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Review

# Computational Intelligence based techniques for islanding detection of distributed generation in distribution network: A review

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ABSTRACT

Accurate and fast islanding detection of distributed generation is highly important for its successful operation in distribution networks. Up to now, various islanding detection technique based on communication, passive, active and hybrid methods have been proposed. However, each technique suffers from certain demerits that cause inaccuracies in islanding detection. Computational intelligence based techniques, due to their robustness and flexibility in dealing with complex nonlinear systems, is an option that might solve this problem. This paper aims to provide a comprehensive review of computational intelligence based techniques applied for islanding detection of distributed generation. Moreover, the paper compares the accuracies of computational intelligence based techniques over existing techniques to provide a handful of information for industries and utility researchers to determine the best method for their respective system.



**Contents**



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## 1. Introduction

The exponential growth in electricity demand has given distributed generation (DG) technology a boost in power systems. The International Energy Agency (IEA) has listed five major factors that contribute to this renewed interest: developments in DG technologies, constraints on the construction of new transmission lines, increased customer demand for higher reliable electricity, the electricity market liberalization, and concerns about climate change [1]. All of these factors are shifting the paradigm of power systems from centralized generation to distributed generation. However, DG changes the nature of the distribution system from passive to active. This has created technical problems. One of the major concerns in operating DG in a distribution system is the possible occurrence of islanding. In the islanding condition, the distribution system connected with the DG is electrically isolated from the main grid, yet continues to be energized by the DG [2]. Islanding can occur due to power system imbalance caused by fault, line, and generator outages, or any other disturbance, which can result in the splitting of the system into some islanded networks.

When islanding occurs, the distribution network is disconnected from the main grid through the circuit breaker operation. The islanded network may consist of a substation, or one or more distribution feeders. This islanding network will be sustained if there is sufficient generation to meet the load demand(s). Furthermore, the islanded distribution networks may continuously be energized, which may cause potential damage to the existing equipment, utility liability concerns, and the reduction of power reliability and power quality. IEEE standard 1547 [3] has outlined the condition that in the case of such situation, the DG should detect the loss of grid connection and disconnect itself from the distribution network within 2 s (100 cycles) of the islanding state occurrence. Some utilities require even faster detection of less than one second to avoid of the start of auto-recloser attempt of reconnection. An example of this is the Danish distribution network, where the auto-recloser time is 500 ms (0.5 s) [4].

In order to prevent these problems, the current practice is to disconnect the DG units when islanding occurs. However, due to the high penetration of DG, this practice will not be an economical option, and may result in the waste of power generation from the DG. The islanding operation may be unintentional or intentional. Intentional islanding of a distribution network may reduce the congestion of transmission and distribution network, improve the overall system performance by reducing the power losses, and improve the voltage profiles. Hence, the islanding operation of a distribution network may be a viable option, provided that the various issues related to it are properly addressed. Various researches have been conducted, and are on-going, with the purpose of making islanding operation a reality [5,6]. In relation to this development, a draft series of guides, referred to as P1547.4 draft guide for design, the operation and integration of distributed resource island system with electric power system has been produced [7], which will serve as a guide for practicing an intentional islanding operation in an electrical power system.

When the distribution network is disconnected from the grid, the first step would be to detect the islanding phenomenon. This requires an efficient islanding detection technique to detect the islanding event in order to operate or disconnect the DG. This is very important, as the failure to accurately detect islanding may result in the failure of the whole distribution network. Two factors are important in islanding detection, which are time and accuracy for each type of DG. Up to now, several remote, passive, active and hybrid islanding detection techniques have been proposed. However, each technique has its merits and demerits. Hence, the research interest shifts towards the application of computational intelligence-based techniques for islanding detection. The computational intelligence based techniques, due to their robustness and ability to easily deal with complex system, may be suitable for islanding detection of DG. This paper reviews the ability of these techniques in accurate and fast islanding detection.

The paper is organized as follows. Section 2 discusses the causes, effects, and solution of unintentional and intentional islanding. Section 3 presents the islanding detection standards and test frame. Section 4 discusses the comparison of different existing islanding detection techniques, along with their limitations. Section 5 and 6 reviews computational intelligence based techniques applications for islanding detection and discussions. Finally, the conclusion is presented.

## 2. Unintentional and Intentional Islanding – Causes, Effects and Solutions

Cascading failures and blackouts are the most significant threats to the security of power systems. Since the previous decade, the world has encountered many power blackouts as a result of cascading failures [8–14]. Cascading failure can be defined as a process where one failure leads to successive failure of other elements of the grid. It may possess high risks towards the integrity of power system network, and might causes it's splitting into various unintentional islands. Furthermore, these unintentional islands may encounter active or reactive power deficiency, which may lead to frequency, angle, or voltage instability. These frequency, angle, or voltage instability may further cause tripping of other region if not controlled properly. During such condition, the secure and reliable operation of the whole power system network in an interconnected mode may be very difficult to control. It may result in the propagation of these instabilities in other stable parts of the network. Hence, intentional or controlled islanding has been utilized as a preventive strategy to minimize the losses caused by unintentional islanding [15]. Intentional islanding is the process of intentionally splitting the grid into separate controllable islands [16].

Recently, the research in an intentional islanding operation of distribution systems has increased due to economical and technical factors [17]. Intentional islanding of power systems is advantageous that it separates the faulty section from the stable section of power system. By doing this, the whole power system is split into controlled island regions for easy handling. In such situation, each island region should have sufficient generation to supply its loads in order to remain operative [15]. Fig. 1 shows an example of power system that is divided into three-island region after successful splitting.

It should also be pointed out that intentional islanding could prevent the system from a total collapse. However, when to island and how to ensure successful islanding, remains uncertain. The correct identification and splitting of power system into various stable islands is a challenging task that is currently being investigated worldwide. Several algorithms have been developed for the identification and splitting of power systems to stabilize islands. Few examples include the identification method based on the search mechanism [15], comprehensive learning particle swarm optimization (CLPSO) algorithm [17], ordered binary decision diagram (OBDD) based algorithm [18], ANN based method [19], two stage stochastic method [20], mixed integer linear programming (MILP) method [21], angle modulated particle swarm optimization (AMPSO) and slow coherency based method [22], algebraic graph based algorithm [23], proper sizing and DG placement based algorithm [24], Line