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Wed-Mo-Po.10-04: Study on DC Fault Current Limiting and Protective Relay Operation of Flux-Coupled Type SFCL-CB

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With the growing integration of renewable energy sources such as photovoltaics, research on DC systems has been actively performed. DC systems offer superior compatibility with renewable energy sources and lower power transmission losses compared to AC systems. However, it faces critical challenges, such as rapid increase of fault currents directly after a fault occurs and the absence of natural current zero-crossing, complicating fault current interruption. To mitigate these issues, significant efforts have been devoted to develop DC superconducting fault current-limiting circuit breaker (SFCL-CB) capable of quickly reducing fault current, thereby alleviating power burden of circuit breaker.

Among the studied SFCL-CB, the flux-coupled type SFCL-CB maintains superconducting state of its superconducting element before a fault occurs, allowing the magnetic flux generated by the windings to cancel each other out. In the event of a fault, the superconducting element transitions to conducting state, inducing voltage across the windings and effectively limiting and interrupting the fault current. However, the interrupting time of flux-coupled type SFCL-CB varies significantly depending on the winding method or turns of the winding, and the interrupting time does not take into account protection coordination with adjacent protective relays, posing a limitation.

In this study, a novel protection coordination-enabled flux-coupled type SFCL-CB with parallel two windings via a iron core was proposed. Also, fault current limiting and protective relay operation of flux-coupled type SFCL-CB was studied in DC system. The protective relay part of flux-coupled type SFCL-CB measures the current flowing through the secondary winding and sends a trip signal to circuit breaker connected in series with the secondary winding. Through simulation results using PSCAD/EMTDC, it was demonstrated that the proposed flux-coupled type SFCL-CB can not only limit fault current effectively but also adjust the trip time based on the fault current magnitude, thereby mitigating the impact on protection coordination with adjacent protective relays. Additionally, the experimental results validated the appropriate winding configuration for the flux-coupled type SFCL-CB with protective relay functionality.

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