Challenges in relay protection

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Present challenges

• **DC lines in parallel with AC lines**
  Faults on DC line cause induced DC currents in the AC systems and AC earthing systems. Challenging for distance protection relays
  - Saturation in conventional P-class CT's
  - Initial simulations show large induced currents with duration >100ms in nearby AC-line
  - Distance relay functions not responding as required; affects phase-selection, direction determination and distance to fault
  - Statnett is investigating use of air gap CT's, type TPY

• **Data quality – Accuracy in calculation model**
  Statnetts PSS/E Nordic grid model have some inaccuracies
  - Transformer data - data collection programme ongoing
  - Generator data - data collection programme starting up
  - Line impedance - impedance measurement starting up
Present challenges

• Extensive use of system protection schemes

The power system is characterized by high utilization, SPS is used to increase transfer capacities

• Many separate SPS's, complicated structure:
  • 50 generators (7300MW), 1500MW load, 100 transmission lines included in SPS
  • Load or production disconnection initiated by relay operation on critical components
  • Fast ramping of HVDC interconnections (emergency power control/runback)
  • Net splitting
• Mal operation -> Large consequences
• Monitoring and coordination
Power station

500 MW

500 MW

500 MW

thermal capacity = 1500 MW

2000 MW

3000 MW load

Transfer corridor A capacity:
- without power disconnection: 1500 MW
- with power disconnection: 2000 MW

B

1000 MW
SPS - Principle drawing

Quick recuiton not tripping of the generators.

Production disconnection switch

Communication switch

Duplicated communication

Green colour - Statnett is operating the switches

Tripping of the generators.

Orange colour – an other concessionaire is operating the switches

Busbar protection

Ground current protection

Overload protection

Station name

Distance protection (duplicated equipment)

Transformer protection results in SPS function if the transformer trips, independent of the cause.

420 kV
300 kV
132 kV
[110 kV, 22 kV]
< 22 kV

Station name
Future challenges

• Increased share of produced energy from renewable energy sources/HVDC/small power
  • Missing/delayed relay protection operation
  • Voltage quality/frequency quality/stability
  → Potensial need/marked for spinning reserves?

• Tougher requirements increase building cost and technical complexity – Statnett is beeing challenged
  • Redundancy in signal transmission cabling
  • Redundant auxiliary power
  • EMP secure control rooms
  • ICT security

How to keep the cost down and maintain a high security of supply?

Statnett R&D project: Fully digitalized substations
  • How to maintain security of supply when building a fully digitalized substation?
  • Different suppliers of primary components, control- and protection equipment in same substation – are the communication protocols between suppliers fully compatible?
  • How to build a substation that can be operated and maintained easily for decades
  • Data transmission and storage
Basic configuration on station bus level
Digital substation – test configuration

1) Voltage UL2 from busbar A and B
2) Voltage UL1-L1 from 4.7kV-600V for optional OLTC