Microgrids Emergency Control and Protection: Key Issues and New Perspectives

Hassan Bevrani, Department of Electrical and Computer Engineering, University of Kurdistan, Sanandaj, Iran
Mehrdad Gholami, Department of Electrical and Computer Engineering, University of Kurdistan, Sanandaj, Iran
Neda Hajimohammadi, Department of Electrical and Computer Engineering, University of Kurdistan, Sanandaj, Iran

ABSTRACT
Economical harvesting of electrical energy on a large scale considering the environmental issues is a challenge. As a solution, Microgrids (MGs) promise to facilitate the widely penetration of renewable energy sources (RESs) and energy storage devices into the power systems, reduce system losses and greenhouse gas emissions, and increase the reliability of the electricity supply to the customers. Although the concept of MG is already established, the control strategies and energy management systems for MGs which cover power interchange, system stability, frequency and voltage regulation, active and reactive power control, islanding detection, grid synchronization, following contingencies and emergency conditions are still under development. Like a conventional power system, a Micro-grid (MG) needs emergency control and protection schemes to have secure and stable operation. Since MG can operate in both grid-connected and islanded mode, in addition to the control loops and protection schemes, extra issues must be considered. Transition between two operation modes requires an extra control plan to eliminate and stabilize transients due to mode changing. This paper presents an overview of the key issues and new challenges on emergency control and protection plans in the MG systems. The most important emergency control and protection schemes such as load shedding methods that have been presented over the past years are summarized.

Keywords: Distributed Generator, Emergency Control, Frequency Control, Islanding, Load Shedding, Microgrid, Protection, Voltage Control

1. INTRODUCTION
Nowadays, Microgrids (MGs) are extensively used beside conventional bulk power system. There is variety of reasons for using MG such as arising power quality, reliability, and availability of power as well as arising efficiency with using exhausted heat from power plant. Micro-grid includes several micro sources and loads. There are different kinds of sources such as synchronous generators, micro turbines, wind turbines, fuel cell and photovoltaic units. These units are known as distributed generators (DG). Except synchronous units, other sources need

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a power electronic interface to couple with distribution network.

A MG is able to operate in either grid-connected mode or islanding mode through opening point of common coupling (PCC). From the grid point of view, a MG can be considered as a controllable load to help it when it needs. From the customer point of view, a MG can have benefits such as decreasing losses, useful for environment, increasing efficiency and reliability. Despite of benefits, some disadvantages exist like not having standards. Around the world, a number of MG demonstration projects have developed different topologies and structures (Awad, 2008).

The MG could be imagined as a quasi-power system includes of generation units, transmission lines and loads. In fact, a MG can experience all operation issues and problem such as faults, tripping generation units, unbalancing between supply and demand and power quality issues that a utility is commonly faced with. Thus, at first step to bring MG into large power system, it must consider all conventional control and protection schemes to have a reliable and secure distribution network. The acceptable voltage and frequency must be always established in a MG. This task is realized by grid in the connected operating mode, i.e. the MG injects or absorbs power from grid and any difference between generated and consumption power is supplied by grid and distribution network as a slack bus. In this state, the MG operates as a controllable load or source. The occurrence of serious fault may lead the MG to the islanding operating mode. Islanding also can be occurred by unplanned events like maintenance. In the islanding mode, MG must tackle to the regulation challenge by itself.

Furthermore, there are extra schemes for MG because of differences between micro-sources (MSs) and bulk power generators and costumer willingness in two cases. MG has multiple generators with small ratings that each one may has different characteristics. Some of them have stochastic nature such as wind turbine and photovoltaic panels that increase the uncertainty factors for designing control and protection plans.

Most of DGs are inverter based and they have not rotating portion, so their inertia is low. Inertia has a main role in transient moments in conventional systems, hence, MG need additional plan to compensate inertia. Also the structures of protection plans may change because of different short circuit level of MG and meshed-structure of MG that lead to multi direction power flow and so need to directional relays. In addition to these issues, one of main reasons for presence of MGs is power quality subject in customer’s point of view. There are customers that pay more for better power quality, and then the customer factor must be added to the existing control schemes such as load shedding plans.

High penetration of DGs in MG makes problems for grid like power quality, protection, short circuit growth and over/under voltage of transient and steady state in point of connection. Also MG creates challenges for emergency control and protection especially in islanding mode due to bidirectional power flow and low fault current level so that the overcurrent based protection schemes my not be more efficient.

Security in MG can be established through emergency control plans such as shutdown of one or more units, demand side management, islanding and load shedding. Over the recent years, just few papers and research reports have been published on emergency control and protection issues in the MG systems (Bevrani et al., 2012). To fill this shortage, the present paper, following a brief explanation on a general MG structure and existing control loops, gives a comprehensive review on various MG emergency control and protection schemes and the relevant standards and challenges. This paper is mainly focused on the contingencies when the MGs are transferring from an operation mode to another one (connecting to islanding mode and vice versa), load shedding, and their related issues. Furthermore, the impact of operating in islanded mode and bidirectional power flow on the MG protection is also investigated.
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