Distribution Feeder Automation

Smart Grid Challenges & Opportunities

Title:
New Protection Method for Automated Distribution Feeders

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Title:
New Protection Method for Automated Distribution Feeders

Content:
Smart Grid
Smart Feeder Switching Benefits
Design Considerations
- Smart Feeder Switching
- Communication
- Review Protection System Practices
- Architecture design considerations
- New FLISR Approach
- New Protection Method
- Field Performance and Feedback
- Software Tools
What is the “Smart Grid”? 

**Electrical Grid**
- Dynamic
- Fast / Real-time

**Current control methods**
1. Measure/ Read
2. Analyze
3. Estimate/Predict
4. Simulate
5. Control

Fast Real-Time Grid Controlled by a Slow Reactionary Systems
Benefits

**Operational**
- Reduced Sustained Outages
- Increase Situational Awareness
- Loss Reduction
- Peak Reduction

**Utility**
- Reduced O&M Costs
- Increased Revenues
- Enhanced Planning & Engineering
- Reduced Supply Cost
- Deferred Capitil Costs

**Customer**
- Avoid Penalties
- Reduced Customer Outage
- Customer Satisfaction
- Reduced Rates
- Reduced Emissions

**Society**
- Improved Public Safety
- First Order Impacts
- Second Order Impacts

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**Smart Feeder Switching**

**FLISR & ATS**

**Load Balancing & VVO**
Smart Feeder Switching

1. Divide into line sections
2. Automate primary gear
3. Isolate faulted line section
4. Provide alternative source
5. Balance load move open points
6. Optimize consumer voltage
7. Automate above switching
Smart Feeder Switching
Important Considerations

Communication System?
1. Fiber
2. Wi-Fi
3. WiMAX
4. Cellular
5. Hybrid
6. Others
Smart Feeder Switching
Important Considerations

System Structure
• Centralized
• Decentralized
1. Coordination
Smart Feeder Switching

Protection System
1. Coordination

Sub

Sub

Sub

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Smart Feeder Switching

Protection System
1. Coordination
Smart Feeder Switching

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Smart Feeder Switching

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Protection System
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- Complex
- Difficult to Implement
- Require capable field relays
Smart Feeder Switching

Important Considerations

- Require Communication
- Complex Protection System
Smart Feeder Switching

Important Considerations

Centralized vs Decentralized

Protection

Yes

No

SCADA

Automation

Yes

Yes

Sub

Yes

Yes

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Smart Feeder Switching
Important Considerations

Control-Center OR Substation

Centralized
Slow and Reactionary

Protection
Automation

Sub

Centralized
Smart Feeder Switching
Important Considerations

- Decentralized
- Fast
- Real-Time

Protection

Yes

Control-Center
OR
Substation

Automation

Yes

Sub

Decentralized

Fast

Real-Time
Smart Feeder Switching
Speed of Operation

Important?

- Reduced Sustained Outages
- Reduced O&M Costs
- Reduced Customer Outage
- Increased Revenues
- Avoid Penalties
- Customer Satisfaction
- Improved Public Safety
- Avoid Penalties
- Reduced O&M Costs
- Reduced Customer Outage
- Increased Revenues
- Avoid Penalties
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How can we improve protection flexibility?

We cannot solve our problems with the same thinking we used when we created them. (Albert Einstein)
Smart Feeder Switching
New Innovations

Conventional Procedure

1. The isolation of a power system fault is first performed by the protection system.
2. The protection system will then test through auto reclose cycles if the fault was temporary in nature.
3. If the fault was permanent in nature the protection will proceed to disconnect the power system fault and lockout.

Automation

1. On confirmation that lockout was reached the system must locate the faulted line section.
2. The faulted line section is then isolated.
3. Power is restored to line sections not connected to the fault.

New Procedure

1. The isolation of a power system fault is first performed by the protection.
2. The protection system will then test through 1 fast auto reclose cycle if the fault was temporary in nature.
3. If the fault was still present the protection will proceed to isolate the fault.

Automation

1. The faulted line section is isolated.
2. Power is restored to line sections not connected to the fault.

Protection

1. The faulted line section is tested for a temporary fault through conventional reclose cycles.
Smart Feeder Switching
Conventional Protection

Sub 1

Sub 2

Hospital
Smart Feeder Switching
Conventional Protection

1. Test for temporary fault 1st reclose Cycle, Open and Close Breaker at Sub 2
Smart Feeder Switching
Conventional Protection

1. Test for temporary fault 1\textsuperscript{st} reclose Cycle, Open and Close Breaker at Sub 2
2. Test for through 2\textsuperscript{nd} Reclose Cycle, Open Breaker at Sub 2 for 3 Seconds and Close.
1. Test for temporary fault 1\textsuperscript{st} reclose Cycle, Open and Close Breaker at Sub 2
2. Test for through 2\textsuperscript{nd} Reclose Cycle, Open Breaker at Sub 2 for 3 Seconds and Close.
3. Test for through 2\textsuperscript{nd} Reclose Cycle, Open Breaker at Sub 2 for 5 Seconds and Close.
Smart Feeder Switching
Conventional Protection

1. Test for temporary fault 1\textsuperscript{st} reclose Cycle, Open and Close Breaker at Sub 2
2. Test for through 2\textsuperscript{nd} Reclose Cycle, Open Breaker at Sub 2 for 3 Seconds and Close.
3. Test for through 3\textsuperscript{rd} Reclose Cycle, Open Breaker at Sub 2 for 5 Seconds and Close.
4. Test for through 4\textsuperscript{th} Reclose Cycle, Open Breaker at Sub 2 for 10 Seconds and Close.

Protection Interruptions at Hospital

Automation Interruptions at Hospital
Smart Feeder Switching
Conventional Protection followed by Automation

1. Test for temporary fault 1st reclose Cycle, Open and Close Breaker at Sub 2
2. Test for through 2nd Reclose Cycle, Open Breaker at Sub 2 for 3 Seconds and Close.
3. Test for through 3rd Reclose Cycle, Open Breaker at Sub 2 for 5 Seconds and Close.
4. Test for through 4th Reclose Cycle, Open Breaker at Sub 2 for 10 Seconds and Close.
5. Open Breaker at Sub 2 issue lockout. Automation is released to locate fault, Isolate the by opening upstream recloser and closing Open Point recloser
1. Test for temporary fault 1st reclose Cycle, Open and Close Breaker at Sub 2

Protection Interruptions at Hospital

Automation Interruptions at Hospital
Smart Feeder Switching
Synchronize Protection and Automation

1. Test for temporary fault 1st reclose Cycle, Open and Close Breaker at Sub 2
2. Isolate Faulted Line Section and Close Open Point Recloser

Protection Interruptions at Hospital
1 sec

Automation Interruptions at Hospital
.3 sec
1. Test for temporary fault 1\textsuperscript{st} reclose Cycle, Open and Close Breaker at Sub 2
2. Isolate Faulted Line Section and Close Open Point Recloser
3. Test for through 2\textsuperscript{nd} Reclose Cycle, Open Breaker at Sub 2 for 3 Seconds and Close.
4. Test for through 3\textsuperscript{rd} Reclose Cycle, Open Breaker at Sub 2 for 5 Seconds and Close.
5. Test for through 4\textsuperscript{th} Reclose Cycle, Open Breaker at Sub 2 for 10 Seconds and Close.
6. Open Breaker at Sub 2 issue lockout.

Protection Interruptions at Hospital
\[0.1 \text{ sec}\]

Automation Interruptions at Hospital
\[0.3 \text{ sec}\]
Smart Feeder Switching
Synchronize Protection and Automation

What is required to synchronize protection and automation?
1. Smart Controllers capable of protection and automation.
2. Modern Communication System.
3. Locate the fault, fast and accurately.
Fault Location or Isolation
Dynamic Current Jump Differential Comparison Protection (jDiff™)

1. \( I \) at P1
   Jump (\( I_j \))

2. Compare
   \( I_{J1} \) & \( I_{J2} \)
   \( I_{J2} \) & \( I_{J3} \)

3. \( I_{J1} \) & \( I_{J2} \)
   \( I_{J2} \) & \( I_{J3} \)
   \( I_{J1} \) & \( I_{J3} \)

\( + \) = Fault
\( + \) = No Fault
Smart Feeder Switching
Differential Protection Benefits

1. Fast and Selective and easy to set.
2. Simple reclose coordination with Fuses or Branch Recloser
3. Reclosing on Isolated Section, reclose triple single or 3 pole based on line section load.
4. Require small communication bandwidth, compare binary information.(jDiff™)
A&N Electrical Cooperative
Bayview to Kellam Loop Feeder

Phase 1

Phase 2

P = Protection
A = Automation
A&N Electrical Feedback form  Riverside Shore Memorial Hospital

Susan McAndrews, VP and hospital administrator.

“We’ve had no outages this year; I hardly even remember the one we had in 2012. We have a lot of traffic accidents that are on the shore – they take out a pole. It’s a lot of work to get that repaired. If that happens, used to be in the past, that we would be down for many hours. That doesn’t happen anymore. This (technology) allows us to stay up essentially all the time. It doesn’t get any better than that – not in healthcare.”
What make all this possible?
NIST Recommended Standard IEC61850

Distributed System of Programmable Logic Controllers (PLC’s)

SCADA / HMI Modes
Switch Status Topology
Fault Detection & Location

IEC61850 “GOOSE” Message
Smart Feeder Switching
IEC61850 Communication Supported?
Smart Feeder Switching
Synchronized Protection and Automation

Advantages

High-Speed Smart Feeder Switching Made Possible

Simplifies Protection and improves Automation flexibility

Easy implementation with modern tools