ADVANCED POWER SYSTEM

Course Code: PSM-101

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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" 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: PSM-101
   Hours per Week: 4
   Credits: 4

   Course Contents:

Module	Topics	40L
1.	**Network matrix:** Physical interpretation of bus admittance and impedance matrices, Y-bus formulation with regulating transformer inclusion, Admittance matrix using singular transformation, Modifications of Y-bus for branch addition/deletion, Per-unit system and system reduction	12
2.	**Complex power flow:** Complex power flow formulation, Gauss–Seidel and Newton–Raphson methods, NR algorithm in rectangular and polar coordinates, Fast decoupled load flow method, Introduction to optimal power flow (OPF)	14
3.	**Power System Stability**: Concepts and classification of stability (rotor angle, voltage, frequency), Modeling of synchronous machines for stability studies, **Transient stability:** swing equation derivation, equal area criterion, numerical solution (Euler, Runge-Kutta), critical clearing angle and time, methods of improving transient stability **Voltage stability:** PV and QV curves, voltage collapse mechanism, L-index, voltage stability margin assessment	14

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 and analyze the importance of Y-bus matrix and its modifications in network modeling.	Analyze, Identify	Understand, Remember
CO2	Apply and analyze load flow studies using Gauss–Seidel method	Apply	Understand, Apply, Analyze
CO3	Apply and analyze load flow studies using Newton–Raphson method.	Apply, Analyse	Understand, Apply, Analyze
CO4	Describe and analyze various stability phenomena of synchronous machines.	Analyze	Understand, Apply, Analyze
CO5	Formulate and evaluate swing equations for multi-machine systems and determine critical clearing times.	Evaluate	Understand, Apply, Analyze
CO6	Assess and analyze voltage stability of power systems using PV/QV curves and indices.	Create	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: PSM-102

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1. **Course Prerequisites:**
    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 provides a comprehensive understanding of the fundamentals and applications of insulating materials in electrical and electronics engineering. It covers the breakdown phenomena in various insulating media—solid, liquid, and gaseous—and explores the generation and measurement of high D.C., A.C., and impulse voltages and currents. The course also emphasizes the study of overvoltage phenomena in electrical power systems, principles of insulation coordination, and high-voltage testing techniques. Through theoretical concepts and practical insights, students will gain the knowledge required to analyze, design, and evaluate high-voltage insulation systems used in modern electrical equipment and power networks.

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

Course Code: PSM-102
Hours per Week: 4
Credits: 4

Course content:

Module	Topics	38L
1.	**Introduction to High Voltage Engineering**: Introduction to high voltage engineering, Electric field analysis: Laplace & Poisson's equations, field mapping. Numerical methods: Finite Difference Method (FDM), Finite Element Method (FEM). Field stress control and grading techniques. High voltage standards and safety regulations.	05
2.	**Generation of High Voltage and High Current:** Generation of high DC voltage: Cockcroft-Walton circuits. Generation of high AC voltage: Cascade transformers, resonant transformers. Generation of impulse voltages and currents: Marx circuit, impulse current generators. Tripping and control of impulse generators. Recent developments in compact HV generators.	08
3.	**Measurement of High Voltage and Current:** Measurement of high voltages: Electrostatic voltmeter, Sphere gap, Potential dividers. Peak voltage measurements using spark gaps. Impulse voltage and current measurement: CRO, digital recorders. High current measurements – resistive shunts, magnetic methods. Calibration techniques, accuracy,	05

	and error analysis.	
4.	**Breakdown in Insulating Media:** Breakdown in gases: Townsend's theory, Paschen's law, Streamer mechanism. Breakdown in liquids: Suspended particle theory, bubble theory. Breakdown in solids: Intrinsic, electromechanical, and thermal breakdown. Composite and nano-dielectric materials. Corona discharges and partial discharges.	05
5.	**High Voltage Testing of Electrical Equipment:** Testing of insulators, transformers, cables, circuit breakers. Non-destructive testing: PD measurements, Tan Delta, insulation resistance. High voltage test circuits and impulse testing. Testing standards: IEC, IEEE, IS Condition monitoring and insulation coordination.	05
6.	**Over voltages and Insulation Coordination:** Types of over voltages: lightning, switching, temporary. Travelling wave phenomena on transmission lines. Protection against over voltages: Surge arresters, shielding, grounding. Insulation coordination and withstand voltage levels. High voltage laboratory layout, equipment, and safety practices.	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 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: PSM-103

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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: PSM-103
   Hours per Week: 4
   Credits: 4

   Course Contents:

Module	Topics	40L
1.	**DC power transmission technology:** Evolution of HVDC Transmission, comparison, advantages & disadvantages of HVDC Transmission over HVAC Transmission, Applications. Basic principles of AC-DC conversion. Converter station configuration. Power Devices (Thyristors, IGBTs),	04
2.	**Line-Commutated Converters (LCC) and Analysis of HVDC converters:** Six-pulse (Graetz bridge) converter operation, waveforms, average DC voltage with and without overlap. Effect of source inductance, overlap angle. Twelve-pulse converter principle, waveforms, advantages. Equivalent circuits of rectifier and inverter, relations between AC and DC quantities. Reactive power requirements.	12
3.	**HVDC Control Systems:** HVDC system control features. Principles of DC link control, constant excitation angle control, VDCOL, constant ignition angle control, Individual phase control and equidistant pulse control. Reactive power control, SVC, STATCOM.	08
4.	**Harmonics and Filters:** Sources of harmonics in line commutated converters, AC and DC side harmonics, harmonics in 6 pulse and 12 pulse converters and its analysis. Smoothing reactor and DC Lines, characteristic variation of harmonic currents with variation of firing angle and overlap. Design of band pass and high pass filters, DC filters, reactive power considerations, power line communication and radio interference noise.	06
5.	**Fault and Protection Schemes in HVDC system:** Converter mal-operations (Commutation failure, arc through, misfire, short circuit in a bridge), DC line faults, converter faults. Protection against overvoltage and overcurrent in a converter station. DC circuit breaker.	04

6.	**Advanced Converter Topologies:** Hybrid HVDC converters (LCC-VSC combination). Multi-terminal HVDC systems and converter requirements. AC-DC system interaction. VSC based HVDC Transmission vs CSC based HVDC Transmission.	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 Peregrinus.

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.

R6: Direct Current Transmission, E.W. Kimbark, Wiley-Interscience, New York.

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: PSM-104

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1. Course Prerequisite:
1. Electric Power systems
2. Network Theory
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: PSM-104
Hours per Week: 4
Credits: 4
Course Content:

Module	**Topics**	**38L**
1.	**System Planning:** Introduction, Objectives & Factors affecting to System Planning, Short Term Planning, Medium Term Planning, Long Term Planning, Reactive Power Planning.	07
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.	08
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

Module	Topics	38L
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 Books:

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.

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 Configuration	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	PO 10	PO 11
CO1	3	3	2	-	-	1	1	-	-	-	1
CO2	3	3	1	2	-	-	1	-	-	-	1
CO3	3	3	-	3	1	-	1	-	-	1	1
CO4	3	1	1	1	2	1	1	-	-	-	1
CO5	3	3	1	1	1	1	1	-	-	-	1

9. Mapping to PSO:

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

POWER SYSTEM APPARATUS

Course Code: PSM-105

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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: PSM-105
   Hours per Week: 4
   Credits: 4

   Course Contents:

Module	Topics	40L
1.	**Power Interruption & Protection Apparatus:** Circuit Breakers: Principles, Construction & Types (VCB, SF6, Air & Oil); Ratings, Duty Requirements, Selection Criteria; Surge Arresters & Surge Absorbers; Insulation Coordination, Basic Impulse Level (BIL).	06
2.	**Flexible AC Transmission Apparatus – FACTS Overview:** Concepts, Opportunities, and Need for FACTS; Classification of FACTS Controllers: Shunt, Series, and Combined Controllers; Operational Principles and Characteristics.	08
3.	**Shunt Compensation Apparatus:** Objectives and Roles of Shunt Compensation; Methods of Controllable VAR Generation; Variable Impedance Type Compensators: TCR, TSR, FC-TCR, Hybrid VAR Generators; Static VAR Compensator (SVC, STATCOM): Transfer Functions, Dynamic Performance; Power Oscillation Damping and Transient Stability Enhancement.	12
4.	**Series Compensation Apparatus :** GCSC, TSSC, TCSC, and SSSC – Operating Principles & Control Strategies; Impact on Power Flow and Stability.	06
5.	**Voltage and Phase Angle Regulating Apparatus:** TCVR (Thyristor Controlled Voltage Regulator); TCPAR (Thyristor Controlled Phase Angle Regulator); Applications in Load Flow and Voltage Control.	04

6.	**Unified Power Flow Controller:** Structure, Operation, and Control; Application in Multi-Objective Power Flow Control.	04

4. Text Books:

T1: Understanding FACTS by Narain G. Hingorani & Laszlo Gyugyi, IEEE Press.
T2: Power System Switchgear & Protection by Sunil S. Rao, Khanna Publisher.

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	Explain the principles, types, and selection criteria of power interruption apparatus (Circuit Breakers).	Explain	Understand
CO2	Analyze surge protection apparatus and perform insulation coordination studies	Analyze	Understand, Apply, Analyze
CO3	Identify the role and applications of FACTS apparatus in enhancing power system flexibility.	Identify	Analyze
CO4	Evaluate shunt compensation apparatus (SVC, STATCOM) for dynamic performance and stability improvements	Evaluate	Apply
CO5	Analyze the control strategies of series compensation apparatus (TCSC, SSSC) and their impact on stability.	Analyze	Understand
CO6	Assess voltage and phase angle regulating apparatus (TCVR, TCPAR) and unified apparatus (UPFC) for integrated power flow control.	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

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	2	-	-	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	-	-	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: PSM-106

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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: PSM-106
Hours per Week: 4
Credits: 4

Course Content:

Module	Topics	39L
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.	07
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).	07
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.	07
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,	06

	Procedure for conducting power quality audit, Cost-benefit analysis, Report preparation and recommendations, Role of utilities and customers.	

4. Text Books:

T1: Electrical Power Systems Quality – Roger C. Dugan, Mark F. McGranaghan, McGraw-Hill Education; 2nd edition, 2002.
T2: Power Quality – C. Sankaran, CRC Press Inc; 1st edition, 2001.
T3: Power System Harmonics – J. Arrillaga, Wiley-Interscience, 1985.

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	2	3	2	2	2	-	-	-	-	-	-
CO3	-	2	3	3	2	-	-	-	-	-	-
CO4	-	-	-	2	2	-	-	-	-	2	2
CO5	-	-	-	2	2	1	1	-	-	-	-
CO6	-	-	-	-	-	2	2	2	-	-	-

9. Mapping to PSO:

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

SOFT COMPUTING TECHNIQUES

Course Code: PSM-114

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

2. **Course Learning Objectives:**
   To understand and apply soft computing techniques such as neural networks, fuzzy logic, and evolutionary algorithms for solving optimization problems in power systems.

3. **Course Name: SOFT COMPUTING TECHNIQUES**
   Course Code: PSM-114
   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).	03
2.	Lamda iteration method: Brief introduction to lambda iteration method, formulate the Lagrange function, Lamda iteration method to solve optimal dispatch problem.	08
3.	Neural Network: Basics of ANN, comparison between artificial and biological neural networks, basic building blocks of ANN, Artificial neural network terminologies and important concepts, pattern recognition, Pitts model, Perceptron model, ADALINE model, Gradient Descent and Delta rule, Back propagation algorithm, Derivation of Back propagation rule in ANN.	06
4.	Fuzzy logic: Classical sets, fuzzy sets, fuzzy properties and operations, Fuzzy logic system, Fuzzification, Defuzzification, Membership functions, Fuzzy rule base.	05
5.	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.	05

6.	Particle Swarm Optimization: Fundamental principle, Velocity updating, Advanced operators, Parameter selection Genetic Algorithm: Introduction to genetic Algorithm, working principle, Principles of Genetic Algorithm, Genetic Operators- Selection, Crossover and Mutation fitness function.	07
7.	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: Algorithms and examples. Kalyanmoy Deb, PHI, Learning Pvt. Ltd.; 2012.
T2: Power system optimization: D. P. Kothari, J. S. Dhillon PHI; 2nd edition, 2010.
T3: Neural networks and fuzzy systems: A dynamical systems approach to machine intelligence; Bart Kosko; PHI Learning; 1994.

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	Analyze the structure, concepts, and applications of Artificial Neural Networks in load forecasting, system identification, control, and pattern recognition.	Measure, Assess	Evaluate, Create
CO4	Design Fuzzy Logic Controllers (FLCs) for power system applications such as induction motor control, excitation control in AVR, and bus bar control.	Determine, Calculate	Create, Apply
CO5	Develop and implement evolutionary optimization algorithms (Differential	Simulate, Analyze	Analyze, Apply

	Evolution, PSO, GA) for single and multi-objective optimization in power systems.		
CO6	Integrate various soft computing techniques to solve real-world power system optimization problems, including economic load dispatch and hydro-thermal scheduling.	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	-
7	-	-	-	-	-	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	-	1
CO2	3	3	1	1	2	2	-	-	1	-	1
CO3	3	3	1	1	2	2	-	-	1	-	1
CO4	3	3	1	1	2	2	-	-	1	-	1
CO5	3	3	1	1	2	2	-	-	1	-	1
CO6	3	3	1	1	2	2	-	-	1	-	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
CO6	3	2	-	2

SMART GRID TECHNOLOGY

Course Code: PSM-115

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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: PSM-115
   Hours per Week: 4
   Credits: 4

   Course Contents:

Module	Topics	36L
1.	**Introduction to Smart Grid:** Basics of Power Systems, Definition of Smart Grid, need for Smart Grid, Smart Grid Domain, enablers of smart grid, smart grid priority areas, regulatory challenges, and smart grids activities in India.	06
2.	**Smart Grid Architecture:** Standards-policies, smart grid control layer and elements, network architectures, IP based systems, power line communications, supervisory control and data acquisition system, advanced metering infrastructure, Building blocks of AMI, Challenges in AMI, AMI needs in the smart grid, Phasor Measurement Unit, the fundamental components of smart grid designs, transmission automation, distribution automation, renewable integration.	09
3.	**Tools and Techniques for Smart Grid:** Computational techniques-static and dynamic optimization techniques for power applications such as economic load dispatch-computational intelligence techniques-evolutionary algorithms in power system-artificial intelligence techniques and applications in power system.	06
4.	**Distributed Generation**: Introduction to distributed energy sources, Characteristics of distributed energy sources, Types of distributed energy sources, Advantages and disadvantages of distributed energy sources, Role in Smart Grid and future energy systems, Micro Grids, Storage Technologies- Electric Vehicles, Environmental impact and Climate	06

	Change, Economic Issues.	
5.	**Smart Grid Applications:** Introduction, Characteristics of smart grid communications technology, Local Area Network, LAN topologies, LAN -Categories of data transmission, House Area Network, Benefits of Home Area Network, Wide Area Network, Broadband over Power line, IP based Protocols, Need of Cloud Computing, Importance of Cloud Computing, Cyber Security for Smart Grid,	09

4. Text Books:

T1: A.G. Phadke and J.S. Thorp, "Synchronized Phasor Measurements and their Applications", Springer, 2nd Edition, 2017, ISBN: 978-3-319-50582-4.

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, 1st Edition, 2012.

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Understand the features and architecture of Smart Grid.	Analyze, Identify	Understand, Remember
CO2	Assess the role of automation and digitization in transmission and distribution.	Identify, Select	Understand, Apply, Analyze
CO3	Analyze the operation of DG and storage technologies.	Identify, Select	Understand, Apply
CO4	Analyze smart grids and distributed energy resources (DER) with evolutionary algorithms.	Analyze	Understand, Apply, Analyze
CO5	Investigate operation and the importance of data acquisition devices and their location for voltage and frequency control.	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	1	1	1
CO2	3	1	1	1
CO3	3	1	1	1
CO4	3	1	1	1
CO5	3	1	1	1

CONDITION MONITORING AND POWER APPARATUS

Course Code: PSM-116

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1. **Course Prerequisite:**

1. Electromagnetic Field theory
2. high Voltage Engineering
3. Electrical and Electronics Measurements
4. 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: CONDITION MONITORING AND POWER APPARATUS**

Course Code: PSM-116
Hours per Week: 4
Credits: 4

Course content:

Module	Topics	38L
1.	**DIAGNOSTIC TESTS:** Introduction, Brief overview of transformer insulation, Degradation of oil-paper insulation system, Degradation of oil, Degradation of paper, Chemical Diagnostic tests, Dissolved gas analysis (DGA), Degree of Polymerization Measurement, Furan Analysis, Conventional Electrical Diagnostic Tests. Insulation resistance test, Polarization index test, C-tanδ test.	10
2.	**ASSESSMENT OF CONDITION:** Dielectric spectroscopy measurement, Polarization Depolarization current (PDC) measurement, Return Voltage Measurement (RVM), Frequency domain spectroscopy (FDS) measurement Advantages of FDS measurement over time domain measurements.	08
3.	**STANDARD TESTS:** Need for testing standards – Standards for porcelain / Glass insulator – Classification of porcelain / glass insulator tests- Tests for cap and pin porcelain/ Glass insulators. High voltage AC testing methods, power frequency tests- Over voltage tests on insulators,	10

	Isolators, Circuit Breakers and power cables.	
4.	**CONTAMINATION:** Contamination flashover phenomena-Contamination Severity- Artificial contamination tests, Laboratory testing versus in-service performance-Case study.	06
5.	**IMPULSE TESTING:** Impulse Testing: Impulse testing of transformers, Detection and classification of Impulse Faults.	04

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.	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	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
CO5	3	2	1	2

Power System Hardware Lab-I

Course Code: PSM-191

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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: PSM-191
   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: PSM-192

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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: PSM-192

   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	PO12
CO1	3	3	3	3	2	-	-	-	-	-	-	2
CO2	3	3	3	2	2	-	-	-	-	-	-	2
CO3	3	3	2	3	2	-	-	-	-	-	-	2
CO4	3	3	3	2	2	-	-	-	-	-	-	2
CO5	3	3	2	3	2	-	-	-	-	-	-	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