

Traveling Wave Differential Protection Technology and Its Application in Ultra-Long-Distance UHVDC Transmission Line

Xinzhou Dong¹, Haozong Wang², Binshu Chen¹, Boliang Jin¹, Xinyuan Li¹, Qihuan Dong³, Shenxing Shi¹, Bin Wang¹, Pengfei Lv⁴, Guoming Qian⁵, Fufeng Chen⁵, Zhanfeng Fan⁶, Baowei Li⁶, Min Xie⁷, Xiaoping Feng⁸
¹Tsinghua University, ²the University of Tennessee at Knoxville, ³Beijing Jiaotong University, ⁴State Grid Corporation of China, ⁵Guodian Nanjing Automation Company, ⁶XJ Electric Company, ⁷State Grid Anhui Electric Power Corporation, ⁸State Grid Xinjiang Electric Power Corporation

Traveling wave differential protection (TWDP) is based on the traveling wave (TW) propagation characteristics of the physical transmission line and therefore holds unique advantages in the protection of long-distance transmission lines. This paper proposes a practical time-domain TWDP scheme specifically designed for high-voltage direct-current (HVDC) lines and provides both theoretical analysis and field validation. A TWDP device, named TP-03, was developed and underwent laboratory testing. The developed protection device 1) can stay valid under a maximum fault impedance of up to 1000Ω under the rated ±1100 kV voltage level; 2) has an operation time of less than 30 ms even with a communication delay of 20 ms. In October 2020, TP-03 devices were first deployed on the Changji-Guquan UHVDC transmission project, which is the highest voltage (± 1100 kV), longest distance (3284 km), and largest capacity (rated 12100 MW) transmission project in the world. During its operation, the devices functioned correctly in several internal faults and external disturbance events. This work represents the first field validation of HVDC TWDP and bridges the gap between theoretical research and real-world applications.

It confirms that TWDP can serve as the main protection for ultra-long-distance HVDC lines, setting a benchmark for future projects.