Chapter 19

Operation of Microgrid and Control Strategies: Microgrid Structure and Its Control Schemes

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ABSTRACT

Microgrids are the most innovative area in the electric power industry today. A microgrid can operate in grid-connected or islanded mode. In islanded mode, microgrids can provide electricity to the rural areas with lower cost and minimum power losses. Several methods have been proposed in the literature for the successful operation of a microgrid. This chapter presents an overview of the major challenges and their possible solutions for planning, operation, and control of islanded operation of a microgrid. Microgrids are the most innovative area in the electric power industry today. Moreover, microgrids provide local voltage and frequency regulation support and improve reliability and power capacity of the grid. The most popular among the control strategies based on droop characteristics, in addition a central controller is described within a hierarchical control scheme to optimize the operation of the microgrid during interconnected operation. Microgrid control methods, including PQ control, droop control, voltage/frequency control, and current control methods are formulated.

INTRODUCTION

Microgrids are the most innovative area in the electric power industry today. Future microgrids could exist as energy-balanced cells within existing power distribution grids or stand-alone power networks within small communities. The significance of microgrids is growing rapidly. Microgrids have a huge potential in boosting the sustainable growth. A microgrid can operate in grid-connected or islanded mode.

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In islanded mode, micro grids can provide electricity to the rural areas with lower cost and minimum power losses. In grid-connected mode, microgrids can help in supporting the main grid in many ways with voltage control, frequency control, and can provide more flexibility, control, and reliability. However, successful operation of a micro grid requires proper planning and there are major challenges regarding the operation, control, and protection of micro grids that need to be tackled for successful deployment of microgrids. Depending on the mode of operation either grid connected mode or islanded mode, necessary control strategies and protection schemes are required. Several methods have been proposed in the literature for the successful operation of a microgrid. This chapter presents an overview of the major challenges and their possible solutions for planning, operation, and control of islanded operation of a micro grid. Micro grids are the most innovative area in the electric power industry today. Future microgrids could exist as energy-balanced cells within existing power distribution grids or stand-alone power networks within small communities.

During the last decades, the deployment of distributed generation (DG) resources has been growing steadily. In this process, the power distribution utilities have been one of the industry’s most concerned stakeholders. The main reason is that DGs are connected primarily within their distribution networks, mainly at Medium Voltage (MV) and High Voltage (HV) level, which have been designed under the paradigm that consumer loads are passive and power flows only from the substations to the consumers and not in the opposite direction. For this reason, many studies on the interconnection of DG within distribution networks have been carried out, ranging from control and protection to voltage stability and power quality among many others. However, different micro-generation technologies, such as micro-turbines (MT), photovoltaic (PV), fuel cells (FC) and wind turbines (WT) with a rated power ranging up to a hundred kWs can be directly connected to the Low Voltage (LV) networks. In this context, micro-generation units, typically located at users’ sites, have emerged as a promising option to meet growing customer needs for electric power with an emphasis on reliability and power quality and contribution to different economic, environmental and technical benefits. Furthermore, it has to be recognized that with increased levels of micro-generation penetration, the LV distribution network can no longer be considered as a passive appendage to the transmission network. On the contrary, the impact of micro-generation at LV levels on power balance and grid frequency may become much more significant. Therefore, a control and management architecture is required in order to facilitate full integration of micro-generation and active load management into the system. One promising way to realize the emerging potential of micro-generation is to take a system approach which views generation and associated loads as a subsystem or a Microgrid (Fini et al., 2016; Alhelou et al., 2018; Zamani et al., 2018; Alhelou et al., 2015; Njenda et al., 2018; Haes Alhelou et al., 2018).

WHAT IS A MICROGRID?

Microgrids comprise LV distribution systems with distributed energy resources (microturbines, fuel cells, PV, etc.) together with storage devices (flywheels, energy capacitors and batteries). Such systems can be operated in a non-autonomous way, if interconnected to the grid, or in an autonomous way, if disconnected from the main grid. The operation of micro-sources in the network can provide distinct benefits to the overall system performance, if managed and coordinated efficiently. There are three major messages delivered from this definition, namely as:
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