



Implementation of a new remote islanding detection method for wind–solar hybrid power plants



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ABSTRACT

The integration of the distributed generation (DG) systems into the power grid is a significant issue to provide a reliable operation of the power system. DG systems must meet some technical requirements to achieve a successful grid connection. Islanding is also a vital issue for a reliable integration of DG systems with the grid. There have been many islanding detection methods researched in the literature, but most of them have some boundaries related to the local load and the inverter. In this study, a new remote islanding detection method is introduced for a developed wind–solar hybrid power plant, and a practical solution is researched by classifying the current methods. The proposed method monitors and controls the grid, local load and the output of the PV inverter in real time with the communication of circuit breakers. The proposed remote control system detects the changes in the currents of the circuit breakers, frequency and the active powers by checking the defined threshold values at all electrical branches of the hybrid DG system. When the breaker current goes to zero, or they are under/over defined threshold values, the circuit breakers are tripped by using a real-time control system that is developed with Labview. The proposed method also checks the frequency, active powers, and reactive powers with the currents in real-time, so it is independent of the load, and it is not inverter resident. Islanding detection time is just a cycle, and it is a considerably short response time according to the current standards. Non-detection zone (NDZ) is also zero in the proposed method. The experimental results prove that the developed remote islanding detection method is easily implemented in wind–solar DG systems, and it is also suitable for real system applications.

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1. Introduction

Recently, Distributed Generation (DG) systems have been developed rapidly, so the solar and the wind energy have been the most important sources in other renewable energies [1]. Grid-tied Photovoltaic (PV) systems and wind turbines also have been coming into prominence in DG systems in parallel to this development [2]. There have been some restrictions for DG systems connecting them to the utility grid just like providing the reliability of the grid, high power quality and safe interaction with a DG system. Islanding is considered as the most important subject to this restriction for DG systems, providing a reliable connection and continuously working with the grid.

Abnormal operating conditions of the grid affect the DG system [3], so the DG system has to be out of the islanding situation that is maybe the significant security problem in a DG system. The islanding operation is defined in a DG that a situation while a DG system continues feeding the load through disconnection of the electrical grid from the load [4]. The islanding operation can cause damage both in the DG system and the grid, so this situation has to be prevented when it occurs. The grid voltage and the grid frequency are not stable in an islanding situation. The operation values vary from the grid reference values in this condition. Thus, a circuit breaker (CB) connected between the grid, and the points of common coupling (PCC) must clear the fault during an islanding operation. Meanwhile, DG still gives the power to the local load if CB cannot be controlled to open the circuit [5]. Voltage Shutdown, equipment failure and short-circuit conditions create the unpredictable interruption of the grid, and these abnormal conditions cause islanding operation in a DG system [6].

There have been two islanding operations called as the intentional islanding and the unintentional islanding [7]. The intentional islanding creates a power island when a disturbance occurs, and this mode sectionalizes the utility system for this aim. Also, a power management plan must be operated in an intentional islanding that created for supplying the local load regularly by DG. Intentional Islanding is usually a planned action organized by the grid authorized people, so it is not hazardous to the power system [8]. However, unintentional islanding can damage the grid due to losing the synchronization of the electrical grid by creating the significant difference in power system stability.

As a result, this situation causes the voltage and frequency being out of desired grid reference ranges and this condition can cause damage to the electrical devices of the system in an islanded DG section [49]. There is also a dangerous situation for the authorized people work in a DG system. They cannot realize that DG continuously provides power to the island portion of the system, and this situation is a dangerous safety problem in the system [50,51]. Even defining this problem in a DG system is a sufficient criterion to understand the importance of the islanding. Hence, islanding detection that is indicated in IEEE standard [7,19] is required to be completed as soon as possible, and this situation always is important for the authorized DG people and companies.

Consequently, a DG consists of a wind-solar hybrid power generating system must be disconnected from the local load by using a circuit breaker that is triggered by a generated control signal because of these restrictions [9,10]. Today, there have been many developments islanding detection techniques and algorithms can be found in the literature [11–13]. These islanding

methods are classified into three main methods called as local, intelligent and remote detection methods. Remote methods are related with measuring system parameters at a DG. In the case, local methods use a remote method between DG and the grid. The fundamental classification of islanding detection methods are also can be shown in Fig. 1 [14].

2. Current islanding detection methods and international standards

Islanding is an important problem to solve in DG systems because it could cause serious problems for damaging equipment in DG system and the danger of death for working people. There have been some standards to define the rules and restrictions for DG systems in islanding mode of operation [14,15]. Mainly, IEEE-1547, IEEE 929, IEC-62116 and Japan standards are necessary for islanding [16–18].

IEEE 929-2000 [19] also defines frequency threshold values, voltage threshold values and required opening time for circuit breaker (CB) in DG systems. Table 1 shows these definitions and threshold values. Islanding is detected according to nominal voltage and frequency values compared with specified values in IEEE 929-2000. Table 1 also indicates the opening time of circuit breaker in defining the conditions for the islanding mode of operation.

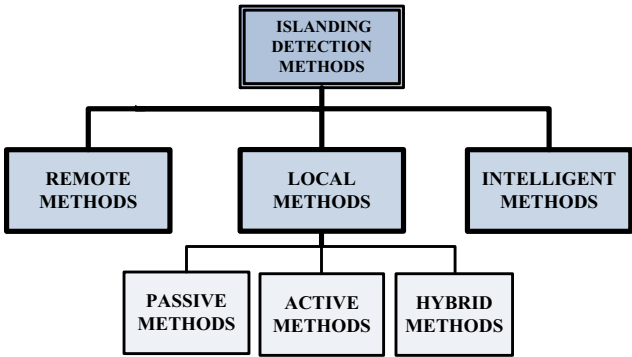


Fig. 1. The classification of islanding detection methods [14].

Table 1
IEEE 929-2000 threshold values for grid connection [19,20]

No	Frequency	Voltage	CB opening time
1	f_{nom}	$0.5V_{nom}$	6 cycles
2	f_{nom}	$0.5V_{nom} < V < 0.88V_{nom}$	2 s/120 cycles
3	f_{nom}	$0.88V_{nom} \leq V \leq 1.10V_{nom}$	Normal operation
4	f_{nom}	$1.10V_{nom} < V < 1.37V_{nom}$	2 s/120 cycles
5	f_{nom}	$1.37V_{nom} \leq V$	2 cycles
6	$(f_{nom} - 0.7) \leq f \leq (f_{nom} + 0.5)$ Hz	V_{nom}	Normal operation
7	$f < (f_{nom} - 0.7)$ Hz	V_{nom}	6 cycles
8	$f > (f_{nom} + 0.5)$ Hz	V_{nom}	6 cycles

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