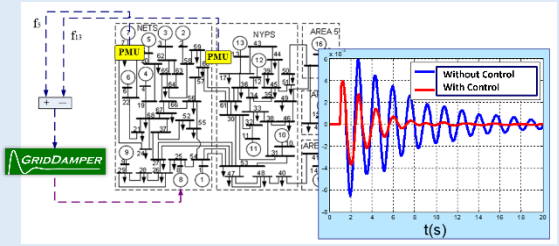
Supplemental Project Notice

OSCILLATION MONITORING, ANALYSIS AND CONTROL

Mitigation of Natural, Forced and Sub-Synchronous Oscillations



PROJECT HIGHLIGHTS

- Improve system operators' situational awareness of various oscillations and help them take proper mitigation actions.
- Apply a comprehensive method to mitigate three major types of power grid oscillations: natural oscillations, forced oscillations, and IBR-induced sub-synchronous oscillations.
- Demonstrate the effectiveness of grid operator software tools that use synchrophasor data for oscillation detection and source localization.
- Design and demonstrate oscillations damping controllers using computer simulations and hardware-in-the-loop experiments on a real-time simulator.
- Offer a measurement-driven approach to enable adaptive capability of the developed controller to accommodate grid operating condition variations.

Background, Objectives, and New Learnings

The growing integration of inverter-based renewable resources (IBRs) into transmission systems can result in increased grid variability and complex dynamic behavior. This presents challenges for transmission system operators to operate the grid securely and reliably. One of these challenges is how to monitor, analyze, and control various types of oscillations, either the traditional natural oscillations, forced oscillations due to external driving sources, or emerging IBR-induced sub-synchronous oscillations (SSOs) due to weak grid conditions or control interactions. Meanwhile, the retirement of conventional synchronous generators will result in insufficient stabilizing capability to mitigate oscillations.

EPRI has developed a comprehensive method that includes software and hardware technologies to monitor, analyze, and control the aforementioned types of power grid oscillations. This method can detect oscillations by using high-resolution synchrophasor data and analyze oscillation frequencies, damping ratios, mode shapes, and especially oscillation origins under different grid operating conditions. EPRI's grid oscillations damping controller, *GridDamper*, can be used to adaptively mitigate oscillations based on a measurement-driven approach.

The objective of this project is to:

- Analyze oscillation issues pertinent to participant's systems;
- Apply monitoring and analysis methods and tools;
- Develop associated controllers to mitigate the selected oscillation types; and
- Demonstrate their performances using dynamic simulations and real-time simulations in a hardware-in-the-loop (HIL) setup.

Benefits

Project results may:

- Improve system operators' situational awareness of various oscillations and assist them to take proper mitigation actions, leading to grid reliability enhancement.
- Help participants better understand the oscillation risk in their footprint and the associated countermeasures to reduce risk.

- Lead to more reliable adoption and field deployment of the technologies on members' power system.
- Help system operators make informed decisions regarding oscillation detection and control, and assess the applicability and adoption of the proposed technologies.

Project Approach and Summary

EPRI plans to conduct the project in two phases. Phase 1 includes oscillation analysis of the system, controller design and demonstration through computer simulations. Phase 2 includes HIL implementation and testing on a real-time simulator. Each phase can be focused on a single or combination of oscillation types.

Phase 1: Simulation-Based Analysis

Natural oscillations: Perform modal analysis of the system to identify the dominant oscillation modes of interest. Then design a controller that can adaptively update feedback signals, actuators, and controller parameters to accommodate grid condition variations.

Forced oscillations: Perform grid vulnerability analysis to identify potential risk of interaction between forced oscillations with natural oscillation mode(s). The EPRI Forced Oscillation Localization Tool (FOLT) will be used to detect forced oscillations, identify whether the source is inside or outside the footprint, estimate source location, and estimate source type. Then design a controller to mitigate forced oscillation.

IBR-Induced SSOs: Apply FOLT tool to detect SSOs and identify the source location using simulated or recorded high-resolution PMU data. An adaptive SSO damping controller will be developed.

EPRI will coordinate with each project participant to collect the required data for the analysis, including the grid model (power flow and dynamic), PMU locations and historical oscillation event data.

Phase 2: HIL Implementation and Testing

Implement the developed controller on a general-purpose hardware platform and integrate the FOLT tool into a software phasor data concentrator (PDC) for HIL testing. Signal amplifiers and PMU devices will be integrated in the HIL test setup to stream synchrophasor data. The performance of the FOLT tool and the controller will be demonstrated on this HIL test setup. Phase 2 requires participation in Phase 1.

Deliverables

1. Phase 1 Technical Report documenting the controller design and the simulation results.
2. Phase 2 Technical Report documenting the results of the HIL experiments conducted.
3. Phase 2 Workshop: Onsite HIL demonstration using participant's or other commonly agreed facility.
4. Simulation models. All models developed for this work will be made available to the participant.

The non-proprietary results of this work will be incorporated into EPRI's R&D programs.

Price of Project

The cost of participation is based on the number of oscillation types and project phases selected for investigation. Contact EPRI for tailored scope options. This project qualifies for self-directed funding (SDF).

Tier	Phase 1	Phase 2
Tier I (One type of oscillations)	$80,000	$100,000
Tier II (Two types of oscillations)	$150,000	$180,000
Tier III (Three types of oscillations)	$200,000	$240,000

Project Status and Schedule

Phase 1 and Phase 2 are each expected to take approximately 12 months.

Who Should Join

Utilities and ISOs interested in the application of PMU technology in mitigating system oscillations.

Contact Information

For more information, contact the EPRI Customer Assistance Center at 800.313.3774 (askepri@epri.com).

Technical Contacts

Lin Zhu at 865.320.4926 (lzhu@epri.com)
Evangelos Farantatos at 650.855.2214 (efarantatos@epri.com)

Additional Contacts (M&TS)

Brian Long at 704.408.8139 (blong@epri.com)
Dan Tavani at 704.773.2025 (dtavani@epri.com)
David Welch at 702.208.8276 (dwelch@epri.com)
Jeff Hlavac at 402.314.1049 (jhlavac@epri.com)

Project ID: 3002028608 **Product ID: 1-118867** **December 2023**

EPRI

3420 Hillview Avenue, Palo Alto, California 94304-1338 USA • 800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com