Experimental Test Bed to Enable Realistic Evaluations for Direct Transfer Trip Relaying via Private Wireless LTE Communications

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Communication for a More Distributed Grid

A highly distributed grid can result in:

More complex communications management

More communications congestion

More cybersecurity vulnerabilities

An increase of advanced energy technologies on the grid requires a proportional growth in secure and reliable communications.

Wireless Communication for Grid Applications

Wireless communications provide a cost-effective alternative to wired solutions and a higher interoperability for a range of grid devices.

Direct transfer relaying is an example of a grid application where utilities need a dependable and low latency wireless communication solution in order to send a trip signal to a remote or far away location.

An example¹:

Fault on feeder
detected by
substation relay

Trip signal sent to
distributed
location

DTT signal trips
distributed
breaker or relay

Research Objectives

Objectives

- Develop an **evaluation platform** to study the **impact from wireless communication** in a low-latency grid application.
- **De-risk wireless communications for utilities** facing high levels of distributed energy resource integration.

Method

- Evaluate direct transfer trip (DTT) events using a **private wireless LTE system integrated with a PV inverter & load system**.

Wireless Scenarios Under Test

- Strong vs. weak LTE signal propagation
- Traffic load vs. no traffic load
- High vs. low priority air-interface traffic queuing

Lab Setup and Measurement

Lab Setup and Measurement – continued

Private LTE Network Setup at NREL's Energy Systems Integration Facility

LTE Wireless
Tower Antennas

LTE Endpoint
Antennas

Wireless
Communication

Server

Recloser

PV Inverter

LTE Gateway Access
Endpoint Equipment

DTT timing is calculated between when the trip signal was sent to when the line current downstream of the breaker drops to 0A.

Experimental Results

- A total of **7 different wireless scenarios** were studied in a DTT application.
- The 7 wireless scenarios were performed **10 times each** to strengthen the statistical confidence of the results.

Key Trends in Results

Latency Calculations for Wireless Direct Transfer Trip Experiments

The **low priority breaker communication** scenarios (IV & VII) resulted in the **highest latency** and **widest range** in DTT timing.

For **high priority breaker communication** scenarios (III & VI), the attenuated wireless scenario had 50.08% greater **range in timing** compared to wireless without attenuation.

Conclusions

1. An evaluation framework was developed for validating private LTE wireless communication performance for grid applications such as DTT.
2. Private LTE wireless technologies are capable of protection for distributed applications.
3. Message prioritization has large impact on communication timing; hence, control of queuing is key component for critical infrastructure applications.

Thank You.

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