Source-Agnostic Time-Domain Directional Relay (2024-026)

Novel time-domain directional protective relay designed to reliably detect grid faults regardless of the type of power source.

Market Overview

The power grid market has witnessed a surge in the integration of renewable energy resources (RERs) driven by growing environmental concerns and the pressing demand for sustainable energy solutions. Consequently, to meet this demand, there is an increased need for inverter-based resources (IBRs) as they are instrumental in facilitating integration of RERs into the power grid. However, IBRs exhibit unique fault characteristics significantly different from synchronous generators (SGs), posing challenges for traditional directional overcurrent relays. These challenges include limited fault currents, absence of negative sequence currents, and rapid changes in output voltage, making traditional phasor-domain relays unreliable.

Technical Summary

The proposed solution is a directional protective relay formulated in the time domain, eliminating the need for polarization techniques. This relay is designed to detect faults reliably regardless of the type of power source, whether IBRs or SGs. It is immune to decaying DC offsets and prefault currents, making it suitable for grids with up to 100% IBR penetration. The relay operates effectively at a sampling rate of 24 samples per cycle, facilitating its implementation in existing commercial numerical relays. Performance validation through PSCAD simulations demonstrates its superiority over current commercial relays.

Applications

- Renewable Energy Grids: Protects transmission and distribution feeders with high penetration of IBRs.
- Hybrid Systems: Suitable for power systems incorporating both IBRs and traditional synchronous generators.
- Microgrids: Enhances protection in microgrids, ensuring stability and reliability.
- Smart Grids: Integrates seamlessly with smart grid infrastructure, enhancing overall grid resilience.

Development Stage

TRL 2/3

Advantages

- **Universal Compatibility:** Functions reliably with both IBRs and synchronous generators.
- **Enhanced Reliability:** Immune to decaying DC offsets and prefault currents.
- **High Compatibility:** Easily integrates with existing commercial numerical relays.
- **Improved Fault Detection:** Superior performance in both transmission and distribution systems.
- **Regulatory Compliance:** Aligns with IEEE standards, ensuring future-proof protection solutions.

App Type	Country	Serial No.	CURF Ref. No.	Inventors
Provisional Patent Application	United States	63/559,243	2024-026	Dr. Sukumar Brahma Prabin Adhikari

About the Inventors

Dr. Sukumar Brahma

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Dr. Sukumar Brahma joined Clemson University as the Dominion Energy Distinguished Professor of Power Engineering in August 2018. His research, widely published and funded by the National Science Foundation, US Department of Energy, Utilities, and other government agencies has focused on different aspects of power system modeling, analysis, and protection. Dr. Brahma is a Distinguished Lecturer and a Fellow of the IEEE. Current research focus is on protection issues in integration of renewables with power systems and new paradigms in protection of smart grid, at both transmission and distribution levels.

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Prabin Adhikari received the Bachelor of Engineering degree from Tribhuvan University in 2017 and the M.S. degree in electrical engineering from Clemson University in 2021. He is currently working toward a Ph.D. degree in electrical engineering at Clemson University. His research interests include the protection of inverter-dominated power grids, power system modeling, and adaptive relaying.

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