ADVANCED POWER SYSTEM

Course Code: EE-501

………

1. **Course Pre-requisites:**
   i. Electric Power System I
   ii. Electric Power system II

2. **Course Learning Objectives:**
   The primary learning objective of an "Advanced Power Systems Analysis" course is to provide students with a deep understanding of complex power system concepts including Y bus matrix by introducing regulating transformer, load flow studies, stability analysis, and emerging technologies, enabling them to analyze, design, and troubleshoot advanced power systems, particularly in the context of modern grid challenges like renewable integration and distributed generation.

3. **Course Name: ADVANCED POWER SYSTEM**
   Course Code: EE-501
   Hours per Week: 4
   Credits: 4

   Course Contents:

Module	Topics	40L
1.	**Network matrix:** Physical interpretation of bus admittance and impedance matrices, introduction to admittance matrix formulation, formation of admittance matrix due to inclusion of regulating transformer, development of admittance matrix using singular transformation, modification of admittance matrix for branch addition/ deletion.	08
2.	**Complex power flow:** Analytical formulation of complex power flow solution, Gauss-Seidal method of power flow, Newton Raphson method of power flow, algorithm for solving power flow problem using N-R method in rectangular form, algorithm for solving power flow problem using N-R method in polar form, fast decoupled load flow method.	12
3.	**Power System Stability**: Definitions, classification of stability-rotor angle and voltage stability, synchronous machine representation for stability study. **Transient stability:** Assumptions for transient stability, derivation of swing equation, swing equation for synchronous machine connected to infinite bus, swing equation for a two machine system, solution of swing equation by Euler and Runge Kutta method, equal area criterion, critical clearing angle, application of critical clearing angle to transient stability of synchronous machine. Methods of improving transient stability: reducing fault clearance time, automatic reclosing, single phase reclosing, electric braking, voltage regulators, fast governor action, high speed excitation system.	02+12 +06

	Voltage stability: Definition and classification of voltage stability, mechanism of voltage collapse, analytical concept of voltage stability for a two bus system, expression for critical receiving end voltage and critical power angle at voltage stability limit for a two bus power system, PV and QV curves, L index for the assessment of voltage stability.	

4. Text Books:

T1: A. Chakrabarti, M.L. Soni, P.V. Gupta, U.S. Bhatnagar, "A text book on Power System Engineering", Dhanpat Rai and Co.

T2: Hadi Saadat, "Power system Analysis", Tata McGraw-Hill Publishing Company Limited.

T3: D. Das, "Power System Analysis", New Age International Publisher.

5. References:

R1: Charles A, Gross John, "Power system Analysis", Wiley & Sons.

R2: John J. Grainger & William D. Stevenson, JR, "Power system Analysis", Tata McGraw-Hill Edition.

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Recall importance of Y bus matrix	Analyze, Identify	Understand, Remember
CO2	To study the load flow analysis by Gauss Seidel method	Identify, Select	Understand, Apply, Analyze
CO3	To study the load flow analysis by N.R. method	Identify, Select	Understand, Apply, Analyze
CO4	Describe and analyze various states of stability studies in Synchronous Machines.	Analyze	Understand, Apply, Analyze
CO5	State swing equation of multi machine system.	Identify	Understand, Apply, Analyze
CO6	Describe and analyze voltage stability of two bus system.	Implement	Evaluate

7. Mapping of course outcomes to module/course content:

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	-	-	-	-	
2	2	3	3	-	-	
3	2	2	2	3	3	3

8. **Mapping of CO to PO:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	3	2	-	-	-	-	-	-
CO2	3	3	3	3	2	-	-	-	-	-	-
CO3	3	3	3	3	2	-	-	-	-	-	-
CO4	3	3	3	3	2	-	-	-	-	-	-
CO5	3	3	3	3	2	-	-	-	-	-	-
CO6	3	3	3	3	2	-	-	-	-	-	-

9. **Mapping to PSO:**

	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	1
CO2	3	3	2	1
CO3	3	3	2	1
CO4	3	3	2	1
CO5	3	3	2	1
CO6	3	3	2	1

HIGH VOLTAGE ENGINEERING

Course Code: EE-502

……….

1. **Course Prerequisite:**
    1. Electromagnetic Field Theory
    2. Electric Power System I
    3. Electrical and Electronics Measurements
    4. Electric Power System II

2. **Course Learning Objectives:**
    This course is designed to review the fundamentals and practices of insulating materials and their applications in electrical and electronics engineering, breakdown phenomenon in insulating material (solid, liquid, and gases), generation and measurement of high D.C., A.C. and impulse voltages and currents, overvoltage phenomenon in electrical power system and insulation coordination, high voltage testing techniques.

3. **Course Name: HIGH VOLTAGE ENGINEERING**

Course Code: EE-502
Hours per Week: 4
Credits: 4

Course content:

Module	Topics	38L
1.	**Overview of High Voltage Engineering**: Air as an Insulation, Concept of Dielectric Strength, Electric field and electrode configuration, Parameters for dependence of Dielectric strength, Introduction to Breakdown of Insulation.	05
2.	**Breakdown of Gases, Solids and Liquids:** Gases: Ionization and decay processes, Townsend's criterion, Paschen's law, streamer theory, and breakdown in electronegative gases. Liquids: Electronic breakdown, breakdown in pure and commercial liquids. Solids: Intrinsic, electromechanical, and thermal breakdown in solid dielectrics, as well as breakdown in composite materials.	08
3.	**Generation of AC high voltages and DC High Voltages:** Generation using transformers in cascade, series resonant circuits, and testing transformers for AC voltage. Generation using rectifier circuits (half and full wave), and electrostatic generators for DC voltage.	05
4.	**Generation of impulse voltages and currents:** Analysis of different circuits, Marx multi-stage impulse generator.	05
5.	**Methods of measuring high voltage and high currents of power frequency and D.C and Impulse:** Methods for measuring AC, DC, and impulse voltages and currents using electrostatic voltmeters, sphere gaps, potential dividers, and other specialized instruments.	05

6.	**Introduction to Lightning phenomenon, Insulation Co-ordination.** Brief reviews of high voltage testing-Methods for different power system equipment.	05
7.	**Introduction to H.V. testing transformer design.** Capacitive voltage transformer. Introduction to partial discharge and partial discharge testing.	05

4. Text Books:

T1: M S Naidu & Kamraju, High Voltage Engineering, Tata McGraw-Hill Publishing Company Ltd.
T2: C.L.Wadhwa, High Voltage Engineering, New Age International Publisher.

5. References:

1. Kueffel & Zangel, High Voltage Engineering Fundamentals, Newnes- An imprint of Butterworth- Heinemann Linacre House, A division of Reed Educational and Professional Publishing Ltd.
2. J. Lucas, High Voltage Engineering, Katson book.

6. Course Outcomes:

Course Outcomes	**Details/Statement**	**Action Verb**	**Knowledge Level**
CO1	Recall importance of high voltage technology.	Analyze, Identify	Understand, Remember
CO2	To study the breakdown phenomena in different dielectrics.	Identify, Select	Understand, Apply, Analyze
CO3	Demonstrate generation of high voltages and Currents.	Identify, Select	Understand, Apply
CO4	Describe and analyze various measurement techniques for high Voltages and Currents.	Analyze	Understand, Apply, Analyze
CO5	Evaluate insulation coordination among different HV apparatus.	Identify	Analyze
CO6	Examine testing methods used for different HV apparatus.	Implement	Evaluate

7. Mapping of course outcomes to module / course content

Module	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**
1	3	-	-	-	-	-
2	2	3	-	-	-	-
3	2	-	3	-	-	-
4	3	-	3	-	-	-
5	3	-	-	3	-	-
6	3	-	-	-	3	
7	2					3

8. Mapping of the Course outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	2	-	-	1	-	-	-	-	1
CO2	3	3	3	2	2	1	-	-	-	-	1
CO3	3	3	3	3	2	2	-	-	-	-	1
CO4	3	3	3	3	2	1	-	-	-	-	1
CO5	3	3	3	3	2	1	-	-	-	-	1
CO6	3	3	3	2	2	2	1	-	-	-	1

9. Mapping to PSO:

	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	1
CO2	3	3	1	2
CO3	3	2	1	2
CO4	3	2	1	1
CO5	3	2	1	2
CO6	3	3	1	2

HVDC TRANSMISSION AND CONVERTERS

Course Code: EE-503

………

1. **Course Pre-requisites:**
   1. Power Electronics
   2. Power System-I
   3. Control System

2. **Course Learning Objectives:**
   Understand the fundamentals of HVDC transmission, explore modern trends and applications of HVDC technology, analyse HVDC converter circuits, examine HVDC system components and operation, evaluate control and protection strategies, analyse power flow and stability in HVDC systems.

3. **Course Name: HVDC TRANSMISSION AND CONVERTERS**
   Course Code: EE-503
   Hours per Week: 4
   Credits: 4

   Course Contents:

Module	Topics	40L
1.	**DC power transmission technology:** Introduction, comparison of AC and DC transmission, limitation of HVDC transmission, reliability of HVDC systems, application of DC transmission, description of DC transmission system, planning for HVDC transmission, modern trends in DC transmission.	04
2.	**Analysis of HVDC converters:** Pulse number, Choice of converter configuration, Simplified analysis of Graetz circuit, Converter bridge characteristics, Characteristics of a twelve-pulse converter, Detailed analysis of converters with and without overlap.	12
3.	**Converter and HVDC system control:** General, Principles of DC link control, Converter control characteristics, Firing angle control, Current and extinction angle control, Starting and stopping of DC link, Power control, control scheme of HVDC converters.	08
4.	**Harmonics and filters:** Generation of harmonics by converters, characteristics of harmonics on DC side, characteristics of current harmonics, characteristic variation of harmonic currents with variation of firing angle and overlap angle, effect of control mode on harmonics, non-characteristic harmonic. Filter configuration, design of band- pass and high pass filter, protection of filters, DC filters, power line communication and RI noise, filters with voltage source converter HDVC schemes.	06
5.	**Fault and protection schemes in HVDC systems:** Nature and types of faults, faults on AC side of the converter stations, converter faults, fault on DC side of the systems, protection against over currents and over voltages, protection of filter units.	04
6.	**Multiterminal HVDC systems:** Types of multiterminal (MTDC) systems, parallel operation aspect of MTDC. Control of power in MTDC. Multilevel DC systems.	06

4. **Text Books:**

T1: HVDC Transmission, S. Kamakshaiah & V. Kamaraju, Tata McGraw Hill Education.
T2: HVDC Power transmission system, K.R. Padiyar, Wiley Eastern Limited.

5. **References:**

R1: Power system stability and control, Prava Kundur, MGH.

R2: High Voltage Direct Current Transmission, J. Arrillaga, Peter Pregrinu.

R3: Extra High Voltage AC Transmission Engineering, Rakosh Das Begamudre, New Age International (P) Ltd.

R4: High Voltage Direct Current Power Transmission, Colin Adamson and N. G. Hingorani, Garraway Limited, London.

R5: The Performance, Operation and Control of EHV Power Transmission Systems, A. Chakraborty, D.P. Kothary, A.K. Mukhopadhyay, Wheeler Pub.

6. **Course Outcomes:**

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Understand the advantages of dc transmission over ac transmission.	Analyze, Identify	Understand, Remember
CO2	Analysis of line commutated converters and voltage source converters in HVDC transmission system.	Identify, Select	Understand, Apply, Analyze, Evaluate
CO3	Application of suitable control strategies used for HVDC transmission system.	Identify, Select	Understand, Apply, Evaluate
CO4	Able to calculate voltage and current harmonics, and design of filters and understand the reactive power necessity of conventional control.	Analyze	Understand, Apply, Analyze
CO5	Protection requirements for HVDC transmission system faults.	Identify	Analyze
CO6	Analysis of multiterminal HVDC systems.	Implement	Understand, Apply, Analyze

7. **Mapping of course outcomes to module/course content:**

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	-	-	-	-	-
2	-	3	-	-	-	-
3	-	-	3	-	-	-
4	-	-	-	3	-	-
5	-	-	-	-	3	-
6	-	1	1	-	-	3

8. **Mapping of CO to PO:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	1	-	-	-	-	-	-	-	-	
CO2	3	2	1	1	-		-	-	-	-	1
CO3	3	2	2	2	2	1	-	-	-	1	1
CO4	3	2	2	1	2	1	-	-	-	-	-
CO5	3	2	1	2	2	1	-	-	-	1	1
CO6	3	2	2	2	2	1	-	-	-	1	1

9. Mapping to PSO:

	PSO1	PSO2	PSO3	PSO4
CO1	1	-	1	-
CO2	3	1	2	1
CO3	3	1	3	1
CO4	3	-	3	1
CO5	3	-	3	1
CO6	3	-	3	1

POWER SYSTEM PLANNING AND RELIABILITY
Course Code: EE-504

....

1. Course Prerequisite:
1. Electric Power systems
2. Electrical Measurements
3. Engineering Mathematics

2. Course Learning Objectives:
Familiarize the basic concepts of power system planning and reliability
Learn security analysis and contingency approaches with environmental considerations.
Explore distribution system design and protective device coordination.
Comprehend and enrich reliability basics, maintenance approaches.

3. **Course Name: Power System Planning and Reliability**
Course Code: EE-504
Hours per Week: 4
Credits: 4
Course Content:

Module	Topics	36L
1.	**System Planning:** Introduction, Objectives & Factors affecting to System Planning, Short Term Planning, Medium Term Planning, Long Term Planning, Reactive Power Planning.	06
2.	**Reliability:** 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.	07
3.	**Generation Planning and Reliability:** 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.	07
4.	**Transmission Planning and Reliability:** Introduction, Objectives of Transmission Planning, Network Reconfiguration, System and Load Point Indices, Data required for Composite System Reliability...	07
5.	**Distribution Planning and Reliability:** Radial Networks, 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, Bus Bar Failure, Scheduled Maintenance, Temporary and Transient Failure, Breaker Failure.	09

4. **Text Book:**

1. R.L. Sullivan “Power System Planning”, Tata McGraw Hill Publishing Company Ltd.

2. Roy Billinton & Ronald N. Allan “Reliability Evaluation of Power System”, Springer Publication.

3. T. W. Berrie “Electricity Economics & Planning”, Peter Peregrinus Ltd., London.

5. Reference Books

1. Jamdade P. G., Jamdade S. G., “Power System Planning and Reliability” Tech-Neo Publications.

2. Goran Strbac, Daniel Kirschen, “Reliability Standards for the Operation and Planning of Future Electricity Networks” now publishers Inc.

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Implement reliability-based planning criteria and risk analysis	Analyze, Identify	Understand, Remember
CO2	Apply security analysis methodologies and approaches	Identify, Select	Understand, Apply, Analyze
CO3	Develop distribution systems and optimize protection coordination	Identify, Select	Understand, Apply
CO4	Utilize advanced reliability evaluation techniques and maintenance approached in real-world scenarios.	Analyze	Understand, Apply, Analyze
CO5	Development Network Configurations	Identify	Analyze

7.Mapping of course outcomes to module / course content

Module	CO1	CO2	CO3	CO4	CO5
1	3	-	-	-	-
2	2	3	-	-	-
3	2	-	3	-	-
4	3	-	3	-	-
5	3	-	-	3	3

8. Mapping of the Course outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	2	-	-	1	1	-	-	-	1
CO2	3	3	3	2	2	1	1	-	-	-	1
CO3	3	3	3	3	2	2	1	-	-	-	1
CO4	3	3	3	3	2	1	1	-	-	-	1
CO5	3	3	3	3	2	1	1	-	-	-	1

9. Mapping to PSO:

	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	1
CO2	3	2	1	2
CO3	3	2	1	2
CO4	3	2	2	1
CO5	3	2	1	2

POWER SYSTEM APPARATUS

Course Code: EE-505

………

1. **Course Pre-requisites:**
   1. Power System
   2. Electromagnetic Field Theory
   3. Electrical & Electronics Measurement

2. **Course Learning Objectives:**
   This course aims to provide students with a deep understanding of various key components and controllers used in power systems. Through this syllabus, the course provides students with a comprehensive understanding of power system apparatus, focusing on circuit breakers, surge protection, and advanced FACTS technologies. This course provides a comprehensive understanding of the various components and devices used in a power system, including their design principles, operating characteristics, limitations and applications enabling students to analyze and design power systems effectively, particularly in relation to equipment selection and system reliability.

3. **Course Name: POWER SYSTEM APPARATUS**
   Course Code: EE-505
   Hours per Week: 4
   Credits: 4

   Course Contents:

Module	Topics	40L
1.	**Circuit Breaker:** Introduction, Operating Principle, Detail study on VCB and SF6 Circuit breaker, Ratings, Selection. Surge Arrester & Surge Absorber. Insulation Co-ordination, BIL	06
2.	**FACTS:** Concepts and general consideration: Opportunities of FACTS. Basic types of FACTS controller. Brief description and definition of FACTS controllers. Shunt connected controller, Series connected controller. Combined series and shunt connected controller	08
3.	**Static Shunt Compensators:** Objectives of Shunt Compensations. Midpoints voltage regulation for line segmentation. Improvements of transient stability, Methods of controllable VAR generation. Variable impedance type static VAR generation, TCR and TSR, FC-TCR (Fixed Capacitor, Thyristor Controlled Reactor), Hybrid VAR Generators. Static VAR Compensator (SVC & STATCOM). Transfer Function and Dynamic Performance. Power Oscillation, Damping. Transient Stability	12
4.	**Static Series Compensators:**.GCSC, TSSC, TCSC and SSSC: Basic Operating Control Schemes for GCSC, TSSC and TCSC	06
5.	**Static Voltage and Phase Angle Regulators:** TCVR and TCPAR,	04
6.	**Unified power flow controller**	04

4. Text Books:

T1: Understanding FACTS by Narain G. Hingorani & Laszlo Gyugyi: IEEE Press

T2: Power System Switchgear & Protection by Sunil S. Rao

5. **References:**

R1: FACTS Controllers in Power Transmission and Distribution by K. R. Padiyar: New Age International Pvt Ltd.

6. **Course Outcomes:**

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Understand the working principles and selection criteria of Circuit Breakers, including VCB and SF6 types.	Explain	Comprehension
CO2	Analyze and design Surge Arresters, Surge Absorbers, and understand Insulation Coordination and BIL concepts.	Analyze	Application
CO3	Comprehend the concepts of FACTS (Flexible AC Transmission Systems) and their application in modern power systems.	Identify	Comprehension
CO4	Evaluate the operation and benefits of various FACTS controllers, such as Shunt, Series, and Combined controllers.	Evaluate	Evaluation
CO5	Understand the principles and performance characteristics of Static VAR Compensators (SVC & STATCOM) in power systems.	Understand	Comprehension
CO6	Analyze the dynamic performance and control schemes of Static Series Compensators, such as GCSC, TSSC, TCSC, and SSSC, including their impact on system stability and power flow.	Analyze	Analysis

7. **Mapping of course outcomes to module/course content:**

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	2	-	-	-	-
2	-	3	-	-	-	-
3	-	-	3	-	-	-
4	-	-	2	3	-	-
5	-	-	2	2	3	-
6	-	-	-	-	-	3
7	3	2	-	-	-	-
8	-	3	-	-	-	-

8. **Mapping of CO to PO:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	2	-	-	1	1	-	-	-	1
CO2	3	3	2	2	1	2	1	-	-	-	1
CO3	2	3	3	3	2	2	3	-	-	-	1
CO4	3	2	2	3	1	1	1	-	-	-	1
CO5	3	3	3	1	2	3	2	-	-	-	1
CO6	2	2	3	2	3	2	2	-	-	-	1

9. Mapping to PSO:

	PSO1	PSO2	PSO3	PSO4
CO1	2	3	1	1
CO2	3	2	1	1
CO3	3	2	1	2
CO4	2	3	2	1
CO5	3	2	1	2
CO6	3	3	2	1

POWER QUALITY AND AUDIT

Course Code: EE-506

………………………………………………………………………………………………

1. Course Prerequisite:

1. Power System
2. FACTS

2. Course Learning Objectives:

By the end of this course, students will be able to understand the fundamentals of power quality, identify common power quality issues such as harmonics, voltage sags/swells, flicker, and interruptions, apply mathematical and analytical tools to quantify various power quality parameters, assess the effects of power quality disturbances on electrical equipment and system performance, evaluate cost–benefit aspects of proposed mitigation strategies and relate power quality auditing to overall energy efficiency and sustainability goals.

3. **Course Name: POWER QUALITY AND AUDIT**
   Course Code: EE-506
   Hours per Week: 4
   Credits: 4

Course Content:

Module	Topics	36L
1	**Introduction to Power Quality:** Definition and importance of power quality, Power quality issues: transients, sags, swells, interruptions, Characteristics of voltage, current, and frequency, Symptoms of poor power quality, Power quality standards (IEEE 519, IEC, etc.). Flicker and its measurement. Tolerance of Equipment: CBEMA curve.	06
2	**Voltage Disturbances:** Short-duration voltage variations: sag, swell, interruptions, Long-duration voltage variations: overvoltage, under voltage, Causes and effects of voltage disturbances, Mitigation techniques, Flicker and its sources.	06
3	**Harmonics:** Harmonic distortion: voltage and current harmonics, Total Harmonic Distortion (THD), Harmonic sources: nonlinear loads, Effects of harmonics on power system components, Measurement and analysis, Harmonic filters (passive, active).	06
4	**Power Quality Monitoring:** Monitoring instruments and techniques, Power analysers and disturbance analysers, Event recorders and data loggers, Measurement protocols, Case studies in power quality monitoring.	06
5	**Power Quality Improvement Devices:** Static VAR compensators (SVC), Dynamic Voltage Restorers (DVR), Uninterruptible Power Supplies (UPS), Surge Protectors and TVSS, Application of FACTS devices for power quality improvement.	06
6	**Power Quality Audit:** Need and scope of power quality audit, Procedure for conducting power quality audit, Cost-benefit analysis, Report preparation and recommendations, Role of utilities and customers.	06

4. Text Books:

T1: Electrical Power Systems Quality – Roger C. Dugan, Mark F. McGranaghan
T2: 2. Power Quality – C. Sankaran
T3: Power System Harmonics – J. Arrillaga

5. References:

R1. Electrical Power Systems Quality", R. C. Dugan, McGraw Hill Education, 2012.
R2. Electric Power Quality, G. T. Heydt , Stars in a Circle Publications, 1991.

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Understand voltage, current, and frequency deviations and their impacts on equipment and system performance.	Analyse, Identify	Understand, Remember
CO2	Recognize disturbances such as harmonics, transients, flicker, voltage sags/swells, and interruptions	Identify, Select	Understand, Apply, Analyse
CO3	Use appropriate instruments and data acquisition methods to assess power quality issues.	Identify, Select	Understand, Apply
CO4	Plan, execute, and document a complete power audit for an industrial, commercial, or utility system	Analyse	Understand, Apply, Analyse
CO5	Assess the cost-benefit and energy savings from proposed power quality improvements.	Analyse	Analyse
CO6	Ensure recommendations align with relevant codes, safety rules and best practices.	Analyse, Identify	Understand, Apply

7. Mapping of course outcomes to module / course content:

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	2	2	-	-	-
2	-	2	3	3	-	-
3	-	-	2	3	-	-
4	-	-	3	2	2	-
5	-	-	2	3	-	-
6	-	-	-	-	3	3

8. Mapping of the Course outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	2	2	2	-	-	-	-	-	-
CO2	-	3	-	2	2	-	1	-	1	-	-
CO3	-	3	3	3	2	-	-	-	-	-	-
CO4	-	-	-	-	-	2	1	2	2	2	2
CO5	-	-	-	-	-	-	1	2	2	2	1
CO6	-	-	-	-	-	-	2	2	-	2	2

9. Mapping to PSO:

	PSO1	PSO2	PSO3	PSO4
CO1	3	2	-	-
CO2	3	3	1	-
CO3	3	2	-	-
CO4	-	2	1	1
CO5	-	-	2	2
CO6	-	2	2	2

SOFT COMPUTING TECHNIQUES

Course Code: EE-507

………

1. **Course Pre-requisites:**
   1. Power System-I
   2. Power System-II
   3. Power Generation Economics

2. **Course Learning Objectives:**
   The course equips students with the ability to understand and apply iterative methods and evolutionary algorithms, analyze their performance and design hybrid intelligent systems capable of solving complex real-world problems with adaptability, efficiency and tolerance to uncertainty.

3. **Course Name: SOFT COMPUTING TECHNIQUES**
   Course Code: EE-507
   Hours per Week: 4
   Credits: 4

   Course Contents:

Module	Topics	38L
1.	Fundamentals of Soft Computing techniques, Definition-Classification of optimization problems-Unconstrained and Constrained Optimization-Optimality Conditions-Classical techniques (Interval halving method, Gradient-based methods).	06
2.	Lamda iteration method: Brief introduction to lamda iteration method, formulate the Lagrange function, Lamda iteration method to solve optimal dispatch problem.	08
3.	Differential Evolution: Fundamental principle, developing DE based solution techniques for OPF problems with single and multiple objectives and comparing the performance and computational effectiveness of DE with other evolutionary and conventional techniques.	07
4.	Particle Swarm Optimization: Fundamental principle, Velocity updating, Advanced operators, Parameter selection, Hybrid approaches (Hybrid of GA and PSO, Hybrid of EP and PSO).	06
5.	Genetic Algorithm: Introduction to genetic Algorithm, working principle, Principles of Genetic Algorithm- Evolutionary Strategy and Evolutionary Programming-Genetic Operators- Selection, Crossover and Mutation fitness function.	07
6.	Application of soft computing techniques in power systems: Algorithms and flow chart of various optimization techniques for solving economic load dispatch and hydro-thermal scheduling problem.	04

4. **Text Books:**

   T1: Optimization for Engineering Design - Kalyanmoy Deb.

   T2: Power System Optimization by D.P. Kothari and J. S. Dhillon.

5. **References:**
   R1: S. N. Sivanandam, S. N. Deepa – *Principles of Soft Computing*, Wiley India, 2nd Edition, 2011.
   R2: Haupt, R. L., Haupt, S. E. – *Practical Genetic Algorithms*, Wiley, 2004.

6. **Course Outcomes:**

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Explain the fundamentals and classifications of optimization problems, including unconstrained and constrained methods, and their optimality conditions.	Analyze, Calculate,	Remember, Understand
CO2	Apply classical optimization techniques and the Lambda iteration method to solve optimal power dispatch problems.	Identify, Evaluate	Analyze, Create
CO3	Develop and implement Differential Evolution algorithms for optimal power flow (single and multi-objective) and compare their performance with other methods.	Measure, Assess	Evaluate, Create
CO4	Design and optimize Particle Swarm Optimization models, including advanced operators, parameter tuning, and hybrid PSO approaches.	Determine, Calculate	Create, Apply
CO5	Apply Genetic Algorithm principles, operators, and evolutionary strategies to solve engineering optimization problems.	Simulate, Analyze	Analyze, Apply
CO6	Formulate and implement soft computing–based solutions for economic load dispatch and hydro-thermal scheduling, using algorithm design and flowcharts.	Determine, Calculate	Create, Apply

7. **Mapping of course outcomes to module/course content:**

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	-	-	1	-	-
2	1	3	-	-	-	-
3	-	-	3	-	-	-
4	-	-	-	3	-	-
5	-	3	-	-	3	-
6	-	-	-	-	-	3

8. **Mapping of CO to PO:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	1	1	2	2	-	-	-	-	1
CO2	3	3	1	1	2	2	-	-	-	-	1
CO3	3	3	1	1	2	2	-	-	-	-	1
CO4	3	3	1	1	2	2	-	-	-	-	1
CO5	3	3	1	1	2	2	-	-	-	-	1
CO6	3	3	1	1	2	2	-	-	-	-	1

9. **Mapping to PSO:**

	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	2
CO2	3	3	1	1
CO3	3	-	1	1
CO4	3	-	2	1
CO5	3	2	-	2

SMART GRID TECHNOLOGY

Course Code: EE-508

....

1. **Course Pre-requisites:**
   1. Electric Power systems
   2. Power Electronics

2. **Course Learning Objectives:**
   The learning objectives of smart grid technology focus on understanding its core concepts, components, and benefits, as well as its role in modernizing energy infrastructure and promoting sustainability.

3. **Course Name: Smart Grid Technology**
   Course Code: EE-508
   Hours per Week: 4
   Credits: 4

   Course Contents:

Module	Topics	36L
1.	**Introduction:** Introduction, Definition of Smart Grid, Concept of Smart Grid Structure, Conventional Grid Vs Smart Grid, Smart Grid Domain, Opportunities and Barriers of Smart Grid, Smart Grid activities in India and developed countries, Key Challenges for Smart Grid.	07
2.	**Architecture:** Components and Architecture of Smart Grid Design, Review of the proposed architectures for Smart Grid, Advanced metering infrastructure, The fundamental components of Smart Grid designs, Transmission Automation, Distribution Automation, Renewable Integration.	07
3.	**Distribution Generation Technologies**: Introduction, Introduction to Renewable Energy Technologies, Types of DGs, Micro Grids, Storage Technologies- Electric Vehicles and PHEVs, Environmental impact and Climate Change, Economic Issues.	08
4.	**Communication Technologies and Smart Grid:** Introduction, Two way digital communications paradigm, Synchro-Phasor Measurement Units (PMUs), Wide Area Measurement Systems (WAMS), Introduction to Internet of Things (IOT), Applications of IOT in Smart Grid, Cyber Security for Smart Grid.	07
5.	**Planning:** Planning aspects of Smart Grid, Operation and control of AC, DC and hybrid Smart Grid, Demand side management, Demand Response, Energy Management, Planning of Smart Grid Systems.	07

4. Text Books:

T1: A.G. Phadke and J.S. Thorp, "Synchronized Phasor Measurements and their Applications", Springer Edition, 2nd Edition, 2017.

T2: Stuart Borlase, "Smart Grids, Infrastructure, Technology and Solutions", CRC Press, 1st Edition, 2012.

5. **References:**
   R1: J. A. Momoh, "Smart Grid: Fundamentals of Design and Analysis," Wiley-IEEE Press, 1 st Edition, March 2012.

6. **Course Outcomes:**

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Able to understand the features and architecture of Smart Grid.	Analyze, Identify	Understand, Remember
CO2	Able to assess the role of automation in transmission and distribution.	Identify, Select	Understand, Apply, Analyze
CO3	Able to understand and analyze the operation of DG and storage technologies.	Identify, Select	Understand, Apply
CO4	Able to understand the communication technologies and cyber-security in Smart Grid.	Analyze	Understand, Apply, Analyze
CO5	Able to understand the planning, operation, control and analysis of Smart Electric Grid.	Identify	Analyze

7. **Mapping of course outcomes to module/course content:**

Module	CO1	CO2	CO3	CO4	CO5
1	3	1	1	2	1
2	3	3	1	2	2
3	2	2	3	2	2
4	3	2	2	3	2
5	3	2	2	2	3

8. **Mapping of CO to PO:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	2	2	1	-	-	-	-	1
CO2	3	3	3	2	2	1	-	-	-	-	1
CO3	3	3	3	2	2	1	-	-	-	-	1
CO4	3	3	3	2	2	1	-	-	-	-	1
CO5	3	3	3	2	2	1	-	-	-	-	1

9. **Mapping to PSO:**

	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	1
CO2	3	2	1	1
CO3	3	2	1	1
CO4	3	2	1	1
CO5	3	2	1	1

CONDITIONING MONITORING AND POWER APPARATUS

Course Code: EE-509

……………………………………………………………………………………………………….

1. **Course Prerequisite:**
   5. Electromagnetic Field theory
   6. High Voltage Engineering
   7. Electrical and Electronics Measurements
   8. Power system

2. **Course Learning Objectives:**
   The course enables students to understand the importance of condition monitoring in improving the reliability and efficiency of power equipment. They learn common failure modes of apparatus such as transformers, rotating machines, cables, and circuit breakers, along with diagnostic techniques like dissolved gas analysis, thermography, and partial discharge measurement. Students gain skills in analyzing monitoring data, predicting faults, and planning condition-based maintenance. The course also emphasizes the use of modern tools, real-time case studies, and industry practices to develop effective predictive and preventive maintenance strategies.

3. **Course Name: CONDITIONING MONITORING AND POWER APPARATUS**

Course Code: EE-509
Hours per Week: 4
Credits: 4

Course content:

Module	Topics	36L
1.	**Introduction of Insulating materials utilized in power-system equipment:** Characterization of insulation condition, Electrical breakdown and operating stresses.	03
2.	**Introduction to electrical insulation design concepts:** Overview of insulation design requirements, Electric stress distributions in simple insulation systems, Multiple dielectric systems, Edge effects, Multiple electrode configurations, Electric stress control.	06
3.	**Insulation defects in power-system equipment:** Suspension and post insulators, Suspension (string) and Post insulators, High-voltage bushings, High-voltage instrument transformers, Oil-impregnated current transformers, Dry-type current transformers, Capacitor-type voltage transformers – CVT, High-voltage power capacitors, High-voltage surge arresters, High-voltage circuit breakers, Gas-insulated systems (GIS), High-voltage cables. Electrical rotating machines: Low-voltage motors, High-voltage machines, Possible insulation failure mechanisms in rotating, CIGRE summary of expected machine insulation degradation, Future of machine insulation. Transformers and reactors: Windings, Transformer insulation structures.	15
4.	**Sensors for insulation condition monitoring:** Ultra-high-frequency sensors, Optical-fibre sensors, Basic physics of optical-fibre sensing, Optical-fibre PD sensors, Optical-fibre temperature sensors, Advantages	06

	and disadvantages of optical-fibre sensors, Directional sensors for PD measurements.	
5.	**Artificial-intelligence techniques for incipient fault diagnosis and condition assessment:** Database for condition assessment, A computer database and diagnostic program, A combined method for DGA diagnosis, Fuzzy-logic fault diagnosis, The conventional methods, A fuzzy-logic method, Asset analysis and condition ranking.	06

4. **Text Books:**

T1: Handbook of Condition Monitoring by B. K. N. Rao, Elsevier Science Publisher.

T2: Condition Assessment of High Voltage Insulation in Power System Equipment by R.E James, Publisher IET.

T3: Condition Monitoring of Rotating Electrical Machine by P. J. Tavner, J. Penman, Publisher IET.

5. **References:**

R1: Machinery vibration Analysis & Predictive Maintenance by Paresh Girdhar, Elsevier publishers**.**

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Able to Identify various modes of failures of power equipment's located in electric power sub stations networks.	Analyze, Identify	Understand, Remember
CO2	Able to describe various diagnostic tests related with condition assessment of power apparatus.	Identify, Select	Understand, Apply, Analyze
CO3	Apply principles and tools to carry out condition assessment studies related with power transformers.	Identify, Select	Understand, Apply
CO4	Able to develop skill to assess and interpret the diagnostic test results for health assessment concerning residual life enhancement and reliable operation before any catastrophic failure of power equipment occur.	Analyze	Understand, Apply, Analyze
CO5	Able to diagnosis fault and condition assessment with AI.	Implementation	Explore

7. Mapping of course outcomes to module / course content:

Module	CO1	CO2	CO3	CO4	CO5
1	3	-	2	-	-
2	2	3	-	-	-
3	3	-	3	-	-
4	3	-	-	3	-
5	-	-	-	-	3

8. **Mapping of the Course outcomes to Program Outcomes:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	2	-	-	1	-	-	-	-	1
CO2	3	3	3	2	2	1	-	-	-	-	1
CO3	3	3	3	3	2	2	-	-	-	-	1
CO4	3	3	3	3	2	1	-	-	-	-	1
CO5	3	3	3	3	2	1	-	-	-	-	1

9. **Mapping to PSO:**

	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	1
CO2	3	3	1	2
CO3	3	2	1	2
CO4	3	2	1	1
CO5	3	2	1	2

POWER SYSTEM HARDWARE LAB-I

Course Code: EE-510

……………………………………………………………………………………………

1. **Course Prerequisite:**
   1. Electric Power System I
   2. Electric Power System II
   3. Advanced Power System Analysis

2. **Course Learning Objectives:**
   Power System Hardware Lab I course aims to provide students with practical experience in analyzing and understanding the behavior of electrical power systems. The course outcomes generally include the ability to analyze dielectric strength of different solid insulating materials. Students also gain experience in testing various protection schemes during faults. Students can gain the practical idea of characteristics of PT and CT.

3. **Course Name: Power System Hardware Lab I**
   Course Code: EE-510

   Hours per Week: 3
   Credits: 2

   Course Content:

Exp. No.	Experiments
1	Determination of break down strength of solid insulating material.
2	Testing on Under Voltage Relay
3	Testing on Earth Fault Relay
4	Testing on Over Current Relay
5	Study on ON load time delay relay (VTT11)
6	Study on OFF load time delay relay (VTT12)
7	Polarity, ratio & magnetizing characteristics test of PT
8	Polarity, ratio & magnetizing characteristics test of CT

4. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	To study the breakdown phenomena in different solid dielectrics.	Analyze, Identify	Understand, Remember, Apply
CO2	Ability to analyze the different characteristics of Under voltage, Over-current and earth fault relay.	Identify, Select	Understand, Apply, Analyze
CO3	Ability to analyze the different characteristics of ON load time delay relay (VTT11) and OFF load time delay relay (VTT12).	Identify, Select	Understand, Apply, Analyze
CO4	To analyze the different characteristics of CT and PT.	Analyze	Understand, remember, Apply, Analyze

5. Mapping of course outcomes to experiment / course content:

Exp. No.	CO1	CO2	CO3	CO4
1	3	–	–	2
2	–	3	–	–
3	–	3	-	–
4	–	3	-	–
5	–	–	3	–
6	–	–	3	–
7	–	–	–	3
8	–	–	–	3

6. **Mapping of the Course outcomes to Program Outcomes:**

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

7. **Mapping Course outcomes to PSO:**

	PSO1	PSO 2	PSO 3	PSO 4
CO1	3	2	1	1
CO2	3	3	1	2
CO3	3	2	1	2
CO4	3	2	1	1

POWER SYSTEM SOFTWARE LAB-I

Course Code: EE-511

....

1. **Course Prerequisite:**
    1. Electric Power System I
    2. Electric Power System II
    3. Advanced Power System Analysis

2. **Course Learning Objectives:**

    Course outcomes typically include proficiency in MATLAB programming, the ability to model and simulate various power system components and circuits. Students should also be able to analyze power flow, fault analysis, and stability studies using MATLAB. The aim also to provide students with a deep understanding of complex power system problem like load flow analysis using ETAP software.

3. **Course Name: Power System Software Lab-I**

    Course Code: EE511

    Hours per Week: 3

    Credits: 2

    Course Content:

Exp. No.	Experiments
1	Study on AC Load Flow using G. S. Method using Matlab
2	Study on AC Load Flow using N. R. Method using Matlab
3	Study on AC Load Flow using FDLF Method using Matlab
4	Study on Economic Load Dispatch without constraints using Matlab
5	Study on Economic Load Dispatch with constraints using Matlab
6	Study on DC Load Flow
7	Study of Swing Equation by Point-by-Point Method.
8	Load flow analysis using ETAP

4. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	To implement Matlab programing knowledge for load flow analysis	Analyze, Identify	Understand, Analyze, Apply.
CO2	To implement Matlab programing knowledge for Economic Load Dispatch	Analyze, Identify	Understand, Analyze, Apply.
CO3	To implement DC Load Flow by software programming	Analyze, Identify	Understand, Analyze, Apply.
CO4	To implement Swing Equation by software programming	Analyze, Identify	Understand, Analyze, Apply.
CO5	To implement ETAP knowledge for load flow analysis	Analyze, Identify	Understand, Analyze, Apply.

5. Mapping of course outcomes to module / course content:

Exp No.	CO1	CO2	CO3	CO4	CO5
1	3		-	-	-
2	3		-	-	-
3	3		-	-	-
4	1	3	-	-	-
5	1	3	-	-	-
6	-	-	3	-	-
7	-	-	-	3	-
8	-	-	-	-	3

6. Mapping of the Course outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	3	2	-	-	-	-	-	-
CO2	3	3	3	2	2	-	-	-	-	-	-
CO3	3	3	2	3	2	-	-	-	-	-	-
CO4	3	3	3	2	2	-	-	-	-	-	-
CO5	3	3	2	3	2	-	-	-	-	-	-

7. Mapping to PSO:

	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	1
CO2	3	2	2	1
CO3	3	3	2	1
CO4	3	2	2	1
CO5	3	3	2	1