ADVANCED TECHNIQUE FOR BALANCED ISLANDING DETECTION OF DG SYSTEM CONNECTED TO GRID

T.S.N VISHNU PRIYA[1], S.R.SAGAR[2], L.VAMSINARASIMHA RAO[3]

[1] *M.Tech Student, EEE Department, SIR C R Reddy College of Engineering, Eluru, Andhra Pradesh, India*
[2] *Associate Professor, EEE Department, SIR C R Reddy College of Engineering, Eluru, Andhra Pradesh, India*
[3] *Assistant Professor, EEE Department, SIR C R Reddy College of Engineering, Eluru, Andhra Pradesh, India*

ABSTRACT

The integration of renewable energy sources and Distributed Generation (DG) systems into power grids is rapidly increasing. However, islanding remains a major challenge affecting system safety and reliability. Islanding occurs when a DG system continues supplying power after disconnection from the main grid. According to the Institute of Electrical and Electronics Engineers IEEE 1547 standard, islanding must be detected within 2 seconds. Conventional passive islanding detection methods have large Non-Detection Zones (NDZ).These methods often fail under balanced load and low power mismatch conditions. This paper proposes a passive islanding detection method based on the Rate of Change of Phase Angle between Positive Sequence Voltage and Current (RCPABPSVAC).The proposed method effectively detects islanding conditions with high sensitivity and accuracy. It also distinguishes islanding events from non-islanding disturbances such as faults and load switching. The performance of the proposed technique is validated using MATLAB Simulink simulation results.

Keywords :-*Distributed Generation (DG), Islanding Detection, Renewable Energy Systems, Passive Islanding Detection.*

1.INTRODUCTION

The increasing demand for electrical energy and the depletion of conventional energy resources have encouraged the integration of renewable energy systems into modern power grids. Renewable energy sources such as solar and wind energy are environmentally friendly and sustainable in nature. These renewable sources are commonly integrated into the distribution network through Distributed Generation (DG) systems. DG systems are small-scale power generation units installed close to the load centers. The integration of DG improves system reliability, reduces transmission losses, and enhances voltage stability. However, the large-scale integration of DG also introduces several protection and operational challenges. One of the major challenges associated with DG systems is islanding detection. Islanding occurs when a part of the power system gets disconnected from the main utility grid but continues to be energized by DG units. This condition can occur due to faults, switching operations, or maintenance activities in the utility network. Unintentional islanding creates safety risks for utility workers and consumers. It may also cause equipment damage due to abnormal voltage and frequency conditions. In addition, islanding affects power quality and overall system stability. Therefore, reliable and fast islanding detection is essential in DG-integrated power systems.

According to the Institute of Electrical and Electronics Engineers IEEE 1547 standard, islanding conditions must be detected within 2 seconds after the disconnection of the grid. Various islanding detection methods such as passive, active, and hybrid techniques have been developed. Among these methods, passive techniques are widely used because of their simple structure and low cost. Passive methods monitor electrical parameters such as voltage, frequency, harmonics, and phase angle variations. However, conventional passive methods suffer from a large Non-Detection Zone (NDZ), especially during balanced load and low power mismatch conditions. As a result, some islanding situations may remain undetected. To overcome these limitations, this project proposes a passive islanding detection technique based on the Rate of Change of Phase Angle between Positive Sequence Voltage and Current (RCPABPSVAC). The proposed method continuously monitors the phase angle variation between positive sequence voltage and current signals. A sudden change in the phase angle indicates the occurrence of islanding conditions. The technique effectively detects islanding even under difficult low power mismatch conditions. It can also differentiate islanding events from non-islanding disturbances such as faults and load switching operations.

2.PROBLEM STATEMENT

The integration of Distributed Generation (DG) systems based on renewable energy sources is rapidly increasing in modern power systems. Although DG improves power reliability and efficiency, it introduces several protection challenges, particularly islanding. Islanding occurs when a portion of the distribution network becomes disconnected from the utility grid but continues to be powered by DG units. This condition may create safety hazards for utility personnel and consumers. It can also cause damage to electrical equipment due to abnormal voltage and frequency variations. According to the Institute of Electrical and Electronics Engineers IEEE 1547 standard, islanding conditions must be detected within 2 seconds. Conventional passive islanding detection methods mainly depend on monitoring parameters such as voltage and frequency. These methods are simple and economical but suffer from large Non-Detection Zones (NDZ). As a result, they fail to detect islanding under balanced load and low power mismatch conditions. Active and communication-based methods improve detection accuracy but increase system complexity and cost. Therefore, there is a need for an efficient passive islanding detection technique with high sensitivity and reduced NDZ. The proposed project addresses this issue by using the Rate of Change of Phase Angle between Positive Sequence Voltage and Current (RCPABPSVAC). The method aims to provide fast, reliable, and accurate islanding detection under various operating conditions. It should also distinguish islanding events from non-islanding disturbances such as faults and load switching.

3.PROPOSED METHODOLOGY

The proposed method uses a passive islanding detection technique based on the Rate of Change of Phase Angle between Positive Sequence Voltage and Current (RCPABPSVAC). A Distributed Generation (DG) system connected to the utility grid is modeled in MATLAB Simulink. Voltage and current signals are continuously measured at the Point of Common Coupling (PCC). The measured three-phase signals are converted into positive sequence voltage and current components. The phase angle between the positive sequence voltage and current is then calculated. During normal operating conditions, the phase angle remains nearly constant. When islanding occurs, a sudden change in the phase angle is observed due to grid disconnection. The Rate of Change of Phase Angle (RCPA) is calculated continuously to detect this variation. The calculated RCPA value is compared with a predefined threshold value. If the threshold is exceeded, the system identifies the occurrence of islanding. A decision-making logic block is used to generate the islanding detection signal. The threshold value is selected carefully to avoid false detection during non-islanding disturbances. Different operating conditions such as faults, load switching, and islanding are simulated for analysis. The proposed method effectively distinguishes islanding events from non-islanding conditions. Simulation results confirm that the technique detects islanding accurately within the limits specified by the Institute of Electrical and Electronics Engineers IEEE 1547 standard.

4.TEST SYSTEM CONFIGURATION

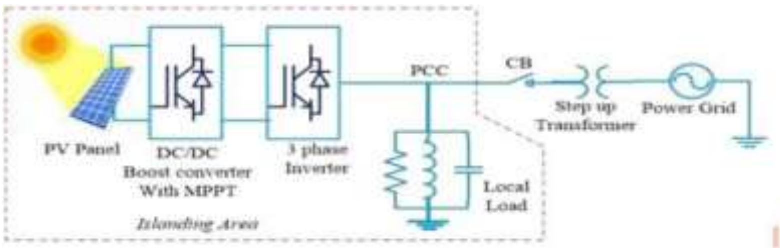
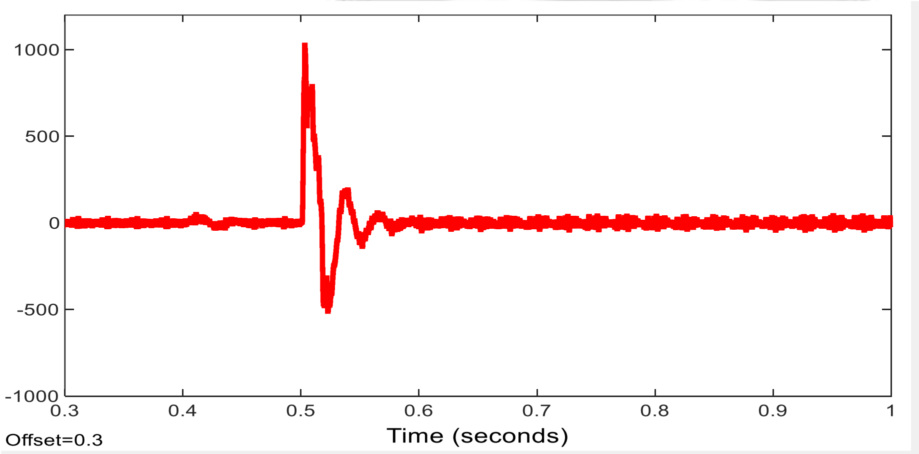


Fig 1: Basic Circuit Diagram

The diagram shows a grid-connected photovoltaic (PV) based Distributed Generation (DG) system used for islanding detection. The system consists of a PV panel, DC/DC boost converter with MPPT, three-phase inverter, local load, transformer, circuit breaker, and utility grid. The PV panel converts solar energy into DC electrical energy. The output voltage of the PV panel is low and variable in nature. A DC/DC boost converter is used to increase and regulate the DC voltage. The converter is connected with a Maximum Power Point Tracking (MPPT) controller to extract maximum power from the PV system. The regulated DC output is supplied to a three-phase inverter. The inverter converts DC power into three-phase AC power suitable for grid connection. The inverter output is connected to the Point of Common Coupling (PCC). A local load is connected at the PCC to represent consumer demand. The PCC is connected to the utility grid through a circuit breaker (CB) and a step-up transformer. The transformer increases the voltage level for grid integration. During normal conditions, both the DG system and utility grid supply power to the local load. When the circuit breaker opens, the grid gets disconnected from the DG system. If the DG continues supplying the local load after disconnection, islanding occurs and the proposed method detects it quickly.

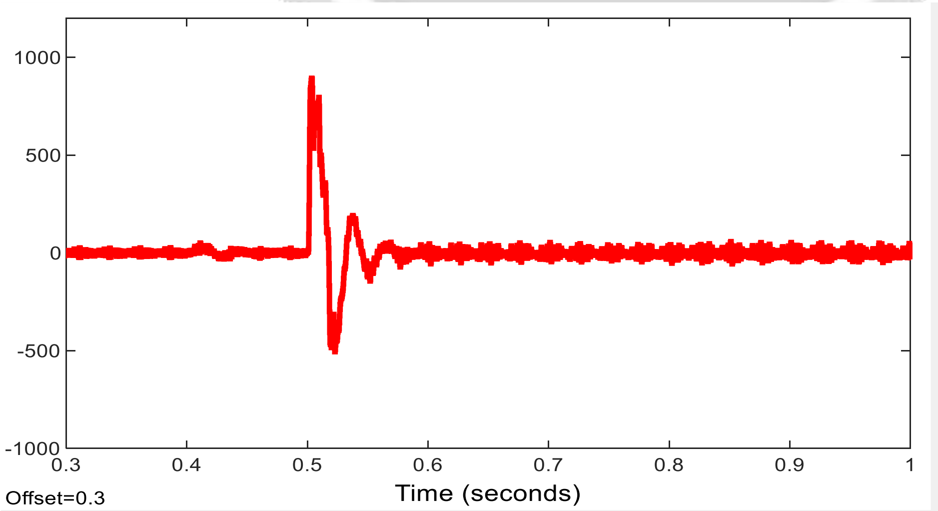
5.SIMULATION RESULTS

Case 1:Balanced loading condition



During balanced loading, the DG capacity is matched with the load demand, resulting in nearly constant voltage and current magnitudes at the PCC. However, slight deviations in the voltage phase angle are observed at the PCC due to the reactive components present in the load. These phase angle deviations exceed the threshold value at 0.502 ms.The measured islanding detection time is 20 msec.

Case 2: Reduced loading condition



During the reduced loading condition, the mismatch between the DG generation capacity and the load demand causes noticeable disturbances at the PCC. Although the voltage and current magnitudes remain relatively stable, significant transient deviations occur in the voltage phase angle due to the reduced active power consumption and the influence of reactive load components. These oscillations cause the phase angle deviation to exceed the threshold value at approximately 0.502 s before gradually settling to a steady-state condition.The islanding detection time is 32 msec.

CONCLUSION AND FUTURE SCOPE

This paper proposed a passive islanding detection technique based on the Rate of Change of Phase Angle between Positive Sequence Voltage and Current (RCPABPSVAC). The proposed method effectively detects islanding conditions in Distributed Generation (DG) integrated power systems. It reduces the Non-Detection Zone (NDZ) and performs efficiently under low power mismatch conditions. The technique also distinguishes islanding events from non-islanding disturbances such as faults and load switching. Simulation results obtained using MATLAB Simulink confirm the accuracy and reliability of the proposed method. The detection time satisfies the standards specified by the Institute of Electrical and Electronics Engineers IEEE 1547 standard. The proposed method can be further improved by integrating intelligent techniques such as Artificial Intelligence and Machine Learning algorithms. Future work may also include hardware implementation and real-time testing of the proposed system. The technique can be extended for microgrid and smart grid applications with multiple DG sources. Thus, the proposed method provides an efficient and promising solution for future renewable energy integrated power systems.

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