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Fault Effect Analysis and Frequency Deviation Detection in Smart Solar Connected Grid

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Abstract- Grid are integrated with distributed energy resources provide many benefits, including high power quality, energy efficiency and low carbon emissions, to the power grid. Grids are operated either in grid-connected or island modes running on different strategies. However, one of the major technical issues in a grid is unintentional islanding, where failure to trip the grid may lead to serious consequences in terms of protection, security, voltage and frequency stability, and safety. Therefore, fast and efficient islanding detection is necessary for reliable grid operations. This paper provides an Analysis of grid islanding detection method, which are classified as local and remote.

Keywords- Photovoltaic; islanding detection; active; passive.

I. INTRODUCTION

In the recent years, renewable energy sources (RESs) have been widely exploited in electrical power systems to mitigate global warming and its hazardous effects. Among all existing technologies, grid-connected photovoltaic system (GCPVS) is gaining prominence due to its various benefits for users and distribution system operators. On the user side, the simple operation, the reduction of the energy trading with the main grid, and its competitive installation costs are the main advantages [1]. From the grid side, the stronger points are efficiency and reliability reinforcement [2].

Similar to other distributed generations (DGs), the interconnection of GCPVSs pose several challenges to the distribution networks (DNs), such as the unintentional islanding operation. This hazardous situation takes place when a microgrid containing both DG(s) and local load is disconnected from the upstream grid by opening the circuit breaker (CB) at the point of common coupling (PCC), as shown in Figure 1 [3-5]. This undesired situation may include power quality (PQ) disturbances such as frequency and voltage deviations, a safety hazard for the network personnel as it is assumed the islanded area is being de-energised, unexpected changes in the fault current level as a consequence of the shift in the earthing system and a damaging effect on electrical machines and transformers due to the out-of-phase reclosing [6]. Considering these aforementioned drawbacks, preventing such conditions and keeping the grid operating safely becomes mandatory. In this context, IEEE Std. 1547–2018 and UL 1741 propose a procedure to be followed in the islanding operating mode and suggest a maximum time of 2 s for ceasing/controlling the DG generation [7, 8]. A common option for constructing a power plant GCPVS is to deploy numerous series of multi-string inverters in parallel, e.g., typically within the range of 50–200 kW nominal output power). Therefore, an effective islanding protection should also tackle the effects of such a practical scenario.

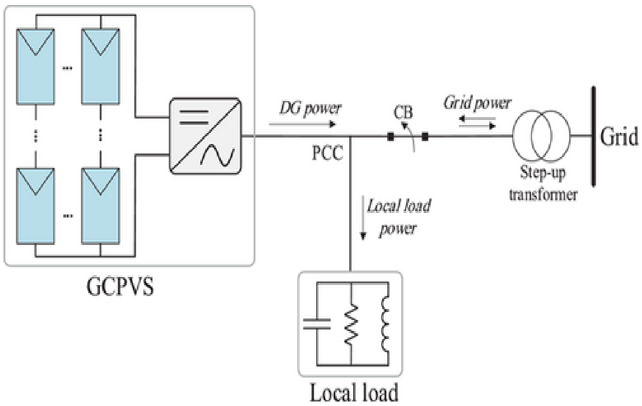

Fig.1 Open in figure viewerPowerPoint

Typical scheme of a GCPVS with parallel RLC loadSeveral islanding detection methods (IDMs) have been presented in the literature, categorised into four main groups: communication-based, passive, active, and hybrid methods [3-5]. The first type relies basically on broadband technologies such as optic-fibre and power line communications for establishing direct communication between the CB of the substation-feeder and the CB located at the DG interconnection bus. Albeit several communication protocols can be established, the islanding mode is normally identified quickly after the operation of the CB between the upstream grid and DG(s) path [9-13]. Although these schemes are known as the most reliable islanding classifiers for both inverter- and synchronous-based technologies, the expensive structure limits its practical implementation in small-scale DGs such as residential GCPVSs [14].

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Passive algorithms use the local measurements acquired at the PCC. In the traditional passive IDMs, time-domain variables are continuously measured and compared to a pre-set threshold [15, 16]. After the island formation, as the main grid is no longer dictating both voltage and frequency, the variables are shifted into a new state according to the mismatch between generation and load. In most cases, this mismatch is large enough for the timeliness shifting of the mentioned state variables beyond the pre-set thresholds. Nevertheless, the worst scenario occurs when negligible power flows to/from the grid and state variables barely deviate from their rated values.

The thresholds of the passive IDMs are thereby assigned eminently small to identify these challenging scenarios. However, this tuning process may cause false operation during some non-islanding events that imply either voltage or frequency deviations, e.g. short-circuit faults, capacitor bank, load/induction motor switching, and transformer energisation. Therefore, optimum thresholds determination is known as the main challenge of the passive IDMs to achieve minimum false tripping in non-islanding incidents and minimum non-detection zone (NDZ), i.e. the cases wherein the employed technique fails to recognise islanding.

Frequency-based [17] and pattern recognition techniques [18] have been recently established to mitigate the NDZ of the traditional time-domain passive-based protection relays. Although these IDMs distinguish islanding and non-islanding states reliably through employing computationally advanced techniques, the high dependency of the threshold settings on the type/size of the DG/network under study is known as their main demerit.

II. ISLANDING DETECTION METHODS

1.Passive Islanding Methods

The passive techniques look for some parameter deviations like voltage magnitude [7], rate of change of frequency [8], harmonics [9], or Phase angle displacement [10]. In the islanding mode, these parameters vary largely at the PCC. The difference between the grid-connected and islanding mode depends on the setting of the threshold values. A lower setting for the threshold for the permissible disturbances in these quantities may cause nuisance tripping. On the other hand, if the setting is too high, then the protective devices will not respond to the islanding condition. The merits of these methods are the fast response and the absence of system disturbances. However, these methods have the disadvantage of having a large non-detectable zone (NDZ) and these protective methodologies might have variable or unpredictable reaction times. More specific passive anti-islanding methods can be discussed as follows:

2.Under/over Voltage and under/over Frequency

Under/over frequency protection techniques (UOF) and under/over voltage protection techniques (UOV) are required for all grid-connected PV inverters. These UOF/UOV protective devices are used as anti-islanding detection techniques and also used to protect the equipment of customers. In Fig 2, the system configuration of a PV inverter that is connected to a variable load is shown. When the PV-inverter is connected to the grid, the active and reactive powers ($P_t + jQ_t$) are delivered by the PV. If the PV power rating is lower than the load power, then the power differences (ΔP and ΔQ) will be supplied from the utility grid. In the case of islanding, a mismatch of some parameters as voltage and frequency will occur.

This behavior of this method may vary depending on ΔP and ΔQ. For more details, if ΔP is not equal to zero then the voltage amplitude at PCC will deviate and the islanding will be detected by the UOV protective relay. Similarly, the phase voltage at PCC changes when ΔQ is not equal to zero, causing a frequency deviation. Additionally, the UOF protection relays will then detect these variations and, consequently, islanding will commence. If the power differences are too large, both voltage and frequency exceed the adjusted limits of the UOF/UOV protective devices, which ultimately trips the circuit breaker. In cases of small differences between the load power and the PV output power, this method may not be able to detect islanding due to the large NDZ. An example of NDZ is given in Figure 3; the mismatch regions of the power components are represented by the shaded area where this method cannot detect the islanding events [9,11,12,13,14].

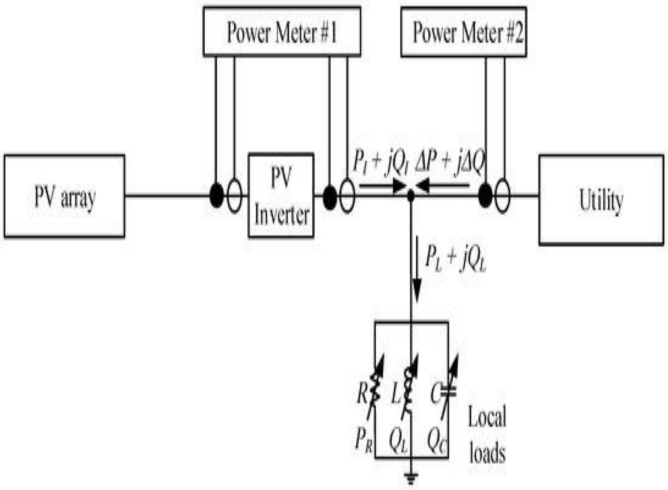

Fig. 2. The test circuit for the islanding detection function in a photovoltaic (PV) power inverter.

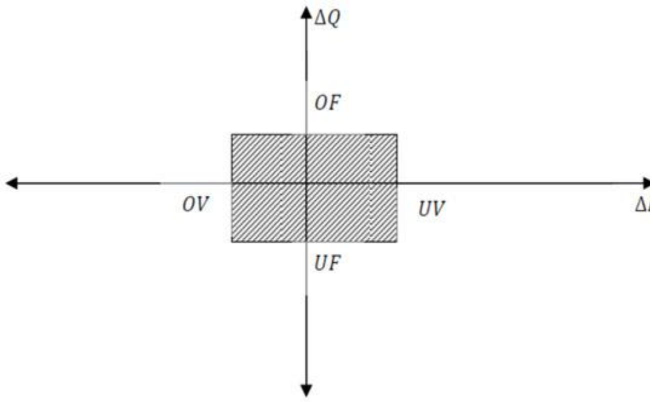

Fig 3. An example of a non-detectable zone (NDZ).

3.Harmonics Detection Method

The Harmonics Detection method concept is based on monitoring the Total Harmonic Distortion (THD) of the PCC voltage to determine whether islanding occurs. In normal operation, the impedance of the power grid is small; the inverter current harmonic component mainly flows into the grid. The PCC voltage is decided by the utility-grid voltage and, usually, the voltage harmonic content is small. When the power supply is disconnected due to the non-linear characteristics, the non-linear load harmonic current flowing into the inverter will also have large harmonics because the non-linearity of the transformer hysteresis output current produces a distortion voltage in the transformer. The islanding conditions can be decided by detecting the harmonic distortion of the output voltage.

This method has several advantages: it is simple, viable, and has a high detection accuracy. It does not influence the power quality and the detection range is wide; the change of the detection effect is not yet investigated under the parallel operation condition of the inverters; the islanding detection during the power match with a load is still very high. The disadvantages of this method are as follows: a large amount of network voltage harmonics due to the non-linear load causes significant limitations and difficulties in practice. This method has an NDZ [15].

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. PROBLEM FORMULATION

Problem identification

- Higher fluctuation on grid connection with PV islanding Phenomenon module.
- Power factor is varies according to load with PV system power generation of grid hence multiple fault achieve in this condition.
- Lower efficiency is main problem on a grid.
- Temperature fluctuation problem with islanding Phenomenon.

In the old method problem, PID controller is reducing the performance of the output power and stability of output voltage. When not apply PID controller the output power is getting 66.45 W. It gets improved when we apply the PID controller and getting the output power is 79.24 W. For further improve the performance of PV system we can apply FACT device, PID both which can further improved the performance of output power. After apply FACT device With PID controller the results of the current, voltages and power get improved. Testing Previous results show that diesel can compensate PV power reduction relatively fast. The proposed method could be used to leveling PV output power fluctuation and reduce the frequency deviations and maintain resilience on the micro grid. “The three test results indicate that diesel generator can compensate for the rise and fall in solar active power in a relatively rapid time (10 to 20 seconds) and maintain the stability of grid frequency”.

V. METHODS FOR DETECTION OF ISLANDING

Islanding detection methods may be divided into four categories: passive inverterresident methods, active inverter-resident methods, active methods not resident in the inverter, and the use of communications between the utility and PV inverter.

- Passive inverter-resident methods rely on the detection of an abnormality in the voltage at the point of common coupling (PCC) between the PV inverter and the utility.
- Active inverter-resident methods use a variety of methods to attempt to cause an abnormal condition in the PCC voltage that can be detected to prevent islanding. 3.

Active methods not resident in the inverter also actively attempt to create an abnormal PCC voltage when the utility is disconnected, but the action is taken on the utility side of the PCC. Communications-based methods involve

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a transmission of data between the inverter or system and utility systems, and the data is used by the PV system to determine when to cease or continue operation.

4. Passive Methods not resident in the inverter such as utility-grade protection hardware for Over/under Frequency and Over/under Voltage protection relaying is the utility fall-back to assure loads are not damaged by out of specification voltage or frequency and may be required for very large PV installations. In this section, we review the existing methods in each of these categories. For each method, we list similar methods with alternate names used in the literature, discuss its theory of operation, strengths, weaknesses, and also the non-detection zone (NDZ) of each method.

The NDZ is the range of local loads (that is, loads inside the potential island) for which the islanding prevention method under consideration can be made to fail to detect islanding. Special attention is given to the behavior of islanding prevention modes in the multiple-inverter case, in which several small PV systems may be operating in a given island instead of one large system. It should be noted that it is usually assumed that the local load (the load inside the potential island) can be modeled as a parallel RLC circuit. This is done because for most islanding prevention methods it is some type of RLC load that causes the most difficulty in detection. In general, nonlinear loads such as harmonic-producing loads or constant-power loads do not present as much difficulty in islanding prevention [1,2].

1.Applicable for standalone microgrid

As mentioned in the last subsection, standards and system operators have emphasised the importance of providing a continuous power supply to the critical loads in the microgrid. Besides fast islanding detection, the frequency and voltage recovery should be conducted to shift smoothly the DGs to the autonomous mode. From this perspective, the employed IDM should cause a sufficient frequency/voltage deviation to identify islanding without destabilizing the GCPVS; thus, it provides both islanding detection and facilitates a seamless transition to standalone mode. Since passive and remote schemes do not inject a disturbance, this part focuses on active and hybrid methodologies.

Most active techniques have been designed to shift a local variable by injecting a periodic disturbance [1]. Therefore, the GCPVS would be destabilised after islanding detection, and its restoration would be infeasible. The transition between grid-connected and autonomous mode would also be time-consuming for a few hybrid IDMs as they attempt to drive a local variable outside the standard range in suspicious islanding events. For example, the MPPT disturbance injection forces the PCC voltage beyond the minimum standard set [2]. Still, most hybrid techniques are designed to slightly change the system conditions of the microgrid/GCPVS for islanding detection without destabilizing the islanded area [8]. For example, a slight active power output reduction is ordered in refs. [5] and [3] to cause a V_{PCC} drop for identifying the islanding operation yet meeting the voltage grid requirements. Therefore, keeping the PCC voltage within the standard range guarantees a smooth voltage recovery for a successful transition to standalone mode.

2.Power quality degradation

As mentioned above, the main pillar of both active and some hybrid IDMs lies in the injection of a disturbance to the VSI, which in turn undermines the PQ of the grid. In AFD and SFS, the harmonic current is injected to drift frequency out of the established IDM thresholds. This disturbance current has been limited to a given setpoint to meet the PQ standard requirements. A harmonic current is used in the IM to detect islanding through the measured harmonic voltage. In this scheme, islanding can be identified taking advantage of a smaller harmonic current than AFD and SFS. This concern has been fixed in the recent voltage-based active and hybrid IDMs, as presented. In these techniques, rather than harnessing frequency or current angle, the current amplitude of the fundamental frequency would be modified for islanding detection purposes. For instance, it is revealed that for a given 1 kW grid-connected photovoltaic system GCPVS, the THD and harmonic spectra of the output current in VPF and modified sliding mode controller meets the IEEE Std. 1547–2018 requirements [7] for a wide range of disturbance sizes and operating points [4].

VII. RESULT AND SIMULATION

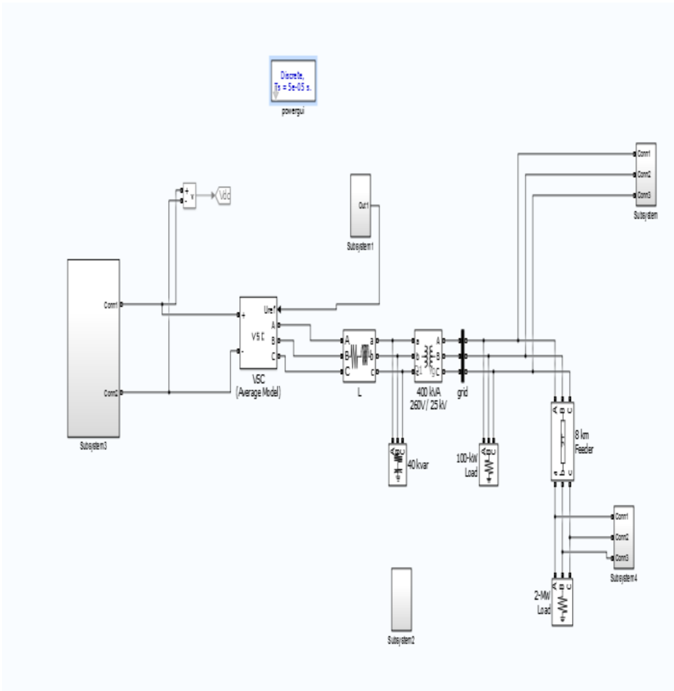

Fig.4 Solar power generation.

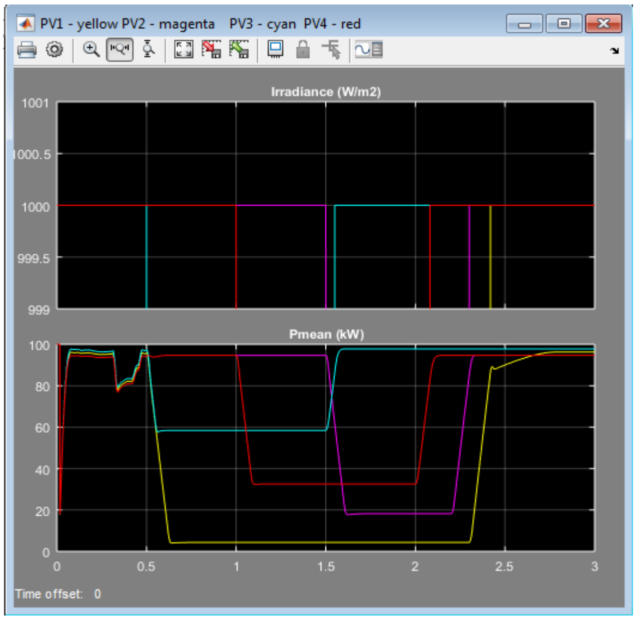

Fig.5 Inputs and Power mean values.

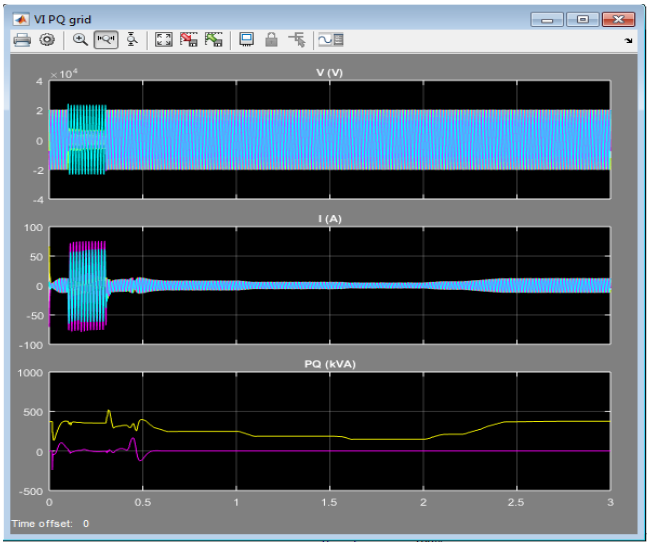

Fig.6 Voltage, current and power curves.

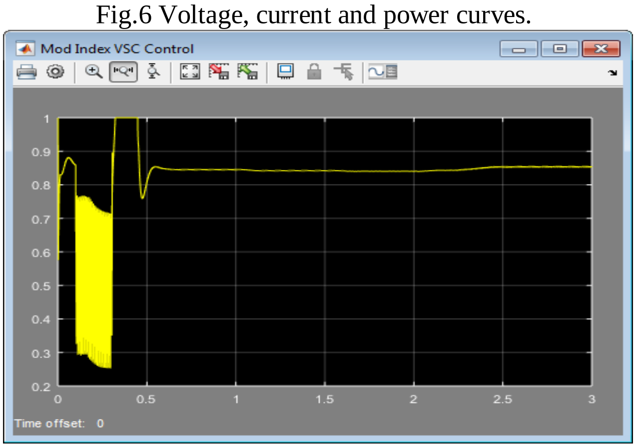

Fig.7 VSC Mod Index.

VIII. CONCLUSION AND FUTURE SCOPE

Conclusions

This paper introduced and analyzed several recent islanding detection methods for gridconnected PV systems. According to the discussion, the research trend of anti-islanding is mainly divided into passive methods, which are based on the measurement of system parameters such as voltage and frequency. Additionally, the active methods which are based on making disturbances on the inverter output voltage or current. As a conclusion of the comparison, the active methods provide faster response, high reliability, and a smaller power degradation. However, the active methods have a large and are difficult to implement as compared with the passive methods. The latter category is simple to implement and has no effect on the output power quality.

However, the passive methods are not trusted for all load conditions as well as it is difficult to set the thresholds due to its large size. In addition, this paper proposes a new perturbation current signal based on the islanding detection of a threephase PV. The injected signal results in a terminal voltage deviation when islanding occurs. However, the rigid grid voltage prevents the changes of the inverter output voltage magnitude during the connection mode.

The proposed islanding detection algorithm was simulated under various load conditions and the simulation results show that the islanding detection time was about 0.1 s, which is very much faster than the required detection time of 2 s. In this Report, an improved frequency drift islanding detection method is proposed, in which a current waveform approximates to cosine is injected to the original reference to reduce the gridinjected current. The Voltage values of the critical parameters. The response time is achieved below one cycle, which enhances the safety of distributed generation. Furthermore the Solar PV module was perfectly modeled as per commercial availability and the FACT Device technique proved to be robust even under drastic climatic changes. The prototype model of the anti-islanding detection system was found to be adoptable in any of the distributed generation facility.

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