MICROGRID SYMPOSIUM, NOVEMBER 28TH – 30TH 2017

Panel Session – State of the Art Microgrid Hardware

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Agenda

Introduction / motivations / HIL uses

Some Example Integration Testing / Validation Approaches

Example Simulation Results

State of the Art Microgrid Hardware

Introduction

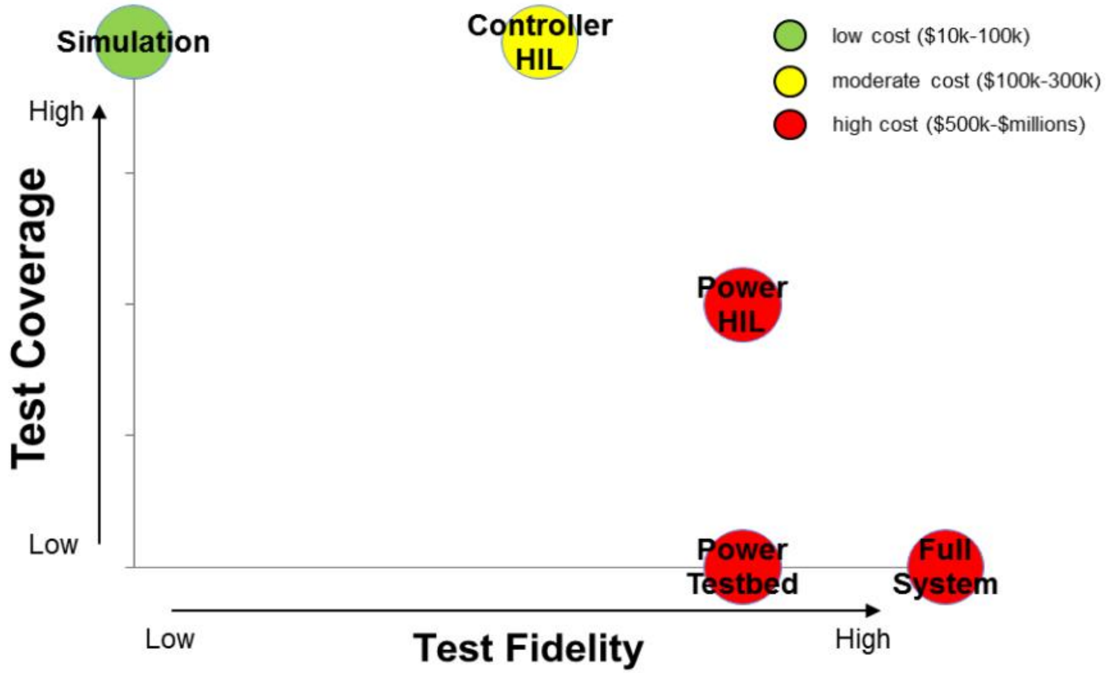
Technical Solution

Microgrid automation and control solutions
- Development
- Testing (libraries and firmware)

High Test Coverage

Moderate Fidelity

Low Setup &
Maintenance Costs



Picture courtesy of MIT Lincoln Lab

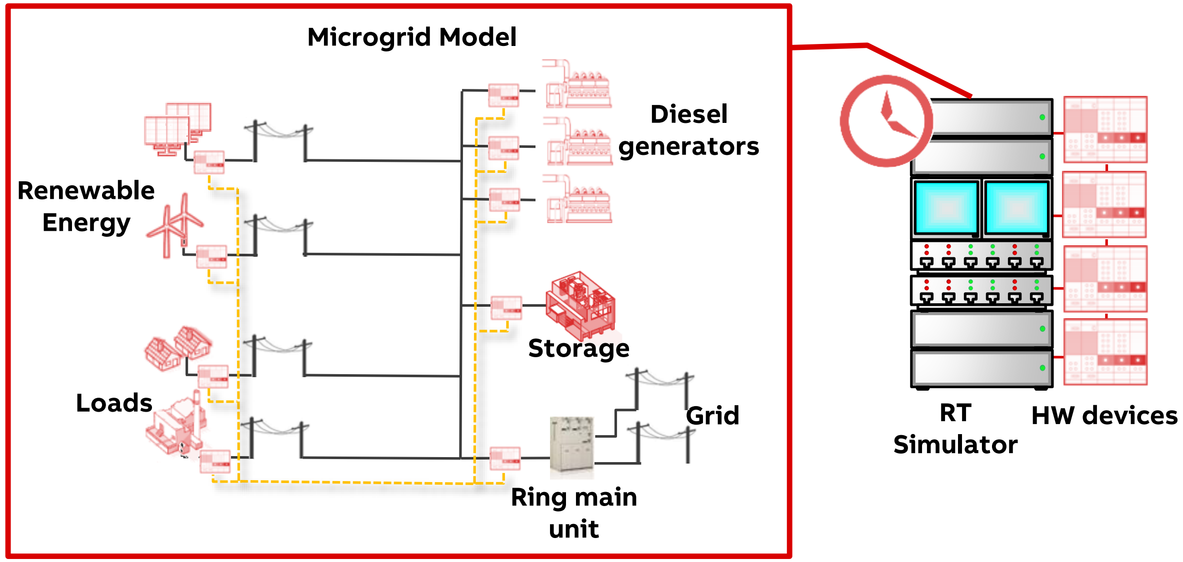
State of the Art Microgrid Hardware

Introduction

Technical Solution

Microgrid automation and control solutions – what we do

- Development (from concept to library implementation)
- Testing (function, unit, and system)
- RT HIL simulation allows detailed modeling of various microgrid components that operate on a wide range of time constants.
  - minutes and seconds for DER dispatch,
  - Hundreds of milliseconds for field device control loop execution and polling,
  - milliseconds for accurate representation of stability- and protection-related phenomena.
- Interfacing real HW devices with real communication, configuration and logics implementations.



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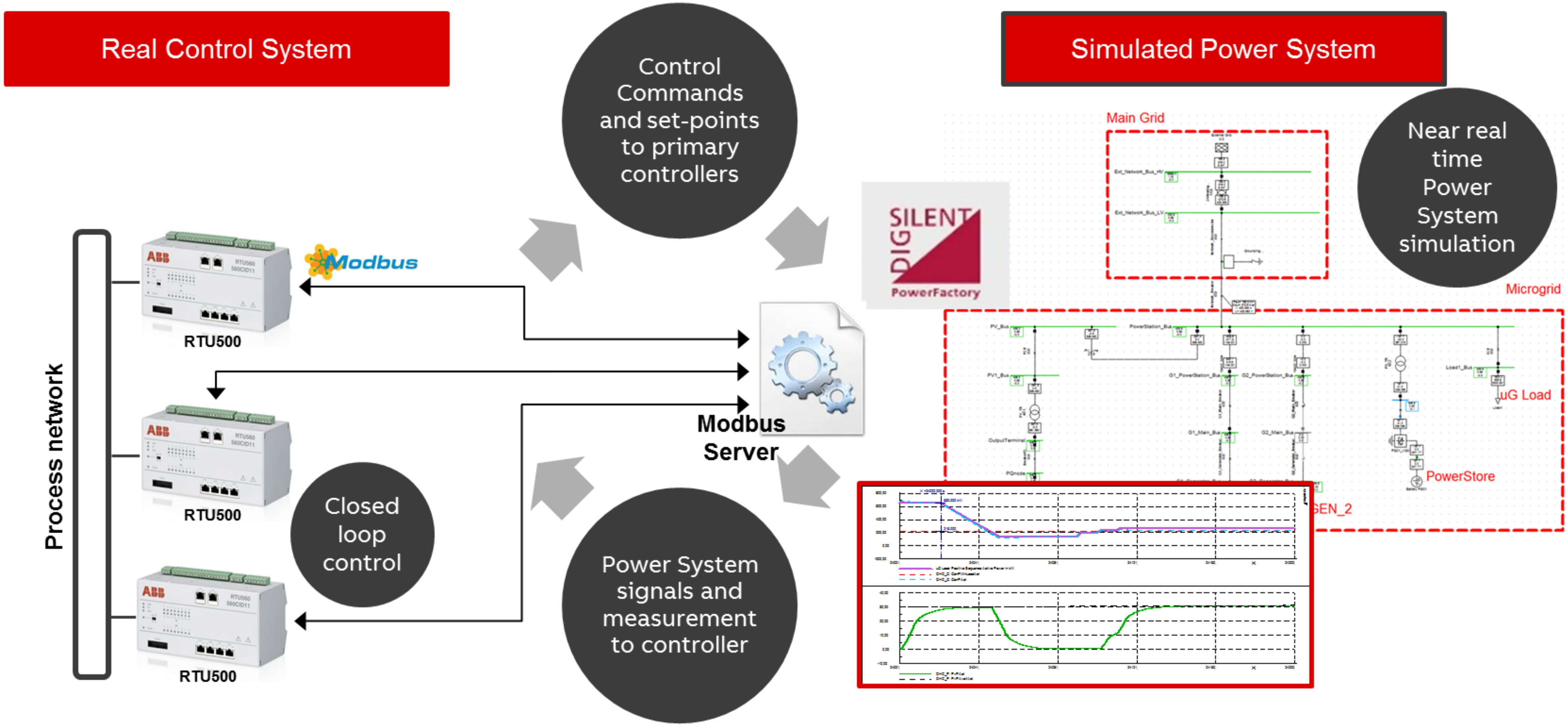
Example Integration Setup



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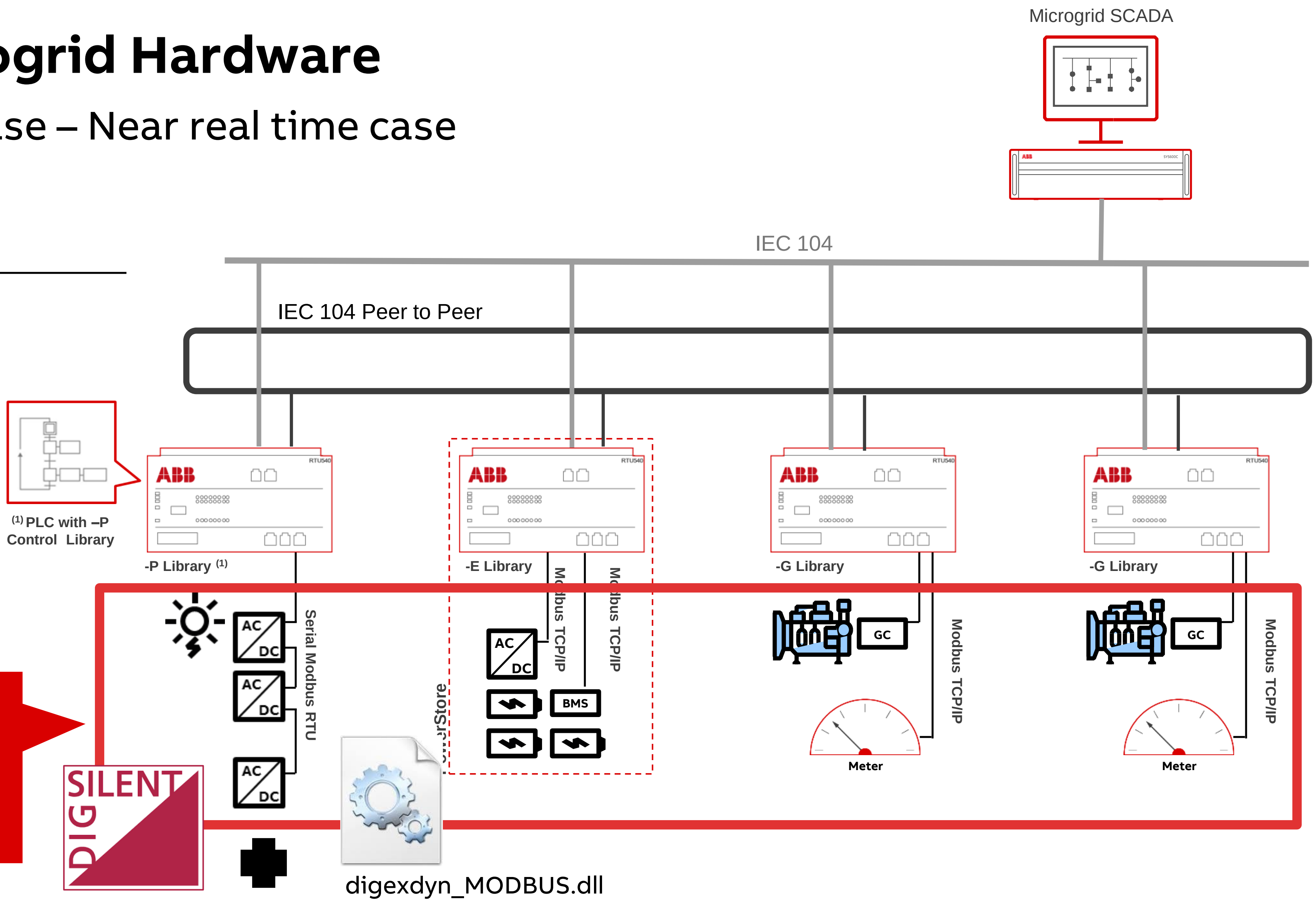
Example Integration Test Case – Near real time case

Use case

- Off-grid
- Load sharing between units (including PowerStore)
- Renewable excess management
- Station reserve management
- Minimum load protection
- Etc.

Field modelled in DIgSILENT Power Factory and simulated in RMS (transient stability) mode.



DIgSILENT Power Factory power systems simulator allows to perform transient stability analysis in RMS mode.

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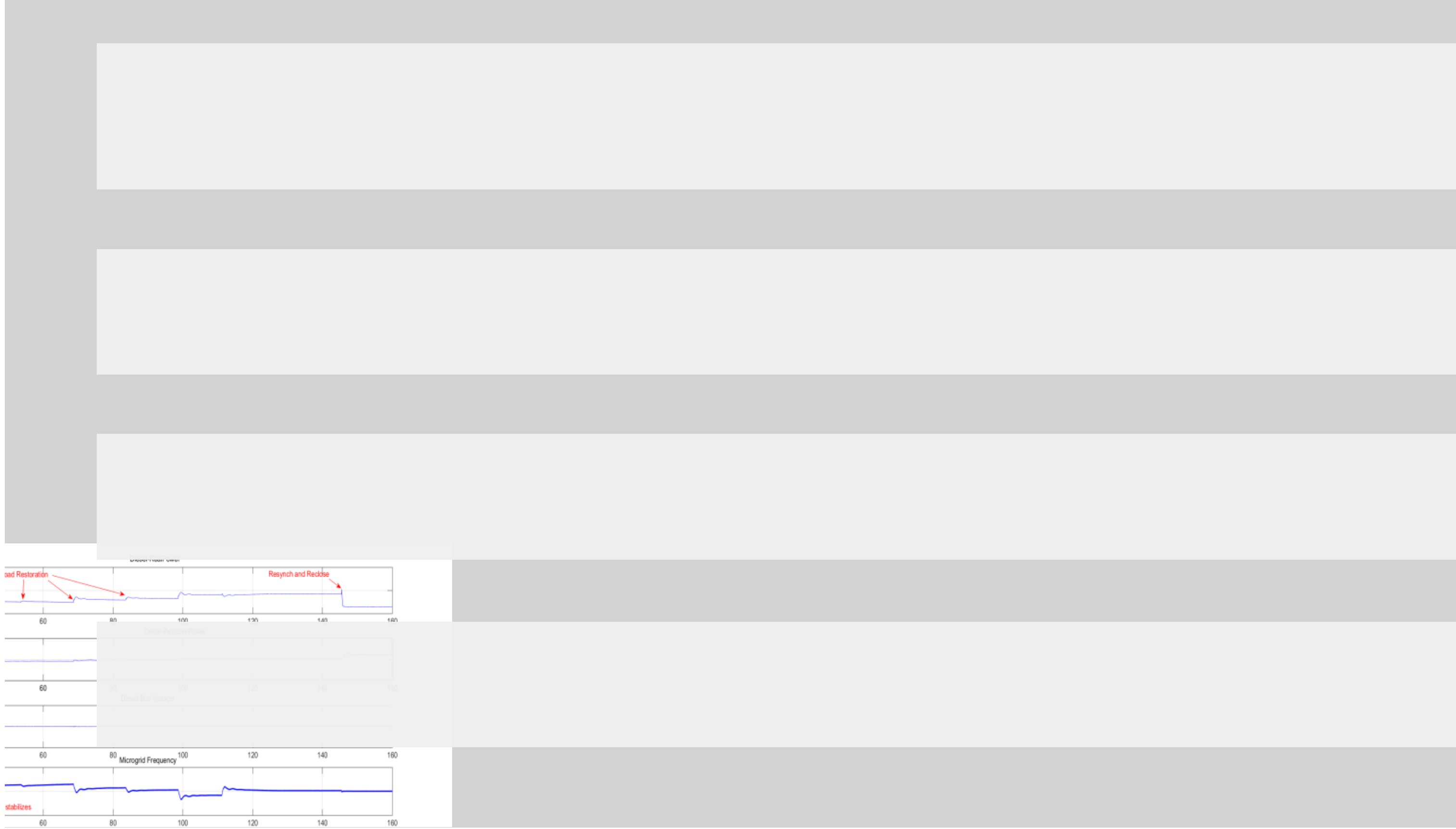
Simulation Results - unplanned islanding, with resynchronization and reconnection to the grid

Initial Conditions

- Microgrid is grid-connected
- Diesel generator is online, lightly loaded and in PQ mode
- Energy Storage System is online and in PQ mode
- Wind generator is on
- PV plant is on

The microgrid control system determines the operating mode by subscribing to the breaker status provided as a GOOSE message by the REF615 relay at the POI.

The status of individual loads and DERs is similarly determined.



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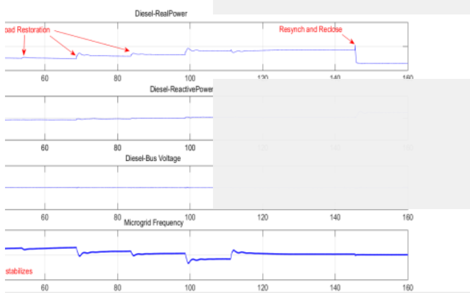
Simulation Results - unplanned islanding, with resynchronization and reconnection to the grid

Area EPS fault

- REF615 relay at the POI detects the fault and trips the POI breaker, at the same time sending a GOOSE message to the microgrid control system.
- Under frequency load shedding is performed by the REF615 according to the settings of its embedded functionalities.



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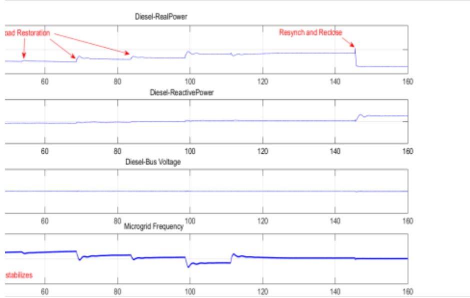
Simulation Results - unplanned islanding, with resynchronization and reconnection to the grid

Load restoration

- Once the diesel generator ramps up, some loads may be restored by the microgrid control system based on the system frequency and available DER capacity.
- The microgrid successfully transitions to islanded mode within the time intervals specified by the standard.



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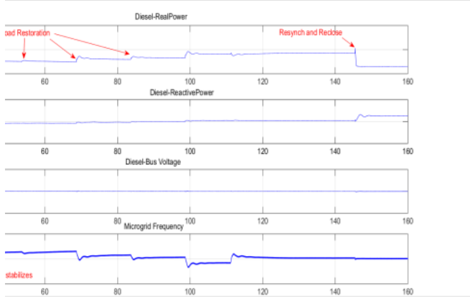
Simulation Results - unplanned islanding, with resynchronization and reconnection to the grid

Grid resynchronization

- When the operator decides to go back from islanded to grid-connected mode, the microgrid control system receives a transition command from the microgrid HMI or SCADA.
- It again performs a topology assessment to determine generation-load balance in the microgrid.
- The REF615 relay at the POI has a built-in sync-check as well as reclosing functions, which can be enabled by the microgrid control system through IEC 61850 communications.



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Simulation Results - unplanned islanding, with resynchronization and reconnection to the grid

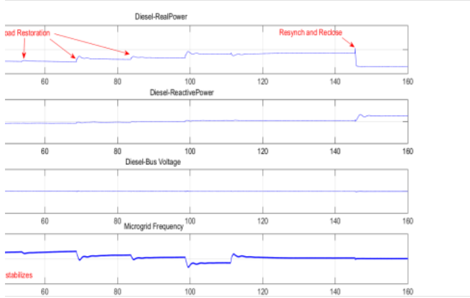
Grid resynchronization

– The microgrid control system also receives voltage phasor and frequency measurements from both sides of the POI breaker through MMS and can issue commands to raise or lower the Microgrid voltage/frequency.

– As soon as the standard conditions are met the POI breaker relay automatically closes the breaker returning the microgrid to grid-connected mode.

– The Microgrid controller can then re-dispatch the generation assets and switch the relay setting groups to the setting group corresponding to grid-connected operation.

– This completes the restoration process, and the microgrid is reconnected to the grid.



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Conclusions

- A **real-time hardware-in-the-loop** simulation with an integrated microgrid controller and protection relays is **helpful** for development, validation and testing of the key microgrid control modes.
- When considered from the perspective of **test fidelity vs. test coverage**, the RTHIL approach offers an **attractive moderate cost option** for microgrid control development and testing as compared to costly power HIL testbeds, while providing better granularity compared to simulation-only methods and ensuring hardware limitations **(comms, cycle times)** are evaluated and **guaranteed**.
- It also **enables testing of integrated protection and control systems** built on top of communications, such as, MODBUS, 104, and IEC 61850.

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