Electrical Power and Energy Systems 99 (2018) 146–155

Contents lists available at ScienceDirect

Electrical Power and Energy Systems

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

A passive islanding detection strategy for multi-distributed generations

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ARTICLE INFO

Keywords:
Islanding detection
Distributed generations (DG)
Loss of grid/mains
Anti-islanding protection

ABSTRACT

Islanding operation is an undesirable event because it can harm the personnel and damage the connected loads. Therefore, islanding operation should be detected and the islanded distributed generation units should be isolated from the rest of the distribution network. This paper presents a simple islanding detection method that is suitable for multiple distributed generation units. The proposed method is based on the concept of the main bus and uses an index called the voltage index to detect islanding operation for large power mismatches. However, for small power mismatches, the line current measured at the main bus is used to disconnect the loads connected to the bus in order to transfer small power mismatches to large power mismatches to detect islanding operation. The simulation results clearly reveal that the proposed method is effective in islanding operation detection and has no non-detection zone. Wind farms power generation system is presented in this paper as an example of distributed generation units.

1. Introduction

Distributed generation (DG) is a small-scale generation that can support increase in the total load demand without investment in the expansion of distribution network by installing the DG units close to the loads. DGs generally refer to renewable distributed energy resources, including wind farms, micro-hydro turbines, photovoltaic (PV), and other generators that are supplied with biomass or geothermal energies [1]. Integration of large numbers of DGs of smaller capacity into utility, which are dispersed according to the availability of renewable energy resources, is resulting in important changes to the topology of the power system. These changes may ultimately convert the power system from vertically to a horizontally-operated power system [2].

Integrating DG into utility has many benefits such as improvement of the power system efficiency, increase the system flexibility, reduction in the power loss and reduction in the environmental pollution. However, this increasing penetration level of DGs has raised many technical concerns such as protection coordination, islanding, safety, system stability, reliability, supply security and voltage regulation [1–4,31]. One of the important concerns that should be taken into account is the islanding operation. Islanding is a situation in which part of the distribution network is isolated from the utility grid and the loads still energized by the local DG units.

Islanding operation is undesirable situation because it leads to safety hazards for personnel and power quality problems for loads. Moreover, islanding operation may lead to damage to the power generation and power supply facilities as a result of unsynchronized reclosure [1–4]. Considering the severe consequences that islanding operation can cause, IEEE STD 1547–2008 specified a delay of two seconds for the DG unit to detect the islanding situation and isolate itself from the distribution system [4].

Until now, several islanding detection methods have been proposed. The islanding detection methods can briefly be divided into two categories, remote methods, where the detection is based on the utility side, and local methods, where the detection is based on the DG side. The performance of each detection scheme is evaluated according to its non-detection zone (NDZ). The NDZ represents the interval in which the detection scheme fails to detect islanding situation once islanding occurred [1,5].

Remote methods are schemes which rely on the communication between the utility and DG units. These techniques are highly reliable and more effective than the local techniques as they eliminate non-detection zone (NDZ). However, they can suffer with communication problems and its implementation implies very high costs [5,6]. The common remote islanding detection techniques are: Power Line Carrier Communication, Supervisory Control and Data Acquisition and Signal Produced by Disconnect [6].

The local methods can be further classified into active and passive methods. Passive methods rely on available local measurements such as voltage, frequency, harmonic distortion, etc. measured on the DG site [1]. The general concept of passive methods is that if the measurements are outside the predetermined thresholds, the protective relay at DG site decides to disconnect the DG [1,7]. Passive methods are preferred due to their smooth implementation and practical solutions as well as

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https://doi.org/10.1016/j.ijepes.2018.01.005
Received 22 June 2017; Received in revised form 9 November 2017; Accepted 5 January 2018
0142-0615/

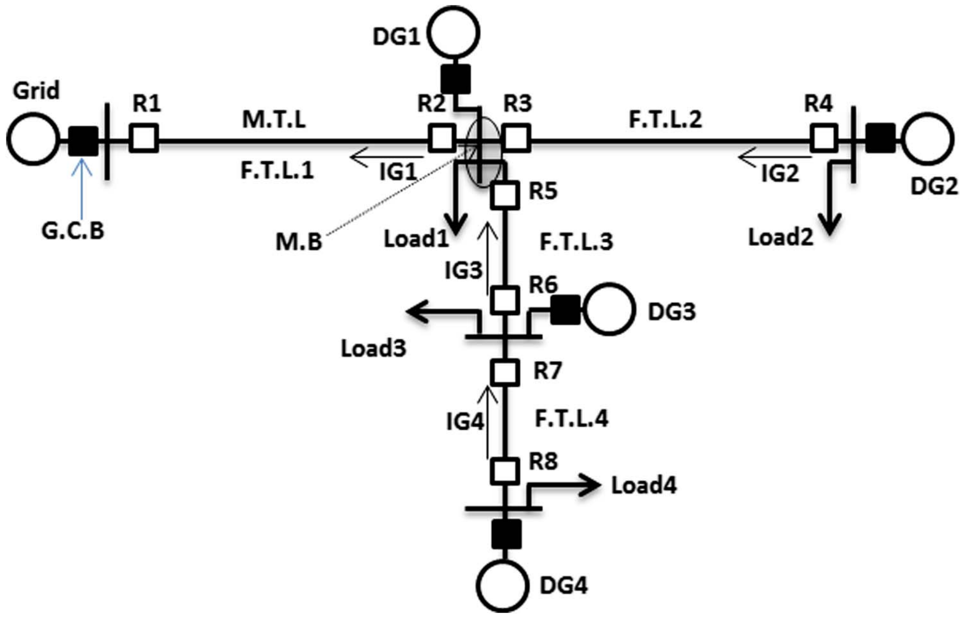

Fig. 1. The distribution system under consideration.

Table 1
The parameters of the model under consideration.

Grid	2500 MVA:120 kV; 60 Hz.
Grid transformer	Step down; 50 MVA; (120/25) kV
DG unit	5 MVA; 575 V; 60 Hz
DG transformer	Step up; 10 MVA; (575/25) kV
Transmission line	R1 = 0.1153 Ω/km; R0 = 0.413 Ω/km; X1 = 1.05 mH/km; X0 = 3.32 mH/km; C1 = 11.33 nF/km; C0 = 5.01 nF/km; Distance: M.T.L. = 50 km; F.T.L2 = 40 km; F.T.L3 = 15 km; F.T.L4 = 15 km;

Table 2
Abbreviations of the scheme.

G.C.B.	Circuit breaker of the grid
M.B.	The main bus of the system
R1	Protective relay no. 1
M.T.L.	Main transmission line
F.T.L1	Front transmission line no. 1
DG1	Distributed generation unit no. 1
IG	The line current of the front transmission line (rms value)

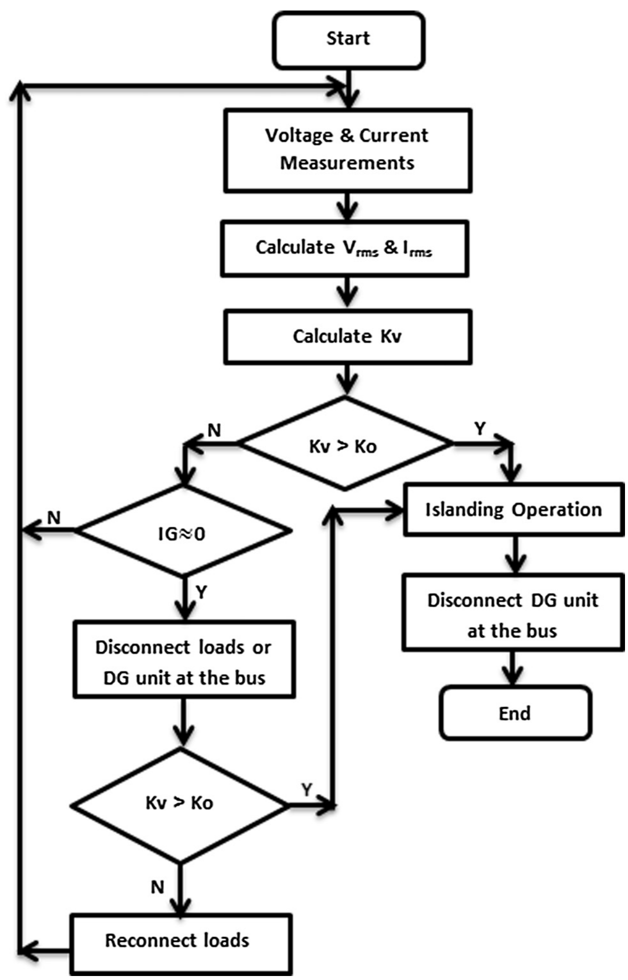

Fig. 2. The flowchart of the proposed strategy for islanding detection.

they do not produce any changes in the power quality [7,8]. Passive methods have some drawbacks such as having a large NDZ and specified threshold values with difficulty [7,9]. The common passive methods include over/under voltage, over/under frequency, over current, voltage phase jump, rate of change of frequency, rate of change of power, and harmonic distortion schemes. A comprehensive survey on passive methods is presented in [6,7,10].

Recently, some different approaches based on combining the passive methods with computational intelligence and modern signal processing methods have been done in order to reduce the non-detection zone and improve the performance of the passive methods. Different approaches based on artificial neural network and fuzzy logic have presented in [1,11–15]. Many researchers have proposed different techniques based on wavelet transform, wavelet packet transform and s-transform (ST) for islanding detection [16–23].

Active methods use disturbing signals in order to cause power mismatches, so that certain system parameters (such as voltage and frequency) drift, when the islanding operation occurs. Active methods have the ability to reduce, even eliminate, the non-detection zone and detect islanding situation accurately compared to passive methods [1,5,7]. However, next to the injection of unwanted perturbations in the distribution system, this external disturbance degrades the output