FDIR Scheme to Improve Electric Service Reliability for Remote Radio Towers

Sponsor: Benton PUD

Mentor: Erik Pryor, Blake Scherer

Jared Crain, Alex Hamlin, Irfan Hossain, Kevin Schindler, Syed Tilal

Washington State University
School of Electrical Engineering and Computer Science

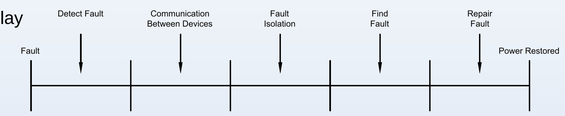
Background

Electric services that are required long distances away like radio towers can be susceptible to power outages due to faults. To mitigate power outage duration and crew traversal time an FDIR scheme can be implemented. While crews traverse the landscape they may have to deal with adverse weather conditions that may make sections of the distribution system only accessible by foot and all terrain vehicles. An FDIR scheme is a protection system that relies on microprocessor based technologies to detect, isolate and help restore power when a fault has occurred. The purpose of this project was to create an FDIR scheme for Benton PUD.

Objectives and Design Considerations

Objectives:

- Reduce outage durations
- Microprocessor-based relay
- Reduce safety risks
- Improve SCADA visibility



Timeline from Fault Occurring to Power Restoration

Considerations:

When a fault occurs there is a sequence of events that take place. The FDIR scheme that was designed tried to minimize each events duration. The main reduction of time is in the fault isolation and physically finding the fault. Using microprocessor based relays and reclosers a fault can be isolated and power can be rerouted. Finding a fault can also be dramatically reduced using drones to quickly find a fault and observe equipment required. Reducing power outage duration would improve reliability and decrease loss in revenue from rate payers and stakeholders of companies.

Description of Design

FCI:

- Placed in visible areas to direct crews to the location of a fault. Reducing the time required to find a fault.

Relays:

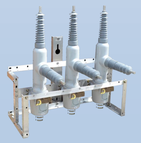
- Relays and reclosers are placed in critical areas that create isolated sections of distribution line in the event of a fault. Reducing time to detect, communicate and isolate fault.

Drones:

- Travel much faster and safer than a crew. Reducing time required to find and repair a fault.

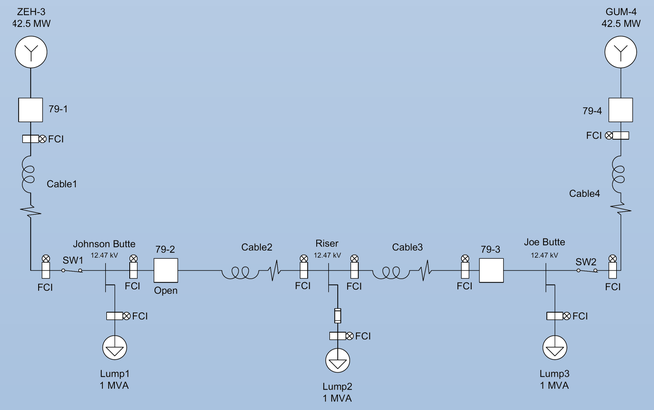
FCI: SEL-AR360

Drone: DJI Inspire 2.0



Recloser: G&W Viper-S

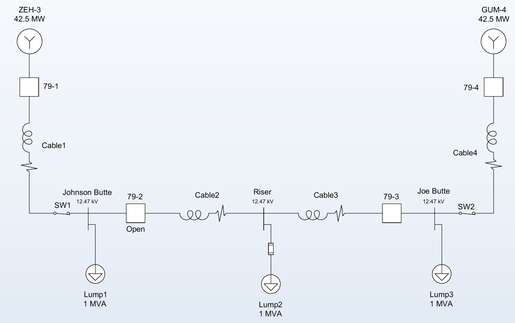
Relay: SEL-351R



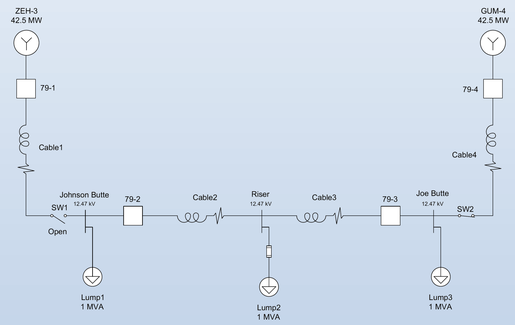
FCI Placement on Distribution System

Modeling and Simulation

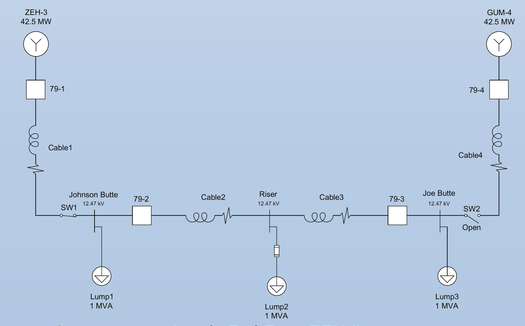
A software model of the distribution system was created in ETAP because it is a comprehensive electric system modeling software. ETAP contains libraries of power system components that can be easily imported into simulations to accurately model responses. There are a total of three operating conditions to keep loads powered by switching the substation that they are fed from. The normal configuration is similar to how the currently is configured.



Normal Configuration



Loads Fed From GUM-4



Loads Fed From ZEH-3

State of Reclosers

Fault Location	79-1 Status	79-2 Status	79-3 Status	79-4 Status	SW1 Status	SW2 Status
Johnson	Open	Closed	Closed	Closed	Open	Closed
Riser	Closed	Open	Closed	Closed	Closed	Closed
Joe Butte	Closed	Closed	Closed	Open	Closed	Open

Loads Fed From GUM-4

Relay	Pickup	Operating Time (ms)
79-2	50.16	152
79-3	100.56	161
79-4	146.88	164

Loads Fed From ZEH-3

Relay	Pickup	Operating Time (ms)
79-1	149.88	160
79-2	101.64	158
79-3	50.64	152

Recommendations and Conclusion

Recommendations:

- Apply for an exception to Federal Aviation Administration regulations
- Implement underground FCI

Conclusion:

- Use of FCI's and drone help reduce time to locate a fault
- Created a FDIR scheme using coordinated devices to reduce time to fix a fault
- Load flow analysis and fault analysis simulation in ETAP showed successful isolation

Future Work

- Extend fiber optic communication
- Complete distribution system model with accurate load data
- Accurately model sources

Broader Impacts

Drones:

- The use of drones could be impacted by the opinion that the public holds. Over the past few years Drones have been scrutinized by news outlets and have become regulated by the FAA. A study done in [1] showed that the public did not have a difference of opinion if a drone or a helicopter was used for the same task. Drones used in very rural areas would be very beneficial to a utility and customers affected by prolonged outages.

Revenue and Reliability:

- Companies may incur a loss of revenue and reliability of a product during an unscheduled power outage. During outages article [2] shows that customers can be affected resulting in a loss of revenue. An example of services that are affected by radio towers losing power is cellphone, radio, television and other emergency services. Customers may lose power but the reliability of service to the customer is very important. An FDIR design works to decrease downtime resulting in a higher reliability.

Cyber Security:

- Smart devices connected over the internet have the potential to be remotely manipulated by people with malicious intent. Cyber security requires large system resources and can be difficult to implement using algorithms to catch intrusions. Article [3] shows that there are advances in algorithms to decrease computing time and reliability. FERC and NERC also require communication protocols to protect the power grid from attacks.

References

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2. "Hourly Downtime Tops $300K for 81% of Firms; 33% of Enterprises Say Downtime Costs >$1M", Itic-corp.com, 2017. [Online]. Available: http://iticcorp.com/blog/2017/05/hourly-downtime-tops-300k-for-81-of-firms-33-of-enterprises-saydowntime-costs-1m/. [Accessed: 27-Mar- 2018].
3. "Cyber & Grid Security," FERC: Electric Reliability: Cyber & Grid Security, 20-Feb-2018. [Online]. Available: https://www.ferc.gov/industries/electric/indusact/reliability/cybersecurity.asp. [Accessed: 27-Feb-2018].

Glossary

FCI – Faulted Circuit Indicator
FDIR – Fault Detection, Isolation and Restoration
FERC – Federal Energy Regulatory Commission
NERC – North American Electric Reliability Corporation
PUD – Public Utility District
SCADA – Supervisory Control And Data Acquisition
SEL - Schweitzer Engineering Laboratories

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