

Diesel Generator Controller Evaluation via Controller-Hardware-in-the-Loop for Various Microgrid Operation Modes

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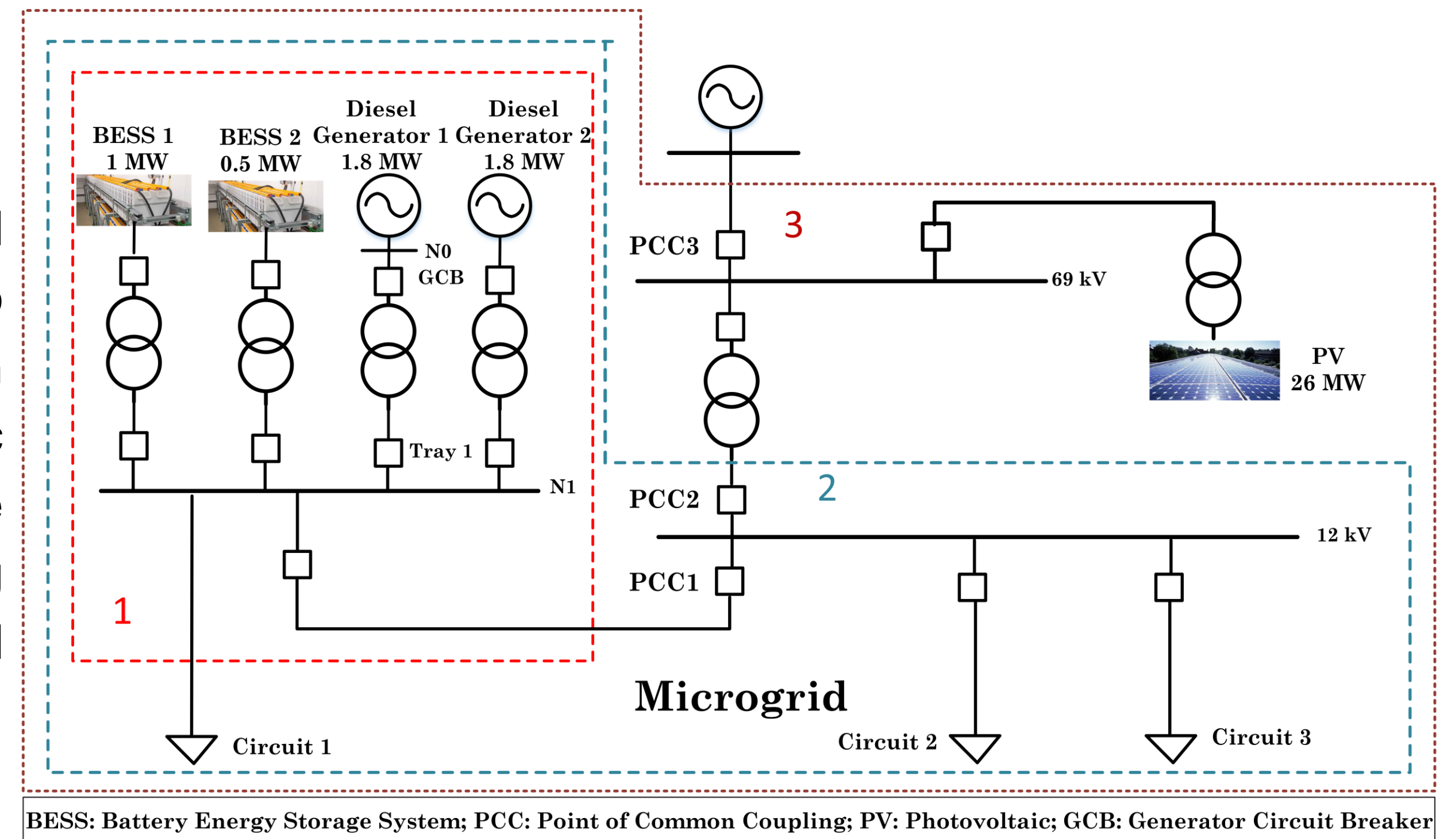
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Abstract

This paper presents the controller-hardware-in-the-loop (CHIL) evaluation of a diesel generator controller for various microgrid operation modes. The model of the diesel generator (governor, exciter, and primary control) is simulated in real time, and the secondary control is implemented in a real hardware controller, the Woodward, which is tested via CHIL with different microgrid configurations under microgrid transition operations. The experimental results demonstrate that the control settings and configuration of the Woodward controller work correctly for different microgrids under microgrid transition operations, which provides confidence for site commissioning.

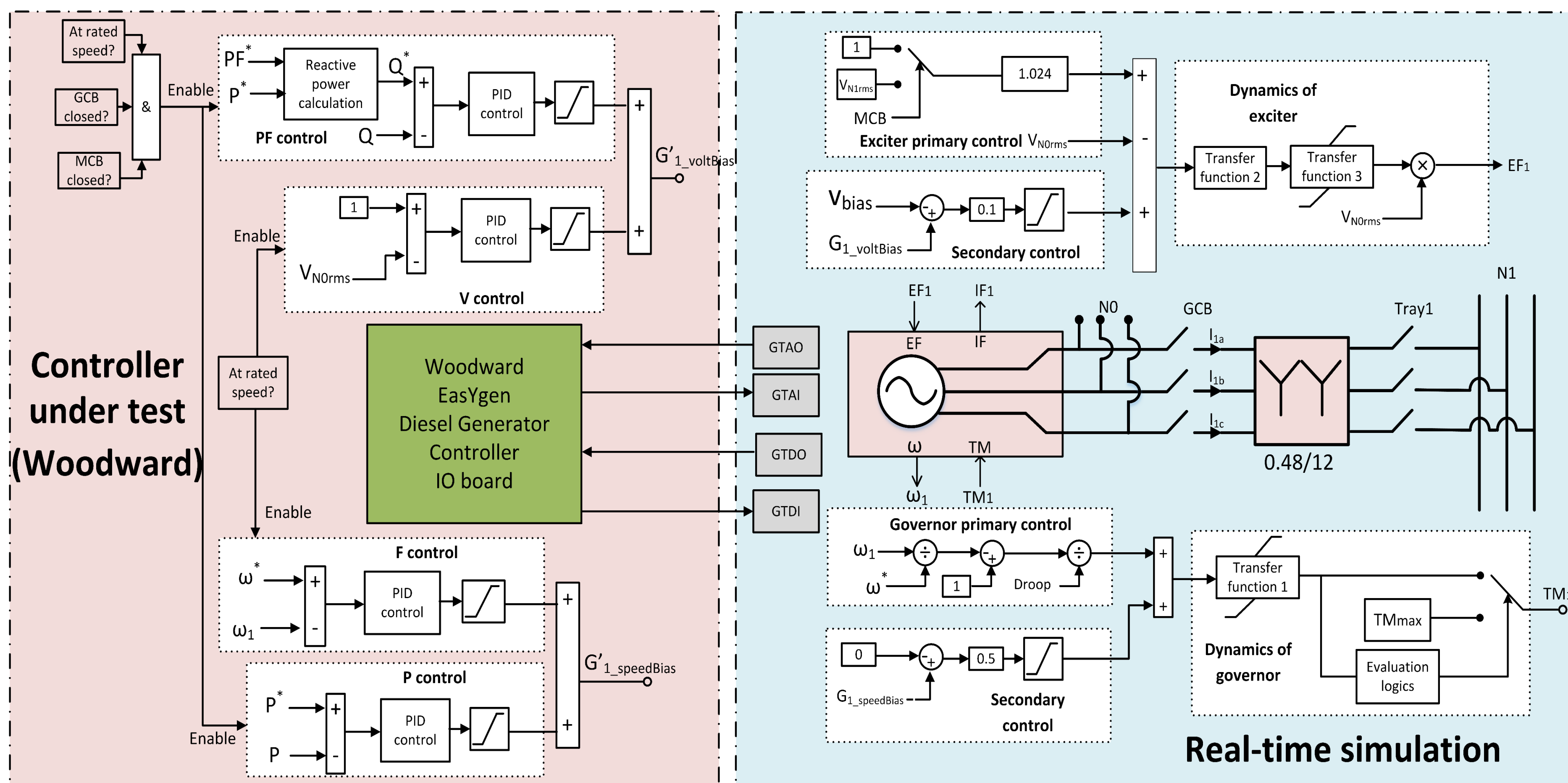
Microgrid Configuration

A real-world microgrid operated in Borrego Springs, California, by San Diego Gas & Electric Company. There are three points of common coupling (PCC) in the microgrid system (Island 1, Island 2, and Island 3).



CHIL Simulation of Diesel Generator Controller

- The generator simulated in RTDS: synchronous machine, governor primary control, exciter primary control
- Woodward EasYgen controller: secondary control (PQ control and VF control), transition logics, protection



Schematic diagram of the CHIL simulation of the Woodward easYgen diesel generator controller

Transition logic in Woodward

Startup and synchronization	Grid-connected	Isochronous
VF control	PQ control	VF control
GCB open	GCB closed	GCB closed
MCB closed	MCB closed	MCB open
Rated speed	Rated speed	Rated speed
V^* and ω^* , internal configured as nominal value	P^* and PF^* , external configured	V^* and ω^* , internal configured as nominal value

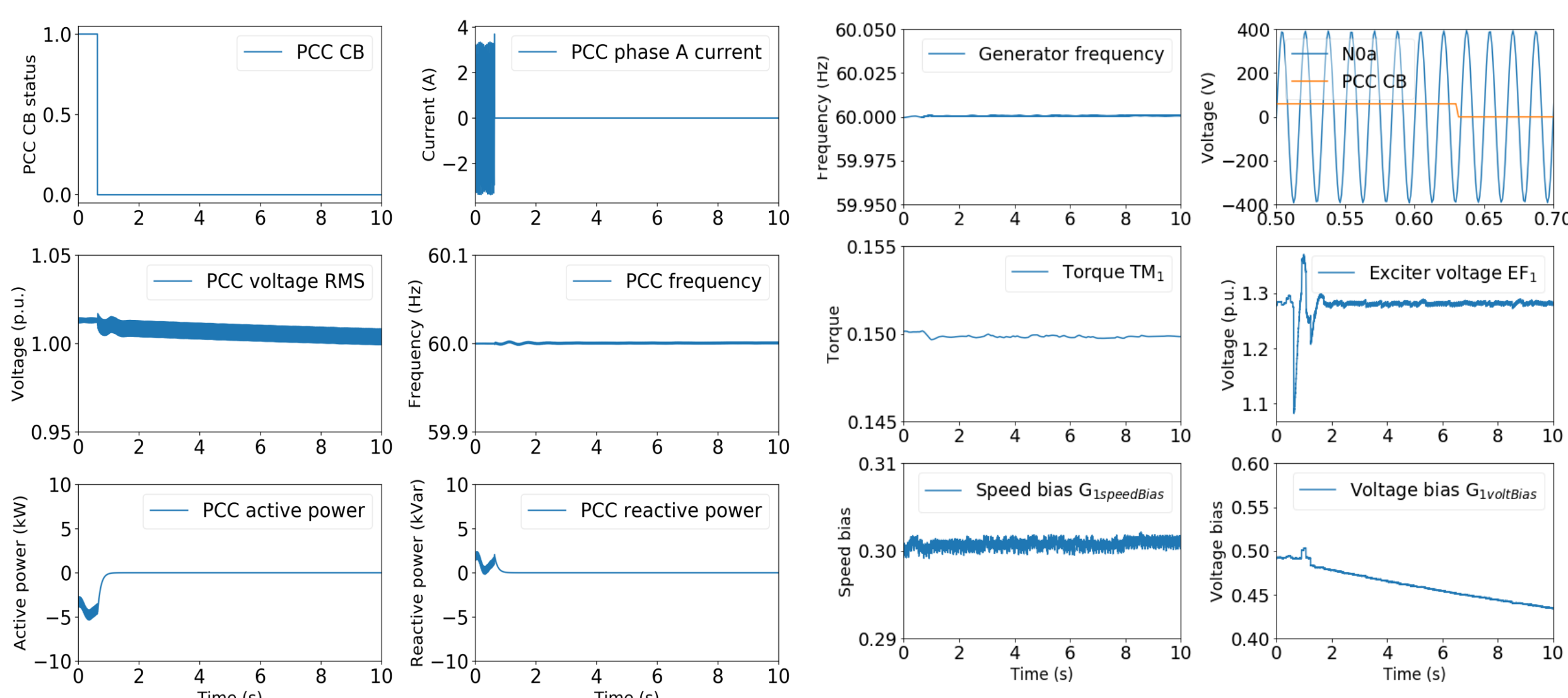
<p>Scaling down</p> <p>Scaling down</p> <p>Scaling down</p>	<p>Scaling up</p> <p>Scaling up</p>	<p>RTDS</p> <p>Woodward #1</p> <p>Woodward #2</p>
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IO connections between the RTDS and the Woodward

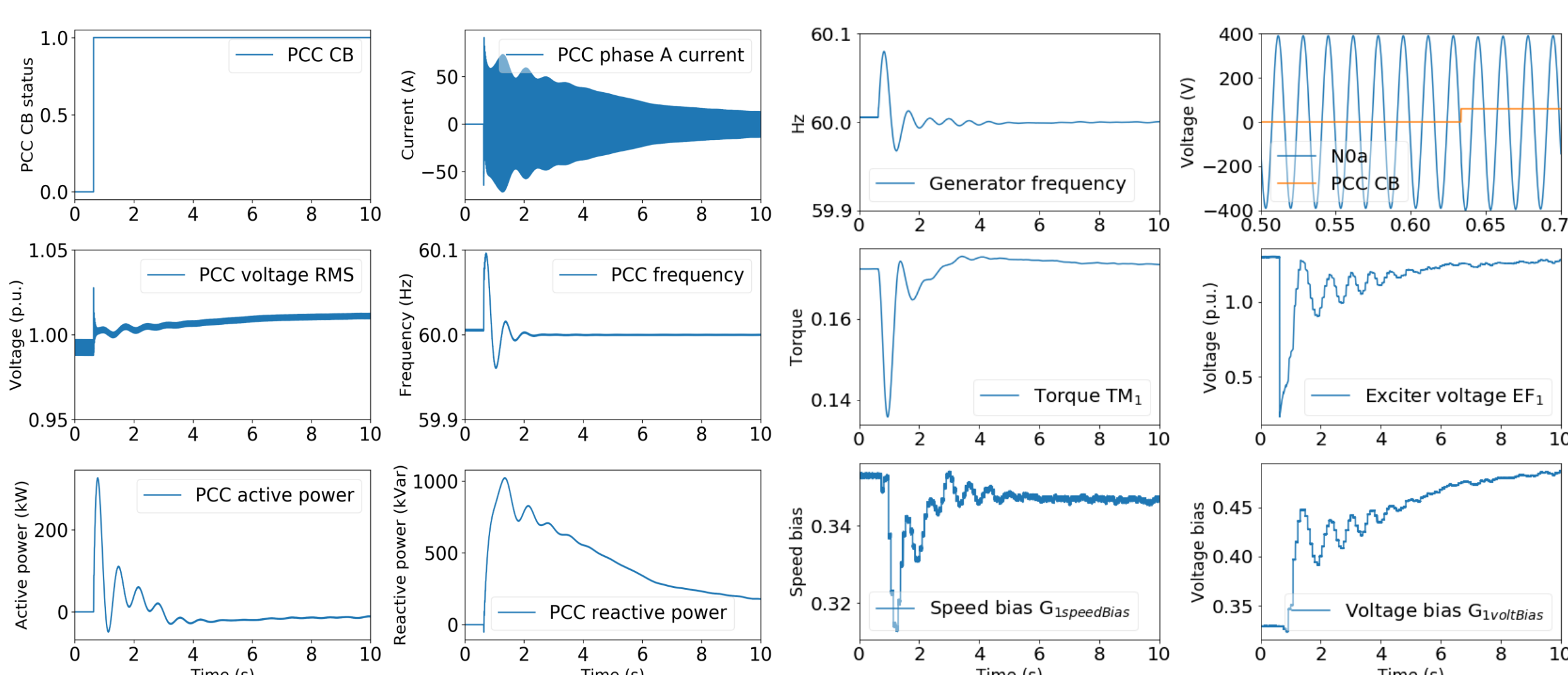
Experimental Results

A. Island 1 Test

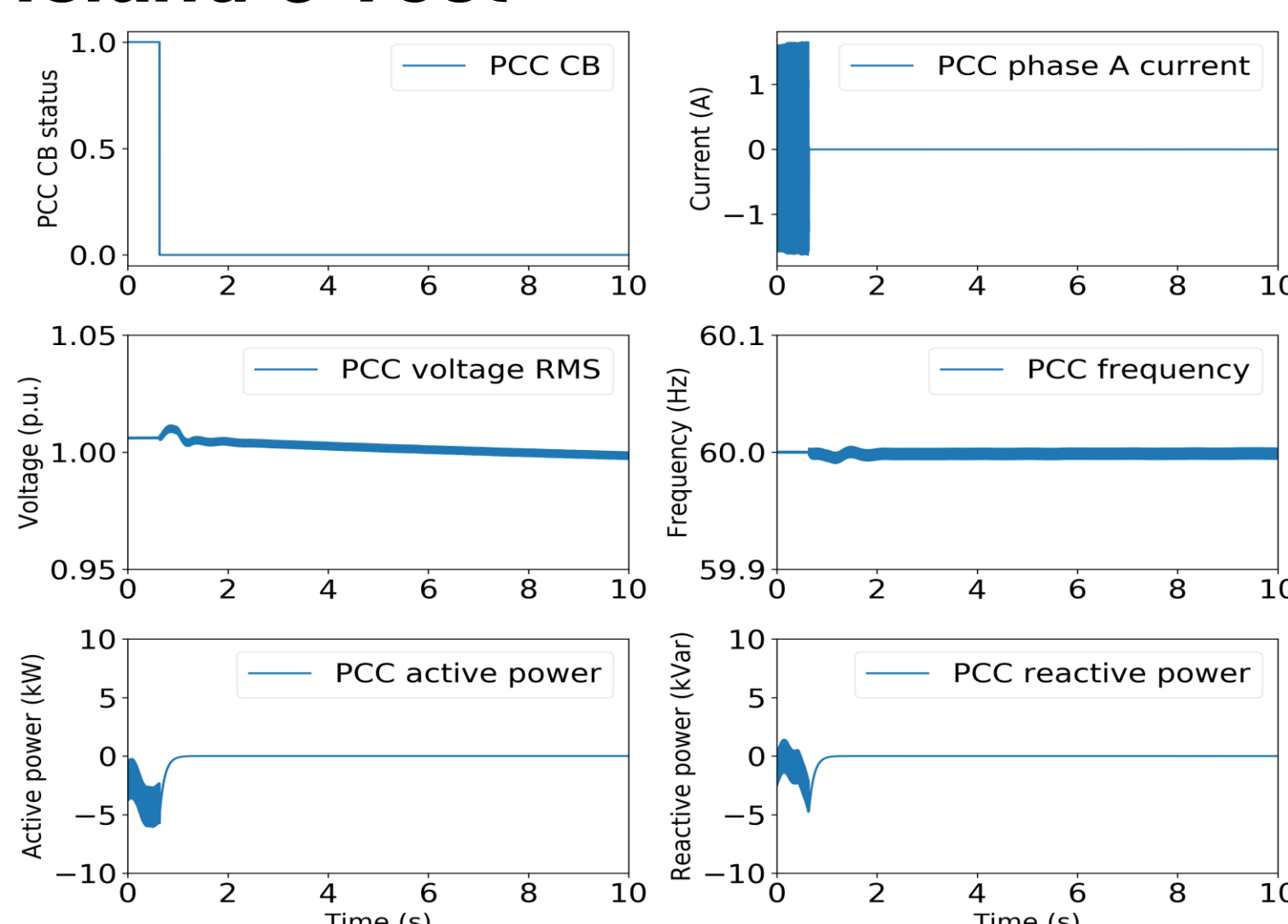
The microgrid system transitions from grid-connected to islanded mode.



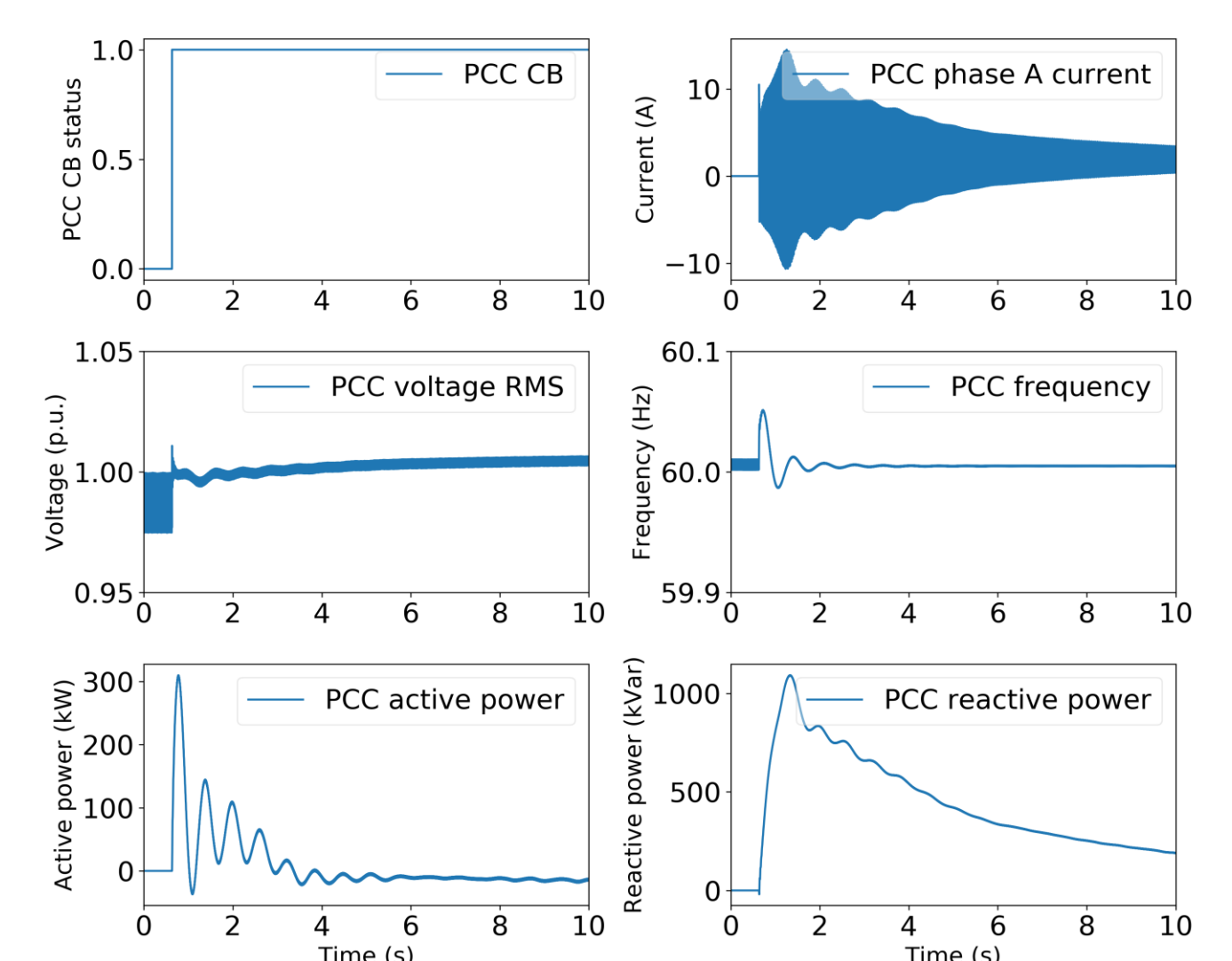
The microgrid system transitions from islanded to grid-connected mode.



B. Island 3 Test



Measurement at PCC1 when microgrid transitions from grid-connected to islanded mode



Measurement at PCC1 when microgrid transitions from islanded to grid-connected mode

Conclusions

This paper presents the modeling and control of a diesel generator for testing microgrid transition operations with a special focus on the transition mechanism of the diesel generator. The CHIL test results for the two test cases show that (1) there is no phase jump in the diesel generator's terminal voltage during planned microgrid transition operation, (2) the diesel generator has better transients when the microgrid disconnects from the main grid than when it reconnects, and (3) the settings/configurations for the controller are appropriate, which provides confidence in the controller for site commissioning.

Additional reading:

California Energy Commission. *Borrego Springs: California's First Renewable Energy-Based Community Microgrid*. Sacramento, CA: 2019. <https://www.energy.ca.gov/2019publications/CEC-500-2019-013/CEC-500-2019-013.pdf>.