Site-Specific Evaluation of Microgrid Controller Using Controller- and Power-Hardware-in-the-Loop

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Abstract

Microgrid assets are built by utilities to improve the resilience and reliability of segments of the distribution system. Controllers with advanced capabilities will operate and control these microgrids with diverse energy technologies, which vary from inverter-based photovoltaics and energy storage systems to conventional diesel generators. There are multiple challenges to building a microgrid controller for a site because of the unique requirements presented by the controllable and uncontrollable elements in a specific microgrid. There are also challenges to testing the performance of the microgrid controller for such unique microgrids.

This paper presents the controller- and power- hardware-in-the-loop (HIL) evaluation platform built to enable site-specific evaluation for a microgrid as well as the test cases used to evaluate the operation of a microgrid controller for a specific site. Finally, this paper presents the results from a subset of the experiments performed to evaluate the microgrid controller.

HIL Platform for Site-Specific Microgrid Controller Evaluation

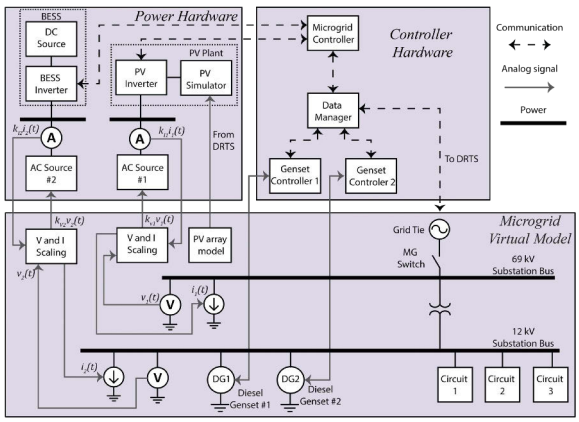


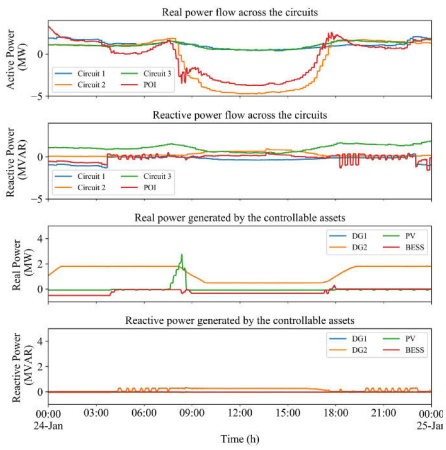
Diagram of HIL platform

Pictures of physical equipment

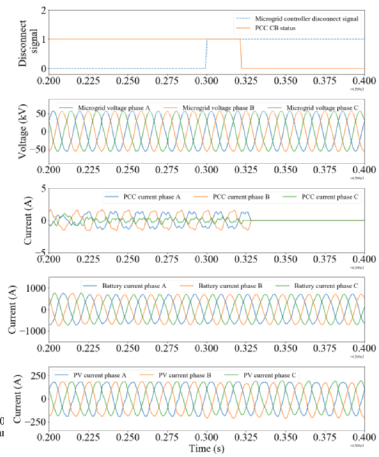
Test Cases and Selected Simulation Results

Four test cases are discussed in the paper. Results from all tests are published in a CEC report; see additional reading.

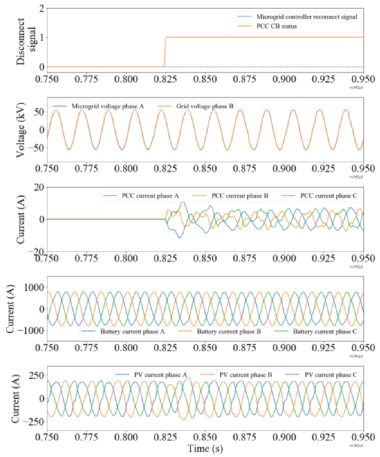
1. Normal grid-connected operation with nondispatchable generation (baseline case)
2. Dispatch in grid-connected mode of operation
3. Dispatch in islanded mode of operation
4. Resynchronization from islanded mode to grid-connected mode.



Grid-connected dispatch



Successful islanding of the microgrid



Successful resynchronization of the microgrid

Conclusions

An HIL test bed to evaluate the performance of a microgrid controller was built in the Energy Systems Integration Facility at the National Renewable Energy Laboratory. This work used site-specific models that determine the microgrid performance.

The setup further used either the same or representative hardware compared to that deployed in the field as well as the same communications protocols as those used in the field.

This paper presented an overall approach to the design of an HIL setup to perform site-specific evaluations of microgrid controller performance and referred the reader to previously published works on specific aspects of the HIL setup. The HIL setup could be used by a utility to run scenarios that can provide useful feedback.

This paper also presented a subset of the test cases evaluated using the test bed and results for these test cases.

Additional Reading

H. Katmale, S. Clark, L. Abcede, and T. Bialek. 2019. *Borrego Springs: California's First Renewable Energy-Based Community Microgrid* (CEC-500-2019-013). Sacramento, CA: California Energy Commission. https://www.energy.ca.gov/2019publications/CEC-500-2019-013/CEC-500-2019-013.pdf.

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