Distribution Network Protection: What Can We Learn from Transmission Protection

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Agenda

- Fundamental differences between transmission and distribution networks
- Characteristics of traditional T & D protection
- Transmission protection techniques applied to distribution
  - Challenges
  - Communication channel requirements
- Conclusions

Fundamental differences between T & D networks

- Transmission network characteristics
  - 2 or 3 terminals
  - Homogeneous conductor sizing
  - Minimal reconfiguration
  - Tapped loads are known (and limited)
  - End-of-Line is known
- Distribution network characteristics
  - Numerous terminals
  - Varying conductor sizes and methods
  - Reconfigurable at will (minimal remote intelligence)
  - Many laterals and hundreds of tapped loads
  - End-of-Line unknown

Characteristics of traditional T & D protection

- Transmission network protection FDIR
  - High speed
  - Highly selective
  - Non-adaptive to network changes
  - Intelligent reclosing
- Distribution network traditional protection FDIR
  - Variable speed
  - Poor selectivity
  - Forgiving of network changes (non-adaptive)
  - Uses reclosing for selectivity

Transmission protection techniques applied to distribution

Can transmission network protection techniques be ported to distribution networks?

Transmission protection techniques applied to distribution

- Over-current protection challenges
  - Reconfiguration changes fault current availability
  - DR cause direction changes in fault current distribution
    - California's goal of 100% renewable by 2050
  - Negative and zero sequence voltage profiles vary greatly
    - Challenging for directional element polarizing
- Over-current protection communication needs
  - Narrow bandwidth, high speed
    - Directional comparison schemes
    - Zone selective interlocking

Transmission protection techniques applied to distribution

- Distance protection challenges
  - Varying conductor sizes creates non-homogeneous impedance
  - Reconfiguration changes impedance to end-of-line
  - Laterals create parallel impedance paths to multiple end-of-lines
  - Tapped loads and DR create apparent impedance
- Distance protection communication needs
  - Narrow bandwidth, high speed
    - Directional comparison schemes

Transmission protection techniques applied to distribution

- Line differential challenges
  - Reconfiguration requires dynamic terminal reassignment
  - Tapped loads and DR create sensitivity challenges
  - Is there a practical limit to the number of terminals?
- Line differential communication needs
  - Wide bandwidth, high speed
    - Are the speed requirements the same for T & D?
    - Standardized data formats to allow plug-and-play with DR devices
      - Could we use type “P” synchro-phasors rather than sampled values to reduce bandwidth requirement?

Transmission protection techniques applied to distribution

What about transfer trip?

Transmission protection techniques applied to distribution

Could we use public cloud based Ethernet solutions?

Security?

Reliability?

Conclusions

- Transmission protection concepts can be applied
  - Significant challenges
  - Best for static networks
  - Might not be flexible enough for large DR penetration
- Unique communication system requirements
  - Speed requirements are not the same for T & D
  - Standardized formats useful for DR
  - Cloud based Ethernet might work

Thank You