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An Islanding Detection of Reactive Power Disturbance and Circuit Breaker System

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Abstract: An islanding detection method for inverter-based distributed generators (DGs) is presented, which is based on perturbing reactive power output. Two sets of disturbances are configured in this method, which have different amplitudes and duration time. The first set of reactive power disturbance (FSORPD) is periodic with small amplitudes to break the reactive power balance during islanding, whereas the magnitude of the second set of reactive power disturbance (SSORPD) is sufficient to force the frequency to deviate outside its threshold limits. Considering all the possible frequency variation characteristics with the FSORPD after islanding, three criterions are designed for switching the disturbance from the FSORPD to the SSORPD. Since DGs located at different positions have the same frequency variation characteristics, the SSORPDs can be added on different DGs at the same time without the need of communication. Therefore, synchronization of the SSORPDs can be guaranteed for the system with multiple DGs and the method can detect islanding with a zero non-detection zone (NDZ) property. According to the anti-islanding test system recommended in IEEE Std.929-2000 and IEEE Std.1547-2003, in the effectiveness of the method has been validated with several case studies in mat lab simulation.

Keywords: Inverter based distribution generation, reactive power disturbance, islanding detection, circuit breaker.

I. INTRODUCTION

The inverter-based distributed generator (DG) uses renewable energy (photovoltaic, wind power, fuel cell and micro turbine, etc to supply power for the network and local load. It is being widely applied to protect environment and make the power industry development sustainable. In order to ensure the safe operation of both the network and the DG, the DG has to be equipped with islanding detection function according to IEEE Std. Islanding is a condition in which a portion of the utility system that contains both the DG and load continues operating while this portion is electrically separated from the main utility. Unintentional islanding can result in power quality problems, serious equipment damage, and even safety hazards to utility operation personnel . Therefore, the DG has to detect islanding effectively in this case and disconnect itself from the network as soon as possible to prevent the damages mentioned above. where the distributed network, the RLC load and the DG are connected at the point of common coupling (PCC). Generally, islanding detection methods can be classified into following three categories: 1) communication-based methods; 2) passive methods; and 3) active methods. Communication-based methods do no harm to the power quality of the power system and have no non-detection zones (NDZs) in theory. However, the cost is much high because of the need of communication infrastructure and the operations are more complex as well . In addition, the effectiveness cannot be guaranteed with the risk of communication breakdown. Therefore, passive and active methods have been well developed. Passive methods determine the islanding condition by measuring system parameters such as the magnitude of the voltage at the PCC, the PCC voltage frequency and phase jump . Accordingly, over/under frequency protection (OFP/UFP), over/under voltage protection (OVP/UVP) and phase jump detection (PJD) are the most widely used passive islanding detection methods. These passive methods are easy to implement and do no harm to the power quality, but they may fail to detect islanding when the local load’s power consumption closely matches the DG’s power output . In order to reduce or eliminate the NDZ, active methods rely on intentionally injecting disturbances, negative sequence components or harmonics into some DG parameters.

Distributed Generation (DG) becomes one of the most important trends of power system engineering. DG is a small electrical power generation devices that provides electric power at or near the load site; it may be connected to the distribution system or to the customer's facilities or both. Generating power near to load site reduces the cost, complexity, interdependencies, and inefficiencies associated with transmission and distribution. It helps on the enhancement of the conventional electric power system. DG has the ability to adopt different sources of energy such as solar, wind, methane, fuel cells, gas turbines, and combustion engines. By having DG, the source is closer to the load and therefore will have fewer losses, provide voltage support, and have more controllability of the system. Integrating DG with the low voltage distribution system, may results in some of problems one of them is islanding. Islanding occur

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when a part of distribution system becomes electrically isolated from the reset of the power system and still energized by the DG that connected to it. Normally, the distribution system doesn't have any sources of active power generation in it, and when a fault occurs in the upstream transmission line it doesn't get power.

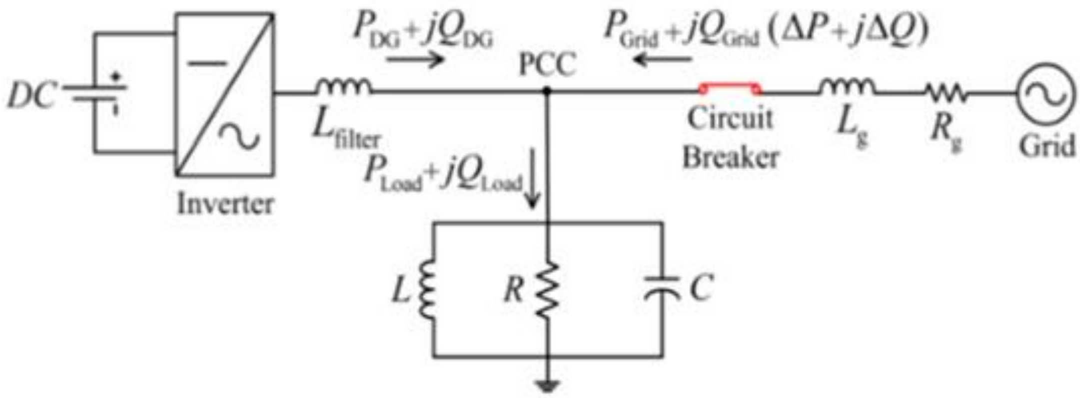
II. ISLANDING DETECTION BASIC PRINCIPLE

This is about islanding detection so it is motivated to carefully define the notation. Loss of mains protection (LOM), loss of grid protection, anti islanding protection and islanding protection are synonyms used around the world. Throughout this work the expression islanding detection has been used. There are mainly two reasons for this. Firstly detection is more neutral than protection. It is not always necessary to protect against islanding. Sometimes it may be enough to be aware of the state, hence the word detection. Secondly the "ing"-part in islanding focuses on the change of states. This refers to detection in the very moment when the island is formed. Why islanding detection? The power systems are complex and not always easy to intuitively understand. They are highly automated and spread over nations and continents. Contingencies and faults occur regularly and many of these events are cleared automatically without human intervention. The utilities are responsible for the safety of the power system. If a part of the power system forms an uncontrolled island there is a risk that personnel sent out for maintenance work in the islanded system get in contact with the live parts of the equipment. This can cause severe injuries and death. Hence it is very important to detect and shut down unintended electric islands. Many distribution feeders have protection systems with automatic reclosing equipment. This is common practice when the feeders are constructed with overhead lines where the fault is likely to disappear after a short interruption. From historical data it has been shown that permanent faults only occurs in 10 to 15 % of the feeder outages (IEEE 2003b). Automatic reclosing increases the availability of the power system since the interruption time is minimized. If, however, the automatic reclosing occurs against an energized feeder with a DER-plant it is not unlikely that the grid voltage and the energy converter at the plant are out of phase. This can cause damages to the installed equipment. Another drawback with automatic reclosing against an energized feeder is that a capacitive switching transient can cause a severe overvoltage. In a lightly damped system the overvoltage can reach three times the nominal voltage or twice the nominal voltage in a more damped system. The capacitances involved in the transients are found in cables and shunt capacitances in the islanded system.

III. PROPOSED METHODOLOGY

The proposed islanding detection method is easy to implement. Firstly, two sets of reactive power disturbances, three criterions for disturbance switching and two criterions for islanding determination have to be configured. Relative parameters are set in advance as well. Generally, the FSORPD is added on the rated reactive power reference of the DG. Constant RLC load is generally considered as the hardest detectable condition for an islanding detection method and it is recommended in the generic system to examine the islanding detection methods' performance. In different types of loads were modeled by varying the load's voltage and frequency dependence parameters and the performance of the OVP/UVP and OFP/UFP methods with different load models was analyzed. It was create that the load's voltage and frequency dependence parameters have no effect on the amount of frequency deviation.

According to IEEE Std.929 and IEEE Std.1547, the recommended test system for islanding detection study is shown in Fig. 1. It consists of an inverter-based DG, a parallel RLC load and the grid represented by a source behind impedance. The operation mode of the DG depends on whether the circuit breaker is closed or not. Since the islanding detection time is very short, the output power can be considered to be constant during the detection. Therefore, using a constant dc source behind a three-phase inverter, the DG is designed as a constant power source. Fig. 2 presents the block diagram of the DG interface control.



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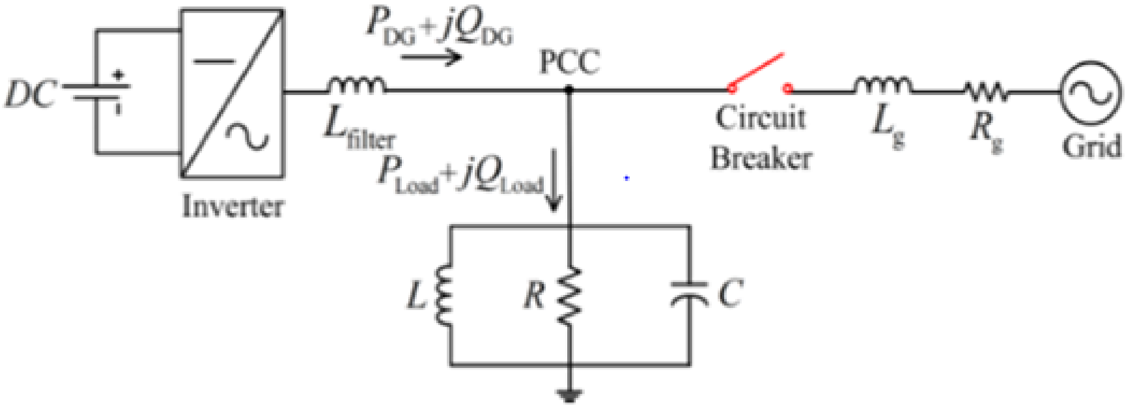

Fig.1 Test system for islanding detection

According to the instantaneous power theory and the Park transformation, the DG can control the active and reactive power output independently based on the dual close loop control structure in the d-q synchronous reference frame . As shown in Figure. 1, when the DG is connected to the utility grid, equations (1) and (2) describe the power flows and the active and reactive power consumed by the load

$$\mathrm{PLoad} = \mathrm{PDG} + \mathrm{PGrid} = 3V^2\mathrm{Pcc}/R \qquad (1)$$

$$\mathrm{QLoad} = \mathrm{QDG} + \mathrm{QGrid} = 3\mathrm{VPcc}\left(\frac{1}{2\pi fl} - 2\pi fc\right) \qquad (2)$$

$$f = \frac{1}{2\pi\sqrt{LC}}$$

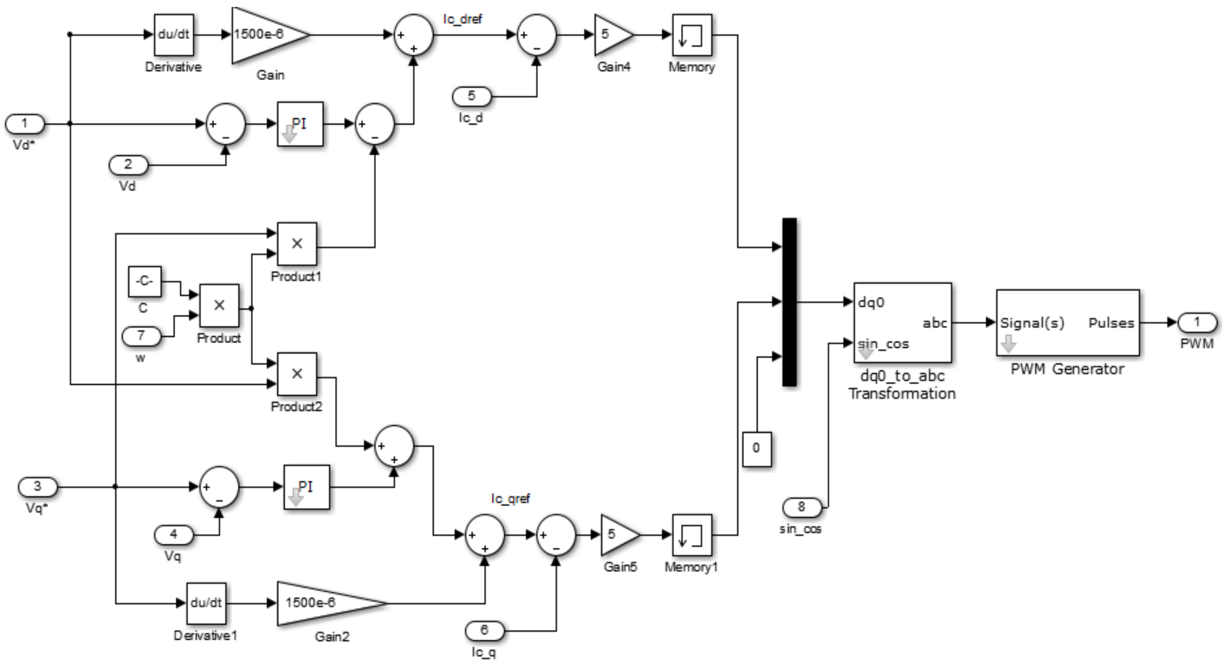

Fig.2 DG interface for constant power control

IV. SIMULATION RESULTS

It can be conditional from fig a. that frequencies in ultimately deviate outside the upper threshold 50.5 Hz and the duration time of this condition is longer than 10 ms. Therefore, the proposed method is capable of detecting islanding effectively in load imbalance conditions as well. Moreover, it also can be seen from that the fluctuation range of the PCC frequency is larger for the more unbalanced load. In order to detect islanding rapidly and reliably, the magnitude of the SSORPD can be set a little bit larger for the serious unbalanced load.

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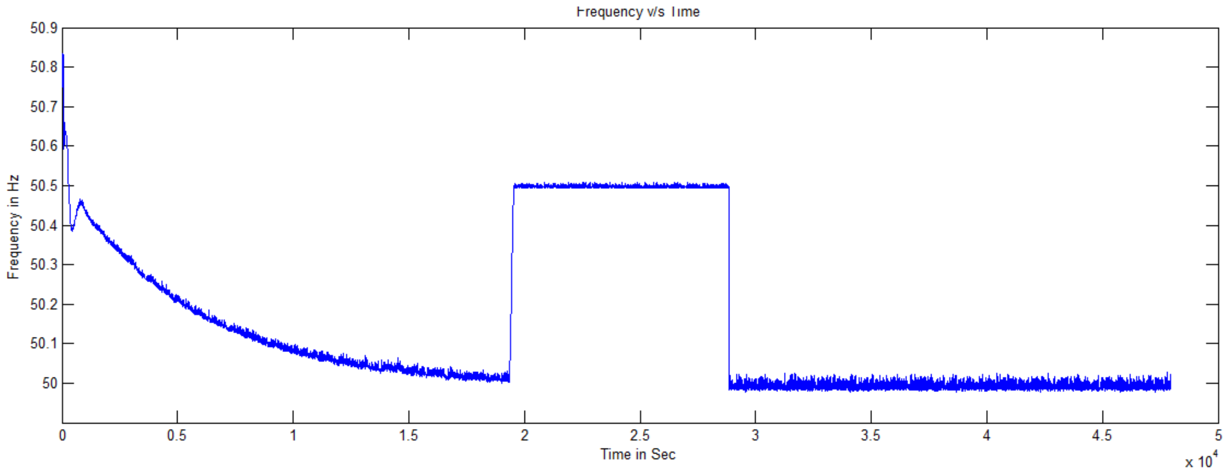

Fig. a Variation of frequency with respect to time with unbalanced load

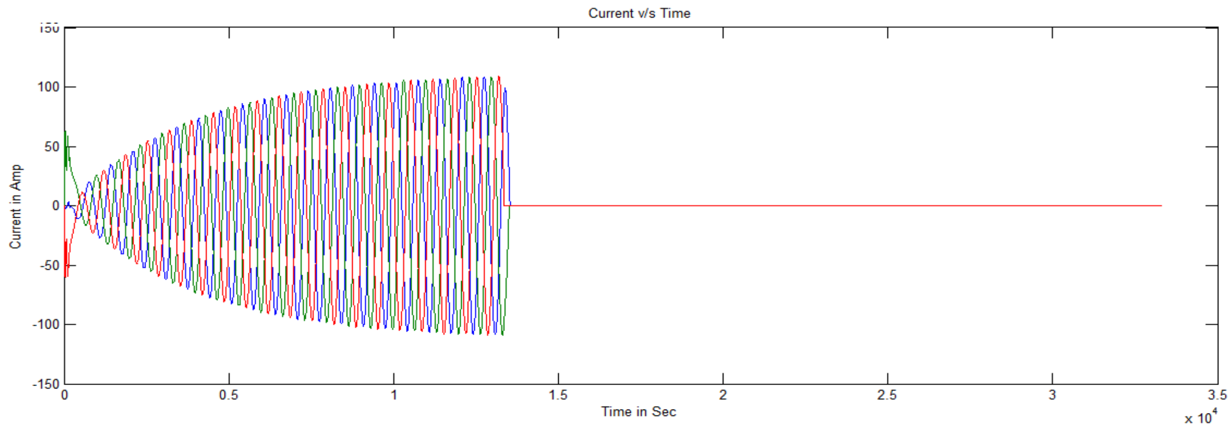

Fig b. Current with respect to time

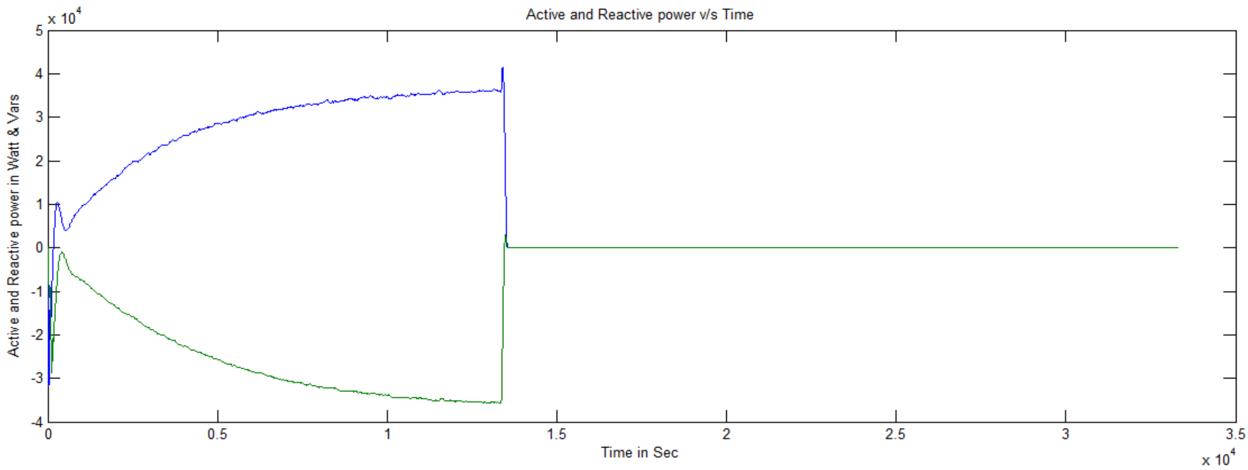

Fig c. Active and Reactive power with respect to time

IV. CONCLUSION

Under constant power control, the inverter-based DG can either operate at unity power factor or generate both active and reactive power simultaneously. For the DG generating both active and reactive power simultaneously, analyzes the relationship between the reactive power disturbance and the frequency variation during islanding. In the proposed method, two sets of reactive power disturbances are designed. They have different magnitudes and duration time for different purposes. Basically, the FSORPD is added on the DG. It is periodic and it aims to destroy the reactive power

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balance between the DG and the load after islanding and then activate the SSORPD. However, the SSORPD has large magnitude. Its purpose is to force the frequency to deviate outside its threshold limits to determine islanding no matter there are power mismatches or not between the DG's rated power output and the load's consumption. Thus, the method can eliminate the NDZ. When the FSORPDs are added on different DGs, they might be asynchronous. Considering all the possible frequency variation characteristics with these FSORPDs after islanding. Moreover, DGs located at different positions can detect the same frequency variation characteristics. Accordingly, the proposed method can effectively and reliably detect islanding for multiple-DG operation. Simulation results verify that the proposed method performs well on islanding detection.

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BIOGRAPHIES

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