A Sequential Tripping Protection Scheme for Single Pole-to-Ground Faults in Ring-Structure Medium Voltage DC Grid

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Power delivery through medium-voltage direct current (MVDC) grids is becoming increasingly advantageous due to advancements in power electronics and the growing integration of DC sources and loads in distribution grids. Significant disparities between DC and AC short-circuit fault behavior, as well as differences in the fault withstand capabilities of grid components, present challenges for directly applying AC protection techniques to DC systems. This paper proposes a sequential tripping protection scheme specifically designed for single pole-to-ground (SPG) faults in MVDC symmetrical monopole grids with ring structures and high-impedance grounding. Key contributions include (i) a comprehensive analysis of fault current and voltage behavior in modular multilevel converter-based MVDC grids; (ii) adaptation of a transverse differential scheme to extend the applicability of the method across diverse grid topologies and operating conditions; (iii) implementation of adaptive current pickup thresholds and a dual-stage relay system to enhance protection dependability and coordination. This adaptive setting is the core novelty distinguishing the method from prior sequential tripping work. The algorithm relies only on local measurements and does not require communication. Its performance is validated through simulation studies of SPG faults in three-, four-, and sixterminal ring-structured DC grids, including both clustered and linear arrangements, using PSCAD/EMTDC. The results demonstrate the algorithm's scalability and secure performance across a wide range of configurations.

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