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On Remote Anti-Islanding Detection Techniques

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SUMMARY

The main challenge of the interconnection between Distributed generation (DG) and utility grid is how to Detect and prevent the problem of Islanding. There are a lot of Standards that are used for organizing the relation between DG Resources with Electric Power Systems (EPS), like IEEE 1547, that ensure that islanding must be detected and removed within 2 seconds since it is occurred. It is important to Prevent Islanding to have generator and consumer equipment protection, power system stability and safety.

Islanding detection is the important issue of power system protection. Variation of several methods for islanding detection can help us to have the best results for detection according to the international and national standards that are used for detecting and island condition. These methods can be generally divided into two types: local detection and remote detection.

A remote method is used for islanding detection on the utility side, whereas a local method is used for islanding detection on the DG side. Local methods are classified in two main categories: passive and active.

Passive methods are based on grid parameters calculations that are easy for implementation but it's main drawbacks is having a large Non-Detection Zone (NDZ). Active methods, that are commonly used at these days, are preferred over passive methods in the point of NDZ as it is reduced in first one, but some drawbacks were predicted as we can face some problems in power quality.
Remote methods such as the communication-based methods, are used nowadays because NDZ at this method is nearly zero.

Our mainly purpose for this paper is focusing on Remote islanding detection methods based on communications-assisted detection. That has some advantages over active and passive detection methods.
There are more types of communications-assisted detection. This paper discusses these types and the advantages and disadvantages of each one.

KEYWORDS- *Anti-Islanding, Phase Comparison, communications, Remote Islanding.*

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INRRODUCTION

In Recent days, there is a rapid development in Distributed Generation (DG) power sources as solar energy, wind energy, fuel cell and etc. [1-2]. Tying the Grid utility with Photovoltaic (PV) systems or any kind of DG sources have some restrictions as it must guarantee safe interaction, providing the reliability of the grid, high power quality between DG and the utility system.
The most important issue for these restrictions is islanding, that mean an isolated sector of the utility grid from the rest of the utility system, which have both load and generation, and still feeding power to the load from DG sources after disconnecting electrical grid from the load [3-4].
Islanding phenomena could occur as a result of these conditions:

1. Human error.
2. Utility switching of the distribution system and loads
3. Failure of Any equipment of the utility will lead to Accidental disconnection and is not detected by the PV inverter or any protection devices.

All these reasons are classified as unintentional islanding that happened without interference of the human, but may cause damaging to the grid due to losing the synchronization of the electrical grid by creating the significant difference in the stability of power system [5].

The other type of islanding is the Intentional one that means a force disconnection of feeding power from the utility side due to a planned action organized by the grid authorized people, so it is not harmful to the power system [6] but There is a hazard situation for these authorized people during work in the maintenance of the system. As They cannot realize that DG continuously provides power to the island portion of the system, and this situation is not a safe to them and may lead to death [7-8].

The islanding phenomena lead to harmful results for both the Grid system and the DG, so this phenomenon must be prevented when it happens. The frequency and voltage of the grid are not stable in an islanding situation and being out of the ranges from the desired grid reference and this condition may cause damage to the electrical equipment of the system in an islanded DG section [9].
Hence, a lot of standards as IEEE standard ensures that islanding detection [10-11] is needed to be completed as soon as possible. Consequently, as shown in figure (1), any Distributed Generations as solar, wind and etc. must be disconnected using a circuit breaker (CB) from the local load as this CB is triggered by a generated control signal because of these restrictions [12,13].

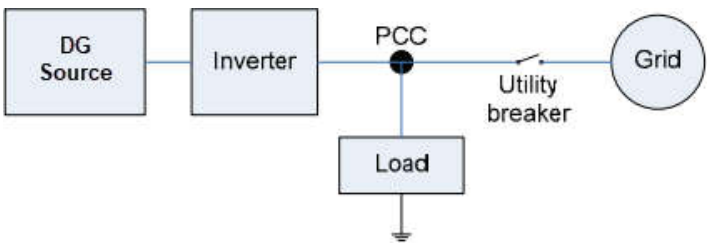

Figure 1. Configuration of the proposed system

ISLANDING DETECTION AND PREVENTION CALSSIFICATION

Recently, many developments for islanding detection techniques can be found in the literature [14–16]. These islanding methods are classified into two main methods called as local and remote detection methods as shown in figure (2).

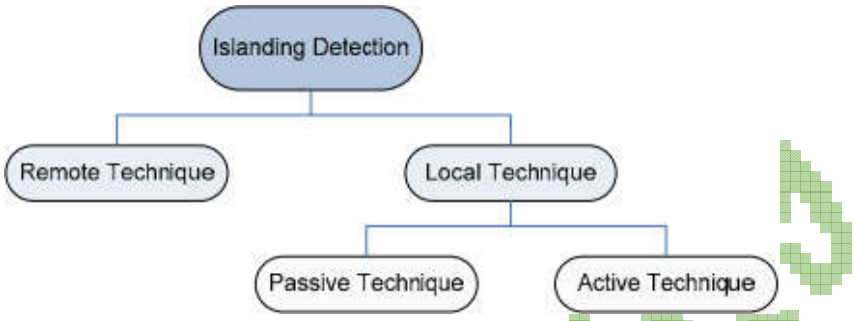

Figure 2. Islanding detection Classification techniques

A. Local Techniques

Local methods used to detect the islanding phenomena with a data available for only the generator station and no need for any external coordination. The benefit of these methods are simplifying installation, easy for maintenance and minimal amount of equipment is required. Types of these Local detection methods can be classified into: passive and active.

1) Passive Methods

Passive local methods use the measurements of current and voltage collected from the generator station to detect islanding state. Under/Over Frequency (UOF)and voltage relays are almost used for this purpose. When the load requirement of power is expected to be larger than the available generation of an island, these methods have a good result for detection the islanding phenomena as the frequency and voltage will not be stable in these states.

When the load and the generation are nearly matched, frequency and voltage will be more stable and the drawbacks of these passive methods will be appeared as it is not able to trigger when desired. This is called (NDZ). In order to reduce it, sensitivity of passive methods must be increased in order to detect the island condition [17-18]. So we can conclude that, if passive methods are to be used, minimum loads that required for the utilities must be greater than available distributed generation (DG) levels.

2) Active Methods

Active local methods are the same as passive in that they only require equipment at the generator station (they are local).

Active methods still repeatedly test the system and observe the feedback response to these tests for detect islanding.This testing summarized of injecting perturbations into the system and checking their response.

If the feedback values exceed a set threshold, islanding is detected. If the generation and the load are more closely matched Active methods would be better than passive methods [17]. Although active methods can be successful, to maintain a certain NDZ, it has bad effect on power quality of the overall system that push us to work with remote methods despite it is very expensive.

B. Remote Islanding Detection Techniques

These Islanding Detection techniques mainly depend on communication between the utility grid and any type of DGs. Based on the relation between the utility receiver status, and the whole circuit breakers(CB) in the line leading to the DG transmitters, Islanding can be detected.

In case of islanding, a signal is sent to trip the DG depends on monitoring the status of CB. Although these methods may have no non detection zone and high reliability, they are too much expensive to be implemented.

In the past, only utility owned made from public telephone companies but, nowadays radio transmitting (AM or FM) and optic fibers can be added to the list [19-20]. All types of these Remote techniques can be listed as follows:

Impedance Insertion

As in Figure 3 The Schematic of this method is presented. This method inserts a low impedance load, usually a bank of capacitors, that is connected to point B when the utility breaker normally open. The normally open switch which connects the capacitor will be closed after a delay. If the local load is balanced, islanding will occur before the capacitor is connected. Upon the capacitor connection, there would be unbalance and the inverter will shut down. The capacitor will cause a change in frequency and current phase. As This disturbance occurred by a phase change and a sudden change of the resonance frequency which can be detected using the Over/Under Frequency (OUF) limits.

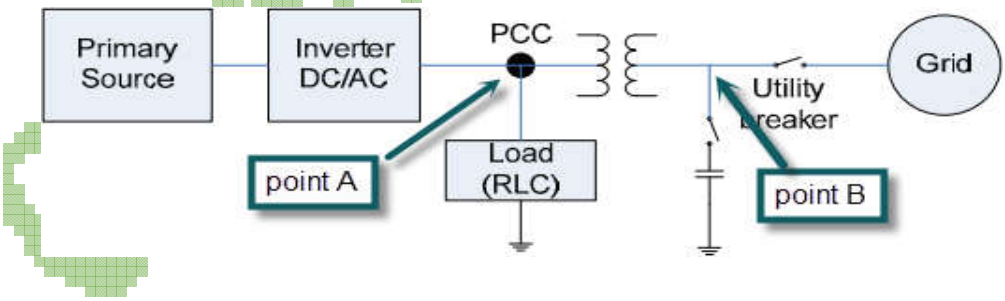

Figure 3. Impedance insertion technique

The advantage of these method, it has no NDZs exist, properly implemented if the delay is small enough it is very effective, As mentioned before, these capacitors are used in most utilities and If the capacitor is already connected, it can simply be disconnected to prevent islanding.

There are some main disadvantages that additional capacitor banks may be needed in most cases, can be expensive, if multiple units are installed at varying times, who should carry the costs of the additional capacitors first, the operation timing of this method is also much longer than that of most of the rest methods. This can lead to equipment damage and the failure to meet certain network compliances, and it may require equipment to be installed on the grid side of the PCC, which can require additional permits and costs [21].

Phasor Measurement Units (PMU)

It is known as a Synchrophasor, and rate of change of frequency (ROCOF). It is required A time synchronization source for PMU. That might directly have supplied from a time broadcast such as local clock using a standard code or from GPS. The system consists of two units, one on the utility substation and the other one at DG and time is stamped before sending to the receiver.
So, it is very easy to determine that DG is synchronized with the grid or not [22-23].

Power Line Carrier Communications (PLCC)

As in Figure 4 The Schematic of this method is presented. This method is relying on the use of the power line as a communication channel. The basic idea is transmitting a low-energy signal continuously between the transmitter (T) founded in the grid side and receiver (R) founded in the DG side.
When this communication is failure, the receiver sends a stopping signal to the inverter and/or a switch (included in the receiver) should be opened for isolating the load from the DG [24-28].
the advantages of the technique are: The output power quality of the inverter is not decreased, Ability to act in areas with high density of Distributed Generation, It does not have an NDZ and doesn't depend on the system size. Some of the disadvantages of this method are : the receiver and transmitter cost may be too high. , it requires multiple signal generators and this has a high cost in comparison with a simple radial system and under abnormal conditions it has NDZ if some loads are operating .

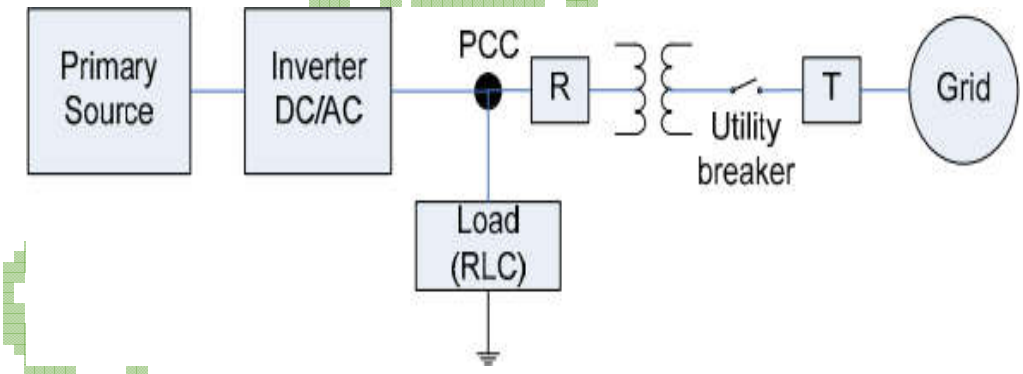

Figure 4. Power Line Carrier Communications Technique

Signal Produced by Disconnect(SPD)

As in Figure 5 The Schematic of this method is presented. This method is similar to the PLCC-based method. The SPD method is based on communication between the inverters and the network for avoiding Islanding. Type of transmission used is The main difference between SPD method and the PLCC-based method as optical fiber, telephone link and microwave link are the types used for SPD. So the state of the switch is almost known by the inverter.
The advantages of this method is the additional supervision and control of both the DG and the grid and it doesn't have NDZ. Unfortunately, this method presents the great disadvantage as every DG connected to the network lead to extra cost. Besides, increment of the communication

wiring and setup communication protocols must be configured in case of telephone communication. And to avoid This problem, radio-frequency communications, must be covered up to cover huge distances, so repeaters can be used, and the range of working frequencies aimed to be established [29-30].

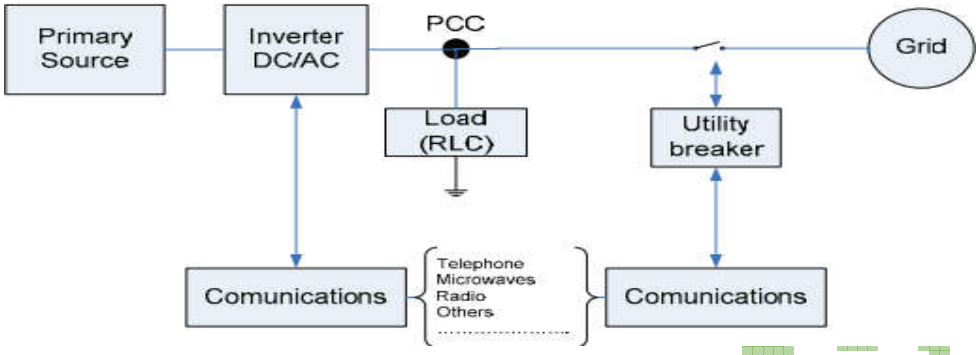

Figure 5. Signal produced by disconnect Technique

Comparison of Rate of Change of Frequency (COROCOF)

This method mainly based on the comparison of the variations in frequency at two different locations in the grid. The receiving relay of COROCOF is the relay located on a generator set that can detect the type of disturbance if local disturbance or disturbance due to the blocking signal from COROCOF sending relay [31].

Supervisory Control and Data Acquisition System (SCADA)

The SCADA system keeps monitoring on the states of circuit breakers. To be sure that the system is in islanded or not, can be known from the information contained in SCADA so it must be sufficient enough. This method collects its data through sensors and communication networks already in normal grid connected mode. If sensors detect any reading, as voltage for example, when the grid is disconnected, a warning system through alarms will be triggered and all the necessary precautions done. We can exercise some control over the inverter If it is connected to the SCADA network, This method has the advantage that allowing a fast response, easing Islanding detection, and eliminating an NDZ.
It has disadvantages that, it gives a slow response in case of the system has one or more disturbances, in the presence of multiple inverters, requiring a large number of sensors and extra features and it is too expensive. Furthermore, it is not applicable in small installations [24].

Transfer Tripping Scheme (TTS)

This method can be applied by using SCADA system as it depends on monitoring the status of all CB and the status of reclosers that may cause island for the distribution system. When a disconnection is detected at the substation, the TTS indicates the islanded area and sends the appropriate signal to DGs according to its detection to either disconnect from the grid or to remain in operation.
advantages of this method, no NDZ in operation as all states of all sensors are sent continuously to the DG from each monitoring point and more simplicity.

The disadvantages are, it requires continuous updating, if the system grows and becomes complex it needed relocation and reconfiguration [32].

CONCLUSION

Unintentional islanding has a lot of harmful results that belongs to power quality issues, safety and equipment damage. Because of these disadvantages, the islanding phenomena must be detected then prevented.

In some cases, there are a complexity for islanding detection, mainly with local detection methods as it isn't reliable when load and generation are nearly matched.

So Remote islanding detection methods considered more effective than local methods as it has the best performance, has nearly zero Non Detection Zone, easy to implement, presents a realistic solution to islanding and is suitable for real system applications in solar-wind DG systems. The contribution of this paper is presenting a detailed classification of these remote methods with explanation of advantages and disadvantages of each method.

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