DISTRIBUTION SYSTEM REAL TIME SIMULATION

FIFTH ANNUAL INTERNATIONAL WORKSHOP ON GRID SIMULATOR TESTING

Nov. 2018
Outline

- Advancement in Distribution System Control operation
- Local Resource Aggregator concept
- Testing Local Resource Aggregator control
- Test Results
- Summary
Power Distribution System Transformation

- Integration of Primary Renewable DER assets:
  - Grid-scale Energy Storage (ES)
  - Grid-scale PV site

- Integration of Secondary-circuit DERs and Controllable Load Assets:
  - Behind-the-meter ES, PV
  - Electric Vehicle (EVs)
  - Direct load control (DLC)
Advanced Distribution System Control Operation

Market Operator

DMS - DSO - DERMS

SCADA Head-End

Regional Resource Aggregation Controller

Primary Assets + Local Aggregator

Secondary Circuit Assets

Local Resource Aggregation Controller
Local Resource Aggregator Concept of Operation

Local Objective:
- XFMR Thermal Limit - avoid overloading (Forward and Reverse)

System-level Objective:
- Power flow management in Primary
- Market participation
Local Resource Aggregator Test Setup

- Grid Simulator
- RTDS Test System
- Local Resource Aggregation Controller
- Impedance Box
- 240 V
- PV Load Bank
- Uncontrollable Load
- Test System Monitoring & Control
- IP Router
- Grid Simulator
- Local Resource Aggregation Controller
- Uncontrollable Load
- PV
- Load Bank
- PV Inverter 1
- PV Inverter 2
- Radio
- EV
- IP Router
Test Case - Reverse Power Flow (Description)

- **Scenario:**
  - PVs+ no EV+ Uncontrollable resistive Load
  - Transformer reverse limit met

- **Procedure:**
  - Sunny conditions for two PVs
  - Uncontrollable Resistive Load variation (Load step-wise decrease)

- **Expectation:**
  - PVs are curtailed evenly to mitigate reverse power flow overload
Test Case - Reverse Power Flow (Plots)
Test Case - Reverse Power Flow (controller UI)

Equal Curtailment of each PV
Test Case- Forward Power Flow (Description)

- **Scenario:**
  - PVs + EV + Uncontrollable resistive Load
  - Transformer forward limit met

- **Procedure:**
  - EV is not close to full charge
  - Sunny conditions for two PVs
  - Uncontrollable Resistive Load variation (Load increase)

- **Expectation:**
  - EV is curtailed to mitigate forward power flow overload
Test Case- Forward Power Flow (Plots)

- XFMR Active Power
  - Y to G

- PV Real Power (Generation)

- EV Real Power (Consumption)
  - EV curtailment

- Background Real Power Load (Consumption)
**Test Case- Forward Power Flow (controller UI)**

<table>
<thead>
<tr>
<th>DER Name</th>
<th>Index</th>
<th>Type</th>
<th>DER State</th>
<th>Comm state</th>
<th>Rating</th>
<th>Curtailment</th>
<th>P</th>
<th>P SP</th>
<th>Q</th>
<th>Q SP</th>
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<tbody>
<tr>
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<td>1</td>
<td>EV</td>
<td>Enable</td>
<td>UP (0) UpTime: 118...</td>
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<td>0.000 kVAR</td>
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<td>PV</td>
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<td>no</td>
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<td>4.753 kW</td>
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**EV Curtailment**
Summary

- Hierarchy of resource aggregation and management in the advanced distribution system was discussed.
- Local Resource Aggregation control concept and objectives was described.
- Testing of Local Resource Aggregator through grid simulator and real-time digital simulation was discussed.
- Selected test results for Local Resource Aggregator functionality were presented.
Thank you!

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