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A New Technology of Comprehensive Islanding Detection

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Abstract

With the widely application of the distributed generation technology, micro grid islanding detection technology has been greatly developed. A new type of islanding detection technique is proposed in this paper. The new detection technology has realized the rapid, efficient, stable and reliable islanding detection, and achieved the zero non detection zone. At the same time, which put money into limit in minimum range. This paper presents the principle of islanding comprehensive detection technology. This paper designs and describes the method to realize the new islanding detection technology. The new technology makes up for a series of shortcomings,such as the non-detection zone (NDZ) is larger of the local testing technology. And it also overcomes a great many shortcomings of the remote detection technology, such as a big investment and too single.

Keywords*: islanding detection, local testing technology, remote detection technology, power quality*

1. Introduction

Distributed generation technology in the rapid development in the world. And as scientific technological progress and economic development, people on the environment demand is increasing day by day. The development and utilization of new energy has been continuously developing[1-3]. Distributed generation technology is not only clean, environmental protection, economic and efficient, but also can improve the stability and flexibility of the whole power system. In recent years, distributed generation and micro grid technology have developed rapidly, and that implement the parallel operation. Distributed generation technology in power system not only to improve the reliability and flexibility of the power, but also bring some new challenges at the same time, an islanding effect is one of them[1-4].

Islanding detection must be a prerequisite for transformation for a micro power grid under certain conditions by the parallel operation mode change to the islanding operation mode[5-6]. Rapidly and efficiently for islanding detection is the key problem to the system of distributed generation has to overcome [4]. Islanding refers to when the power company or power supply enterprises due to power failure of grid-connected power generation system and the load to form a self-contained power that supply electric power company cannot control range. The self-sufficiency of islanding phenomenon will make serious effects to repair personnel and electrical equipment even the power grid. So the distributed generation system need to be able to timely detect the occurrence of islanding [2-7].

At present, the islanding detection methods include local detection and remote detection technology. and local detection technologies including active technology and passive technology. Remote detection technologies have a lot of shortcomings. For example, remote detection method requires additional equipment, high cost, complicated

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operation, poor economy and need a lot of certification. Because of its high cost, this method is not widely used in the small DG. It is suitable for high power grid-connected of distributed power station. With the development of smart grid, this method will have great development potential and space. When the power off, passive detection methods are adopted to detect the inverter output voltage amplitude, frequency, phase, and the harmonic is abnormal to determine whether produce islanding or not [6-8].

Local detection methods also exist many defects. For example: NDZ is larger; It is difficult to accurately set the threshold, which is not only higher than the normal run-time values, but also less than the values of islanding. In order to reduce the NDZ, local detection methods often to improve the sensitivity of the device, but this can cause no fault tripping and affect the normal operation of the system. In certain circumstances, great NDZ.

Some parameters cannot be measured directly, and need to get the complex calculation, and the influence of the error of calculation and the computation time may also produce some known and unknown to the detection effect [4-9].

At present, the domestic study on islanding detection technology mainly concentrated in the local detection technology, relatively few research on remote detection technology. In view of the traditional active frequency detection method exists some non detection zone.

Reference [7] proposes the positive and negative half cycle disturbance. But it still exists defects affect the power quality and voltage fluctuation. Reference [8] proposes 2N current voltage cycle perturbation method. This method has the problem of long testing time at the same time. Reference [9] proposes the frequency change and load change ratio $\Delta f / \Delta p_L$ method for measuring index. There is a problem of existence of the test results by the data error influence, and there are some limitations.

A new technology of islanding comprehensive detection is proposed in this paper. This technology synthesizes the characteristics of the local detection technology and remote detection technology. The technology overcomes the problems of active detection technology of NDZ is large, the threshold threshold is difficult to accurately set. And comprehensive islanding detection method for relative to the remote detection technology investment is not so much.

2. Preliminaries

2.1. The Flow Chart of Micro Grid Islanding Detection Principle

One of the key technical problems of micro grid switching control mode is the islanding detection. Islanding detection technology plays an important role in the micro grid operation process. It is no exaggeration to say that the islanding detection is a prerequisite for the normal operation of micro grid. As shown below, it is the most basic principle chart of the micro-grid islanding detection. The flow chart of micro grid island detection principle description of each process and steps of islanding detection technology.

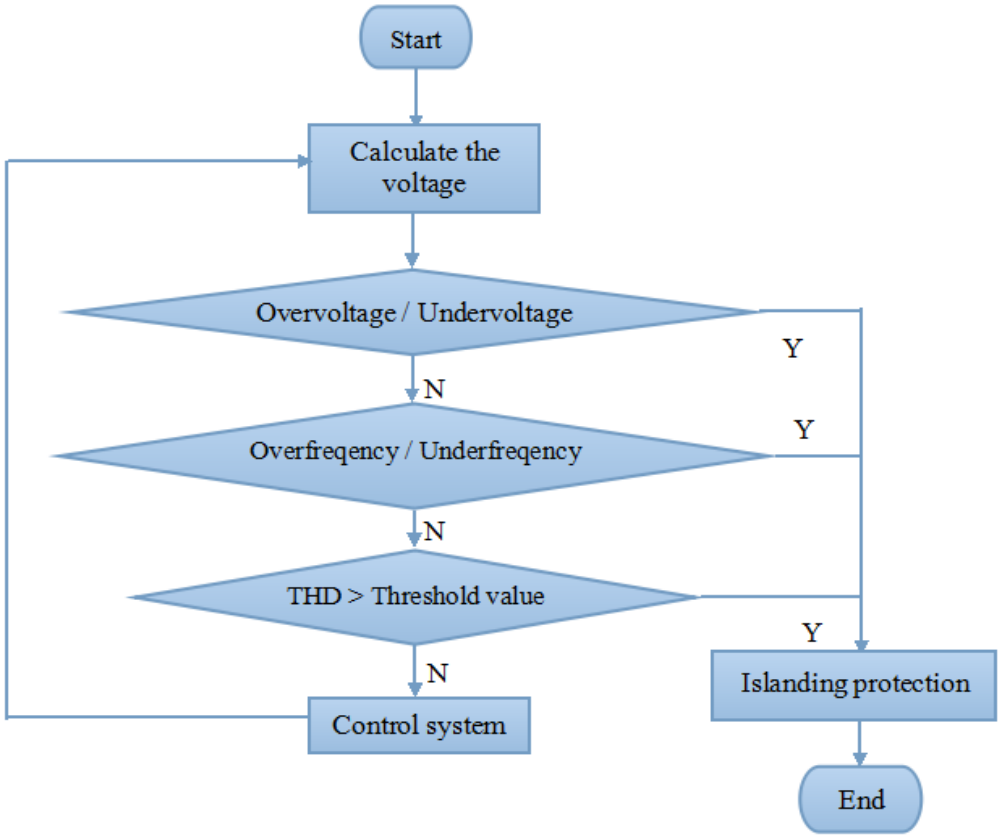

Figure 1. The Flow Chart Of Micro Grid Island Detection Principle

2.2. Local Detection Technology

Local detection techniques include active detection technology and passive detection technology. Active detection method refers to the human add one active disturbance signal to the system. Under the grid connected mode, because of the influence of large power grid, the role of disturbance signal is very small that will not affect the measurement. When the islanding is generated, the inverter output perturbation will accumulate rapidly, triggering the islanding detection device at the time of beyond the permitted scope [8-10].

Active detection technology mainly includes the impedance measurement method, the Sandia voltage offset method, active frequency drift method, slip frequency drift detection method and the Sandia frequency shift method. Before and after the islanding, the electric parameters such as voltage, frequency and phase will change. By detecting the changes, whether the islanding produce or not can be determined. Passive detection technology will not affect the system, but its NDZ is larger.

The local passive methods can be divided into voltage / frequency detection method, voltage harmonic detection method and phase jump detection method, *etc*.

2.3. Remote Detection Technology

Remote islanding detection methods detect islanding in the grid side. General remote detection technology does not exist DNZ and has a better reliability. Remote detection technology through communication between the grid and the DG to complete the detection. It is refers to between the grid and distributed power through communication to contact, islanding detection has achieved very high reliability [10-15].

However, because of the need of communication equipment, so the cost is higher than the local technology. Remote technology including PLCC method, the transmission circuit breaker tripping method and SCADA technique, *etc*. The main principle of PLCC method is via a signal generator is connected with the secondary side of the substation busbar. The equipment unceasingly transmitted the carrier communication signal for distribution line by the PLCC system, and at the same time each DG device is provided with a signal receiver. If the receiver is not detected the signal, then a breaker between the substation and the DG equipment operation, namely the DG device in a state of the islanding [5-11].

Supervisory Control And Data Acquisition (SCADA) through the detection of the auxiliary contacts of each switching node to monitor system status. When the islanding produced, SCADA system can quickly determine the islanding region. At the same time circuit breaker working state through the SCADA system to DG, DG and local load disconnect[18-20].

But the remote detection methods require additional testing equipment, at the same time also increase financial and human inputs, this be the impact of the main defects in practical application. In addition, remote detection of distributed grid trip time is not fixed, also is changing.

2.4. Islanding Detection Circuit is Recommended by IEEE

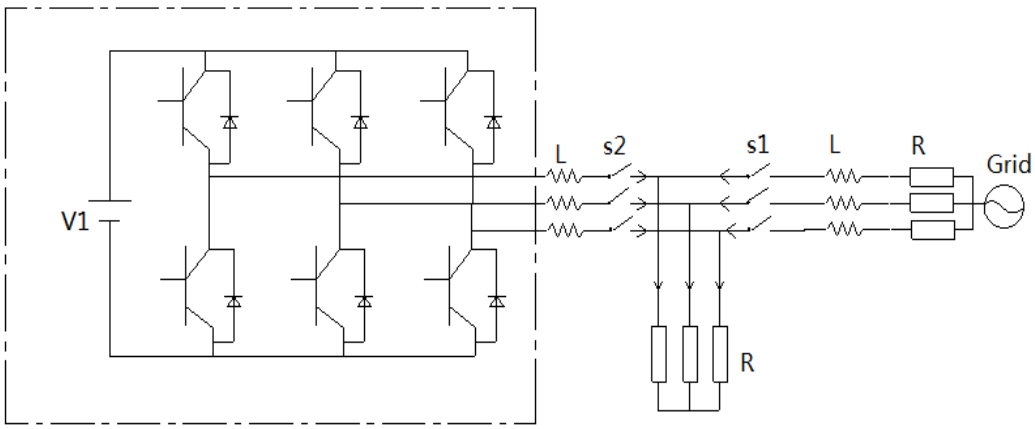

Figure 2. The Islanding Test Circuit Of IEEE Recommended [11]

DG consists of a DC power supply and the three-phase grid connected inverter, local load using RLC parallel circuit, and the public power grid using the ideal voltage source and the equivalent resistance anti of R and L express. To simulate the islanding occurs through a disconnect from the S1, S2 is a synchronization switch of DG. i_{grid} is a grid current, i_{dg} is DG current, i_{load} is load current, v_{pcc} is a node voltage of PCC [11-12].

3. Comprehensive Islanding Detection Method

A new type of comprehensive islanding detection method is proposed in this paper. The technology combines the function of local detection technology and remote detection technology. Islanding comprehensive detection technology is proposed in this paper to solve a series of problems in the process of islanding detection of non detection zone is large and difficult to set the threshold threshold, reduction of voltage quality, *etc*.

At the same time, the requirements of properly to minimize equipment cost and investment are reached. The operation complexity of the device is reduced, at the same time, do not need too much certification, increasing the economy. Comprehensive islanding detection method does not affect the power quality and has good economic feasibility; It is easy to adapt to the expansion of change and the system of power network topology structure, can adapt to the future development of smart grid.

4. The Working Principle of the Integrated Islanding Detection Method

Islanding comprehensive detection technology through the detection of inverter output voltage total harmonic distortion (THD) to implement the islanding detection; Detect whether the voltage frequency range of the common coupling point beyond the scope of protection for detecting an islanding; Detection of the phase difference between the inverter output current and voltage to achieve islanding detection. Islanding integrated testing technology could detect the above three kinds of variation at the same time to implement the island detection. The inverter output voltage total harmonic distortion; The common coupling point voltage frequency range is beyond the scope of protection; The phase difference between the inverter output current and voltage. One of the above three be detected can be used to determine micro power grid has produced an islanding.

New type of integrated detection technology compared with traditional islanding detection technology has the following advantages: The accuracy rate of islanding detection resulting in higher; More insurance, which is not easy to have missed and has no non detection zone; Comprehensive islanding detection method for islanding detection can achieve the most comprehensive; Whether it is the kind of causes of the island, will be detected out by comprehensive islanding detection method; Comprehensive islanding detection method does not influence the quality of electric energy; There are good economic feasibility; More flexible, easy to adapt to the change of system expansion and network topology, which can adapt to the future development of smart grid.

The principle diagram of the island comprehensive detection technology is as follow:

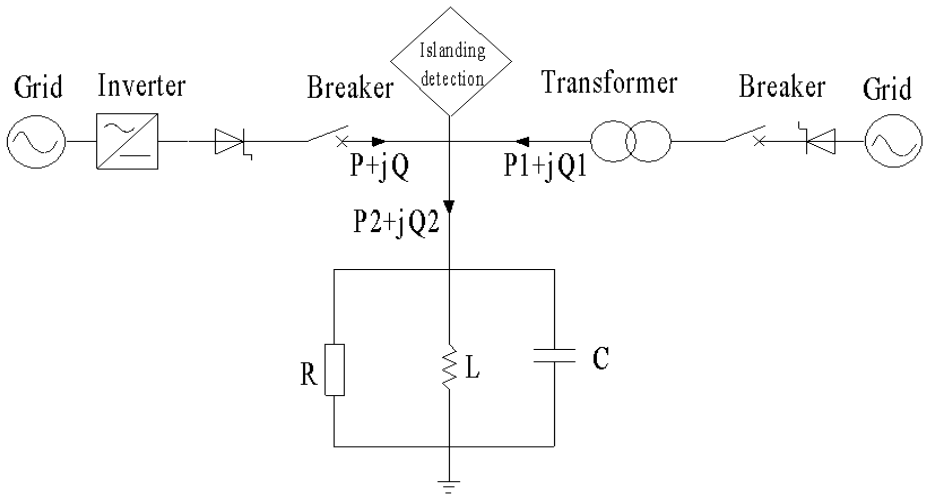

Figure 3. The Principle Diagram of the Island Comprehensive Detection Technology

When the circuit breaker is closed, the system is in the state of grid connected power generation. At this time, the active and reactive power of grid system flow into public connected is $P+jQ$. Load power is equal to $P2+jQ2$. Combined active power and

reactive power provided by Power grid is equal to P. So the following formula can be derived:

$$P + P1 = P2$$
$$Q + Q1 = Q2$$

(1)

5. The Design and Implementation Method of Comprehensive Islanding Detection Method

Comprehensive islanding detection method can be divided into the following three kinds of work mode. And the comprehensive islanding detection method can seamlessly switch free intelligence in between these three modes.

① Comprehensive islanding detection method work in the model of detection total harmonic distortion (THD)in the inverter output voltage terminal to realize the islanding detection.

In this operating mode, when the grid disconnected, due to nonlinear hysteresis characteristics of transformer, the output current distortion voltage in transformer. The harmonic current generated by the inverter into nonlinear load will produce much harmonic. Comprehensive islanding detection by monitoring the output voltage harmonic distortion can judge whether the islanding.

At the same time, SCADA system can quickly determine the islanding region. At the same time circuit breaker working state through the SCADA system is sent to DG, DG and local load disconnect. The perfect combination of such local detection technology and remote detection technology ensures that all indexes of islanding detection.

② Comprehensive islanding detection method work in the model of detection whether the voltage frequency range at the point of common coupling is beyond the scope of protection to realize the islanding detection.

In this operating mode, when power off, if the inverter output power and the local load power imbalance, then DG system output voltage or frequency will change. If the voltage and frequency variation than the normal threshold setting, islanding can be detected. At the same time the PLCC technology also work, so to ensure the accuracy of islanding detection.

③ Comprehensive islanding detection method work in the model of detection the phase difference between voltage and current of inverter output to realize the islanding detection.

In this operating mode, when power off, the voltage of the common coupling point is determined by the output current of the inverter and the load impedance. For the non resistive load, voltage phase at the point of common coupling mutations, which through the phase between the detection voltage and output current difference can determine whether to produce island.

Schematic flow diagram of islanding detection technology is as follow:

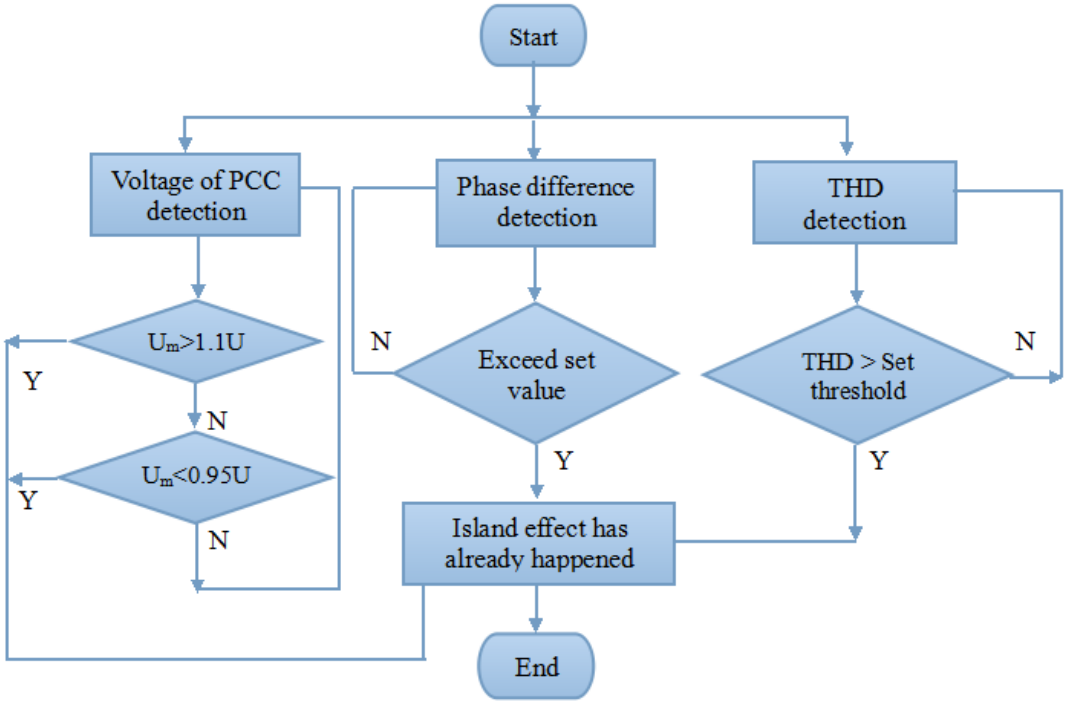

Figure 4. Island Comprehensive Detection Technology Principle Chart

Described as islanding detection principle that, first of all, the comprehensive islanding detection method to detect three cases.

①Voltage PCC is detected, which to determine whether U_m in the appropriate interval. If U_m is not in the appropriate range is the islanding, the converse is not the islanding.

②The phase difference is detected, so as to judge whether the phase difference exceeds the set value. If the phase difference exceeds the set value has occurred the island, but the reverse is not the islanding.

③THD is detected, so as to judge whether the THD is greater than the set threshold value. If THD is greater than the set threshold value is the islanding, the converse is not the islanding.

6. Conclusion

Through the demonstration and analysis above can obtain that the comprehensive islanding detection method synthesizes the advantages of local detection technology and remote detection technology. The technology overcomes the local detection technology has the disadvantages of non detection zone. At the same time, comprehensive islanding detection also make up the remote island detection technology is too single and the disadvantage of large investment. Comprehensive islanding detection method does not influence the quality of electric energy; There are good economic feasibility; More flexible, easy to adapt to the change of system expansion and network topology, which can adapt to the future development of smart grid.

However, to achieve comprehensive islanding detection method is also facing many problems. For example, this paper only discusses DG islanding detection method, and does not involve the problem of control strategy of the DG grid connected and islanding.

It is gratifying to some extent these problems can be solved but has not reached the ideal state. Therefore, in the field of islanding detection, the prospects of comprehensive detection technology development and application are very good.

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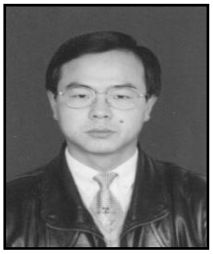

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