Review: Different Techniques for Islanding Detection of Distributed Generators in Power System

[1]Sushil M. Sukalkar, [2]Prof. Y. D. Shahakar

[1]Reseach Scholar, [2]Assistant Professor,
[1,2] Electrical Engineering Department,
[1,2] P. R. Pote (Patil) College of Engineering & Management, Amravati.

Abstract : In grid-connected, Distributed Generation Systems, the problem of inadvertent islanding in grid connectivity continues to be a problem (DGS). The purpose of this paper is to provide a basic review of common islanding detection methods. Anti-islanding remains a problem with no apparent solution due to the numerous forms of Distributed Generation (DG) and their magnitude in relation to distribution networks, as well as the risk of out-of-phase reclosing.
This paper is present the general review of different islanding detection techniques for distributed generators in microgrid system like multi-agent distributed neural network based islanding detection, impedance measurement based islanding detection method, Slantlet transform as a signal processing method, NDZ based approach, phase-shifted feed-forward voltage based approach, parallel inductive impedance switching approach, hybrid islanding detection methods and two level islanding detection method. Main concentration of this paper is review of recent islanding detection technique from year 2017 to 2021.

***Index Terms* – Islanding condition, Distributed generator.**

1. INTRODUCTION

There are certain concerns with the current power system using distributed generators (DGs) that have yet to be remedied. One of these challenges is the identification of islanding in a timely and precise manner [1,2]. The number of DGs being introduced into electrical distribution systems is growing all the time, and it is the most difficult notion in current power system scenarios, since DG islanding can lead to a reduction in proficiency, excellence, dependability, and supply quality [3,4]. The notion of Distributed Energy Resources (DER) is evolving from a local to a system-wide concern [5]. The electricity grid gets more difficult when DGs are connected [6]. The grid connection procedure is further assured to be seamless with the deployment of the reference power transition link [7,8].
The fundamental problem that researchers face is not a lack of data, but rather the efficiency with which they use complicated electrical quantities [9]. Unintentional islanding in DGs grid connectivity is still a significant concern in grid-connected systems, as the system may fail to activate the safety devices during the islanded state [10]. As a result, problems with power quality, protection, reverse power flow, and system stability arise. As a result, islanding must be discovered and eradicated as quickly as possible, as recommended by grid regulations. IEEE recommends a maximum response time of 2 seconds in response to islanding detection. This will have to be reflected in future islanding prevention technologies. Safety precautions must be taken to ensure proper functioning of these new DGs in order to avoid uncontrolled and unwanted power injection into the grid, as well as possible equipment and personnel damage.
As a result, a comprehensive investigation is required to resolve this problem. As a result, for a DG-connected grid system, anti-islanding with a quick response time is critical. Researchers offered a number of models to address the issues provided by islanding DGs, including one that deals with the effects of purposeful islanding and clears it as quickly as feasible. Different organisations including as the IEEE, IEA, and IEC created the standards, which were revised on a regular basis to underline the need of islanding detection in a DG linked grid in order for the system to run properly.

2. DIFFERENT TECHNOLOGY FOR ISLANDING DETECTION OF DISTRIBUTED GENERATOR

2.1 Multi-agent Islanding Detection

A new multi-agent distributed neural network based islanding detection technique is given by the author [1]. One of the applications of the suggested algorithm is the planned wide area monitoring, control, and protection system (WAMPAC).
As a result, the proposed WAMPAC structure and its primary components, such as WAMS, WACS, and WAPS, are outlined. These components are meant to have situational awareness in order to conduct both control and protective operations. The multi-agent concept and neural network method are utilised in several WAMPAC control and protection applications to provide rapid and accurate reactions to various situations such as WAMS equipment failures or data transmission lag. The islanding detection application and its algorithms are discussed in depth to demonstrate the usefulness of the developed techniques. The suggested approach is tested on the IEEE-118 bus power system and its performance under various disturbances is proven. It is demonstrated that the need for islanding is properly predicted, allowing for corrective actions such as restricted islanding execution to avoid wide-area blackout.

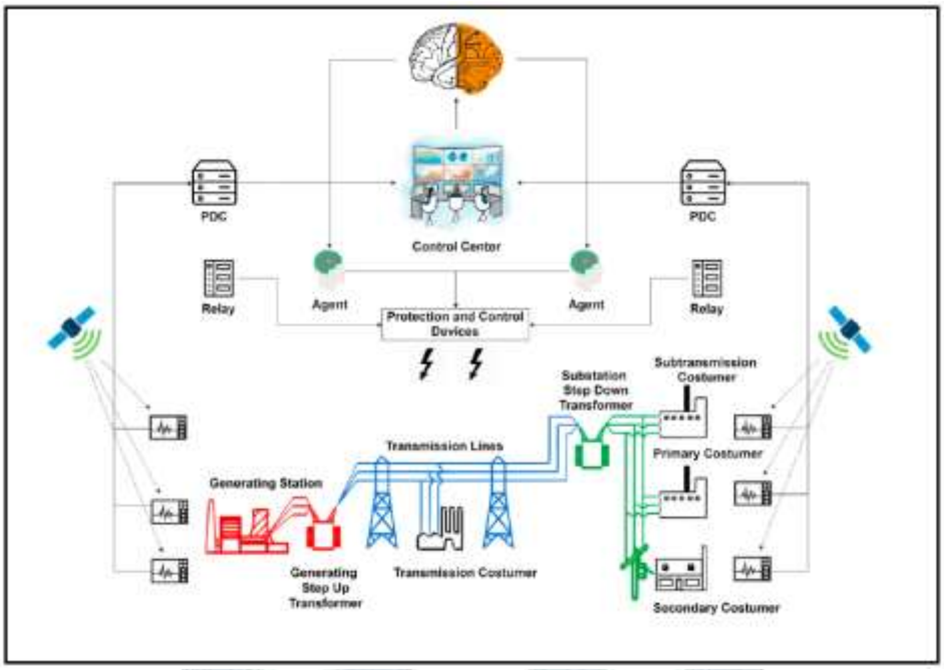

Fig.1. The Multi-agent structure for WAMPAC [1]

It is discussed how the suggested islanding detection application methodology in developed WAMPAC works. To have an adaptive scheme that considers oscillatory characteristics, the algorithm is run in three frames: offline, online, and real-time. The agents are allocated to each of the discovered coherent groups, and real-time stability evaluation is performed via distributed neural network design. The methodology is tested on an IEEE 118-bus test case, and it is demonstrated that the uncontrolled islanding scenario can be anticipated accurately and quickly.

2.2 Impedance islanding detection method

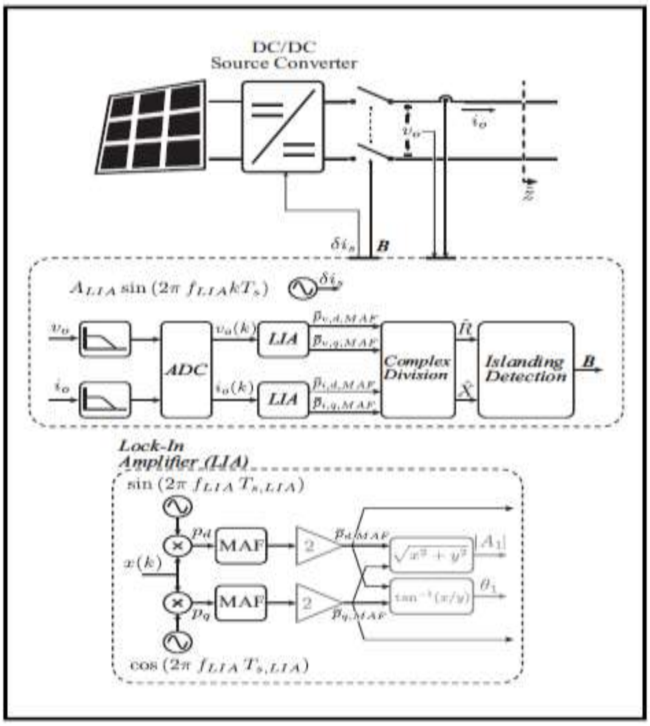

Fig.2. Block diagram of the proposed impedance-based islanding detection method [2]

The identification of islanding in both AC and DC grids is crucial since failing to do so might result in unstable operating points and hazard to the user and equipment. While AC grid islanding has received a lot of attention, DC grid detection approaches are still in their infancy. A line regulating converter interacts with the main grid to regulate voltage by exchanging power with it, while distributed generators, loads, and storage focus on optimising their energy production/consumption profile. The majority of recent islanding detection approaches in DC grids rely on over/under voltage ranges (which fail if the load matches the source during the event) or the injection of ever greater disturbances (which take time and disturb the operating point). A novel impedance-based approach for islanding detection is presented in this paper. A digital Lock-In Amplifier, as well as sensors often found in PV systems, are used to accomplish the approach. This approach, which employs impedance, is capable of promptly detecting and reacting to an islanding event. This approach has the following advantages: 1) low amplitude signal injection; 2) fast detection; and 3) excellent sensitivity.

The suggested approach is based on a digital Lock-In Amplifier, which enables high-accuracy impedance detection with minimal computing, and may be implemented in real-time industrial microcontrollers. Due to a close match between the load and the source converter, the proposed technique permits identification of the islanding event even when voltage-based methods would not be able to identify it. Furthermore, instead of massive perturbations, the suggested technique achieves so by injecting only a very little identification signal into the system. The suggested method's simulation results have been shown, demonstrating its capacity to distinguish the islanding condition from the non-islanded operation event when the load closely matches the converter's output under various types of loads (constant resistance, constant power, constant current, and mixed loads).

2.3 Ridgelet probabilistic neural network based Islanding detection

Finding a good methodology to identify an islanding problem is one of the difficult difficulties for a grid-connected embedded generator. To avoid safety dangers, power quality difficulties, equipment damage, and voltage and frequency instability, the approach must be able to distinguish islanding from other grid disruptions and quickly disconnect distributed generation (DG). The Slantlet transform is proposed as a signal processing approach for extracting the important properties that distinguish islanding from other disturbances in this paper. To categorise islanding and grid disturbances, a ridgelet probabilistic neural network (RPNN) is used. To train the RPNN, a modified differential evolution (MDF) method is suggested, which includes a novel mutation phase, crossover process, and selection mechanism.

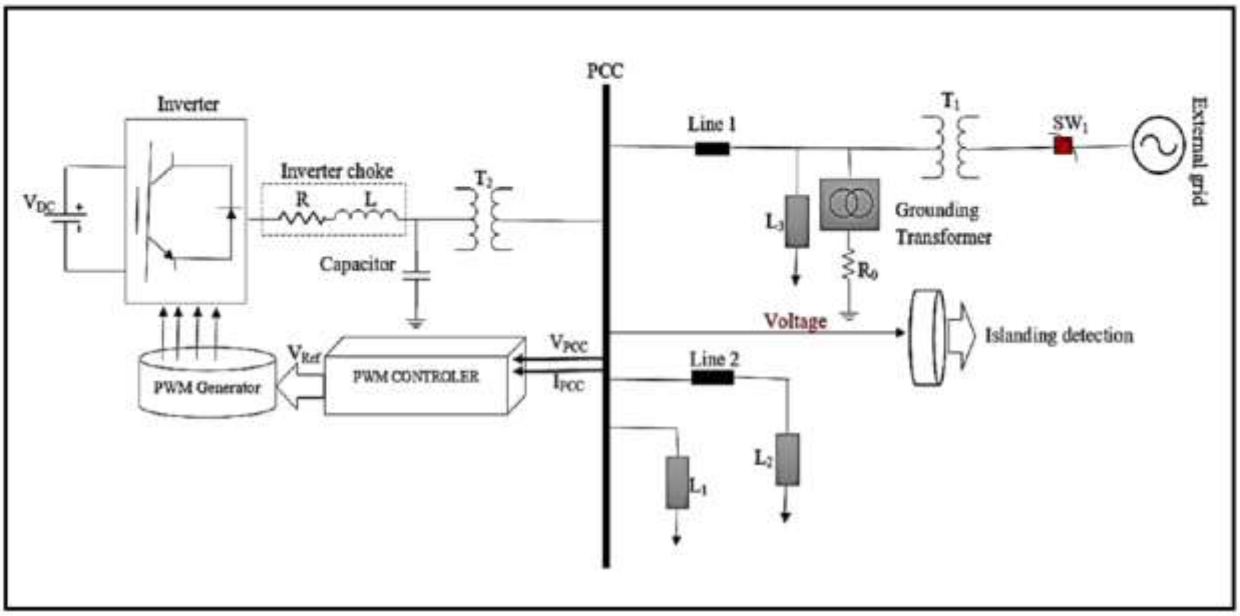

Fig.3. Ridgelet probabilistic neural network based Islanding detection [3]

A Slantlet Transform methodology was developed to extract characteristics of the three phase voltage signals at the point of common coupling (PCC) in order to identify islanding from non-islanding grid interference, according to the author [3]. The approach was compared to a DWT approach using RPNN and PNN as classifiers. Different disturbance signals were used to test the proposed technique, including reactive and active power imbalances in the case of islanding, as well as non-islanding grid disturbance events like voltage sags, voltage swells, non-linear load switching, capacitor bank switching, and motor starting. Under both normal and noisy conditions, the suggested detection strategy with RPNN and SLT gives 100 percent accuracy. Furthermore, employing error criteria, the results of the classifier with various feature extraction methods reveal that the RPNN classifier outperforms the PNN classifier. Furthermore, four statistical search techniques, namely PSO, GA, SA, and DE, were used to evaluate the efficiency of the proposed modified deferential evolution (MDE) for the training of ridgelet probabilistic neural network (RPNN), and the results show that RPNN with MDE is more accurate than the other statistical search techniques. The suggested MDF is computationally light and requires just a limited number of training samples.

2.4 NDZ based approach for islanding detection

For both inverter and synchronous machine-based distributed generating units, the author presented [4] an unique passive-based anti-islanding strategy. Unfortunately, most passive anti-islanding approaches fail to identify the islanding scenario when the active/reactive power disparity is close to zero.

The author presented a new islanding detection approach based on chaos theory [4] that can identify islanding with a near-zero active power imbalance. As an input signal to a forced Helmholtz oscillator, the approach employs the changed frequency of the point of common coupling connection. The forced Helmholtz oscillator's key benefit over other oscillators is the evident transition between chaotic and regular movements. The threshold for detection index is determined by this modification. In simulations for two separate case studies, non-islanding transient occurrences, which can produce a large variance in the frequency-based input signal of the detector, are taken into account. Different forms of malfunctions, load changes, capacitor bank switching, and motor starting are all examples of these occurrences.

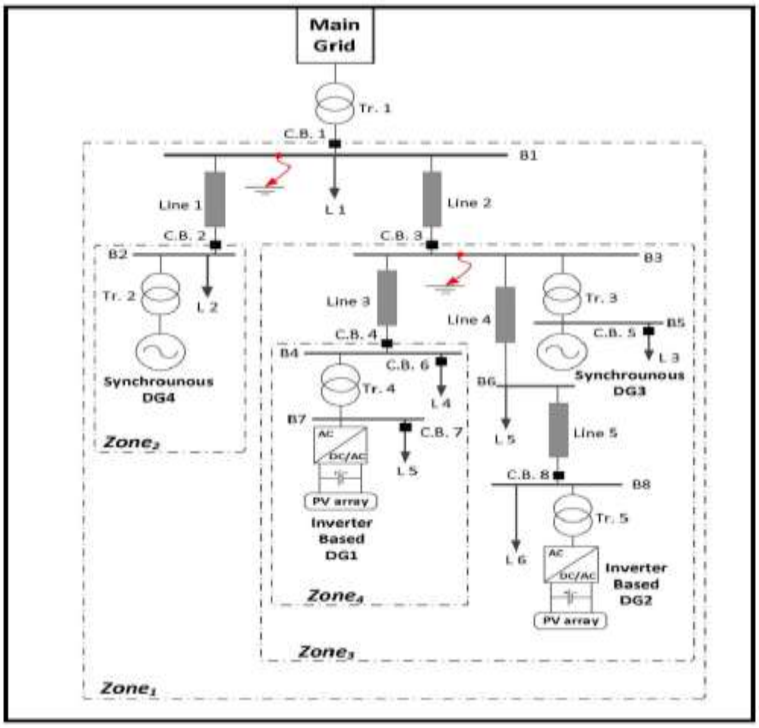

Fig.4. NDZ based approach for islanding detection [4]

It was found that the suggested technique has a very low NDZ, particularly for inverter-based DGs, and that it can detect islanding situations with active power imbalances of less than 0.4 percent for synchronous and hybrid-based DGs. As a consequence, even when the active power imbalance is near to zero, the method's capabilities and dependability have been assessed. It has been compared to doffing oscillator and oscillation frequency based anti-islanding approaches in terms of NDZ and detection time, and the superiority of the suggested technique has been established. It was also demonstrated that the suggested approach is better to the doffing oscillator-based islanding detection approach since it clearly distinguishes between normal and chaotic motion by reaching infinity with its output signal. Finally, compared to existing passive approaches, determining thresholds for the proposed detection index is easier and more easy.

2.5 NDZ Passive Islanding Detection

For microgrids, the islanding phenomena is frequently undesired since it can disrupt power services and damage equipment. Islanding is sometimes necessary to isolate a possible problem. Passive islanding strategies are simple to instal, but their non-detection zone (NDZ) is too vast. Anti-islanding methods can detect islanding, leading distributed generators (DGs) to stop delivering power to loads in microgrids. By regulating the output power of the inverters, the author [5] was able to lower the NDZ of passive islanding strategies. The anti-islanding technology is being used to operate a hybrid AC/DC microgrid construction.

To guarantee that all power generated by DGs can be completely used, the over/under (OUV) voltage and over/under frequency (OUF) approaches are employed to identify the islanding phenomena at the point of common coupling (PCC). The employment of passive anti-islanding strategies to combat the islanding phenomena is widespread, however the NDZ of passive anti-islanding approaches is considerable. This approach provided a novel PQ approach that can identify NDZ areas and adjust output power to keep the operating point out of the NDZ zone.

2.6 Current controller based Islanding detection

A novel islanding detection method based on phase shifted feed-forward voltage was proposed by the author [6]. The PCC voltage is monitored concurrently in the grid-connected inverter system, and those values are utilised as feed-forward values in the current controller. The phase of the feed-forward voltage is changed in this approach to identify the islanding state. The suggested approach modulates the phase of feed-forward voltage when the recorded PCC frequency varies.

The suggested approach makes positive feedback to the frequency because the phase angle of feed-forward voltage is governed by the fluctuation of measured frequency of PCC voltage. It is considered an islanding operation when the frequency fluctuation exceeds the permitted range. Because the suggested method's frequency response is quick, the islanding operation could be recognised in 90 milliseconds despite a high quality-factor (Qf) of 10. Furthermore, the suggested approach does not create continuous reactive power when the grid is in normal condition but the grid frequency fluctuates within the permitted range, lowering the quality of inverter output power. Finally, because there is no restriction on reactive power input, the suggested approach has a very tiny NDZ.

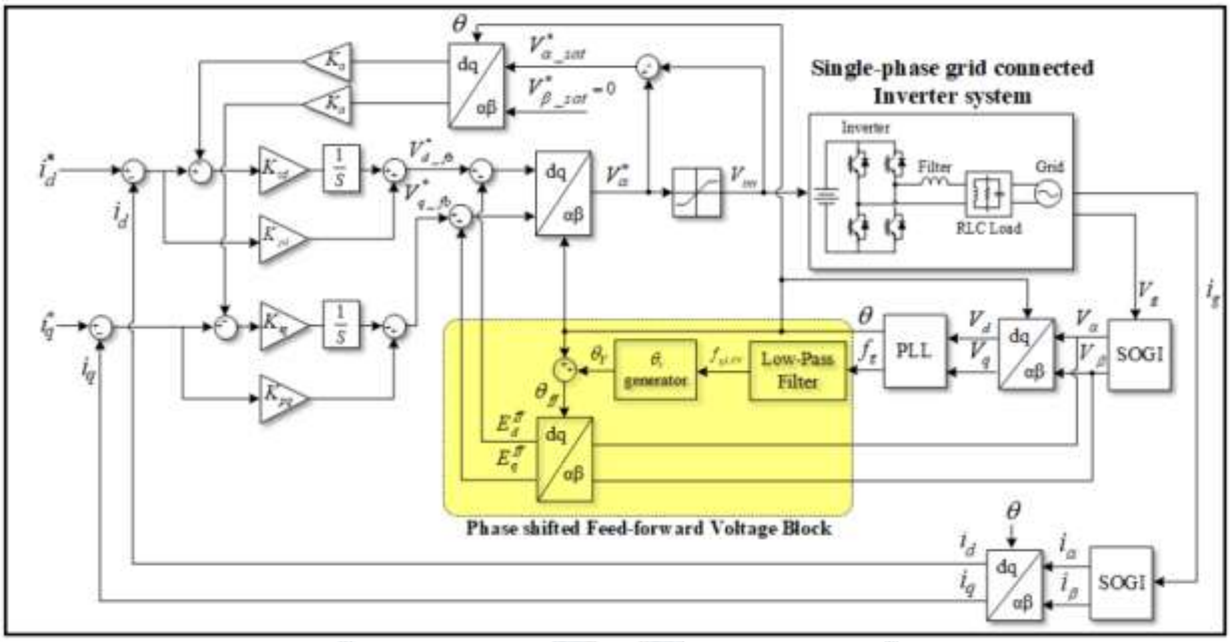

Fig.5. Block diagram of current controller with proposed islanding detection method [6]

For islanding detection, the proposed technique makes advantage of the current controller term. As a result, in typical conditions, the reactive power caused by modest grid frequency variations is managed by the current controller. As a result, the power quality is far superior to that of conventional active approaches. The suggested solution is simple to implement and suitable to grid-connected inverters, as it does not require a sophisticated algorithm. The suggested method's viability was tested in 600W single-phase applications.

2.7 NDZ and Active Power Technique for Islanding Detection

For the safety of employees and the safe functioning of equipment, timely islanding detection and differentiation between islanding and non-islanding disturbance situations are critical. A hybrid islanding detection approach for distribution systems with synchronous distributed generation (SDG) was presented by the author [7], which is based on two active and reactive power management loops and a signal processing methodology. By analysing the terminal voltage of SDG, the control loops speed up islanding identification at early phases of instability. Extensive simulations back up the proposed technique.

The findings show that the suggested technique is capable of detecting islanding circumstances in a timely and precise manner, as well as distinguishing between islanding and non-islanding occurrences, even when the active and reactive power between generation and demand is quite near. Furthermore, the suggested technology has minor effects on power quality and can allow the islanded system to run independently after being disconnected from the main grid.

Under islanding settings, the control loops introduce a little amount of marginal instability in the system, which does not impair power quality under normal operating settings. As a result, the proposed hybrid system outperforms passive approaches that have a high NDZ and active techniques that have a negative influence on power quality and lack the capacity to operate autonomously in islanded mode. It is also demonstrated that the suggested hybrid technique accurately identifies non-islanding disturbances from islanding disturbances.

Even when generation meets demand perfectly, islanding events can be discovered in as little as 200 milliseconds. It should be noted that the same strategy may be used to produce mild unstable situations under islanding using inverter-based DG by altering their control loops. The unstable numbers can then be quickly analysed to discover a state of instability. However, the significance of this research lies in the use of the suggested approach in synchronous DGs, because their control loops have a slower dynamic reaction than inverter-based DGs.

2.8 Parallel impedance based islanding detection

The first technique [8] involves monitoring the rate of change of voltage (dv/dt) at the DG output and using a new islanding detection approach based on parallel inductive impedance (PII) switching at the DG connection point. Switching the PII produces fluctuation in the dv/dt in the suggested method. When DG runs in parallel with the main grid, this fluctuation is extremely tiny, but when islanding occurs, the variations are extremely considerable. As a result, the dv/dt is used to detect both islanding and non-islanding scenarios; however, the Fast Fourier Transform (FFT) is used to process the variation of the dv/dt in order to properly assess the dv/dt variations.

The impact of switching various impedance types on the FFT(dv/dt) is fully examined to pick the kind of inserted impedance. It is shown that solely inductive impedance performs better than other types of impedance. Comprehensive simulation studies in MATLAB are used to evaluate the suggested method's performance. The suggested technique preserves its efficiency for both inverter- and synchronous-based DGs, according to simulation findings. Furthermore, in comparison to previous known approaches, the suggested technique not only has a significant impact on the reduction of disruptions caused by a tiny quantity of PII, but it also completely removes the non-detection zone.

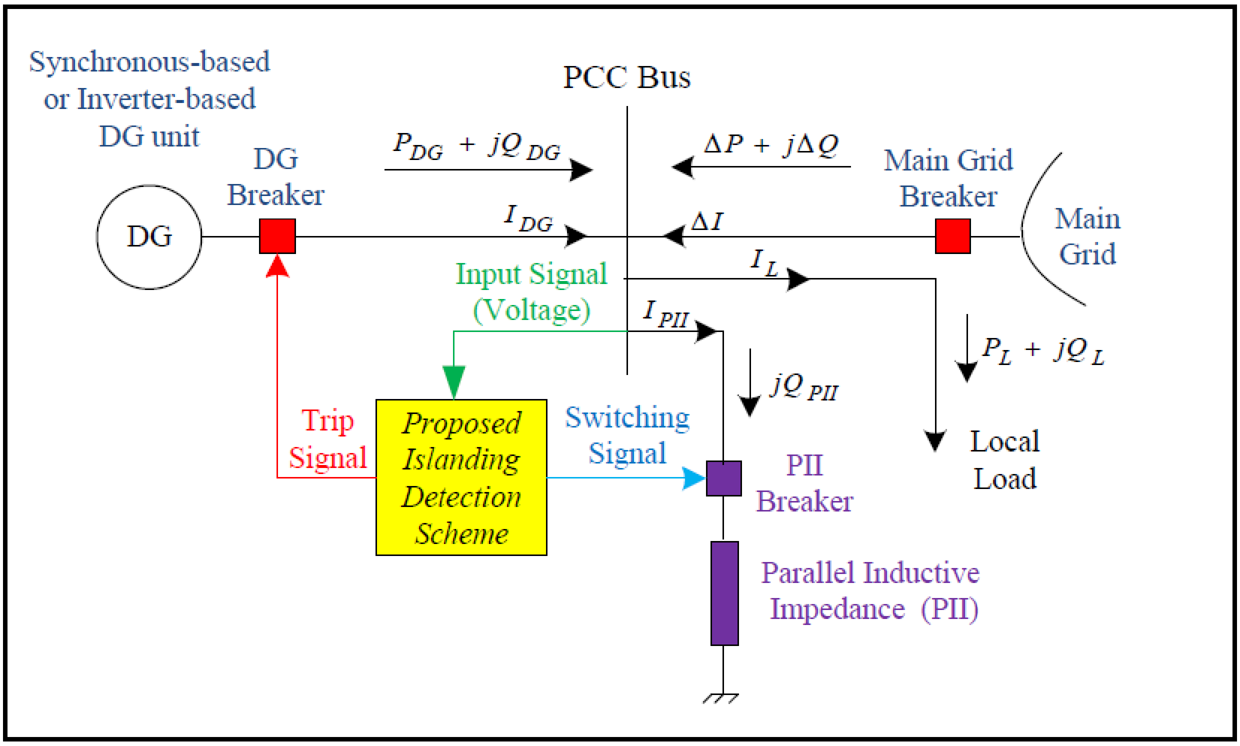

Fig.6. Schematic diagram of the typical power system equipped with the proposed islanding detection scheme [8]

The FFT(dv/dt) variations may be utilised to discriminate between islanding and non-islanding events using inductive impedance switching. An analytical analysis of the suggested plan is offered to demonstrate the efficiency of the suggested plan. Furthermore, a series of simulations is run under various operating situations, with the results indicating that the suggested methodology can readily and efficiently discern between islanding and other power system disruptions, even under the most adverse situations.

2.9 Bilateral reactive power variation based islanding detection

A hybrid islanding detection approach for inverter-based distributed generating units was proposed by the author [9]. To begin, this strategy does a thorough examination of the characteristics of inverter-based DGs and derives design guidelines for the hybrid approach. The suggested technique then combines the passive approach of voltage imbalance and total harmonic distortion (VU/THD) detection with the active approach of bilateral reactive power variation based on these principles (BRPV).

In particular, the BRPV technique is only triggered when the VU/THD method suspects an islanding state. As a result, the performance of islanding detection may be considerably increased without sacrificing power quality. Furthermore, this technology alters the traditional VU/THD method to provide rapid and precise detection, and the threshold setting concept is investigated for the first time using an analogous circuit approach.

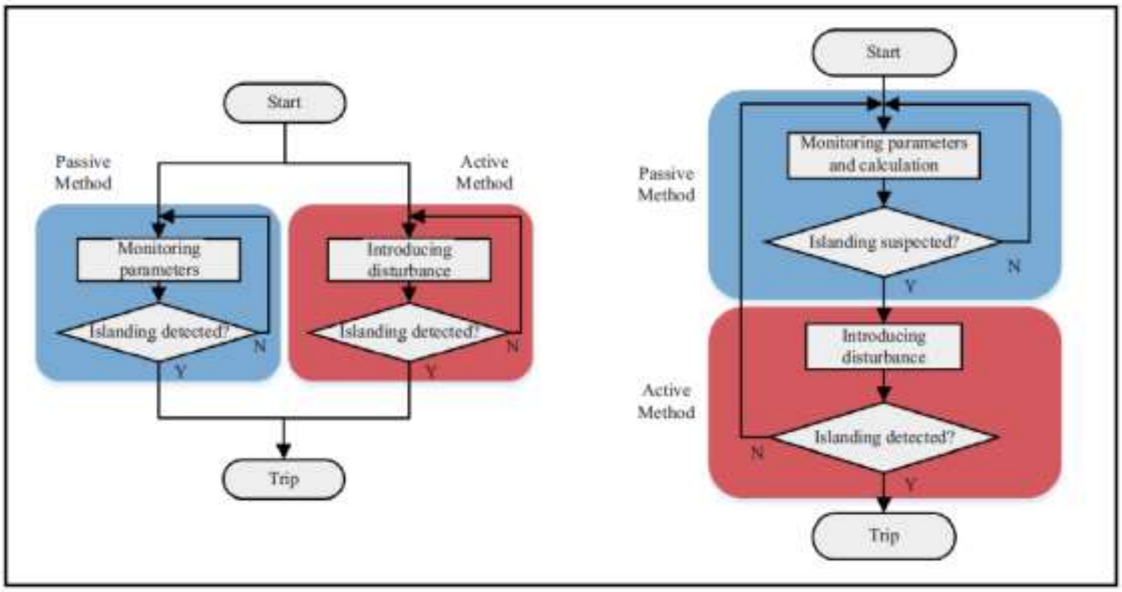

Fig.7. Operational principle for the combination of passive method and active method in parallel mode as well as Operational principle of hybrid method [9]

A hybrid technique is presented based on these concepts, which is ideal for inverter-based DG and can function correctly in multiple inverter systems. The suggested technique combines the VU/THD and BRPV methods, with the BRPV approach being used only when the VU/THD technique suspects an islanding state. The performance of islanding detection can be considerably enhanced by combining them. It has been demonstrated that by appropriately selecting parameters, the suggested technique can identify the islanding state in a timely manner, eliminating NDZ and preventing nuisance trips at the same time. Furthermore, the BRPV solely affects reactive power without producing harmonics, and has no influence on power factor. For inverter-based DGs, the suggested technique has the better islanding detection capability, according to a comparison study.

2.10 rate of change of active power output (ROCOP)

For grid-connected photovoltaic systems (GCPVSs) based microgrids, this author presents a rapid and reliable two-level islanding detection technique (IDM). The magnitude of the rate of change of output voltage (ROCOV) is estimated at the first level of the proposed IDM. If this variable reaches a certain threshold, a disturbance is introduced into the duty cycle of the DC/DC converter after a certain time delay, deviating the system operating point from its maximum power point (MPP) condition. In islanded mode, this results in a significant drop in active power output and voltage.

As a result, in islanding states, the ROCOV and rate of change of active power output (ROCOP) indices, evaluated in the second stage, pose large negative sets at the same time. In non-islanding switching occurrences, however, at least one of these variables has a near-zero variation. Using hardware-in-the-loop (HiL) simulation experiments, the described technique was evaluated under substantial islanding and non-islanding scenarios for a case study system with two PV power plants. Within 510 ms, the reported findings show exact islanding categorization with an excellently tiny non-detection zone (NDZ). The given IDM has the benefits of self-standing thresholds, no adverse influence on output power quality, and a simple and low-cost construction.

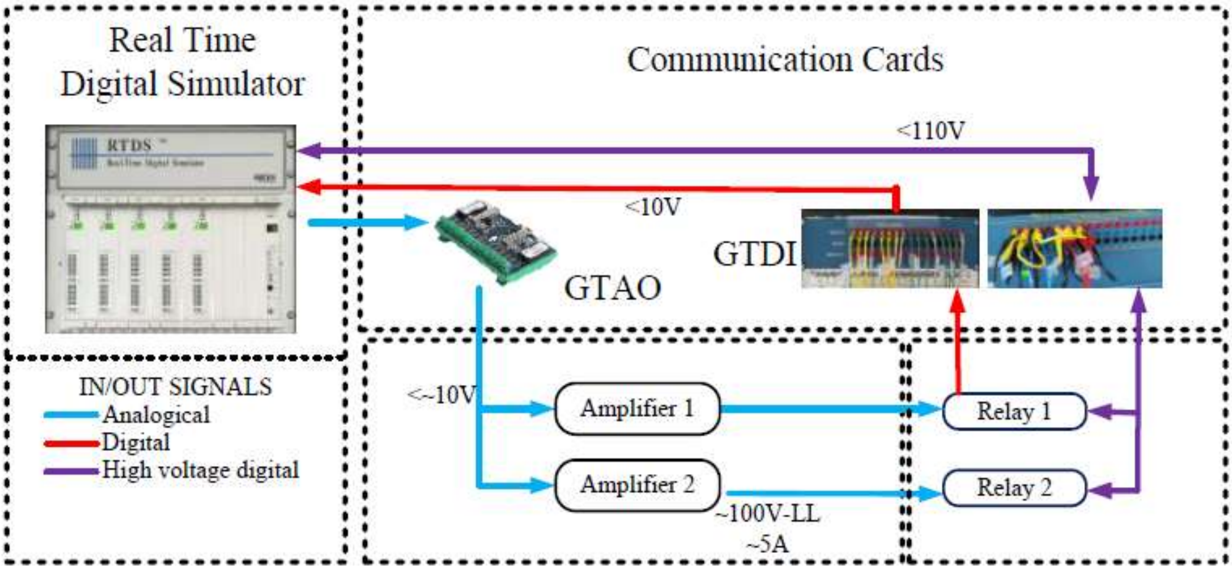

Fig.8. Implementation of the HiL tests in RTDS environment [10]

When the measured ROCOV exceeds a threshold, a disruption in the duty cycle of the DC/DC converter is triggered in the first level of the proposed IDM. In islanding states, this disruption pulls the GCPVS operating point away from MPP, resulting in strong negative values for ROCOV and ROCOP of the second level at the same time. For a case study system with two large-scale PV systems, the suggested IDM was put through comprehensive real-time HiL simulation experiments. The results showed that correct islanding classification could be achieved in less than 510 milliseconds, regardless of power imbalance, load quality factor, or DG penetration, even in the situation of several DGs.

The MPP has been restored following islanding identification using the MPPT technique, according to the results. Unlike typical active IDMs, the GCPVS may generate its full available power in microgrid following islanding categorization. This functionality is taken advantage of to allow for quick reconnection and autonomous operation of GCPVS in a microgrid.

Furthermore, a comparison of the suggested technique to a few current IDMs reveals that it is superior in terms of ease of implementation and cost-effectiveness, as well as self-standing and uncomplicated threshold determination. As a result, it may be easily integrated with existing VSIs to serve as a powerful and efficient tool for islanding identification.

3. CONCLUSION

This paper is present the general review of different islanding detection techniques for distributed generators in microgrid system like multi-agent distributed neural network-based islanding detection, impedance measurement based islanding detection method, Slantlet transforms as a signal processing method, NDZ based approach, phase-shifted feed-forward voltage based approach, parallel inductive impedance switching approach, hybrid islanding detection methods and two-level islanding detection method. The main concentration of this paper is the review of recent islanding detection technique from the year 2017 to 2021.

The islanding detection is the most important requirement for solar PV grid or wind turbine microgrid system. Because during islanding condition there will be frequency deviation occurs in the microgrid system. This paper will be helpful in future for scholars and students who studied in the field of islanding detection of a distributed generator microgrid system.

REFERENCES

[1] Isazadeh, G., Kordi, M., Eghtedarnia, F., & Torkzadeh, R. (2017). A new wide area intelligent multi-agent islanding detection method for implementation in designed WAMPAC structure. *Energy Procedia*, *141*, 443-453.

[2] Paz, F., & Ordonez, M. (2018, June). An impedance-based islanding detection method for dc grids. In *2018 9th IEEE International Symposium on Power Electronics for Distributed Generation Systems (PEDG)* (pp. 1-7). IEEE.

[3] Ahmadipour, M., Hizam, H., Othman, M. L., & Radzi, M. A. (2019). Islanding detection method using ridgelet probabilistic neural network in distributed generation. *Neurocomputing*, *329*, 188-209.

[4] Bakhshi, M., Noroozian, R., & Gharehpetian, G. B. (2017). Novel islanding detection method for multiple DGs based on forced Helmholtz oscillator. *IEEE Transactions on Smart Grid*, *9*(6), 6448-6460.
[5] Zhang, X., Gamage, D., Rashid, Y., Manglani, V., & Ukil, A. (2019, January). Pq control-based novel passive islanding detection method for renewable energy application. In *2019 International Conference on Electronics, Information, and Communication (ICEIC)* (pp. 1-4). IEEE.
[6] Kim, D. U., & Kim, S. (2019). Anti-islanding detection method using phase-shifted feed-forward voltage in grid-connected inverter. *IEEE Access*, *7*, 147179-147190.
[7] Zamani, R., Golshan, M. E. H., Alhelou, H. H., & Hatziargyriou, N. (2019). A novel hybrid islanding detection method using dynamic characteristics of synchronous generator and signal processing technique. *Electric Power Systems Research*, *175*, 105911.
[8] Rostami, A., Jalilian, A., Zabihi, S., Olamaei, J., & Pouresmaeil, E. (2019). Islanding detection of distributed generation based on parallel inductive impedance switching. *IEEE Systems Journal*, *14*(1), 813-823.
[9] Wang, G., Gao, F., Liu, J., Li, Q., & Zhao, Y. (2020). Design consideration and performance analysis of a hybrid islanding detection method combining voltage unbalance/total harmonic distortion and bilateral reactive power variation. *CPSS Transactions on Power Electronics and Applications*, *5*(1), 86-100.
[10] Bakhshi-Jafarabadi, R., Sadeh, J., de Jesus Chavez, J., & Popov, M. (2020). Two-level Islanding Detection Method for Grid-connected Photovoltaic System-based Microgrid with Small Non-detection Zone. *IEEE Transactions on Smart Grid*.