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Load Frequency Control of a Microgrid using Fractional Order PID Controller

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***Abstract*— This paper emphasis on Load frequency control of a micro-grid using fractional order proportional integral derivative (FOPID) controller based. The microgrid consist of wind energy, solar energy, ultra-capacitor, and diesel generator. The main objective is to design a robust controller that can ensure good frequency control of the micro-grid by reducing the fluctuations of the system frequency during addition or withdrawal of load, perturbation, or change in weather due to renewable energy sources. The mathematical model of the micro-grid is developed and simulated using MATLAB/SIMULINK. The results of frequency deviation obtained by robust FOPID and PID controller are compared for model validation and represented in per unit as well as the deviation response. The former depicts a better load frequency control with reduced overshoot and low settling time**.

Keywords — Load frequency control (LFC); Micro-grid (MG); FOPID Controller; Renewable energy, Frequency Control

I. INTRODUCTION

In the design and operation of electrical power systems, load frequency control (LFC) is critical [8]. It is the process used to restore frequency balance between load and generation in an electrical power system such as micro-grid (MG). The basic goal of LFC is to maintain the scheduled power while keeping the system frequency at a predetermined nominal value [2]. Better control mechanisms for the generating sources included in the MG are necessary to manage and keep frequency variations within the prescribed limits. In an islanded mode, the Micro-grid (MG) under consideration for this work is a coordinated local grid fed by local renewable and distributed energy resources (DER) such as solar, wind, ultracapacitor, and diesel generators (DG). The intermittent nature of primary renewable resources in the Micro-grid, such as wind and photovoltaic (PV), makes frequency control a difficult task [4]. Secondary sources include an ultra-capacitor and a diesel generator. The Energy Storage System is frequently used in micro-grid systems to provide energy to linked loads, and the diesel generator is used to compensate for the required power in the micro grid by employing a governor, turbine, and speed regulator. Thus, the main objective is to design a robust controller that can ensure good frequency performance of the micro-grid (islanded mode) by reducing the fluctuations of the system frequency especially during addition or withdrawal of load, perturbation, or variation in weather because of the renewable energy resources integrated into the micro-grid.[5] Therefore, a good controlling technique of load frequency is very important in a MG to supply reliable and quality electric power. The quality of generated electricity in MG depends on the system output, it must be constant frequency and maintain the schedule power. This will help to provide quality power to electric users when the central grid fails for any reason or to remote areas with difficult terrain that cannot access central grid and to ensure that power is delivered to essential and non-critical loads in a cost-effective way.

II. REVIEW OF RELATED WORKS

In this section, the research would review relevant and related materials on LFC of a micro-grid power system. During the steady state functioning of a power system, the load demand changes in the form of Kinetic Energy stored in the generator prime mover set, resulting in a variation in speed and frequency [10]. As a result, load frequency control is important for the power system's safe operation.

A study was carried out by [4] Dhananjay Kumar *et.al*, on modeling and frequency control of a community micro-grid (CMG) under stochastic solar and wind sources. To compensate for the effect of modeling uncertainty, a robust controller architecture for CMG is suggested and when a robust controller is used instead of an integer PID controller, frequency overshoot and settling time are reduced by 30%.

Anil Annamraju *et al*. presented a LFC technique for an independence hybrid microgrid with high renewable penetration utilizing a fuzzy logic-based PI controller [1]. The control technique is based on a PI controller that has been tweaked to perfection using a fuzzy logic approach. The simulation findings support the proposed approach's resilience and effectiveness.

The fundamental purpose of the LFC in a multi-source microgrid with renewable energy sources is to keep the system's frequency constant while maintaining a sustainable power supply. The proposed method was put to the test in a case study, and the results showed that modifying the PID controller's parameters improved frequency performance [2].

Load Frequency Control (LFC) was investigated using PID controller parameters and inclination coefficient [8]. The power system
instabilities and nonlinear obstacles of governors and turbines are considered in the suggested technique. The results

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