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Stabilization of frequency in Multi-Microgrid system using barnacle mating Optimizer-based cascade controllers

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A R T I C L E I N F O

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A B S T R A C T

This paper presents a new control strategy in multi-microgrid system for supressing the variations of frequency and of tie-line power flow due to intermittent nature of renewable sources and frequently varying load demands. A novel cascade combination of fractional order-based integral derivative and proportional integral derivative with filter called CFOID-FOPIDN controller is utilized as secondary controller for automatic generation control. In this work, diverse sources such as photovoltaic, wind, diesel engine, fuel-cell, electrical vehicles and battery energy storage systems are considered for investigations under various uncertainties conditions. A newly developed barnacle mating optimizer is presented to tune the CFOID-FOPIDN for diminishing the frequency and tie-line power changes. Moreover, the amalgamation of redox flow batteries and modern flexible alternating current transmission system device like distributed power flow controller is integrated into the system for ameliorating the dynamic stability of the system. The tested outcomes show that the barnacle mating optimizer-based CFOID-FOPIDN controller with the combination of distributed power flow controller and redox flow batteries exhibits low fluctuation rate for frequency (5.6 s for area-1 and 5.5 s for area 2) and tie-line power (6.2 s). Finally, the robustness of the CFOID-FOPIDN is validated under three operating conditions, such as step load perturbations, change in wind speed, irradiance, and change in both wind and irradiance levels.

Introduction

In the recent years, an uninterrupted increase of load demand, liberalization in the energy market, increasing of expenses for transmission and utilization, and deteriorating environmental circumstances have substantially accelerated the breakthrough of microgrids. Various renewable and green energy (RGE)-based power generating units and groups of loads at different locations can be defined as microgrids (MGs). The MG is an attainable alternative to endorse the incorporation of renewable and sustainable energy sources with conventional sources in order to reduce the dependency on traditional power sources [1,2]. Furthermore, the MG can be directed a significant role in upcoming interconnected power systems.

The privileges of the MGs are to provide a good quality of power without any violation in electrical parameters, to demonstrate the finer performance at all considerable loading conditions, to be required less cost for sustaining, and to be upgraded as quickly. Considering these advantages, exceptional communication and advanced controlling approaches have been transmuted the structure of the traditional isolated microgrid into a multi-microgrid (MMG) system with the assists of tie-lines [3,4]. The difficult objective of the MMGs is to be equalized the delivering power and utilizing load demand without affecting the frequency and voltage due to fast changes in atmospheric circumstances.

Moreover, the stability and controllability of the interconnected multi-area microgrid or multi-microgrid system is mainly depending on the scheduled values of frequency and voltage. Therefore, in the recent years, there has been an increasing interest in interconnected MMGs with automatic generation control (AGC) for mitigating the frequency variations [5,6]. The preliminary regulating activities of AGC are investigated by governor speed, but these are not sufficient to acceptably alleviating the oscillations against unpredicted perturbations. Regarding this, a complementary controller is required to subside the frequency and tie-line power changes, and hence to maintain the system dynamic stability.

The past ten years have witnessed increasingly rapid advances in the

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