Renewable and Sustainable Energy Reviews 56 (2016) 1–17

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Fault location and isolation in micro-grids using a digital central protection unit

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ARTICLE INFO

Article history:
Received 22 October 2014
Received in revised form
27 May 2015
Accepted 22 October 2015

Keywords:
Micro-grid
Central protection unit
Grid-connected mode
Islanded mode
Fault location
Fault isolation

ABSTRACT

Currently, there are significant interests in deployment of renewable and low carbon energy sources in the form of micro-grids for local energy generation. Micro-grids operate in two modes, namely stand-alone and grid-connected. This poses a problem in micro-grid protection settings, in a sense that the fault current magnitude in a micro-grid reduces drastically during its transition from being grid-connected to stand-alone mode of operation. This paper presents a micro-grid protection scheme based on positive-sequence component using PMUs and a digital CPU. The salient feature of the proposed scheme in comparison with the previous works is that it has the ability to protect both radial and looped micro-grids against different types of faults with the capability of single-phase tripping. Furthermore, since the CPU is capable of updating its pickup values (upstream and downstream equivalent positive-sequence impedances of each line) after the first change in the micro-grid configuration (such as transferring from grid-connected to islanded mode and or disconnection of a line, bus, or DER either in grid-connected mode or in islanded mode), it can protect micro-grid against subsequent faults. Finally, in order to verify the effectiveness of the suggested scheme and the CPU, several simulations have been undertaken by using DIgSILENT PowerFactory and MATLAB software packages.

Contents

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http://dx.doi.org/10.1016/j.rser.2015.10.162
1364-0321/

1. Introduction

In traditional power systems, a few large centralized power generation plants are deployed to produce a bulk power. The generated power is then transferred to consumers over long transmission lines. Today, the world is more concerned about environmental issues and energy security, thus, governments around the world are progressively developing renewable energy to reduce environmental problems caused by the conventional energy sources. Due to rapid increase in global energy consumption and decline of fossil fuels, the demand for new generation capacities and their local connection at the distribution level has increased [1].

Utilizing renewable energy through DG and distributed storage in large scale can potentially solve problems such as energy shortage and global climate change. Available and currently emerging technologies for DG units are selected depending upon the connection with the utility. Conventional DG units which can be directly connected to the grid are micro-alternators, low head hydro units, combustion engines, etc., while DG units which require VSI for their connection to grid are fuel cells, photovoltaic systems etc. [2].

Extensive increase of DG penetration and the presence of multiple DG units at distribution level have brought about the concept of the micro-grid. A micro-grid is a portion of power system which includes one or more DG units that can operate in islanded mode or in connection with the main grid [3–7]. The philosophy of micro-grid protection is that it functions in grid-connected mode of operation under normal circumstances, but in case a fault takes place in the main grid side, it shall be disconnected from the rest of the network and is transferred to the islanded mode [8–10]. Fig. 1 shows the structure of a typical micro-grid.

The most significant advantage of micro-grid is that it can provide high- reliability and high- quality power for the customers who need uninterruptible power supplies. In addition, a significant cost saving comes from the application of CHP systems in micro-grids. Notwithstanding numerous advantages provided by micro-grids, they may pose some technical challenges which need to be fulfilled for researchers. Micro-grid protection and its entities is one of them [11–13]. Protection of micro-grids cannot be attained by the same philosophies which have traditionally been applied in distribution networks. The reason is that a protection scheme for micro-grids should take the followings into account: (a) bidirectional power flow in feeders; (b) existence of looped feeders; (c) decreased magnitude of the fault current in stand-alone operation mode [14–16]. As a result, the traditional

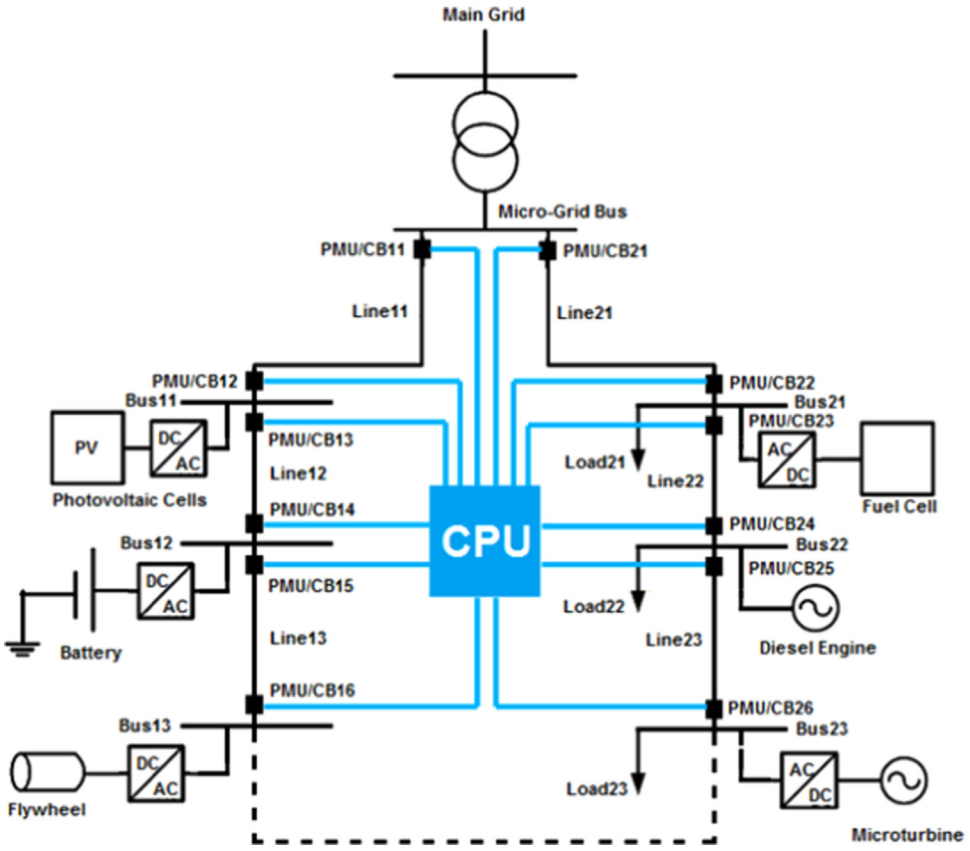

Fig. 1. Structure of a typical micro-grid.