Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 05, May-2019

Islanding Detection of the Photovoltaic Grid Connected System

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***Abstract*:-The photovoltaic grid-connected system is rapidly developed and applied due to the cleaning, renewable and wide distribution of solar. This paper is to solve the problem about islanding detection brought by the photovoltaic grid-connected generation system. Therefore, it analyses the reason happened and potential hazards of the Islanding problem and introduces the existing detection method for islanding detection. Due to insufficiency of the existing method, it put forward a new solution that combined the negative sequence voltage positive feedback voltage with active power positive feedback to the islanding detection. The amount of change of the frequency and the voltage is introduced to the voltage - active power positive feedback, which can effectively and fast detect the island.Islanding occurs in wide area. Therefore, this paper is the overview of the islanding detection methods. There are local methods such as active method and passive. But in future there is the scope of hybrid methods and remote methods. Hybrid method means a combination of active as well as passive method. Remote methods is the communication based methods.**

Keywords: Photovoltaic; islanding detection; active; passive

I. INTRODUCTION

In our country, the solar energy is widely distributed, which is expected to ease the power shortage situation. But a large number of photovoltaic power generation devices are injured to the grid, which will bring a new problem - islanding detection. The island effect is that the photovoltaic grid-connected generation system of user side will be cut itself off from the power grid because fails to detect the change
of state power when the power supply is suddenly stopped because of accident or maintenance, which will form a power supply area with surrounding load without control.
The island effect can cause major hazards

1. The safety of maintenance personnel of power company.
2. The capacity of photovoltaic island power supply system is less than the load capacity, which photovoltaic island power supply system may be easily burn by the overload condition.
3. Resulting in instability of the voltage and frequency.
4. After reclosing action, switch is cut off again, which may cause impact to the photovoltaic grid-connected generation system and other electrical equipment.

Therefore, it is very important to study the islanding detection and there protection measures to eliminate the impact caused by islanding effects.[1]

II. EXISTING ISLANDING DETECTION METHOD

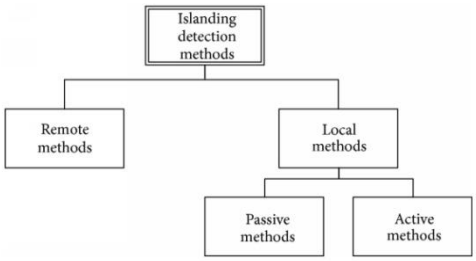

Fig 1 Block diagram of islanding detection methods.

The islanding detection methods are classified into two main parts as shown in fig 1. The remote methods and local methods. The local methods is further sub divided into Passive methods, Active methods and Hybrid methods. And remote methodsare the communication based methods.

A)Passive detection

Passive methods include any system that attempts to detect transient changes on the grid, and use that information as the basis as a probabilistic determination of whether or not the grid has failed, or some other condition has resulted in a temporary change. Passive methods work on measuring system parameters such as variations in voltage, frequency, harmonic distortion, etc. Passive techniques are fast and they don't introduce disturbance in the system but they have a large non detectable zone (NDZ) where they fail to detect the islanding condition.

a)Under/over Voltage and under/over Frequency

When islanding effect happened, the imbalance of active power will cause the change of frequency and the imbalance of reactive power will cause the change of voltage. If the change of frequency and voltage exceeds the threshold value, the over/under voltage and over/under frequency detection device will send alarm and stop the output of inverter or switch to island operation mode. As

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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shown in Fig.2, the load is expressed as RLC equivalent circuit, the impedance of the loadfor[6-8]

When breaker is closed, PV system is parallel running to provide P + jQ power to a point, and the load get active power Pload and reactive power Qload , the power is provided by power grid for:

$$\Delta P = Pload - P$$

$$\Delta Q = Qload - Q$$

It has defect is that the detection method will be failure when the capacity of distributed power supply is match with the capacity of load.

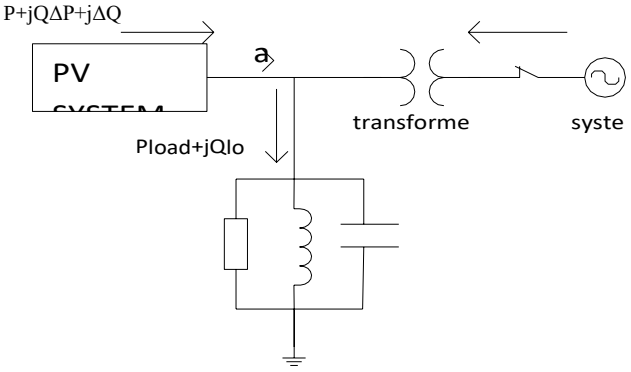

Fig 2 Block diagram of grid-connected PV system

b)Phase mutation detection method

When distributed power supply is connected to the power grid, power factor for 1, the output current, frequency and phase is completely consistent, and the phase difference is zero between the output voltage and current. When the powers supply loss, the load will be supplied by photovoltaic grid-connected generation system.

At the same time, the phase of the voltage and current depends on the load.Phase mutation detection method is simple and can be realized easily. Butwhen the load impedance angle is close to zero, it will be failure due to the limitation of the set threshold value.[6]

c)Harmonic detect

When distributed power supply is connected to the power grid, because the resistance is small in the big power grid, the total harmonic distortion rate is very low at a point. When the island formed, the output current of inverter will flow into the load, because the load impedance is more than the internal resistance of the big power grid, which will produce great harmonic voltage. It can detect the harmonic voltage to in judge island form or not at the point of common coupling.[7] It has also defect is that the action threshold value is difficult to determine. It will be failure when the islanding system does not has a distribution transformer or a strong low-connectedness loads or non-linear loads require matching the harmonic current needs injection with the harmonic current output by inverter.

d) Advantages and disadvantages of passive methods

1) ADVANTAGES

- Short detection time
- Do not perturb the system
- Accurate when there is a large mismatch in generation and demand in the islanded system.

2) DISADVANTAGES

- Difficult to detect islanding when the load and generation in the islanded system closely match.
- Special care has to be taken while setting the thresholds.
- If the setting is to aggressive then it could result in nuisance tripping.

B)Active detection

Active islanding detection method is based on the injection of a small disturbance signal to certain parameters at the PCC[13]. The concept of this method is that small disturbance signal will become significant upon entering the islanding mode of operation in order to help the inverter to cease power conversion. Hence, the values of system parameter will be varying during the cessation of power conversion, and by measuring the corresponding system parameters, islanding condition can be detected[11], as shown in Fig.3.

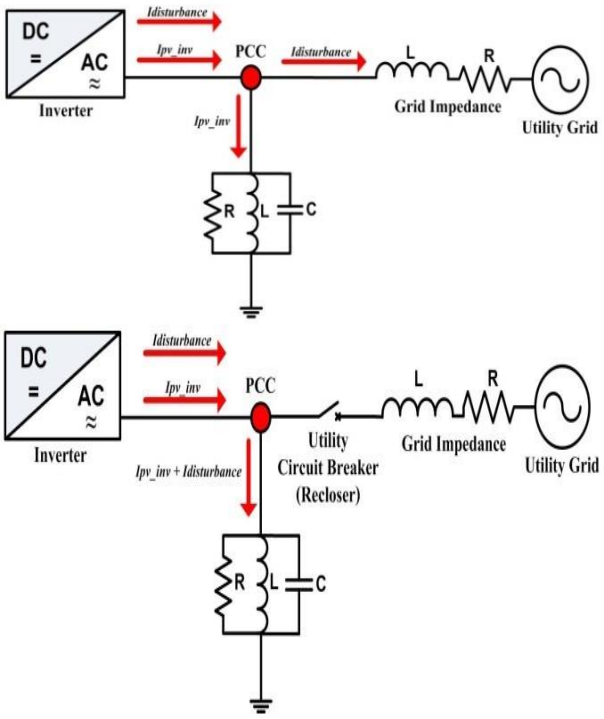

Fig 3 The path of disturbance signals during an islanding condition, (a) before the circuit breaker is opened, (b) after the circuit breaker is opened.

Active methods involve feedback control technique that detects changes in the parameters such as frequency or voltage at the PCC[10]. In the case when the PV inverter behaves as a current source, the current supplied to the utility is expressed by the following equation.

iPV_inv=IPV_inv sin (ωPV+φPV)

(iPV-inv = IPV-inv + Idisturbance), ωPVis the frequency and φPVis phase angle. These three parameters can be

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ISSN: 2278-0181
Vol. 8 Issue 05, May-2019

varied and modified, or can be set as disturbance signals[9].

a)Active frequency drift (AFD)

1.Sandia Frequency Shift

Sandia Frequency Shift (SFS) method, commonly known as Active Frequency Drift with Positive Feedback (AFDPF), is a new method improved from Active Frequency Drift (AFD). SFS using positive feedback by creating a slightly misaligned phase angle at inverter output current through adding truncations or dead times to the current's waveform[14]. Hence, the inverter output current frequency will be forced to a different value than the grid's frequency[15-17]. The chopping frequency expressed in equation is determined to be a function of error in the grid frequency.

$Cf = Cf_o + K(f_a - f_{line})$

Where Cf_0 is the chopping, K is an accelerating gain, fa is the measured frequency of V_{PCC}, and f_{line} is the line frequency.

When the utility grid is connected, Cf is low because the utility grid will stabilize the V_{PCC} by providing a solid phase and frequency reference. Once the utility grid is disconnected, phase error arise between V_{PCC} and $i_{PV\text{-}inv}$waveforms[13]. This causes the PV inverter to increase the frequency of $i_{PV\text{-}inv}$ in order to eliminate the phase error. The voltage response of load again has its zero crossing advanced in time with respect to where it was expected to be, at which times the PV inverter still detects a phase error and keep increases its frequency[9]. This results in increase in the value of Cf, until the frequency has drifted far enough from ω_0 to be detected by the OFP/UFP, and finally stops inverter operation.

2.Sandia Voltage Shift

Sandia Voltage Shift (SVS) uses positive feedback technique to prevent islanding based on amplitude of voltage at PCC. When the utility grid is connected, there will be very small or no effect on the power of the system. But once the utility is disconnected, there is reduction in V_{PCC}. According to load impedance's relationship, this reduction will continue and as a result, current and power output reduces. Therefore, this reduction in amplitude of V_{PCC} can be detected by UVP. It is possible either to increase or decrease the power output of the inverter, leading to corresponding OVP/UVP to trip and stops inverter operation[9,13,18].

b)Reactive power export error detection

As for the inverter which can export both active and reactive power, to detect the reactive power demand of load at all times. The DG generates a level of reactive power flow to break the balance of reactive power. This power flow can only be
maintained when the grid is connected. Islanding can be detected if the level of reactive power flow is not maintained at the set value. The drawbacks of this method are the control measurement is complex and the existence of nonlinear load will cause large voltage harmonic of grid which will makes the action threshold hard to determine.[8] With active methods, islanding can be detected even under the match of generation and load, which is not possible in case of the passive detection methods. Active methods directly interact with the power system operation by introducing perturbations. However, these methods are not suitable for in the system where DG has to generate power at unity power factor because of the asynchronous disturbance.

c)ADVANTAGES AND DISADVANTAGES OF ACTIVE METHODS

1) ADVANTAGES

- Can detect islanding even in a perfect match between generation and demand in the islanded system.

2) DISADVANTAGES

- Introduce perturbation in the system.
- Detection time is slow as a result of extra time needed to see the system response for perturbation.
- Perturbation often degrades the power quantity and significant enough, it may degrade the system stability even when connected to the grid.

C)Communication based islanding detection method

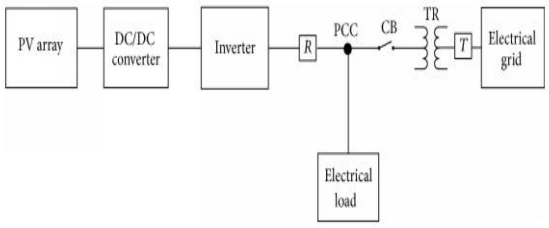

Fig 4General structure of communication based methods

Communication based methods have the best performance, compared to the passive and active methods; because of these methods all circuit breakers are monitored by the control system. Installing sensors and telecommunication devices to the system makes these methods have high system and operating cost. Therefore, communication based methods are generally used in high powered systems having critical loads so power quality does not change and the system is
stable. In addition, these methods are used for the system cost is not important, compared to power quality of the system[18].

a)SCADA based method

It uses placement of voltage sensors at the location where DG is connected and integration of those sensors in the SCADA system for monitoring and alarming the PV system to disconnect in case of islanding. With an increasing number of DGs connected to the grid, real time monitoring of voltage for each generator in distribution grid can be cumbersome process.

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b)WAMS based method

Wide Area Measurement System (WAMS) uses measurement devices for the measurement of the grid parameters like voltage, frequency, and etc. WAMS is specifically built for the monitoring of the power system network and it overcome the drawback of the slow processing time of SCADA system. Its mode of communication is through Global Positioning System (GPS) so their processing time is in micro seconds. It uses mainly two devices for the process Phasor measurement unit (PMU) and Frequency network (FNET).[19-21]

c)ADVANTAGES AND DISADVANTAGES OF REMOTE METHODS

1) ADVANTAGES

- Highly reliable

2) DISADVANTAGES

- Expensive to implement especially for small systems.

D) Hybrid method

Hybrid methods employ both the active and passive detection techniques. The active technique is implemented only when the islanding is suspected by the passive technique.

Hybrid methods are the newly proposed methods in which the combination of active method and passive methods are used. Due to disadvantage of communication based method for small systems. Therefore this methods is introduced. Some of the hybrid techniques are discussed as follows:

a) Technique based on positive feedback (PF) and voltage imbalance (VU):

This islanding detection technique uses the PF (active technique) and VU (passive technique). The main idea is to monitor the three-phase voltages continuously to determinate VU which is given as

$$Vu = \frac{v+sq}{v-sq}$$

V+Sq and V-Sq are the positive and negative sequence voltages, respectively. Voltage spikes will be observed for load change, islanding, switching action, etc. Whenever a VU spike is above the set value, frequency set point of the DG is changed. The system frequency will change if the system is islanded.[21]

b) Average rate of voltage change with Real Power Shift

Most of the DGs around the world are required to operate at unity power factor. There will be deficiency of reactive power once the islanding condition occurs and capacitor banks are the sole source of reactive power in the islanding condition as the DGs operating at unity power factor. The amount of reactive power they produce is a function of the voltage and once the voltage changes, as a result of islanding, the reactive power generated by the capacitor bank will also change, which will further change the voltage.[22]

c) ADVANTAGES AND DISADVANTAGES OF HYBRID METHODS

1) ADVANTAGES

- Have small NON DETECTION ZONE.
- Perturbation is introduced only when islanding is suspected.

2) DISADVANTAGES

- Islanding detection time is prolonged as both passive and active methods is implemented.

III. COMPARISON OF DIFFERENT ISLANDING METHODS

Passive methods are the basic protection packages of every distributed generator connected to utility grid. They are easy to implement and grid friendly. Protection settings for these methods are done in the relay by changing their threshold values.

In last decade, Active methods are used for detecting islanding due to their less detection zone than the passive methods and less cost than communication method. But the Active methods have main drawback of intentionally injecting disturbances in the system and make it unstable and reduce power quality of the power system.

Communication based method are the future used method in respect to the cost compatibility as the power system is growing toward the intelligent system and called as Smart grid.

Hybrid methods are the best alternatives for the compensation of drawback existing in the following methods. They are the combination of two methods and it will be cost effective than communication based methods.

IV CONCLUSION

From this paper we have studied the different islanding detection methods in Photovoltaic grid connected generation system. And we have come to know that which islanding method is used in future. We have studied new islanding detection method which can be largely used in future is communication based methods.We compare the different islanding methods and seen how the methods are changing with time. And also we have seen the basic structures of all the islanding detection methods.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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