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TECHNICAL PAPER PRESENTATION
“PROTECTION CHALLENGES AND SOLUTIONS ENABLING HIGH DER PENETRATION IN DISTRIBUTION SYSTEMS.”

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ABOUT THE AUTHOR

BRIEF BIO

Dr. Ning Kang has 10 years experience in the areas of power system protection, control and optimization, and renewable integration. At Argonne, she has been leading several Department of Energy funded projects investigating impact of high DER penetration on distribution systems and bulk power systems. Dr. Kang also has 5 years industry R&D experience when she was a Senior R&D Engineer at the ABB US Corporate Research Center. She has published more than 30 journal and conference papers, book chapters, and white papers. She holds 6 US patent applications. Dr. Kang is also a registered Professional Engineer in North Carolina.
Overview

- Overview of Distribution System Protection
- Challenges to Distribution System Protection
- Solutions to Distribution System Protection Coordination
Distribution System Protection Overview

- **Overcurrent protection philosophy**
  - Reply on measured currents to distinguish faults from nominal load currents

- **Distribution system protection devices**
  - Reclosers
  - Sectionalizers
  - Fuses

- **Protection coordination scheme**
  - Relay settings must ensure selectivity and sensitivity
  - Based on one-way power flow
  - Upstream protection device closest to the fault reacts first to clear the fault
  - Each relay provides backup to the next downstream relay with a time delay
Distribution System Protection Challenges

- **Increased fault current**
  High penetration of DERs will contribute to a higher magnitude of fault current induced by a fault on the feeder causing challenges to fault interrupting devices

- **Sympathetic tripping**
  When a fault occurs on a distribution feeder, the aggregate fault current contribution from the DERs on the adjacent feeder may cause sympathetic tripping of the circuit breaker of the adjacent feeder.

- **Desensitizing protection devices**
  When the fault impedance is non-zero, and DERs are contributing to the fault current, the fault current contribution from the substation or upstream source may be reduced. The reduction in fault current will desensitize the protection device at the source.
Distribution System Protection Challenges

- **Coordination between DERs and feeder protection devices**
  IEEE Standards 1547 mandates protection relay be able to detect voltage/frequency deviations and trip with pre-specified time responses, and isolate itself within two seconds of the formation of an unintentional islanding. Poor coordination between DER protection relays and feeder protection devices may lead to nuisance fuse blowing, reclosing out of synchronism, sectionalizer miscount, etc.

- **Fault ride-through requirements of DER protection devices**
  IEEE Standard 1547 amendment stipulates that DERs have voltage and frequency ride-through capability in case of a contingency on the transmission system. This provision may pose challenges to the coordination between the DER’s protection relays and the distribution grid protection devices.
Distribution Protection Coordination Solutions

A dynamic protection setting scheme based on holistic short-circuit analysis for DMS

- **DER communicates output schedule or forecast to DMS**
  Frequency determined by communication bandwidth and communication speed of distribution systems. One minute frequency assumed in this discussion.

- **DMS receives available measurements**
  Including measurements from line sensors, smart meters, and intelligent electronic devices (IEDs)

- **DMS performs short-circuit analysis and determines feeder protection device settings**
  Consider the as-operated circuit connectivity and knowledge of DER output in the system

- **DMS communicates feeder protection device settings**
  To feeder protection devices through SCADA
Distribution Protection Coordination Solutions

Coordination Schemes between DER and Distribution System Protection Devices

Communication-based local coordination scheme
Intelligence at the distribution feeder protection device (e.g. reclosers) will first determine whether the fault is temporary or permanent. Communication-based local coordination scheme will then coordinate the sequence of actions of DER protection relays and feeder protection devices to avoid nuisance fuse blowing, reclosing out of synchronism, sectionalizer miscount, etc.

Non-communication-based local coordination scheme
Does not require communication between distribution protection devices and DER protection devices, but rather coordinates their actions by managing the DER voltage/frequency deviation based protection functions and anti-islanding schemes. In addition, distribution protection devices such as reclosers may be required to install additional voltage sensing relays to facilitate proper coordination.
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