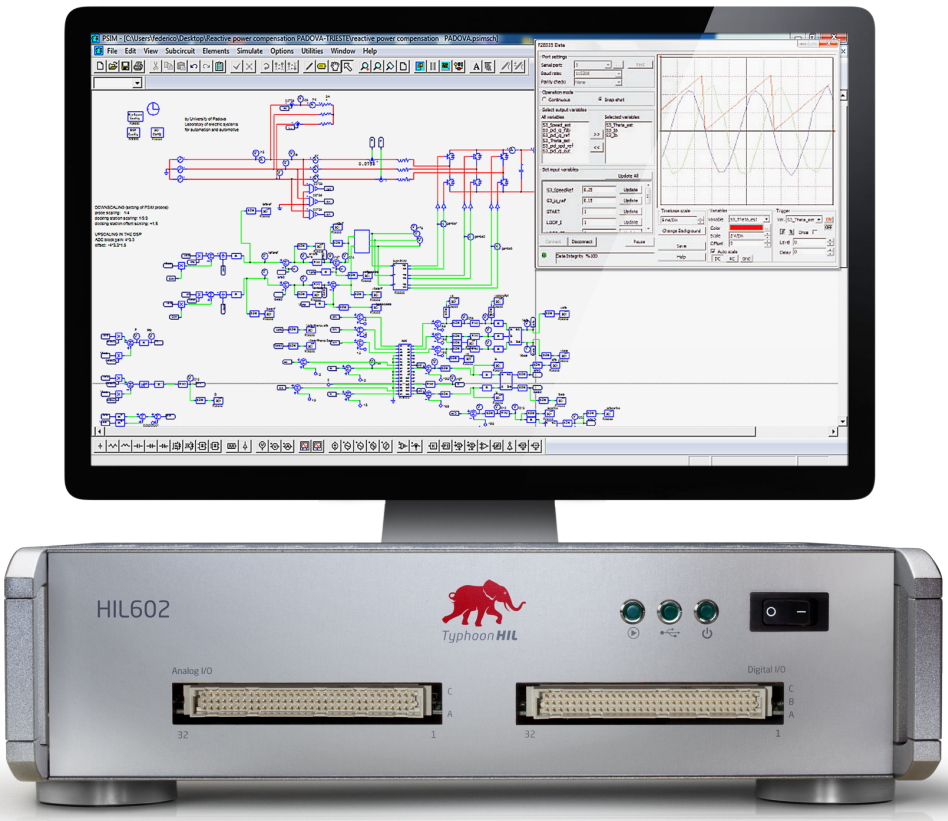



# Rapid prototyping solution tailored for power electronics.

Discover a complete power electronics rapid control prototyping solution that takes you from zero to a validated design in no time.

POWERSIM

Typhoon HIL

# Rapid Development of Converter-based Reactive Power Compensator at *University of Padova*.

*"Literally within a few hours we got comfortable with HIL600, we were able to automatically generate the control code from PSIM, port the code to a HIL DSP Interface Board, and reproduce both the PSIM off-line simulation results and the real hardware results. PSIM's auto code generation capability significantly sped up the controller development while HIL completely removed all the constraints of testing a controller with a real power stage and enabled complete test automation."*

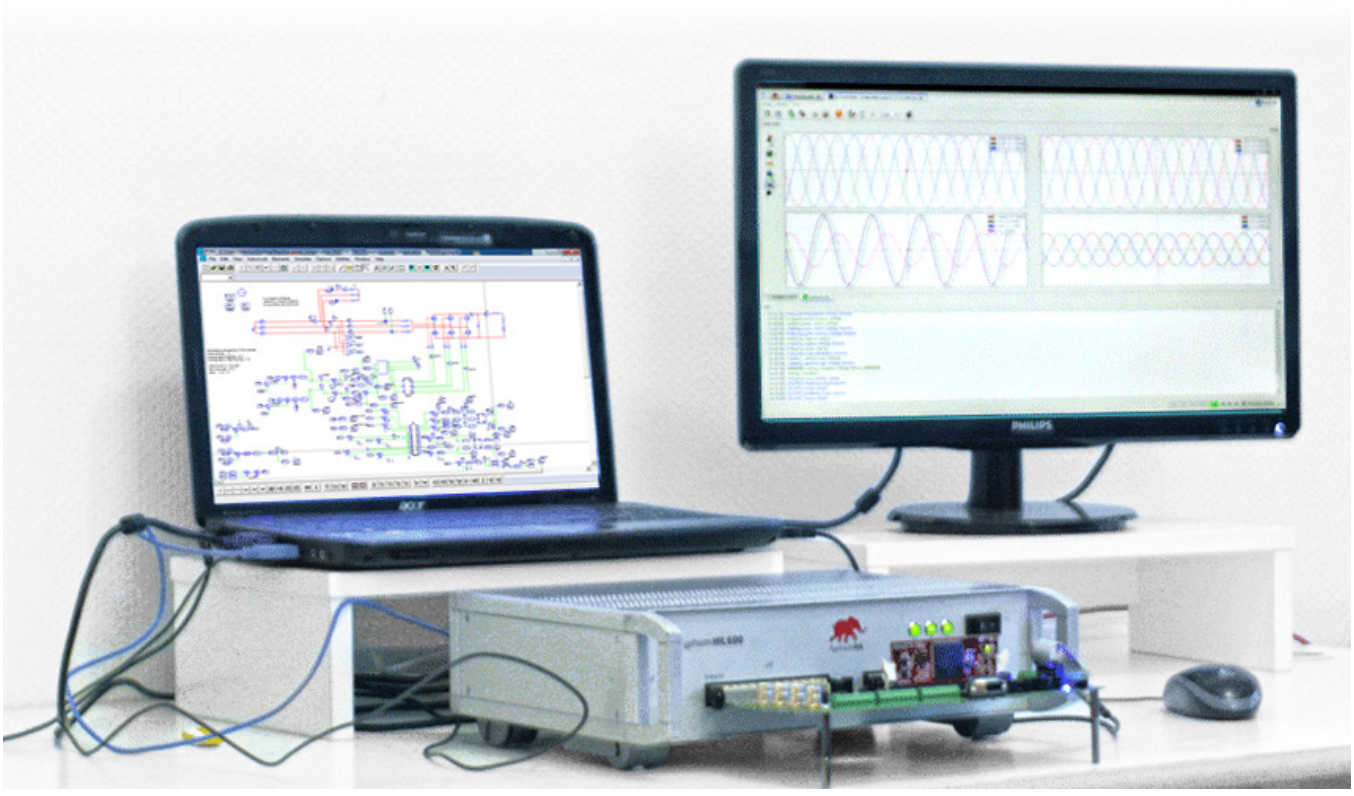
*Prof. Giuseppe Buja*
*Professor of Power Electronics*
*University of Padova, Italy*

## Introduction

Reactive power compensation and harmonic filtering enhance power quality and improve electrical network efficiency, resulting in considerable economical savings for end customers. The University of Padova is developing controls for a converter-based reactive power compensator. The goal of the project is to design and verify a system that provides fast and agile reactive power grid support. In this configuration, the loads are directly supplied with active power from the grid while the reactive power is injected from the converter. It is anticipated that in the future, power electronics equipment in electrical vehicles, solar/wind inverters, and energy storage systems will provide ancillary grid support services, one of them being voltage control via reactive power injection.

## From simulation to prototype

A major challenge of the project was to develop a complex control algorithm, and to test and verify the controller under various operating conditions. The basic control concept was first developed and implemented in off-line simulation in PSIM. Using PSIM's SimCoder Module and TI Target, DSP related elements, such as ADC and PWM, were added to the schematic. After the system is fully tested in simulated,



Grid-tie inverter simulated in HIL configuration in real-time and controlled with automatically generated code from PSIM Simcoder module.

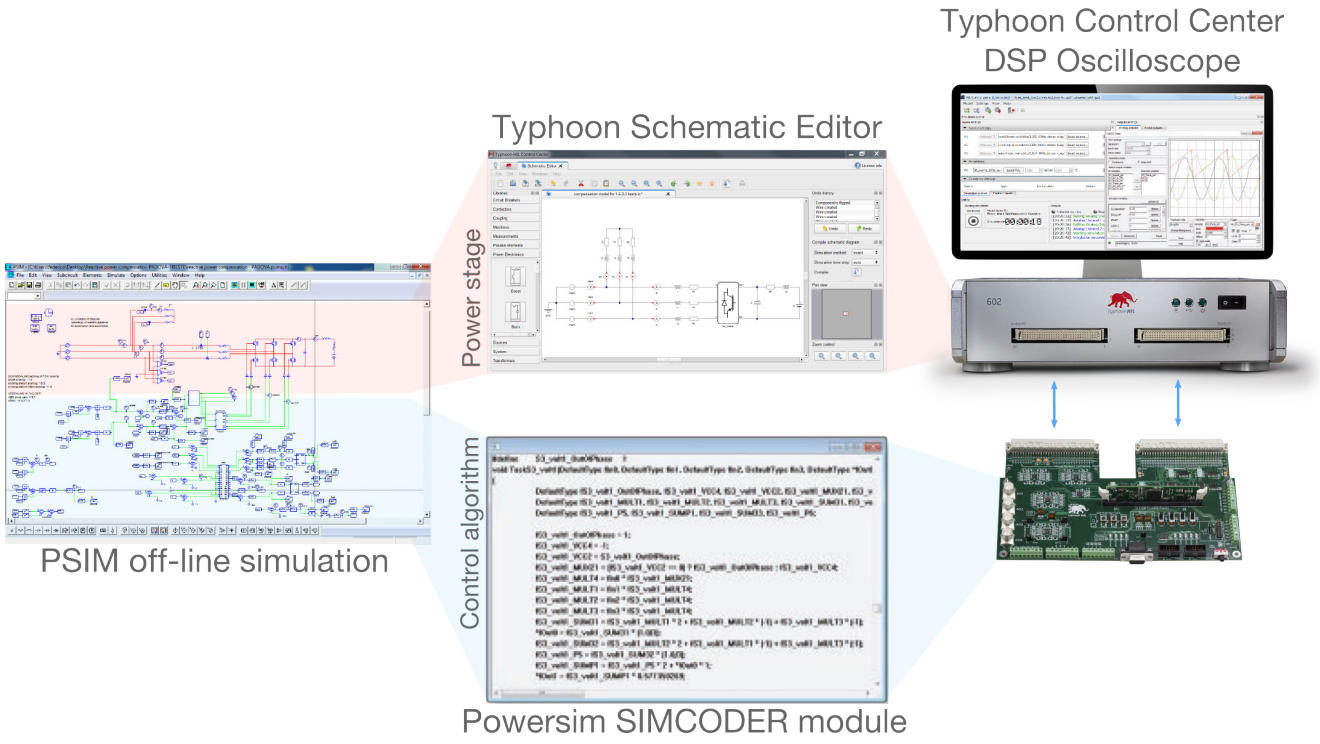
*"This project effectively demonstrates the advanced power electronics design workflow. It starts with the PSIM off-line simulation and automatic code generation , followed by rapid prototyping using Typhoon HIL real-time emulation to test the control extensively in HIL environment, and concludes with porting fully tested controller onto a real converter."*

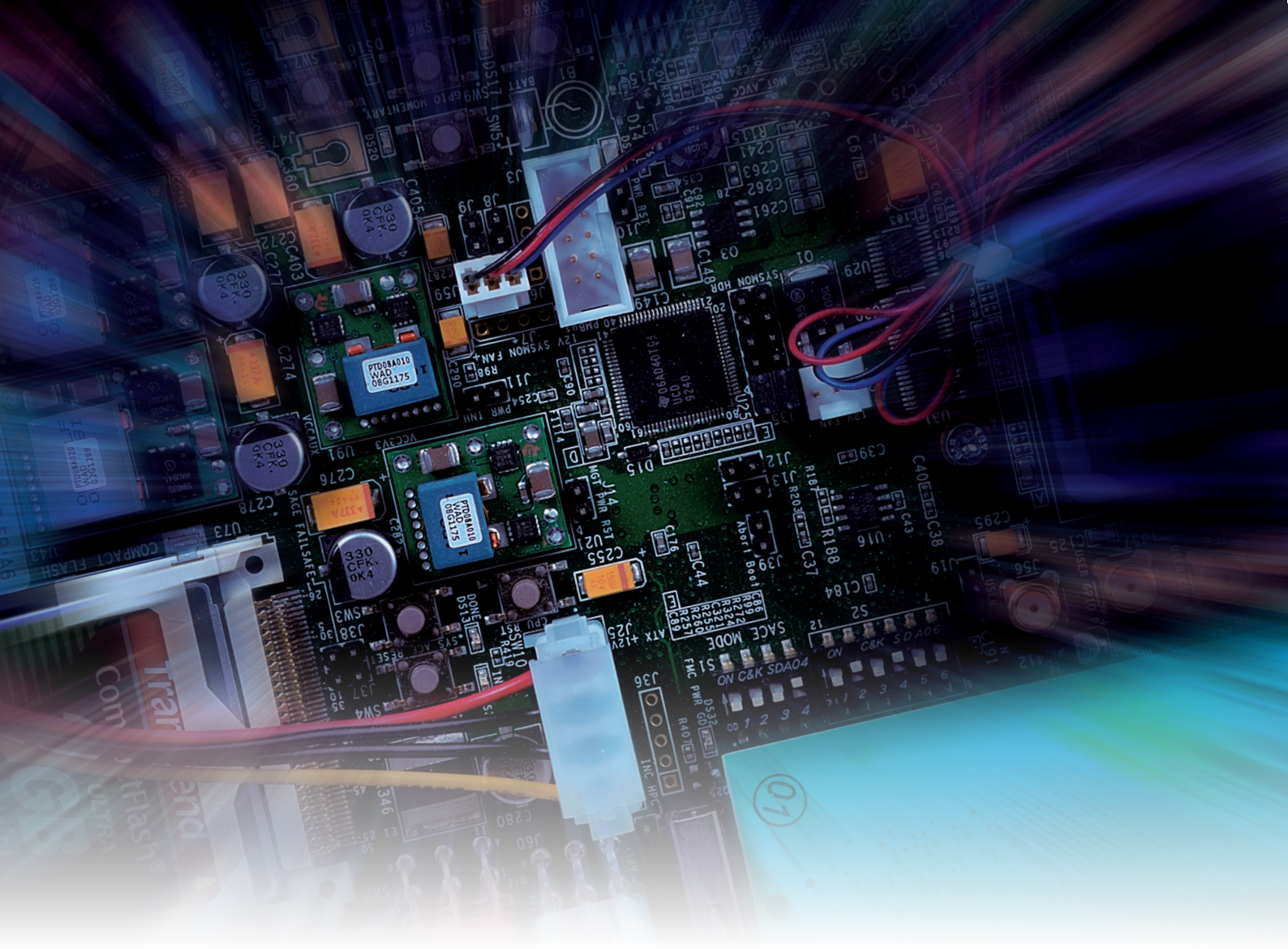
DSP code was automatically generated for TI DSP. The auto generated code was then ported to the *Typhoon HIL DSP Interface Board* plugged directly onto the *Typhoon HIL600* emulator. The power stage of the system was created in Typhoon's schematic editor, and a model for the power stage was compiled and uploaded to HIL600. In a very short time, all the voltage and current loops were closed, and the control code was running with the power stage emulated in real-time in the hardware-in-the-loop setup. Although, connecting the TI DSP board to the system, getting used to the Typhoon HIL software environment, and drawing the the grid-connected converter schematic took a few hours, in less than a day, the HIL real-time simulation was running and generating the same voltage and current waveforms as the PSIM off-line simulation. The control code, run on the experimental setup with the real controller hardware and power converter, yielded results that were almost identical to both PSIM results and HIL results.

After initially performing standard tests, the ones that are easily done with the real converter hardware, the team from the University of Padova and the University of Trieste started performing more complex tests that are either impossible or too expensive to do with the real hardware setup. Test scenarios, such as *grid voltage harmonics, unbalanced grid voltage, load unbalance*, were quickly emulated with the HIL setup, enabling the testing of control algorithms against a wide spectrum of real-life scenarios. The ease with which one can generate various grid conditions in the HIL, and how these tests can be automated, opens new possibilities in controller software quality control.

## New control design paradigm

The combination of the off-line simulator PSIM and its auto code generation capability, coupled with the Typhoon HIL real-time emulator, offers a significant advantage in the design, analysis, and testing of the overall system. It allows the control algorithm, control hardware, and power stage to be developed independently of each other. Furthermore, it helps streamline the design process and greatly reduces the overall development time and effort. Even though the real hardware setup is the ultimate test and the final stage of the development, the HIL setup provides a less expensive, more comprehensive, fully repeatable, and faster test and verification approach. In addition, the HIL provides a path towards completely automated control software regression tests that just can not be done in any other way.






Powersim Inc.

2275 Research Blvd, Suite 500
Rockville, MD 20850
phone: +1 (301) 841-7445
www.powersimtech.com
info@powersimtech.com

Typhoon HIL, Inc.

339 Hurley St. #1
Cambridge, MA 02141
phone: +1 (617) 909-0087
www.typhoon-hil.com
info@typhoon-hil.ch


POWERSIM

Typhoon HIL