Solutions to Common Distribution Protection Challenges

Jeremy Blair, Greg Hataway, and Trevor Mattson
Schweitzer Engineering Laboratories, Inc.
Common Distribution Protection Problems

- Unnecessary operations on fast curve due to inrush
- Long protection times as multiple devices coordinate
- Operation of feeder relay caused by conductor slap
- Closure into faults in loop schemes from lack of communication
Distribution System Protection

Challenges

- Zones of protection are large and diverse
- Selectivity is classically established using time
- Topology is dynamic
- Maximum load conditions can be close to minimum fault conditions
Distribution System Protection

Advantages

• Multiple shots of reclosing
• Measurements distributed across the protected system

• Advanced feeder relays and recloser controls
  ▪ Event records
  ▪ Historical data
  ▪ Multiple protection elements
  ▪ Custom logic
Eliminate Unnecessary Fast-Curve Operations

Problem

- High speed
- High sensitivity
- Low security during inrush
  - Magnetizing inrush
  - Load inrush
- Frequent exposure to inrush due to reclosing
Eliminate Unnecessary Fast-Curve Operations
Example – R2 Trips on Inrush When R1 Recloses

- **Feeder 1**
  - 1 Fast Curve
  - 2 Slow Curves

- **Feeder 2**
  - 1 Fast Curve
  - 2 Slow Curves
Eliminate Unnecessary Fast-Curve Operations

Solution 1 – Use Slower Fast Curve

<table>
<thead>
<tr>
<th>Current (A)</th>
<th>Time (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10,000</td>
<td>0.01</td>
</tr>
<tr>
<td>1,000</td>
<td>0.1</td>
</tr>
<tr>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
</tr>
<tr>
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<td>100</td>
</tr>
<tr>
<td>100</td>
<td>1,000</td>
</tr>
<tr>
<td>10,000</td>
<td>10,000</td>
</tr>
</tbody>
</table>

Graphs showing the comparison of fuse, recloser slow, and recloser fast time versus current.
Eliminate Unnecessary Fast-Curve Operations
Solution 2 – Predict Inrush and Block Fast Curve

Enable Fast Curve

Cycles

0.25
10

27A2
27B2
27C2

50P4
Eliminate Unnecessary Fast-Curve Operations
Solution 3 – Detect Inrush With Second Harmonic

![Graph showing current (A) over cycles]

- TRIP
- HBL2T
- 51P2T
- 51P2
- 51P1T
- 51P1
Reduce Time-Overcurrent Protection Times

Problem

- Typical coordination interval is ~ 0.2 second
- Fuse size (100T) may be limited by downstream load
- Feeder curve may be limited by upstream overcurrent protection or damage curves
Reduce Time-Overcurrent Protection Times

Example

- Recloser installed between feeder and 100T fuse is meant to improve feeder sectionalization
- Coordination interval does not allow for it

\[
\begin{align*}
T &= 0.237 \text{ s} @ 6,000 \text{ A} \\
T &= 0.038 \text{ s} @ 6,000 \text{ A}
\end{align*}
\]
Reduce Time-Overcurrent Protection Times
Solution 1 – Faster Curve on Reclose

- Allow feeder and recloser to miscoordinate on first time-overcurrent trip

![Graph showing time-current relationships for feeder and recloser.]

- \[ T = 0.217 \text{ s} @ 6,000 \text{ A} \]
- \[ T = 0.038 \text{ s} @ 6,000 \text{ A} \]
Reduce Time-Overcurrent Protection Times
Solution 1 – Faster Curve on Reclose

- Allow feeder and recloser to miscoordinate on first time-overcurrent trip
- Use faster curve on recloser for subsequent time-overcurrent trips
Reduce Time-Overcurrent Protection Times
Solution 2 – Even Faster Curve on Reclose

• Allow feeder and recloser to miscoordinate on first time-overcurrent trip
Reduce Time-Overcurrent Protection Times
Solution 2 – Even Faster Curve on Reclose

- Allow feeder and recloser to miscoordinate on first time-overcurrent trip
- Use instantaneous or short time-delay overcurrent to reduce through-fault energy
Prevent Feeder Lockout Due to Conductor Slap Problem

Fault develops downstream of recloser
Prevent Feeder Lockout Due to Conductor Slap Problem

Fault develops downstream of recloser

Magnetic field from fault current causes upstream conductors to contact
Prevent Feeder Lockout Due to Conductor Slap

**Problem**

Fault develops downstream of recloser

Magnetic field from fault current causes upstream conductors to contact

Feeder trips, but recloser may not trip
Prevent Feeder Lockout Due to Conductor Slap
Example – Multiple Conductor Slaps After Fault Clears

Recloser

Feeder
Pitting and Beading Due to Conductor Slap
Prevent Feeder Lockout Due to Conductor Slap

Solution

Overcurrent

Recloser Cycling

Three-Phase Undervoltage Source Side

Good Voltage

Count Up

Reset

Trip and Lockout

Alarm

Preset Value

Cycles

Seconds

0

10

60

0

60
Prevent Restoration of Faulted Lines in Noncommunicating Loop Schemes

Problem

![Diagram showing the comparison between FDR (Fast Detection and Restoration) and RCL (Remote Control Loop) schemes in preventing restoration of faulted lines. The left side shows a failure scenario where FDR is able to isolate the fault more effectively, leading to faster restoration. The right side shows a scenario where RCL may not isolate the fault as efficiently, potentially leading to slower restoration.]
Prevent Restoration of Faulted Lines in Noncommunicating Loop Schemes

**Solution**

- **Feeder 2nd Open Interval**: 3 seconds
- **Recloser 2nd Open Interval**: 5 seconds
Conclusion

• Data from modern relays help explain complex distribution protection problems

• Multiple protection elements and custom logic can improve
  - Security of fuse-saving schemes
  - Selectivity of tightly coordinated feeders
  - Speed of overcurrent protection during reclose cycle
  - Security of feeders at risk of conductor slap
  - Selectivity of noncommunicating loop schemes