E.G.S. PILLAY ENGINEERING COLLEGE

(Autonomous)

Approved by AICTE, New Delhi | Affiliated to Anna University, Chennai
Accredited by NAAC with „A" Grade | Accredited by NBA
NAGAPATTINAM – 611 002

B.E. ELECTRICAL AND ELECTRONICS ENGINEERING

Full Time Curriculum and Syllabus

Fourth Year – Eighth Semesters

SEMESTER VIII								
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Maximum Marks**		
						CA	**ES**	**Total**
1903EE022	Elective-IX (PEC-IV) **Flexible AC Transmission Systems**	3	0	0	3	40	60	100
1903EE025	Elective-X (PEC-V) **High Voltage Engineering**	3	0	0	3	40	60	100
1904EE851	Project Work	0	0	14	7	50	50	100
Total		**6**	**0**	**14**	**13**	**130**	**170**	**300**

PROFESSIONAL ELECTIVE COURSES (PEC) –IV &V

Course Code	Course Name	L	T	P	C	Maximum Marks		
						CA	ES	Total
1903EE016	Power System Stability	3	0	0	3	40	60	100
1903EE017	Power System Transients	3	0	0	3	40	60	100
1903EE018	Power System Economics	3	0	0	3	40	60	100
1903EE019	Micro and Smart Grid	3	0	0	3	40	60	100
1903EE020	Power System Restructuring and Deregulation	3	0	0	3	40	60	100
1903EE021	Modern Transmission Systems	3	0	0	3	40	60	100
1903EE022	Flexible AC Transmission Systems	3	0	0	3	40	60	100
1903EE023	Advanced Insulation Systems	3	0	0	3	40	60	100
1903EE024	Power Quality	3	0	0	3	40	60	100
1903EE025	High Voltage Engineering	3	0	0	3	40	60	100

1903EE016 **POWER SYSTEM STABILITY**

L	T	P	C
3	0	0	3

PREREQUISITE:

1.Power System Analysis

COURSE OBJECTIVES:

1.To understand the problems associated with power system stability

2.To learn the control techniques to enhance power system stability

COURSE OUTCOME:

After completion of the course, Student will be able to

CO1 Understand the outline power system stability

CO2 Discuss the classification of power system stability

CO3 Explain about Excitation systems of power system stability

CO4 Describe the Modeling of equipments in power system stability

CO5 Summarize the power system stability enhancement

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

Power system stability problem and identification, Basics of rotor angle stability and voltage stability, Classification of stability, Fundamental concepts of stability of dynamic systems, Small signal stability of a single machine infinite bus system, Necessity of power system stability control.

MODULE I **STABILITY CLASSIFICATION** **9 Hours**

Transient stability- Rotor angle stability, Voltage stability, Transient stability, Midterm and long term stability, Frequency stability, Comparative study of stability classification, Analysis of unbalanced fault.

MODULE I **EXCITATION SYSTEMS** **9 Hours**

Requirement of excitation system, Types of excitation system -AC and DC Excitation, Dynamic performance of excitation system, Modeling of excitation system, Parameter estimation in synchronous generator,Load compensation, Effect of excitation regulation in power system stability, Recent trend in excitation system, Description of excitation system model recommended by IEEE.

MODULE IV **MODELLING OF EQUIPMENT AND LOAD** **9 Hours**

Description of synchronous machine, Equivalent circuit of direct and quadrature axis, Magnetic saturation, Constant flux linkage model (Classical model), Representation of two winding and three winding transformer, Load modeling concepts- Modeling of induction motor and synchronous motor, Modeling of steam turbine, Modeling of thermal energy systems.

MODULE V **ENHANCEMENT OF POWER SYSTEM STABILITY** **9 Hours**

Concept of stability in dynamic systems, Transient stability enhancement, Power system stabilizer (PSS),Nonlinear multivariable excitation controller, Prevention of voltage collapse, Performance of protective relaying, Numerical integration methods of transient stability studies, Role of FACTS devices in stability operation, Case study of an over generating and under generating Indian power station.

TOTAL: 45 HOURS

FURTHER READING:

1. Security analysis in power system.
2. Power system modeling using solution techniques

REFERENCES:

1. Prabha Kundur, “Power system stability and control”, Tata McGraw Hill publications, 5th edition, 2006.
2. Jicheng Li, “Design and applications of Modern synchronous generator Excitation systems” Wiley IEEE Press, 2019.
3. Jan Machowski, ZbigniewLubosny, Janusz.W.Bialek, James R.Bumby, “Power system Dynamics: Stability and control”, third edition, Wiley &Sons, 2020.
4. Leonard.L.Grigsp, “Power system stability and control”, CRC Press, 2012.
5. Prof. DebapriyaDass IIT Kharagpur, “Power system dynamic, control and monitoring” NPTEL Course.

1903EE017	POWER SYSTEM TRANSIENTS	L	T	P	C
		3	0	0	3

PREREQUISITE:

1. Transmission and Distribution.
2. Power Electronics.

COURSE OBJECTIVES:

1. To study the generation of switching transients and their control.
2. To study the mechanism of lighting strokes and travelling waves.
3. To compute the transients in travelling waves &integrated power system.

COURSE OUTCOMES:

After completion of the course, Student will be able to

CO1 Understand the Survey of Transients

CO2 Summarize the concepts of switching transients and their control.

CO3 Explain lighting strokes and its effect in power system..

CO4 Discuss the mechanism of travelling waves.

CO5 Explain the transients in integrated power system.

MODULE I INTRODUCTION AND SURVEY OF TRANSIENTS 9 Hours

Review and importance of transients, Causes of transients, RL circuit transient with sine wave excitation, Double frequency transients, Different types of power system transients, Effect of transients on power systems, Role of transient study in system planning.

MODULE II SWITCHING TRANSIENTS 9 Hours

Over voltages due to switching transients, Resistance switching, Load switching, Normal and abnormal switching transients; Current suppression, Current chopping, Capacitance switching - Capacitance switching with restrike/ multiple restrikes, Illustration for multiple restriking transients, Ferro resonance.

MODULE III LIGHTNING TRANSIENTS 9 Hours

Review of the theories in the formation of clouds and charge formation, Rate of charging of thunder clouds, Mechanism of lightning discharges and characteristics of lightning strokes, Model for lightning stroke, Factors contributing to good line design, Protection from lightning.

MODULE IV TRAVELING WAVES ON TRANSMISSION LINE 9 Hours

Computation of transients, Transient response of systems with series and shunt lumped parameters and distributed lines, Traveling wave concept, Step response, Bewley‟s lattice diagram, Standing waves and natural frequencies, Reflection and refraction of travelling waves.

MODULE V TRANSIENTS IN INTEGRATED POWER SYSTEM 9 Hours

The short line and kilometric fault, Distribution of voltages in a power system, Line dropping and load rejection, Voltage transients on closing and reclosing lines, Over voltage induced by faults, Switching surges on integrated system, Qualitative application of EMTP for transient computation.

TOTAL: 45 HOURS

FURTHER READING:

1. Analysis power system transient using wavelet transform.
2. Case study about the effect of transients developed in home appliances.

REFERENCES:

1. Allan Greenwood, "Electrical Transients in Power Systems", Wiley Inter Science, New York, 2nd Edition, 2010.
2. Pritindra Chowdhari, "Electromagnetic transients in Power System", John Wiley and Sons Inc., 2nd Edition, 2009.
3. Indulkar.C.S, Kothari.D.P, Ramalingam.K, "Power System Transients – A statistical approach", PHI Learning Private Limited, 2nd Edition, 2010.
4. Ramanujam.R, "Computational Electromagnetic Transients: Modeling, Solution Methods and Simulation"I K International Publishing House Pvt. Ltd, 2014.
5. SakisMeliopoulis.A.P, "Power System Grounding and Transients: An Introduction", CRC Press; 1st Edition 2015

1903EE018	POWER SYSTEM ECONOMICS	L	T	P	C
		3	0	0	3

PREREQUISITE:

1. Power system analysis
2. Power system operation and control

COURSE OBJECTIVES:

1. To understand the economic fundamentals and principles of decision making involved in power system operation.
2. To learn about cash flows, evaluation of investments and risk management in power system operations.

COURSE OUTCOMES: After completion of the course, Student will be able to

CO1 Understand the Basic Concepts of Power Economics
CO2 Summarize the Economic operation of Power System
CO3 Explain the electricity pricing in Market Design
CO4 Make use various models for analysis of power market
CO5 Explain the Risk Management In Power System Operation

MODULE I BASIC CONCEPTS OF POWER ECONOMICS **9 Hours**

Fundamentals of markets, Individual demand, Demand and individual demand function, Modeling of producers and consumers, Opportunity cost,Producer‟s revenue, Elasticity of supply, Market equilibrium- Wholesale and retail competition.

MODULE II ECONOMIC OPERATION OF POWER SYSTEM **9 Hours**

Economic operation, Load flow calculation, Load flow outages, Constrained optimization, Load frequency control, Spinning reserve, Generation scheduling, Calculation of transfer capabilities of transmission interfaces.

MODULE III MARKET DESIGN **9 Hours**

Electricity pricing -Uniform pricing, Nodal pricing, Power bidding - Multiple block bidding, Demand side bidding, Day-ahead market, Transmission losses, Reserve market, Power cost compensations, Transmission rights.

MODULE IV POWER MARKET ANALYSIS **9 Hours**

Background of microeconomics, Fundamentals of non-cooperative game theory, Game model for market analysis-System dispatch model, Equilibrium analysis, Market power analysis, Market power measurement indices, Electricity market experiments.

MODULE V RISK MANAGEMENT IN POWER SYSTEM OPERATION **9 Hours**

Risk in the electricity markets, Risk management in the electricity market, Forecasting electricity prices - Short term price forecasting, Midterm and long term price forecasting, Managing price risk through simulation based method, Impact of CO_2 price on power system generation scheduling and electricity prices.

TOTAL: 45 HOURS

FURTHER READING:

1. Next Generation optimization for Electric power systems
2. Challenges in power sector regulation.

REFERENCES:

1. Deqiang Gan,DonghanFeng, Jun Xie, “Electricity Markets and power system economics”, CRC Press, Taylor &Francis group, 2014.
2. Daniel S.Kirchen, Goran Strabac, “Fundamentals of power system economics”, Wiley, edition.
3. JinZhong, “Power System Economics and Market operation”, CRC Press, Taylor &Francis group, 2018.
4. James Momoh, LamineMili, “Economic Market Design and Planning for Electric Powersystems‟‟, Wiley,

1903EE019	MICRO AND SMART GRID	L	T	P	C
		3	0	0	3

PREREQUISITE :

Power Electronics

COURSE OBJECTIVES:

1. Understand the fundamental elements of the smart grid and illustrate the concepts of control techniques in smart grid.
2. The concepts of microgrid, its types, modes of operation and importance.
3. Control aspects of microgrid.
4. Various microgrid pilots and microgrid components.

COURSE OUTCOMES:

After completion of the course, Student will be able to

CO1 Understand the fundamental elements of the smart grid.

CO2 Understand various sensing and measurement technologies involved with the smart grid.

CO3 Know the significance of microgrid and its types.

CO4 Know various control strategies of microgrid.

CO5 Have an idea of various microgrid components.

MODULE I SMART GRID ARCHITECTURAL DESIGNS 9 Hours

Need for implementation of smart grid, Smart grid initiatives, Overview of the technologies required for the smart grid, Working definition of the smart grid based on performance measures, Representative architecture, Functions of smart grid components, Smart devices interface component, Storage component.

MODULE II GRID MONITORING AND CONTROL TECHNOLOGY 9 Hours

Transmission subsystem component, Monitoring and control technology component, Intelligent grid distribution subsystem component, Demand side management component.

MODULE III INTRODUCTION TO MICROGRID 9 Hours

Basic concepts, Architecture, Operational conditions, Merits and Demerits, Functionalities and variables in microgrid, Issues in microgrid, Types of microgrid-LV microgrid, MV microgrid - DC microgrid, AC microgrid, Hybrid, Microgrid as part of smarter grid.

MODULE IV CONTROLLERS FOR MICROGRID 9 Hours

Three phase converter, Three phase voltage source inverter (VSI), Boost converter, PWM techniques, P-Q control, Structure of the VSI PQ controller, Power Voltage (PV) control scheme, Frequency (V/F) control scheme, Generation control based on droop concept, Adaptive droop control, Phase locked loop for synchronization.

MODULE V MICROGRID COMPONENTS 9 Hours

Micro grid pilots: KERI – CERTS, Intelligent Electronic Devices (IED), Micro grid Management System (MMS), Static Transfer Switch (STS), RTU/ Gateway, Smart metering, Sensing Devices.

Total: 45 Hours

FURTHER READING:

1. Communication for micro grids
2. Microgrid protection

REFERENCES:

1. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, “Smart Grid Technologies and Applications”, John Wiley Publishers Ltd., 2012.
2. Lars T. Berger, Krzysztof Iniewski, “Smart Grid applications, Communications and Security”, John Wiley Publishers Ltd., 2012.
3. Caitlin G. Elsworth, “The Smart Grid and Electric Power Transmission”, Nova Science Publishers, 2010.
4. JukkaIhamäki, “Integration of microgrids into electricity distribution networks” Master‟s Thesis in Lappeenranta University of Technology, 2012, pages-105.
5. Eric Sorotomme, S.S.Venkata, Joydeep Mitra, “Microgrid protection using communication assisted digital relays”, IEEE transaction on power delivery, vol.25, No.4, pp.2789-2796, 2010.

1903EE019	MICRO AND SMART GRID	L	T	P	C
		3	0	0	3

PREREQUISITE :

Power Electronics

COURSE OBJECTIVES:

5. Understand the fundamental elements of the smart grid and illustrate the concepts of control techniques in smart grid.
6. The concepts of microgrid, its types, modes of operation and importance.
7. Control aspects of microgrid.
8. Various microgrid pilots and microgrid components.

COURSE OUTCOMES:

After completion of the course, Student will be able to

CO1 Understand the fundamental elements of the smart grid.

CO2 Understand various sensing and measurement technologies involved with the smart grid.

CO3 Know the significance of microgrid and its types.

CO4 Know various control strategies of microgrid.

CO5 Have an idea of various microgrid components.

MODULE I SMART GRID ARCHITECTURAL DESIGNS 9 Hours

Need for implementation of smart grid, Smart grid initiatives, Overview of the technologies required for the smart grid, Working definition of the smart grid based on performance measures, Representative architecture, Functions of smart grid components, Smart devices interface component, Storage component.

MODULE II GRID MONITORING AND CONTROL TECHNOLOGY 9 Hours

Transmission subsystem component, Monitoring and control technology component, Intelligent grid distribution subsystem component, Demand side management component.

MODULE III INTRODUCTION TO MICROGRID 9 Hours

Basic concepts, Architecture, Operational conditions, Merits and Demerits, Functionalities and variables in microgrid, Issues in microgrid, Types of microgrid-LV microgrid, MV microgrid - DC microgrid, AC microgrid, Hybrid, Microgrid as part of smarter grid.

MODULE IV CONTROLLERS FOR MICROGRID 9 Hours

Three phase converter, Three phase voltage source inverter (VSI), Boost converter, PWM techniques, P-Q control, Structure of the VSI PQ controller, Power Voltage (PV) control scheme, Frequency (V/F) control scheme, Generation control based on droop concept, Adaptive droop control, Phase locked loop for synchronization.

MODULE V MICROGRID COMPONENTS 9 Hours

Micro grid pilots: KERI – CERTS, Intelligent Electronic Devices (IED), Micro grid Management System (MMS), Static Transfer Switch (STS), RTU/ Gateway, Smart metering, Sensing Devices.

Total: 45 Hours

FURTHER READING:

3. Communication for micro grids
4. Microgrid protection

REFERENCES:

6. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, “Smart Grid Technologies and Applications”, John Wiley Publishers Ltd., 2012.
7. Lars T. Berger, Krzysztof Iniewski, “Smart Grid applications, Communications and Security”, John Wiley Publishers Ltd., 2012.
8. Caitlin G. Elsworth, “The Smart Grid and Electric Power Transmission”, Nova Science Publishers, 2010.
9. JukkaIhamäki, “Integration of microgrids into electricity distribution networks” Master‟s Thesis in Lappeenranta University of Technology, 2012, pages-105.
10. Eric Sorotomme, S.S.Venkata, Joydeep Mitra, “Microgrid protection using communication assisted digital relays”, IEEE transaction on power delivery, vol.25, No.4, pp.2789-2796, 2010.

1903EE020 POWER SYSTEM RESTRUCTURING AND DEREGULATION

L	T	P	C
3	0	0	3

PREREQUISITE:

Power system operation and control

COURSE OBJECTIVES:

1. To learn the competition in the generation and supply of electricity.
2. To understand the utilities in the deregulation of power market.

COURSE OUTCOME

After completion of the course, Student will be able to

CO1 Understand the fundamental power market structure

CO2 Understand the electricity pricing and price forecasting

CO3 Know the significance of Electric Power industry Restructuring in India

CO4 Discuss the Deregulation of Electric Power Systems

CO5 Explain the Power Management and Monitoring In Various Countries

MODULE I POWER MARKET STRUCTURE- OVERVIEW 8 Hours

Objective of market operation, Electricity market model, Design of electricity markets, Computational tools for electricity markets, Power market types, Electricity demand operation and reliability, Unit commitment in restructured markets, Short term load forecasting, Energy policies of Indian Government.

MODULE II ELECTRICITY PRICING 9 Hours

Issues of Electricity pricing, Traditional Price regulation (Indian Scenario), Impacts of Industry restructuring on electricity pricing, Bidding of electric power, Transmission pricing, Electricity price volatility, Electricity price simulation module, Performance evaluation of price forecasting, Price spike analysis, Applications of price forecasting.

MODULE III ELECTRIC POWER INDUSTRY RESTRUCTURING IN INDIA 8 Hours

Introduction to restructuring, Development of electric power industry in India, Expansion of power networks, Power management system of electric power industry in India, Power market in India, Ancillary services for restructuring power.

MODULE IV DERUGULATION OF ELECTRIC POWER SYSTEMS 12 Hours

Introduction to deregulation - Indian Scenario, Competition in the energy market, Independent system operator, Retail price providers, Wholesale electricity market characteristics, Market clearing and pricing, Bilateral trading, Market models, Competition in supply, Information management, Scope of demand side management.

MODULE V POWER MANAGEMENT AND MONITORING 8 Hours

Power wheeling, Development in international transmission pricing, Security management in deregulated environment, Congestion management in deregulation, Ancillary service management in US, UK and China, Reliability analysis in deregulation, Hierarchical levels of reliability, Usability of internet in power trading.

TOTAL: 45 HOURS

FURTHER READING:

Power system economic operation

REFERENCES:

1. Loi Lee Lai, "Power System restructuring and deregulation", John Wiley & Sons, 2001.
2. Kankar Bhattacharya, Math H.J. Bollen, Jaap E. Daalder, "Operation of Restructured power system", Springer science Media, New York, 2001.
3. Nouredine Hadjsaïd, Jean-Claude Sabonnadière, "Power systems and Restructuring", Wiley Publishers, 2001.
4. Steven Soft, Power System Economics, Wiley Publishers, 2002.
5. P. Venkatesh, B. V. Manikandan, S. Charles Raja, A. Srinivasan, "Electrical Power Systems: Analysis, Security and Deregulation", PHI Learning Private Ltd, 2012.
6. "Power System Restructuring", NPTEL Video Lecture –IIT Delhi, 2012.

1903EE021	MODERN TRANSMISSION SYSTEMS	L	T	P	C
		3	0	0	3

PREREQUISITE:

Generation, Transmission and Distribution

COURSE OBJECTIVES:

1. To be exposed to the interaction between HVAC and HVDC system.
2. To familiarize various protection schemes of transmission system.

COURSE OUTCOME

After completion of the course, Student will be able to

CO1 Understand about the modern transmission system

CO2 Describe the EHV AC transmission system

CO3 Describe the EHV DC transmission system

CO4 Discuss the Protection In EHV DC Transmission System

CO5 Explain the various testing of extra high voltage

MODULE I INTRODUCTION 9 Hours

Need of EHV transmission, Standard transmission voltage, Comparison of EHV AC and DC transmission systems and their applications and limitations, Surface voltage gradients in conductor, Distribution of voltage gradients on sub-conductors, Mechanical considerations of transmission lines, Modern trends in EHV AC and DC transmission.

MODULE II EHV AC TRANSMISSION 9 Hours

Corona loss, Corona current, Audible noise - Generation and characteristics, Corona pulses generation and properties, Radio Interference (RI) effects, Over voltage due to switching, Ferro resonance, Reduction of switching surges on EHV system, Principle of half wave transmission.

MODULE III EHV DC TRANSMISSION 9 Hours

Types of dc links, Converter station, Choice of converter configuration and pulse number, Effect of source inductance on operation of converters, Principle of dc link control, Converter controls characteristics, Firing angle control, Current and excitation angle control, Power control, Starting and stopping of DC link.

MODULE IV EHV DC TRANSMISSION SYSTEM PROTECTION 9 Hours

Converter faults, Protection against over currents and over voltage, Smoothing reactors, Generation of harmonics, AC and DC filters, Multi – Terminal DC systems (MTDC): Types, Control, Protection and application.

MODULE V EXTRA HIGH VOLTAGE TESTING 9 Hours

Characteristics and generation of impulse voltage, Generation of high AC and DC voltages, Measurement of high voltage by sphere gaps and potential dividers, Consideration for Design of EHV Lines, Design factors under steady state limits, EHV line insulation design based upon transient over voltages. Effects of pollution on performance of EHV lines.

TOTAL: 45 HOURS

FURTHER READING:

Flexible AC Transmission system

REFERENCES:

1. Narain G. Hingorani, Laszlo Gyugyi, “Understanding FACTS: Concepts & Technology of Flexible AC Transmission System”, Wiley India Pvt. Ltd., 2011.
2. Mohan Mathur P, Rajiv K Varma, “Thyristor–Based Facts Controllers for Electrical Transmission Systems”, John Wiley and Sons Inc., India, 2011
3. Padiyar K R, “HVDC Transmission Systems”, New Age International Publishers Ltd., New Delhi , 2002.
4. Arrillaga J, “High voltage Direct Current Transmission”, IEE Publications, London, UK, 1999.
5. Kimbark E W, “Direct Current Transmission”, Wiley Inter science, New York, 1971.

1903EE022 **FLEXIBLE AC TRANSMISSION SYSTEMS**

L	T	P	C
3	0	0	3

COURSE OBJECTIVE:

1. To understand the reactive power control techniques

. To educate on different FACTS devices with their specifications.

COURSE OUTCOMES:

After completion of the course, Student will be able to

CO1 Discuss about various FACTS devices used in Reactive power control

CO2 Study the characteristics of static synchronous compensator

CO3 Make use of different modes of operation of static series compensator for stability studies

CO4 Investigate the characteristics of static VAR compensator

CO5 Describe the characteristics and application of UPFC

MODULE I INTRODUCTION **9 Hours**

Fundamentals of AC power transmission, Transmission problems and needs, Emergence of FACTS, FACTS control considerations, FACTS controllers.

MODULE II STATCOM **9 Hours**

Principles of shunt compensation, Variable impedance type and switching converter type, Static Synchronous Compensator (STATCOM) configuration, Characteristics and control.

MODULE III STATIC SERIES COMPENSATOR **9 Hours**

Principles of static series compensation using GCSC, TCSC and TSSC, Applications, Static Synchronous Series Compensator (SSSC).

MODULE IV STATIC VOLTAGE REGULATOR AND STATIC VAR COMPENSATOR **9 Hours**

Static Voltage Regulator - Principles of operation, Steady state model and characteristics of a static voltage regulator, Phase shifters, Power circuit configurations.
Static VAR Compensator - Voltage control by SVC, Advantages of slope in dynamic characteristics, Influence of SVC on system voltage, Design of SVC voltage regulator.

MODULE V UPFC CHARACTERISTICS AND APPLICATIONS **9 Hours**

UPFC - Principles of operation and characteristics; Independent active and reactive power flow control; Comparison of UPFC with the controlled series compensators and phase shifters.

TOTAL: 45 HOURS

REFERENCES:

1. Hingorani, L. Gyugyi, "Concepts and Technology of flexible AC transmission system", Standard Publishers Distributors, 1st Edition, 2011.
2. R.M. Mathur and R.K. Varma ," Thyristor - Based FACTS Controllers for electrical transmission systems", Wiley India Pvt. Limited Publications, 1st Edition, 2011
3. K.R.Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age International Publications, 1st Edition, 2009.
4. https://nptel.ac.in/courses/108/107/108107114
5. https://nptel.ac.in/courses/108/107/108107114

1903EE023 ADVANCED INSULATION SYSTEMS

L	T	P	C
3	0	0	3

PREREQUISITE:

1. High Voltage Engineering
2. Measurements and Instrumentation

COURSE OBJECTIVES:

1. To select the appropriate insulation material and to understand about failures.
2. To familiarize about dielectrics and vacuum insulation.
3. To acquire knowledge on advanced measuring and testing techniques.

COURSE OUTCOMES:

After completion of the course, Student will be able to

CO1 Remember the insulation materials its properties.

CO2 Familiarize about different dielectrics.

CO3 Understand about the vacuum insulation.

CO4 Recognize the insulation testing of electrical installations.

CO5 Understand ethical issues, advanced measurement and diagnostic technologies.

MODULE I INSULATION MATERIALS AND FAILURES 9 Hours

Electrical discharge - Partial break down, Classification of electric fields, Types of dielectrics, Electric strength of dielectrics, Organic and inorganic insulation materials, Insulation materials properties and application, Causes of insulation degradation, Failure modes, Recent insulation testing and diagnostic techniques.

MODULE II DIELECTRICS 9 Hours

Sources of dielectrics, Characteristics of dielectrics, Behavior of dielectrics in electric fields, Machine insulation system, Insulation defects - Insulation stress, Composite insulation system, Nano-dielectrics, Properties and handling of Sulphur hexafluoride, Applications.

MODULE III VACUUM INSULATION 9 Hours

Breakdown electron emission, Pre-breakdown conduction, Effective condition of electrodes, Breakdown mechanism in vacuum, Factors affecting breakdown voltage, Vacuum circuit breaker, Space application, Tutorial.

MODULE IV INSULATION TESTING 9 Hours

Classification of testing, Procedures and standards, Testing automation, Partial discharge test, Dielectric loss test, Insulation testing of equipment, Testing of transformer and cable accessories, Testing of electrical switchgear and circuit breakers, Testing of motor and generators.

MODULE V ADVANCED MEASUREMENT AND DIAGNOSTIC TECHNOLOGIES 9 Hours

Digital impulse recorders, Digital techniques in testing, Testing automation, Electric field measurements, Electro optic sensors, Magneto optic sensors, Space charge measurement techniques, Electro-optical imaging techniques, Insulation resistance measuring instruments, Ethical issues.

TOTAL: 45 HOURS

FURTHER READING:

1. Advanced high voltage testing laboratories and facilities available in the world.
2. A Case study/Survey report on Gas Insulated Line (GIL) and its employment opportunities.

REFERENCES:

1. Ravindra Arora, Wolfgang Mosch, “High Voltage and Electrical Insulation engineering”, Wiley-IEEE press, 2011.
2. Paul Gill, “Electrical Power Equipment Maintenance and Testing”, Second Edition, CRC Press, Taylor & Francis group, 2009.
3. H.Malik, A.A.Al-Arainy and M.I.Qureshi, “Electrical Insulation in Power Systems”, CRC Press, Taylor & Francis group, UK, 1997.
4. D.L.McElroy and J.F.Kimpflen “Insulation material, Testing and Applications”, ASTM publications, Philadelphia, 1990.
5. E.Kuffel, W.S.Zaengl and J.Kuffel “High Voltage Engineering”, Newnes, New Delhi, 2000.
6. NPTEL Course, “Electrical Insulation in Power Apparatus & Systems” by Dr. Nandini Gupta, IIT-Kanpur.

1903EE024	POWER QUALITY	L	T	P	C
		3	0	0	3

PREREQUISITE:

1. Power system analysis

COURSE OBJECTIVES:

1. To discuss various power quality issues
2. To understand the different method to enhance power.

COURSE OUTCOME:

After completion of the course, Student will be able to

CO1 Gain basic knowledge on power quality issues and its monitoring.

CO2 Acquire the basic knowledge on harmonics and its impact in power system**.**

CO3 Understand the concepts of power compensation and conditioners.

CO4 Gain knowledge on power quality management

CO5 Explain the active devices for power enhancement

MODULE I POWER QUALITY OVERVIEW 9 Hours

Power quality issues, Terminologies and standards, Overvoltage transients- Voltage swell, Voltage sag, Voltage fluctuations, Waveform distortion, Voltage flicker, Current unbalance, Harmonics, Power frequency variation, Electromagnetic interferences, Power outages, Indian standards of power quality.

MODULE II POWER TRANSIENTS AND HARMONICS 9 Hours

Type and causes of transients, Switching transients, Ferro resonance, Interruption of fault current, Harmonics nature, Causes of voltage and current harmonics, Harmonic current mitigation, Effects of harmonics, Harmonics in rotating machines, Harmonics in arc furnaces, IEEE standards of Harmonics.

MODULE III POWER COMPENSATION AND CONDITIONERS 9 Hours

Nonlinear loads, Filters classification, Fundamentals of load compensation, Compensation of harmonic frequency, Shunt and series compensators, Power factor improvement, Static VAR compensators, Voltage regulation, Power factor correction, Power factor penalty, Case study of SVC Compensation in Indian railways projects.

MODULE IV POWER QUALITY MANAGEMENT 9 Hours

Pre-conditions of monitoring- Monitoring techniques, Transient disturbance analyzers, Oscilloscopes, Data Loggers and chart recorders, Spectrum analyzers, Flicker meter, Frequency response measurement, Harmonic monitoring system, IEEE recommended measurement techniques for harmonics.

MODULE V ACTIVE DEVICES FOR POWER ENHANCEMENT 9 Hours

Applications of power electronic devices in power transmission and distribution system, Utility customer interfaces- DSTATCOM, DVR, UPQC, UPS, Power quality sensitivity issues, Interconnection standards, Power quality performance requirements and validation, Role of compensators in future energy delivery.

TOTAL: 45 HOURS

FURTHER READING :

1. State on the art of hybrid power filters
2. Recent trends and advances in power quality.

REFERENCES:

1. C.Sankaran, “Power Quality “CRC press, 2002.
2. Angelo Baggini, “Handbook of Power Quality”, Wiley, 2008.
3. Mohammad A. Masoum, Ewald Fuchs, “Power Quality in Power Systems and Electrical Machines”, 2nd Edition, Elsevier science, 2015.
4. R. C. Durgan, M. F. Me Granaghen, H. W. Beaty, “Electrical Power System Quality”, McGraw-Hill, 2nd Edition, 2003.
5. R.Sastryvedam, Mulukutla.S.Sarma “Power quality VAR compensation in power system”, CRC Press, 2008 edition.
6. Prof.Avik Bhattacharya, IIT Roorkee, “Power quality improvement technique”, NPTEL video lecture.

1903EE025 **HIGH VOLTAGE ENGINEERING** **L T P C**
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COURSE OBJECTIVES:

1. To understand the over voltage phenomenon
2. To explain the dielectric breakdown in solid, liquid and gaseous dielectrics
3. To understand the high voltage generation and measurement techniques
4. To specify testing methods and standards in high voltage equipment testing

COURSE OUTCOME:

After completion of the course, Student will be able to

CO1 Understand the overvoltage phenomenon.
CO2 Acquire the knowledge on dielectric breakdown
CO3 Understand the Generation of High Voltage And High Current.
CO4 Understand the Measurement method of High Voltage And High Current
CO5 Explain the Insulation Coordination and High Voltage Testing

MODULE I OVERVOLTAGE PHENOMENON **9 Hours**

Electric field stresses, Estimation and control of electric stress, Natural causes of overvoltage, Lightning phenomenon, Mathematical modeling of lightning, Overvoltage due to switching surges, Surge voltage distribution and control.

MODULE II DIELECTRIC BREAKDOWN **9 Hours**

Properties of dielectric materials, Gaseous breakdown in uniform and non-uniform fields, Corona discharges, Vacuum breakdown, Conduction and breakdown in pure and commercial liquids, Maintenance of oil quality, Breakdown mechanisms in solid and composite dielectrics.

MODULE III GENERATION OF HIGH VOLTAGE AND HIGH CURRENT **9 Hours**

Generation of high DC voltage- Rectifiers, Voltage multipliers, Van de Graff generator.
Generation of high impulse voltage- Single and multistage Marx circuits.
Generation of high AC voltages- Cascaded transformers, Resonant transformer and Tesla coil.
Generation of switching surges, Generation of impulse currents, Triggering and control of impulse generators.

MODULE IV MEASUREMENT OF HIGH VOLTAGE AND HIGH CURRENT **9 Hours**

High resistance with series ammeter – Dividers, Resistance, Capacitance and Mixed dividers, Peak voltmeter, Generating voltmeters, Capacitance voltage transformers, Electrostatic voltmeters, Sphere gaps, High current shunts, Digital techniques in high voltage measurement.

MODULE V HIGH VOLTAGE TESTING AND INSULATION COORDINATION **9 Hours**

Principles of insulation coordination, Testing of electrical apparatus- Insulators, Bushings, Circuit breakers, Cables, Transformer, Test, Specifications of high voltage laboratories.

TOTAL: 45 HOURS

FURTHER READING:

1. Insulation engineering
2. International testing standards for high voltage apparatus

REFERENCES:

1. E. Kuffel and W.S. Zaengl, J.Kuffel, “High voltage Engineering fundamentals”, Newness 2nd Edition Elsevier, New Delhi, 2005.
2. S.Naidu and V. Kamaraju, “High Voltage Engineering”, 5th Edition, Tata McGraw Hill, 2013.
3. Subir Ray, “An Introduction to High Voltage Engineering”2nd Edition, PHI Learning Private Limited, New Delhi, 2013.
4. https://nptel.ac.in/courses/108104048

1904EE851	PROJECT WORK	L	T	P	C
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Course Objectives

1 To develop skills to formulate a technical project.
2 To give guidance on the various tasks of the project and standard procedures.
3 To teach use of new tools, algorithms and techniques required to carry out the projects.
4 To give guidance on the various procedures for validation of the product and analyses the cost effectiveness.
5 To provide guidelines to prepare technical report of the project.

Course Outcomes (COs)

After completion of the course, students will be able to
CO1 Formulate a real world problem, identify the requirement and develop the design solutions
CO2 Identify technical ideas, strategies and methodologies
CO3 Utilize the new tools, algorithms, techniques that contribute to obtain the solution of the project
CO4 Perform test and validate through conformance of the developed prototype
CO5 Analysis the cost Effectiveness of the project
CO6 Explain the acquired knowledge through preparation of report and oral presentations

GUIDELINE FOR REVIEW AND EVALUATION

The students may be grouped into 2 to 4 and work under a project supervisor. The device/ system/component(s) to be fabricated may be decided in consultation with the supervisor and if possible with an industry. A project report has to be submitted by the group with the fabricated model, which will be reviewed and evaluated for internal assessment by a committee constituted by the head of the department. At the end of the semester examination, the project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the head of the department.