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Testbed for Mitigation of Power Fluctuation on Micro-Grid

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UC San Diego

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UC San Diego Team

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Outline

- Introduction
- Testbed for mitigation of power fluctuation
  - Overview
  - “Portable” cabinet
  - Controller
- Preliminary tests on the testbed
- Future work

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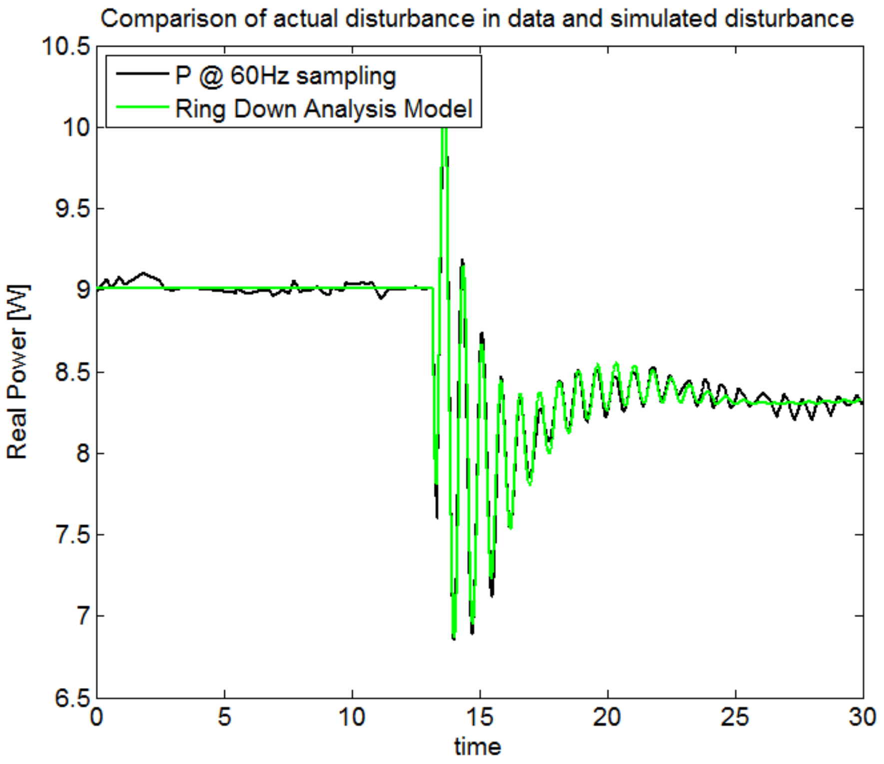
Introduction

Introduction

Motivation for mitigation of power fluctuation

- Power fluctuation occurs intermittently on micro-grid.
- Conventional generation tends to stabilize and maintain synchronous operation of the system by the inertia in the form of spinning rotational mass.
- As more renewable energy generation is added to the utility grid, it could result in instability and poorly damped oscillations in AC frequency and power on micro-grid.



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Objectives of building a testbed

- Simulate a power fluctuation
  - Motor load
  - Oscillatory circuitry

- Detection of instantaneous fluctuations
  - Phasor Measurement Unit (PMU)
  - Instantaneous power sensor

- Verification of data-based dynamic modeling (system identification) techniques

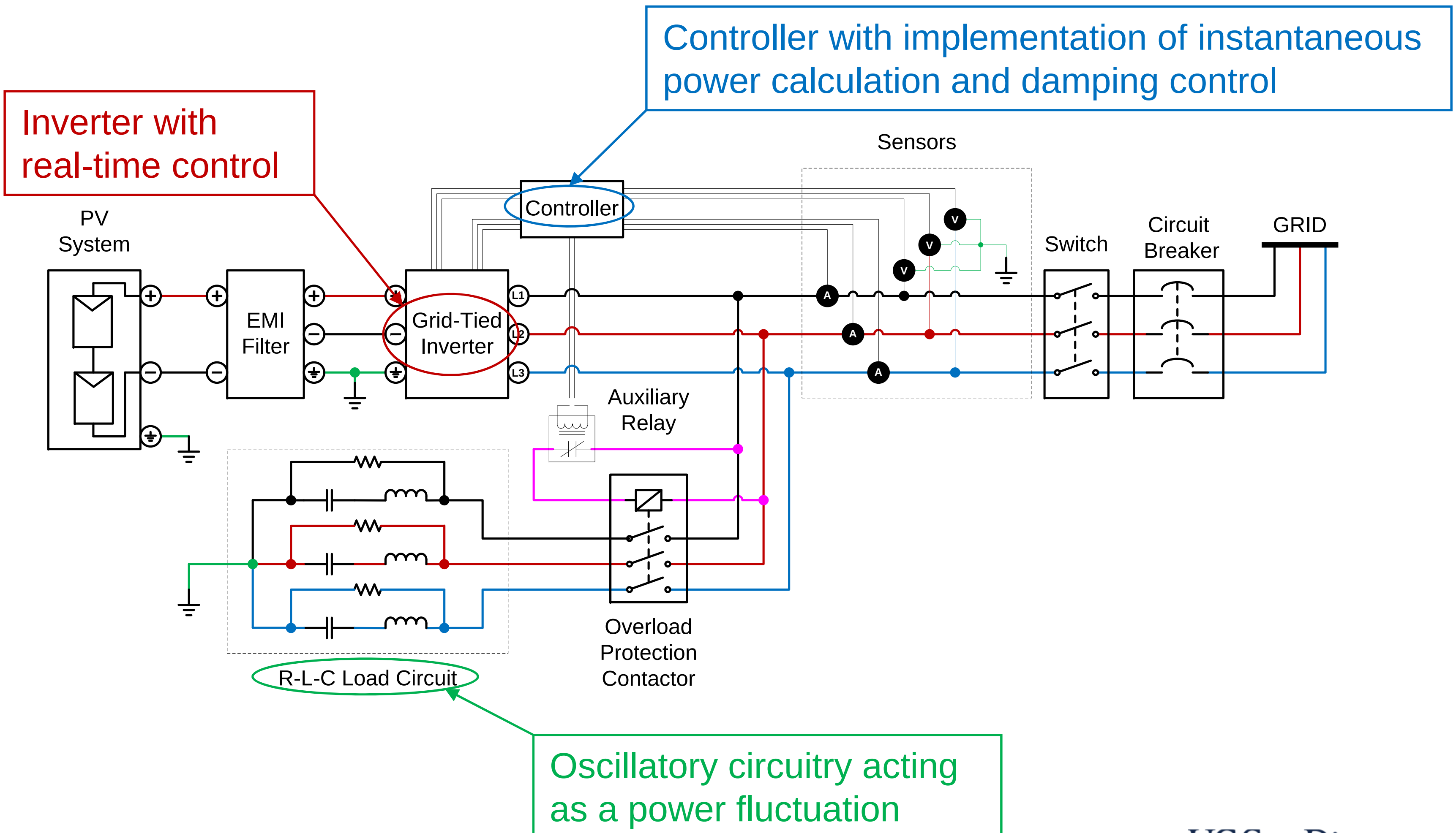
- Damping controller design and implementation
  - Embedded devices

- Capability of real-time control of an inverter
  - An inverter with real-time active/reactive power control

Testbed

Testbed – Overview

System diagram



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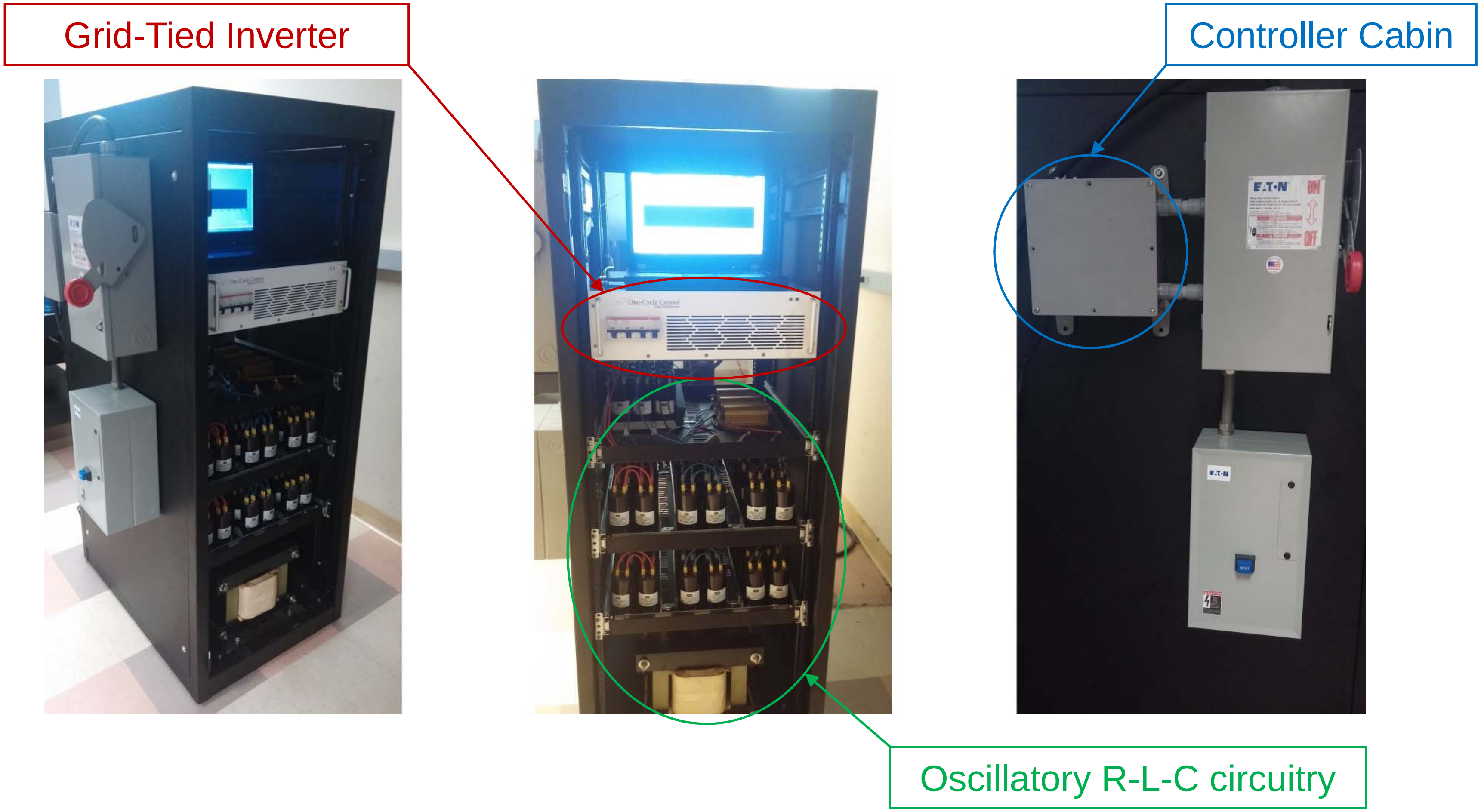
“Portable” cabinet



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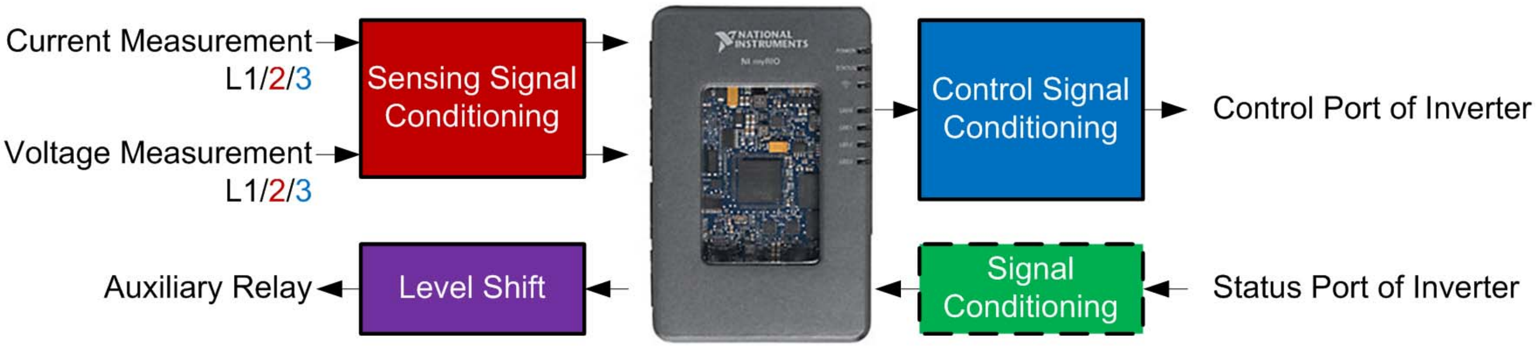
Testbed – Key Components

Controller

Manufacturer: National Instruments
Model: NI myRIO-1900

- Processor: Xilinx Z-7010 (Duo Core, 667MHz)
- Memory: (ROM) 256MB (DDR3) 512MB
- Wireless: IEEE 802.11 b,g,n
- Analog Input: 12 bits – 500 kS/s
- Analog Output: 12 bits – 345 kS/s

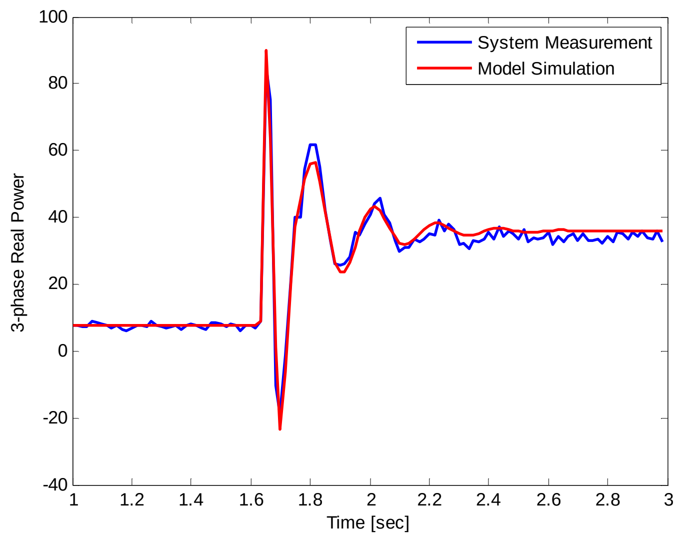


Preliminary Tests

Preliminary Tests

Test of simulating power fluctuation

- For safety consideration, a programmable DC power supply is installed for testing.
- The power fluctuation generated by the oscillatory circuitry is measured and modeled as follows: $f_n \approx 5\text{Hz}$



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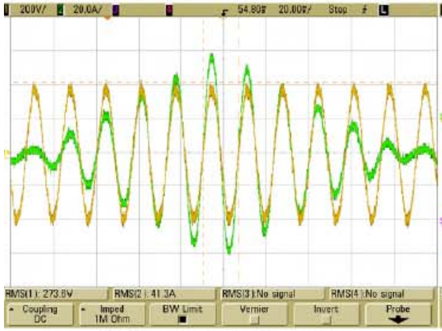
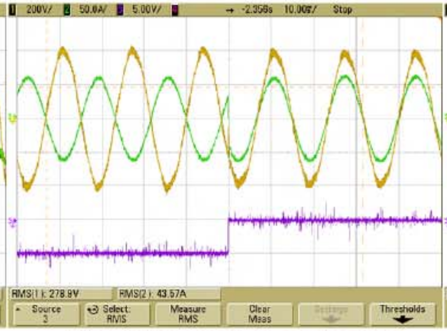
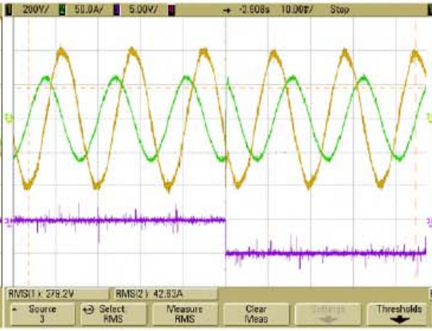
Four-quadrant grid-tied inverter (GTI)

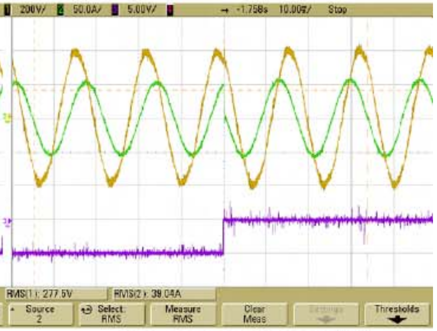
Manufacturer: One-Cycle Control (OCC)
Model: GTI3100A6208/3652IR-PQ

• Max. Power:	36kW
• AC Voltage Range:	208V ±10%
• Rated DC Voltage:	365VDC
• Max. AC/DC Current:	100Arms / 100A
• Weight:	65lb
• Size:	23in × 17.5in × 5.25in


Continuous current control


Step active current reversal control

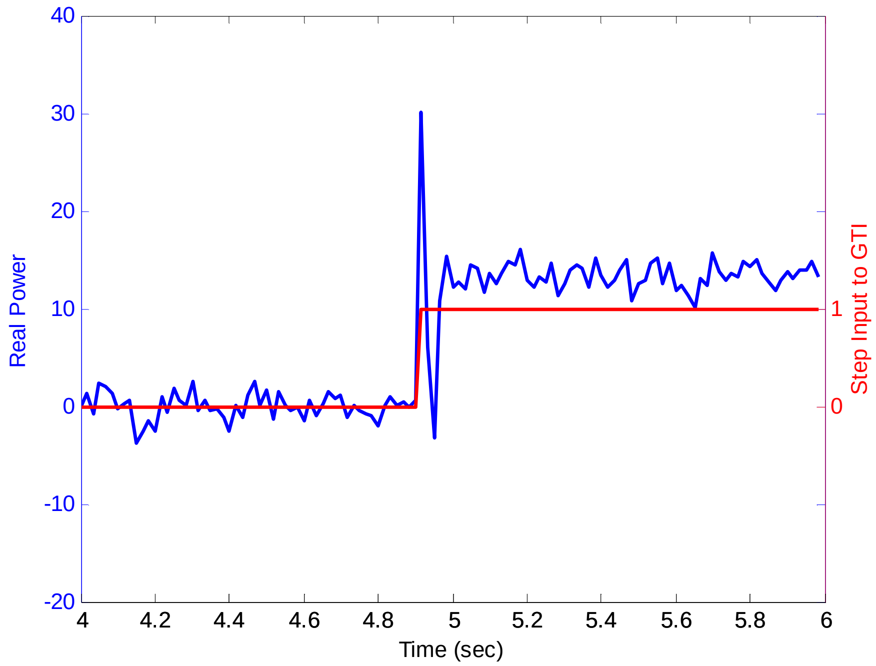

Step reactive current reversal control


Step current phase control

Preliminary Tests

Capability test of real-time active/reactive power control

- Dynamic response of the OCC-GTI is tested with a step control input.
- The OCC-GTI is capable to be controlled in real time.



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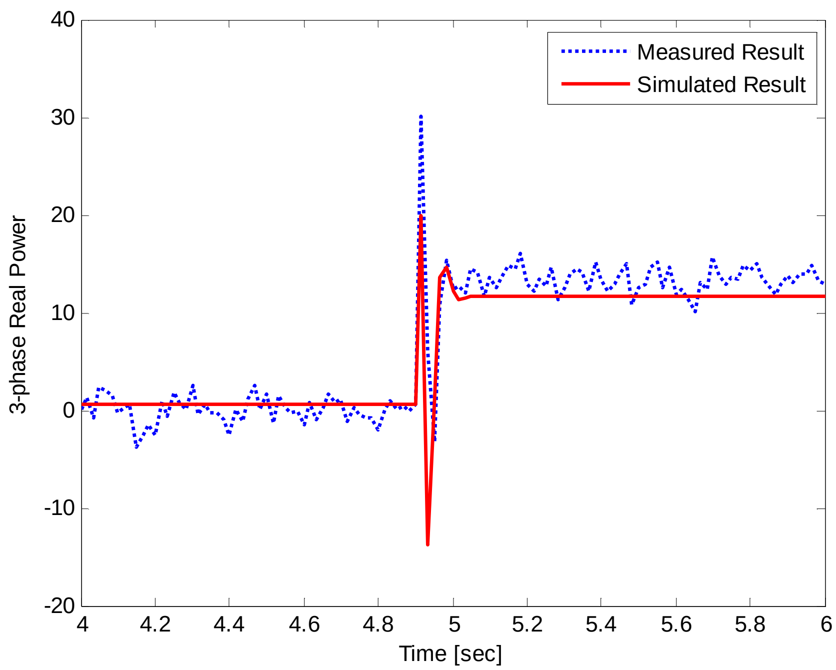
Verification of data-based system identification on the GTI output

- Based on the measured data obtained by previous tests, a low-order model built within Prediction Error (PE) framework is capable to capture the dynamics.



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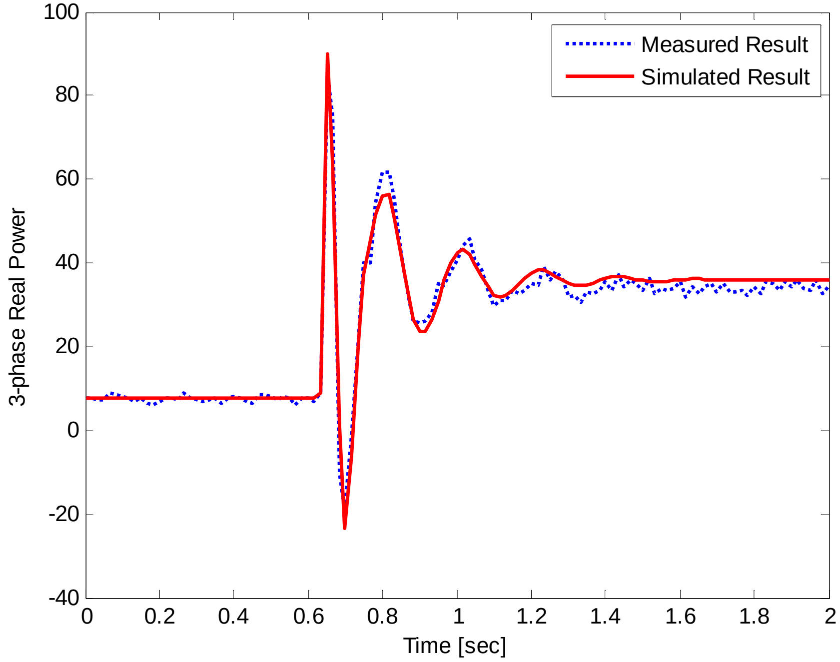
Preliminary Tests

Verification of data-based system identification on the disturbance

- Dynamic response of the oscillatory circuitry is tested.
- A low-order model built by Step-Based Realization (SBR) method is capable to capture the dynamics well.



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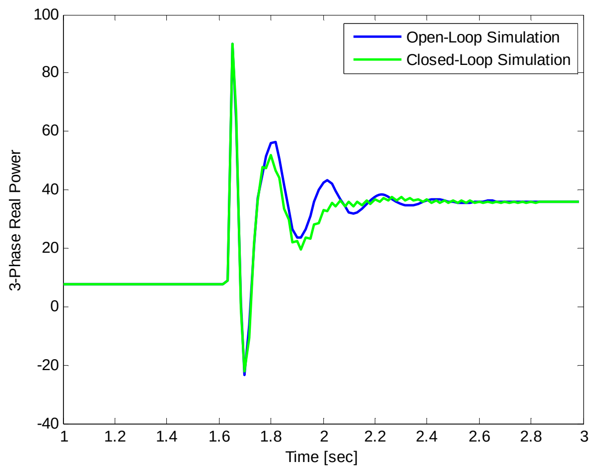
Preliminary Tests

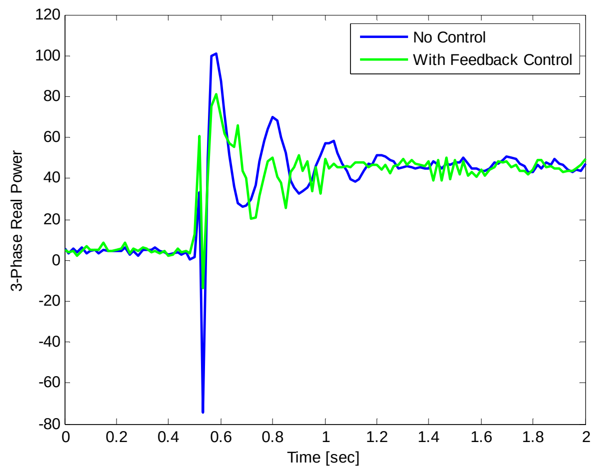
Damping control algorithm design and implementation

- A preliminary damping control algorithm is designed based on modeling of the system described previously.
- The control algorithm is implemented in the controller.

Control Algorithm Design



Control Algorithm Implementation



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Conclusions

- The oscillatory circuitry in the testbed is able to simulate a power fluctuation.
- The grid-tied inverter provided by One-Cycle Control is capable to be controlled in real time.
- The controller is able to process the instantaneous power calculation and real-time control.
- The designed control algorithm is able to dampen the oscillation generated by the oscillatory circuitry.

Future Work

Future Work

Large-scale integration tests

- Integration with Phasor Measurement Unit (PMU)
- Integration with photovoltaic (PV) systems
- Large-scale tests on UCSD micro-grid

Thank you