DER Gateway to Support Real-Time Control and Situational Awareness in Distribution Grids
Project Team
Challenge:
  • Cost-effective solutions for smaller DER (<500kVA) are not readily available on the market

Project Objective:
  • Investigate options for making DER more visible to distribution operations and support real-time control
  • Develop a technology solution that addresses the monitoring and controls gap associated with smaller DER (<500kVA)

Specifically, a gateway was developed with the following objectives:
  • Enhance situational awareness and state estimation
  • Employ the same interface to manage DER to enhance grid modernization applications such as
    – Fault location, isolation, and service restoration (FLISR)
    – Voltage and VAR optimization (VVO)
    – Dispatch of DER assets into wholesale markets
DER Gateway Architectures

Cloud-Based Third-Party Aggregator Communications and Control Diagram

Field Message Bus Communications and Control Diagram
DER Gateway Block Diagram and Data Flow

- DER Feeder Aggregator and controller
- Feeder Aggregator Communications Interface
- DER Operation Mode Management
- Agent Based Scheduler (future)
- DER Set point Management
- Decentralized Energy Data Platform (future)
- PMU Processing (future)
- DER Communications Interface
- Sensor Interface (optional)
- DER
- Sensors

Communication
Analog
Internal Data Flow
Test Set up
Overview of Lab Set-up
Laboratory Setup

HP Server

CRIO

Raspberry Pi

RTDS Lab

RTAC
Fishkill Plains Milsoft Model Reduction

- Grouped load and PV into subset of buses, separated by major overhead conductors
- Developed the reduced SLD in RSCAD
- Validate by comparison of load flow in both software
- Shared SLD, excel format of network, and load flow results with V&R Energy for implementation in DSE
Load and PV Profile (Circuit 8093)

Net Load (kW)

2MW PV Generation (kW)
RTDS Model of Test System
Data Flow between RTDS and V&R Energy

- **D-PMU ROSE**
  - CSV
  - CSV

- **cRIO**
  - CSV

- **OpenFMB (DDS)**

- **Next Generation DER Gateway**

- **RTAC**
  - Modbus
  - DNP3

- **RTDS**

**Measurements**

- C37.118

**Set-points**
Use Case Testing
## Gateway Use Cases

<table>
<thead>
<tr>
<th>#</th>
<th>Application</th>
<th>Use case</th>
<th>Project Scope</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Distribution System Monitoring and Situational Awareness</strong></td>
<td>1.1 Disaggregation of load and DER</td>
<td></td>
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<td></td>
<td></td>
<td>1.2 Monitoring of voltage compliance for DER locations</td>
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<td></td>
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<td>1.3 FLISR enhancement through improved prefault load calculation</td>
<td>✔</td>
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<tr>
<td></td>
<td></td>
<td>1.4 Micro-phasor measurement unit (uPMU) for improved state estimation</td>
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<tr>
<td>2</td>
<td><strong>DER Management</strong></td>
<td>2.1 Managed operation of BTM DERs and FTM assets for thermal constraints</td>
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<td></td>
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<td>2.2 BTM DER operation for dispatch</td>
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<td></td>
<td>2.3 DER Volt-Var Optimization integration</td>
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<tr>
<td>3</td>
<td><strong>Market Participation</strong></td>
<td>3.1 Community energy market participation using agent-based controls</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>3.2 Blockchain for local market settlement</td>
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<tr>
<td>PMU</td>
<td>DSE</td>
<td>Switches</td>
<td>Demo System Operator</td>
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<tr>
<td>1- Send PMU data for feeders</td>
<td>1- Send DER generation measurements</td>
<td>3- Send prefault operating topology</td>
<td>4- Simulate fault and isolation</td>
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<tr>
<td>5- Send PMU data for feeders</td>
<td>5- Send DER generation measurements</td>
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<tr>
<td></td>
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<td>6- Updated system states</td>
<td>7- Simulate the restoration step</td>
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### FLISR

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<tr>
<th>Test Day</th>
<th>Error in estimation of prefault load (kW)</th>
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<tr>
<td>June 9, 2020</td>
<td>467</td>
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<tr>
<td>June 14, 2020</td>
<td>475</td>
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<td>March 5, 2020</td>
<td>473</td>
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<td>March 7, 2020</td>
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**Active Power Measured at Bus 101**

![Graph showing active power measured at Bus 101](image)
<table>
<thead>
<tr>
<th>Test Day</th>
<th>Average Incremental Voltage Reduction (%)</th>
<th>Maximum System Voltage (pu)</th>
<th>Minimum System Voltage (pu)</th>
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<tbody>
<tr>
<td></td>
<td>DER Enhanced Case</td>
<td>Base Case</td>
<td>DER Enhanced Case</td>
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<tr>
<td>22-Jan-20</td>
<td>0.30%</td>
<td>1.06</td>
<td>1.07</td>
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<tr>
<td>26-Jan-20</td>
<td>0.33%</td>
<td>1.09</td>
<td>1.10</td>
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<tr>
<td>5-Mar-20</td>
<td>0.13%</td>
<td>1.08</td>
<td>1.08</td>
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<td>7-Mar-20</td>
<td>0.19%</td>
<td>1.08</td>
<td>1.08</td>
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<td>9-Jun-20</td>
<td>0.17%</td>
<td>1.10</td>
<td>1.11</td>
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<td>14-Jun-20</td>
<td>0.12%</td>
<td>1.09</td>
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**Substation Voltage January 22**

**Reactive Power Output of PV Groups - Jan 22**

**Voltage at Various Buses for Jan 22**
Summary

- DER gateway was successfully implemented in hardware and shown to enhance many distribution applications
- The gateway provides many useful measurements to a hybrid DSE
- Hybrid DSE represents a logical interim step to full DSE before sufficient distribution connected PMUs are deployed for a fully observable system
- The distributed control architecture offers many benefits relative to integration of BTM DER via third-party aggregators cloud interface
- Field demonstration of the concept will be required to better understand field deployment challenges and costs
Thank you!

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