Doctorat (PhD) Project Proposal

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Field: Electrical Engineering

Title*:* **A Droop Centralized Control Framework Enhancement in Smart Microgrids**

Abstract/Summary

The increasing integration of renewable energy sources and distributed generation (DG) resources to microgrids necessitates advanced control strategies to ensure efficient, reliable, and stable operation. Traditionally, Droop Control has been employed as a decentralized control technique, allowing DG units to share loads proportionally without relying on high-speed communication. However, the growing complexity of microgrids named Smart Micro-grids, coupled with the need for improved coordination and optimization, has led to the exploration of centralized control frameworks that may incorporate Droop Control principles.

This PhD project aims to develop a novel Droop Control-based centralized control framework for managing distributed generation resources using Micro-Phasor Measurement Units (Micro-PMUs) data within a microgrid. The proposed framework will combine the local robustness of Droop Control with the global optimization capabilities of centralized control, offering enhanced system performance, reliability, and flexibility as well as it will integrate advanced technologies like Micro-PMUs, AI-based control, or improved communication protocols. This PhD project addresses specific challenges within smart microgrids, such as voltage stability, power quality, or seamless transition between grid-connected and islanded modes. Through simulation and analysis, the effectiveness of this proposed centralized droop control framework will be evaluated under various operating conditions.

Index Terms: Smart microgrids, µPMUs, Voltage stability, droop control technique, AI and Optimization techniques.

1. Introduction and Background:

The transition towards smart grids is revolutionizing energy distribution, with microgrids playing a crucial role in this evolution. Distributed Generation Resources (DGRs), such as photovoltaic systems, wind turbines, and energy storage devices, are vital components of microgrids. Efficient management of these resources is essential for ensuring system reliability, stability, and resilience, especially as microgrids function in both grid-connected and islanded modes.

This project proposes an innovative centralized control framework based on Micro-Phasor Measurement Units (Micro-PMUs) data and droop control technique to optimize the performance of distributed generation resources in smart microgrids. By centralizing the control of multiple DG units, this framework enables coordinated responses to changes in load and generation, enhancing the overall stability and efficiency of the microgrid. It addresses the limitations of traditional decentralized droop control by introducing a centralized supervisory controller that optimizes power sharing, improves system voltage stability and reliability, and mitigates risks associated with islanding and other operational challenges.

Through simulation and analysis using Simulink/Matlab, the effectiveness of the proposed centralized droop control framework can be evaluated under various operating conditions such islanded and connected mode for showing its enhanced performance, particularly in maintaining voltage stability and power quality, while also providing flexibility in integrating renewable energy sources. This research may contribute to the advancement of robust and adaptive control strategies for next-generation of microgrids such as smart microgrids.

2. Research Objectives:

The main objectives of this PhD research are:

- To develop a centralized control framework that leverages the real-time data provided by Micro-PMUs to optimize the operation of distributed generation resources in smart microgrids.
- To design and implement a droop control strategy within the centralized framework that ensures stable and efficient power sharing among DGRs.
- To evaluate the effectiveness of the proposed control framework in enhancing the stability, reliability, and efficiency of microgrids under various operating conditions, including both islanded and connected mode.
- To implement advanced control algorithms that dynamically adjust Droop parameters and optimize power flow within the microgrid.
- To validate the proposed framework through simulation or/and experimental testing on a microgrid testbed.

3. Literature Review

The literature review will cover:

- The evolution of droop control techniques in decentralized and centralized frameworks for microgrids.
- The application of Micro-PMUs in enhancing situational awareness and control in power systems.
- Current challenges and limitations in managing DGRs in smart microgrids, with a focus on the role of centralized versus decentralized control strategies.

4. Research Methodology:

-Literature Review: Conduct an extensive review of existing Droop Control techniques, application of Micro-PMUs in enhancing situational awareness and control in power systems; centralized control strategies, and hybrid control approaches for microgrids.

- System Design: Develop a smart microgrid model incorporating DGRs, energy storage systems (ESS), loads, Micro-PMUs, and communication infrastructure to facilitate real-time data exchange.

- Control Framework: Implement a centralized control algorithm based on droop control techniques that utilize data from Micro-PMUs to make informed decisions on power distribution and load management and hence it dynamically adjusts Droop parameters and optimize the operation of the microgrid.

- Simulation and Analysis: Use simulation tools such as MATLAB/Simulink to model and test the proposed control framework under various scenarios, including load variations, renewable energy fluctuations, and fault conditions.

- Validation: Compare the performance of the proposed framework with existing decentralized droop control methods, focusing on metrics such as system stability, power quality, response time, load sharing accuracy, and overall system efficiency.

5. Expected Contributions:

- Development of an advanced Micro-PMU based droop control framework that enhances the centralized management of DGRs in smart microgrids.

- Contribution to the body of knowledge on the integration of Micro-PMUs in microgrid control systems, with a focus on improving stability and reliability as well as operational efficiency.
- Provision of insights and tools that can be used by researchers and industry practitioners to optimize microgrid performance, particularly in scenarios with high penetration of renewable energy sources.

5. Timeline

The research is expected to be completed over a period of four years, with the following timetable:

Year	Task to be performed
Year 1	**Comprehensive literature review, system modeling, and initial framework design.**
Year 2	**Implementation of the control algorithm and integration of Micro-PMUs into the framework.**
Year 3	**Simulation, testing, and validation of the control framework under various scenarios.**
Year 4	**Final analysis, thesis writing, and dissemination of research findings through journal publications and conferences.**

6. Requirements

- **Monthly Meetings:** A monthly meeting (either face-to-face or virtual) will be held to present research progress and facilitate discussions.
- **Progress Reports:** A detailed progress report will be submitted every six months.
- **Publication Requirement:** The candidate will be expected to publish at least one technical paper in an indexed journal (Scopus or WoS).

7. Resources Required

- Access to simulation software (MATLAB/Simulink).
- Micro-PMUs for real-time data acquisition and control (Tool is available in our Laboratory).
- Computational resources for running simulations and data analysis such as Station or powerful

PC.

8. Biographies

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