Improved Rate of Change of Voltage (ROCOV) Based Multi-terminal HVDC Grid Protection

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ABSTRACT:

Multi-terminal high voltage direct current (MT-HVDC) grids facilitate delivering energy collected from the dispersed remote and renewable sources to the load centres efficiently. Unlike AC transmission, power can be transmitted through submarine/underground cables with the HVDC. In addition, MT-HVDC grids offer higher flexibility for power trading and increased redundancy. Therefore, a number of MT-HVDC grids such as European Super Grid and Atlantic Wind Connection are proposed. However, lack of protection techniques that satisfies the speed, sensitivity, security, and selectivity requirements are considered as major obstacles for deploying MT-HVDC grid technology. Development of an improved MT-HVDC grid protection scheme is the motivation.

Fault current grows very rapidly to large steady state value in DC transmission circuits. Therefore, it is required to detect faults as soon as a fault is occurred. In order to limit rate of rising fault current for some extend inductors are place at the boundary of each transmission line. Sudden increase of current during a fault results in a change in the voltage across the boundary inductors. Presence of higher rate of change of voltage (ROCOV) at the line side of the boundary inductors is used as an indicator of a fault in ROCOV based fault detection schemes. Although the ROCOV based fault detection schemes are faster than other fault detection schemes, to satisfy sensitivity and selectivity requirements imposed by a typical MT-HVDC grid applications, it is required to improve the ROCOV based schemes by making them more selective against the variations of ROCOV due to events such as faults and breaker openings on transmission lines outside of the protected zone.

Direction of the fault with respect to a boundary inductor can be determined by comparing the ROCOV values at two sides of the boundary inductor as the rate of change of voltage at the fault side is higher than that of the healthy side. The impact of external events on the ROCOV relays can be eliminated by using the so determined fault directions. Furthermore, a fault always causes a drop of voltage while a breaker opening always causes an increase of voltage. Therefore, the sign of the ROCOV value can be used to distinguish a fault from a breaker opening. A significant improvement of the security and sensitivity could be observed after incorporating the above two functions in conventional protection scheme.

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