ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 5, Issue 2, February 2018

A Comprehensive Review on Recent Development of Islanding Detection Method

[1] Diksha A.Shinde, [2] Prof. R. S. Somalwar
[1] M-tech (IPS) Student,[2] Assistant Professor
[1][2] Department of Electrical Engineering, DMIETR, Wardha, India

***Abstract* - Incredible growth in demand of electricity with efficient, reliable and eco-friendly power has motivated progress of distributed generation (DG). This is located at distribution system and now a day renewable energy sources used as a DG. But problem of using DG is unintentional islanding, which has perspective to make voltage and frequency out of synchronism and can damage equipment along with thoughtful issue of worker safety. Hence system should identify islanding and avoid its adverse effect. There are many islanding detection methods (IDM) but there is no such technique by which all the problems related to islanding being solved. In this paper new islanding detection technique is proposed on the basis of voltage ripple at inverter side of micro-grid base system. Its performance will be verified under wide range of operating condition in MATLAB/Simulink software.**

Index Terms— Distributed Generation (DG), Islanding Detection Method (IDM), Non-detection Zone (NDZ), Unintentional Islanding.

I. INTRODUCTION

In recent year there is tremendous increase in demand of electricity. Along with that requirement of efficient, reliable, environment friendly and cost effective power is necessity of today [1]. For this, there is need to modify the structure of present electric power system (EPS) which is designed for one way large power flow. Distribution generation sources are bidirectional and can fulfil the entire requirements. The energy source connected to utility grid at distribution level is called distribution generation (DG) unit. Most of the DG uses renewable sources such as solar, wind, fuel cell, mini-hydro plant etc. However a major problem of using DG sources in present EPS is unintentional islanding. Islanding is defined as the condition which occurs when part of EPS is unintentionally being fed by DG sources.

This phenomenon is hazardous to the life of a person under maintenance work and also it can damage the equipment because islanding has potential to make the line voltage and frequency go out of synchronization with the grid. Severe damage due to high current and large mechanical torque can develop when reclosing is done under such condition. Therefore islanding must be monitored and accurately detected as mandated in standard like IEEE 1547 [2]. Graph in figure1 shows the number of paper published in IEEE conference and journal on IDM in year 2005 to 2016. It shows growth in research related to IDM, and from 2011 researcher work on this area inherently.

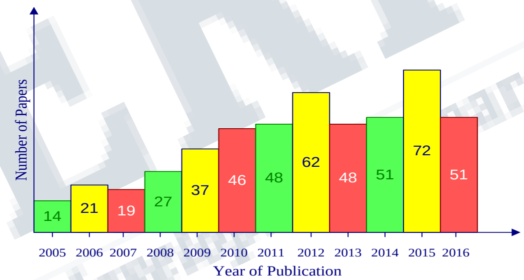

Fig1: Number of papers published in year 2005-2016

II. ISLANDING DETECTION METHOD

Many studies have been done to develop fast and strong IDM also called anti-islanding technique, which are categorized as shown in figure2 based on their measuring parameter and performance.

A. Local Islanding Detection Technique:

This IDM is subdivided into passive, active and hybrid IDM, and it is depends on the measurement of system parameter like voltage, frequency, power, etc. at local site.

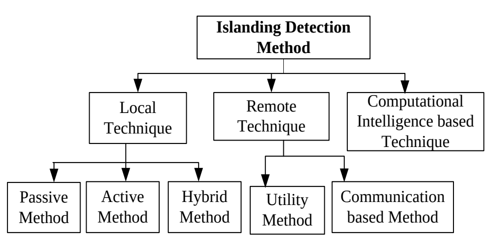

Fig.2: Comprehensive classification of IDM

IFERP
connecting engineers... developing research

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 5, Issue 2, February 2018

1. Passive Islanding Detection Method:

It is old and very popular IDM in which the system parameter varies greatly at PCC when a system gets islanded; these parameters are monitored and used for islanding detection on the basis of its threshold setting. Different types of passive IDM are given below.

***a) Over/ under voltage (OVP/UVP) and over /under frequency (OFP/UFP*):** Is oldest and simple time domain IDM, based on setting the permissible range of voltage and frequency at PCC [3-5]. In islanded case, change in real and reactive power delivered by grid is not equal to zero (ΔP& ΔQ≠0) then PCC voltage and frequency respectively will fluctuate. It has large NDZ with unpredictable reaction time.

b) Phase Jump Detection (PJD): It observers phase difference between PCC voltage (V_{pcc}) & output current of an inverter (I_{inv})[4-5]. Its implementation is easy, does not affect system stability and its effectiveness is unaffected by multi-DG, with detection time of 10-20ms, but PJD has NDZ.

c) Monitoring Voltage and Current Harmonics*:* It searches for the change in total harmonic distortion (THD) and 3rd, 5th &7th harmonics at PCC. Its effectiveness is unaffected by adding DGs and detection time is45ms [5]. However, it is difficult to meet threshold criteria and has some NDZ.

d) The rate of Change of Output Power (ROCOP): It observes rate of change of power (dP/dt) over defined sample cycle at DG output. It is efficient for large power mismatch but not for small, and has detection time of 24-26ms [3, 6].

e) The rate of Change of Frequency (ROCOF):A criterion used is the rate of change of frequency (df/dt) measured over 2-50cycles[7].Its detection time is about 24ms and is reliable in case of large power mismatch (P_{DG}≠ P_{load}), but fails to operate when there is no power mismatch (P_{DG}=P_{load}).

f) The rate of Change of Frequency over Power (ROCFOP): It works on the principle of monitoring the rate of change of frequency over load power (df/dP_L). It is highly reliable, efficient, has smaller NDZ, and detection time is 100ms [5].

g) Voltage Unbalance and Total Harmonic Distortion: It combines two passive methods, and is proposed and verified using radial distribution network of IEEE 32 bus system in [8]. It increases accuracy, but it is computationally expensive and its threshold selection depends on the system.

h) IDM based on ESPRIT: Is proposed in [9] in year 2011 using IEEE 34 bus system. It uses statistical signal processing algorithm for islanding detection having accuracy close to 100% and its detection time is about 150ms, but it has some NDZ in cases like zero power mismatch.

i) The angle between Negative Sequence Voltage & Current: It is proposed in 2014 by estimating absolute value of angle between negative sequence voltage and current at DG end in micro-grid. Its detection time is 5ms with small NDZ [5].

j) Change of Source Impedance: It monitors the change in system impedance at PCC due to change in switching frequency of inverter proposed in year 2015[10]. It is unaffected by presence of DG of different switching frequency with no NDZ. In islanded case, it doesn't include capacitor bank and transformer which affect its performance.

k) Oscillation Frequency: Is recently proposed in 2015, based on the estimation of frequency oscillation given in [11] for synchronous DG. Its detection time is less than 40ms with NDZ less than 1.6% of DG power.

l) ***Wavelet packet Transform:*** Is frequency domain technique proposed in year 2015[12], uses non-stationary frequency signal containing signature data capable of identifying islanding within 40ms, but it is expensive to implement.

m) Voltage Ripple based Method: Is time domain IDM proposed in [13] in 2016 and monitors the ripple content at PCC because in islanded condition this ripple increases considerably due to impedance change. Its detection time is 300ms with zero NDZ and is highly efficient.

All these IDM are easily implemented with minimal cost in micro-grid but NDZ is the major limitation. Recently developed voltage ripple based IDM has zero NDZ and can detect islanding faster without affecting system performance.

2. Active islanding Detection Method:

It works on the principle of adding small disturbances in some parameter of DG output by the inverter. In grid-connected mode added disturbances do not affect any due to stability effect of a grid otherwise; it leads to the change in parameters at PCC which can be used for islanding detection. Various active IDM are given below.

a) Active frequency Drift method (AFD): Its basic principle is to disturb the current waveform at PCC. Impedance based AFD is proposed in [14] 2015 using grid-tied inverter. It is simple with small NDZ and detection time is about 2s [3]. Implementation of AFD in multi-DG is complicated and requires extra precaution, it also affect power quality.

b) Frequency Jump (FJ) method: Is the modification of AFD, adds one dead zone at every three cycles in the current waveform and islanding can be detected by the change in voltage frequency. It is efficient with one DG, but its effectiveness decreases by adding multiple DG in parallel [3].

c) Impedance Measurement (IM): It changes the output current amplitude of DG which varies inverter output current in islanded case. It has small NDZ with 0.77-0.99s detection time. Efficiency decreases as DG increases [3].

d) Negative Sequence Current Injection: Is proposed in [15] 2008, adds the 2-3% negative sequence component in voltage source inverter, as in islanded case it contributes voltage unbalance. It is highly accurate and can detect islanding in 60ms also not sensitive to load changes, but has NDZ.

e) Phase-PLL perturbation: It adds disturbances at inverter output and observes voltage waveform at PCC using Goertzel algorithm, proposed in 2011[16]. It has detection time of 120ms, but it is complicated and has NDZ.

f) Virtual Capacitor/Virtual Inductor: [17] has proposed virtual inductor based IDM for grid-connected DG in year 2007 It affects system performance.

g) High-Frequency Signal Injection: In this IDM high-frequency impedance are measured at inverter terminal in micro-grid, and is proposed in [18] in year 2014 but is complicated and affect system performance.

h) Variation of Reactive Power: It searches deviation in frequency and voltage amplitude, and changes output power injected by inverter proposed in [19]2015. Its implementation is easy and detection time is 0.3-0.75s with small NDZ. It affects power quality and transient stability of system.

i) Sandia Frequency Shift (SFS) or Active Frequency Drift with Positive Feedback (AFDPF): For efficient operation even in multi-DG AFD utilizes positive feedback which increases chopping fraction and frequency deviation. Its detection time is 0.5s but affects the power quality of the system and has NDZ [3].

j) Sandia Voltage Shift (SVS): It is similar to the SFS in which inverter changes its current and power output by applying positive feedback to the voltage amplitude at PCC. In islanded case, output power changes and it accelerates the voltage drift. It is easy to implement, but it slightly disturbs power quality and reduces inverter efficiency [3].

k) Sliding Mode Frequency Shift (SMS) or Active Phase Shift (APS): It monitors frequency and utilizes positive feedback to vary voltage phase of PCC. It has small NDZ, detection time of 0.4s, and its implementation is easy, but it affects power quality and system transient stability [3, 15].

From above, it is observed that most of the methods do not have NDZ but deteriorate the power quality and affects performance of the system.

3. Hybrid Islanding Detection Method:

It combines feature of active and passive method to get advantages and overcome the drawbacks related to them. The active method works only when passive method unable to detect islanding. Some of the hybrid methods proposed from the year 2006-15 is summarized in table1.

Table 1: Taxonomy of Hybrid IDM

Technique	**Year of Propose**
SMS & PJD with Varying QF	2006
VU & Frequency Set point	2007
ROCOV and Real Power Shift	2009
SFS and Q-F Droop Curve	2010
Positive feedback and RPV	2013
SMS and Q-F Combination	2014
Q-f Droop & RPV	2014
Positive Feedback & VU	2014
NJSMS and Q-F	2015
SFS and ROCOF	2015

B. Remote Islanding Detection Technique:

This technique is classified as utility based and communication-based technique. Its sub-types are-

1. Utility Level Based IDM: Installs impedance of low value on utility grid, Ex. Impedance insertion, is efficient with zero NDZ, but expensive and reaction time is slow [3].

2. Communication-Based Method: It is based on communication between DG, grid protection and monitoring system, which are able to detect islanding. If voltage is observed on isolated DG side, then an alarm is activated and related circuit breaker is operated. Its types are Supervisory Control and Data Acquisition system (SCADA) [3], Power Line Carrier Communication (PLCC)[20], Synchrophasor or PMU [21], Auto-ground Switch, Signal Produced by

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 5, Issue 2, February 2018

Disconnect (SPD) [20] based IDM.

C. Computational Intelligence Based IDM

This technique uses an adaptive algorithm, which may be trained to identify islanding and non-islanding condition. Its examples are Artificial Neural Network (ANN), Adaptive Neuro-Fuzzy Interface System (ANFIS), Artificial Immune System (AIS), Fuzzy Logic Control, and Decision Tree (DT) Based IDM [22]. Computational intelligence based technique gives accurate islanding detection within short time but they are computationally expensive.

Table 2: Comparison of Islanding Detection Method

Technique / Parameter	Local Technique			Remote		Computational Intelligence Based
	Passive	**Active**	**Hybrid**	**Utility**	**Communication Based**	
Principle of Operation	Changes in system parameters are monitored at PCC	Add the Disturbance signal	Combines passive & active method	Install Specific equipment at utility side	Communication between DG & utility system	Uses adaptive algorithm with PCC parameter
Detection Time	Short	Long	Long	Long	Short	Short
NDZ	Large, but eliminated by recent technique	Small	Very Small	None	None	None
Influence on Power Quality	None	High	Very Small	None	None	None
Cost	Low	Low	Low	Very High	Extremely High	Medium
Multi-DG operation	Possible	Not possible	Possible	Possible	Possible	Possible
Effect on Distribution System	None	High	Low	None	None	None
Effectiveness	Depend on supply & load condition	Effective	Very effective	Very effective	Most effective	Most effective
Error Detection Rate	High	Low	Low	None	None	None
Effectiveness in Multi- inverter	Very Effective	Performance reduces	Effective	Effective	Highly Effective	Effective
Reliability	Low	High	High	High	High	High
Limitation	Selection of threshold setting is difficult	Affect power quality &stability of system negatively	Accuracy is small with long detection time	Expensive and its reaction time is slow	Very expensive and complicated in design	Accuracy reduces with change in topology of system

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 5, Issue 2, February 2018

III. PROPOSED WORK

Figure 3 shows the single line diagram of single phase grid connected micro-grid system containing two DG with single phase inverter connected in parallel, which will analyzed for various conditions using MATLAB/Simulink software. An inductor (L) filter with a capacitor bank is used to filter out the harmonics produced by the high frequency switching in the inverter. Two DG with single phase inverter forms the micro-grid which is connected to the parallel RLC load and utility grid through coupling transformer at point of common coupling (PCC). Ac power output of inverter is synchronized with the utility grid using a phase locked loop (PLL). Islanding condition is simulated by opening the contacts of circuit breaker connected between grid and PCC. For monitoring parameters at different condition, voltage and current sensors are used at different position. Simulation specifications of proposed system are shown in table 3.

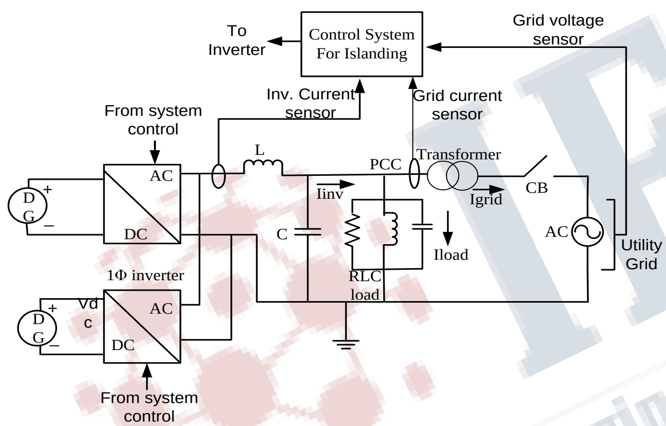

Fig: Fig.3: Single line diagram of proposed system

Table 3: simulation parameter of proposed system

Parameter	Value
PV array maximum power output	1kW
Load active power	1 kW
System frequency	50 Hz
Dc link Voltage V_{dc}	400 V
Load quality factor	1
Filter Inductance L	30mH
Grid voltage	1phase, 230V

A passive IDM based on finding voltage ripple at inverter side of micro-grid using time domain spectral analysis will be proposed and it will analyzed for different load condition such as $P_{DG}>P_L$, $P_{DG}<P_L$, $P_{DG}=P_L$, where PDG & PL are DG and load power.

IV. DISCUSSION

All the IDM with detail is given in this paper from that it is seen that conventional passive methods are easy to implement, does not affect system and non-expensive but it has large NDZ in cases like zero power mismatch. The active method gives accurate islanding detection without any NDZ; however, it increases the complexity and affects the stability of system inversely. The hybrid method combines advantages of the active and passive method and it has small NDZ with reduced power degradation, but the issue of accuracy and detection time remains unsolved. Remote techniques are efficient without any NDZ but its design is complicated and expensive, and relatively slow in case of system disturbances. Computational intelligence based IDM is robust technique without any NDZ, but a drawback is; if the topology of power system changes (extra load or generator is added or removed) the data will change and this will decrease its accuracy and it require extensive training. Comparative analysis of IDM with twelve different parameters is given in table 2. After the above review, it is observed that there is no such technique by which all the problems related to IDM being solve. Hence paper is going to propose new computationally proficient passive IDM based on finding ripple content in the voltage at inverter side of the given system by taking the reference of technique given in [13].

V. CONCLUSION

Review of all IDM with their desired traits is done in this paper for the recent development in micro-grid and distributed energy resources. As unintentional islanding is annoying and destructive, it should be detected within minimal time and appropriate action must be taken to evade it. Many researches were done on IDM are given in this paper with their comparison on different parameter and it is cooperative for getting correct method for definite application. A new IDM will be introduce in future, based on finding ripple content of voltage at inverter side for given single phase grid connected micro-grid system and it will be analyzed for different load condition.

REFERENCES

[1] J. Heeter, T. Nicholas," Status and Trend in the U.S. voluntary green power market (2012 data)," National Renewable Energy Lab, Golden, CO, USA, Tech. Rep. NREL/TP-6A20-60210, Oct. 2013.

[2] "IEEE standard for interconnecting distributed resources with electric power systems," IEEE Std.1547.2-2008, pp. 1-217, April 2009.

[3] W. Bower, M. Ropp," Evaluation of islanding detection method for utility interactive inverters in PV systems," Sandia National Lab., Albuquerque, NM, USA, TECH. Rep. SAND2002-3591, 2002.

[4] W. Y. Teoh, C. W. Tan," An overview of islanding detection methods in photovoltaic systems," World Academy of science, E&T Int. Journal of Electrical, CS. E&C Engineering, Vol. 5, no. 11, pp. 1337-1344, 2011.

[5] C. Li, C. Cao, Y. Cao," A review of islanding detection method for micro-grid," Renewable and Sustainable Energy Reviews, Vol. 35, pp. 211-220, 2014.

[6] P. Mahat, Z. Chen, B. Bak-Jensen," Review of islanding detection methods for distributed generation," IEEE Int. Conf. on Electrical Deregulation, Restructuring & Power Tech, Vol.3 Pp. 2743-2748, April 2008.

[7] Wen-Yeau Chang, Hong-Tzer Yang," An integrated passive islanding detection method for DG," WSEAS Trans. on Systems, Vol. 8, no.11, pp.1207-1216, Nov.09.

[8] Vivek Menon, M. H. Nehrir," A hybrid islanding detection technique using VU and frequency set point," IEEE Trans. on PS, Vol.22. No.1, Pp.442-448,Feb.07.

[9] W. Najy, H. Zeineldin, A. Alaboudy, W.Woon," A Bayesian passive islanding detection method for inverter-based distributed generation using ESPRIT," IEEE Trans. PD, Vol.26, No. 4, pp2687-2696, Oct. 2011.

[10] P. Yazdkhasti, C. P. Diduch," An islanding detection method based on measuring impedance at the point of common coupling," IEEE Conf. on Electrical & Computer Eng. Vol.28, Pp.57-62, May 2015.

[11] G. Marchesan, M.R. Muraro, G. Cardoso, L. Mariotto, A.P. de Morais," Passive method for distributed island detection based on oscillation frequency," IEEE Transaction on Power Delivery, 2015

[12] H. T. Do, X. Zhang, N. V. Nguyen, ShanShou Li, Tho T. Chu," Passive islanding detection method using wavelet packet transform in grid-connected photovoltaic systems," IEEE transaction on power electronics, 2015.

[13] B. Guha, R. J. Haddad, Y. Kalaani," Voltage ripple based passive islanding detection technique for grid-connected photovoltaic inverters," IEEE PS Technology Systems Journal, Vol.3, No.4, pp.143-154, Dec 16.

[14] Bo Wen, D. Boroyevich, R. Burgos, Z. Shen, P. Mattavelli," Impedance-based analysis of active frequency drift islanding detection for grid-tied inverter system," IEEE Trans. on Industry Application,2011.

[15] H. Karimi, A. Yazdani, R. Iravani," Negative sequence current injection for fast islanding detection of a distributed resource unit,' IEEE Transaction on Power Electronic, Vol. 23, No. 1, pp. 298-307, Jan 2008.

[16] D. Velasco, C. Trujillo, G. Garcer, E. Figuerer," An active anti-islanding method based on phase PLL perturbation," IEEE Transaction on Power Electronics, Vol. 26, No.4, pp. 1056-1066, April 2011.

[17] H. Jou, W. Chiang, J. Wu," virtual inductor based islanding detection method for grid-connected power inverter of distributed power generation system," IET Renew. Power Gen. pp. 175-181, 2007.

[18] F. Briz, D. Diaz-Reigosa, C. Blanco, J. Guerrero," Coordinated operation of parallel-connected inverters for active islanding detection using high-frequency signal injection," IEEE Transaction on Industry Appl, 2013.

[19] X. Chen, Y. Li," An islanding detection method for inverter-based distributed generators based on the reactive power disturbance," IEEE Trans. on PE, 2015.

[20] W. Xu, G. Zhang, C. Li, W. Wang, G. Wang, J. Kliber," A power line signaling based technique for anti-islanding protection of distributed generators – part 1: Scheme and analysis," IEEE transaction on power delivery, Vol.22, No.3, pp.1758-1766, July 2007.

[21] Y. Guo, K. Li, D. Laverty, Y. Xue," Synchrophasor based islanding detection for distributed generation systems using systematic principle component analysis approaches," IEEE Trans. on Power Delivery, 2015.

[22] J. Laghari, H. Mokhils, M. Karimi, A. Bakar, H. Mohamad," Computational intelligence based techniques for islanding detection of distributed generations in distribution network: a review," Energy Conservation and Management, Vol.88, pp. 139-152, 2014.