

An Outlier-Based Single-Ended Protection Scheme for Multi-Terminal MMC-HVDC Grids Based on Hilbert-Huang Transform

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Protection of High Voltage Direct Current (HVDC) grids is a crucial step that requires further advancements to ensure the secure integration of green renewable energy sources (RESs). This paper proposes a fast, reliable, and selective single-ended primary protection scheme for multi-terminal HVDC grids. In the proposed scheme, Hilbert-Huang Transform (HHT) is applied to local voltage measurements to extract the instantaneous frequency and energy features. Abrupt changes in these features during internal faults are detected as outliers. Simultaneous outliers in the extracted features correspond to internal faults, which offers a setting-less fault detection criterion; thus, eliminating the need for simulation-based and grid-specific thresholds. The proposed scheme can detect internal faults with high fault resistances up to 1000 Ω within 1 ms. In addition, the proposed scheme can reliably distinguish between internal and external faults even when the boundary reactor size is as small as 10 mH. A four-terminal HVDC grid is simulated in PSCAD/EMTDC software, and various fault scenarios are investigated to verify the effectiveness of the proposed scheme in detecting and discriminating between internal and external faults under severe fault conditions.