Enhanced Islanding Detection Scheme in Distributed Generation Using Phase Angle Analysis of Negative Sequence Superimposed Components

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Abstract—This article presents a unique local islanding detection technique specifically designed for AC microgrids, which are integral components of Distributed Generation (DG) systems. Unlike traditional methods (active methods) that actively disrupt the system, this approach is entirely passive, avoiding any potential harm to the system's stability, power quality, and reliability. This method relies on the phase angle between the negative sequence superimposed components of current and voltage. Islanding is determined by consistently observing the cumulative sum of this phase angle. A significant advantage of this methodology is its ability to almost eliminate the large non- detection zone issue that plagues many passive islanding detection techniques. This means that the method can detect islanding events more consistently across various operating conditions. Simulation studies have been carried out using PSCAD/EMTDC software which demonstrates the efficacy of the introduced technique. Tests on different network setups and diverse types of DGs confirm its ability to achieve the smallest possible non detection zone and detect islanding within 15 ms, significantly faster than the typical response time of reclosers (around 150 ms). The proposed scheme is finally tested and validated in the RTDS simulator with dSPACE (DSP-1104) controller.

Index Terms—Cumulative sum of the phase angle (CS_2), distributed generation (DG), non-detection zone (NDZ), rate of change of frequency (ROCOF), rate of change of voltage (ROCOV).

I. Introduction

A. Motivation and Background

THE rising costs of fossil-based energy, along with increasing environmental concerns, have led to major changes in the framework, performance, and development of power grids, pushing them to operate near capacity for maximum infrastructure use. As a result, distributed power systems are being widely adopted, reducing transmission losses, dependency on carbon-based fuels, and ultimately improving the efficacy and consistency of distribution networks through a shift towards renewable energy systems (RES). While distributed generation offers numerous benefits, it also comes with challenges. The major concern of the RES integration is the islanding [1]. This occurs when the main grid experiences an outage, but the DG system keeps supplying power to a local section of the system. Islanding can be either scheduled, like during maintenance, or unscheduled, caused by faults and switching actions [2]. Unscheduled islanding, where a portion of the grid stays powered, poses significant challenges and several safety risks. These include potential harm to end-users, infrastructure, and system operators due to erratic frequency and voltage fluctuations. Additionally, the island may experience extreme stress when reattached to the primary grid, and inadequate grounding practices can further exacerbate these dangers [3]. Regulations, like IEEE Std. 1547, mandate that DGs must immediately disconnect from the main grid within a short timeframe (typically 2 s) to minimize safety risks during unplanned islanding events.

B. Literature Review

Before tripping the DG, accurate islanding detection is crucial. Four main detection techniques exist: 1) passive; 2) active; 3) hybrid; and 4) communication-based techniques. Passive techniques consistently observe system variables such as frequency, voltage, impedance, current, total harmonic distortion (THD), etc. at a designated point. By drawing a comparison between these monitored values with predetermined thresholds, the system is able to detect islanding events. Passive methods are preferred as they utilize readily accessible data from the DG node, avoiding any disruptions to the normal operation of the DG. Despite their advantages, passive methods have a major limitation: the Non-Detection Zone (NDZ). This pertains to scenarios where the method is unsuccessful in detecting the islanding. Several passive techniques have been developed which include, phase angle [4], rate of change of frequency (ROCOF) [5], under/over voltage (UVP/OVP) [6], THD in currents [7], rate of change of real power (ROCOP) [8], phase shift [9], and rate of change of voltage magnitude (ROCOV) [10].

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