Simplifying Protection System Design for Distribution Substations

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Outline

The project
- Overview of Orion
- Distribution substation protection upgrade

Possible tools / solutions
- Project goals and constraints
- Tools considered

The project
- As implemented

Results
- Performance against goals
- Path for the future
Existing protection system for a small rural substation
## Project requirements

### Lifecycle
- Relay lifespan $<<$ SWG lifespan
- Account for future replacement

### Design
- Custom vs. standard
- Repeatable

### Safety
- Operations
- Arc flash

### Business
- Cost
- Resource Utilization
Initial protection system design

Simplifying Distribution Protection
65th Annual Texas A&M April 2-5, 2012

Initial concept for new design

Relays in panels in separate room

Meets criteria for:
- Lifecycle (partially)
- Safety (mostly)
- Design (partially)
- Business (partially)
## Limitations to this solution

<table>
<thead>
<tr>
<th>Lifecycle</th>
<th>Still reliant on copper wiring, explicit physical design</th>
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</thead>
<tbody>
<tr>
<td>Design</td>
<td>Still a custom design for every installation</td>
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<tr>
<td>Safety</td>
<td>High energy signals still in relay room</td>
</tr>
<tr>
<td>Business</td>
<td>Still significant resources required for every project</td>
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Limitation is that of the relays: copper wiring, and single zone
## Technology to improve solution

<table>
<thead>
<tr>
<th>IEC 61850</th>
<th>Multi-zone protection relays</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Complicated</td>
<td>• Physical wiring is complicated, time consuming</td>
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<tr>
<td>• Change in philosophy</td>
<td></td>
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<tr>
<td>• Network communications based</td>
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**Perceptions are also a limiting factor in applying tools**
IEC 61850 technical concepts

Self-description of data
- Object-oriented modeling through logical nodes

Peer-to-peer communications
- GOOSE, client-server through MMS

Sampled values
- Special form of peer-to-peer
Using 61850 concepts on field wiring

The real limitation is field wiring

- Copper wiring, analog data transmission
- Every piece of information requires 2 wires
- Every wire must be designed

GOOSE, sampled values addresses field wiring between control room and relays

- All data on fiber optic network
- “Process bus”
Addressing perceptions

61850 doesn’t have to be “hard”
- Solutions, architecture “fit for purpose”

Multi-zone protection relays
- Process bus eliminates wiring concerns
New tools

Process interface unit (PIU)
- Sampled values per 61850
  - 8 currents or 4 currents/4 voltages
- Contact I/O
- Point-to-point architecture
  - Fit-for-purpose for distribution sub

Multizone protection relays
- Up to 6 zones of protection
- Enabled for process bus
- Feeder, bus, transformer options available
New Rural Substation Design

Three separate components
- Multiple zone relays in separate panels
- Fiber optic cables
- PIUs

Multi-feeder protection

New Rural Substation Design

Transformer Protection

Dif Fiber Comm
Tx Trip
OClInstHV
EFInstHV
Dif (Fr)
Dif (Inst)
Dif (EF) LV
EFDefT/LV
LV CB Trip
OCl/TLV
EFDefT/LV1
EFDefT/LV2
OV EF[DefT]1 Block

Mech Trip
BucRc[Main]
PrRc[Main]
Pressure/TCH
Oil Flow (TCH)

AVR
Temp
Digital
Tips Temp

CB110
BZ Trip
CB111
OC (IT)
CB112
BZ Trip
CB133
BZ Trip
CB134
BZ Trip
OC (CIB Fail)

CB111
OC (IT)
CB112
OC (IT)
CB113
OC (Inst)
CB114
OC (Inst)

CB111
OC (IT)
CB112
OC (IT)
CB113
OC (Inst)
CB114
OC (Inst)

CB111
OC (IT)
CB112
OC (IT)
CB113
OC (Inst)
CB114
OC (Inst)

PIU 1
CB802
SA 3

SA 2

T1
33/11 kV
7.3/10 MVA
Dyn11
6.8% @ 7.3 MVA

VT110

11 kV

CB111
CB112
CB113
CB114

PIU 3
PIU 4

Bus Protection

OC / EF
Fiber Comm

CB111
CB112
CB113
CB114

PIU 2
CB110

Three separate components
- Multiple zone relays in separate panels
- Fiber optic cables
- PIUs

Multi-feeder protection
Actual installation

11 kV switchgear

PIU mounted in 11 kV switchgear
Actual installation – cont.

PIU mounted in 33 kV breaker

Complete relay panels
Actual installation – cont.

Rear view of relay panel

Traditionally wired panel
Fiber cable distribution

- Using same fiber cable for both PIU and relay
- All cables end at patch panel / DC bus
- DC bus provides power to both relays and PIUs
- Each relay and each PIU protected by individual MCB
New design meets goals

**Lifecycle**
- All components (relays, PIUs) are connectorized components
- No touching field wiring in future

**Design**
- Relay panel design constant
- Field wiring constant

**Safety**
- Relays separate
- No high energy signals at relays

**Business**
- Repeatable design, simple install
- Max utilization of resources

Simple, component-based approach
Larger substations
Economics

Panel and cable costs have escalated recently

For a sub of this size the IEC 61850 PIU solution is probably still slightly more expensive

Quick simple installation

Provides future flexibility - future expansion at this substation requires 3 ended line differential and conversion to 66 kV. Only need to mount an additional IED in the panel and connect power, a fiber jumper and SCADA comms.
## Other design factors

<table>
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<th>Interoperability</th>
<th>Testing</th>
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| • Based on 1 of commercially available IEC 61850 process bus profiles  
  • Profile to use specified by Orion  
  • Is interoperability for process bus truly desirable? | • Relays, PIUs commissioned as system  
  • Orion used temporary wireless network to test  
  • PIUs can be tested offsite and replaced  
  • Multiple zone relay can be connected to spare PIU, safely isolating |
Conclusions

Pick right tools for job

Design solution around your needs, requirements
  • What problem are you trying to solve?

Orion design delivers specific solutions
  • Lifecycle costs, design and installation costs, safety requirements, business requirements
Thank you!