Topology Agnostic Detection and Location of Fault in DC Microgrid Using Local Measurements (2021-020)

Novel Technique of Detecting Fault and Determining Fault Location on a DC Feeder Well Within the Critical Time Using Only Single-Ended Local Measurements

Market Overview

This topology agnostic fault detection and location technology is the first such technology that is system-independent, uses only local measurements, and is closed form (non-iterative). Combining these attributes allows this technology to operate quickly to meet the needs of the growing DC microgrid market. This speed advantage bridges a major challenge for DC microgrids by protecting components from speed critical fault events. This technology can also inform the protection needs of high voltage DC lines, which are part of most power systems. Clemson University researchers have developed a fault detection system possessing superior speed and simpler implementation enabling faster protection for component devices as well as determining the location of faults in real time.

Technical Summary

The topology agnostic fault detection and location technique meets speed critical application needs to address current rises that can occur on the order of tens of microseconds in a dc circuit as a result of a fault. When a fault occurs on a feeder-section in a dc microgrid, the current contributions from the dc link capacitors associated with dc-dc converters or ac-dc rectifiers dominate the fault current first. Capacitors resist the rapid change of voltage. So, for a short period of time the capacitor will act like a constant voltage dc source while discharging through the fault. Within this time the current through the dc line will have the same response as it would have for an ideal voltage source instead of the capacitor. So, measurements from this initial period are used to determine the fault location. The method uses only local measurements, preventing delay due to communication. Furthermore, the technique has a fixed execution time due to being non-iterative. System independence allows for a simpler to implement system because the calculation of protection thresholds is based only on the feeder being protected and not on the topology of the whole system. When the rest of the system changes, when an adjacent line is out of operation for example, the thresholds do not have to be recalculated. These features of the technology are conducive to simple and efficient operation to protect vulnerable devices from quickly rising currents during fault events.

Application

This technology protects circuit breakers and vulnerable component devices in converters from high current caused by a fault. This method also determines the location of the fault in real time for quick isolation required in DC systems.

Development Stage

TRL 3: Proof of Concept

Advantages

- System-independence, which allows for simpler implementation
- Fast fault detection enabled by using only local measurements with a non-iterative method
- Controllable fault detection speed by choosing the sampling frequency
- Usable for any resistance faults, including high resistance faults

App Type	Country	Serial No.	Patent No.	CURF Ref. No.	Inventors
Provisional	United States	63/242,253	NA	2021-020	Munim Bin Gani Dr. Sukumar Brahma

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Munim Bin Gani is a Ph.D. Graduate Research Assistant in Clemson University's Electrical Engineering program. He earned his Bachelor's Degree in Electrical and Electronics Engineering from the Bangladesh University of Engineering and Technology and Master's Degree in Electrical Engineering from New Mexico State University. His research focuses on power system protection, DC/AC/Hybrid microgrids, and dynamic simulation of power systems.

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Dr. Sukumar Brahma is a Dominion Energy Distinguished Professor of Power Engineering in the Holcombe Department of Electrical and Computer Engineering at Clemson University. He earned Ph.D. in Electrical Engineering from Clemson University. Prior to joining Clemson, he served as the William Kersting Endowed Chair Professor at New Mexico State University. Dr. Brahma has chaired The Institute of Electrical and Electronics Engineers (IEEE) Power and Energy Society's Power and Energy Education Committee, Life-Long Learning Subcommittee and Distribution System Analysis Subcommittee. He is a member of the Power System Relaying and Control Committee (PSRCC), where he has been contributing to and leading working groups that produce reports, guides, and standards in the area of power system protection. He has been an editor for IEEE Transactions on Power Delivery and served as Guest Editor-in-Chief for the Special Issue on Frontiers of Power System Protection for the journal. 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.

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