BHARATI VIDYAPEETH
(DEEMED TO BE UNIVERSITY), PUNE

Faculty of Engineering And Technology
M.Tech. Electrical Engineering
New Syllabus

M.Tech Electrical Engineering (Power Systems) CBCS Pattern (2019)

STRUCTURE & EXAMINATION PATTERN

Semester I									**Total Duration: 20 hrs/week Total Marks :500 Total Credits: 18**		
Subjects	**Teaching Scheme (Hrs) Hrs./Week**		**Examination Scheme (Marks)**						**Examination Scheme (Credits)**		**Total Credits**
	L	**P**	**Theory**	**Unit Test**	**Attendance**	**Tutorial/assignments**	**TW**	**Pract/ Oral**	**TH**	**TW/PR /OR**	
Research Methodology	04	--	60	20	10	10	-	--	04	-	04
FACTS and HVDC	04	--	60	20	10	10	-	--	04	-	04
Advanced Microcontroller & Its Applications	04	02	60	20	10	10	25	25	04	01	05
Power System Modeling	04	02	60	20	10	10	25	25	04	01	05
Total	**16**	**04**	**240**	**80**	**40**	**40**	**50**	**50**	**16**	**02**	**18**

Semester II									**Total Duration: 20 hrs/week Total Marks :500 Total Credits: 18**		
Subjects	**Teaching Scheme (Hrs) Hrs./Week**		**Examination Scheme (Marks)**						**Examination Scheme (Credits)**		**Total Credits**
	L	**P**	**Theory**	**Unit Test**	**Attendance**	**Tutorial/ assignments**	**TW**	**Pract/ Oral**	**TH**	**TW/PR/ OR**	
Power Systems Dynamics	04	--	60	20	10	10	--	--	04	-	04
Digital Protection of Power System	04	02	60	20	10	10	25	25	04	01	05
PLC & SCADA	04	02	60	20	10	10	25	25	04	01	05
Elective - I	04	--	60	20	10	10	--	--	04	--	04
Total	**16**	**04**	**240**	**80**	**40**	**40**	**50**	**50**	**16**	**02**	**18**

Semester III									**Total Duration: 28 hrs/week** **Total Marks : 500** **Total Credits: 40**		
Subject	**Teaching Scheme (Hrs) Hrs./Week**		**Examination Scheme**						**Examination Scheme (Credits)**		**Total Credits**
	L	**P**	**Theory**	**Unit Test**	**Attendance**	**Tutorial/ assignments**	**TW**	**Pract/ Oral**	**TH**	**TW/PR /OR**	
Power Quality Issues	04	02	60	20	10	10	25	25	04	01	05
Elective –II	04	02	60	20	10	10	25	25	04	01	05
Self-Study Paper-I	04	--	60	20	10	10	-	-	04	-	04
Dissertation Stage –I	-	07	-	-	---	--	25	25		21	21
Seminar	-	05	-	-	**--**	**--**	25	25	-	05	05
Total	**12**	**16**	**180**	**60**	**30**	**30**	**100**	**100**	**12**	**28**	**40**

Elective – I	**Elective - II**
a) Power Sector Restructuring & Deregulation b) Power system planning & reliability	a) Advanced Control system b) Advanced Power Electronics & Drives

Semester IV									**Total Duration: 14 hrs/week** **Total Marks : 325** **Total Credits: 34**		
Subject	**Teaching Scheme (Hrs) Hrs./Week**		**Examination Scheme**						**Examination Scheme (Credits)**		**Total Credits**
	L	**P**	**Theory**	**Unit Test**	**Attendance**	**Tutorial /assignments**	**TW**	**Pract/ Oral**	**TH**	**TW/PR/OR**	
Self-Study Paper-II	04	--	60	20	10	10	-	-	**04**	**-**	**04**
Dissertation Stage –II	-	10	-	-	--	-	150	75		30	30
Total	**04**	**10**	**60**	**20**	**10**	**10**	**150**	**75**	**04**	**30**	**34**

List of Self Study paper I & II

Self Study Paper I	**Self Study Paper II**
Condition Monitoring of Electrical Equipments	Electrical Power Capacitors
Energy Storage Devices	Nano technology & its applications in Electrical Engineering
Digital Measurement Techniques	High voltage insulation system & design
Energy Conservation & Audit	Use of synchronized measurement techniques in power system
Solar PV & Wind energy systems	Distributed Generation
Demand response & demand side management	Smart Grid - Automation System for State Transmission Utility
Digital Signal Processing Applications in Power Systems	Substation design

RESEARCH METHODOLOGY			
TEACHING SCHEME:		**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Theory: 04 Hours / Week		End Semester Examination: 60 Marks	04 Credits
		Continuous Assessment: 40 Marks	

UNIT - I	**Fundamentals**	**(08 Hours)**
	Definition, Research Characteristics, Research Need, Objectives and types of research, Motivation and objectives – Research methods vs Methodology, Types of research – Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical	
UNIT - II	**Formulation of research problem**	**(08 Hours)**
	Research Formulation – Defining and formulating the research problem - Selecting the problem - Necessity of defining the problem - Importance of literature review in defining a problem – Literature review – Primary and secondary sources – reviews, treatise, monographs-patents – web as a source – searching the web - Critical literature review – Identifying gap areas from literature review - Development of working hypothesis. Summarizing a Technical Paper -summary template , Online tools - Google, CiteSeer, ACM Digital Library, IEEE, The on-line Computer Science bibliography, Searching patents	
UNIT - III	**Research design methods**	**(08Hours)**
	Research design, sampling design and scaling techniques – Research design – Basic Principles- Need of research design — Features of good design – Important concepts relating to research design, basic principles of experimental designs, implications of sample design, steps in sample design, criteria of selecting sampling procedure, characteristics of good sampling design, different types of sample design. Scaling techniques: measurement scales, sources of error, technique of developing measurement tool, important scaling techniques, scale construction techniques.	
UNIT - IV	**Statistical analysis**	**(08 Hours)**
	Data Collection and analysis:- Observation and Collection of primary and secondary data - Methods of data collection, processing operations, types of analysis, statistics in research, measures of central tendency, measures of dispersion, measures of asymmetry, measures of relationships, simple regression analysis, multiple correlation and regression, partial correlation.	
UNIT - V	**Research Paper & Thesis writing**	**(08 Hours)**
	Reporting and thesis writing – Structure and components of scientific reports - Types of report – Technical reports and thesis – Significance – Different steps in the preparation – Layout, structure and Language of typical reports – Illustrations and tables - Bibliography, referencing and footnotes - Oral presentation – Planning – Preparation –Practice – Making presentation –	

	Use of visual aids - Importance of effective communication - Documentation and presentation tools: LATEX. Types of technical papers - Journal papers, Conference papers, Survey papers, Poster papers, Review papers Comparison, Structure of a survey, conference and journal paper, Organization and flow of thesis/ Project report, Research proposal: preparation, budgeting, presentation, funding agencies for engineering research,	
UNIT - VI	**Research ethics, IPR and publishing**	**(08 Hours)**
	Ethics: ethical issues. IPR: intellectual property rights and patent law, techniques of writing a Patent, filing procedure, technology transfer, copy right, royalty, trade related aspects of intellectual property rights Publishing: design of research paper, citation and acknowledgement, plagiarism tools, reproducibility and accountability.	

Text Books:

1. Kothari, C.R., Research Methodology: Methods and Techniques. New Age International
2. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., An introduction to Research Methodology, RBSA Publishers
3. Suresh Sinha, Anil K Dhiman,Research Methodology, ESS Publications,Volumes 2
4. Day R.A., How to Write and Publish a Scientific Paper, Cambridge University Press
5. Wadehra, B.L. Law relating to patents, Trade Marks, copyright designs and geographical indications. Universal Law Publishing

Reference Books:

1. Louis Cohen, Lawrence Manion and Keith Morrison, Research Methods in Education, 7th Edition, Cambridge University Press, ISBN – 978-0415-58336-7
2. Anthony, M., Graziano, A.M. and Raulin, M.L., Research Methods: A Process of Inquiry, Allyn and Bacon
3. Ranjit Kumar, Research Methodology: A Step by Step Guide for Beginners, 2nd Edition, APH Publishing Corporation
4. Leedy, P.D. and Ormrod, J.E., Practical Research: Planning and Design, Prentice Hall
5. Fink, A., Conducting Research Literature Reviews: From the Internet to Paper. Sage Publications
6. Leslie Lamport, ' Latex: A document preparation system' Addison Wesley, Reading, Massachusetts, second

Syllabus for Unit Test:	
Unit Test -1	UNIT – I, UNIT – II, UNIT - III
Unit Test -2	UNIT – IV, UNIT – V, UNIT - VI

FACTS & HVDC

TEACHING SCHEME:	EXAMINATION SCHEME:	CREDITS ALLOTTED:
Theory: 04 Hours / Week	End Semester Examination: 60 Marks	04 Credits
	Continuous Assessment: 40 Marks	

UNIT - I	**FACTS:**	**(08 Hours)**
	Conventional methods to increase transmission capacity, Series, Shunt reactors, Phase shifting transformers, Synchronous condensers, Flexible AC transmission controllers Basics, Challenges and needs, Static Power converter structures, AC controller based structures, DC link converter topologies, Converter output and harmonic control, Power converter control issues	
UNIT - II	**Shunt and Series Compensation:**	**(08 Hours)**
	Operation and control of thyristor controlled reactor, Thyristor switched Capacitor, SVC, STATCOM configuration and control, Applications of SVC, Power oscillation damping, Mitigation of sub-synchronous resonance, TCSC operation, Layout and protection, Applications of TCSC, Static Synchronous Series Compensator (SSSC)	
UNIT - III	**Unified Power Flow Controller:**	[08 Hrs]
	UPFC configuration, Independent real and reactive power flow control, Control scheme for UPFC, Basic control system for P and Q control, Dynamic performance, Operational constraints of UPFC, Power flow studies in UPFC embedded systems	
UNIT - IV	**General Background of HVDC Transmission:**	**(08 Hours)**
	EHV AC versus HVDC Transmission, Different configurations of HVDC link - Monopolar, Bipolar, Back to Back, Power flow through HVDC link, Equation for HVDC power flow, Connections of three phase six pulse and twelve pulse converter bridges, Voltage and current waveforms. Effect of delay angle, Extinction angle, Overlap angle, Control of DC voltage	
UNIT - V	**Multi Terminal HVDC:**	**(08 Hours)**
	Bipolar HVDC terminal, Converter transformer connections, Switching arrangements in DC yard for earth return to metallic return, HVDC switching system, Switching arrangements in a bipolar HVDC terminal, Sequence of switching operations, HVDC circuit breakers, DC current interruption, Commutation principle, Probable types and applications of HVDC circuit breakers, Multi-terminal HVDC systems, Parallel tapping, Reversal of power, Configurations and types of multi-terminal HVDC systems, Commercial multi terminal systems	
UNIT - VI	**Protection and Control:**	**(08 Hours)**
	Faults and abnormal condition in bipolar, Two terminal HVDC system, Pole-wise segregation, Protective zones, Clearing of DC line faults and reenergizing, Protection of converters, Transformer, Converter valves, DC yards, Integration of protection and controls, Hierarchical levels of control, Block diagram, Schematic diagram, Current control, Power	

	control, DC voltage control, Commutation channel, Master control, Station control, Lead station, Trail station, Pole control, Equidistant firing control, Synchronous HVDC link, Asynchronous HVDC Link	

Text Books:

1. E.Acha, V.A.Agelidis, O.Anaya-lara and TJE MillerNewnes, Power Electronic control in Electrical Systems Oxford.
2. N.G. Hingorani and L.Gyugi, Understanding FACTS- IEEE Press, New York.
3. J. Arrilaga, Y.H.Liu and N.R.Watson, Flexible Power Transmission- The HVDC Options, John Wiley and sons Ltd., New York.

Reference Books:

1. T J E Miller, "Reactive Power Control in Electric Systems", John Wiley
2. Padiyar K R "FACTS Controllers in Power Transmission & Distribution", New Age.
3. R. Mohan and R.K.Varma, "Thyristor-Based FACTS Controllersfor Electrical Transmission Systems", IEEE Press.

Syllabus for Unit Test:	
Unit Test -1	UNIT – I, UNIT – II, UNIT – III
Unit Test -2	UNIT – IV, UNIT – V, UNIT – VI

Advance Micro controllers and applications

TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Theory: 04 Hours / Week	End Semester Examination: 60 Marks	04 Credits
	Continuous Assessment: 40 Marks	
	TW&OR : 50 Marks	01 Credits

UNIT - I	Introduction to PIC 16F8XX family and development tools. CPU architecture and instruction set. Harvard architecture and pipelining, program memory considerations, register file structure and addressing modes, CPU registers.	(08 Hours)
UNIT - II	PIC peripherals I/O ports, external interrupts and timers, timer operation, ADC, short overview of synchronous serial port, serial peripheral interface I2C bus.	(08 Hours)
UNIT - III	Learning MPLAB (V 5.0 or above) Integrated development environment from Microchip (Assembler and simulator),Study of applications like motor control, temperature control, lamp dimmer, 4X4 matrix keyboard and LCD interfacing etc.	(08 Hours)
UNIT - IV	ARM & AVR Processors : RISC, ARM design philosophy, ARM fundamentals, instruction set, thumb instruction set, exception & interrupt handling, efficient C programming, optimizing ARM assembly code, AVR architecture, instruction set, hardware interfacing, communication links and design issues.	(08 Hours)
UNIT - V	Interfacing considerations: Intel process communication, synchronization of processes, tasks, threads, devices & buses for networks, hardware-software co-design embedded programming in C/RT Linux	(08 Hours)
UNIT - VI	Real time operating systems: Survey of software architectures- round robin, with interrupts, function queue scheduling, RTOS architecture, selecting an architecture, task states, task and data semaphores and shared data, message queues, mailboxes ,pipes, timer functions, events, memory management, interrupt routines in an RTOS environment, basic design using RTOS, embedded software development tools, Micro C/OS- II, VX works.	(08 Hours)

Reference Books:

1. Microchip PIC family Microcontroller handbook
2. Design with PIC microcontrollers –John Peatman, Pearson Education Asia ,LPE
3. Rajkamal,''Embedded system –architecture, programming and design",TMH Publication, edition 2003
4. David Simon," An embedded software Primer", Pearson education , Asia
5. Jonathan W. Valvano, Brooks, Cole" Embedded Microcomputer systems-Real time interfacing" Thomson Learning

Syllabus for Unit Test:	
Unit Test -1	UNIT – I, UNIT – II, UNIT – III
Unit Test -2	UNIT – IV, UNIT – V, UNIT – VI

Power System Modeling

TEACHING SCHEME:	EXAMINATION SCHEME:	CREDITS ALLOTTED:
Theory: 04Hours / Week	End Semester Examination: 60 Marks	04Credits
	Continuous Assessment: 40 Marks	
	PR & OR : 50 Marks	01 Credits

UNIT – I	**Modeling of Non-Electrical Parameters:**	**(08 Hours)**
	Different areas of power system analysis, Need for mathematical modeling of power system, Simplified models of non-electrical components such as boiler, steam & hydro turbine, governor system	
UNIT – II	**Modeling of Transformers:**	**(08 Hours)**
	Transformer modeling for two winding transformer, tap-changer, phase shifting transformer, three winding transformer and auto-transformer	
UNIT – III	**Modeling of Transmission Line:**	**(08 Hours)**
	Modeling of transmission network, Transformation to Alpha-Beta components using D-Q components, Steady state equations	
UNIT – IV	**Synchronous Machine Modeling:**	**(08 Hours)**
	Introduction, Park's Transformation, Flux Linkage Equation, Voltage Equations, Formulation of State-Space Equation, Current Formulation, Per Unit Conversion, Normalizing Voltage equations, Normalizing Torque Equations, Torque & Power Equivalent Circuit of Synchronous Machine	
UNIT – V	**Excitation System Modeling :**	
	Types of excitation systems, Control and protective systems, Modeling of excitation systems (excitation system components and entire excitation system, Voltage Response Ratio, Exciter voltage ratings	**(08 Hours)**
UNIT – VI	**Load Modeling:**	
	Basic Load Modeling concepts, Static load representation, Dynamic load representation, Induction motor (as load) modeling, synchronous motor (as load) modeling, acquisition of load model parameters	**(08 Hours)**

Text Books:

1. K. R. Padiyar", Power System Dynamics", B.S. Publications
2. John J. Granier & W.D. Stevenson Jr., "Power System Analysis ", 4th Edition, McGraw Hill International Student Edition
3. Olle Elegard, "Electrical Energy System Theory - An Introduction", TMH Publishing Company, 2nd Edition
4. Kundur, "Power System Dynamics & Control", IEEE Press, New York

Reference Books:

1. Anderson & Foud, "Power System Control & Stability", Vol-I, IEEE Press, New York
2. P.S.R Murthy, " Power System Operation & Control"

Syllabus for Unit Test:	
Unit Test -1	UNIT – I, UNIT – II
Unit Test -2	UNIT – III, UNIT – IV
Unit Test-3	UNIT –V, UNIT-VI

Power System Dynamics		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Theory: 04 Hours / Week	End Semester Examination: 60 Marks	04 Credits
	Continuous Assessment: 40 Marks	

UNIT - I	**Classical Methods of Power System Dynamic Studies**	**(08 Hours)**
	Equality and inequality constraints in power system operation, state transition diagram, concept of system security and stability, classical model of system of one machine connected to infinite bus, Clark diagram for two machines series reactance system, extension of Clark diagram to cover any reactance network, elementary model of overall power system	
UNIT - II	**Small Signal Stability:**	**(08 Hours)**
	Small signal analysis, analysis of synchronizing & damping torque, state equation for small signal model, Simplified synchronous machine model, calculation of initial conditions, system simulation, improved model of synchronous machine, small signal stability of multi machine system	
UNIT - III	**Large Signal Analysis:**	**(08 Hours)**
	Elementary view of transient stability, Large signal analysis, Analysis using numerical integration methods (Modified Euler's, Runge-Kutta), Simulation of power system dynamic response, Analysis of unbalanced faults, Case study of a large system	
UNIT - IV	**Power System Stabilizers:**	**(08 Hours)**
	Basic concepts of control signals in power system stabilizers (PSS), Structure and tuning, Field implementation, PSS design and application, Future trends	
UNIT - V	**Multi-machine system:**	**(08 Hours)**
	Simplified model, Improved model of the system for linear load, Inclusion of load and SVC, Introduction to analysis of large power system	
UNIT - VI	**Voltage stability:**	**(08 Hours)**
	Definition, Factors affecting voltage stability & collapse, Analysis & comparison of angle & voltage stability and voltage instability & collapse, Control of voltage instability, islanding - necessity, methods, advantages and disadvantages, implication on power system dynamic performance	

Text Books:

1. Anderson &Foud, "Power system Control & Stability", IEEE press, New York
2. OlleElgerd, "Electrical Energy System Theory - An Introduction", TMH

Reference Books:

1. K R Padiyar, "Power System Dynamics", B S Publications
2. PrabhaKundur, "Power system Stability & control", TMH
3. C.W.Taylor, "Power System Voltage Stability", TMH
4. R. A. Walling, " Distributed Generation Islanding", N.W. Miller

Syllabus for Unit Test:	
Unit Test -1	UNIT – I, UNIT – II, UNIT – III
Unit Test -2	UNIT – IV, UNIT – V, UNIT – VI

Digital Protection of Power System

TEACHING SCHEME:	EXAMINATION SCHEME:	CREDITS ALLOTTED:
Theory: 04Hours / Week	End Semester Examination: 60 Marks	04 Credits
	Continuous Assessment: 40 Marks	
	TW & OR : 50 Marks	01 Credit

UNIT – I	**Introduction:**	**(08 Hours)**
	Need for Power system protection, Digital Protection: State of Art, Merits of Microprocessor relaying scheme, Power System Components, Basic Philosophy of Protection Scheme, Section of Protection Scheme, Circuit Breakers and Relays, Types and Applications. Architecture of Modern Digital Relay	
UNIT - II	**Static Relays:**	**(08 Hours)**
	Introduction to Static Relay, Overcurrent Relay, Distance Relay, Protection Schemes of transmission lines, Switched distance relay, Poly-phase relay, Relay as Comparator - Dual input Comparator, Relay characteristics by comparison of constants, Multi-input comparator, Pilot Relaying Scheme	
UNIT - III	**Elements of Digital Protection:**	**(08 Hours)**
	Basic components of a digital relay, Signal conditioning subsystem: Transducers, Surge protection circuits, Analog filtering and analog multiplexers, Conversion subsystems, Sampling Theorem, Digital filter signal aliasing error, Sample and hold circuit, Digital multiplexing, Digital to analog conversion, Analog to digital conversion, Digital relay subsystem, Digital relay as unit	
UNIT – IV	**Digital Protection of Transmission Line:**	**(08 Hours)**
	Protection scheme of transmission line, Distance Relay, Travelling wave relays. Digital protection scheme based on fundamental signal: hardware design, software design, Digital protection of EHV/UHV transmission line based on travelling wave phenomena, New relaying scheme using amplitude comparison	
UNIT – V	**Digital Protection of Transformer and Synchronous Generator:**	**(08 Hours)**
	Faults in Transformer, Schemes used for Transformer Protection, Digital Protection of Transformer Faults in Synchronous generator, Protection schemes for Synchronous generator, Digital Protection of Synchronous Generator	
UNIT – VI	**Artificial Intelligence in Power System Protection:**	**(08 Hours)**
	Introduction, An Expert System (ES) for Protective Relay Settings: Introduction, Problem Description, ES Approach, Typical Application, Fuzzy Logic (FL) for Power system Protection: Introduction, Problem Description, FL Approach, Artificial Neutral Network (ANN) in Phase Selection: Introduction, Problem Description, Measurement of fault generated in high frequency components, ANN Approach	

Text Books:

1. "Digital Protection – Protective Relaying from Electro-Mechanical to Microprocessor" By L.P. Singh. 2nd Edition, Reprint-2004, New Age International Publisher, New-Dehli.
2. "Digital Power System Protection" By S.R. Bhide. PHI Learning Private Limited, New Delhi.
3. "Artificial Intelligence Techniques in Power Systems", By Kevin Warwick, Auther Ekwue & Raj Aggarwal, Publication : Institution of Electrical Engineers, London, UK.
4. "Digital Protection for Power system" by A.T Johns and S.K. Salman. Peter Peregrinus Ltd. Of The Institute of Electrical Engineers, London, United Kindom.
5. "Soft Computing Techniques and its Applications in Electrical Engineering" By Dr. Devendra Chaturvadi,

Publication: Springer – Verlag Berlin Heidelburg.	
Reference Books:	
1. "Power System Protection 4: Digital Protection and Signalling" edited by ETA Electricity Training Association. Published by Institute of Engineers, London, UK.	
2. "Digital Signal Processing in Power System Protection and Control" By Waldemar Rebizant, Janusz Szafran, Andrzej Wiszniewski.	
Syllabus for Unit Test:	
Unit Test -1	UNIT – I, UNIT – II, UNIT - III
Unit Test -2	UNIT – IV, UNIT – V, UNIT - VI

PLC and SCADA		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Theory: 04 Hours / Week	End Semester Examination: 60 Marks	04 Credits
	Continuous Assessment: 40 Marks	
	Term Work: 50 Marks	01 Credits

UNIT – I	**Introduction to PLC**	**(08 Hours)**
	Definition & History of PLC, Overall PLC system, PLC Input and Output modules, CPU, Interfaces, Power supplies, PLC advantages and disadvantages, Selection criteria for PLC, Architecture of Industrial Automation Systems, Process Control, PID Control, Predictive Control, Introduction to Sequence Control, PLCs and Relay Ladder Logic, Hardware environment	
UNIT – II	**PLC Programming**	**(08 Hours)**
	Programming equipments, Construction of PLC ladder diagram, Basic components and symbols in ladder diagram, Ladder logic, Functional block, Structural text, Instruction, trouble shooting, features, programming ON/OFF Inputs to produce ON/OFF outputs, Networking of Sensors, Actuators and Controllers: The Fieldbus, The Fieldbus Communication Protocol	
UNIT – III	**PLC Applications**	**(08 Hours)**
	Analog PLC operation, PID control of continuous processes, simple closed loop systems, closed loop system using Proportional, Integral & Derivative (PID), PLC interface, Motors Controls: AC Motor starter, AC motor overload protection, DC motor controller, Variable speed (Variable Frequency) AC motor Drive	
UNIT – IV	**SCADA**	**(08 Hours)**
	Need of SCADA system, Features, SCADA architecture – First generation, Second generation, Third generation, HMI, MTU, RTU, IED's, 7 Layers of OSI, Communication requirements for SCADA (communication protocols – DNP, IEC, Ethernet, TCP/IP, Modbus, UDP), Client – Server based communication concept, SCADA Benefits	
UNIT – V	**SCADA in Power System**	**(08 Hours)**
	Operation and control of interconnected power system, Automatic substation control, SCADA configuration, Energy Management System (EMS), system security, State estimation, SCADA system security issues overview	
UNIT – VI	**Supervisory Management**	**(08 Hours)**
	Networked SCADA environment with implementation examples, Substation Automation and Equipment condition monitoring using SCADA, Distribution system design mapping, trouble call management, Customer level intelligent automation system, computer level monitoring and control of equipments	

Text Books:

1. Terson, "Power System Control Technology", Prentice Hall
2. Green, J. N, Wilson, R, "Control and Automation of Electric Power Distribution Systems", Taylor and Francis, 2007
3. Turner, W. C, " Energy Management Handbook", 5th Edition, 2004
4. Gary Dunning, "Introduction to Programmable Logic Controllers", Thomson, 2nd Edition
5. John W. Webb, Ronald A. Reis, "Programmable Logic Controllers: Principles and Application", 5th Edition
6. Stuart A Boyer, "SCADA supervisory control and data acquisition"

Reference Books:	
1. Handschin, E. “Energy Management Systems”, Springer Verlag, 1990	
2. Gordan Clark, Deem Reynders, “Practical Modem SCADA Protocols”	
Syllabus for Unit Test:	
Unit Test -1	UNIT – I, UNIT – II, UNIT - III
Unit Test -2	UNIT – IV, UNIT – V, UNIT - VI

(Elective – I) Power Sector Restructuring & Deregulation		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Theory: 04 Hours / Week	End Semester Examination: 60 Marks	04 Credits
	Continuous Assessment: 40 Marks	

UNIT - I	**Power Sector in India** Introduction to various institutions in an Indian Power sector such as CEA, Planning Commissions, PGCIL, PFC, Ministry of Power, State and Central governments, REC, Load Dispatch Centers ,Utilities and their roles. Critical issues / challenges before the Indian power sector, Electricity act 2003-Provision in the Generation, Transmission& Distribution Sector, Various national policies and guidelines under this act.	**(08 Hours)**
UNIT - II	**Fundamentals of Economics& Power Sector Regulation** Fundamentals of economics applicable to Power Sector, Consumerbehavior, Supplier behavior, Market Equilibrium, Short- run & Long- run costs, Various costs of production-Total cost (TC), Average fixed cost (AFC), Average variable cost (AVC), Average cost (AC) and Marginal cost (MC),Relationship between short-run and long-run average costs, Perfectly competitive market, Concept of life cycle cost , Annual rate of return , methods of calculations of Internal Rate of Return(IRR) and Net Present Value(NPV) of project, Role of regulation and evolution of regulatory commission in India, Types and methods of economic regulation, Regulatory process in India.	**(08 Hours)**
UNIT - III	**Power Tariff** Different tariff principles (marginal cost, cost to serve, average cost), Consumer tariff structures and considerations, different consumer categories, telescopic tariff, fixed and variable charges, time of day, interruptible tariff, and different tariff based penalties and incentives etc., Subsidy and cross subsidy, life line tariff, Comparison of different tariff structures for different load patterns. Government policies in force from time to time. Effect of renewable energy and captive power generation on tariff,Availability based tariff, Latest reformsand amendments	**(08 Hours)**
UNIT - IV	**Power sector restructuring and market reform** Introduction to power sector restructuring,Reasons for restructuring / deregulation of power industry, Understanding the restructuring process-Entities involved, The levels of competition, The market place mechanisms and Sector-wise major changes required , Different industry structures and ownership models, Market models based on contractual arrangements-Monopoly Model, Single buyer Model, Wholesale competition model and Retail competition model, Marketarchitecture, Timeline for various energy markets, Bilateral / forward contracts, The spot market, Models for trading arrangements, ISO or TSO model,Reasons and objectives of deregulation of various power systems acrossthe world-The US, The UK, The Nordic Pool and The developing countries.Congestion Management, Ancillary Services	**(08 Hours)**
UNIT - V	**Electricity Markets Pricing and Non-price issues** Electricity price basics, Market Clearing price (MCP), Zonal and locational MCPs, Dynamic, spot pricing and real time pricing, Dispatch based pricing, Power flows and prices. Optimal power flow Spot prices for real and reactive power. Unconstrained real spot prices, constrains and real spot prices.Non price issues in electricity restructuring (quality of supply and service, environmental and social considerations),Global experience with	**(08 Hours)**

	electricity reforms in different countries.	
UNIT - VI	**Transmission Planning and Pricing** Transmission planning& operation in open access power systems, Introduction & Principles of transmission pricing, Differenttransmission pricingmethods, Transmission cost allocation methods, Marginal & Composite pricing Paradigms & their comparison, Introduction to transmission loss allocation & various methods of loss allocation, Debated issues in transmission pricing, Congestion issues and management,Ancillary Service Management, Forward ancillary service auction. Power purchase agreements.	**(08 Hours)**

ReferenceBooks:

1. Loi Lei Lai, 'Power System Restructuring &Deregulation, John Wiley & Sons Ltd.
2. "Know Your Power", A citizens Primer On the Electricity Sector, Prayas Energy Group, Pune
3. Sally Hunt, "Making Competition Work in Electricity", 2002, John Wiley Inc
4. Electric Utility Planning and Regulation, Edward Kahn, American Council for Energy Efficient Economy
5. D. S. Kirschen& G. Strbac,'Fundamentals of Power System Economics', John Wiley & Sons Ltd.
6. Steven Stoft,'Power System Economic Designing markets for Electricity, Wiley-Inter Science.
7. M Shahidepour, Hatim Yamin, Zuyi Li,'Market Operations in Electrical Power Systems, Forecasting, Scheduling and Risk Management', Wiley Inter Science.

References:

1. Regulation in infrastructure Services: Progress and the way forward - TERI, 2001
2. Maharashtra Electricity Regulatory Commission Regulations and Orders - www.mercindia.com
3. Various publications, reports and presentations by Prayas, Energy Group, Pune www.prayaspune.org
4. Central Electricity Regulatory Commission, Regulations and Orders - www.cercind.org
5. Electricity Act 2003 and National Policies – www.powermin.nic.in
6. Market Operations in Electric Power Systems Forecasting, Scheduling and Risk Management –Mohammad Shadepur, HatimYatim, Zuyi Li.
7. BhanuBhushan, "ABC of ABT - A primer on Availability Tariff" - www.cercind.org

Website: NPTEL-Phase II-

Syllabus for Unit Test:	
Unit Test -1	UNIT – I, UNIT – II, UNIT – III
Unit Test -2	UNIT – IV, UNIT – V, UNIT – VI

(Elective – I)POWER SYSTEM PLANNING AND RELIABILITY		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Theory: 04 Hours / Week	End Semester Examination: 60 Marks	03 Credits
Practical: 02 Hours / Week	Continuous Assessment: 40 Marks	
	Term Work: 25 Marks	01 Credit

UNIT - I	**Unit 1: Load Forecasting :**	**(06 Hours)**
	Introduction, Factors affecting Load Forecasting, Load Research, Load Growth Characteristics, Classification of Load and Its Characteristics, Load Forecasting Methods -(i) Extrapolation (ii) Co-Relation Techniques, Energy Forecasting, Peak Load Forecasting, Reactive Load Forecasting, Non-Weather sensitive load Forecasting, Weather sensitive load Forecasting, Annual Forecasting, Monthly Forecasting, Total Forecasting, Objectives & Factors affecting to System Planning , Short Term Planning, Medium Term Planning, Long Term Planning. [10 hrs]	
UNIT - II	**Unit 2: Probability theory**	**(06 Hours)**
	Introduction to probability, Probability distributions : Random variables, density and distribution functions. Mathematical expectation. Binominal distribution, Poisson distribution, normal distribution, exponential distribution, Weibull distribution. Normal Gaussian, Gamma and Beta distribution. Correlation and regression	
UNIT - III	**Unit 3: Reliability**	**(06 Hours)**
	Reliability, Failure, Concepts of Probability, Evaluation Techniques (i) Markov Process (ii) Recursive Technique, Stochastic Prediction of Frequency and Duration of Long & Short Interruption, Adequacy of Reliability, Reliability Cost.	
UNIT - IV	**Unit 4: Generation Planning and Reliability :**	
	Objectives & Factors affecting Generation Planning, Generation Sources, Integrated Resource Planning, Generation System Model, Loss of Load (Calculation and Approaches), Outage Rate, Capacity Expansion, Scheduled Outage, Loss of Energy, Evaluation Methods. Interconnected System, Factors affecting interconnection under Emergency Assistance.	
UNIT - V	**Unit 5: Transmission Planning and Reliability**	**(06 Hours)**
	Transmission Planning and Reliability: Introduction, Objectives of Transmission Planning, Network Reconfiguration, System and Load Point Indices, Data required for Composite System Reliability.	
UNIT - VI	**Unit 6: Distribution Planning and Reliability**	**(06 Hours)**
	Radial Networks – Introduction, Network Reconfiguration, Evaluation Techniques, Interruption Indices, Effects of Lateral Distribution Protection, Effects of Disconnects, Effects of Protection Failure, Effects of Transferring Loads, Distribution Reliability Indices. Parallel & Meshed Networks -Introduction, Basic Evaluation Techniques, Bus Bar Failure, Scheduled Maintenance, Temporary and Transient Failure, Weather Effects, Breaker Failure.	

Text Books:	
1. Roy Billinton& Ronald N. Allan, Reliability Evaluation of Power System - Springer Publication.	
2. R.L. SullivanPower System Planning -, Tata McGraw Hill Publishing Company Ltd.	
3. Miler& Freund's, Probability and Statistic for Engineers, Pearson Education, Richard Johnson.	
Reference Books:	
1. X. Wang & J.R. McDonald, Modern Power System Planning –, McGraw Hill Book Company	
2. T. Gönen, Electrical Power Distribution Engineering - McGraw Hill Book Company	
3. B.R. Gupta Generation of Electrical Energy –, S. Chand Publications	
4. A.S. Pabla, Electrical Power Distribution Tata McGraw Hill Publishing Company Ltd.	
5. T.W.Berrie, Electricity Economics & Planning –, Peter Peregrinus Ltd., London	
Syllabus for Unit Test:	
Unit Test -1	UNIT – I, UNIT – II, UNIT - III
Unit Test -2	UNIT – IV, UNIT – V, UNIT - VI

Power Quality Issues		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Theory: 04 Hours / Week	End Semester Examination: 60 Marks	04 Credits
	Continuous Assessment: 40 Marks	

UNIT - I	**Voltage sag; swells and interruptions** Introduction; importance of power quality; terms and definitions of power quality as per IEEE std. 1159. Sources & Effects of Power Quality Problems; Sources of sag; swell and interruptions; Estimation of voltage sag performance; Fundamental principles of protection; solutions at end user level; utility systems and fault clearing issues; motor starting sags; evaluation of the economics of different alternatives.	**[8Hrs]**
UNIT - II	**Transient Over- Voltages** Sources of transient over voltages; capacitor switching; lightening; Ferro resonances and other switching transients; Principles of over voltage protections; devices of over voltage protections; Utility capacitor switching transients; Utility system lightening protection; managing Ferro resonance; switching transients problems with loads; computer tools for transient analysis.	**[8Hrs]**
UNIT - III	**Fundamentals of Harmonics and its Analysis** Introduction; the Mechanism of Harmonic Generation; Definitions and Standards: Factors Influencing the Development of Standards, Existing Harmonic Standards, General Harmonic Indices. Introduction to Harmonic Analysis; Fourier Series and Coefficients; Simplifications Resulting from Waveform Symmetry; Complex Form of the Fourier Series; Convolution of Harmonic Phasors; The Fourier Transform; Sampled Time Functions; Discrete Fourier Transform (DFT); The Nyquist Frequency and Aliasing; Fast Fourier Transform (FFT); Window Functions; Efficiency of FFT Algorithms; Alternative Transforms.	**[8Hrs]**
UNIT - IV	**Harmonic Sources and Distortions** Harmonic Sources : Introduction; Transformer Magnetization Nonlinearities; Rotating Machine Harmonics; Distortion Caused by Arcing Devices; Single-Phase Rectification; Three-Phase Current-Source Conversion; Three-Phase Voltage-Source Conversion; Thyristors-Controlled Reactors. Harmonic Distortion : Introduction; Resonances; Effects of Harmonics on Rotating Machines; Effect of Harmonics on Static Power Plant; Harmonic Interference with Power System Protection; Effect of Harmonics on Consumer Equipment; Interference with Communications.	**[8Hrs]**
UNIT - V	**Computation, Assessment and Harmonic Elimination** Harmonic Computation : Introduction; Direct Harmonic Analysis; Derivation of Network Harmonic Impedances from Field Tests; Transmission Line Models; Underground and Submarine Cables; Load Models; Computer Implementation; Examples of Application of the Models; Harmonic Elimination : Introduction; Filter Design Criteria; Network Impedance for Performance Calculations; Tuned Filters; Damped Filters; Conventional Filter	**[8Hrs]**

	Configurations; Band-Pass Filtering for Twelve-Pulse Converters; Distribution System Filter Planning; Filter Component Properties; D.C. Side Filters; Active Filter	
UNIT - VI	**Power quality monitoring; Assessment & Mitigation** Need and approaches followed in power quality monitoring; objectives and requirements; Initial site survey; Power quality Instrumentation; Selection of power quality monitors; monitoring location and period; Selection of transducers; Harmonic monitoring; Transient monitoring; event recording and flicker monitoring. Power Quality assessment; Power quality indices and standards for assessment; waveform distortion; voltage and current unbalances; Power assessment under waveform distortion conditions. Power quality state estimation; State variable model; observability analysis; capabilities of harmonic state estimation; Test systems; Mitigation techniques at different environments.	**[8Hrs]**

References:

1. Understanding power quality problems; voltage sag and interruptions - M. H. J. Bollen IEEE press; 2000; series on power engineering.
2. "POWER SYSTEM HARMONICS", Second Edition By Jos Arrillaga and Neville R. Watson; John Wiley and Publication, 2003 ISBN: 0-470-85129-5.
3. Electrical power system quality - Pogei C. Dugan; Mark F. McGranghan; Surya santoso; H. Wayne Beaty; second edition; McGraw Hill Pub.
4. Power system quality assessment - J. Arrillaga; M.R. Watson; S. Chan; John Wiley and sons.
5. Electric power quality - G. J. Heydt.
6. Power system harmonics: Computer modeling and analysis- Enriques Acha; Manuel Madrigal; John wiley and sons ltd.
7. Power System Harmonics – J. Arrillaga & N. Watson
8. IEEE std 519-1992/ IEEE std 1159 IEEE recommended practices and requirements for harmonics control in electrical power system.
9. ECBC Code 2007 (Edition 2008) published by Bureau of Energy Efficiency; New Delhi Bureau of Energy Efficiency Publications Rating System; TERI PUBLICATIONS GRIHA Rating System; LEEDS Publications

Syllabus for Unit Test:	
Unit Test -1	UNIT – I, UNIT – II, UNIT – III
Unit Test -2	UNIT – IV, UNIT – V, UNIT – VI

(Elective – II) **Advanced Control System**		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Theory: 04 Hours / Week	End Semester Examination: 60 Marks	03 Credits
	Continuous Assessment: 40 Marks	

UNIT - I	**PID Control:**	**(08 Hours)**
	Review of classical and modern control concepts: PID control and tuning approaches, Selection of Variables for Control, PID Controller Tuning for Dynamic Performance - Determining Tuning Constants for Good Control Performance, Ziegler-Nichols method, Correlations for Tuning Constants, Fine-Tuning the Controller Tuning Constants, Controller tuning based on stability – Dead beat and self tuning, Rate feedback	
UNIT - II	**State Variable Analysis:**	**(08 Hours)**
	Control System Analysis Using State Variable Methods, Conversion of transfer function to phase variable and canonical variable model, Eigen value and eigen vector, Kalman's test and Gilbert's Test for controllability and observability analysis and design of control system in state space, Pole placement, State observer, Design of control system with Luenberger observer	
UNIT - III	**Nonlinear and Robust Control:**	**(08 Hours)**
	Nonlinear Systems and Equilibrium Points, Concepts of Stability, Describing function analysis, Phase plane analysis, Linearization, Feedback Linearization, Input-output linearization, Input-State Linearization Concept of robust control, Description and categorization of system uncertainties, System and signal norms, Small gain theorem, Robust stability, Design of robust control, Introduction to H-∞ control.	
UNIT - IV	**Digital Control:**	**(08 Hours)**
	Structure of the Digital Control System, ADC, DAC, Effects of Sampling of continuous time signals, Quantization, Sample and hold, Reconstruction of signal, Sampling Theorem**, A**liasing, Elementary discrete-time signals, Impulse response, Linear convolution and its properties, Z transform: Basics, Properties, Inverse Z transform using power series and partial fraction difference equation, Stability analysis in z- plane with Jury's stability criteria	
UNIT - V	**Frequency Analysis:**	**(08 Hours)**

	Frequency response of first order and second order systems, Polar plot, Bode plot, Bode plot from Sweep Frequency Response Analysis (SFRA) of transformer and its conclusion, Phase and group delays, Ideal filters and their pole zero locations, Zero phase and linear phase transfer functions Exponential representation of Fourier series and Fourier transform of continuous time signals, The Fourier series for discrete-Time periodic signals (only concept), The Fourier transform of discrete-time a periodic signals (only concept), Discrete Fourier Transform, Properties: Periodicity, Linearity, Symmetry properties, Circular convolution, Linear convolution using circular convolution, Fast Fourier Transform: Radix 2 DIT and DIF algorithms	
UNIT - VI	**Optimal Control:**	**(08 hours)**
	Parameter optimization and optimal control problems, Hamiltonian formulation of optimal control problem, Hamilton-Jacoby equation, Linear regulator problem, Quadratic performance criterion, Numerical solution of Matrix Riccati equation, Pontryagin's minimum principle, Application to optimal control of discrete and continuous systems (quadratic performance index, analysis and design of finite and infinite time), Linear Quadratic Regulators, Introduction to Linear Quadratic Gaussian approach	

Text Books:

1. 'Modern Control Engineering'- Katsuhiko Ogata, Prentice Hall India, 5th edition 2010.
2. 'Non-linear Systems', by Hassan Khalil, Prentice Hall.
3. Digital Control – Ogata , Prentice Hall India

Reference Books:

1. Digtal Control- B.C.Kuo
2. 'Digital Control and State Variable Methods' by M. Gopal, Tata-McGraw-Hill Publishing Company Limited
3. Optimal Control: Linear Quadratic Methods' Brian D. O. Anderson, John Barratt Moore, Dover Publications, 2007

Syllabus for Unit Test:	
Unit Test -1	UNIT – I, UNIT – II, UNIT – III
Unit Test -2	UNIT – IV, UNIT – V, UNIT – VI

(Elective – II) ADVANCED POWER ELECTRONICS AND DRIVES			
TEACHING SCHEME:		**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Theory: 04 Hours / Week		End Semester Examination: 60 Marks	04 Credits
Practical: 02 Hours / Week		Continuous Assessment: 40 Marks	
		Term Work: 25 Marks	01 Credit
UNIT - I	**Converters:**		**(08 Hours)**
	Voltage Source Converters Review of 3-ph-full wave bridge converter, operation and harmonics, 3 level voltage source converters. PWM converter. Generalized technique of harmonic elimination and voltage control. Advanced modulation techniques (space vector modulation, 3rd harmonic PWM) Comparison of PWM techniques. Converter rating **Current source converters** (i) Matrix Converter: 3×3 matrix converter, principle of working, mathematical treatment, comparison of matrix converter with multipulse converter (ii) Self and Line commutated current source converter: Basic concepts of CSC, converters with self commutating devices		
UNIT - II	**Multilevel Inverters:**		**(08 Hours)**
	Multilevel concept, Types of multilevel Inverters, diode clamped multilevel inverter, flying-capacitors multilevel inverters, cascaded multilevel inverter, switching device currents, D.C. link capacitor voltage balancing, features of multilevel inverters, comparison of multilevel inverters. Applications of multilevel Inverter: Reactive power compensation Back to back intertie system		
UNIT - III	**DC Drives:**		**(08 Hours)**
	Single phase and 3 phase converter drives. Four quadrant Chopper drives, closed loop control of DC motor, Permanent magnet DC motor drives, DC Servo drives, applications		
UNIT - IV	**Induction Motor Drives:**		**(08 Hours)**
	3 phase induction motor control, stator voltage control/rotor voltage control, voltage and frequency control, current control, closed loop control of 3-phase induction motor. Soft starters, comparison of variable frequency drives, Speed control by static slip power recovery, induction motor servo drives, applications.		
UNIT - V	**Synchronous Motor Drives:**		**(08 Hours)**
	Voltage and frequency control, closed loop control of synchronous motors. Synchronous motor servo drive with sinusoidal waveform, synchronous motor servodrive with trapezoidal waveform. Load commutated invertor drives, speed control of synchronous motors by cyclo-convertors, applications		
UNIT - VI	**Akagi's p-q theory**		**(08 Hours)**
	Conventional concepts of active and reactive power in single phase and three phase circuits-Equation of power with sinusoidal voltage source and non-linear loads -αβo transformation of three phase four wire system-Akagi's instantaneous power (pq) theory-relationship between Akagi's components and conventional active and reactive power application of pq theory to reactive and harmonic power compensation in simple circuits.		

Text Books:	
1. Bimal K Bose, Modern power electronics and AC drives, Pearson education asia	
2. G. K. Dubey, Fundamentals of Electrical Drives CRC press 2002	
3. VedamSubrahmanyam Electric Drives: Concepts &Appl Tata McGraw-Hill	
4. Power electronics convertors, applications and design, Ned Mohan, Tore M Undeland, William P Robbins, Wiley India Pvt. Ltd., 2009	
5 E. Acha, Miller & Others, Power Electronic Control in Electrical Systems (Newnes, Oxford publication) – first Edition	
6 M. H. Rashid Power Electronics, Prentice Hall of India Pvt. Ltd. New Delhi, (3rd Edition)	
7. R Krishnan, Electric motor drives, modeling, analysis and control, PHI learning Pvt. ltd. 2001	
8. S.K. Pillai, A first course in electrical drives, Newage international publishers. 2010	
Reference Books and Papers:	
1. E. H. Watanube, R.M. Stephen and Maurico Ardes "New Concepts of instantaneous active and reactive powers in Electrical systems with Generic loads" (IEEE transaction on Power Delivery Vol.8, no.2 April 1993, PP-697-703	
2. L. Benchaita, S. Sadaate and A. Salemnia – "A comparison of voltage source and current source shunt Active filter by simulation and Experimentation" (IEEE Transaction on Power Systems, Vol 14, No.2, May 99, PP 642-647	
3. H. Akagi, E.H. Watanabe and M. Aredes "Instantaneous Power Theory and Applications to Power Conditioning, IEEE Press, New York	
Syllabus for Unit Test:	
Unit Test -1	UNIT – I, UNIT – II, UNIT - III
Unit Test -2	UNIT – IV, UNIT – V, UNIT - VI

Following Elective and self study subjects are added in 2015 course

Addition of Elective Courses

1. **M.Tech Electrical Sem II Elective I**

   a. Electric & Hybrid Vehicles
   b. Application Softwares in Electrical Engineering

2. **M.Tech Electrical Sem III Elective II**

   a. Energy Management and Auditing
   b. Simulation & Programming

   Addition of Self Study Subject :

3. **M.Tech Electrical Sem III Self Study I**

   a. Electrical codes and standards

4. **M.Tech Electrical Sem IV Self Study II**

   b. Industrial Safety practices

Elective-I: Electric & Hybrid Vehicles		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Theory: 04 Hours / Week	End Semester Examination: 60 Marks	Theory : 04
Practical: 02 Hours / Week	Internal Assessment: 40 Marks	Practical : 01

Course Pre-requisites:

The Students should have prior knowledge of Electrical Engineering

Course Objectives:

1. Explain the basics of electric and hybrid electric vehicles, their architecture
2. Discuss the design and component sizing and the power electronics devices used in electric and hybrid electric vehicles. \
3. Analyse various electric drives suitable for electric and hybrid electric vehicles.
4. To help the students for understanding the concept of powertrain sizing and energy management system
5. Understanding of different energy storage technologies and power electronics system used for electric and hybrid electric vehicles

Course Outcomes: After learning this course students will be able to

1	Identify Electric Vehicle (EVs)-issues, trends, systems.
2	Classify Electric Vehicle(EVs)
3	Explain Electric Vehicle Architecture
4	Explain Hybrid Vehicle Architecture
5	Describe Power train components of Electric and Hybrid Vehicles
6	Apply energy management strategies to Electric Vehicle systems

UNIT – I	**Electric Vehicle-issues, trends, systems**	**(08 Hours)**
	Past, Present & Feature of EV, Current Major Issues, Recent Development Trends, EV Concept, Key EV Technology, State-of-the Art EVs & HEVs, Comparison of EV Vs IC Engine. EV System: EV Configuration: Fixed & variable gearing, single & multiple motor drive, In-wheel drives EV Parameters: Weight, size, force, energy & performance parameters.	
UNIT - II	**Classification of EVs**	**(08 Hours)**
	Classification of EVs in reference of: Propulsion devices, Energy sources, Energy carriers, Pure Electric Vehicles (PEV), Hybrid Electric Vehicles (HEV) and Plug-in Hybrid Electric Vehicles (PHEV), Configurations: Battery Electric Vehicles (BEV), Fuel cell electric vehicles (FCEVs), Conventional full HEV.	
UNIT - III	**Hybrid Vehicle Architecture**	**(08 Hours)**
	Introduction - Concept of Hybrid Electric Drive trains - Architectures of Hybrid Electric Drive trains - Series and Parallel Hybrid Electric Drive trains – Coupling Modes - Operating Modes – Hybridization factor – Plug-in hybrid electric vehicles (PHEVs) – Performance characteristics	
UNIT -IV	**Electric Vehicle Architecture**	**(08 Hours)**
	Introduction- Configurations - Traction Motor Characteristics - Tractive Effort and Transmission Requirement – Power Flow Control in Electric Drive train – Positioning of Motors - Vehicle Performance - Tractive Effort in Normal Driving - Energy Consumption – Single and Multi Motor drives	
UNIT -V	**Power train components of Hybrid and Electric Vehicles**	**(08 Hours)**
	Traction Motor Types – Configuration and Control - DC Motor- Brushless DC Motor – BLDC	

	Motor Control - Switched Reluctance Motor – AC Induction – Motor Drives and Introduction to Power electronic components – Electronic Control Unit of Motors – Various Control Modes – Drive system Efficiency	
UNIT - VI	**Power train Energy Management System** :	**(08 Hours)**
	Introduction to energy management strategies - classification of energy management strategies - rule based and optimization strategies - real-time working of energy management system in HEV - model-based design and simulation process - Implementation issues of energy management strategies	

Term Work: The term work shall consist of minimum eight experiments

1. Study of BLDC / PMSM/AC Induction electric vehicle motor
2. Study of various batteries used for Electric Vehicle(Industry visit to manufacturing company)
3. Study of basic controllers for Electric Vehicle
4. Study of electric vehicle lighting system
5. Study of electric vehicle charger (Demonstration at EV company/MSEB charging point)
6. Modeling & simulation of electric vehicle/hybrid electric vehicle with professional software
7. Study of performance of electric vehicle using professional software
8. Demonstration of electric vehicle manufacturing (Industry visit to manufacturing company)

Project Based Learning

Case studies, Demonstration of syllabus topic by using professional software/hardware models

Reference Books:

1. Hybrid Electric Vehicle System Modeling and Control - Wei Liu, General Motors, USA, John Wiley & Sons, Inc., 2017.
2. Hybrid Electric Vehicles – Teresa Donateo, Published by ExLi4EvA, 2017
3. Electric and Hybrid Vehicles Power Sources, Models, Sustainability, Infrastructure and the Market Gianfranco Pistoia Consultant, Rome, Italy, Elsevier Publications, 2017.
4. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, MehrdadEhsaniYiminGao Stefano Longo Kambiz M. Ebrahimi, Taylor & Francis Group, LLC, 2018.
5. Hybrid, Electric & Fuel-Cell Vehicles Jack Erjavec, Delmar, Cengage Learning.
6. Electric and Hybrid Vehicles, Tom Denton, Taylor & Francis, 2018.
7. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2010.
8. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2009.
9. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003

Syllabus for Unit Test:

UnitTest-1	UNIT–I, UNIT–II, UNIT-III
UnitTest-2	UNIT–IV, UNIT–V, UNIT-VI

Elective-I: Application Softwares in Electrical Engineering		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Theory: 04 Hours / Week	End Semester Examination: 60 Marks	Theory : 04
Practical: 02 Hours / Week	Internal Assessment: 40 Marks	Practical : 01

Course Pre-requisites:

The Students should have knowledge of

Basic Electric Machines, Magnetic Theory, Introduction to Electrical Power system , Structure of Electrical power system, Sources of Electrical Energy, Elements of Power system

Course Objectives:

- Students will get well familiar with importance of electrical design, different design techniques and application of tools for electrical design and analysis.

Course Outcomes: Students will be able to

1.	Relate the basic knowledge of electrical system with electrical design
2.	Understand the importance of software tool and explore its GUI
3.	Apply the knowledge of toolbar for understanding the design concept
4	Identify various electrical applications as per software tools
5	Discuss the methods of software simulation in electrical engineering
6	Apply the knowledge for design and analysis of electrical machines

UNIT - I	**Introduction to Electrical Design:**	08 Hours
	Introduction to Electrical System for Electrical Design and analysis, Application of Electrical Design, Purpose of Electrical Design, Basic Design philosophy, Importance of Results from design tools, design optimization, Standard Rules for Electrical Design.	
UNIT - II	**Introduction to ETAP Software:**	08 Hours
	Introduction to ETAP software, Importance of ETAP for System design, History of ETAP, Key features & Benefits of ETAP, Codes & Standards, Working with ETAP software- Starting ETAP software, Creating a new project, Changing the Project standard, File Management, Exploring GUI.	
UNIT - III	**Toolbar and Library for ETAP:**	08 Hours
	Toolbar Description - Project Toolbar, Theme Toolbar, System Toolbar, Mode Toolbar, Base & Revision Toolbar, Inserting Circuit Elements- Library for Circuit Elements, System Elements and Components, Element Classification - AC Elements , DC Elements , AC-DC Elements , Instrumentation Elements , Component Editor	
UNIT - IV	**Introduction to ANSYS Maxwell software:**	08 Hours
	Introduction to ANSYS Maxwell software and general applications, Applications of software in electrical engineering, Maxwell solvers-electric and magnetic solution, GUI, RMXprt tool, Introduction to 2D simulation, Introduction to 3D simulation.	
UNIT - V	**ANSYS Maxwell software simulation:**	08 Hours
	Finite element method, Selection of Geometry and solver types, Defining analysis plane, selection of solver, model units, Exploiting magnetic/excitation symmetry in model, Assigning material properties, Assigning excitation and boundary conditions, Model verification.	
UNIT - VI	**Electric Machine simulation:**	08 Hours

	Need for machine simulation, Applications of ANYSY Maxwell software for machine simulation, Design and analysis of any one electric machine using RMXprt tool, Maxwell 2D simulation, Maxwell 3D simulation, Discussion on simulations results.	

Term Work:

The term work shall consist of record of minimum eight experiments in ETAP and ANSYS with flowchart and results from below list.

1. Prepare the list of tools used for Electrical Design and Analysis
2. Prepare a new project and change the project standard using ETAP software
3. Study of system toolbars in details with its application in ETAP software
4. Study of system elements and components in ETAP software
5. Study of Library for ETAP software and its applications
6. Study the components editor and its working in ETAP software
7. Design and analysis of any one conventional electrical motor using RMXprt tool.
8. Study of 2D model for any one conventional electrical motor using ANSYS Maxwell software.
9. Study of 3D model for any one conventional electrical motor using ANSYS Maxwell software
10. Design and analysis of any one special purpose machine using RMXprt tool.
11. Study of 2D model for any one special purpose machine using ANSYS Maxwell software.
12. Study of 3D model for any one special purpose machine using ANSYS Maxwell software.

Project based Learning:

1. Obtain and prepare Single Line Diagram from any real time project in ETAP software without any errors.
2. Develop a substation SLD of any voltage level by giving suitable input parameters
3. Generate reports through above analysis and give presentation on the results obtained.
4. Designing Induction motor/BLDC motor/ Switched Reluctance motor as per specifications using RMXprt.
5. 2D model of assigned machine through ANSYS Maxwell software.
6. Develop an article based on any content related to ETAP software get it published in conference/technical journal, etc.
7. Develop an article based on any content related to ANSYS software get it published in conference/technical journal, etc.

Text Books:

1. Hemchandra Madhusudan Shertukde, “Power Systems Analysis Illustrated with MATLAB and ETAP”, CRC Press, Taylor and Francis Group
2. Vivek Ravindran, Prajith Kumar, Sumit Tomar, “Modeling, Simulation and Optimization of a Power System Network: A case study using ETAP software”, LAP Lambert Academic Publishing.
3. John E.Matsson, “An introduction to ANSYS Fluent 2021”, SDC Publications.
4. Huei-Huang Lee, “Finite Element Simulations with ANSYS Workbench 2021 Theory, applications and case studies ”, SDC Publication.

Reference Books:

1. T.Stolarski, Y.Nakasone,S.Yoshimoto “Engineering analysis with ANSYS software”, BH Publication.
2. Saeed Moaveni, “Finite Element Analysis Theory and application with ANSYS”, Third edition, Pearson publication .
3. Dr.Marius Rosu, Dr.Ping Zhou, Dr.Dingsheng Lin, “Multiphysics Simulation by Design for Electrical Machines, Power electronics and Drives”, IEEE Press Wiley.

Syllabus for Unit Test:

UnitTest-1	UNIT–I, UNIT–II, UNIT-III
UnitTest-2	UNIT–IV, UNIT–V, UNIT-VI

Elective-II: Energy Management and Auditing		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Theory: 04 Hours/Week	End Semester Examination: 60 Marks	Theory : - 04
	Continuous Assessment: 40 Marks	Total : - 04

Course Pre-requisites:	
The students should have knowledge of	
1.	Various energy conversion process
2.	Measurements and instrumentation for electrical & non-electrical parameters

Course Objectives:	
	This course introduces knowledge about different energy sources and the economics behind it. It also explores energy various conservation techniques and methods of auditing. It also explores the knowledge of financial aspects of energy conservation & auditing. The course is designed to learn different methods.

Course Outcomes: Students will be able to	
1.	Identify the energy scenario at national and international level along with the energy conservation act.
2.	Understand the rolls and responsibilities of energy manager and various analysis techniques.
3.	Understand various types of Energy Audit and maximizing system efficiency
4	Get the Knowledge of financial aspects related to energy conservation.
5	Understand the various techniques of Energy Efficiency in Electrical Utilities.
6	Understand the various techniques of Energy Efficiency in Thermal Systems

UNIT - I	**Energy Scenario**	**(08 Hours)**
	Energy sources-Primary and Secondary, Commercial and Non-commercial, Energy scenario in India and Global scenario, Energy Security, Energy and GDP, Energy Intensity, Energy conservation and its importance, Energy Conservation Act 2001 and related policies, Role of Non- conventional and renewable energy.	
UNIT - II	**Energy Management and Integrated Resource Planning**	**(08 Hours)**
	Definition and Objectives of Energy management, Energy management strategy, Key elements, Responsibilities and duties of Energy Manager, Energy efficiency Programs, Energy Monitoring System, Importance of SCADA, Analysis techniques, Cumulative sum of differences (CUSUM)	
UNIT - III	**Energy Audit**	**(08 Hours)**
	Definition, need of energy Audit, Types of Energy Audit, maximizing system efficiency, Optimizing the input energy requirements, fuel and energy substitution, Energy Audit instruments and metering, thermography, SMART metering	
UNIT - IV	**Financial Analysis and Management**	**(08 Hours)**
	Investment need, financial analysis techniques, Calculation of Simple Pay-back period, return on investment, cash flows, risk and sensitivity analysis, Time value of money, Net Present value, Breakeven analysis, Cost optimization, Cost and Price of Energy services, Cost of Energy generated through Distributed Generation	
UNIT - V	**Energy Efficiency in Electrical Utilities**	**(08 Hours)**
	Electrical billing, power factor management, distribution and transformer losses, losses due to unbalance and due to harmonics, Demand Side Management, Demand-Response, Role of tariff in DSM and in Energy management, TOU tariff, Power factor tariff, Integrated Resource Planning and Energy Management Energy conservation in Lighting systems, HVAC, Electric Motors, Pump and Pumping systems.	
UNIT - VI	**Energy Efficiency in Thermal Systems**	**(08 Hours)**

	Fuels and combustion, properties of Fuel Oil, coal and gas, storage and handling of fuels, principles of combustion, combustion of oil, coal, gas. Energy efficiency in Boilers, Steam systems, Furnaces, Insulation and Refractors.	

Text Books:

1. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-1, General Aspects (available online)
2. Guide books for National Certification Examination for Energy Manager / Energy 55 Auditors Book-2, Thermal Utilities (available online)
3. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-3, Electrical Utilities (available online)
4. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-4,(available online)

Reference Books:

1. S. C. Tripathy, "Utilization of Electrical Energy", Tata Mc Graw HillEnergy Technology - S. Rao, Dr. B B Panelkar - Khanna Publication
2. Success stories of Energy Conservation by BEE, New Delhi (www.bee-india.org)

Syllabus for Unit Test:

Unit Test -1	UNIT – I, UNIT – II, UNIT - III
Unit Test -2	UNIT – IV, UNIT – V, UNIT - VI

Elective-II: Simulation And Programming		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Theory: 04 Hours/Week	End Semester Examination: 60 Marks	Theory : - 04
	Continuous Assessment: 40 Marks	Total : - 04

Course Pre-requisites:	
The Students should have knowledge of	
1.	Students should have knowledge of Fundamentals of Electrical Engineering, basic mathematics and basic computer operation
Course Objectives:	
	The course introduces fundamental concepts of simulation and programming for problem solving
Course Outcomes: After learning this course students will be able to	
1	Describe the concept of simulation
2	Identify and apply knowledge of software simulation
3	Describe and Analyze Programming Techniques using application software's.
4	Describe fundamental concepts of MATLAB Simulink
5	Apply knowledge MATLAB Simulink in Electric Applications
6	Elaborate the scope and applications of PCB design

UNIT – I	**Introduction to Simulation:**	08 Hours
	What is simulation: Modeling basics, computer simulation (Popularity and advantages, different kinds of simulation), How simulation gets done (by hand, programming in general languages, simulation languages, high level simulators, Uses of simulations (past , present, future). **Fundamentals of simulation:** Goals of simulation study, Analysis options(educated guessing, queueing theory, mechanistic simulation), Pieces of simulation model(entities, attributes, variables, resources, queues, statistical accumulators, events, simulation clock, starting and stopping), Event driven hand simulation, Event and process oriented simulation Randomness in simulation, Simulation with spread sheets, conducting simulation studies.	
UNIT - II	**Software Tools and Simulation:**	08 Hours
	Types of Analysis: Bias point, Time domain, AC Sweep, DC Sweep, Parametric, Monte Carlo, Noise analysis. **Schematic Design:** Introduction, Description of P-Spice, Types of analysis, Description of simulation software tools (like OrCAD / PROTEL / Proteus / Microcap) Schematic Description: Introduction, Input files, element values, Nodes, circuit elements, sources, output variables, format of circuit and output files, drawing the schematic, Design rule Check (DRC), Netlist details.	
UNIT -III	**Introduction to MATLAB programming:**	08 Hours

	Introduction, starting and ending a MATLAB session, Fundamentals of MATLAB programming (MATLAB variables, arrays, matrices, matlab operators- arithmetic, relational, logical, MATLAB graphics(plots, subplots, other types of plots), benchmarking and looping functions(branching functions, looping functions), miscellaneous functions(string function, input/output function), *examples on above topics*, advantages of MATLAB, limitations of MATLAB, various matlab commands & their explanation. Introduction to GUI.	
UNIT -IV	**MATLAB Simulink Basics:**	08 Hours
	Introduction, Introduction to simulink, starting simulink, simple examples on starting a simulink, solving differential equations in simulink, Commonly used blocks, application block sets (power system toolbox) , user defined functions, Simulink modeling.	
UNIT - V	**MATLAB Basic Electrical Engineering Applications:**	08 Hours
	Basic electrical engineering applications(introduction, elementary definitions, basic waveforms, average value -RMS value -peak value, ohms law, Kirchhoff's laws, independent and dependent Dc sources, series and parallel circuits, resonance phenomenon, network theorems, apparent power- active power-reactive power, three phase source and load simulation, transformers. Application related to Wind and Solar.	
UNIT -VI	**PCB Design and its Applications:**	08 Hours
	Simulation of following circuits: half wave & full wave rectifier, Zener shunt regulator, transistorized RC coupled amplifier, clipper and clamper. Introduction to PCB design.	

Term Work: The term work shall consist of record of minimum eight experiments and not limited to

List of experiments:

1. Schematic drawing & component symbol creation
2. Hierarchical schematic drawing
3. Simulation and analysis (bias point analysis, time domain, AC sweep, DC sweep, parametric) of :RLC Circuit.
4. Experiments based on PCB design which would include component placement, setting design rules, auto routing and interactive routing.
5. Experiments based on noise analysis and Monte-carlo analysis
6. To simulate simple calculator that performs basic tasks such as addition, subtraction, multiplication and division with special operations like computing xy and x!.
7. To accept the number and Compute a) square root of number, b) Square of number, c) Cube of number d) check for prime,
   d) factorial of number e) prime factors
8. To accept two numbers from user and compute smallest divisor and Greatest Common Divisor of these two numbers.
9. To accept a number from user and print digits of number in a reverse order.
10. To input binary number from user and convert it into decimal number.
11. Experiment on unit 3: Listing of some common MATLAB commands and executing with examples
12. Experiment on unit 4 : Basic simulation projects
13. Experiment on unit 5: Solving network theorems using MATLAB

Project based learning:

1) Project based on Network Theorems in MATLAB

2) Design of Regulated Power supply in Proteus

3) Design of Electronic circuitry for household applications in Proteus

4) Design of Household applications on PCB

5) Design of Electrical based applications in MATLAB

Text book:

1. M. H. Rashid 'Introduction to P-spice using OrCAD for circuits and Electronics' –Pearson Education

Reference Books:

1. User manuals of PROTEL, PROTEUS, OrCAD, Microcap.
2. W.C. Bosshart 'Printed Circuit Boards-Design & Technology'–Tata McGraw-Hill Publication.
3. R. G. Dromey, "How to Solve it by Computer", Pearson Education India; 1st edition, ISBN10: 8131705625, ISBN-13: 978-8131705629 Maureen Spankle, "Problem Solving and Programming Concepts", Pearson; 9th edition, ISBN-10: 9780132492645, ISBN-13: 978- 0132492645
4. Romano Fabrizio, "Learning Python", Packt Publishing Limited, ISBN: 9781783551712, 1783551712
5. Paul Barry, "Head First Python- A Brain Friendly Guide", SPD O'Reilly, 2nd Edition, ISBN:978-93-5213-482-3
6. Martin C. Brown, "Python: The Complete Reference", McGraw Hill Education, ISBN-10: 9789387572942, ISBN-13: 978-9387572942, ASIN: 9387572943
7. Jeeva Jose, P. Sojan Lal, "Introduction to Computing & Problem Solving with Python", Khanna Computer Book Store; First edition, ISBN-10: 9789382609810, ISBN-13: 978- 9382609810
8. Simulation with Arena by W.David Kelton, randall P. Sadowski, nancy B. Swets(Mc Graw Hill international edition)
9. MATLAB and SIMULINK for engineers by Agam Kumar Tyagi (Oxford University Press).
10. MATLAB and its Applications in Engineering by Raj Kumar Bansal, Ashok Kumar Goel, Manoj Kumar Sharma(Pearson India Education Services Pvt Ltd.)
11. Introduction to MATLAB programming toolbox and sumulink by Jaydeep Chakravorthy (University Press India Private Limited)

Assignments:

Assignments should be able to verify course outcome and skills of group work, communication skills. One assignment on each unit (total 6 assignments).

Syllabus for Unit Test:

Unit Test -1	UNIT – I, UNIT – II, UNIT - III
Unit Test -2	UNIT – IV, UNIT – V, UNIT - VI

Self study-I: Electrical Codes & Standards		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Theory: 04 Hours/Week	End Semester Examination: 60 Marks	Credits : 04
	Continuous Assessment: 40 Marks	

Course Pre-requisites:		
The Students should have prior knowledge of		
	Standard values needed for better working of electrical power systems	
Course Objectives:		
	Understand the Basics of Electrical Codes & Standards for electrical power systems	
Course Outcomes:	After learning this course students will be able to	
1	Understand the Basics of Electrical Codes & Standards	
2	Understand the recommended standards for Transformers, Earthing & hazardous areas	
3	Understand the Electrical Codes & Standards for Lighting & Side flashes	
4	Understand the Electrical Codes & Standards for Illumination, Lift and escalators.	
5	Understand the Electrical Codes & Standards for Power distribution, conductors, cables	
6	Understand the Electrical Codes & Standards for Electrical Installation & hardware material used in distribution networks	
UNIT – I	**INTRODUCTION to Electrical Codes & Standards**	**(08 Hours)**
	Basics of Electrical Codes & Standards, Standard values, International system of units, electrical units & their equivalents, , Summary of Indian Electricity rules, degree of protection for electrical equipment, Insulating materials	
UNIT - II	**Transformers:**	**(08 Hours)**
	Recommended sizes of cables on secondary side (for 11kv.0.433 transformers manufactured as per IS:2026-1977).Dieelctric strength of transformer oil as per IS:1866-1978**.** Testing of transformers as per BS 171. **Earthing:** Extracts of IS:3043-Electrical shocks & fire hazards, IS:5216-Dos & Donts. **Hazardous areas:** Electrical Installations in Hazardous areas (abstract from National Electric code-1985 and STEC 7 recommendations)	
UNIT -III	**Lighting & Side flashes**	**(08 Hours)**
	Protection of buildings & Allied structures against lighting: Protection of buildings & Allied structures against lighting (Extracts from IS:2309 and STEC 7 recommendations). standard clearances of electrical lines as per BS:162-1961 and BS:159-1957 **Lighting:** Introduction, recommended type of lighting protection system, recommended materials for component parts for lighting protection system , minimum dimensions of component parts of lighting protective system, recommendation as per IS:2309-1989 and STEC for buildings. **Side flashes:** Introduction, Recommendation as per IS:2309-1989 and STEC	

UNIT -IV	**Illumination, Lift and escalators.**	**(08 Hours)**
	Illumination: Introduction, Recommended values of illumination for different parts of domestic dwelling, glare index for commercial building,hospitals,hotels,assembly halls,cienemas,art galleries, sports buildings,industrial buildings, recommendation for mounting heights of luminaries. Illumination of roads & electrical installations (extracts from national electric code). **Lift and escalators:** Introduction, Bureau of standards on lifts and escalators.	
UNIT - V	**Power distribution, conductors, cables,**	**(08 Hours)**
	Power distribution: Tubular steel poles for overhead power lines (extracts from IS;2713 - Part I to III – 1980. **Conductors:** Technical specifications as per IS:7098(1)-1988, IS:398(Part IV) 1994. **Cables:** Heavy duty-insulated power cables manufactured as per IS:692-1973, Household cables as per IS:694-1990, Household cables as per BS:2004-1961	
UNIT -VI	**Electrical Installation & hardware material used in distribution networks**	**(08 Hours)**
	Electrical Installation: Design of electrical power installation as per IEC 364 standards. **Hardware material used in distribution networks:** Dimensions, normal weights etc for steel tubes(specidfications as per IS:1239(partI)-1979 & speicifications BS:1387-19670, Tolerance on diameter of black enameled MS conduit pipes as per IS:9537(PartII)1981	

Term Work:

The term work shall consist of record of minimum eight experiments and not limited to following topics:

1. Reading, understanding and checking practically Electrical Codes & Standards for **Transformers** at University campus/industrial organizations .
2. Reading, understanding and checking practically Electrical Codes & Standards for **Earthing locations** in University campus/industrial organizations.
3. Reading, understanding and checking practically Electrical Codes & Standards for **Protection of buildings & Allied structures against lighting** in University campus/industrial organizations.
4. Reading, understanding and checking practically Electrical Codes & Standards for **Illumination facilities** in University campus/industrial organizations.
5. Reading, understanding and checking practically Electrical Codes & Standards for **Lifts** in University campus/industrial organizations.
6. Reading, understanding and checking practically Electrical Codes & Standards for **Power distribution, conductors, cables** in University campus/industrial organizations.
7. Reading, understanding and checking practically Electrical Codes & Standards for **Electrical Installation & hardware material used in distribution networks** in University campus/industrial organizations.
8. Reading, understanding and checking practically Electrical Codes & Standards for **Hazardous areas if any** in University campus/industrial organizations.

Text Books:

1. Gorti Ramamurthy, Handbook of Electrical Power Distribution, University press, Second edition

Reference Books:

1. Frederic P Hartwell, National Electrical Code 2020 Handbook, Mc graw hill, 30th edition
2. Alonzo Robert J, Electrical Codes, Standards, Recommended Practices and Regulations , William Andrew Publishing, English- Hardcover

3. https://www.bis.gov.in/ , Bureau of Indian Standards (BIS) Catalogues , Year Of Publication: 2013 & 2023 4. National Electric code 2011 & 2016, Government of India (https://law.resource.org/pub/in/bis/S05/is.sp.30.2011.pdf) 5. Guide For Using National Building Code Of India 2016, Bureau Of Indian Standards (https://cpwd.gov.in/Publication/Booklet-Guide-for-Using-NBC-2016.pdf) 6. The Indian Electricity Rules,1956 (https://www.dgms.net/IErules1956.pdf) 7. NESC Handbook (sixth edition) - National Electrical Safety Code Handbook,IEEE, (https://ieeexplore.ieee.org/servlet/opac?punumber=4670086), 2007	
Unit Test:	
Unit Test -1	UNIT – I, UNIT – II, UNIT - III
Unit Test -2	UNIT – IV, UNIT – V, UNIT - VI

Self study-II: Industrial Safety Practices		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS:**
Theory: 04 Hours/Week	End Semester Examination: 60 Marks	Credits : 04
	Continuous Assessment: 40 Marks	

Course Pre-requisites:

Students should have basic knowledge of safety practices

Course Objectives:

1. To make students aware about the hazards while working in industry and respond appropriately in an emergency.
2. To help prevent workplace injuries, illnesses and fatalities.
3. To reduce and remove existing dangers to improve working conditions.

Course Outcomes:

Students are expected to:

1	To understand importance of safety
2	To understand process safety management
3	To evaluate safety in hazardous area
4	To apply the knowledge of Industrial safety engineering
5	To review of IE rules and acts and their significance
6	To analyse case studies on Industrial Safety Practices

Topics covered

UNIT - I	**Importance of Safety:** Health and environment. Health safety and environmental policy, fundamentals of safety, classification of accidents, Managements responsibility, objectives of safety management, National safety council, Employees state insurance act 1948, approaches to prevent accidents, principles of safety management, safety organization, safety auditing, maintenance of safety, measurements of safety performance, industrial noise and noise control, Industrial Psychology, Industrial accidents and prevention.	**(08 Hours)**
UNIT - II	**Process safety management:** Process safety management, legal aspects of safety, safety with respect to plant and machinery, the explosive act 1884, Petroleum act 1934, personal protective equipment, classification of hazards, protection of respiratory system, work permit system, hazards in refineries and process plants, safety in process plants, pollution in some typical process industry. Safe working practices, housekeeping, safe working environment, safety device and tools, precaution in use of ladders, safety instruction during crane operation, safety instruction for welding, burning and cutting and gas welding equipment, electrical safety, case studies, safety in use of electricity, electric shock phenomena, occurrence of electric shock, medical analysis of electric shock and its effect, safety procedures in electric plants, installation of Earthing system.	**(08 Hours)**
UNIT - III	**Safety in hazardous area:** Hazard in industrial zones, classification of industrial Enclosures for gases and vapors. Mechanical, Chemical, Environmental and Radiation hazards, Machine guards and safety devices, slings, load limits, lifting tackles and lifting equipment, hydrostatic test, Chemical hazards, industrial toxicology, toxic chemicals and its harmful effects on humans, factors influencing the effect of toxic materials, Units of concentration, control measure, environmental hazards, devices for measuring radiation, safety analysis and risk analysis, risk management, First aid, Safety measures to avoid occupational diseases.	**(08 Hours)**

UNIT -IV	**Industrial Safety Engineering:** Industrial Lighting : Purpose of lighting, Uses of good illumination, recommended optimum standards of illumination, Design of lighting installation, Standards for lighting and colour. Vibration and Noise : Activities related to vibrations, its impact on human health, abatement Sources, effects of noise on man, Measurement and evaluation of noise, Silencers, Practical aspects of control of noise. Safety at various Industries: Agro-Industry, Sugar Industry, Textile Industry etc.	**(08 Hours)**
UNIT-V	**Review of IE rules and acts and their significance**:	**(08 Hours)**
	Objective and scope –ground clearances and section clearances – standards on electrical safety - safe limits of current, voltage –Rules regarding first aid and fire fighting facility. The Electricity Act, 2003.	
UNIT-VI	**Case studies on Industrial Safety Practices:** Case studies in various industries like: Processing industry, Hazardeous material industry, Engineering applications industry etc	**(08 Hours)**

Practicals:

List of Practical's to be performed in the laboratory:

1. Demonstration and training of how to use breathing apparatus,
2. Demonstration and training of Emergency evacuation drill,
3. Train students how to rescue employees using emergency rescue equipments inside confined space.
4. With the help of gas detector train students check the level of oxygen and other, Gases in industries,
5. Training of using of windo meter to measure speed level of wind,
6. Train students use noise level meter and find out different level of noise of different equipments and teach them how to be safe,
7. Train students how to use personal protective equipment ,
8. First Aid training and demonstration.

Project based learning:

1. Study of Home And Industrial Safety Using Fire And Gas Detection System kit/system
2. Industrial IoT Safety project (IIOT): Industrial Internet of Things using Arduino & ESP8266
3. Study of Anti-Collision Light : LGKT017 Simple Circuit Project
4. Study of First Aid Kits & Construction Safety
5. Study of Personal Protective Equipment (PPE) Kit for industry
6. Study of Electrical Safety Kit for industry
7. Case studies on – Learning industrial Safety through films/Videos
8. Case studies on – Learning industrial Safety through posters/charts
9. Case studies on – Learning industrial Safety through periodicals, research publications
10. Conducting electric safety audit of any institute/Engineering college
11. Conducting power quality audit of any institute/Engineering college
12. Auto power supply control from 4 different sources
13. Over Voltage/Under Voltage Electrical Appliance Protector
14. ATM Machine Gate Security System
15. Do-it-yourself intelligent camera

Note: The term work shall be the record of minimum eight experiments performed from the above list.

Project based learning: Student shall demonstrate minimum one concept based on syllabus topic.

Reference Books:

1. Industrial safety management By: L.M. Deshmukh Publishers: Tata McGraw Hill ,New Delhi Year: 2006 Edition: First
2. Industrial safety health and environment Management system By: R.K. Jain & Sunil S. Rao Publishers: Khanna Publishers Year: 2008 Edition: Second

Unit Test:

Unit Test -1	UNIT – I, UNIT – II, UNIT - III
Unit Test -2	UNIT – IV, UNIT – V, UNIT - VI

BHARATI VIDYAPEETH
(DEEMED TO BE UNIVERSITY), PUNE

Faculty of Engineering And Technology
M.Tech. Electrical Engineering
Old Syllabus

BHARATI VIDYAPEETH
(DEEMED TO BE UNIVERSITY) Pune.

Faculty of Engineering & Technology
Programme: M. Tech. (Electrical) (2015 Course)
Course Structure & Syllabus
(Choice based credit systems-2015)
M. Tech (Electrical)
Semester I to IV

Vision of the Institute
To be World Class Institute for Social Transformation through Dynamic Education

Mission of the Institute

- To provide quality technical education with advanced equipments, qualified faculty members, infrastructure to meet needs of profession and society.
- To provide an environment conducive to innovation, creativity, research and entrepreneurial leadership.
- To practice and promote professional ethics, transparency and accountability for social community, economic and environmental conditions.

Vision of the Department:

To develop electrical engineers with professional skills to suit global needs.

Mission of the Department:

- To provide quality education through blend of core and interdisciplinary courses with industry-institute interaction.
- To provide an environment conducive to develop and implement new ideas in engineering and technology.
- To practice and promote interpersonal and leadership skills to work with commitment for social responsibilities

Program Specific Objectives (PSOs)

- **PSO 1:** Able to apply fundamental knowledge of Electrical Engineering to identify, formulate and investigate real time problems of electrical sector and allied fields.

- **PSO 2:** Analyze, design and integrate Electrical systems using modern tools and techniques in electrical sector and create passion for life-long learning and research in advanced fields.

Program Outcomes (POs)

After completing the electrical engineering programme the students will be able to:

1. Apply knowledge of mathematics, basic science and engineering fundamentals to solve complex problems in electrical engineering.
2. Identify problem in electrical systems based on available data and interpret the results.
3. Design electrical systems that meet specified needs with safety considerations.
4. Design and conduct experiments, analyze and interpret data.
5. Use modern electrical engineering softwares and tools.

6. Create awareness of electrical engineering solutions for social benefit considering current and upcoming tools / technologies.
7. Understand the impact of engineering solutions in a global, economic, environmental context.
8. Demonstrate ethics and professional abilities.
9. Work effectively as an individual and as a member in a diverse team.
10. Communicate effectively in both written and verbal form.
11. Demonstrate knowledge and understanding of engineering and management principles for execution of projects.
12. Recognize the need and ability to learn technological changes.

Programme Educational Objectives (PEOs)

The M. Tech Electrical Engineering Programme is preparing the graduates:

PEO 1: To develop professional skills in students to provide solution to problems in electrical and allied fields.

PEO 2: To develop students with conducive learning attitude for lifelong learning.

PEO3: To demonstrate behavioral skills and ethics.

Proposed Structure of M. Tech Electrical Engineering (Power Systems)
CBCS Pattern (2015-16)

STRUCTURE&EXAMINATIONPATTERN

SemesterI									**TotalDuration:20 hrs/week** **TotalMarks:500** **TotalCredits:18**		
Subjects	**Teaching Scheme(Hrs) Hrs./Week**		**ExaminationScheme (Marks)**						**Examination Scheme (Credits)**		**Total Credits**
	L	**P**	**Theory**	**Unit Test**	**Attendance**	**Tutorial/assignments**	**TW**	**Pract/ Oral**	**TH**	**TW/PR /OR**	
Research Methodology	04	--	60	20	10	10	-	--	04	-	04
FACTS and HVDC	04	--	60	20	10	10	-	--	04	-	04
Advanced Microcontroller & Its Applications	04	02	60	20	10	10	25	25	04	01	05
Power System Modeling	04	02	60	20	10	10	25	25	04	01	05
Total	**16**	**04**	**240**	**80**	**40**	**40**	**50**	**50**	**16**	**02**	**18**

SemesterII									**TotalDuration:20 hrs/week** **TotalMarks:500** **TotalCredits:18**		
Subjects	**Teaching Scheme(Hrs) Hrs./Week**		**ExaminationScheme (Marks)**						**Examination Scheme (Credits)**		**Total Credits**
	L	**P**	**Theory**	**Unit Test**	**Attendance**	**Tutorial/ assignments**	**TW**	**Pract/ Oral**	**TH**	**TW/PR/ OR**	
Power Systems Dynamics	04	--	60	20	10	10	--	--	04	-	04
Digital Protection of Power System	04	02	60	20	10	10	25	25	04	01	05
PLC& SCADA	04	02	60	20	10	10	25	25	04	01	05
Elective-I	04	--	60	20	10	10	--	--	04	--	04
Total	**16**	**04**	**240**	**80**	**40**	**40**	**50**	**50**	**16**	**02**	**18**

SemesterIII									**TotalDuration:28hrs/week TotalMarks:500 Total Credits: 40**		
Subject	**Teaching Scheme(Hrs) Hrs./Week**		**ExaminationScheme**						**Examination Scheme (Credits)**		**Total Credits**
	L	**P**	**Theory**	**Unit Test**	**Attendance**	**Tutorial/ assignments**	**TW**	**Pract/ Oral**	**TH**	**TW/PR /OR**	
Power QualityIssues	04	02	60	20	10	10	25	25	04	01	05
Elective–II	04	02	60	20	10	10	25	25	04	01	05
Self-Study Paper-I	04	--	60	20	10	10	-	-	04	-	04
Dissertation Stage –I	-	07	-	-	---	--	25	25		21	21
Seminar	-	05	-	-	--	--	25	25	-	05	05
Total	**12**	**16**	**180**	**60**	**30**	**30**	**100**	**100**	**12**	**28**	**40**

Elective–I	**Elective- II**
a) PowerSectorRestructuring&Deregulation b) Powersystemplanning&reliability	a) AdvancedControlsystem b) AdvancedPowerElectronics&Drives

SemesterIV									**TotalDuration:14 hrs/week TotalMarks:325 Total Credits: 34**		
Subject	**Teaching Scheme(Hrs) Hrs./Week**		**ExaminationScheme**						**Examination Scheme (Credits)**		**Total Credits**
	L	**P**	**Theory**	**Unit Test**	**Attendance**	**Tutorial /assignments**	**TW**	**Pract/ Oral**	**TH**	**TW/PR/OR**	
Self-Study Paper-II	04	--	60	20	10	10	-	-	**04**	**-**	**04**
Dissertation Stage –II	-	10	-	-	--	-	150	75		30	30
Total	**04**	**10**	**60**	**20**	**10**	**10**	**150**	**75**	**04**	**30**	**34**

ListofSelfStudypaperI&II

SelfStudyPaperI	**SelfStudyPaperII**
ConditionMonitoringofElectricalEquipments	ElectricalPowerCapacitors
EnergyStorageDevices	Nanotechnology&itsapplicationsinElectrical Engineering
DigitalMeasurementTechniques	Highvoltageinsulationsystem&design
EnergyConservation&Audit	Useofsynchronizedmeasurementtechniquesin powersystem
SolarPV&Windenergysystems	DistributedGeneration
Demandresponse&demandsidemanagement	SmartGrid-AutomationSystemforState TransmissionUtility
DigitalSignalProcessingApplicationsinPower Systems	Substationdesign

RESEARCHMETHODOLOGY			
TEACHINGSCHEME:		**EXAMINATIONSCHEME:**	**CREDITS ALLOTTED:**
Theory:04Hours/Week		EndSemesterExamination:60 Marks	04 Credits
		ContinuousAssessment:40Marks	

UNIT-I	**Fundamentals**	**(08Hours)**
	Definition,ResearchCharacteristics,ResearchNeed,Objectivesandtypesof research, Motivation and objectives – Research methods vs Methodology, Typesofresearch–Descriptivevs.Analytical,Appliedvs.Fundamental, Quantitativevs.Qualitative,Conceptualvs.Empirical	
UNIT-II	**Formulationofresearchproblem**	**(08Hours)**
	ResearchFormulation–Definingandformulatingtheresearchproblem- Selecting the problem -Necessity of defining the problem - Importance ofliteraturereviewindefining aproblem–Literaturereview–Primary and secondarysources – reviews, treatise, monographs-patents – web as a source – searching the web - Critical literature review – Identifying gap areas from literaturereview- Developmentofworkinghypothesis.SummarizingaTechnicalPaper - summarytemplate,Onlinetools -Google,CiteSeer,ACM DigitalLibrary,IEEE,Theon-lineComputerScience bibliography, Searchingpatents	
UNIT-III	**Researchdesignmethods**	**(08Hours)**
	Research design, sampling design and scaling techniques – Research design– Basic Principles- Need of research design — Features of good design – Important concepts relating to researchdesign, basic principles of experimentaldesigns,implicationsofsampledesign,stepsinsampledesign, criteria of selecting sampling procedure, characteristics of good sampling design,differenttypesofsampledesign.Scalingtechniques:measurement scales, sources of error,technique of developing measurement tool, important scaling techniques, scale construction techniques.	
UNIT-IV	**Statisticalanalysis**	**(08Hours)**
	Data Collection and analysis:- Observation and Collection of primary and secondarydata -Methodsofdatacollection,processingoperations,types of analysis, statistics in research,measures of central tendency, measures of dispersion, measures of asymmetry, measures ofrelationships, simple regression analysis, multiple correlation and regression, partial correlation.	
UNIT-V	**ResearchPaper&Thesiswriting**	**(08Hours)**
	Reportingandthesiswriting–Structureandcomponentsof scientificreports - Types of report – Technical reports and thesis – Significance – Different steps in the preparation – Layout,structure and Language of typical reports – Illustrations and tables - Bibliography, referencingand footnotes - Oral presentation – Planning – Preparation –Practice – Making presentation –	

	Useofvisual aids - Importanceofeffectivecommunication - Documentation and presentationtools: LATEX.Types of technical papers - Journal papers, Conference papers, Survey papers, Poster papers, Review papers Comparison, Structure of a survey, conference and journal paper, Organizationandflowofthesis/Projectreport,Researchproposal: preparation, budgeting, presentation, funding agencies for engineering research,	
UNIT-VI	**Researchethics,IPRandpublishing**	**(08Hours)**
	Ethics:ethical issues. IPR: intellectual property rights and patent law, techniques of writing a Patent, filing procedure, technology transfer, copy right, royalty, traderelated aspects of intellectual property rights Publishing: design of research paper,citationandacknowledgement,plagiarismtools,reproducibilityand accountability.	

TextBooks:

1.Kothari,C.R.,ResearchMethodology:MethodsandTechniques.NewAgeInternational

2.Garg,B.L.,Karadia,R., Agarwal,F.and Agarwal,U.K.,AnintroductiontoResearch Methodology,RBSAPublishers

3.SureshSinha,AnilKDhiman,ResearchMethodology,ESSPublications,Volumes2

4.DayR.A.,HowtoWriteandPublishaScientificPaper,CambridgeUniversityPress

5.Wadehra, B.L. Lawrelatingtopatents,TradeMarks,copyrightdesigns and geographical indications.UniversalLawPublishing

ReferenceBooks:

1.LouisCohen, LawrenceManionandKeithMorrison,ResearchMethodsinEducation,7th Edition,CambridgeUniversityPress,ISBN –978-0415-58336-7

2. Anthony,M.,Graziano,A.M.andRaulin,M.L.,ResearchMethods:AProcessof Inquiry,AllynandBacon

3. RanjitKumar,ResearchMethodology:AStepbyStepGuidefor Beginners,2ndEdition, APHPublishingCorporation

4.Leedy,P.D.andOrmrod, J.E.,PracticalResearch: PlanningandDesign,PrenticeHall

5. Fink,A.,ConductingResearch LiteratureReviews:FromtheInternettoPaper.Sage Publications

6.Leslie Lamport, 'Latex:Adocumentpreparation system'AddisonWesley,Reading, Massachusetts,second

SyllabusforUnitTest:	
UnitTest-1	UNIT–I,UNIT –II,UNIT-III
UnitTest-2	UNIT–IV,UNIT –V,UNIT-VI

FACTS& HVDC		
TEACHINGSCHEME:	**EXAMINATIONSCHEME:**	**CREDITSALLOTTED:**
Theory:04Hours/Week	EndSemesterExamination:60Marks	04 Credits
	ContinuousAssessment:40Marks	

UNIT-I	**FACTS:**	**(08Hours)**
	Conventional methods to increase transmission capacity, Series, Shunt reactors, Phase shifting transformers, Synchronous condensers, Flexible AC transmission controllers Basics, Challenges and needs, Static Power converter structures, AC controller based structures, DC link converter topologies,Converteroutputandharmoniccontrol,Powerconverter controlissues	
UNIT-II	**ShuntandSeriesCompensation:**	**(08Hours)**
	Operation and control of thyristor controlled reactor, Thyristor switched Capacitor, SVC, STATCOM configuration and control, Applications of SVC, Power oscillation damping, Mitigation of sub-synchronous resonance,TCSCoperation,Layoutandprotection,Applicationsof TCSC,StaticSynchronousSeriesCompensator(SSSC)	
UNIT-III	**UnifiedPowerFlow Controller:**	[08Hrs]
	UPFC configuration, Independent real and reactive power flow control, Control scheme for UPFC, Basic control system for P and Q control, Dynamic performance, Operational constraints of UPFC, Power flow studies in UPFC embedded systems	
UNIT-IV	**GeneralBackgroundofHVDCTransmission:**	**(08Hours)**
	EHV AC versus HVDC Transmission, Different configurations of HVDC link - Monopolar, Bipolar, Back to Back, Power flow through HVDC link, Equation for HVDC power flow, Connections of three phase six pulse and twelve pulse converter bridges, Voltage and current waveforms.Effectofdelayangle,Extinctionangle,Overlapangle, ControlofDCvoltage	
UNIT-V	**MultiTerminalHVDC:**	**(08Hours)**
	BipolarHVDCterminal, Convertertransformerconnections, Switching arrangements in DC yard for earth return to metallic return, HVDC switchingsystem,SwitchingarrangementsinabipolarHVDCterminal, Sequence of switching operations, HVDC circuit breakers, DC current interruption,Commutationprinciple,Probabletypesandapplicationsof HVDC circuit breakers, Multi-terminal HVDC systems, Parallel tapping, Reversal of power, Configurations and types of multi-terminal HVDCsystems,Commercialmultiterminalsystems	
UNIT-VI	**ProtectionandControl:**	**(08Hours)**
	Faults and abnormal condition in bipolar, Two terminal HVDC system, Pole-wise segregation, Protective zones, Clearing of DC line faults and reenergizing, Protection of converters, Transformer, Converter valves, DCyards,Integrationofprotectionandcontrols,Hierarchicallevelsof control,Blockdiagram,Schematicdiagram,Currentcontrol,Power	

	control,DCvoltagecontrol,Commutationchannel,Mastercontrol, Stationcontrol,Leadstation,Trailstation,Polecontrol,Equidistant firing control, Synchronous HVDC link, Asynchronous HVDC Link	

TextBooks:
1.E.Acha,V.A.Agelidis,O.Anaya-laraandTJEMillerNewnes,PowerElectroniccontrolin ElectricalSystems Oxford.
2.N.G.HingoraniandL.Gyugi,UnderstandingFACTS-IEEEPress,New York.
3.J.Arrilaga,Y.H.LiuandN.R.Watson,FlexiblePowerTransmission-TheHVDCOptions,
JohnWileyandsonsLtd.,NewYork.
ReferenceBooks:
1.T JEMiller, "ReactivePowerControlin ElectricSystems",John Wiley
2. PadiyarKR"FACTSControllersinPowerTransmission&Distribution",NewAge.
3. R.MohanandR.K.Varma,"Thyristor-BasedFACTSControllersforElectricalTransmission Systems",IEEEPress.

SyllabusforUnitTest:	
UnitTest-1	UNIT–I,UNIT–II,UNIT–III
UnitTest-2	UNIT–IV,UNIT–V,UNIT–VI

AdvanceMicrocontrollersandapplications

TEACHINGSCHEME:	**EXAMINATIONSCHEME:**	**CREDITSALLOTTED:**
Theory:04Hours/Week	EndSemesterExamination:60Marks	04 Credits
	ContinuousAssessment:40Marks	
	TW&OR:50 Marks	01 Credits

UNIT-I	IntroductiontoPIC16F8XXfamilyanddevelopmenttools.CPU architectureandinstructionset.Harvardarchitectureandpipelining, programmemoryconsiderations,registerfilestructureandaddressing modes, CPU registers.	(08Hours)
UNIT-II	PICperipherals I/Oports,externalinterruptsandtimers,timeroperation,ADC,short overview of synchronous serial port, serial peripheral interface I2C bus.	(08Hours)
UNIT-III	Learning MPLAB (V 5.0 or above) Integrated development environmentfromMicrochip(Assemblerandsimulator),Studyof applications like motor control, temperature control, lamp dimmer, 4X4 matrix keyboard and LCD interfacing etc.	(08Hours)
UNIT-IV	ARM & AVR Processors : RISC, ARM design philosophy, ARM fundamentals, instruction set, thumb instruction set, exception & interrupthandling, efficientCprogramming,optimizingARMassembly code,AVRarchitecture,instructionset,hardwareinterfacing, communicationlinksanddesignissues.	(08Hours)
UNIT-V	Interfacing considerations: Intel process communication, synchronizationofprocesses,tasks, threads, devices & buses for networks,hardware-softwareco-designembeddedprogrammingin C/RT Linux	(08Hours)
UNIT-VI	Real time operating systems: Survey of software architectures- round robin, with interrupts, function queue scheduling, RTOS architecture, selecting an architecture, task states, task and data semaphores and shared data, message queues, mailboxes ,pipes, timer functions, events, memorymanagement,interruptroutinesin anRTOSenvironment,basic designusingRTOS,embeddedsoftwaredevelopmenttools,Micro C/OS-II,VXworks.	(08Hours)

ReferenceBooks:

1. MicrochipPICfamilyMicrocontrollerhandbook
2. DesignwithPICmicrocontrollers–JohnPeatman,PearsonEducationAsia,LPE
3. Rajkamal,''Embeddedsystem–architecture,programminganddesign",TMHPublication, edition2003
4. DavidSimon,"AnembeddedsoftwarePrimer",Pearsoneducation, Asia
5. JonathanW.Valvano,Brooks,Cole"EmbeddedMicrocomputersystems-Realtime interfacing"ThomsonLearning

SyllabusforUnitTest:	
UnitTest-1	UNIT–I,UNIT–II,UNIT–III
UnitTest-2	UNIT–IV,UNIT–V,UNIT–VI

PowerSystemModeling			
TEACHINGSCHEME:		**EXAMINATIONSCHEME:**	**CREDITSALLOTTED:**
Theory:04Hours/Week		EndSemesterExamination:60Marks	04Credits
		ContinuousAssessment:40Marks	
		PR&OR:50Marks	01Credits
UNIT– I	**ModelingofNon-ElectricalParameters:**		**(08Hours)**
	Differentareasofpowersystemanalysis,Needformathematicalmodelingof powersystem,Simplifiedmodelsofnon-electricalcomponentssuchasboiler,steam&hydroturbine,governorsystem		
UNIT– II	**ModelingofTransformers:**		**(08Hours)**
	Transformermodelingfortwowindingtransformer,tap-changer,phaseshifting transformer,threewindingtransformerandauto-transformer		
UNIT– III	**ModelingofTransmissionLine:**		**(08Hours)**
	Modelingoftransmissionnetwork,TransformationtoAlpha-Betacomponents usingD-Qcomponents,Steadystateequations		
UNIT– IV	**SynchronousMachineModeling:**		**(08Hours)**
	Introduction, Park's Transformation, Flux Linkage Equation, Voltage Equations, FormulationofState-SpaceEquation,CurrentFormulation,PerUnitConversion,NormalizingVoltageequations,NormalizingTorqueEquations,Torque&Power EquivalentCircuitofSynchronousMachine		
UNIT– V	**ExcitationSystemModeling:**		
	Typesofexcitationsystems,Controlandprotectivesystems,Modelingofexcitationsystems(excitationsystemcomponentsandentireexcitationsystem, VoltageResponseRatio,Excitervoltageratings		**(08Hours)**
UNIT– VI	**LoadModeling:**		
	BasicLoadModelingconcepts,Staticloadrepresentation,Dynamicloadrepresentation,Inductionmotor(asload)modeling,synchronousmotor(asload) modeling,acquisitionofloadmodelparameters		**(08Hours)**
TextBooks:			
1.K.'.Padiyar",PowerSystemDynamics",B.S.Publications			
2.JohnJ.Granier&W.D.StevensonJr.,"PowerSystemAnalysis",4th Edition,McGrawHillInternational StudentEdition			
3. OlleElegard,"ElectricalEnergySystemTheory-AnIntroduction",TMHPublishingCompany,2nd Edition			
4. Kundur,"PowerSystemDynamics&Control",IEEEPress,NewYork			
ReferenceBooks:			
1.Anderson&Foud,"PowerSystemControl&Stability",Vol-I,IEEEPress,NewYork			
2.P.S.'Murthy,"PowerSystemOperation&Control"			
SyllabusforUnitTest:			
UnitTest-1		UNIT– I,UNIT–II	
UnitTest-2		UNIT–III,UNIT– IV	
UnitTest-3		UNIT–V,UNIT-VI	

PowerSystemDynamics		
TEACHINGSCHEME:	**EXAMINATIONSCHEME:**	**CREDITSALLOTTED:**
Theory:04Hours/Week	EndSemesterExamination:60Marks	04Credits
	ContinuousAssessment:40Marks	

UNIT-I	**ClassicalMethodsofPowerSystemDynamicStudies**	**(08Hours)**
	Equalityandinequalityconstraintsinpowersystemoperation,statetransitiondiagram,conceptofsystemsecurityandstability,classicalmodelofsystemofonemachineconnectedtoinfinitebus,Clarkdiagramfortwomachinesseriesreactancesystem,extensionofClarkdiagramtocoveranyreactancenetwork, elementarymodelofoverallpowersystem	
UNIT-II	**SmallSignalStability:**	**(08Hours)**
	Smallsignalanalysis,analysisofsynchronizing&dampingtorque,stateequationforsmall signalmodel,Simplifiedsynchronousmachinemodel,calculationofinitialconditions,systemsimulation,improvedmodelofsynchronousmachine,small signalstabilityofmultimachinesystem	
UNIT-III	**LargeSignalAnalysis:**	**(08Hours)**
	Elementaryviewoftransientstability,Largesignalanalysis,Analysisusing numerical integration methods (Modified Euler's, Runge-Kutta),Simulationofpowersystemdynamicresponse,Analysisofunbalancedfaults,Casestudyofalargesystem	
UNIT-IV	**PowerSystemStabilizers:**	**(08Hours)**
	Basicconceptsofcontrolsignalsinpowersystemstabilizers(PSS),Structureand tuning,Fieldimplementation,PSSdesignandapplication,Futuretrends	
UNIT-V	**Multi-machinesystem:**	**(08Hours)**
	Simplifiedmodel,Improvedmodelofthesystemforlinearload,Inclusionofload andSVC,Introductiontoanalysisoflargepowersystem	
UNIT-VI	**Voltagestability:**	**(08Hours)**
	Definition,Factorsaffectingvoltagestability&collapse,Analysis&comparisonofangle&voltagestabilityandvoltageinstability&collapse,Controlofvoltageinstability,islanding-necessity,methods,advantagesanddisadvantages, implicationonpowersystemdynamicperformance	

TextBooks:

1. Anderson&Foud,"Power systemControl&Stability",IEEEpress,NewYork
2. OlleElgerd,"ElectricalEnergySystemTheory-An Introduction",TMH

ReferenceBooks:

1. KRPadiyar,"PowerSystemDynamics",BSPublications
2. PrabhaKundur,"PowersystemStability&control",TMH
3. C.W.Taylor,"PowerSystemVoltageStability", TMH
4. R.A.Walling,"DistributedGenerationIslanding",N.W.Miller

SyllabusforUnitTest:	
UnitTest-1	UNIT– I,UNIT–II,UNIT–III
UnitTest-2	UNIT– IV,UNIT–V,UNIT–VI

DigitalProtectionofPowerSystem			
TEACHINGSCHEME:		**EXAMINATIONSCHEME:**	**CREDITSALLOTTED:**
Theory:04Hours/Week		EndSemesterExamination:60Marks	04Credits
		ContinuousAssessment:40Marks	
		TW&OR:50Marks	01Credit
UNIT– I	**Introduction:**		**(08Hours)**
	NeedforPowersystemprotection,DigitalProtection:StateofArt,MeritsofMicroprocessor relayingscheme,PowerSystemComponents,BasicPhilosophyofProtectionScheme,Sectionof ProtectionScheme,CircuitBreakersandRelays,Types andApplications.ArchitectureofModernDigitalRelay		
UNIT-II	**StaticRelays:**		**(08Hours)**
	IntroductiontoStaticRelay,OvercurrentRelay,DistanceRelay,ProtectionSchemesoftransmissionlines,Switcheddistancerelay,Poly-phaserelay,RelayasComparator-DualinputComparator,Relaycharacteristicsbycomparisonofconstants,Multi-inputcomparator,PilotRelayingScheme		
UNIT-III	**ElementsofDigitalProtection:**		**(08Hours)**
	Basiccomponentsofadigitalrelay,Signalconditioningsubsystem:Transducers,Surgeprotectioncircuits,Analogfilteringandanalogmultiplexers,Conversionsubsystems,SamplingTheorem,Digitalfiltersignalaliasingerror,Sampleandholdcircuit,Digitalmultiplexing,Digitaltoanalogconversion,Analogtodigitalconversion,Digitalrelay subsystem,Digitalrelayasunit		
UNIT– IV	**DigitalProtectionofTransmissionLine:**		**(08Hours)**
	Protectionschemeoftransmissionline,DistanceRelay,Travellingwaverelays.Digitalprotectionschemebasedonfundamentalsignal:hardwaredesign,softwaredesign,DigitalprotectionofEHV/UHVtransmissionlinebasedontravellingwave phenomena,Newrelayingschemeusingamplitudecomparison		
UNIT– V	**DigitalProtectionofTransformerandSynchronousGenerator:**		**(08Hours)**
	FaultsinTransformer,SchemesusedforTransformerProtection,DigitalProtectionofTransformer FaultsinSynchronousgenerator,ProtectionschemesforSynchronousgenerator,DigitalProtectionofSynchronousGenerator		
UNIT– VI	**ArtificialIntelligenceinPowerSystemProtection:**		**(08Hours)**
	Introduction,AnExpertSystem(ES)forProtectiveRelaySettings:Introduction,ProblemDescription,ESApproach,TypicalApplication,FuzzyLogic(FL)forPowersystemProtection:Introduction,ProblemDescription,FLApproach,ArtificialNeutralNetwork(ANN)inPhaseSelection:Introduction,ProblemDescription,Measurementoffaultgeneratedinhighfrequencycomponents,ANNApproach		
TextBooks:			
1."DigitalProtection–ProtectiveRelayingfromElectro-MechanicaltoMicroprocessor"ByL.P.Singh.2nd Edition,Reprint-2004,NewAgeInternationalPublisher,New-Dehli.			
2."DigitalPowerSystemProtection"ByS.R.Bhide.PHILearningPrivateLimited,NewDelhi.			
3."ArtificialIntelligenceTechniquesinPowerSystems",ByKevinWarwick,AutherEkwue&RajAggarwal, Publication:InstitutionofElectricalEngineers,London,UK.			
4."DigitalProtectionforPowersystem"byA.TJohnsandS.K.Salman.PeterPeregrinusLtd.OfTheInstitute ofElectricalEngineers,London,UnitedKindom.			
5."SoftComputingTechniquesanditsApplicationsinElectricalEngineering"ByDr.Devendra Chaturvadi,			

Publication:Springer–VerlagBerlinHeidelburg.	
ReferenceBooks:	
1.“PowerSystemProtection4:DigitalProtectionandSignalling”editedbyETAElectricityTraining Association.PublishedbyInstituteofEngineers,London,UK.	
2.“DigitalSignalProcessinginPowerSystemProtectionandControl”ByWaldemarRebizant,JanuszSzafran,Andrzej Wiszniewski.	
SyllabusforUnitTest:	
UnitTest-1	UNIT– I,UNIT–II,UNIT-III
UnitTest-2	UNIT– IV,UNIT–V,UNIT-VI

PLCandSCADA		
TEACHINGSCHEME:	**EXAMINATIONSCHEME:**	**CREDITSALLOTTED:**
Theory:04Hours/Week	EndSemesterExamination:60Marks	04Credits
	ContinuousAssessment:40Marks	
	TermWork:50Marks	01Credits

UNIT–I	**Introductionto PLC**	**(08 Hours)**
	Definition&HistoryofPLC,OverallPLCsystem,PLCInputandOutputmodules,CPU,Interfaces,Powersupplies,PLCadvantagesanddisadvantages,SelectioncriteriaforPLC,ArchitectureofIndustrialAutomationSystems,ProcessControl,PIDControl,PredictiveControl,IntroductiontoSequenceControl,PLCsandRelayLadderLogic, Hardwareenvironment	
UNIT–II	**PLCProgramming**	**(08 Hours)**
	Programmingequipments,ConstructionofPLCladderdiagram,Basiccomponentsandsymbolsinladderdiagram,Ladderlogic,Functionalblock,Structuraltext,Instruction,troubleshooting,features,programmingON/OFFInputstoproduceON/OFFoutputs,NetworkingofSensors,ActuatorsandControllers:TheFieldbus,The FieldbusCommunicationProtocol	
UNIT–III	**PLCApplications**	**(08 Hours)**
	AnalogPLCoperation,PIDcontrolofcontinuousprocesses,simpleclosedloopsystems,closedloopsystemusingProportional,Integral&Derivative(PID),PLCinterface,MotorsControls:ACMotorstarter,ACmotoroverloadprotection,DC motorcontroller,Variablespeed(VariableFrequency)ACmotorDrive	
UNIT–IV	**SCADA**	**(08 Hours)**
	NeedofSCADAsystem,Features,SCADAarchitecture– Firstgeneration,Secondgeneration,Thirdgeneration,HMI,MTU,RTU,IED's, 7 Layers of OSI, Communication requirementsforSCADA(communicationprotocols– DNP,IEC,Ethernet,TCP/IP,Modbus,UDP),Client– Serverbasedcommunicationconcept,SCADABenefits	
UNIT–V	**SCADAinPowerSystem**	**(08 Hours)**
	Operationandcontrolofinterconnectedpowersystem,Automaticsubstationcontrol,SCADAconfiguration,EnergyManagementSystem(EMS),systemsecurity, Stateestimation,SCADAsystemsecurityissuesoverview	
UNIT–VI	**SupervisoryManagement**	**(08Hours)**
	NetworkedSCADAenvironmentwithimplementationexamples,SubstationAutomationandEquipmentconditionmonitoringusingSCADA,Distributionsystemdesignmapping,troublecallmanagement,Customerlevelintelligentautomation system,computerlevelmonitoringandcontrolofequipments	

TextBooks:

1.Terson,"PowerSystemControlTechnology",PrenticeHall

2.Green,J.N,Wilson,R,"ControlandAutomationofElectricPowerDistributionSystems",Taylorand Francis,2007

3.Turner,W.C,"EnergyManagementHandbook",5th Edition,2004

4.GaryDunning,"IntroductiontoProgrammableLogicControllers",Thomson,2nd Edition

5.JohnW.Webb,RonaldA.Reis,"ProgrammableLogicControllers:PrinciplesandApplication",5th Edition

6.StuartABoyer,"SCADAsupervisorycontrolanddataacquisition"

ReferenceBooks:	
1.Handschin,E.“EnergyManagementSystems”,SpringerVerlag,1990	
2.GordanClark,DeemReynders,“PracticalModemSCADA Protocols”	
SyllabusforUnitTest:	
UnitTest-1	UNIT–I,UNIT –II,UNIT-III
UnitTest-2	UNIT–IV,UNIT –V,UNIT-VI

(Elective–I)PowerSectorRestructuring&Deregulation		
TEACHINGSCHEME:	**EXAMINATIONSCHEME:**	**CREDITSALLOTTED:**
Theory:04Hours/Week	EndSemesterExamination:60Marks	04Credits
	ContinuousAssessment:40Marks	

UNIT-I	**PowerSectorinIndia** IntroductiontovariousinstitutionsinanIndianPowersectorsuchasCEA,PlanningCommissions,PGCIL,PFC,MinistryofPower,StateandCentralgovernments,REC,LoadDispatchCenters,Utilities andtheirroles.Criticalissues/challengesbeforetheIndianpowersector,Electricityact2003-ProvisionintheGeneration,Transmission&Distribution Sector,Variousnationalpoliciesandguidelinesunderthisact.	**(08 Hours)**
UNIT-II	**FundamentalsofEconomics&PowerSectorRegulation** FundamentalsofeconomicsapplicabletoPowerSector,Consumerbehavior,Supplierbehavior, MarketEquilibrium,Short-run&Long-runcosts,Variouscostsofproduction-Totalcost(TC),Averagefixedcost(AFC),Averagevariablecost(AVC),Averagecost(AC)andMarginalcost(MC),Relationshipbetweenshort-runandlong-runaveragecosts,Perfectlycompetitivemarket,Conceptoflifecyclecost,Annualrateofreturn, methodsofcalculationsofInternalRateofReturn(IRR)andNetPresentValue(NPV)ofproject,Roleofregulationandevolutionofregulatorycommissioninindia,Typesandmethodsof economicregulation,RegulatoryprocessinIndia.	**(08 Hours)**
UNIT-III	**PowerTariff** Differenttariffprinciples(marginalcost,costtoserve,averagecost), Consumertariffstructuresandconsiderations,differentconsumercategories,telescopictariff, fixedandvariablecharges,timeofday,interruptibletariff,anddifferenttariffbasedpenaltiesandincentivesetc.,Subsidyandcrosssubsidy,lifelinetariff,Comparisonofdifferenttariffstructuresfordifferentloadpatterns.Governmentpoliciesinforcefrom timetotime.Effectofrenewableenergyandcaptivepowergenerationontariff,Availabilitybasedtariff,Latestreformsandamendments	**(08 Hours)**
UNIT-IV	**Powersectorrestructuringandmarketreform** Introductiontopowersectorrestructuring,Reasonsforrestructuring/deregulationofpowerindustry,Understandingtherestructuringprocess-Entitiesinvolved,Thelevelsofcompetition,Themarketplacemechanismsand Sector-wisemajorchangesrequired,Differentindustrystructuresandownershipmodels,Marketmodelsbasedoncontractualarrangements-MonopolyModel,SinglebuyerModel,WholesalecompetitionmodelandRetailcompetitionmodel,Marketarchitecture,Timelineforvariousenergymarkets,Bilateral/forwardcontracts,Thespotmarket,Modelsfortradingarrangements,ISOorTSOmodel,Reasonsandobjectivesofderegulationofvariouspowersystemsacrosstheworld-TheUS,TheUK,TheNordicPoolandThedevelopingcountries.Congestion Management,AncillaryServices	**(08 Hours)**

UNIT-V	**ElectricityMarketsPricingandNon-priceissues** Electricitypricebasics,MarketClearingprice(MCP),ZonalandlocationalMCPs,Dynamic,spotpricingandrealtimepricing,Dispatchbasedpricing,Powerflowsandprices.OptimalpowerflowSpotpricesforrealandreactivepower.Unconstrainedrealspotprices,constrainsandrealspotprices.Nonpriceissuesinelectricityrestructuring(qualityofsupplyandservice,environmentalandsocialconsiderations),Globalexperiencewith	**(08 Hours)**
	electricityreformsindifferentcountries.	
UNIT-VI	**TransmissionPlanningandPricing** Transmissionplanning&operationinopenaccesspowersystems,Introduction&Principlesoftransmissionpricing,Differenttransmissionpricingmethods,Transmissioncostallocationmethods,Marginal&CompositepricingParadigms&theircomparison,Introductiontotransmissionlossallocation&variousmethodsoflossallocation,Debatedissuesintransmissionpricing,Congestionissuesandmanagement,AncillaryServiceManagement,Forwardancillaryserviceauction.Powerpurchaseagreements.	**(08 Hours)**

ReferenceBooks:

1. LoiLeiLai,'PowerSystemRestructuring&Deregulation,JohnWiley&SonsLtd.
2. "KnowYourPower",AcitizensPrimerOntheElectricitySector,PrayasEnergyGroup,Pune
3. SallyHunt,"MakingCompetitionWorkinElectricity",2002,JohnWileyInc
4. ElectricUtilityPlanningandRegulation,EdwardKahn,AmericanCouncilforEnergyEfficientEconomy
5. D.S.Kirschen&G.Strbac,'FundamentalsofPowerSystemEconomics',JohnWiley&SonsLtd.
6. StevenStoft,'PowerSystemEconomicDesigningmarketsforElectricity,Wiley-InterScience.
7. MShahidepour,HatimYamin,ZuyiLi,'MarketOperationsinElectricalPowerSystems,Forecasting, Scheduling and Risk Management', Wiley Inter Science.

References:

1. RegulationininfrastructureServices:Progressandthewayforward-TERI,2001
2. MaharashtraElectricityRegulatoryCommissionRegulationsandOrders-www.mercindia.com
3. Variouspublications,reportsandpresentationsbyPrayas,EnergyGroup,Punewww.prayaspune.org
4. CentralElectricityRegulatoryCommission,RegulationsandOrders-www.cercind.org
5. ElectricityAct2003andNationalPolicies–www.powermin.nic.in
6. MarketOperationsinElectricPowerSystemsForecasting,SchedulingandRiskManagement–MohammadShadepur,HatimYatim,ZuyiLi.
7. BhanuBhushan,"ABCofABT-AprimeronAvailabilityTariff" -www.cercind.org

Website:NPTEL-PhaseII-

SyllabusforUnitTest:	
UnitTest-1	UNIT– I,UNIT–II,UNIT–III
UnitTest-2	UNIT– IV,UNIT–V,UNIT–VI

(Elective–I)POWERSYSTEMPLANNINGANDRELIABILITY		
TEACHINGSCHEME:	**EXAMINATIONSCHEME:**	**CREDITSALLOTTED:**
Theory:04Hours/Week	EndSemesterExamination:60Marks	03Credits
Practical:02Hours/Week	ContinuousAssessment:40Marks	
	TermWork:25Marks	01Credit

UNIT-I	**Unit1:LoadForecasting:**	**(06 Hours)**
	Introduction,FactorsaffectingLoadForecasting,LoadResearch,LoadGrowthCharacteristics,ClassificationofLoadandItsCharacteristics,LoadForecastingMethods -(i)Extrapolation(ii)Co-RelationTechniques,EnergyForecasting,PeakLoadForecasting,ReactiveLoadForecasting, Non-WeathersensitiveloadForecasting,WeathersensitiveloadForecasting,AnnualForecasting, MonthlyForecasting,TotalForecasting,Objectives&FactorsaffectingtoSystemPlanning,ShortTermPlanning, MediumTermPlanning,LongTermPlanning.[10hrs]	
UNIT-II	**Unit2:Probabilitytheory**	**(06 Hours)**
	Introductiontoprobability,Probabilitydistributions:Randomvariables,densityanddistributionfunctions.Mathematicalexpectation.Binominaldistribution,Poissondistribution,normaldistribution,exponentialdistribution,Weibulldistribution.Normal Gaussian,GammaandBetadistribution.Correlationandregression	
UNIT-III	**Unit3:Reliability**	**(06 Hours)**
	Reliability,Failure,ConceptsofProbability,EvaluationTechniques(i)MarkovProcess(ii)RecursiveTechnique,StochasticPredictionofFrequencyandDurationofLong&Short Interruption,AdequacyofReliability,ReliabilityCost.	
UNIT-IV	**Unit4:GenerationPlanningandReliability:**	
	Objectives&FactorsaffectingGenerationPlanning,GenerationSources,IntegratedResourcePlanning,GenerationSystemModel,LossofLoad(CalculationandApproaches),OutageRate,CapacityExpansion,ScheduledOutage,LossofEnergy,EvaluationMethods.InterconnectedSystem,Factorsaffectinginterconnectionunder EmergencyAssistance.	
UNIT-V	**Unit5:TransmissionPlanningandReliability**	**(06 Hours)**
	TransmissionPlanningandReliability:Introduction,ObjectivesofTransmissionPlanning,NetworkReconfiguration,SystemandLoadPointIndices,Datarequiredfor CompositeSystemReliability.	
UNIT-VI	**Unit6:DistributionPlanningandReliability**	**(06 Hours)**
	RadialNetworks– Introduction,NetworkReconfiguration,EvaluationTechniques,InterruptionIndices,EffectsofLateralDistributionProtection,EffectsofDisconnects,EffectsofProtectionFailure,EffectsofTransferringLoads,DistributionReliabilityIndices.Parallel&MeshedNetworks-Introduction,BasicEvaluationTechniques,Bus BarFailure,ScheduledMaintenance,TemporaryandTransientFailure,WeatherEffects,BreakerFailure.	

TextBooks:	
1.RoyBillinton&RonaldN.Allan,ReliabilityEvaluationofPowerSystem-SpringerPublication.	
2.R.L.SullivanPowerSystemPlanning-,TataMcGrawHillPublishingCompanyLtd.	
3.Miler&Freund's,ProbabilityandStatisticforEngineers,PearsonEducation,RichardJohnson.	
ReferenceBooks:	
1.X.Wang&J.R.McDonald,ModernPowerSystemPlanning–,McGrawHillBookCompany	
2. T.Gönen,ElectricalPowerDistributionEngineering-McGrawHillBookCompany	
3.B.R.GuptaGenerationofElectricalEnergy–,S.ChandPublications	
4. A.S.Pabla,ElectricalPowerDistributionTataMcGrawHillPublishingCompanyLtd.	
5.T.W.Berrie,ElectricityEconomics&Planning–,PeterPeregrinusLtd.,London	
SyllabusforUnitTest:	
UnitTest-1	UNIT– I,UNIT–II,UNIT-III
UnitTest-2	UNIT– IV,UNIT–V,UNIT-VI

PowerQualityIssues		
TEACHINGSCHEME:	**EXAMINATIONSCHEME:**	**CREDITSALLOTTED:**
Theory:04Hours/Week	EndSemesterExamination:60Marks	04Credits
	ContinuousAssessment:40Marks	

UNIT-I	**Voltagesag;swellsandinterruptions** Introduction;importanceofpowerquality;termsanddefinitionsofpowerqualityasperIEEEStd.1159.Sources&EffectsofPowerQualityProblems;Sourcesofsag;swellandinterruptions;Estimationofvoltagesagperformance;Fundamentalprinciplesofprotection;solutionsatenduserlevel;utilitysystemsandfaultclearingissues;motor startingsags;evaluationoftheeconomicsofdifferentalternatives.	**[8Hrs]**
UNIT-II	**TransientOver-Voltages** Sourcesoftransientovervoltages;capacitorswitching;lightening;Ferroresonancesandotherswitchingtransients;Principlesofovervoltageprotections;devicesofovervoltageprotections;Utilitycapacitorswitchingtransients;Utilitysystemlighteningprotection;managingFerroresonance;switchingtransientsproblemswithloads;computertoolsfortransientanalysis.	**[8Hrs]**
UNIT-III	**FundamentalsofHarmonicsanditsAnalysis** Introduction;theMechanismofHarmonicGeneration;DefinitionsandStandards:FactorsInfluencingtheDevelopmentofStandards,ExistingHarmonicStandards,GeneralHarmonicIndices. IntroductiontoHarmonicAnalysis;FourierSeriesandCoefficients;SimplificationsResultingfromWaveformSymmetry;ComplexFormoftheFourierSeries;ConvolutionofHarmonicPhasors;TheFourierTransform;SampledTimeFunctions;DiscreteFourierTransform(DFT);TheNyquistFrequencyandAliasing;FastFourierTransform(FFT); WindowFunctions;EfficiencyofFFTAlgorithms;AlternativeTransforms.	**[8Hrs]**
UNIT-IV	**HarmonicSourcesandDistortions** HarmonicSources:Introduction;TransformerMagnetizationNonlinearities;RotatingMachineHarmonics;DistortionCausedbyArcingDevices;Single-PhaseRectification;Three-PhaseCurrent-SourceConversion;Three-PhaseVoltage-SourceConversion;Thyristors-ControlledReactors. HarmonicDistortion:Introduction;Resonances;EffectsofHarmonicsonRotatingMachines;EffectofHarmonicsonStaticPowerPlant;HarmonicInterferencewithPowerSystemProtection;EffectofHarmonicsonConsumerEquipment;Interferencewith Communications.	**[8Hrs]**
UNIT-V	**Computation,AssessmentandHarmonicElimination** HarmonicComputation:Introduction;DirectHarmonicAnalysis;DerivationofNetworkHarmonicImpedancesfromFieldTests;TransmissionLineModels;UndergroundandSubmarineCables;LoadModels;ComputerImplementation;ExamplesofApplicationoftheModels; HarmonicElimination:Introduction;FilterDesignCriteria;NetworkImpedanceforPerformanceCalculations;TunedFilters;DampedFilters;ConventionalFilter	**[8Hrs]**

	Configurations;Band-PassFilteringforTwelve-PulseConverters;DistributionSystem FilterPlanning;FilterComponentProperties;D.C.SideFilters;ActiveFilter	
UNIT-VI	**Powerqualitymonitoring;Assessment&Mitigation** Needandapproachesfollowedinpowerqualitymonitoring;objectivesandrequirements;Initialsitesurvey;PowerqualityInstrumentation;Selectionofpowerqualitymonitors;monitoring locationandperiod;Selectionoftransducers;Harmonicmonitoring;Transientmonitoring;eventrecordingandflickermonitoring. PowerQualityassessment;Powerqualityindicesandstandardsforassessment;waveformdistortion;voltageandcurrentunbalances;Powerassessmentunderwaveformdistortionconditions.Powerqualitystateestimation;Statevariablemodel;observabilityanalysis;capabilitiesofharmonicstateestimation;Testsystems; Mitigationtechniquesatdifferentenvironments.	**[8Hrs]**

References:

1. Understandingpowerqualityproblems;voltagesagandinterruptions-M.H.J.BollenIEEEpress;2000;seriesonpowerengineering.
2. "POWERSYSTEMHARMONICS",SecondEditionByJosArrillagaandNevilleR.Watson;JohnWileyandPublication,2003ISBN:0-470-85129-5.
3. Electricalpowersystemquality-PogeiC.Dugan;MarkF.McGranghan;Suryasantoso;H.WayneBeaty;secondedition;McGrawHillPub.
4. Powersystemqualityassessment-J.Arrillaga;M.R.Watson;S.Chan;JohnWileyandsons.
5. Electricpowerquality-G.J.Heydt.
6. Powersystemharmonics:Computermodelingandanalysis-EnriquesAcha;ManuelMadrigal;Johnwileyandsonsltd.
7. PowerSystemHarmonics–J.Arrillaga&N.Watson
8. IEEEstd519-1992/IEEEstd1159IEEErecommendedpracticesandrequirementsforharmonicscontrolinelectricalpowersystem.
9. ECBCCode2007(Edition2008)publishedbyBureauofEnergyEfficiency;NewDelhiBureauofEnergyEfficiencyPublicationsRatingSystem;TERIPUBLICATIONSGRIHARatingSystem;LEEDSPublications

SyllabusforUnitTest:	
UnitTest-1	UNIT– I,UNIT–II,UNIT–III
UnitTest-2	UNIT– IV,UNIT–V,UNIT–VI

(Elective–II)**AdvancedControl System**		
TEACHINGSCHEME:	**EXAMINATIONSCHEME:**	**CREDITSALLOTTED:**
Theory:04Hours/Week	EndSemesterExamination:60Marks	03 Credits
	ContinuousAssessment:40Marks	

UNIT-I	**PIDControl:**	**(08Hours)**
	Review of classical and modern control concepts: PID control and tuning approaches, Selection of Variables for Control, PID Controller Tuning for Dynamic Performance - Determining Tuning Constants for Good Control Performance, Ziegler-Nichols method, Correlations for Tuning Constants, Fine-Tuning the Controller Tuning Constants, Controller tuning based on stability – Dead beat and self tuning, Rate feedback	
UNIT-II	**StateVariableAnalysis:**	**(08Hours)**
	Control System Analysis Using State Variable Methods, Conversion of transfer function tophase variable and canonical variable model, Eigen value and eigen vector, Kalman's test and Gilbert's Test for controllabilityandobservabilityanalysisanddesignofcontrolsystemin state space, Pole placement, State observer, Design of control system with Luenberger observer	
UNIT-III	**NonlinearandRobustControl:**	**(08Hours)**
	Nonlinear Systems and Equilibrium Points, Concepts of Stability, Describing function analysis, Phase plane analysis, Linearization, Feedback Linearization, Input-output linearization, Input-State Linearization Concept of robust control, Description and categorization of system uncertainties, System and signal norms, Small gain theorem, Robust stability, Design of robust control, Introduction to H-∞ control.	
UNIT-IV	**Digital Control:**	**(08Hours)**
	Structure of the Digital Control System, ADC, DAC, Effects of Sampling of continuous time signals, Quantization, Sample and hold, Reconstruction of signal, Sampling Theorem**, A**liasing, Elementary discrete-time signals, Impulse response, Linear convolution and its properties, Z transform: Basics, Properties, Inverse Ztransform using power series and partial fraction difference equation, Stability analysisin z- plane with Jury's stability criteria	
UNIT-V	**FrequencyAnalysis:**	**(08Hours)**

	Frequency response of first order and second order systems, Polar plot, Bode plot, Bode plot from Sweep Frequency Response Analysis(SFRA)oftransformeranditsconclusion,Phaseandgroupdelays, Ideal filters and theirpole zero locations,Zero phase andlinear phase transfer functions Exponential representation of Fourier series and Fourier transform of continuous time signals, The Fourier series for discrete-Time periodic signals(onlyconcept),TheFouriertransformofdiscrete-timeaperiodic signals (only concept), Discrete Fourier Transform, Properties: Periodicity, Linearity, Symmetry properties, Circular convolution, Linear convolution using circular convolution, Fast Fourier Transform: Radix 2 DIT and DIF algorithms	
UNIT-VI	**OptimalControl:**	**(08hours)**
	Parameter optimization and optimal control problems, Hamiltonian formulation of optimal control problem, Hamilton-Jacoby equation, Linear regulator problem, Quadratic performance criterion, Numerical solution of Matrix Riccati equation, Pontryagin's minimum principle, Application to optimal control of discrete and continuous systems (quadratic performance index, analysis and design offinite and infinite time), Linear Quadratic Regulators, Introduction to Linear Quadratic Gaussian approach	

TextBooks:
1.'ModernControlEngineering'-KatsuhikoOgata, PrenticeHall India,5thedition 2010.
2.'Non-linearSystems',byHassanKhalil,PrenticeHall.
3.DigitalControl–Ogata,PrenticeHall India
ReferenceBooks:
1.DigtalControl-B.C.Kuo
2.'DigitalControlandStateVariableMethods'byM.Gopal,Tata-McGraw-HillPublishing Company Limited
3.OptimalControl:LinearQuadraticMethods'BrianD.O.Anderson,JohnBarrattMoore, DoverPublications,2007

SyllabusforUnitTest:	
UnitTest-1	UNIT–I,UNIT–II,UNIT–III
UnitTest-2	UNIT–IV,UNIT–V,UNIT–VI

(Elective–II)ADVANCEDPOWERELECTRONICSANDDRIVES			
TEACHINGSCHEME:	**EXAMINATIONSCHEME:**	**CREDITSALLOTTED:**	
Theory:04Hours/Week	EndSemesterExamination:60Marks	04Credits	
Practical:02Hours/Week	ContinuousAssessment:40Marks		
	TermWork:25Marks	01Credit	
UNIT-I	**Converters:**		**(08Hours)**
	VoltageSourceConverters Reviewof3-ph-fullwavebridgeconverter,operationandharmonics,3levelvoltagesourceconverters.PWMconverter.Generalizedtechniqueofharmoniceliminationandvoltagecontrol.Advancedmodulationtechniques(spacevectormodulation,3rd harmonicPWM)ComparisonofPWMtechniques.Converterrating**Currentsourceconverters** (i) MatrixConverter:3×3matrixconverter,principleofworking,mathematicaltreatment,comparisonofmatrixconverterwithmultipulseconverter (ii) SelfandLinecommutatedcurrentsourceconverter:BasicconceptsofCSC,converter swithselfcommutatingdevices		
UNIT-II	**MultilevelInverters:**		**(08Hours)**
	Multilevelconcept,TypesofmultilevelInverters,diodeclampedmultilevelinverter,flying-capacitorsmultilevelinverters,cascadedmultilevelinverter,switchingdevicecurrents,D.C.linkcapacitorvoltagebalancing,featuresofmultilevelinverters,comparisonofmultilevelinverters.Applicationsofmultilevel Inverter:ReactivepowercompensationBacktobackintertiesystem		
UNIT-III	**DCDrives:**		**(08Hours)**
	Singlephaseand3phaseconverterdrives.FourquadrantChopperdrives,closedloopcontrolofDCmotor,PermanentmagnetDCmotordrives,DCServodrives, applications		
UNIT-IV	**InductionMotorDrives:**		**(08Hours)**
	3phaseinductionmotorcontrol,statorvoltagecontrol/rotorvoltagecontrol,voltageandfrequencycontrol,currentcontrol,closedloopcontrolof3-phaseinductionmotor.Softstarters,comparisonofvariablefrequencydrives,Speed controlbystaticslippowerrecovery,inductionmotorservodrives,applications.		
UNIT-V	**SynchronousMotorDrives:**		**(08Hours)**
	Voltageandfrequencycontrol,closedloopcontrolofsynchronousmotors.Synchronous motorservodrivewithsinusoidalwaveform,synchronousmotorservodrivewithtrapezoidalwaveform.Loadcommutatedinvertordrives,speed controlofsynchronousmotorsbycyclo-convertors,applications		
UNIT-VI	**Akagi'sp-qtheory**		**(08Hours)**

	Conventionalconceptsofactiveandreactivepowerinsinglephaseandthreephasecircuits-Equationofpowerwithsinusoidalvoltagesourceandnon-linearloads-αβo transformationofthreephasefourwiresystem-Akagi's instantaneous power(pq)theory-relationship between Akagi's components and conventional activeandreactivepowerapplicationofpqtheorytoreactiveandharmonicpowercompensationinsimplecircuits.	

Text Books:	
1.BimalKBose,ModernpowerelectronicsandACdrives,Pearsoneducationasia	
2.G.K.Dubey,FundamentalsofElectricalDrivesCRCpress2002	
3.VedamSubrahmanyamElectricDrives:Concepts&ApplTataMcGraw-Hill	
4.Powerelectronicsconvertors,applicationsanddesign,NedMohan,ToreMUndeland,WilliamP Robbins,WileyIndiaPvt.Ltd.,2009	
5 E.Acha,Miller&Others,PowerElectronicControlinElectricalSystems(Newnes,Oxfordpublication)–firstEdition	
6 M.H.RashidPowerElectronics,PrenticeHallofIndiaPvt.Ltd.NewDelhi,(3rdEdition)	
7.RKrishnan,Electricmotordrives,modeling,analysisandcontrol,PHIlearningPvt.ltd.2001	
8.S.K.Pillai,Afirstcourseinelectricaldrives,Newageinternationalpublishers.2010	
Reference Book and Papers:	
1.E.H.Watanube,R.M.StephenandMauricoArdes"NewConceptsofinstantaneousactiveand reactivepowersinElectricalsystemswithGenericloads"(IEEEtransactiononPowerDeliveryVol.8, no.2April1993,PP-697-703	
2.L.Benchaita,S.SadaateandA.Salemnia–"A comparisonof voltage sourceand current source shunt Activefilterbysimulationand Experimentation"(IEEETransactiononPowerSystems,Vol14,No.2, May99,PP642-647	
3. H.Akagi,E.H.WatanabeandM.Aredes"InstantaneousPowerTheoryandApplicationstoPower Conditioning,IEEEPress,NewYork	
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UnitTest-1	UNIT– I,UNIT–II,UNIT-III
UnitTest-2	UNIT– IV,UNIT–V,UNIT-VI