ISSN No:-2456-2165

A Paper on use of Passive Techniques for Islanding Detection

Mubarak Rashid
Department of Electrical Engineering,
Ganga Institute of Technology and Management,
Kablana, Jhajjar, Haryana, India

Abstract:- Customers are calling for higher power reliability and performance from the power sector to shift for disrupted generations as a result of the development in new technologies like as fuel cells, wind generators, photovoltaic and other breakthroughs in power electronics. Due to environmental concerns, distributed generation (DG) is the primary source and aim in the electricity business. However, islanding is the idea gained after a part of a power system electrically isolates itself from the rest of the network while being powered by distributed generators. The capacity of a DG to identify the islanding is a key idea that emerges at this point. The present industry is working on the issue of isolating the distribution generator from the entire system on the fault occurrence because the failing of which might harm the DG and the loads. So every distributed generator must have been equipped with such an islanding sensing element, generally known as an anti-islanding devices, like a ROCOF relay or a vector surge relay, in order to do this.

Keywords:- *islanding detection, islanding, issues with islanding, methods of detection, proposed technique, conclusion, scope for future*.

I. INTRODUCTION

This thesis addresses a specific issue that arises at the point where a dispersed generating facility interacts with the remaining of the electrical network. A power system islanding detection might be used to describe the issue. In the recent years, the issue has received much research and discussion. Later in the thesis, the numerous techniques that may be utilised to identify the islanding will be presented. The least squares method is primarily suggested in this study and is well discussed.

II. ISLANDING DETECTION FOR DISTRIBUTED GENERATION

This paper propose a brand-new approach to islanding detection which can be performed on power distribution buses with a 25KV or lower voltage and is intended to safeguard DG fueled systems. This process known as islanding can be defined as when a portion of the non-utility generating units is disconnected from the main electricity network, is frequently thought to be undesirable due to the risk of existing equipment being damaged, utility liability issues, and a decline in power quality and reliability. Current islanding detection techniques typically keep an eye on over/under voltage, current, and frequency conditions both passively and actively, but each technique has a – anti operating condition with different degrees of power quality malfeasance that is referred to as the "non detection zone" (NDZ). The islanding detection approach created in this paper uses the existence of naturally occurring and intentionally created unbalanced circumstances to expand the theoretically correct idea of impedance measurement into symmetrical component impedance domain. A generalised approach enables the protecting engineer to decide when this method may be utilised most successfully by exploring specific scenarios where such a islanding detection method outperforms current methods.

III. ISLANDING

As depicted in fig. 1, islanding can be defined as the process by which a part of the distribution network gets electrically separated from rest of the network while still being powered from DG connected to it. With DG, this assumption is no longer true because a distribution system no longer has any active power production sources inside of it and no longer loses power when a transmission line fault occurs upstream. Almost all utilities now mandate that DG be immediately removed from the grid in the event of islanding. Islanding may occur accidentally or on purpose. Islanding of generators may occur when the electrical grid is shut down for maintenance work. Because of the loss of a grid is voluntary, the islanding is termed as unintentional islanding, which is more interesting.

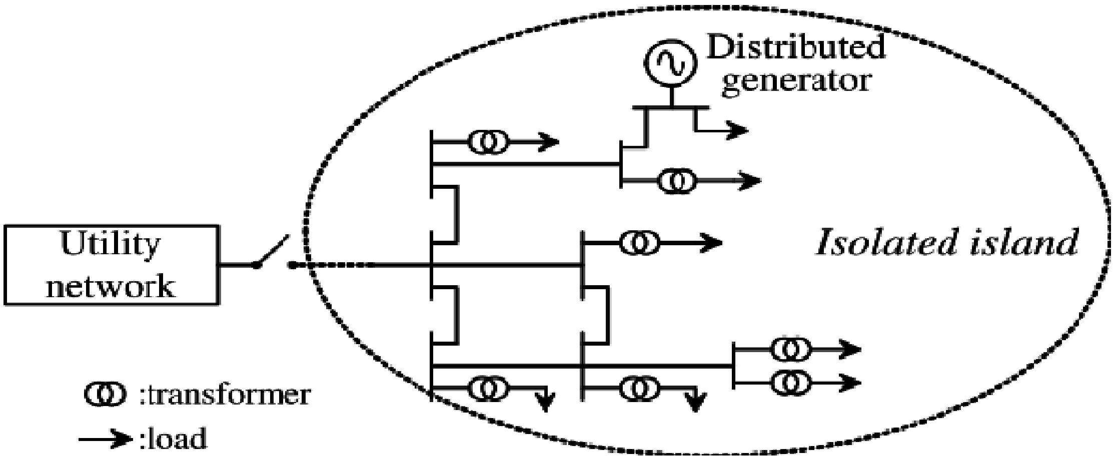

Fig. 1: Scenario of islanding operation

IV. ISSUES WITH ISLANDING

Although islanding operations provide certain advantages, there are also some disadvantages. The following are a few of them:

- DG sources supplying a network when primary exciting sources have already been isolated and marked out may endanger the safety of line workers.
- A specified allowable level may not be maintained for the voltage and frequency.
- The DG interconnection may not effectively ground an islanded system. A sudden reclosing might cause the DG to close out of phase. Huge mechanical torqueses as well as currents are thus produced, endangering the prime movers' generators. Additionally, transients are produced, which might harm electrical as well as other equipment.
- The degeneration of the electrical parts as a result of voltage and frequency fluctuations is just one of the problems that might emerge from this.

These factors make it crucial to precisely and promptly identify islanding.

V. METHODS OF DETECTION

Techniques for detecting islanding rely on connectivity between utilities and DGs. These strategies may be more reliable than those used locally, but they are more expensive to apply, making them uneconomical. The following are some methods for detecting faraway islands:

- Active methods
- Passive methods
- Hybrid methods

Passive techniques of detection are most frequently utilised.

A. PASSIVE METHODS

Passive approaches measure system characteristics including voltage, frequency, harmonic distortion, and other fluctuations. Whenever the system is islanded, these characteristics differ significantly. The thresholds chosen for the above parameters are used to determine whether a situation is islanding or not. Choosing the threshold value requires special consideration in order to differentiate between islanding and other network/system disorders. Although passive approaches are quick and don't disturb the network, they also have a significant Non-Detectable Zone (NDZ) where they are unable to identify the isolation state.

Several methods for detecting passive islanding can be used, some of which are as follows:

- Rate of change of reactive power
- Rate of change of frequency(RCOF)

B. Rate of change of reactive power

According to this plan, DG produces a certain amount of reactive power either at the Reed relay connection point or at the Point of Common-Coupling (PCC) lying between distribution generator point and the power grid. Only once power grid is linked this electricity flow continue. If somehow the degree of reactive power flow isn't really kept constant at the prescribed value, then islanding is detected. By periodically raising internal induced emf/voltage of the synchronous generator-based DG and observing the voltage change and reactive power just at point where the distribution generator is attached to the distribution system, islanding may be identified. Islanding is indicated by a significant shift with in terminal voltage and a nearly unchanged reactive power. This method's main disadvantages are that it is sluggish and that it cannot be utilised in a system where the DG must provide electricity with a unity power factor.

This approach is based on calculating the reactive power change rate (dq/dt) on the DG side. The (dq/dt) before and after islanding scenarios will differ significantly.

C. Rate of change of frequency

Whenever the distribution generator is isolated, its RCOF, df/dt, will be quite high. We can determine its ROCOF by

ROCOF, $(df/dt)=(\Delta p/2HG)*f$

p = power imbalance on the generator side.
H = DG/system's moment of inertia.
G = DG/system's rated generating capacity.

Tiny systems contain small H & G whereas large systems have high H & G, resulting in a greater value of df/dt. The frequency rate change (RCOF) relay keeps track of waveform of the voltage and activates if the RCOF is greater than specified value for a reliable amount of time. The configuration must be specified so that the relay activates only in the event of an island state and not when the load changes. This strategy doesn't work if the DG's capacity equals its local loads, but it is quite dependable when there is a significant power discrepancy. However, this approach and the change rate of power algorithm have the benefit that even when they are unable to identify islanding due to load and generation mismatches in the islanded system, any new instance load change would often result in islanding being identified.

VI. PROPOSED TECHNIQUES

Phasor measuring unit (PMU) is one of the techniques used in synchronised wide area measurements (WAM) to detect RCOF.

Phasor voltage signal and frequency measurements are performed using least square phasor estimation method. Voltage and current signals frequently contain noise, which can cause phasor estimation errors. Least square estimation across a suitable data window has also been used to estimate the input voltage signal's frequency.

A. *Phasor estimation algorithm using least square method*

Considering a voltage signal of single phase that has been tampered with by Gaussian noise ϵ(t)

$x(t) = XmCos(\omega t+\phi) + \epsilon(t)$ (1)

And to get the following results, the x(t) signal is evenly sampled N times throughout each cycle:

$Xn = XmCos(2\pi n/N+\phi) + \varepsilon_n$ (2)

ϕ = phase angle

Xm = magnitude of peak voltage

ω = nominal frequency (radians)

ε_n = zero Gaussian noise having variance of σ².

Also phasor of given signal is as:

$$X = \frac{X_m}{2} e^{j\omega} = X_r + jX_i$$

$$X_n = X_m \mathrm{Cos}(\phi)\mathrm{Cos}(n\theta) - X_m \mathrm{Sin}(\phi)\mathrm{Sin}(n\theta)$$

Where $\theta = \frac{2\pi}{N}$

$$X_n = X_r \mathrm{Cos}(n\theta) - X_i \mathrm{Sin}(n\theta) \quad (3)$$

By employing a data window of M samples, it is possible to approximate the ascertain phasor from collected data.

$Vk = VmSin(\theta k)Cos(\theta v) + VmCos(\theta k)Sin(\varphi v)$

$Vk\text{-}1 = VmSin(\theta k\text{-}1)Cos(\varphi v) + VmCos(\theta k\text{-}1)Sin(\varphi v)$

$Vk\text{-}2 = Vm\ Sin\ (\theta k\text{-}2)Cos\ (\varphi v) + V\ Cos\ (\theta k\text{-}2)\ Sin(\varphi v)$

Where $\theta_k = \omega t_k$

Arranging the equations in the matrix format we get

$$\begin{bmatrix} Vk \\ Vk-1 \\ Vk-2 \end{bmatrix} = \begin{bmatrix} Sin(\theta k) & Cos(\theta k) \\ Sin(\theta k-1) & Cos(\theta k-1) \\ Sin(\theta k-2) & Cos(\theta k-2) \end{bmatrix} \begin{bmatrix} VmCos(\phi v) \\ VmSin(\phi v) \end{bmatrix}$$

(4)

Showing in the form of matrix:

[x] = [B][X] +[ϵ] (5)

Coefficients of [X] can be found from solution of least square method by using [B], which decreases the sum $[[\epsilon]^T[\epsilon]]$ i.e.

$$Q = \sum_{n=0}^{N-1} \varepsilon_n{}^2 :$$

The of error vector's covariance matrix is assumed to be :

$W = \sigma^2[I]$.

Hence the solution of least square of =n (4) to provide estimated phasor is:

$$[X] = [B^TW^{-1}B]^{-1}[B^TW^{-1}][x] = [B^TB]^{-1}[B]^T[x] \quad (6)$$

One benefit of the least square approach over discrete Fourier transform is that least sruare approach can be used to compute phasors by using the fractional cycle of data windows, which are frequently employed in creating applications of high-speed relaying. B^TB does not generate a simple matrix if samples of M number are used to estimate the sinusoidal input phasor signal collected with a rate of N number of samples per cycle in such a way that M is fewer than N, which increases the computational cost.

Thus, is same as the standard deviation for error in phasor estimation. Because of this, the error is reduced when sampling rates are greater or larger data windows are employed. The predicted phasor angle is not consistent throughout time. The predicted phasor angle rotates once every power system cycle under steady state circumstances because it varies at a set rate. Each sample causes the phasor angle to grow by 2N radians. The phase angle must be normalised using some reference since it is helpful for analysis if it remains unchanged under steady state conditions. The reference $e^{-j\omega n}$ has already been utilised. In which ω = 2ωN . Every time the power system cycles, it makes one spin that is the reverse of what the phasor predicted. To generate a normalised phasor, every sample of estimated phasors acquired using the above procedure is multiplied with this reference phasor.

B. Frequency estimation algorithm using least square method

We have seen the phase angles calculated in previously are utilised to calculate the frequency s well as change of frequency (COF). The rotational speed of the phasor is referred to as frequency. A representation of the phase angle at any moment is as follows:

$$\varphi\ t = \int \omega(t) = \varphi_0 + \Delta\omega t + t^2\omega'/2 \qquad (7)$$

Where ωt is the frequency in radians, Δω is the frequency change, and ω′ is the frequency change rate. Tș being sampling time, the measurements of the angle between phases of the vector with length N is obtained by:

$$\begin{bmatrix}\varphi_0\\ \varphi_1\\ \varphi_2\\ \bullet\\ \bullet\\ \varphi_{N-1}\end{bmatrix} = \begin{bmatrix}1 & 0 & 0\\ 1 & T_S & T_S^{\ 2}\\ 1 & 2T_S & 2^2T_S^{\ 2}\\ \bullet & \bullet & \bullet\\ \bullet & \bullet & \bullet\\ 1 & (N-1)T_S & (N-1)^2T_S^{\ 2}\end{bmatrix}\begin{bmatrix}\varphi_0\\ \Delta\omega\\ \omega^{','}\end{bmatrix} + \begin{bmatrix}\varepsilon_{\varphi 0}\\ \varepsilon_{\varphi 1}\\ \varepsilon_{\varphi 2}\\ \bullet\\ \bullet\\ \varepsilon_{\varphi N-1}\end{bmatrix}$$

It is anticipated that the vector [φ] will change monotonically across the window of "N" samples.

Using the matrix form we get:

$$\varphi = [A][F] + [\epsilon] \qquad (8)$$

The left pseudo-inverse of [A] is used to get the coefficients [F] using the least squares method, which minimises the sum $[[\epsilon]^T[\epsilon]]$.

$$F = [A^TA]^{-1}[A]^T[\varphi] \qquad (9)$$

$$\text{COF}(\Delta f) = \frac{\Delta\omega}{2\pi}$$; and thus the frequency can be obtained as ;

$f = f_0 + \Delta f$;

where f_0 is the nominal fundamental frequency.

VII. CONCLUSION

The various methods used for islanding detection are discussed as well as compared in this paper. We can see that one of the major problems in today's power system is the quick and accurate pinpointing of islanding, as many distribution networks have seen quite DG penetration and there are not many problems related to islanding that still need to be cleared. In distributed systems the management of islanding is viewed as a major alternative to increase supply transfer and quality in future, hence islanding identification is crucial.

VIII. FUTURE SCOPE

- More research is needed to address the issues brought on by unexpected load changes that might result in false alarms during the islanding detection procedure.
- More research has to be done on the issue caused by the Non-detection Zone (NDZ). The primary performance indicator for any islanding procedure is NDZ.
- On a power distribution network that complies with IEEE standards and has numerous DG interfaces, the performance of the suggested solutions will be examined.

REFERENCES

[1.] America recovery and reinvestment act of 2009. “Synchrophasor technologies and their deployment in the recovery act smart grid program”,US department of energy. August 2013.
[2.] “C37.118-2005 - IEEE Standards for Synchrophasors for Power System”, IEEE power engineering power system relaying society, pp. 1-57, 03 April 2006.
[3.] IEEE. Standard 15477M. “Standard for interconnecting Distributed
[4.] Resources with EIectric Power Systems”, June 2003.
[5.] K. E Martin, D. Hamai, M. G. Adamiak, S. Anderson and M. Begovic, “Exploring the IEEE Standard C37.118–2005 Synchrophasors for Power Systems”, IEEE Transactions on Power Delivery, Vol. 23, No. 4, October 2008.
[6.] L. Chang, C. Diduch, and P. Cusack, "Development of standards for interconnecting distributed generators with electric power systems," IEEE Canadian Conference on Electrical and P o I Y ~) Engineering., Montreal. May, 2003.