Utility Implements Communications-Assisted Special Protection and Control Schemes for Distribution Substations

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City of College Station (COCS)  
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• Provides electric power to residential and commercial customers

• Is composed of
  ▪ ~20 miles of transmission lines
  ▪ ~458 miles of distribution lines
  ▪ 7 substations
Traditional 13.2 kV Distribution Substation

- Electromechanical relays
- No bus differential protection
- No breaker failure backup
- No automatic source transfer
- Four feeders per bus supplied from main breaker
- Challenge coordinating for simultaneous fault conditions
13.2 kV Distribution Substation for Special Protection and Control Scheme (SPCS)
Communications Link Supervision for High-Speed Data Bits

<table>
<thead>
<tr>
<th>IEDs</th>
<th>Status Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROK = 1</td>
<td>Communications channel good</td>
</tr>
<tr>
<td>ROK = 0</td>
<td>Communications channel bad</td>
</tr>
</tbody>
</table>

Inverse (NOT) of ROK is used to create digital alarm bit to alert operations of communications failure.
Communications Link Supervision in Logic Processors

<table>
<thead>
<tr>
<th>Logic Processors</th>
<th>Status Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>COM = 1</td>
<td>Communications channel good</td>
</tr>
<tr>
<td>COM = 0</td>
<td>Communications channel bad</td>
</tr>
</tbody>
</table>

Communications link supervision in logic processors only allows received data bits of good quality to be considered in algorithms.
Different Schemes Implemented

- **Fast bus tripping scheme** for significantly reduced bus fault-clearing time
- **Breaker failure protection scheme** for shorter breaker failure clearing time
- **Double-circuit feeder trip scheme** for faster clearing of simultaneous faults without causing substation outage, and **stall reclose logic** for system availability
- **Automatic source transfer scheme (ASTS)** for higher power system availability
SCPS Six Major Design Criteria

- Dependability
- Security
- Selectivity
- Resilience
- Speed
- Cost
Limitation of traditional bus protection philosophy

- Bus fault is cleared with time-delayed transformer backup protection
- Typical fault-clearing time is between 0.6 and 1.0 seconds

Solution

- Bus differential protection is fast and secure, but has added cost
- Fast bus tripping scheme is fast and cost-effective
Fast Bus Tripping Scheme
Fault on Bus 1
Fast Bus Tripping Scheme
Fault on F1 Feeder Circuit
Limitation of traditional breaker failure protection philosophy

- Fault is cleared with upstream inverse-time overcurrent protection
- Long fault-clearing times lead to equipment damage or reduced equipment lifespan

Solution

- Dedicated, fast breaker failure protection scheme using existing IEDs and communications backbone
- Low implementation cost with minimal wiring
Breaker Failure Protection Scheme
Fault on Bus 1
Double Circuit Feeder Trip Scheme and Stall Reclose Logic

Limitation of traditional system

- Simultaneous faults may cause coordination issues
- Main breaker 51 element may misoperate
- IED overcurrent pickup and time-dial settings must be adjusted (resulting in slower tripping)

Solution

- Double-circuit feeder trip scheme with low implementation cost
- Fast 51 element setting and improved service reliability
Double Circuit Feeder Trip Simultaneous Fault
Stall Reclose Logic

- Bus 1
  - M1
  - TIE
  - F1, F2, F3, F4
- Bus 2
  - M2
  - F5, F6, F7, F8

- Logic Processor T1
- Logic Processor T2
Limitation of traditional system

- Less power system availability with more disruption
- Long restoration times

Solution

- ASTS that automatically switches from primary source to alternate source
- Short restoration times to improve power system availability
ASTS Transformer Fault
Other Schemes

• Multiple SPCSs run in parallel and coordinate with each other as complete, integrated solution

• Other control logic is implemented to improve system availability and dependability
  ▪ Hot-line mode
  ▪ IED health alarm
Questions?