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A Review on: Evaluating Passive Parameters for Enhanced Islanding Detection in Distributed Generation Systems

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Abstract*: This paper provides an overview of power system islanding and island detection methods. Islanding detection strategies for a distribution system with distributed generation (DG) are roughly classified as remote and local. A remote islanding detection technique detects islanding on the utility side, whereas a local technique detects islanding on the distribution grid side. Local techniques can be further classified into passive, active, and hybrid techniques. The islanding detection strategies for DG are described and analysed.*

Keywords: DG – Diesel Generator.

I. INTRODUCTION

There has been a transition worldwide towards renewable sources of energy, and Distributed Generation (DG) systems are coming up in the electrical grid. These are the systems where the installation of renewable energy will help deliver a sustainable, efficient, and resilient promise of the power supply. Nevertheless, the integration of these systems within the grid infrastructure will bring with it only fresh complexities, more particularly in view of the phenomenon of islanding.

The electric islanding is the situation when any portion of the grid, which is supported by the DG units, becomes electrically isolated from the main power grid due to faults, maintenance, or some other instances of disturbances. This can further lead to isolation without the knowledge of the grid operators and hence can possibly create hazardous conditions, destroy equipment, and reduce the quality of end consumer power. DG units may also expose the maintenance personnel to risk of life since they may inadvertently keep giving power during islanding conditions when work may be done on the line under the assumption it is de-energized.

Therefore, owing to the risks associated with islanding, development of reliable islanding detection becomes of prime importance for the security and stability of the grid as well as the DG systems. Various detection techniques generally fall into three broad categories: active, passive, and hybrid methods. Active methods imply the introduction of perturbations and the analysis of the response of the system, though it is intrusive in relation to the power quality. Differences in passive methods, on the other hand, relay on intrinsic tracking of electrical parameters, such as frequency, voltage, and phase angle. Such parameters are more benign regarding invasiveness of measurement, but they may lead to less reliable methods when applied to balanced loads. This paper discusses the assessment of the passive parameters for the purpose of islanding detection. It attempts to critically analyze the efficacy, raise deep on the challenges in reaching at the right detection, and considering the recent advancements that have been made to improve their performance. This has improved the passive method of islanding detection in order to ensure the smooth and safe operation of DGs within the modern energy landscape, hence creating an environment conducive to their much-required continued growth in the deployment of renewable energies. Islanding occurs when the distributed generation (DG) system is disconnected from feeding a local area or "island", although it remains isolated from a bigger utility grid.

Such disconnection might result from any cause, be it fault or routine grid maintenance. The occurrences of islanding rely on the operational scenarios, from intended separations for grid servicing to unintentional outages due to severe weather. While islanding may be desirable in some cases, for instance, serving in emergencies as a power supply, it can, on the other hand, create safety hazards such as risks to electric shock for utility workers and may in turn cause damage to grid and customer equipment if it occurs unintentionally. There are a lot of DG technologies, which will cause islanding, and which include solar photovoltaics (PV), wind turbines, small-scale hydroelectric generators, and combined heat and power (CHP) plants.

The trend in these technologies is driven by the potential to curtail greenhouse gas emissions, provide energy security, and lower transmission losses by generating power on-site or close to the site of power use. The standards and requirements enable DG systems to be met on the protection of islanding to be mitigated.

This contains standards such as IEEE 1547 in the USA, and similar international requirements on the acceptable performance of DGs for safe grid interconnection, which includes rapid detection and disconnection of the islanded systems. However, detection of islanding is yet to be realized since distributed sources of DG have highly diverse nature that exhibit varied activities usually complex on the electrical grid.

In non-disruption to capture the islanding event, passive detection methods may have a problem for balanced load that results in an islanding event, where islanding is a non-detection event in non-detection zones (NDZs). The disturbances introduced in the system might affect the power quality due to the active techniques being more reliable in the detection of islanding. Key to the continuing research thrust would be development of methods of detection that are sensitive and, importantly, non-intrusive to make its mark on the safe and reliable operation of the grid in the presence of the increasing penetration of distributed generation.

II. METHODOLOGY

The passive islanding detection methods remain crucial regarding the safety and reliability of the distributed generation systems.In essence, the methods are largely based on the monitoring of the natural electrical characteristics within the grid and the absence of active injection of perturbations in the system. Our goal is islanding an islanding event, in the sense that some portion of the network, which contains distributed generation sources, gets disconnected from the main power grid, but still manages to function in isolation. Passive detection approach is based on monitoring the variations in some main electrical parameters. These are the voltage, the frequency, the harmonics, and the phase angle. In addition to the increased frequency and harmful harmonics, voltage also deviates significantly from its nominal value in the islanded mode because regulation by the bigger grid is missing. Similarly, frequency can become unstable when the balance between generation and load is disturbed.

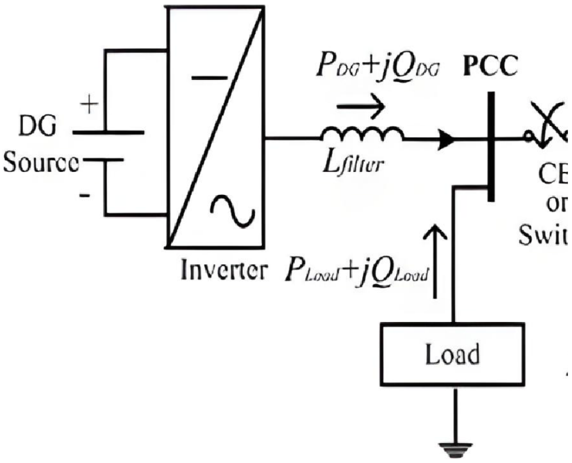

Fig 1. Grid Interactive DG System for Islanding Detection

The possible effects can be raised harmonics that are caused by distorted electric wave forms and phase angle shifts that can indicate that synchronization of the DG with the grid is not being well matched.Each parameter avails a distinct measure of effectiveness for the detection of islanding and corresponds to a different kind of limitation.Voltage and frequency are among the most popular parameters since they are easily available for measurement and usually depict altered conditions during islanding events promptly.However, it may fail in cases where the DG is well synchronized with the load, which causes a non-detection zone (NDZ) where islanding remains undetected.

Harmonics and the phase angle are somewhat more challenging to monitor and analyze but add more to the detection arsenal when changes in voltage and frequency are not clear in changing their characteristics. In comparative analysis, one cannot say one passive parameter is the best for islanding detection in a universal sense, since the system conditions differ, and the existence of NDZs.

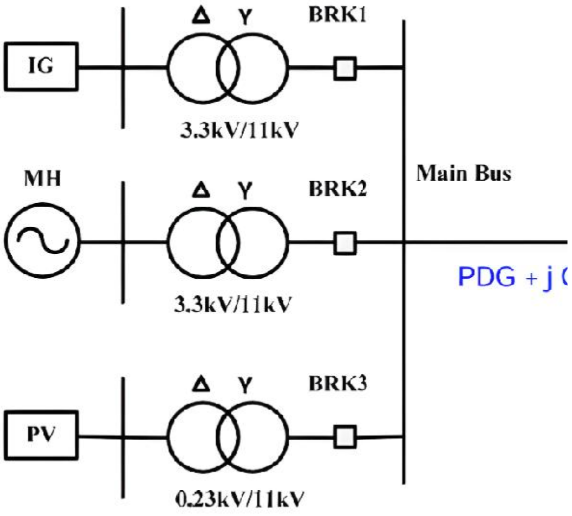

Fig 2. Standard Test System

The combination of these parameters is thus often used to improve the possibility of detection and minimalizing false positive or negative rates. This will therefore exploit the strength of every parameter and at the same time compensate for its individual limitations and weaknesses and as a result, a more reliable and robust islanding detection in the distributed generation systems is then attained.

III. 3.CHALLENGES AND LIMITATIONS OF PASSIVE DETECTION

However, passive islanding detection methods are always preferred because of their non-intrusiveness and simplicity. They come up with many issues and problems, which can hinder their correct detection. One such problem is non-detection zone (NDZ). NDZs refer to states in which the passive detection system cannot differentiate the grid connected state from the islanded state. This is basically when the power produced by the DG is nearly equal to the local load demand with very light margins between the two that therefore produce very minor deviations in voltage and frequency parameters, and the system fails to detect an islanding alert. Load balancing also plays a critical role in the efficacy of passive detection methods.

In cases where the load keeps on changing or it is possible to stabilize the load through the DG, the conventional islanding signatures may be masked, and hence the probability of islanding will go undetected. Therefore, due attention to load prediction and monitoring is a must to minimize NDZs; however, it is practically difficult as power consumption is unpredicted to forecast. Moreover, it would be disallowed to overlook the impact of power quality and grid support features on passive detection accuracy.

Devices of power electronics such as inverters in solar PV systems are the major source of harmonics into the grid, and it can compromise the abilities of passive methods in their detection. The passive methods depend on the indicators of the condition of islanding, which exist in many combinations of the active methods, ranging from voltage regulation to frequency droop control, for instance, in modern inverters. False alarms and missing alarms are the core issues.

A false positive happens when the system incorrectly recognizes an islanding condition, which could result in a disturbing event due to the unnecessary disconnection of the DG from the grid, thus causing disturbances and inefficiencies. On the contrary, the false negative case is presented when there is actually an islanding event, but it is not detected by the system, therefore creating danger conditions and possible damage in the grid infrastructure. Rates of these false detections are influenced by the sensitivity of the passive methods in their essence as well as further settings of the thresholds, adopted in the definition of an islanding event. Sensitivity to islanding balanced with immunity to normal grid variations is a delicate balance needing delicate tuning and often a compromise between the two. In general, it can be said that passive detection methods constitute a core part of islanding detection schemes, and therefore their challenges and limitations need continual research and development for augmented performance as well as for integration with other methods toward an increased degree of safe and reliable operation of distributed generation systems.

IV. RECENT ADVANCES IN PASSIVE ISLANDING DETECTION

Recent improvements in passive islanding detection have been characterized by novel research initiatives aimed at improving the feasibility and application of these methods in distributed generation systems. One major advancement is the use of deep learning techniques, which utilize advanced artificial intelligence, to enhance classification accuracy. These techniques show promise in resolving the issues associated with traditional passive detection by providing a more dynamic and adjustable approach.

Furthermore, there has been a strong emphasis on improving passive characteristics for islanding detection. For example, a thorough literature analysis emphasizes the significance of evaluating numerous passive factors and their roles in providing timely detection while maintaining power quality. This study contributes to a more sophisticated knowledge of how different passive factors can be strategically used for effective island recognition.In addition to parameter improvement, recent investigations have introduced simple yet effective passive detection approaches. One notable example is the implementation of a passive islanding detection system based on the phase angle of positive sequence voltage (PAOPSV). This technique outperforms other factors in terms of sensitivity and accuracy, meeting the demand for dependable islanding identification in a variety of settings.

Practically, these developments have the potential to improve the stability and safety of distributed generation systems. Deep learning approaches improve real-time flexibility, making them appropriate for dynamic grid situations with changing loads and conditions. The refining of passive parameters and the introduction of novel detection algorithms provide solutions that reduce non-detection zones while increasing the overall reliability of islanding detection.

To summarize, recent developments in passive islanding detection not only add to our theoretical understanding of these methods, but they also have practical ramifications by overcoming obstacles and proposing more effective and adaptable techniques. These advancements pave the path for improved islanding detection systems, assuring the resilience and dependability of distributed generation across different energy landscapes.

V. CASE STUDIES

A New Passive Islanding Detection Approach Considering Dynamic Load in Microgrid

Implementation: We proposed a unique passive detection approach for microgrids that considers dynamic load behaviour.

Results: Improved islanding problem resolution in microgrid scenarios.

Reliability: Improved detection of islanding occurrences under dynamic load variations.

Lessons learned: Emphasized the significance of accounting for dynamic load behavior in microgrids for successful islanding identification.

Reinforcement Learning Based Islanding Detection Using Passive Approach

Implementation: We proposed a unique passive detection approach for microgrids that considers dynamic load behaviour.

Results: Improved islanding problem resolution in microgrid scenarios.

Reliability: Improved detection of islanding occurrences under dynamic load variations.

Lessons learned: Emphasized the significance of accounting for dynamic load behavior in microgrids for successful islanding identification.

Passive Islanding Detection in Microgrids Using Artificial Intelligence

Implementation: Using artificial intelligence, we modelled and simulated voltage regulation for passive islanding detections with distributed generation.

Results: Provided information on the use of artificial intelligence for voltage control in passive islanding detection.
Reliability: Improved reliability by utilizing artificial intelligence approaches.
Lessons Learned: Showed the advantages of merging conventional passive approaches with current artificial intelligence for more reliable island spotting.

VI. CONCLUSION

In conclusion, the evaluation of passive characteristics for islanding detection demonstrates their importance in providing stable and accurate methods for detecting islanding events in distributed generating systems. Various studies have shown that passive measures, such as measuring voltage, frequency, and other system parameters, improve the overall effectiveness of islanding detection. These methods, while intrinsically slower, provide a solid foundation for detecting islanding instances, particularly when combined with other active or hybrid approaches. The many case studies and research findings demonstrate the adaptability and applicability of passive islanding detection methods in a variety of system configurations and operating scenarios.

The future of passive islanding detection approaches seems optimistic, with continual developments in signal processing, machine learning algorithms, and integration with other detection methods. The investigation of fresh ways, as indicated by current research, shows that passive methods will continue to evolve, improving their efficiency and usability in various microgrid and distributed generation scenarios. As technology advances and the energy environment changes, passive islanding detection approaches will play an increasingly important role in assuring the stability and safety of distributed energy systems. To develop the subject, future research should focus on improving passive islanding detection algorithms to reduce non-detection zones, increase detection speed, and improve overall accuracy. Furthermore, interdisciplinary cooperation among power systems engineers, data scientists, and control experts may result in creative solutions that overcome the issues associated with passive approaches. Continuous investigation of real-world applications, field trials, and validation studies will yield valuable insights into the practical deployment of passive islanding detection methods, guiding the development of standardized approaches for widespread implementation in distributed generation systems.

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