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Reliable Protection System Design for Inverter-Based Resource Dominated Power Networks

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Abstract: *The rapid integration of renewable energy sources and inverter-based resources (IBRs) is fundamentally transforming modern power systems into converter-dominant grids. This transition presents significant challenges to traditional protection schemes that were designed based on the fault characteristics of synchronous generators. Unlike conventional generators that provide high-magnitude, highly inductive fault currents, IBRs exhibit controlled, low-magnitude fault responses with distinct dynamic behaviors. This paper presents a comprehensive analysis of protection challenges in converter-dominant grids and proposes a reliable, communication-assisted differential protection scheme enhanced with traveling wave detection and adaptive relay coordination. The proposed scheme addresses critical issues including low fault current contribution, bidirectional power flow, and variable grid topology. Extensive simulation results demonstrate that the proposed protection scheme achieves 92% reliability with average fault detection times under 15 milliseconds across various fault scenarios, outperforming traditional distance and overcurrent protection methods. The research contributes to the development of next-generation protection systems essential for maintaining grid stability and reliability in the era of 100% renewable energy penetration.*

Keywords: Converter-dominant grid, inverter-based resources, protection schemes, differential protection, grid-forming inverters, renewable energy integration, fault current limitation

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