Redundancy Strategies for Distribution Protection

Michael Thompson, Bernard Matta, and Ray Connolly
Schweitzer Engineering Laboratories, Inc.
Outline

- Background
- Redundancy practices
  - Breaker failure
  - Distribution substation
  - Distribution feeder
- Challenges with not designing for redundancy
- Solutions
- Conclusions
Redundancy is less common for distribution

**Historical paradigms**
- Less system impact for uncleared faults
- Many more circuits to protect
- Radial operation allows upstream backup

**New realities**
- Greater focus on reliability to individual loads
- Higher consequences for delayed clearing
- Scarce resources to perform detailed coordination
- Significantly reduced costs with multifunction relays
Redundancy practices

- Transformer zone
  Typically redundant
- Bus zone
  Sometimes redundant
- Feeder zone
  Practices vary
  Focus of the paper
Breaker failure

- Redundant protection makes fault detection dependable
- Breaker failure makes fault clearing dependable
- Upstream backup is no longer relied upon
- Breaker failure is available in multifunction relays
Transformer zone

- Typically redundant
  - System A, 87T
  - System B, 50/51 AND 63SPR or second 87T
  - Separate 86 tripping relays

- Remote backup not possible
  - Ground relays blocked by delta windings
  - Phase relays blocked by impedance
  - Transformers require high sensitivity
Bus zone

- Typical selective high-speed schemes
  - 87B, differential
  - 50ZI, zone interlock
  - 50AF, arc-flash
- Dual 87B is often not possible
- Time-delayed backup common
- New schemes make redundancy possible
Feeder zone (focus of paper)

- Operational and maintenance considerations
- Organizational considerations
- Challenges of relying on upstream backup
- Functions that should be redundant
- Economical methods to provide redundancy
Operational considerations

- Circuits must be removed from service for
  - A relay failure
  - Periodic maintenance
- Alternate feeds may not be available or may require extensive switching
- Urgency can lead to human performance issues
Organizational considerations

- Boundaries of responsibility
  - Substation engineers
  - Distribution engineers

- Relying on bus main to back up feeders makes cross-boundary communication critical
Challenges of relying on upstream backup

- Increased complexity
  - Setting bus main requires knowledge of feeder topology
  - Coordination is critical
  - Loadability must be addressed

- Poor performance
  - Slow clearing and reduced dependability
  - Increased stress to transformers
  - Loss of service to healthy feeders
Functions that should be redundant

Recommended
- Fault detection, 51P/G and high-set 50P/G
- Hot-line tag enabled elements
- Manual control

Optional
- Reclosing
- Fuse-saving scheme
Feeder redundancy options

- Apply two multifunction feeder relays
  - Simplest option
  - No compromises
  - Requires twice as many relays and more panel space
- Apply multirestraint 87B relay for bus zone
- Apply a multifeeder redundant relay to each panel
Apply multirestraint 87B

- 50/51 elements in bus relay provide redundancy for fault detection
- Scalability limited to buses with five feeders
- No additional relays required
Apply a multifeeder redundant relay to each panel

- Multirestraint differential relay – 50/51 protection for three circuits
- Redundancy for fault detection
- Scalable to as many feeders as needed
- Economical – Only one additional relay for up to three feeders is required
Apply a multifeeder relay to each panel
Conclusions

- Historical paradigms not fully relevant today
- Distribution system reliability is critical for individual consumers
- Distribution is much messier than transmission
- Relying on upstream backup is
  - More complex
  - Lower performance
  - Less reliable
- Designing for redundancy solves many problems
- Barriers to applying breaker failure at all voltage levels are gone
Conclusions

- Paper provides ideas for implementing redundant bus protection
  - 50ZI schemes require no added relays
  - 50AF schemes can also be a second high-speed selective system

- Paper provides ideas for implementing redundant feeder protection
  - Using dual feeder relays
  - Using protection in bus relay requires no added relays
  - Using a multifeeder redundant relay requires few added relays

- Paper has two informative appendixes
  - Methods to improve loadability of phase overcurrent relays
  - Methods to implement 51G elements in a bus relay
Questions?