Improving Auto-Sectionalizing Schemes with IEDs

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Background
- Improve Snohomish PUD’s transmission line auto-sectionalizing scheme by:
  - Implementing high-voltage fault indicators to detect faults
  - Programming an automation controller communicating over a fiber optic network
  - Better revealing the location of a fault and removing only faulted areas
  - Working under a limited public utility budget:
    - Targeting most fault concentrated area
    - Detecting faults without adding additional transformers
    - Working with a non-radial transmission network:
      - Limited equipment selection for High Voltage Lines
      - Utilizing relatively new Fiber Optic Communications
      - Detecting direction of current

System One-line

Auto-Sectionalizing Logic
- Transmission Lines monitored for 2 cycle fault condition. Preset values in Figure 5 determined from Aspen OneLiner.
- Fault conditions trigger flowcharts Figure 6 & 7 which can be followed logically from Figure 8.

<table>
<thead>
<tr>
<th>Rj 1</th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
<th>B4</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ILG]</td>
<td>2LG (B-C)</td>
<td>L1</td>
<td>R1</td>
<td>L2</td>
</tr>
</tbody>
</table>

| Rj 2 & Rj 3 at B2 |
| [ILG] | 2LG (B-C) | L1 | R1 | L2 |

| Rj 4 at B3 |
| [2LG] | L1 | R1 | L2 |

Data Protocols
- SCADA
- DNP3
- ZigBee

Data Retrieval
- Wireless (150ft)

GridSense Gateway
- Supports Serial or LAN connection
- Makes Collected Data available to the SCADA

Security
- ZigBee protocol encrypts traffic and is secure from cyber-attacks
- DNP3 difficult to eavesdrop over fiber-network

Test & Validation

Software & Tools
- Aspen OneLiner – fault current analysis on our network topology
- Cedar Logic – test logic
- SEL AcSELerator – program SEL-2411 controller

Conclusion
- Reduces the number of circuit breaker re-closures
- Improves safety
- Reduces wear on expensive equipment
- Improves the accuracy of locating faults

Recommendations for Future Work
- More LineIQ connections for South Loop
- Upgrading switches and breakers
- Faster LineIQ algorithm processing speed

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