Islanding Detection Method Based On Impedance Measurement

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ABSTRACT: *Distributed generators (DGs) require detection of islanding condition due to personnel safety hazards and equipment damages. A new islanding detection method based on impedance measurement at the point of common coupling is studied. With this method, the D.G. (Distributed Generator) connected to grid is supplying power to the plant (acting as a load), when grid is disconnected then variation in impedance at the point of common coupling is measured. When the grid becomes unavailable, the variation in impedance is considerably higher than that of the preset threshold value, this variation is enough to indentify the islanding. In addition, this method is highly robust to different grid disturbances and stiffness and effective for multiple DGs running in parallel*

Keywords -*Distributed generation, interconnected system, Islanding detection, non detection zone, Remote techniques.*

Introduction

Recently, due to environmental pollution and exhaustion of fossil fuel, distributed generation (DG) system using renewable energy source including wind power, micro-hydro, solar photovoltaic and landfill gas has become one of the main issues. Distributed generation (DG) may make a contribution to improve quality of power, minimize peak loads and eliminate the need for reserve margin, high efficiency operation and safety. An islanding condition occurs when the DGs and local loads are disconnected from the grid, the DGs keep supplying the power into the local loads [1][2]. Unintentional islanding of the DGs gets results such as low power-quality, interference to grid-protection devices, equipment damage, and even personnel safety hazards. Most DGs may be connected in parallel and supply power into power grids as well as local loads. Therefore, DG must be operated in such an inherently safe manner that DG should supply the generated power to the network loads only if the utility power supply is present.[3] If DG is feeding the power to the networks without the utility supply, then it produces several negative impacts on utility power system and the DG itself, such as the safety hazards to utility personnel and the public, the quality problems of electric service to the utility customers, and serious damages to the DG if utility power is wrongly restored [4].Therefore, during the interruptions of utility power, the connected DG must detect the loss of utility power and disconnect itself from power grid as soon as possible. This paper deals with a particular problem that occurs at the interface between a distributed generation plant and the rest of the power system. The problem can be described as islanding detection in power systems. The problem has been investigated and discussed extensively in the last few years [5][6].

Recent interest in distributed generator installation into low voltage busses near electrical consumers has created some new challenges for protection engineers that are different from traditional radially based protection methodologies. Islanding is the situation in which a distribution system becomes electrically isolated from the remaining power system, yet the load continuously energized by DG connected to it.

EXISTING ISLANDING DETECTION TECHNIQUES

Islanding detection techniques can be divided into remote and local techniques and local techniques can further be divided into passive, active and hybrid techniques as shown in Figure 1[6].

Remote islanding detection techniques are based on communication between grid and DGs. Although these techniques may have better reliability than local techniques, they are expensive to implement and hence uneconomical [1] [2] .Some of the remote islanding detection techniques are as follows[6]:

- Power Line Signaling Scheme
- Transfer Trip Scheme

Local detection Techniques are based on the measurement of system parameters at the DG site, like voltage, frequency, etc [3]. It is further classified as

- Passive Detection Techniques
- Active Detection Techniques
- Hybrid Detection Techniques

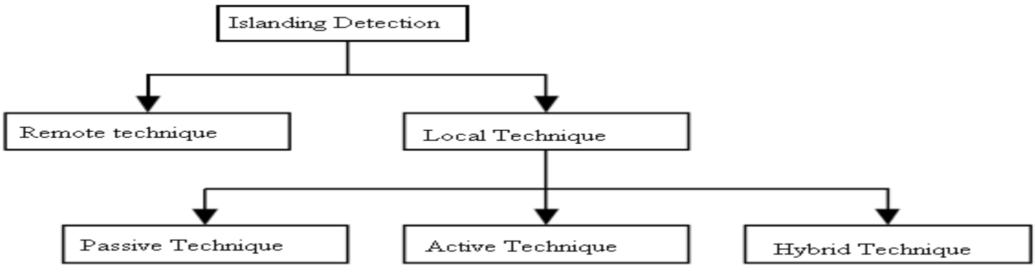


Figure1: Islanding detection techniques

Passive Detection Technique

Passive detection technique is that technique which uses the grid parameters and measurements (voltage, frequency, harmonic content, etc.) in order to detect islanding operation. The boundary limits of these parameters define the non detection zone (NDZ). If the local loads have similar power capacity of the DG system, i.e., all the generated power is consumed locally, then voltage and current levels at the point of common coupling (PCC) will only vary slightly when islanding occurs.[1][4] The system variables will be then within the boundary limits and the islanding condition will remain undetected. Passive methods have, therefore, a large NDZ. This technique is conceptually simple and easy to implement and do not introduces any change to the power quality of the system.[6]

Active Detection Technique

Active detection technique directly interacts with the power system operation by introducing perturbations. In this technique, a perturbation is injected in the current waveform to drive one of the system parameters out of its limits during islanding operation [1][2]The idea of this technique, is that a small perturbation will result in a significant change in system parameters when the DG is islanded, whereas the change will be negligible when the DG is connected to the grid. In order to reduce the NDZ, particularly in cases where the local loads are close in capacity to the DG system active detection technique has been proposed. [6]

Hybrid Detection Technique

Hybrid detection technique employs both the active and passive detection techniques. The active technique is implemented only when the islanding is suspected by the passive technique.[6]

COMPARISONS OF ISLANDING DETECTION TECHNIQUES

Islanding Detection Techniques	Advantages	Disadvantages	Examples
1. Remote Techniques	Highly Reliable	Expensive to implement specially for small system	• Transfer trip scheme • Power line signaling scheme
2. Local Techniques a) Passive Techniques	• Short detection time • Do not perturb the system • Accurate when there is a large mismatch in generation and demand in the islanded system.	• Difficult to detect islanding when the load and generation in the islanded system closely match • Special care has to be taken while setting the thresholds • If the setting is too aggressive then it could result in nuisance tripping	• Rate of change of output power scheme • Rate of change of frequency scheme • Rate of change of frequency over power scheme • Change of impedance scheme • Voltage unbalance scheme • Harmonic distortion scheme

b) Active techniques	• Can detect islanding even in a perfect match between generation and demand in the islanded system (Small NDZ	• Introduce perturbation in the system • Detection time is slow as a result of extra time needed to see the system response for perturbation • Perturbation often degrades the power quantity and if significant enough, it may degrade the system stability even when connected to the grid	• Reactive power export error detection scheme • Impedance measurement scheme • Phase (or frequency) shift schemes (like SMS, AFD, AFDPF and ALPS
c) Hybrid Techniques	• Have small NDZ. • Perturbation is introduced only when islanding is suspected.	• Islanding detection time is prolonged as both passive and active technique is implemented	• Technique based on positive feedback and voltage imbalance • Technique based on voltage and reactive power shift.

Table 1: Comparisons of islanding detection techniques [5]

Islanding Detection Based on Impedance Measurement

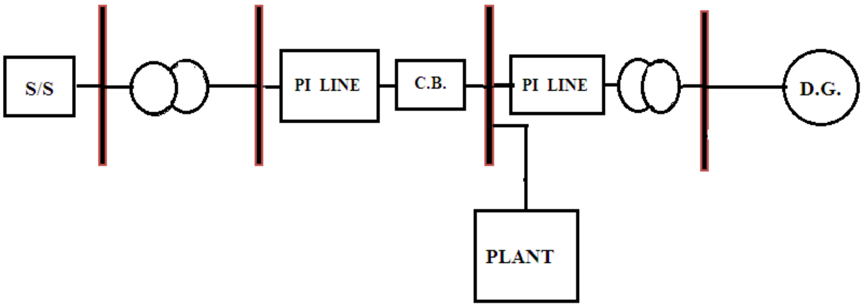


Figure 2: Single line diagram of distributed system with DG

Islanding is the situation in which a distribution system becomes electrically isolated from the remaining power system, yet continues to be energized by DG connected to it. Distributed or dispersed generation may be defined as generating resources other than central generating stations that is placed close to load being served, usually at customer site. It serves as an alternative to or enhancement of the traditional electric power system. The commonly used distributed resources are wind power, photo voltaic, hydro power. The figure-2 shows the single line diagram of the distribution system with DG.

The model used shown in figure-2 is having a wind farms using detailed model of a Doubly-fed Induction generators (DFIG) driven by a wind turbine. The wind farm consists of wind turbines connected to a grid through a feeder, a load and filter is connected at the generation bus. Wind turbines using a doubly fed induction generator (DFIG) where the stator winding is connected directly to the grid while the rotor fed at variable frequency. The DFIG technology allows extracting maximum energy from the wind for low wind speeds by optimizing the turbine speed, while minimizing the mechanical stress on the turbine during gusts of wind. The optimum turbine speed producing maximum mechanical energy for a given wind speed is proportional to the wind speed. The wind speed is maintained constant.

The voltage and current signals are retrieved and corresponding impedance is measured at the target DG location for islanding conditions and non-islanding conditions. The relay for DG unit is placed at the DG end to collect the voltage and current information for both islanding and non-islanding conditions. The possible situations of islanding conditions are as follows:

- Tripping of main circuit breaker (CB) for islanding conditions
- Loss of power on the PCC bus.

- Sudden load change at the target DG location.

The above conditions are simulated under possible variations in operating loading at normal and islanded conditions. The complete simulation is carried out using MATLAB-SIMULINK software.

Result

The islanding detection method described in this paper is implemented in Matlab & Simulink software for grid connected to distributed generator supplying the load The comparison between islanding and non-islanding conditions (normal operation) is carried out and experimental results obtained on the basis of voltage, current, active power & reactive power measurements are as follows:

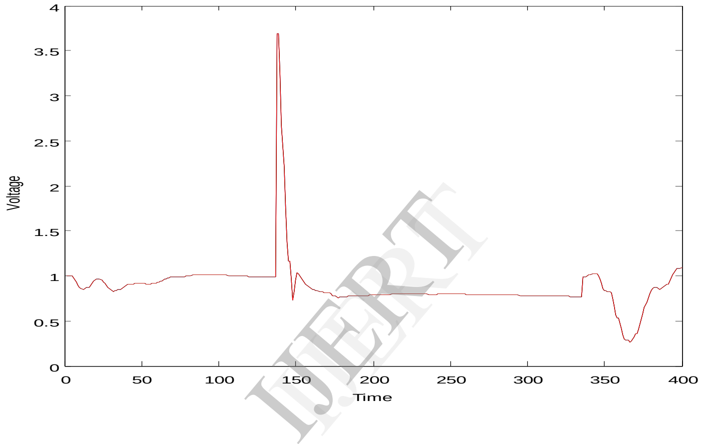


Figure 3 Simulink result of voltage waveform for non-islanding condition

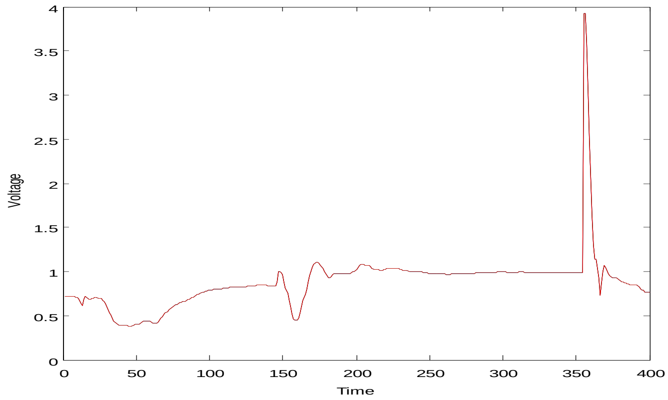


Figure 4 Simulink result of voltage waveform for islanding condition

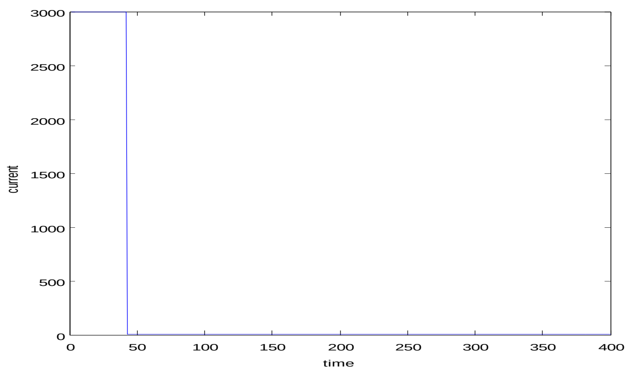


Figure 5 Simulink result of current waveform for non- islanding condition

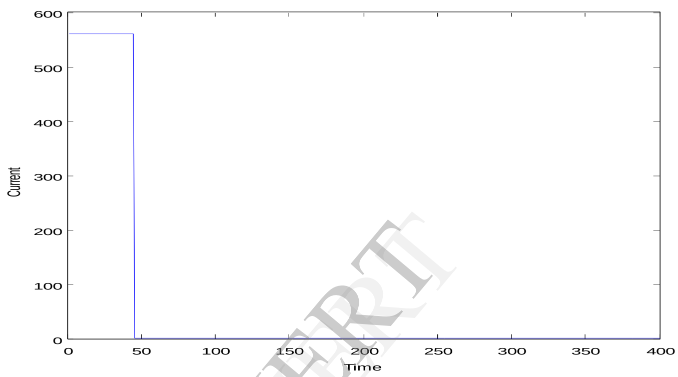


Figure 6 Simulink result of current waveform for islanding condition

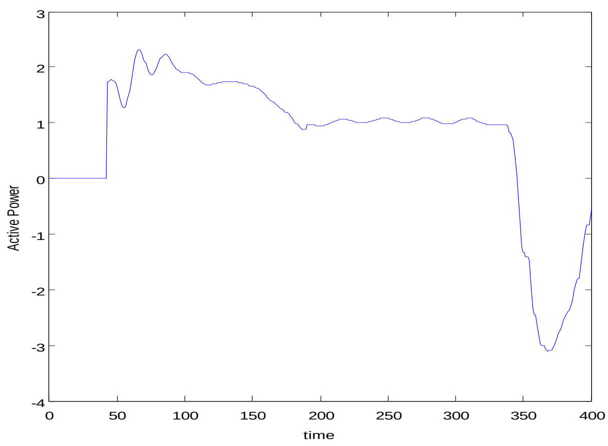


Figure 7 Simulink result of active power waveform for non-islanding condition

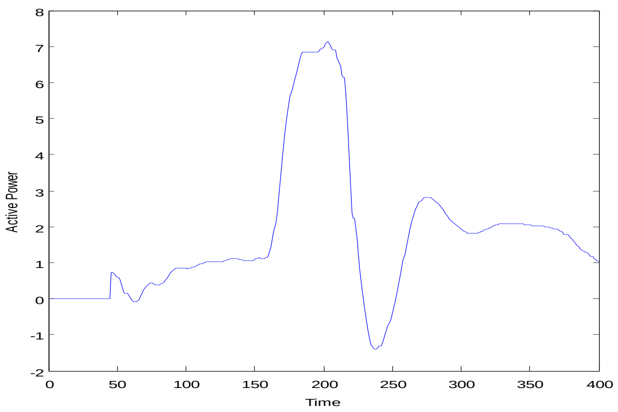


Figure 8 Simulink result of active power waveform for islanding condition

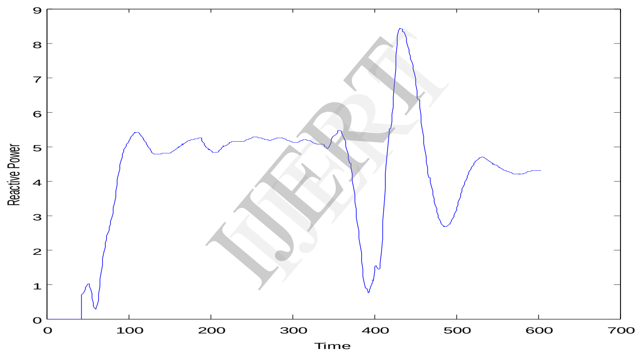


Figure 9 Simulink result of reactive power waveform for non-islanding condition

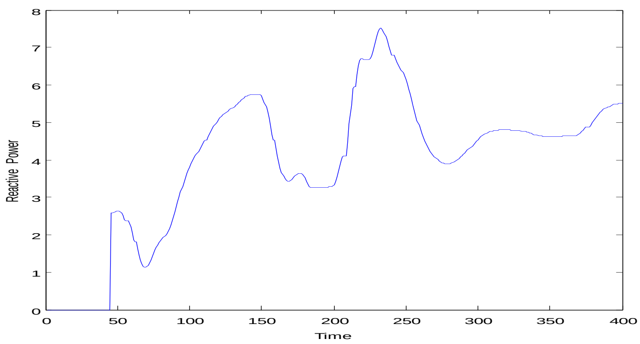


Figure 10 Simulink result of reactive power waveform for islanding condition

Proposed Method for Islanding Detection

As the experiment is carried out there is considerable variation in impedance measured at point of common coupling as shown in figure 11 (for non-islanded condition) and figure 12 (for islanded condition)at the target DG location. Thus the impedance seen at the target DG location has been computed to detect the islanding conditions. The impedance has been one of the key indicators in disturbance conditions such as islanding process. Thus, during the islanding process, the impedance provides vital information which can be effectively used for islanding detection.

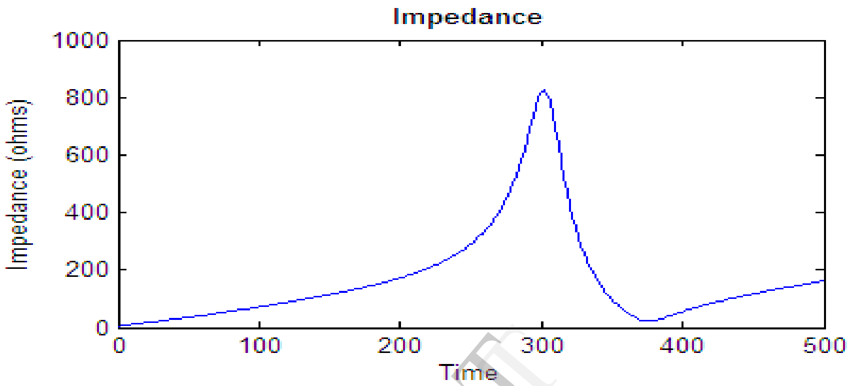


Figure 11 Simulink result of impedance waveform for non-islanding condition

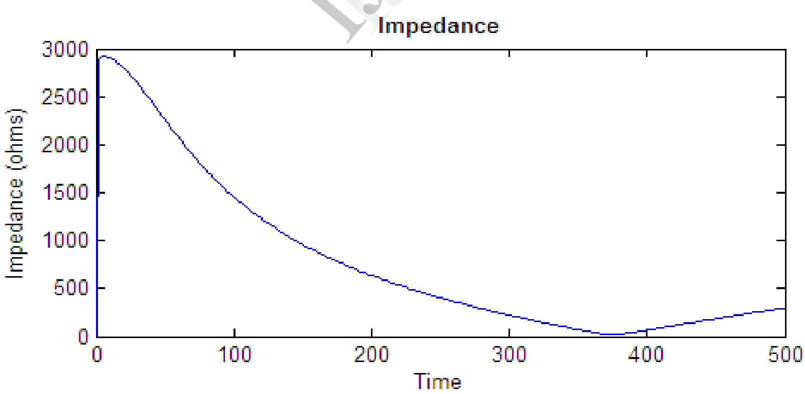
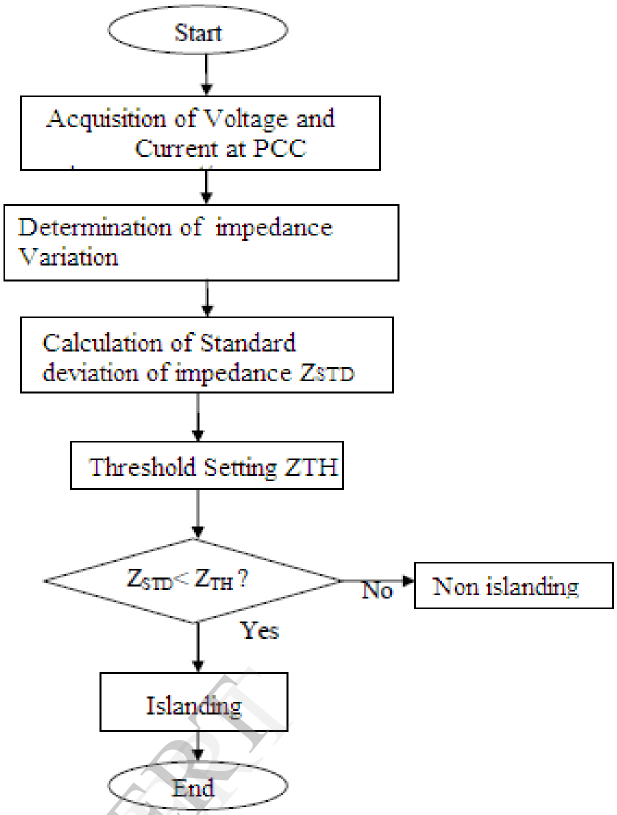


Figure 12 Simulink result of impedance waveform for islanding condition

Proposed Algorithm for Islanding Detection



According to above algorithm we continuously measure voltage and current and hence variation in impedance at DG end location, as islanding occurs there is quiet large variation in impedance i.e as shown in figure 13 on islanding condition (Z_{TH}) as compared to non-islanding condition (Z_{STD}) shown in figure 12. If Z_{TH} is greater than Z_{STD} , it refers to islanding condition, so islanding is detected.

Conclusion

This paper describes and compares different islanding detection techniques. Accurate detection of islanding is one of the major challenges in today's power system with many distribution systems already having significant penetration of DG as there are few issues yet to be resolved with islanding. Islanding detection is also important as islanding operation of distributed system is seen a viable option in the future to improve the reliability and quality of the supply .The proposed technique investigates the voltage, current and impedance for islanding detection in distributed generations. The impedance is found out for both islanding and non-islanding events, and it is observed that the standard deviation of the impedance of non-islanding event is very low compared to islanding condition, thus able to detect the islanding events effectively. Thus the proposed method is highly effective for islanding detection.

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