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Review: Islanding Detection Techniques for Microgrid System

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Abstract - *Due to the variable power management capability of distributed generators (DGs), DGs and microgrids are coupled with each other increases day by day. Most of the cases DGs sources are solar pv system, wind turbine system, battery sources, diesel generators etc. These DGs sources need to connect more and more number with future power grid. The inverter technology are used to connect DGs system power grid or microgrid system without any power fluctuations. The major grid operators need DGs to conform with international standards such as IEEE 1547, IEC 61727, UL 1741 for safe service with these grid-connected DGs. Most of microgrid system need to following international standard for connection DGs system with microgrid system like IEEE 1547, IEC 61727, UL 1741. Islanding condition means small portion of microrid is driven by few DGs sources and drive load of such microgrid without using main power grid system voltage or power. But such unintentional islanding condition may cause dangerous condition to human or worker on this microgrid. By adjusting the power quality, traditional multiple methods for assessing islanding activity detect the islanding.*

This paper is review the different techniques for islanding detections of DGs in microgrid system like Impedance measurement based islanding detection method, Transient components calibration based Islanding Detection method, ANFIS based Islanding detection method, Transfer learning model based Islanding detection method, Reactive power P&O anti-islanding method, Low voltage ride through (LVRT) Islanding Detection method, Signal trajectory pattern recognition Based Islanding Detection Method, Phase shifted feed-forward voltage based method, Rate of change of reactive power measurement based Islanding detection method, Two level Islanding detection method, Graph Search Method based Islanding detection, Active Unintentional Islanding Detection, Hybrid Islanding Detection Method.

Key Words: *Distributed Generators (DGs), Islanding detection*

1. INTRODUCTION

Interconnection of distributed generation (DG) to electrical grid system has increased significantly as the demand for clean and continuous electricity is thriving. Though, there are several issues to be dealt with, before DG becomes an essential part of the grid. One of the major challenges with the grid connected DG is reliable detection of unintentional islanding event occurrence. It is defined as "A condition in which a portion of the utility system that contains both loads and distributed energy resources (DER) remains energized while isolated from the remainder of the utility system [1]". Hence, in [1] it is recommended that all distributed generators should be disconnected from the main grid in case of islanding and disconnection is continued till the restoration of normal grid supply, so as to give protection to the generators and loads connected to the system. Several techniques for detection of islanding phenomenon have been reported in recent years.

The power generation sources connected to the consumer side of the grid, at the distribution network, for local production and consumption are termed as distributed generation (DG) sources. This scheme alleviates the losses that would otherwise occur in a conventional transmission network, where the power generation sources are at a remote location. DG is effective in terms of reducing transmission losses, cost of new system to transmit more power and also other complexities related to long transmission networks. Also, DG can be used as an emergency source at times of grid failure or during natural calamities. On the flip side, DG also has some shortcomings. The intermittent nature of the renewable sources makes the control of power extremely difficult. In addition to this, the conventional power network is designed for unidirectional flow of power, meaning from power sources to the distribution side. The introduction of DG sources in a distribution network has given rise to problems that make seamless integration of DG sources cumbersome. One of the key problems that arise due to increased DG penetration is islanding. Islanding is a phenomenon where a DG continues to energize the local loads even when the power supply from the utility grid is absent or discontinued. Islanding can either be intentional or unintentional. Intentional islanding is a planned event and necessary care is taken to avoid occurrence of any problems. Unintentional islanding on the other hand is an unplanned event.

In recent years, the development and deployment of distributed generation (DG) systems such as photovoltaic (PV), fuel cells, and wind power have been increasing due to high energy demand worldwide and the nearing exhaustion of fossil resources. DG systems connected with the grid should have functions to ensure reliability and safety and are essentially required to have an anti-islanding method. Unintentional islanding can cause safety problems to maintenance personnel and damage DG systems and loads, and therefore DG systems should be able to quickly detect islanding and be disconnected from the grid when islanding occurs.

2. DIFFERENT ISLANDING DETECTION TECHNIQUES

2.1 Impedance measurement based islanding detection

Islanding detection is very much difficult task in both DC and AC microgrid system which may cause unstable operation of microgrid and also dangerous condition for workers or users. While various methods or techniques was developed for islanding detection in AC mircogrid but for DC microgrid this is on still initial stage. In most of hybrid power system utilized the three phase voltage regulator converters for synchronization of hybrid system with main grid by exchange of power with main AC grid system. For such hybrid power system, most of the focus was storage devices, distributed generator and loads energy production or consumption profile optimization. Range of over-voltages and under-voltage was utilized for most of the islanding detection techniques which may be fails due to load follows the voltage profile nearer to source voltage profile. Also such system was added disturbances in system which may disturb the operating point and operating time of system. The method [1] used in this paper utilized the lock in Amplifier with sensors for voltage and current measurement with solar PV system. Using measurement of exact impedance of microgrid line, this method able to detect islanding condition as quickly as possible. This proposed method offers: 1) injection of low amplitude of signals; 2) detection of islanding at very high speed; and 3) more sensitive for islanding events. The analysis and behaviors of such proposed system was analyzed for different types of loads like constant current load, constant resistance load, constant power consumption load.

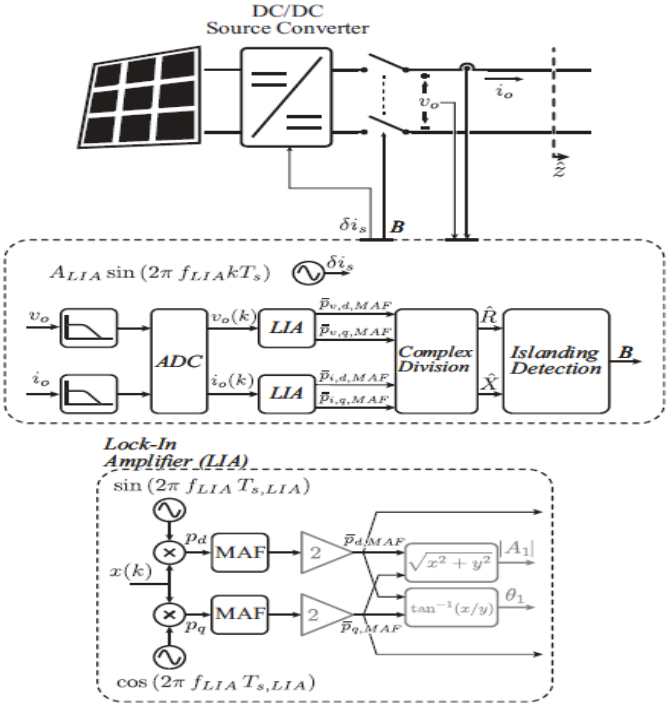

Fig-1: Proposed impedance measurement based islanding detection of microgrid system block diagram [1]

This method [1] is based on impedance matching of load and source that make this method better for detection of islanding even if voltage based algorithm not working. Also this method used the small signal for injection in microgrid system for identification of islanding in place of large distress. Simulation result of proposed approach shows the proposed approach is differential the islanding condition of system from non-islanding condition of the system even when the load is variable or constant load like constant current load, constant power load, constant resistive load and all types of loads.

2.2 Transient components calibration based islanding detection

Author presents [2], analysis of transient response of distributed generator system during faults and switching conditions in islanding microgrid. This method is based on transient index value (TIV) as well as positive sequence superimposed current angle at point of common coupling. Three phase voltage signals measured at Distributed generator end is utilized for computation of TIV.

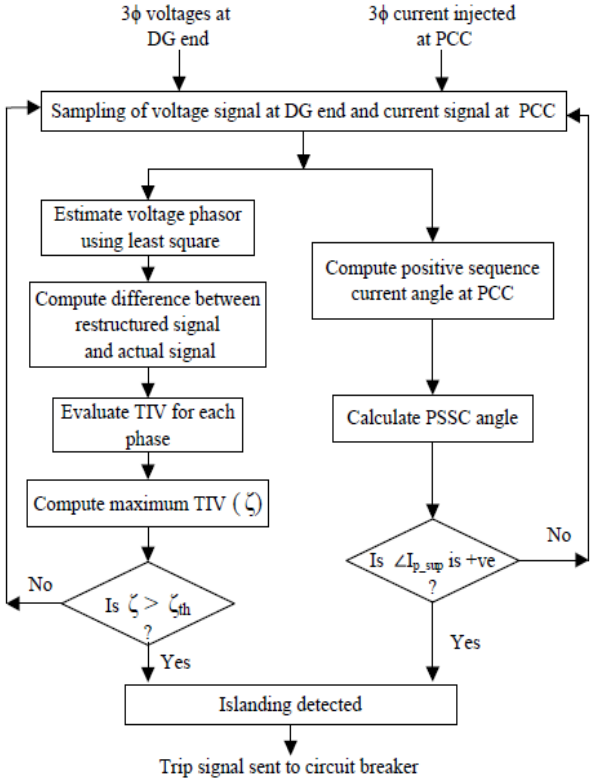

Fig-2: Flow chart of proposed transient component based approach [2]

The performance analysis of proposed system is done on practical distribution power system network which includes thermal power plant, wind turbine DGs system, PV system. The simulation results shows the, propose approach is highly reliable and faster response for detection of islanding condition. This is proposed system compare with existing

different passive islanding detection techniques for zero active and reactive power mismatch power condition as well as nonlinear load based occurrence of transient conditions. In this method, the detection of islanding is based on measurement of DGs end side voltage measurement and injected current at point of common coupling (PCC). Result obtain for this system is more accurate and reliable based on system parameters changes. This system is tested for different conditions for islanding detection like reactive power and active power mismatching condition. This method also able to detect the various critical conditions events like faults conditions, switching of large connected load, open of distributed generator circuit breaker as well as capacitor switching operation. Also variable non linear load has no any adverse effect for detection of islanding condition. This approach reduces the detection of non-linear zone and reliability of operation conforms after testing of system. The advantage of proposed integral technique are fasted islanding detection less than one cycle of current as well as simple computational algorithm, more compatible reliable.

2.3 ANFIS based islanding detection method

The author presents [3], Adaptive Neuro-Fuzzy Inference system based islanding detection for islanding event detection in low voltage based inverter interface microgrid power system. The ANFIS controller has ability to generate the nonlinear mapping for inputs as well as its pattern recognition ability make it strong tool for islanding detection. ANFIS controller continuous observe the seven types of data which is measured at point of common coupling like root man square three phase voltage and current, total harmonics distortion three phase voltage and current using fast Fourier transform method, power frequency of microgrid as well as active power and reactive power of microgrid. All this parameters measures during real time operation of microgrid system.

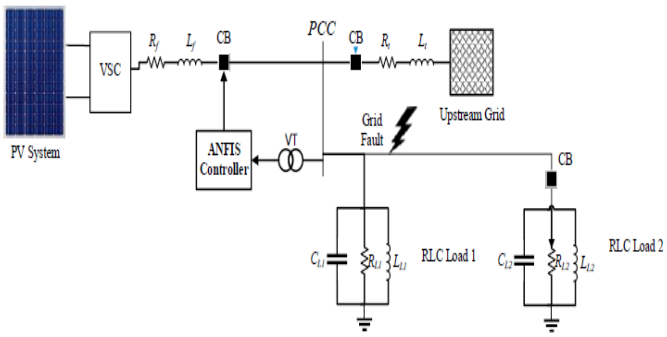

Fig-3: ANFIS based islanding detection technique [3]

The proposed system is reduce the chance of non detection zone in mircogrid and monitoring of power system parameters reduces the influences of power quality issues. Also, one of the main aim of this system is reducing NZD operation with maintaining the power quality issue. The proposed detection techniques has less detection time for islanding event detection and better accuracy as compared with old conventional methods.

The accuracy and performance of proposed system depends upon training data set, sample time as well as number of samples for optimization of proposed technique. The input data for ANFIS is taken from point of common coupling of real time solar PV system through automatic measurement reading system. This system is tested based on UL1741 standard on different loading conditions, two parallel connected distributed generators, different grid faults and load controlled switches system. Also, this method is compared with old previous methodology for islanding detection. Here, it clear that, based on comparison ANFIS system is more accurate and fast for islanding condition detection during different loading conditions. Also, this method not affects the power quality of microgrid system. Also operate at different environmental condition.

2.4 Transfer learning based islanding detection method

For increasing demand of power system is completed using distributed generator sources like solar pv system, wind turbine system etc. But use of more renewable distributed generators sources made system protection, operation and control very difficult to design and complex to achieve. Big issue to use of renewable energy sources in mircogrid system is islanding event. This method [4] proposed the technique for detection of islanding in mircogrid using transfer learning for image classification.

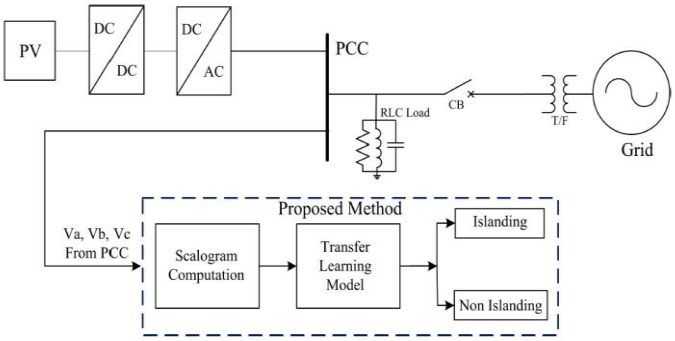

Fig-4: Schematic of the system used for transfer learning model [4]

This method is possible to implement by using time series data in scalogram images taken from microgrid system. The images which used for this method is taken from wavelet transform subsystem which measured at point of common coupling of mircogrid system. In next step, apply the transfer learning using AlexNet software for pre-trained network. But some modification required to made in pre-trained ANN network for detection of islanding events. This CNN nework is trained for both islanded and non-islanded training data set. The accuracy of proposed transfer learning based approach is 98.78%. Also it is clear that transfer learning

based approach is more compatible for detection islanding events in mircogrid system.

2.5 Reactive power P & O Based islanding detection method

If unintentional islanding detection done as quickly as possible then a grid connected system is supply constant power with inverter system with critical loading condition and normal loading condition. In this method, presents the indirect current control method in which smoothly transfer the inverter instant during mode changing and also make the stable voltage for critical load. However, old conventional islanding detection methods not applied to the indirect current control based method since only when voltage magnitude and frequency of voltage not required to vary during islanding condition. This method presents [5] a reactive power P&O anti-islanding method for indirect current control approach. The proposed method detect the islanding condition by observing the reactive power changing during islanding condition. Also, this method generates the small amount of signal for reactive power perturbation at the output side of inverter. In this proposed approach, inverter provide good power supply to critical load without any distortion.

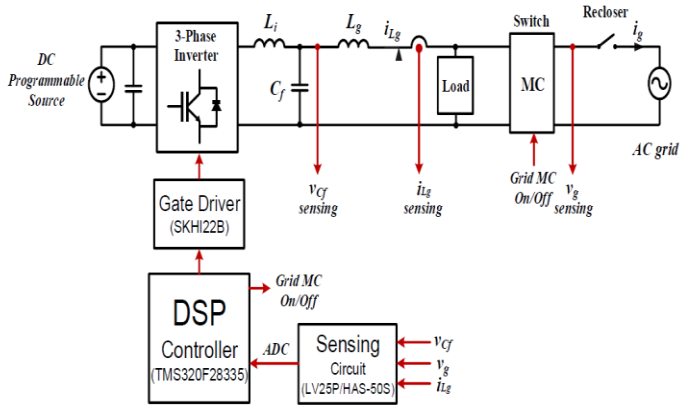

Fig-5: Anti-islanding detection method block diagram [5]

This system is tested on 1kW three phase inverter system with three phase RLC load quality factor of 2.5. This method is effective with 2 number of distributed generator system with IEEE 1547 and following with 929 standards. This system is able to provide seamless and stable voltage for critical loading condition.

2.6 Low voltage ride through (LVRT) Islanding detection method

Author presents a two stage inverter based islanding detection method [6]. This method is unique because this method does not depend upon the instantaneous voltage measurement of microgrid system. This method detects the islanding condition by using saturation of PI controller of the outer loop of proposed system. This function may be cause mal-operation due to sudden changes in loads or other power system transient. This proposed algorithm is more reliable as compared with other voltage measurement based islanding detection methods. This method proposed LVRT based islanding detection method and also proposed anti-islanding detection method. Hence overall system is consist of these three types of controller for obtaining the smooth transition mode changing between grid connected and stand alone mode of operation of system.

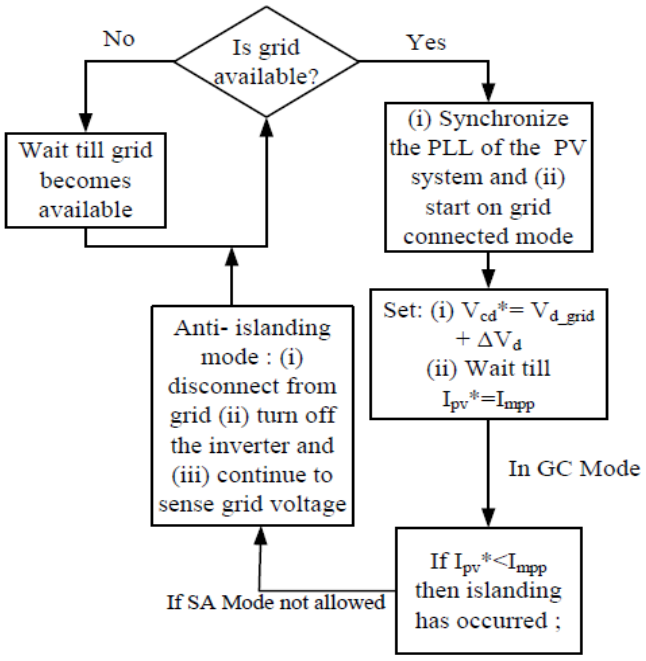

Fig-6: Flow chart of two stage inverter system [6]

Benefit of this method is that this system is insensitive to disturbances. Also this system work on instantiations measurement of system voltage. This system detects the islanding condition with on 2 sec of time after done of islanding. Also this system follows the IEEE 1547 standards. Such LVRT based system performance not affect due to the voltage sag condition. Because, LVRT system is based on calibrations of inequality condition which is based on integration of instantaneous grid system voltage. The proposed LVRT control system operation is varies from stand alone to grid connected mode of operation with seamless operation mode. Also, these entire mode are featured with maximum power point tracking (MPPT). The digital platform DSP TMS320F2812 is for testing of complete system. This system is very fast system for detection of islanding conditions and also provide low voltage ride through operation of system.

2.7 Signal trajectory pattern recognition based islanding detection method

For future growth of microgrid system, it is very much important to grow distributed generators system with continuous power flow capability to grid system. It is required to supply islanded microgrid by available DGs

system without degraded power quality, otherwise DGs must be disconnected from islanded microgrid system. Hence, we need to identify islanding condition as early as possible to disconnect the DGs system or change the mode of operation of DGs. This method proposed the islanding detection method called passive islanding detection using pattern recognition technique for synchronous DGs system. This system used the intelligent relay system for accurate detection of islanding condition in smart grid system. This method [7] easily distinguish from grid connected disturbances of system even if the generation and loads are closely matched the voltage profile during islanding.

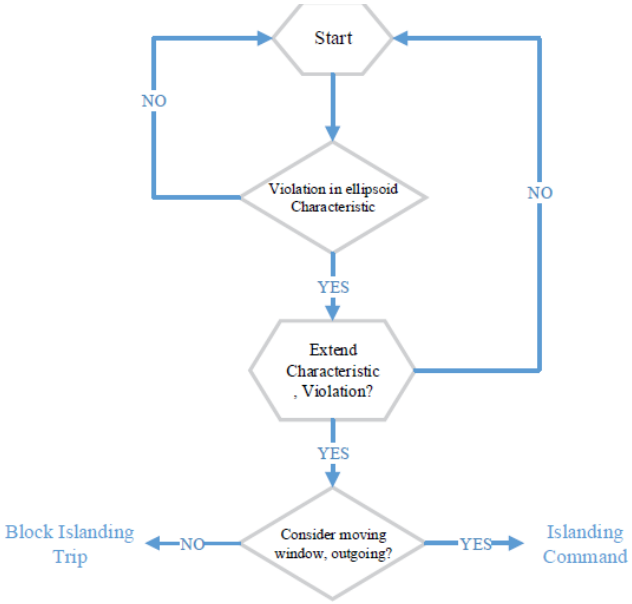

Fig-7: Signal trajectory pattern recognition base islanding detection [7]

2.8 Graph search method based islanding detection

Islanding condition means small portion of microrid is driven by few DGs sources and drive load of such microgrid without using main power grid system voltage or power. But such unintentional islanding condition may cause dangerous condition to human or worker on this microgrid. There are various conventional methods are available for detection of islanding condition in microgrid system without affecting power quality of system. But such conventional methods may not operate properly even if uses various power quality improvement devices. This method is detect the islanding condition based on system configuration calculation [11]. The connection links between distributed generators to main power system source checked using graph search method. If graph theory shows the renewable energy sources and main power source connected with microgrid then it is not islanding condition and vice-versa. The simulation result for proposed system shows that system follows the IEEE 1547 standard for islanding condition detection in system.

3. CONCLUSION

This paper is review the different techniques for islanding detections of DGs in microgrid system like Impedance measurement based islanding detection method, Transient components calibration based Islanding Detection method, ANFIS based Islanding detection method, Transfer learning model based Islanding detection method, Reactive power P&O anti-islanding method, Low voltage ride through (LVRT) Islanding Detection method, Signal trajectory pattern recognition Based Islanding Detection Method, Phase shifted feed-forward voltage based method, Rate of change of reactive power measurement based Islanding detection method, Two level Islanding detection method, Graph Search Method based Islanding detection, Active Unintentional Islanding Detection, Hybrid Islanding Detection Method.

This paper will be very much useful for researcher and students those working on Islanding detection in microgrid for Distributed Generators like solar PV system, Wind turbine system, Battery operated system, Fuel cell based system and tidal energy system etc. This paper will be extend in future for islanding detection in IEEE 14 bus microgrid system using Adaptive Neuro-Fuzzy Inference system (ANFIS), Fuzzy logic (FLC) and Back-propagation based Neural Network techniques (BP-ANN). At last we will compare effectiveness for all three techniques with each other for islanding detection.

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