Advanced Islanding Detection Scheme Based on Zero Sequence Phase Angle for AC Microgrids

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***Abstract*—This paper introduces a new, localized islanding detection method for Distributed Generation (DG) systems connected to the main power grid with a focus on applications in AC microgrids. In contrast to conventional active methods, which intentionally disturb the system, this method is completely passive, ensuring no adverse effects on power quality, stability, or reliability. This method focuses on the phase angle between two specific components, the superimposed component of zero sequence current (ΔI_0) and voltage (ΔV_0). By continuously monitoring the cumulative sum (CumSum) of this phase angle at the DG connection point, the system can identify islanding events. The calculated values of ΔI_0 and ΔV_0 exhibit inconsistencies in their magnitudes and variations due to real power imbalance, making them unsuitable for islanding detection. A key benefit of this approach is its capability to nearly eliminate the issue of large non-detection zones (NDZ), a common problem with many passive islanding detection methods. As a result, the technique can identify islanding events more reliably under a wide range of operating conditions. Simulation studies were conducted using PSCAD/EMTDC software to showcase the effectiveness of the proposed method. Testing across various system configurations verified its capability to minimize the NDZ and detect islanding events in under 10 milliseconds, far quicker than the usual response time of reclosers, which is approximately 150 ms. The proposed approach was further tested and validated using the RTDS simulator in conjunction with the dSPACE (DSP-1104) controller.**

***Index Terms*—Cumulative sum (CumSum), cumulative sum of the phase angle (SC_O), distributed generation (DG), microgrid (MG), non-detection zone (NDZ), renewable energy source (RES), rate of change of frequency (ROCOF).**

Received 24 September 2024; revised 29 November 2024; accepted 9 February 2025. Date of publication 7 March 2025; date of current version 9 July 2025. Paper 2024-PSEC-1311.R1, presented at the 2023 IEEE 3rd International Conference on Smart Technologies for Power, Energy and Control, Trivandrum, India, Dec. 17–20, and approved for publication in the IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS by the Power Systems Engineering Committee of the IEEE Industry Applications Society [DOI: 10.1109/STPEC59253.2023.10430559]. This work was supported by the Department of Science and Technology (DST), Government of India, under Grant SER-1801-EED and Grant SER-1851-EED. *(Corresponding author: Javeed Bashir.)*

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Color versions of one or more figures in this article are available at https://doi.org/10.1109/TIA.2025.3549016.

Digital Object Identifier 10.1109/TIA.2025.3549016

I. INTRODUCTION

A. Motivation and Literature Review

THE escalating prices of fossil fuels and natural gas, coupled with mounting environmental challenges, have driven significant transformations in the structure, operation, planning, and regulation of modern power grids. The intensifying economic, political, and environmental pressures are driving power grids to operate at near-capacity levels, necessitating the optimal utilization of existing infrastructure. Consequently, distributed generation systems are experiencing rapid growth. Integrating these systems into the primary power grid is imperative. They not only mitigate energy losses during transmission but also curtail reliance on fossil fuels. This transition to renewable energy sources ultimately augments the efficiency and reliability of distribution systems. Although distributed generation presents several advantages, it is not without its drawbacks. A primary concern associated with integrating RES into the grid is the potential for islanding [1]. This phenomenon arises when the main power grid fails, but the distributed generation system continues to supply electricity to a localized portion of the network. Islanding can occur intentionally, as part of planned maintenance, or unintentionally, due to system faults or switching operations [2]. Unplanned islanding, where a segment of the power grid remains energized, presents substantial challenges and safety hazards. These risks encompass potential harm to consumers, equipment, and utility workers arising from unpredictable voltage and frequency variations. Furthermore, the isolated section of the grid may encounter severe stresses during reconnection to the main grid, and insufficient grounding measures can amplify these hazards [3]. Standards such as IEEE Std. 1547 stipulate that DG units must automatically separate from the primary grid within a brief period (usually 2 seconds) to mitigate safety hazards during unintended islanding incidents.

Prior to disconnecting the DG unit, precise islanding detection is paramount. There are four primary detection methods: I) passive II) active III) hybrid, and IV) communication-based techniques. Passive techniques involve continuous monitoring of system variables like impedance, current, voltage, total harmonic distortion (THD), and frequency at a specific location. By comparing these measured values against established thresholds, the system can identify islanding occurrences. Passive detection techniques are favored due to their reliance on easily accessible data at the DG bus, minimizing interruptions to the DG system's regular operation. However, passive methods have a significant drawback known as the NDZ. This refers to operational