PMU-based oscillation detection, characterization and source identification

Project type:	☒ Semester project	☒ MSc thesis	☒ Internship
Project responsible (email):	paolo.romano@zaphiro.ch		

Project description and objectives:

Power system oscillations—whether caused by faults, control interactions, or generator dynamics—can threaten grid stability and reliability. Phasor Measurement Units (PMUs) provide high-resolution, time-synchronized measurements that enable real-time monitoring and analysis of such oscillations. This project aims to develop a data-driven framework using PMU data to detect, characterize, and identify the source of oscillations in a power system. The project will explore algorithms for oscillation detection (e.g., Prony analysis, spectral methods, machine learning), estimate modal characteristics (frequency, damping, mode shape), and propose approaches to pinpoint the most likely source or contributing element of the oscillation.

Objectives:

- Develop algorithms for real-time oscillation detection using PMU data.
- Characterize oscillation modes in terms of frequency, damping ratio, and energy contribution.
- Implement source identification techniques to locate the origin of oscillations.
- Evaluate performance using synthetic or real-world PMU datasets.

Tasks:

- **Literature Review:** Study existing methods for oscillation detection and modal analysis using PMUs. Review signal processing and machine learning approaches relevant to the problem.
- **Data Acquisition and Preprocessing:** Obtain PMU data (from open datasets or simulations such as IEEE test systems). Preprocess data for noise filtering and synchronization.
- **Oscillation Detection:** Implement algorithms to detect sustained or growing oscillations (e.g., FFT, Prony, or AR-based methods). Compare detection accuracy and computational performance.
- **Oscillation Characterization:** Extract modal parameters such as frequency, damping ratio, and mode shape. Visualize time-domain and frequency-domain characteristics.
- **Source Identification:** Apply energy-based or participation factor-based methods to locate oscillation sources. Validate using test scenarios or benchmark systems.
- **Evaluation and Reporting:** Analyze results and compare algorithm performance. Prepare a final report and presentation summarizing findings, challenges, and recommendations.

This project, could be developed in full or partly during a single student project.

Required skills:

- Strong background in **power systems** and **power system dynamics**.
- Familiarity with **phasor measurement units (PMUs)** and **synchrophasor data**.
- Knowledge of **signal processing** (e.g., FFT, Prony, wavelet, spectral analysis).
- Programming proficiency in **MATLAB**, **Python**, or similar environments.
- Understanding of **machine learning** techniques (optional but beneficial).
- Ability to perform **data analysis** and **visualization**.

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Other benefits and/or compensation:
Depending on the final project type, scope and deliverables, Zaphiro may consider providing additional adequate compensation.
About Zaphiro:
Zaphiro is an innovative smart grid company based in Lausanne, Switzerland, and Milan, Italy, that was founded in 2017 as a spin-off from EPFL and is backed by well renowned international groups such as ABB and CDP Ventures. Our product, SynchroGuard, is the first distribution grid monitoring & automation system based on D-PMU (Distribution-Phasor Measurement Unit) technology, specifically designed to easily retrofit distribution substations and integrate with existing control room solutions (e.g., SCADA, DMS). SynchroGuard helps utilities increase grid observability, particularly in presence of high DER penetration, and improve grid resiliency by reducing the impact of blackouts on their consumers.