Severity adapted fault clearing strategy

Cost-efficient HVDC grid protection strategy for networks combining cables and overhead lines.

CONTEXT

A significant proportion of potential renewable energy production sites are located in remote locations far from metropolitan areas. HVDC systems offer a viable solution for transporting this energy without causing congestion in the AC transmission network. Rather than installing new cable lines, a cost effective solution is to convert existing AC Over Head Line (OHL) corridors into DC lines or to build new DC OHL.
The different fault and conductor characteristics of the OHL compared to a cable relieve new challenges from a protection perspective. In fact, OHLs have a higher lineic inductance than cables and fault resistances of several tens of Ohms are likely to occur. Thus, a fault event leads to a lower voltage drop and lower fault current contribution which may entail fault detection failures at distant substations.
The integration of OHL evokes a second problem when applying non-selective fault clearing strategies. The fault probability of OHL is at least twelve times higher compared to cable faults therefore increasing the frequency of temporary shutdown of the entire MTDC grid.

TECHNOLOGY DESCRIPTION

The proposed severity-adapted fault clearing strategy (SA-FCS) employs mechanical DC circuit breaker (DCCB) at each line end and at each converter station DC output. Low value DC limiting reactors (DCR) are also installed in series with the DCCBs. In the proposed SA-FCS different protection sequences are applied depending on the fault characteristics such as fault distance and fault resistance. The faults are thus classified into low impact faults and high impact faults.
Low impact faults are all combinations of fault resistance and distance that lead to a peak fault current, measured at the faulty line end, which is below a certain level of current breaking capability of the DCCB. Low impact fault are therefore cleared in a selective manner by opening only the DCCBs of the faulty line.
High impact faults are all combinations of fault resistance and distance that entail a peak fault current, measured at the faulty line end, which exceeds the aforementioned level of current breaking capability. High impact fault are therefore cleared in a non-selective manner by opening all the DCCBs of the adjacent lines and, in a second time, by opening the DCCB of the faulty line once the current has decreased. Once the faulty line is isolated the adjacent healthy lines are reclosed to restore the power. It should be noted that, for high impact faults, only the busbars directly related to the faulty line are implied in the fault clearing sequence.
The severity of the fault is evaluated at each busbar individually. Considering this, a fault can be discriminated as a high impact fault for the busbar which is close to the fault but as a low impact fault for the remote busbar.
The fault impact discrimination algorithm can be based on a Rate Of Change Of Voltage (ROCOV) principle. Indeed, the ROCOV value decreases with increasing fault distance and fault resistance. Other type of algorithms based on different approaches could also give accurate approximation of the fault resistance and distance of the fault.

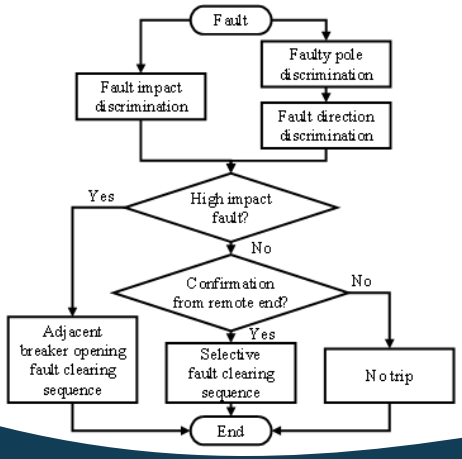

Fig. Primary sequence of the severity adapted fault clearing strategy

APPLICATION DOMAIN

MTDC grid combining OHL and cables
Possible extension of the protection strategy for MTDC grid composed by 100% cables.

ADVANTAGES

Compared to a Full-selective strategy, the proposed strategy uses cost effective mechanical DC breaker instead of ultra-fast hybrid DC breaker and lower value of DC limiting reactor which further reduces the cost and the risk of DC voltage dynamic instabilities.
The proposed strategy is able to selectively eliminate the fault for most of the OHL faults with a similar power restoration time equal to a full-selective strategy.

TRL SCALE

1 2 3 4 5 6 7 8 9

DELIVERABLES

- Virtual mock-up within EMTP-RV
- Patent pending FR2006522 “Semi-selective protection strategy for hybrid OHL and cable MTDC system”.
- PhD Manuscript from Pascal TORWELLE “Development of an HVDC grid protection strategy based on hybrid overhead and cable lines”

SCIENTIFIC REFERENCE

Compliance of a cable-based protection strategy for OHL grids: Analysis and remediation, P. Torwelle, A. Bertinato, B. Raison, Trung Dung Le & M. Petit, DPSP 2020.

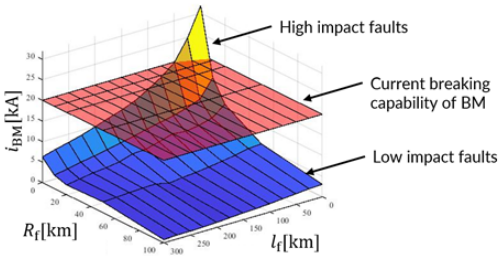

Fig. Current to be cleared by the line breaker module within 15 ms as a function of fault distance and resistance

Contact: sebastien.silvant@supergrid-institute.com