Evaluation of Solar Inverter using Power-hardware-in-the-loop Simulation (PHILS)

Carl Ho and Mandip Pokharel, 17.05.2017, Winnipeg, 02:00pm

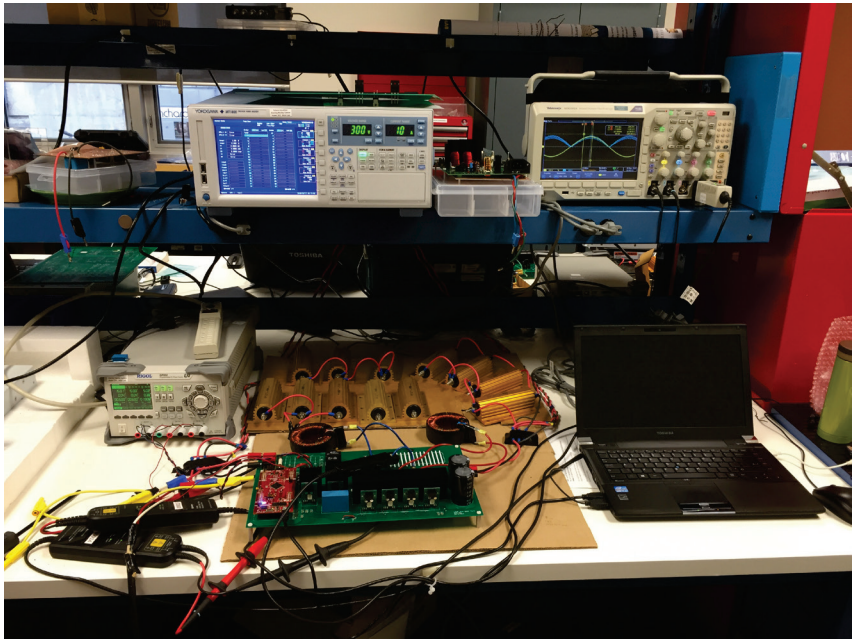
University of Manitoba

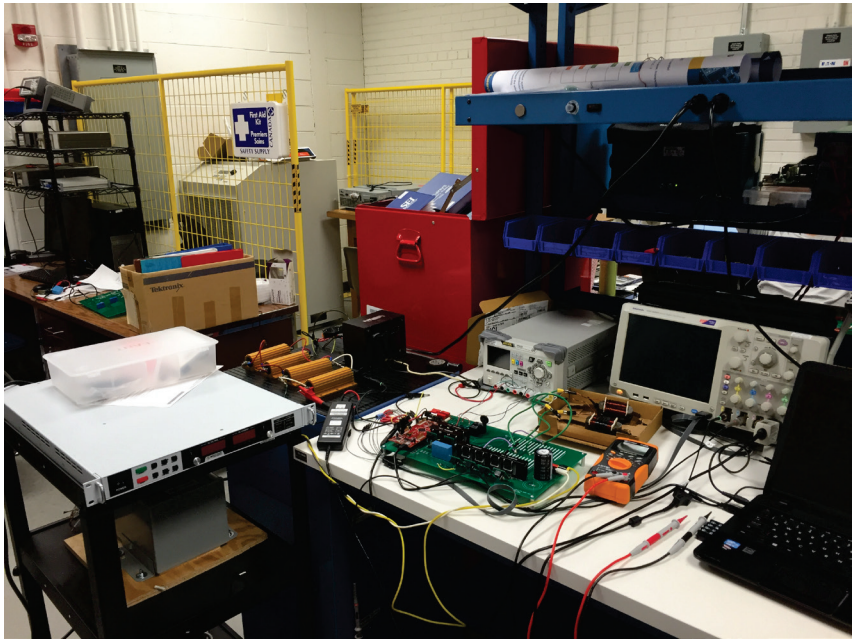
Outline

- Introduction of Solar Inverter
- Operating Principles of PHILS
- PHILS Testbed at UofM
- Experimental Results
- Conclusions and Future Work

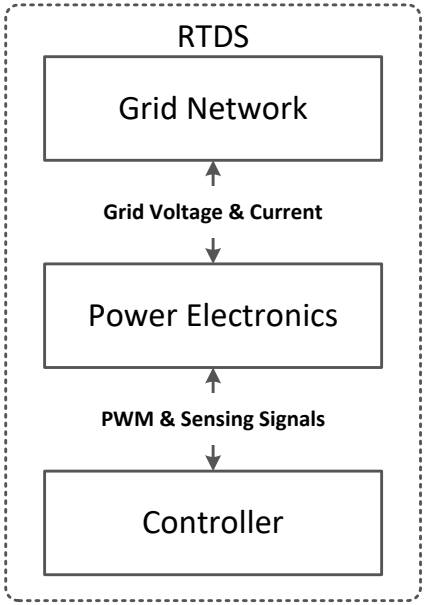
Facilities of RIGA Lab @ UofM

- Renewable Energy Interface and Grid Automation Lab

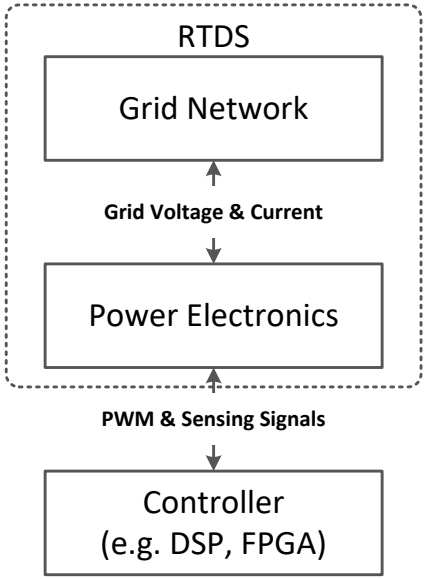




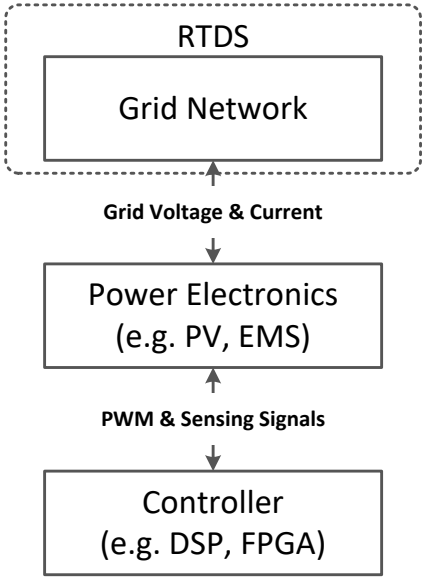
RTDS and Modern Power Electronics



Real Time Simulation

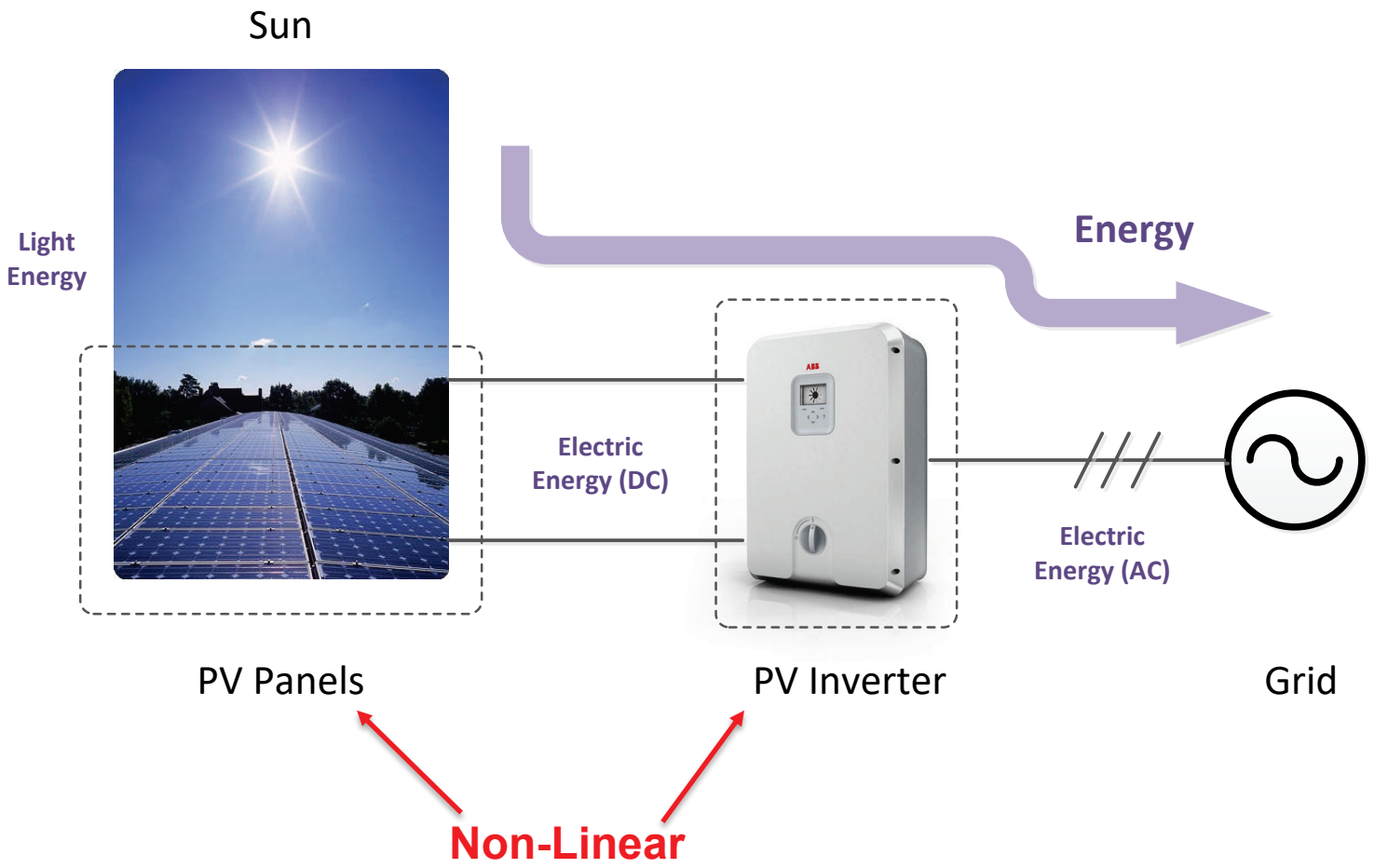


Controller-HIL Simulation



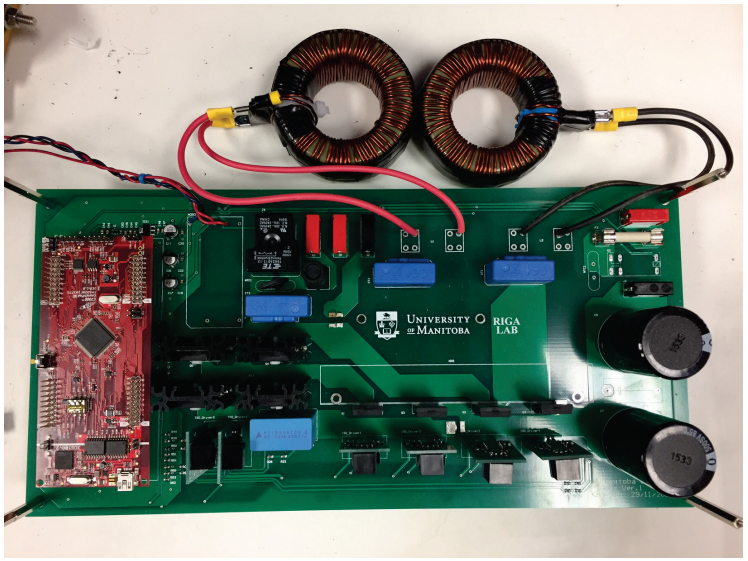
Power-HIL Simulation

Role of Solar Inverter



Importance of PHILS for PV Inverter Industry

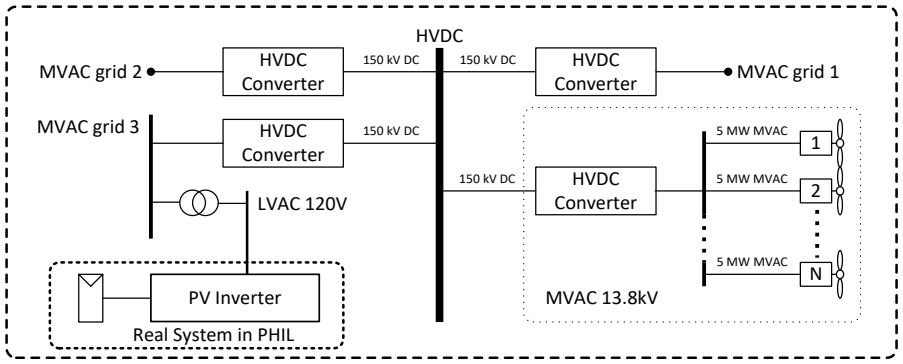
- Burn-in System
- Power Quality Issue
  - low-voltage ride through (LVRT)
  - Weak grid
  - Current Quality
- Control Capability
  - Communications
  - Smart Functions



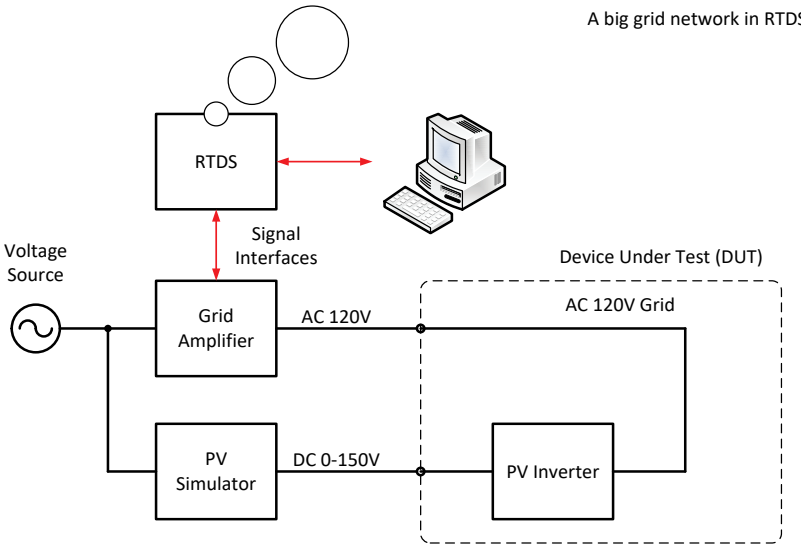
- Nonlinearity of PV Inverter
  - Controller
  - Semiconductors
  - Magnetic Devices

Typical System Configuration of PHILS

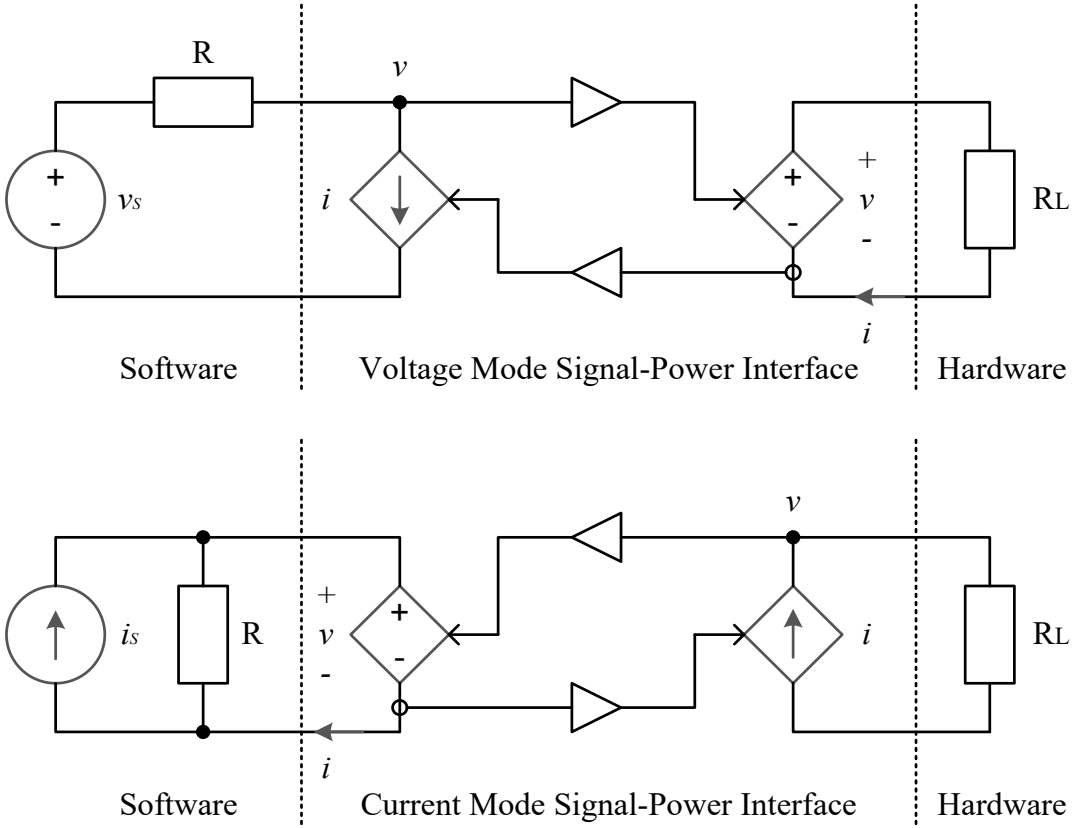
- Software
  - Low frequency
  - Big grid networks
- Hardware
  - High frequency
  - Non-linear system
  - Real power flow



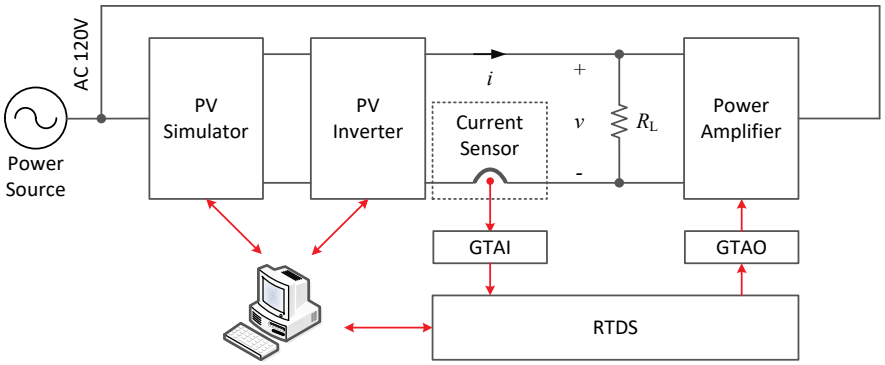
A big grid network in RTDS



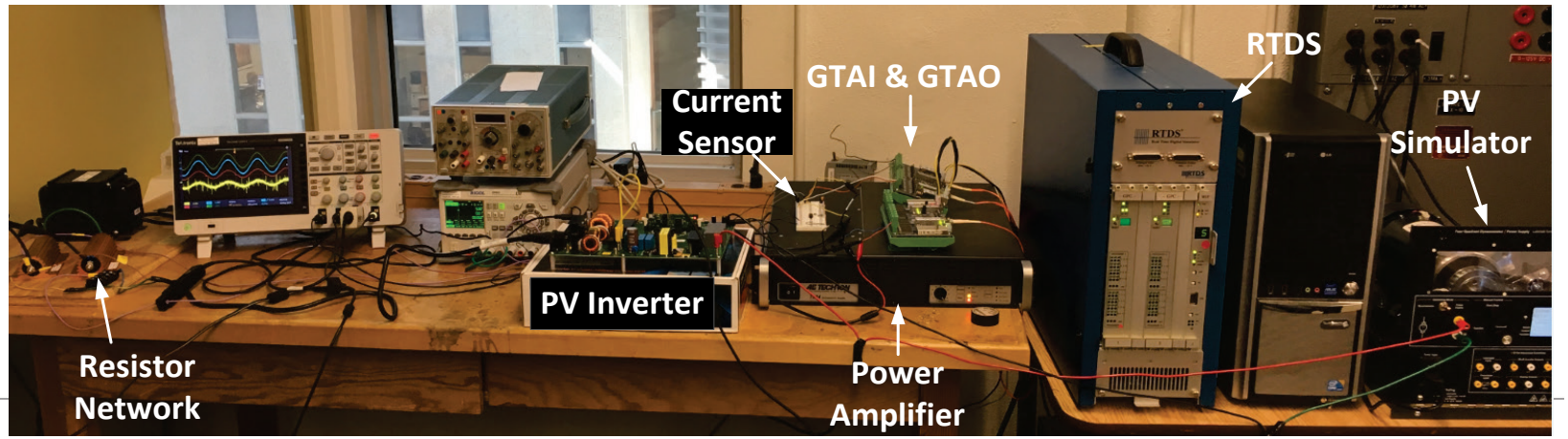
Software-Hardware Interfaces



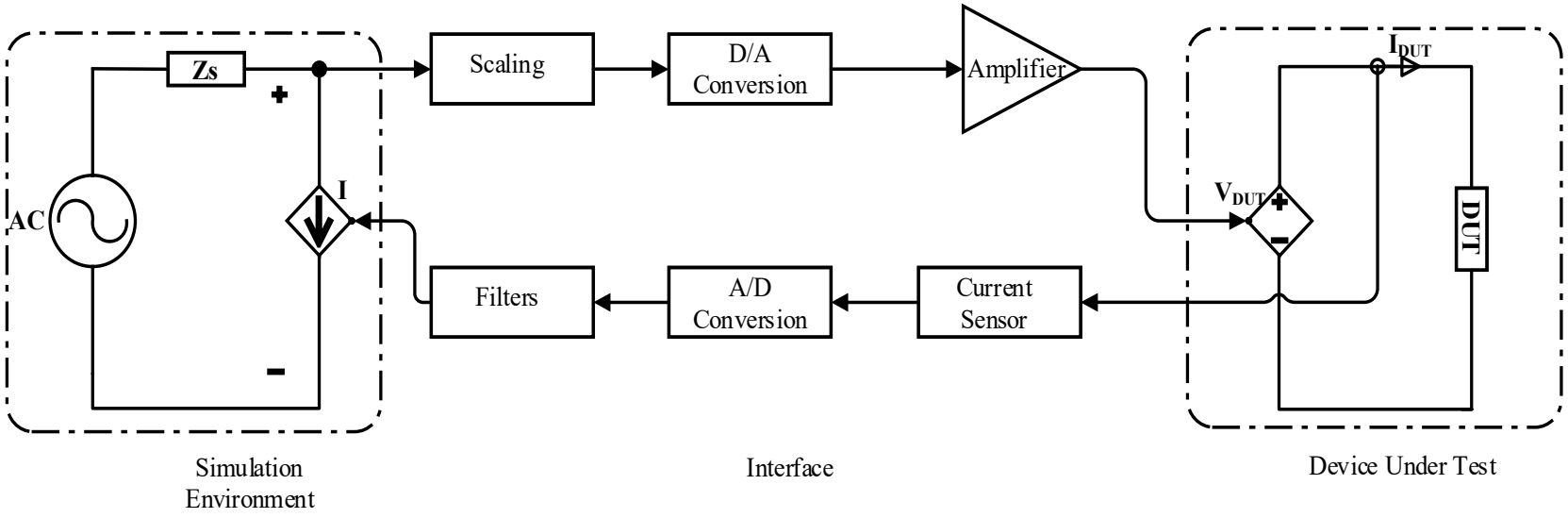
PHILS Test Bed at University of Manitoba



Parameter	Value	Parameter	Value	Parameter	Value
PV Simulator		PV Inverter		Amplifier	
V_{oc}	48.5V	V_{out}	120V	P_0	1kVA
I_{sc}	2.862A	Type	3 Level	Gain	20
P_{in}	140W	P_0	140W	Type	Linear



Critical Components in the Loop



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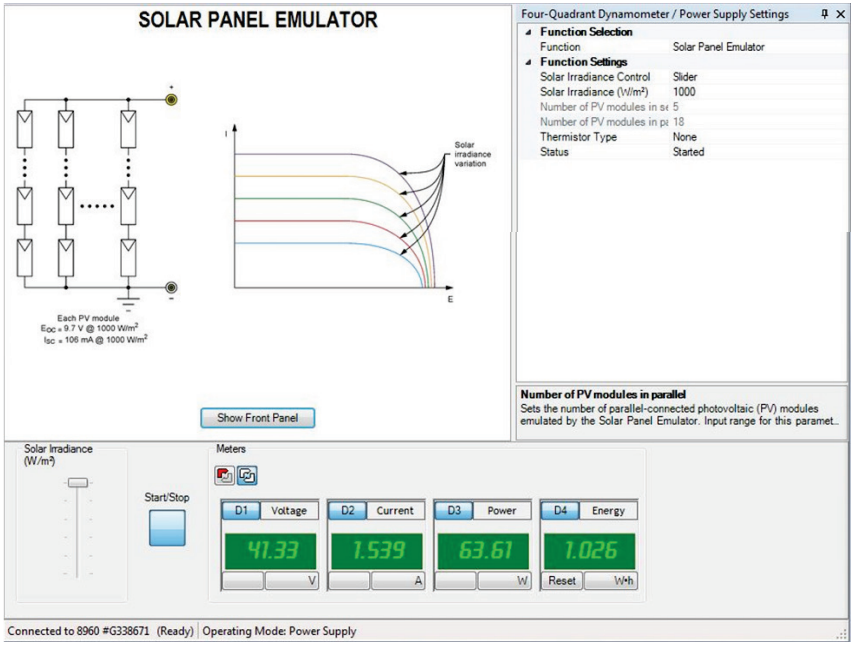
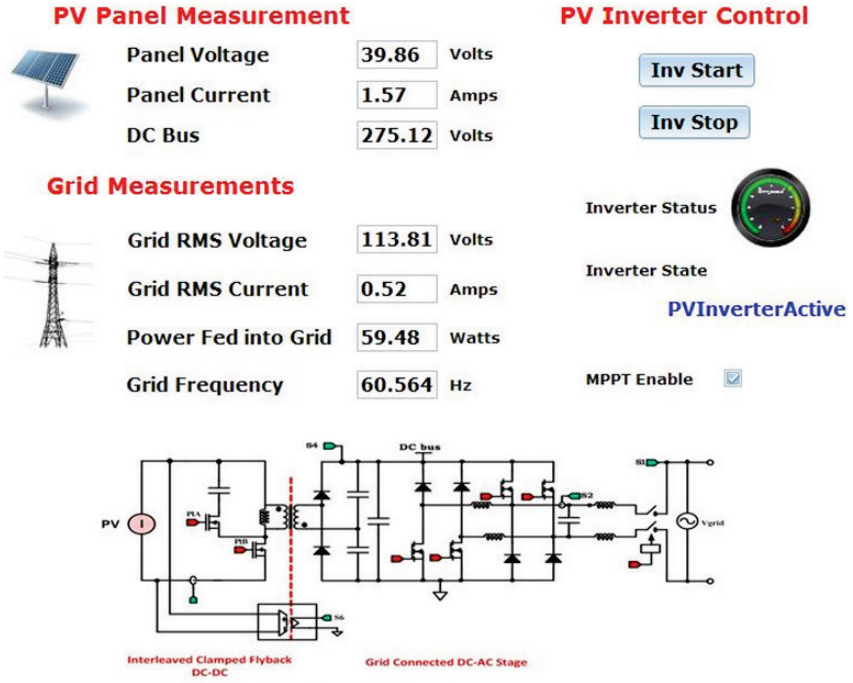
Experimental Results – User Interfaces

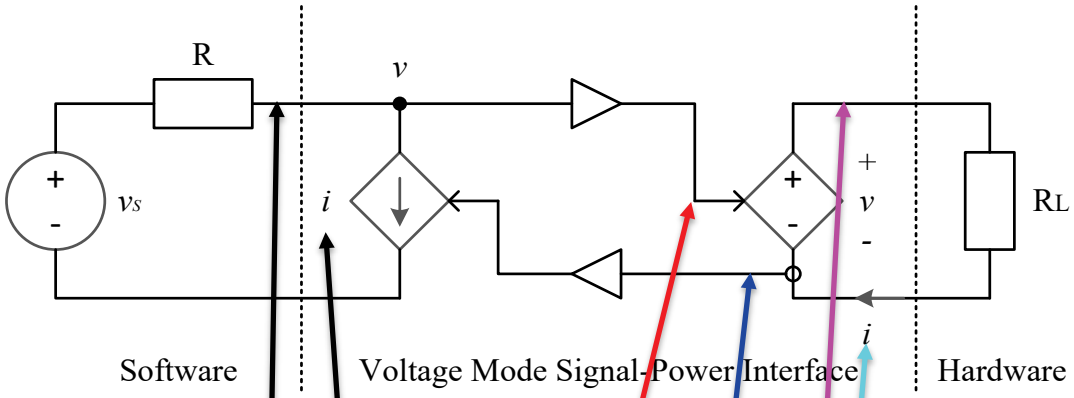


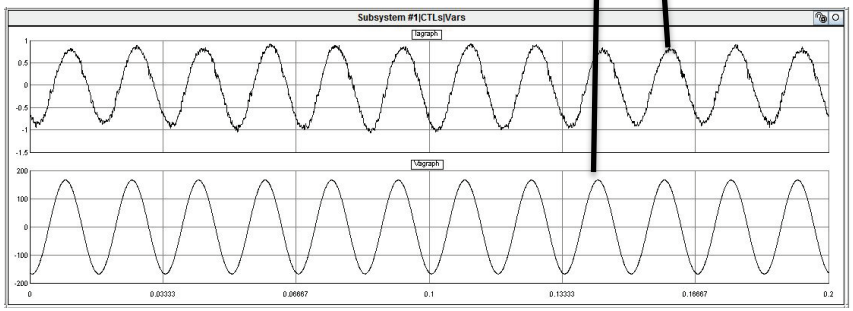
Solar Panel Emulator Interface

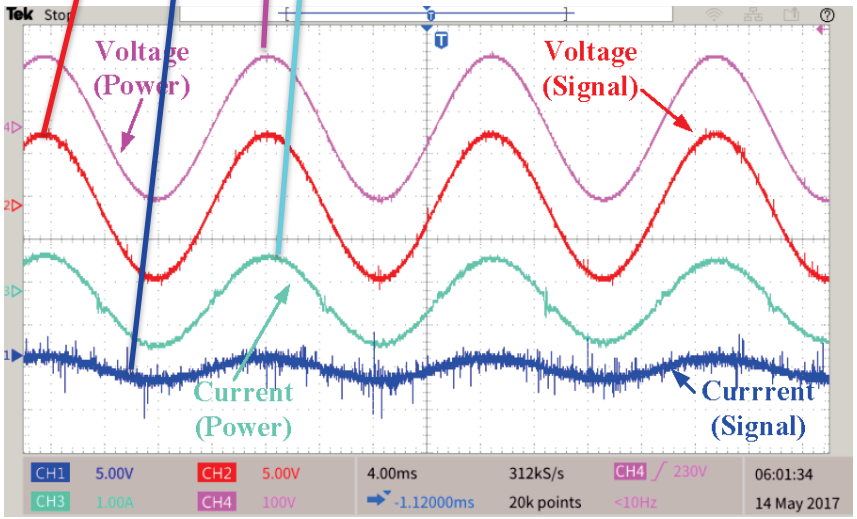


Solar Inverter Interface

Experimental Waveforms - Steady State







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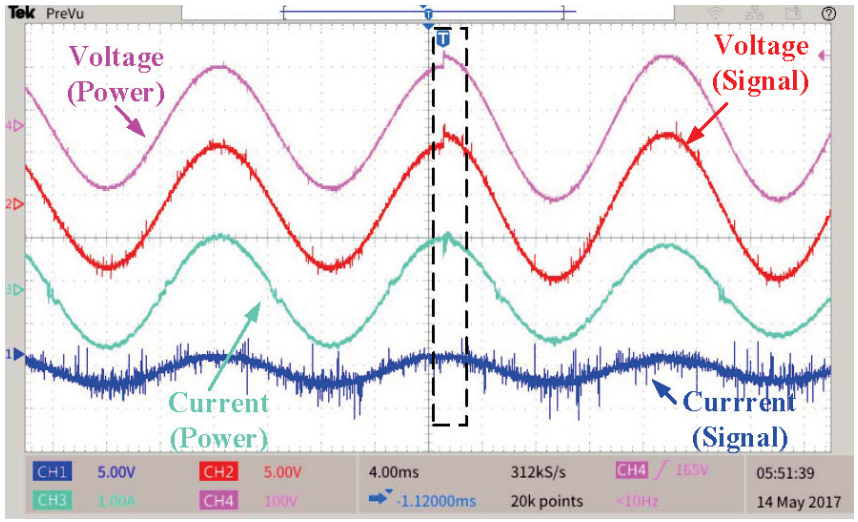
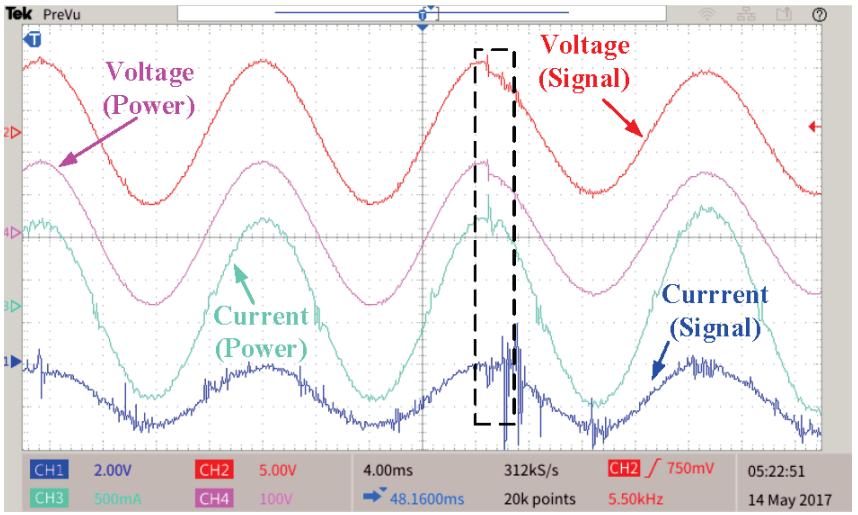
Experimental Waveforms – Transients





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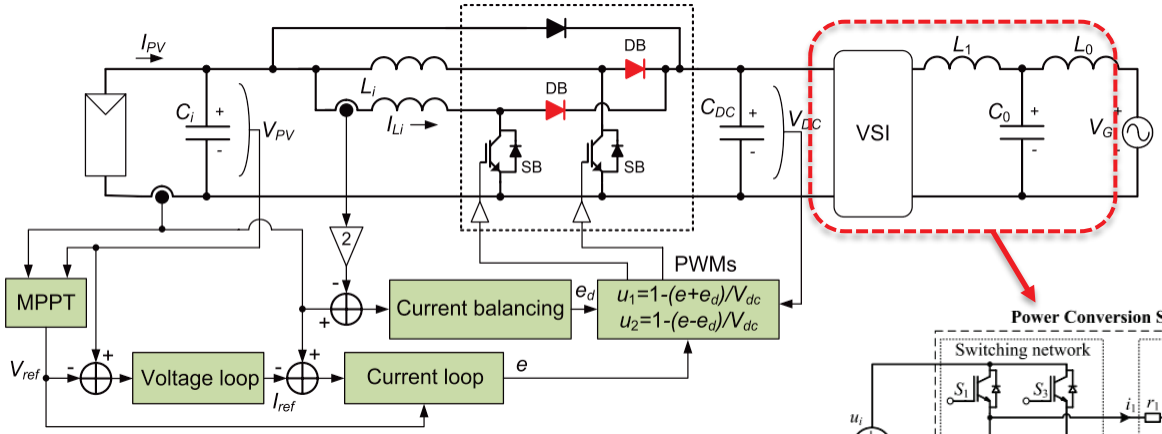
Conclusions

- A Solar Inverter has been evaluated in a Power-Hardware-in-the-Loop system.
- Power Quality Issues have been studied.

Future Work – Stability Analysis of PHILS



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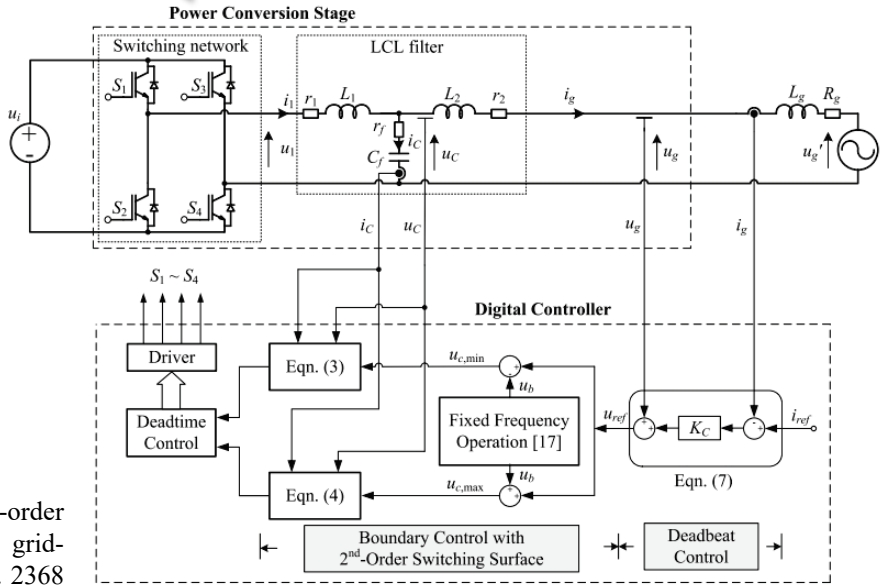

Y. He, H. Chung, C. Ho, and W. Wu, "Use of boundary control with second-order switching surface to reduce the system order for deadbeat controller in grid-connected inverter", *IEEE Trans. on Power Electronics,* Vol. 31, No. 3, pp. 2368 – 2653, Mar. 2016.

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