# Training Course on Power System Stability and Resilience

Professional Development Training Course Outline

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|---|---|---|---|
| **Category** | Engineering | **Duration** | 10 Days |
| **Base Fee** | $3,000 USD | **Delivery Mode** | Online / On-site Hybrid |

## Course Introduction

### Introduction

In today’s increasingly complex and dynamic power systems, ensuring grid stability and system resilience is paramount for uninterrupted energy delivery. The growing integration of renewable energy sources, smart grids, and distributed generation has introduced new challenges related to frequency regulation, voltage control, fault tolerance, and dynamic performance. Training Course on Power System Stability and Resilience is designed to empower professionals with the technical expertise to design, monitor, and manage stable and robust electric power networks under normal and extreme conditions.

Through a blend of theoretical concepts, hands-on modeling, and real-world case studies, participants will gain mastery over transient, small-signal, and voltage stability, as well as strategies for improving grid resilience against cyber threats, natural disasters, and high-impact low-probability (HILP) events. Using cutting-edge tools like DIgSILENT PowerFactory, MATLAB/Simulink, and PSS/E, the course equips participants to anticipate disturbances, assess system behavior, and implement effective countermeasures to maintain grid integrity and long-term reliability.

## Programme Curriculum

### Training Course on Power System Stability and Resilience

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**Course duration**

10 Days

## Course Objectives

1. Understand key concepts of power system stability
2. Analyze transient and small-signal stability
3. Evaluate voltage and rotor angle stability
4. Simulate system behavior under disturbances
5. Use tools like PowerFactory and PSS/E for modeling
6. Design protection systems for improved resilience
7. Apply wide-area monitoring and control systems (WAMS)
8. Model and mitigate cascading failures
9. Improve grid resilience to climate-related disruptions
10. Implement control systems for frequency and voltage regulation
11. Conduct black-start and restoration planning
12. Integrate cybersecurity into grid stability protocols
13. Utilize AI and predictive analytics for stability forecasting

## Organizational Benefits

1. Ensuring uninterrupted power delivery through enhanced grid stability
2. Reducing downtime and system failure risks
3. Improving operational decision-making with real-time data analytics
4. Strengthening resilience against cyber-attacks and HILP events
5. Enhancing workforce capability in modern power systems
6. Meeting regulatory and compliance standards (NERC, IEEE)
7. Optimizing investment in protection and automation systems
8. Enabling rapid recovery from grid disruptions
9. Supporting smart grid and renewable integration initiatives
10. Positioning as a leader in utility modernization and innovation

## Target Participants

1. Power system engineers and analysts

2. Grid operators and dispatchers
3. Utility managers and infrastructure planners
4. Electrical protection engineers
5. SCADA and automation specialists
6. Energy policy makers and regulators
7. Renewable energy developers
8. Academic researchers in power systems

## Course Outline

### Module 1: Fundamentals of Power System Stability

1. Definition and classification
2. Operating states and system dynamics
3. Power flow fundamentals
4. Impact of load and generation variability
5. Case Study: Frequency Instability in a Wind-Dominated Grid

### Module 2: Transient Stability Analysis

1. Generator response to faults
2. Swing equation and equal area criterion
3. Critical clearing time
4. Stability margin evaluation
5. Case Study: Fault-Induced Generator Instability

### Module 3: Voltage Stability and Control

1. Voltage collapse mechanisms
2. Reactive power and VAR support
3. Load modeling for voltage studies
4. Static vs dynamic voltage analysis
5. Case Study: Reactive Power Deficiency in Urban Grid

### Module 4: Rotor Angle and Small-Signal Stability

1. Synchronous machine modeling
2. Eigenvalue analysis
3. Damping controllers and PSS design
4. Modal analysis techniques
5. Case Study: Oscillatory Instability in Interconnected Grid

### Module 5: Frequency Stability and Regulation

1. Primary, secondary, tertiary control
2. Governor dynamics
3. Load-frequency control schemes
4. Impact of renewables on frequency
5. Case Study: Frequency Drop in Isolated Microgrid

### Module 6: Simulation Tools for Power System Stability

1. Overview of PSS/E and DIgSILENT
2. MATLAB/Simulink modeling basics
3. Running dynamic simulations
4. Data acquisition and visualization
5. Case Study: Transient Analysis Using PowerFactory

### Module 7: Resilience Concepts and Metrics

1. Defining resilience in power systems

2. Key indicators (MTBF, MTTR, SAIDI)
3. Risk-based planning and probabilistic analysis
4. Resilience vs reliability
5. Case Study: Post-Hurricane Grid Recovery Metrics

## Module 8: Wide-Area Monitoring and Control (WAMS)

1. Role of PMUs and synchrophasors
2. System observability and situational awareness
3. Control strategies using real-time data
4. WAMS deployment architecture
5. Case Study: Real-Time Oscillation Detection in India

## Module 9: Protection Systems and Automation

1. Relay coordination and fault isolation
2. Protection schemes for stability enhancement
3. Microprocessor-based relays
4. Adaptive protection systems
5. Case Study: Fault Ride-Through Using Modern Relays

## Module 10: Dynamic Load and Generator Modeling

1. Load model classifications
2. Renewable generation modeling
3. Dynamic equivalencing
4. Aggregated modeling for simulation
5. Case Study: Modeling PV Inverters Under Dynamic Loads

## Module 11: Cybersecurity and Grid Resilience

1. Cyber threats to grid stability
2. Risk assessment and defense strategies
3. NERC CIP compliance
4. Secure SCADA architecture
5. Case Study: Ukraine Power Grid Cyberattack

## Module 12: Black-Start and System Restoration

1. Black-start sources and criteria
2. Grid synchronization techniques
3. Coordination with control centers
4. Restoration sequence planning
5. Case Study: Regional Grid Restoration Plan

## Module 13: Renewable Integration and Stability

1. Impact of solar and wind variability
2. Grid codes for renewables
3. Inertia and synthetic inertia concepts
4. Control strategies for high-RES penetration
5. Case Study: Wind Farm Integration in Europe

## Module 14: AI and Machine Learning for Stability Forecasting

1. Forecasting outages and disturbances
2. Anomaly detection and classification
3. Predictive control algorithms
4. Neural networks and reinforcement learning
5. Case Study: ML Model for Predicting Voltage Swings

## Module 15: Future Trends in Resilient Power Systems

1. Grid-forming inverters
2. Virtual power plants (VPPs)
3. Climate adaptation strategies
4. Resilience-enhancing market mechanisms
5. Case Study: Smart Resilience in Tokyo's Power Grid

## Training Methodology

This course employs a participatory and hands-on approach to ensure practical learning, including:

- Interactive lectures and presentations.
- Group discussions and brainstorming sessions.
- Hands-on exercises using real-world datasets.
- Role-playing and scenario-based simulations.
- Analysis of case studies to bridge theory and practice.
- Peer-to-peer learning and networking.
- Expert-led Q&A sessions.
- Continuous feedback and personalized guidance.

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| Start Date | End Date | Location | Price |
|---|---|---|---|
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| **23 Nov 2026** | 04 Dec 2026 | Physical | $3,000 |
| **23 Nov 2026** | 04 Dec 2026 | Physical | $6,000 |
| **23 Nov 2026** | 04 Dec 2026 | Physical | $6,000 |
| **23 Nov 2026** | 04 Dec 2026 | Physical | $12,000 |
| **23 Nov 2026** | 04 Dec 2026 | Physical | $9,000 |
| **23 Nov 2026** | 04 Dec 2026 | Physical | $12,000 |
| **23 Nov 2026** | 04 Dec 2026 | Physical | $12,000 |

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