

Frequency control improvement of two adjacent microgrids in autonomous mode using back to back Voltage-Sourced Converters



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ABSTRACT

Typically microgrid is composed of Distributed Generators (DGs), storage devices and loads which can be operated in grid-connected or islanding mode. Microgrid brings merits to both suppliers and consumers; hence, there would be a lot of microgrids at the distribution level with different load curves and DG types in near future interchanging their surplus/shortage of supply with each other or the utility grid. Upon inception of a fault in an individual macrogrid, it would be disconnected from the utility grid and operates in an autonomous mode. For the microgrids with all inverter-based DGs, the frequency maybe considerably deviated from the nominal value upon disconnection from the utility-grid; that is impermissible for consumers. In this paper, the interconnection of two adjacent inverter-based microgrids with different frequencies is proposed, using Back to Back Voltage-Sourced Converters (BTB VSCs) with local controllers in order to maintain the frequency in emergencies. By application of the proposed algorithm, two microgrids could play the role of an auxiliary supply/demand for each other without the necessity of implementing a communication link between the two microgrids. Simulation results show that the BTB VSCs with the proposed control strategy can effectively improve the frequency control task of the two microgrids simultaneously.

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Introduction

In recent decades, the use of DGs is progressively increasing in both suppliers and consumers sides. Important reasons of the interest in using renewable energy resources could be listed as follows [1–3]:

- Decreasing the greenhouse gas emissions due to the electricity generation.
- Increasing the cost of fossil fuels and their limitations.
- Efficient use of energy resources (Combined Heat and Power Production).
- Rapid increase of energy consumption in developing countries and the limitation of transmission lines capacity.
- Increasing of the sensitive loads in the consumers' side and the use of backup resources.

The increasing penetration of distributed energy resources in the distribution network introduces a new concept called “microgrids”, referring to groups of loads and different DG resources

which can be operated in macrogrid (utility grid-connected) mode or autonomous (islanding) mode [2]. In normal condition, a microgrid works in grid-connected mode, in which the voltage and frequency of the microgrid are determined by the macrogrid. When the microgrid is disconnected from the grid, it will be operated in the islanding mode in which its control strategy should be changed in order to create a reference for the voltage and frequency [4]. On the other hand, most of the DG resources are connected to the grid by power electronic interfaces. Having these interfaces give technical and operational features to the microgrid which makes it different from the traditional ones. These differences create a new field of researches in control, operation and protection of the microgrids.

Ref. [3] reviews the previous researches in the area of microgrids done by E.U., U.S, Japan and Canada. Different local and central control strategies for power sharing between generating units in microgrids are well presented. In [5] the control management strategy of the microgrid with several generating units and droop characteristics for active power control in islanding mode is presented and a new approach to control the accessible charged energy due to the energy storage devices limitation is proposed. Moreover, the accurate efficiency of the droop-characteristics approach in frequency stability of microgrid with wind turbines is concluded in [6]. Ref. [7] highlights the role of power electronic

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interfaces in microgrids, especially Voltage Source Inverter (VSI) and introduces the droop-characteristics procedure as an accurate and proven approach for microgrids' control.

A microgrid operates in one of these two modes:

- If the amount of generated power in microgrid is less than the consumer's load, then the main grid will compensate the shortage of power supply.
- If the power generation is more than the consumer's load, then the surplus of the generated power will be injected to the main grid.

Considering the mentioned operating modes, adjacent microgrids can cooperate during the fault condition in order to balance the generation and consumption. Hence, microgrids can help each other and improve their performance during islanding condition by using proper control strategy. Regarding this important point, the direct connection of two adjacent microgrids with central controller to improve their dynamic performance is presented in [8] and significant improvements are achieved in comparison to the individual operation.

In this paper, the interconnection of two adjacent microgrids through BTB VSC with local controllers is proposed. In this system, two microgrids would help each other to restore frequency in the autonomous mode without any communication system between them. The results show that the frequency control of the two connected microgrids is significantly improved during the islanding mode.

Our main contributions underlie on the application of control logics applied to local control of BTB VSCs in order to provide collaborative operation for two individual microgrids without the necessity of informing any of them the supply/demand of the other. The proposed algorithm identifies the necessity for power

exchange between the two microgrids locally. Upon existence of such a necessity, it regulates the exchange power between them in such a way to achieve the maximum collaboration with the minimum changes in the microsourses' output powers. Therefore, the proposed BTB VSCs can effectively identify the excess/shortage of supply of the microgrids just by measuring the frequency of each microgrid and without the necessity of any communication link. Upon identification of the requirement, it regulates the exchange power between the two microgrids. It is worth mentioning that the proposed system can connect two microgrids with different nominal frequency and voltage levels, the performance remains intact.

Sample microgrid structure and specifications

Microgrids are introduced as radial low voltage distribution networks. Regarding the type of available fuels, different types of controllable resources (Diesel generator, Micro turbine and Fuel cell) can be used in microgrid microsourses with the presence of uncontrollable resources (Wind turbine, Photovoltaic and etc). Ref. [9] compares different experimental microgrids and tests microgrids which are introduced in literatures.

In this paper the test microgrid presented in [10] is used with some changes in the generating resources and loads in order to evaluate the proposed method for frequency control. The single line diagram of the test system is illustrated in Fig. 1, indicating that each low-voltage microgrid is connected to the macrogrid via a static switch; and consisting of loads, controllable/uncontrollable resources and also storage devices (flywheel or battery). All energy resources in both microgrids are connected to the network via inverter interfaces. In normal operation mode, two microgrids are connected to the macrogrid, so if a fault happens in the macrogrid, then the two microgrids would be separated from the

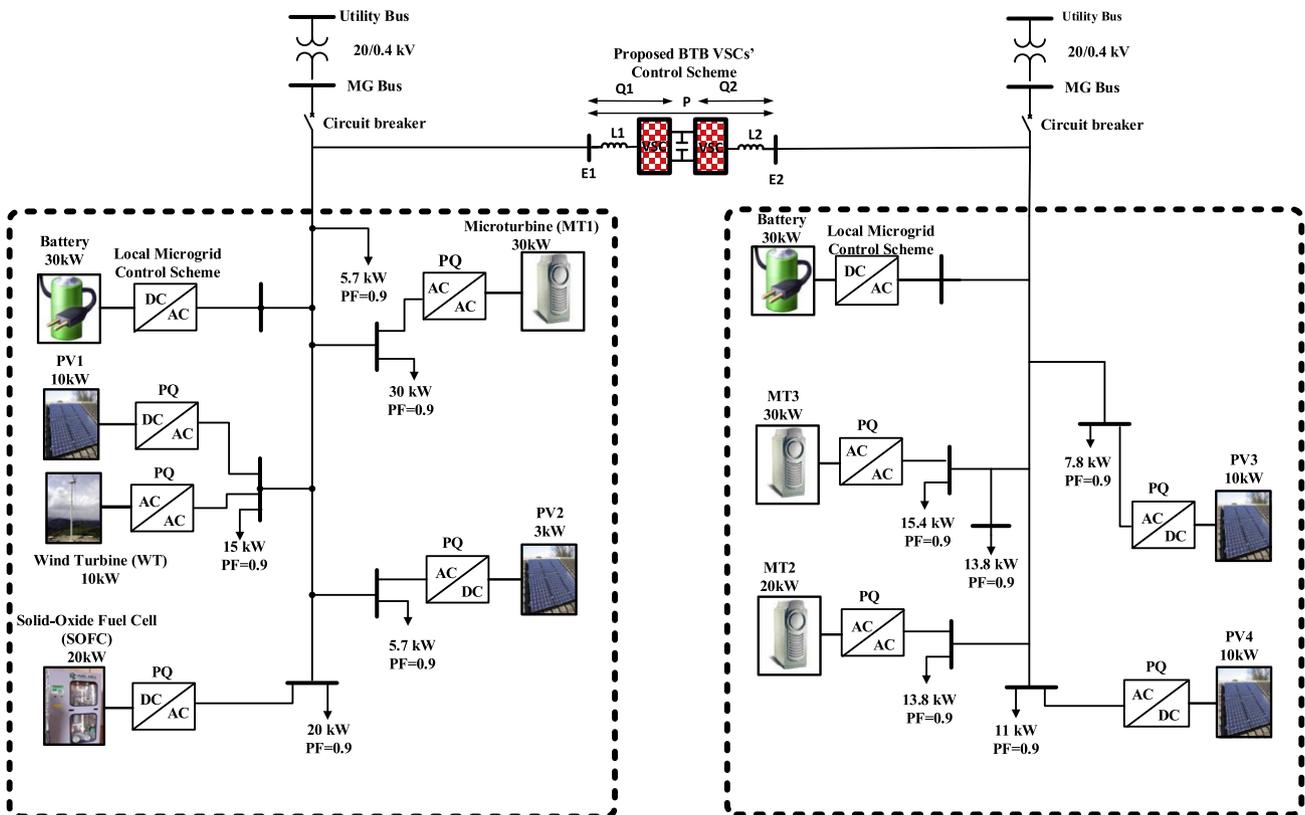


Fig. 1. Microgrids' structures and their connection via BTB VSCs.

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