Study Committee B5

Applications of Emerging Technology for Protection, Automation and Control PS 2

Paper ID - 1093

Experiences with Fault Location in Different Networks Applying Travelling Wave Technology

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Motivation

- Increased complexity of network structure and power flow management can lead to failures of conventional protection and monitoring technology
- Different challenges of the existing fault location methods with different star point groundings
- Perspective refurbishment of traveling wave technology for power system protection

Common fault location and its problems

- In solid earthed networks, impedance-based (single-ended) or voltage-profile-based (double-ended) fault location can be applied, however following aspects can contribute to fault location errors:
  - uncertainty in line parameters (settings)
  - challenges in phasor estimation for current (e.g. saturation) or voltage (e.g. arc voltage), accuracies of the instrument transformers
  - intermediate infeed, parallel systems, line segments, line compensations, line transpositions
  - significant load flow, high-resistance faults
  - combined faults: evolving faults, intersystem faults
- In solid compensated networks fault location using common methods in case of the earth faults is not possible.

Possible advantages of travelling wave fault location

- In solid earthed networks:
  - \+ simple parametrization: length of the line segment and wave speed in the segments, simple calculation approach
  - \+ independent of instrument transformer accuracies
  - \+ independent of nonlinearities coming from both secondary and primary system
  - \+ not impacted by network complexity (parallel systems, compensation devices, modern technology based on power electronics)
  - \+ not impacted by fault complexity
- In solid compensated networks, fault location in typical cases possible and with very high accuracy.

Challenges for fault location using travelling wave technology

Very accurate detection of the travelling wave requires

- accurate detection on travelling wave coming from primary system disturbances
- very high sampling rate > 1 MHz (for digital signal processing)
- very high synchronization accuracy (range of ns)
- high-pass characteristic of both primary and secondary instrument transformers

Basics of fault location using travelling wave technology

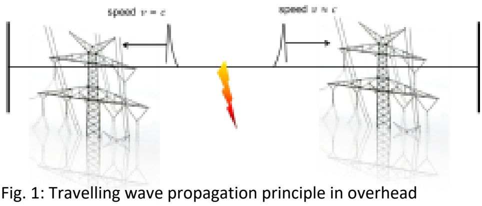

Fig. 1: Travelling wave propagation principle in overhead line

- Travelling waves are caused by abrupt changes in primary system (like faults, switching…)
- Travelling wave propagate with high speed from the point of origin (for lines nearly speed of light)
- Travelling waves can be measured in currents and voltages (for instance at the terminals)

Double sided fault location uses first waves detected on local and remote side of the line.

Single sided fault location uses first wave as well as reflected waves on the fault place

Combination between travelling waves from voltage and current leads to detection of fault direction

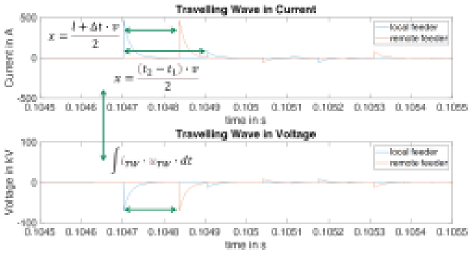

Fig. 2: Simulated travelling wave in current and voltage

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Pilot installations

- 110 kV compensated network with intermediate infeed monitored by 3 travelling wave recorders

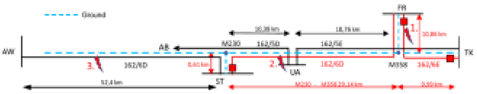

Fig. 3: 110kV-network part with initiated earth-to-phase faults

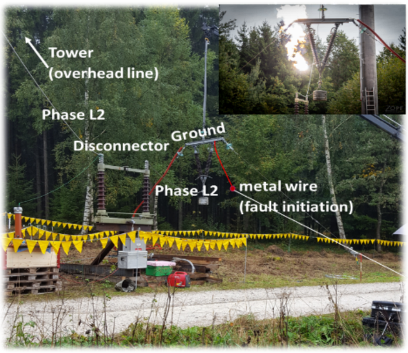

Fig. 4: Field tests (110kV)

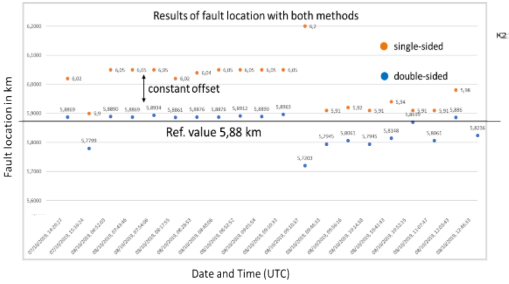

Fig. 5: Result of fault location (110kV)

- 400 kV solid earthed network with 117 km length and 2 installed travelling wave recorders

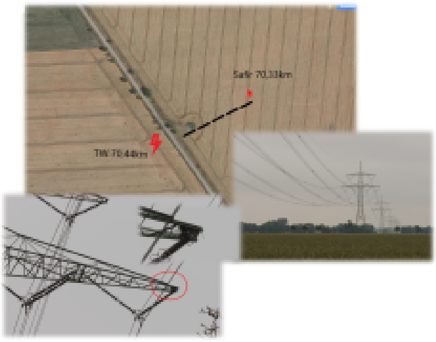

Fig. 6: Result of fault location (400kV)

Fig. 7: Recorded travelling wave for the case from figure 5

- 525 kV solid earthed network with 300 km length and 2 installed travelling wave recorders

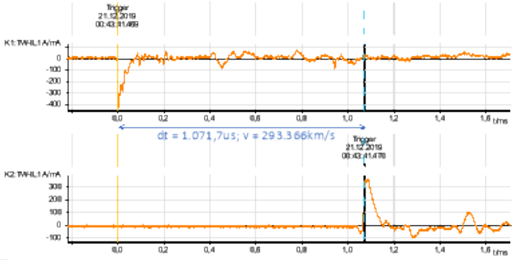

Fig. 8: Recorded travelling waves for external fault in 525kV line

Conclusion and outlook

- Application of traveling wave fault location solves a lot of problems existing in conventional fault location approaches
- Further research needed to clarify some observed effects during pilot installations
- Transfer of experiences on the medium voltage network as well as cable network
- Research on “autonomously” operating and reliable travelling wave protection devices necessary

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