwali, Min Dai "Integration of Green and Renewable Energy in Electric Power Systems", Wiley	
[T2]	Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response",CRC Press	
[T3]	Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley Publications.	
[T4]	Stuart Borlase, "Smart Grids-Infrastructure, Technology and Solutions", CRC Press, Taylor and Francis group	
[T5]	James Momoh, "Smart Grid-Fundamentals of design and analysis", Wiley Publications.	

Reference Books :	
[R1]	Nikos Ziargyriour, "Micro grid, Architecture and Control", IEEE Press, Wiley Publications.
[R2]	Yang Xiao, "Communication and Networking in Smart Grids", CRC Press, Taylor and Francis group
[R3]	Lars T. Berger and Krzysztof Iniewski, "Smart Grid-Applications, Communications and Security", Wiley Publications.
[R4]	Mladen Kezunovic, Mark G. Adamiak, Alexander P. Apostolov, Jeffrey George Gilbert "Substation Automation (Power Electronics and Power Systems)", Springer Publications.
[R5]	Smart grid handbook for regulators and policy makers November 2017,ISGF

Contents beyond Syllabus

- Case study of Smart grid at Ponducherry (India)
- Case study Smart Grid by Toshiba Japan
- California University-Microgrid
- Illinois Institute of Technology-Case study

Assignment Topics :

- Difference between conventional and smart grid, Functions of Smart Grid, Opportunities and Barriers of Smart Grid, Drivers of SG in India, Functionalities and key components of smart grid
- Smart storage technologies and applications – Battery(flow and advanced), SMES, Super Capacitors, Compressed Air Energy Storage(CAES) and its comparison, PMU, Remote Terminal Unit (RTU):Block diagram and function of each block, Intelligent Electronic Devices (IED).
- Concept of Microgrid, need and applications of Microgrid, Microgrid Architecture.
- Power Quality and EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources.
- Communication Architecture of SG, Wide Area Measurement System (WAMS), Home Area Network (HAN), Neighbourhood Area Network (NAN), Wide Area Network (WAN).

****

Project II

Course Name : Project II **Course Number : 403151**		
Teaching Scheme **Tutorial : 6 Hrs. / week**	**Credits** **Th : 06**	**Examination Scheme [Marks]** **Oral : 100 Marks** **Term Work : 50 Marks**
Designation of the Course : Professional-Core		
Prerequisites : All subjects		

Course Objectives :

1.	To explore and to acquire specified skill in areas related to Electrical Engineering
2.	To develop skills for carrying literature survey and organize the material in proper manner.
3.	To provide opportunity of designing and building complete system/subsystem based on their knowledge acquired during graduation.
4.	To understand the needs of society and based on it to contribute towards its betterment and to learn to work in a team.
5.	To ensure the completion of given project such as fabrication, conducting experimentation, analysis, validation with optimized cost.
6.	Present the data and results in report form
7.	Communicate findings of the completed work systematically

Course Outcomes :
At the end of the course, a graduate will be able to –

CO1.	Design and develop complete system or subsystem using their technical skills.
CO2.	Work in team and ensure satisfactory completion of project in all respect.
CO3.	Handle different tools to complete the given task and to acquire specified knowledge in the area of interest.
CO4.	Provide solutions to the current issues faced by the society.
CO5.	Practice moral and ethical values while completing the given task.
CO6.	Communicate effectively findings in the verbal and written form.

Course Contents :

The student shall complete the remaining part of the project which is an extension of the work carried out in VIIth Semester. For exceptional cases, change of topic has to be approved by Internal Assessment Committee consisting of Guide, Project Coordinator and Head of Department.
Student should incorporate suggestions given by examiner in project I.
The student shall complete the remaining part of the project which consists of design, simulation, fabrication of set up required for the project, analysis and validation of results and conclusions.
The student shall prepare duly certified final report of the project work in the standard format in MS Word / LaTex. Student should maintain Project Work Book.

****