OPAL-RT TECHNOLOGIES

Success Story

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

Hardware-In-the-Loop Platform at Clean Energy Research Laboratory, Nanyang Technological University

Nanyang Technological University (NTU) is an autonomous research university in Singapore, with 33,000 undergraduate and postgraduate students in eight colleges or schools. NTU is consistently ranked amongst the world's best universities in all of the major college and university rankings. In the 2018 QS World University Rankings, NTU is ranked 11th in the world and 1st in Asia.

1. Clean Energy Research Laboratory, NTU

The Clean Energy Research Laboratory (CERL) is located in the School of Electrical and Electronic Engineering (EEE), NTU, focuses on research & development of energy management techniques, energy storage strategies, control and design of power converters, etc, for use in smart grids and microgrids. While conducting HIL testing of electrical motor controls, the real-time simulation should be as close to reality as possible. To achieve this, the simulation should be sampled below one microsecond, which also results in very low communication latency.

Currently, several research projects, including the project “Novel Hierarchical Transactive Energy Management System (HTEMS) Incorporating Predictive Assessment Techniques for Enhanced Community Market Participation”*, are conducted in CERL. The HTEMS project is funded by EMA, Singapore over a period of 3.5 years (1st May 2015 – 30th October 2018).

Every year, CERL hosts several Postgraduate (PhD, MEng and MSc) projects, Final Year Projects (FYPs) and Design & Innovation projects (DIPs) to fulfil its responsibilities to and support of postgraduate and undergraduate education.

**Project details available at http://eeeweba.ntu.edu.sg/power_projects/ntu-HTEMS/*

Figure 1 A glimpse of CERL, NTU

2. Challenges

The research and education projects conducted in CERL are mainly related to complex power systems dealing with novel concepts and applications in smart grids and microgrids. The system setup may involve multiple microgrids and each may have renewable energy sources, energy storage devices, power converters, etc. Building a physical hardware setup for a large multi-microgrid system for test validation of new regulation strategies is significantly tedious, time-consuming and costly. For projects with limited time and funding, this is usually not practical, especially during the early stages of the project.

3. Solution

Figure 2 HIL platform in CERL

With funding provided by EMA and NRF CREATE, the OPAL-RT real-time digital simulators OP5600 and OP5607 are installed at CERL. Using the OP5600, OP5607, microgrid and hardware devices available in the lab, the HTEMS project team built a hardware-in-loop (HIL) platform. The HIL platform enables integrated simulation of a complete hardware and software system with one part digitally simulated in OPAL-RT devices and the other part using external hardware devices. Compared to a 100% physical hardware platform, the HIL platform has the advantages of a shorter setup time, lower cost, and easier re-configurable setup. Specifically, the reconfigurable feature makes hardware testing of controllers much simpler and makes it possible to implement multiple projects on OPAL-RT simultaneously on OPAL-RT simulators. It is perfect for solving the aforementioned challenge.

4. Results

Based on the HIL platform, the HTEMS research team conducted several HIL experiments on the hybrid AC/DC microgrid, hybrid energy storage system, dynamic voltage restorer, etc. The associated research results were reported in several submitted or accepted top-tier journal and conference papers.

Moreover, several undergraduate FYP and DIP students who adopted the HIL platform for project development and demonstration managed to get one paper accepted by the 2018 IEEE International Conference on Innovative Smart Grid Technologies (ISGT ASIA). The DIP students won second place in the competition among the ten EEE Smart Grid DIP focus groups.

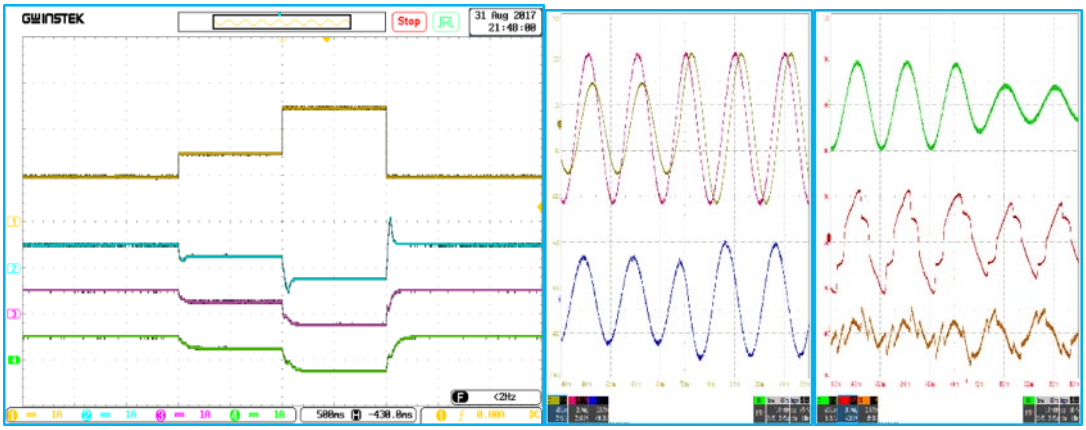

Figure 3 Selected HIL results

To further enhance the capability of the HIL platform, a 45kVA three-phase power amplifier was purchased and will be added to the power-HIL (PHIL) setup. The power amplifier can interface to more equipment, such as the lithium-ion batteries, super-capacitors, programmable power sources and loads in CERL. It will significantly expand the test range and performance characteristics of the smart grid and microgrid setup compared to those offered by the current platform. The proposed PHIL setup will generate superior results and useful outcomes, which will benefit both researchers and students.

About this success story

The success story is Presented by HTEMS* Team

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* This research is supported by the National Research Foundation, Prime Minister's Office, Singapore under the Energy Programme and administrated by the Energy Market Authority (EP Award No. NRF2014EWT-EIRP002-005).

About OPAL-RT TECHNOLOGIES

OPAL-RT is the world leader in the development of PC/FPGA Based Real-Time Digital Simulator, Hardware-In-the-Loop (HIL) testing equipment and Rapid Control Prototyping (RCP) systems to design, test and optimize control and protection systems used in power grids, power electronics, motor drives, automotive industry, trains, aircrafts and various industries, as well as R&D centers and universities

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