Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 06, June-2018

A Study of Various Islanding Detection Methods in Microgrids

Suranjana Bharadwaj
Department of Electrical Engineering
Girijananda Chowdhury Institute of Management and Technology
Guwahati, India

***Abstract*—. The microgrids are generally a network consisting of small scale generators supplying a small area but they are not entirely isolated but also connected to the national grid in most of the cases. Islanding is an emergency condition where the main grid goes off while the DG is still connected to the system. This causes potential threat to the whole system. The system may collapse if it is not detected fast and remedial action is not taken. This research work tries to do a systematic study of common methods of islanding detection available and draw necessary conclusions.**

Keywords— ANN, Fuzzy, Islanding, Microgrid, Zone of non-detection, Active, Passive

I. INTRODUCTION

With the modern emerging technologies, the power system has been transforming itself from its previous giant, bulky form to small, smart functional units which are more reliable and convenient. While doing so, more and more new concepts are being introduced like renewable distributed generation, micro-grids etc. The microgrids are mostly consisting of renewable sources (wind power plants, solar PV, micro plants, cell based systems etc.) which are also connected to the main grid. This brings the necessity to analyze the system during dynamic conditions like islanding. Since there is no option to keep operating reserve in some of the renewable sources like wind power, their speed regulation and automatic generation control becomes very difficult. Islanding situations may occur due to many reasons, the most common being fault in a tie-line between transmission and distribution network. Islanding causes the following adversities in a power system:

i) It prevents automatic re-connection of the devices.
ii) Fatal accidents may occur when some workers may not know that the system is still alive even after the grid supply has been disconnected.
iii) Load vs. generation imbalance may occur in the system.
(iv) The system may be subjected to abnormal voltage and frequency fluctuations.

Due to all these reasons, the islanding situation should be very much detected well and system should be disconnected from all type of sources for its safety. In some specific, specially designed microgrids, the system can be allowed to go for islanding. In such cases, the DG's should be capable enough to handle the total load, in absence of the main grid supply. It is recommended that all DG's should be equipped with devices to detect the islanding situation and prevent it from occurring. Studies are going on to find better techniques of islanding detection.

II LITERATUE REVIEW

In recent times, power supply system has been undergoing a lot of changes from the previous bulk power production to small scale consumer oriented productions. In this picture distributed generation has come into play and the concept of "microgrids" has emerged. These microgrids are nothing but small scale grids which can operate either independently or in conjunction with the main grid of that area. These microgrids generally consist of renewable sources out of which most widely discussed and applied are wind turbine plants, solar PV, micro hydro plants, cell based systems etc. With more and more penetration of these renewable sources to the system the entire system orientation has been changed. This increases the security and reliability of the system as one does not need to solely depend upon a grid connected bulk supply system.

With the increasing importance of distributed generation more and more new terms are being introduced and being used by researchers worldwide which did not even exist in the literature of electrical engineering maybe 50-60 years ago. Such terms include distributed generation, embedded generation, de-centralized generation, demand side management, remote area power supply, islanding, situational awareness etc. The renewable resources that get more importance in India are small power wind generators, solar PV systems, biomass gasifier based power generation, micro hydro plants etc. The history of renewable energy research in India is more than a century old but it became prominent only during the 70's when the oil crisis occurred and it led to search of new renewable alternatives. At present renewable energy contributes 18.37% of the total installed power capacity in India as reported in 2017. The Ministry of New and Renewable Energy (MNRE) is trying to come up new projects in remote areas which are not accessed by the national grid yet. The process continues and India shows a significant growth in renewable energy source installations in recent years. Researches are going on in numerous directions in the field of distributed generation with renewable sources. Extensive research is going on in the area of developing islanding detection algorithms. Delberis A. Lima and Jayme E. Silva Filho have come up with a dynamic assessment of islanding detection in distributed renewable generation under different condition of load and generation. They have presented a new scheme based on telecommunication-aided synchrophasor measurement for sensitivity and speed optimization.[1] Aziah Khamis Hussain Shareef Erdal , Bizkevel Tamer Khatiba has come up with a survey of various islanding detection techniques and their advantages and

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 06, June-2018

disadvantages.[2]Anila Antony and Devika Menon has prosoped different islanding detection techniques for distributed Generation[7] Other significant work include Emilio J. Estébanez and Víctor M. Moreno's study to evaluate the performance of active islanding-detection algorithms in distributed-generation Photovoltaic Systems.[8] While in islanding situation the power system parameters (voltage, frequency etc.) undergoes changes. Safdar Raza and Hazlie Mokhlis have come up with a sensitivity analysis of different power system parameters during islanding detection which becomes helpful for future researchers. [11] Another important research has been done by Ajit A. Renjit and his team who have analysed the frequency dynamics in islanded microgrids. [14]

In this manner studies are going on in all the aspects, with this new scope of research has opened up, new facts are being established and all these sum up in making the distributed renewable generation

III CLASSIFICATION OF DIFFERENT METHODS OF ISLANDING DETECTION

Though in recent time, microgrids have been equipped with various kinds of renewable sources, the most considerable are solar PVs and wind power plants. In this particular paper we would like to concentrate on islanding detection of PV systems. The connection of the PV systems to the grid may cause several technical problems. The feasibility of such an interaction depends of various factors e.g. the layout of the inverters, type of anti-islanding techniques used, load vs. power generation balance, change in the behavior of the load connected etc.

The exact number of islanding detection methods that actually exist is very difficult to detect. It is an area of research which is advancing at a very rapid pace. Everyday some new method has been emerging out. The methods are roughly divided into the following categories: Active methods, Passive methods, Hybrid methods, Methods using communication techniques and lastly Advanced Methods using Artificial Intelligence. They can be defined as below.

Active methods can be defined as those methods which introduce a small signal of disturbance to the system in order to detect possible islanding conditions. For this, it is needed to monitor the changes the properties of that signal undergo. These properties include voltage, frequency, impedance etc.
Different types of active islanding detection method are:

i) Impedance measurement
ii) Negative sequence current injection
iii) Slip mode frequency shift
iv) Frequency bias
v) Active frequency drift
vi) Voltage feedback etc.

Active methods are simple and robust, have a small ZND (Zone of none-detection)
Passive methods are those methods where we try to introduce some component which will take into account the transient changes on the grid and by using that information, it decides whether the grid has failed or not by comparing it with some predetermined threshold value. . This method mainly monitors the changes in various system parameters. These changes are possibly,

(i) Under voltage/overvoltage
(ii) Under frequency/over frequency
(iii) Rate of change of frequency
(iv) Rate of change of voltage
(v) Rate of change of real power(P)
(vi) Rate of change of reactive power(Q)
(vii) Harmonics Detection
(viii) Impedance monitoring
(ix) Voltage phase jump

Passive methods are generally simple low cost methods which require little hardware. Using passive method, the power quality of the distribution network remains unaffected. These methods possess the disadvantages of a large ZND (Zone of non-detection)

Hybrid methods are a combination of both active and passive methods. They tend to utilize the best features of both of these. They have a very small ZND and signals are injected only at certain intervals of time. This helps in retaining the power quality of the system. But with increasing complexity of the system, the islanding detection time sufficiently increases.

In methods using communication techniques, PLC and SCADA are being implemented. The signals communicated between the PV Inverters and utility are processed and this gives a status of the system. If islanding occurs, there will be certain changes in these signals which will be reflected in SCADA. This is a more advanced method with less chance of errors but it is difficult to implement practically and not cost effective.

IV SOME ADVANCED METHODS OF ISLANDING DETECTION

Artificial Intelligence can act as a successful tool for islanding detection techniques. Artificial Intelligence comes handy when the existing conventional systems fail to give satisfactory results. Mainly there are two areas where vast research has been going on. These two areas are:

i) Artificial neural network based islanding detection
ii) Fuzzy controller based islanding detection

Artificial neural network (ANN) has proven itself as a great solver for solving complex problems related to science and engineering. In power system, ANN has proved itself to be a path breaking tool for many new innovations. It is being applied in various fields of power system e.g. power system operation and control, stability, security etc. An ANN is a network consisting of neurons which are similar to biological neurons of human brain. In a human brain, a neuron is connected to thousands of other neurons. Each neuron is capable of collecting information from thousands of neurons and sending the same to thousands of other neurons. Similar to this, the neurons of ANN also collect data from other neurons, do some processing on the data and then pass on the data to other neurons or nodes through links. Each link is associated

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 06, June-2018

with a certain weight. There are generally two types of network structure of ANN known as Feedforward and Feedback. In power system problems, multilayer Feedforward networks are generally adopted the block diagram of the same is shown below.

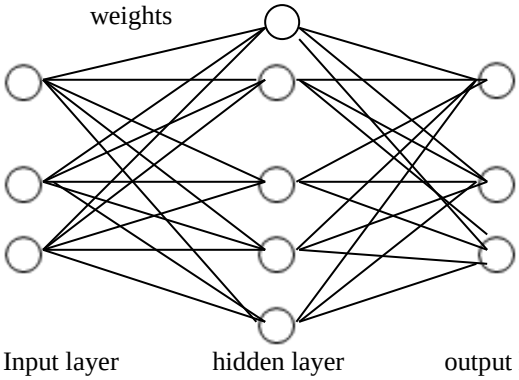

Fig.1 A three layer ANN with input, output and hidden layer

The network shown in fig.1 mainly consists of layers and nodes. There are three layers and several nodes. The middle layer is called hidden layer while the other two layers are input and output layer respectively. The flow of information is always left to right and there is no feedback path. The output of the ANN can be adjusted by adjusting the weight of the links connecting the links. If the desired output has been obtained then there is no need of adjustment of the weights. This phase of adjusting the weights of the ANN to get the desired output is known as the training phase. The next phase is the testing phase where the ANN is tested with random unknown inputs to check its efficiency.

While doing the testing part, some algorithm must be there which will link the output of any node in the output layer to the input node. Such algorithms are known as Activation Functions. The activation functions detect the lapse between the desired output and the actual output and put a command to the input node so that weight adjustments can be done to minimize the error and get the desired output.

For detection of islanding condition, the power system network will be re-structured as a multilayer feed-forward ANN. Now a certain parameters will be chosen e.g. rate of change of frequency, rate of change of voltage, rate of change of real power(P), rate of change of reactive power(Q) etc.

The test system is simulated using software after applying different scenarios of load and operating conditions. Output of these simulations show values of the parameters mentioned above under different conditions. The simulations for islanding cases are done by disconnecting the main grid supply at different load levels and checking the values of the parameters at these conditions. Other conditions applied to the network may be different types of faults (LG, LLG, and LLLG). The fault conditions are applied on different buses and the effect of the parameters are checked for each fault on each bus.

The output of the software will be applied to the ANN network and ANN will automatically detect whether islanding has occurred or not. For this, a matrix is formed whose elements will be the data obtained from the simulation software. The rows of the matrix will indicate the number of different scenarios of system disturbance whereas the columns will indicate the rate of change of parameters and finally the output column will indicate 1 if islanding occurs and 0 if there is no islanding.

The concept of fuzzy logic can be applied for islanding detection in conjunction with the passive way of detection where the changes in certain parameters are monitored to check whether islanding has occurred or not. Application of fuzzy logic concepts has increased tremendously in recent years in almost every aspect of research. It is a multivalued logic which is becoming popular day by day because of its analogy to the logical reasoning done by human mind. Here we can apply linguistic values to the variables using membership functions. The main component of a fuzzy system is the *fis* i.e. fuzzy inference system. Each fis will have certain rule bases. There will be certain input variables and certain output variables. The output variable will be linked to the input variables with the help of fuzzy IF-THEN rule. Using if-then rules, the output may be expressed in terms of inputs not by any mathematical equations but with the help of logical reasoning. Each of these input/output variables will possess their own membership functions. Generally triangular or trapezoidal membership functions are used. Other important component of a fuzzy system is the fuzzifier and the de-fuzzifier. The fuzzifier converts the crisp or numerical value to be processed by the fis into a fuzzy value (linguistic term). After completing the processing of the value again it is converted from crisp value into fuzzy value.

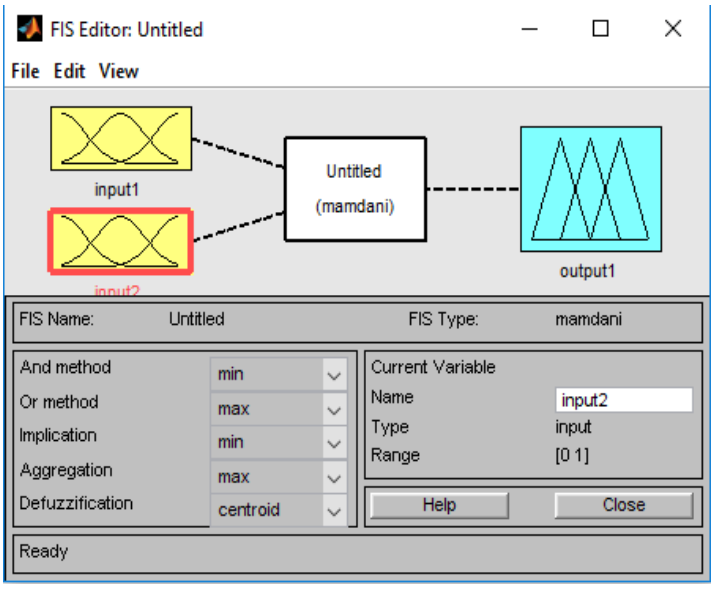

Fig.2 Editor Window for fis with two input variable and one output variable in MATLAB environment

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 06, June-2018

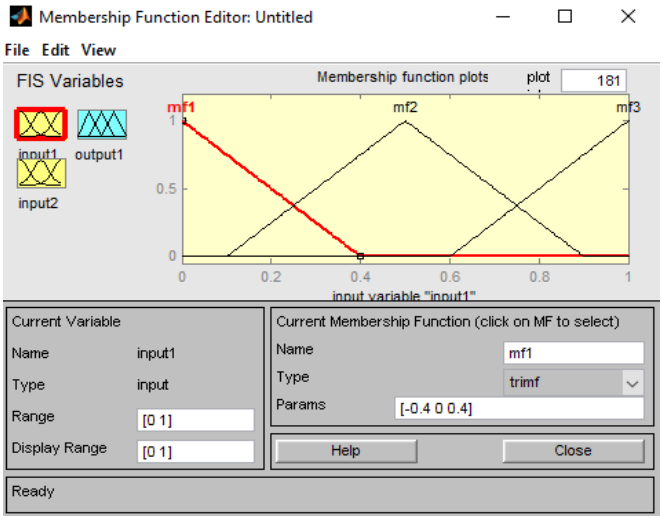

Fig.3 Editor Window for membership function of input variable in MATLAB environment

To determine what if-then rule to incorporate with a particular fis, it is necessary to pre-construct a decision tree (DT). A DT is nothing but a pictorial view of the logical base on which the different if-then rules will be constructed. Generally a DT is constructed using block diagrams.

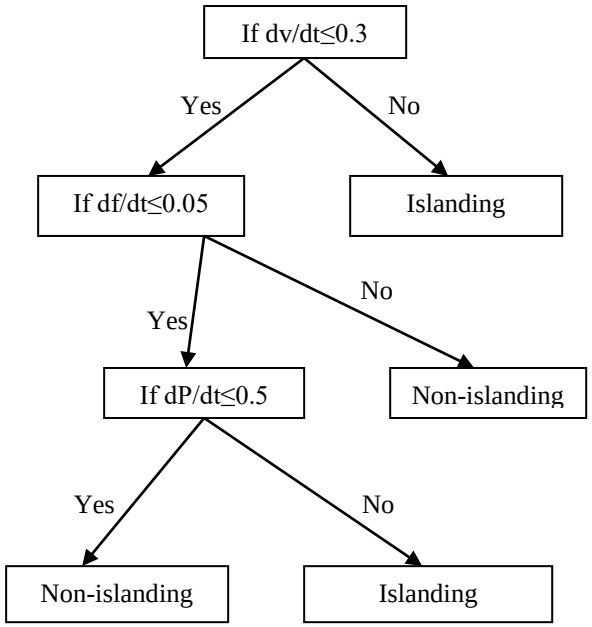

Fig.4 Construction of a decision tree

Fig. 1 shows a DT for representational purpose. In actual case there may be more branches and more layers of decision making to it.

The input variables will be those parameters considered in the passive detection methods, e.g. under voltage/overvoltage, under frequency/over frequency, rate of change of frequency, rate of change of voltage, rate of change of real power(P), rate of change of reactive power(Q) etc. The output variable may be an indicating variable which will have value 0 for non-islanding cases and 1 for islanding cases. In this way, using fuzzy control, decision making becomes fast, easy and reliable.

The collaboration of different intelligence technique like fuzzy-neural, fuzzy-PSO, fuzzy-GA etc. are coming up. These type of collaboration helps to extract the best features out of both the systems whereas nullifying the unwanted properties. System performance increase to a great extent but system complexities also increases considerably.

V CONCLUSION

This paper mainly discusses in detail about islanding condition, the detection methods that exist, their classification and details about a few islanding techniques. The methods can be broadly divided into active, passive, hybrid, involving communication and using artificial intelligence techniques.. Each method has been discussed with necessary examples. In part IV. Emphasis is put on discussing about the application of neural networks and fuzzy logic for getting better performance of islanding detection. Every method has its own feature, advantage and disadvantage. While choosing a particular detection method, one has to do a comparative analysis in terms of his own requirement. Faster detection may be achieved with the help of advanced methods but again those methods come at a heavy cost and may not be practically implementable due to its increased complexity. Therefore one has to do a compromise between cost and efficiency

REFERENCES

[1] Delberis A. Lima, Jayme E. Silva Filho, “Dynamic Assessment for Islanding Detection and Situational Awareness with Distributed Generation”, Power Tech, 2017 IEEE Manchester, 20 July, 2017

[2] Aziah Khamis HussainShareef Erdal Bizkevel Tamer Khatiba, “A review of islanding detection techniques for renewable distributed generation systems”, RENEWABLE AND SUSTAINABLE ENERGY REVIEWS, ELSEVIER, VOL28, Dec 2013, pages: 483-493

[3] Fatemeh ghalavand, Hossien Kazemi Karegar, “New Hybrid Islanding Detection In DC Link For Hybrid Networks”, 2017 25th Iranian Conference on Electrical Engineering (lCEE 2017)

[4] Robert Spousta, Steve Chan, “Electrical Islanding Detection based on the Integration of Synchronized Phasor Measurements”, FTC 2016 - Future Technologies Conference 2016, 6-7 December 2016 | San Francisco, United States

[5] Meng Hui Wang, Mei-Ling Huang, Kang-Jian Liou, “Islanding detection method for grid connected photovoltaic systems”, IET Renewable Power Generation

[6] Anila Antony, Devika Menon, “Islanding Detection Technique of Distribution GenerationSystem”, 2016 International Conference on Circuit, Power and Computing Technologies [ICCPCT]

[7] Emilio J. Estébanez, Víctor M. Moreno “Performance Evaluation of Active Islanding-Detection Algorithms in Distributed-Generation Photovoltaic Systems: Two Inverters Case”, IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 58, NO. 4, APRIL 2011

[8] Soumya R. Mohanty, Nand Kishor, “Comparative Study of Advanced Signal Processing Techniques for Islanding Detection in a Hybrid Distributed Generation System”, IEEE TRANSACTIONS ON SUSTAINABLE ENERGY, VOL. 6, NO. 1, JANUARY 2015

[9] Gustavo Marchesan, Matias Rossato Muraro, Ghendy Cardoso, Jr., Lenois Mariotto, and A. P. de Morais, “Passive Method for Distributed-Generation Island Detection Based on Oscillation Frequency”, IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 31, NO. 1, FEBRUARY 2016.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 06, June-2018

[10] Safdar Raza, Hazlie Mokhlis, "A Sensitivity Analysis of Different Power System Parameters on Islanding Detection", IEEE TRANSACTIONS ON SUSTAINABLE ENERGY, VOL. 7, NO. 2, APRIL 2016
[11] Hieu Thanh Do, Xing Zhang, "Passive-Islanding Detection Method Using the Wavelet Packet Transform in Grid-Connected Photovoltaic Systems", IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 31, NO. 10, OCTOBER 2016
[12] Fuwen Yang, Nan Xia, and Qing-Long Han, "Event-Based Networked Islanding Detection for Distributed Solar PV Generation Systems", IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS, VOL. 13, NO. 1, FEBRUARY 2017
[13] Ajit A. Renjit, Abrez Mondal, Mahesh S. Illindala, "Analytical Methods for Characterizing Frequency Dynamics in Islanded Microgrids With Gensets and Energy Storage", IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, VOL. 53, NO. 3, MAY/JUNE 2017
[14] Xiaolong Chen, Yongli Li, "An Islanding Detection Method for Inverter-Based Distributed Generators Based on the Reactive Power Disturbance", IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 31, NO. 5, MAY 2016
[15] Antonis G. Tsikalakis, Nikos D. Hatziargyriou, "Centralized Control for Optimizing Microgrids Operation", IEEE TRANSACTIONS ON ENERGY CONVERSION, VOL. 23, NO. 1, MARCH 2008
[16] Pavlos S. Georgilakis, Nikos D. Hatziargyriou, "Optimal Distributed Generation Placement in Power Distribution Networks: Models, Methods, and Future Research", IEEE TRANSACTIONS ON POWER SYSTEMS, VOL. 28, NO. 3, AUGUST 2013
[17] Guo-Kiang Hung, Chih-Chang Chang, Chern-Lin Chen, "Automatic Phase-Shift Method for Islanding Detection of Grid-Connected Photovoltaic Inverters", IEEE TRANSACTIONS ON ENERGY CONVERSION, VOL. 18, NO. 1, MARCH 2003
[18] Sung-Il Jang, Kwang-Ho Kim, "An Islanding Detection Method for Distributed Generations Using Voltage Unbalance and Total Harmonic Distortion of Current", IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 19, NO. 2, APRIL 2004
[19] Thomas Ackermann, Go¨ran Andersson, Lennart So¨der, "Distributed generation: a definition", Electric Power Systems Research 57 (2001) 195–204