Research & Development Policy of Grid-India: 2024

SUBMISSION OF RESEARCH OBJECTIVE

Annexure-1

1. Research Objective (Topic):

Oscillation Source Detection using Hybrid Methods

2. Lead of project-GM and above: (Name, Designation, & Department) Sh Sunil Kumar Aharwal

3. Co-Ordinator of Project (Name, Designation, & Department): Bikas Kumar Jha, Purn Prakash Chand, Sugata Bhattacharya, Paritosh Pathak.

4. Key Problem Areas: [Briefly Outline the current Challenges to address with Research]:

Challenges in Oscillation Source Detection: Modern grids with high renewable penetration exhibit complex and weakly damped oscillations that are challenging to attribute to specific sources. Nonlinearities from power electronics and inverter-based resources complicate traditional modal and energy-based analysis methods. Fast and computationally efficient algorithms are required to detect and locate oscillation sources in real-time for operational use. Translating oscillation source detection results into actionable control signals remains a research gap.

India's renewable energy projection for 2030 is to generate 500 GW of electricity from non-fossil fuel sources. In Northern Region, renewable generation is mainly concentrated in Rajasthan RE complex and low SCR is observed at various pooling stations in Rajasthan. Hence accurate detection of source of oscillation is of great importance in Northern region.

At NRLDC, OSLP tool is deployed for oscillation source detection which uses DEF method. While the DEF method is valuable for detecting oscillation sources in power systems, its limitations in handling nonlinearities, sensitivity to noise, computational complexity, and challenges in renewable-dominated grids highlight the need for complementary or alternative approaches.

5. Briefly outline the detail of methodology used for research:

Research Approach:

Analyze limitations of existing techniques for oscillation detection in modern power systems.

Identify gaps in computational efficiency, robustness, and practical implementation.

Identify the best algorithm/method that accurately detects oscillation source.

Data Collection Methods:

Use high-resolution, time-synchronized voltage, current, and frequency data from PMUs placed at strategic grid locations.

Employ power system simulation tools (e.g., PSS®E, MATLAB, DIgSILENT PowerFactory) to model oscillation events and system responses under varying scenarios.

Analyze historical data of grid disturbances to validate oscillation source detection algorithms.

Analytical techniques:

Propose a hybrid approach integrating traditional methods with machine learning and wide-area monitoring data. Use modal decomposition and participation factors derived from PMU data. Train models for pattern recognition of oscillation sources using historical and simulated event data.

Test methodologies on real-time PMU data to ensure accuracy and robustness.

6. Citation/References (Relevant Literature/Technical Papers):

i. Report on “Power System Oscillation Source Analysis & Fault Signature Analysis in Southern Region”, SRLDC, Grid Controller of India Ltd

ii. Kundur, P., Paserba, J., Ajjarapu, V., et al. (2004). "Definition and classification of power system stability IEEE/CIGRE joint task force on stability terms and definitions." IEEE Transactions on Power Systems, 19(3), 1387–1401. doi:10.1109/TPWRS.2004.825981

iii. D. Osipov, S. Konstantinopoulos and J. H. Chow, "A Cross-Power Spectral Density Method for Locating Oscillation Sources Using Synchrophasor Measurements," in IEEE Transactions on Power Systems, vol. 38, no. 6, pp. 5526-5534, Nov. 2023, doi: 10.1109/TPWRS.2022.3229255