Power Laboratory in a Box.

New way of learning real life power electronics for the 21st century power electronics engineers

www.typhoon-hil.com
Who we are.

Typhoon HIL, Inc. is a technology leader in the ultra-high fidelity Hardware-in-the-Loop (HIL) real-time emulators for power electronics. Our solutions are extensively used for power electronics control system design, development and automated quality assurance (QA).

Applications

Typhoon HIL products are used for the design, development and automated quality assurance (QA) of power electronics control systems. Our systems are used worldwide for a range of applications such as motor drives, PV converters, active filters, traction, telecom, research, and teaching.

Research and Development

As an innovative power electronics company, we not only focus on research and development of new products, but also closely work with our customers to help them solve their unique challenges and to customize our products to their specific needs and requirements.

Products

Typhoon HIL offers ultra-high fidelity real-time Hardware-in-the-Loop (HIL) emulation systems (with 1µs simulation time step) and industrial controllers for power electronics. Our products are distinguished by leading edge technology, unrivaled performance, ease of use stemming from complete vertical integration of the toolchain, and affordability. Our application specific digital processor architecture and real-time simulation algorithms have set the standard for ultra-high fidelity power electronics HIL systems.

Contact us

We are an international company serving customers on three continents, and we are aware that our success depends on our ability to listen and work closely with our customers to help them solve their pressing QA problems. Hence, we take pride in being flexible and providing you the right solution for your particular needs.
The problem we have solved.

Typhoon products directly address power electronics control design, testing, and QA with a sophisticated ultra-low latency Hardware-in-the-Loop real-time emulator based on our digital processor and vertically integrated software toolchain.

Relevance of the problem

Testing power electronics controls is an extremely time consuming, expensive, and dangerous process, that has to be done in a high-power laboratory, i.e. next to a spinning machinery and/or with grid connected converters. In addition, this approach to testing can not cover all the operating conditions, operational scenarios, and faults. Hence, test until time or money run out is still prevailing in industry.

Our solution directly reduces quality assurance costs that today amount to 2-4% of overall revenues.

Solution approach

Our ultra-low latency Hardware-In-the-Loop (HIL) technology enables automated type and routine tests of power electronics control systems which dramatically improve the bottom line by:

- Reducing time to market
- Eliminating control system quality cost
- Streamlining end of line testing.

The four key applications of HIL technology are:

- Renewable power generation
- Industry automation
- Transportation
- Research and education.
What we offer.

HIL400—virtual laboratory in a box—is a compact, easy to use, desktop unit that eliminates the need for dangerous and expensive high-power laboratory. With our Hardware-in-the-Loop system, students experience hands on design, optimization, and testing of real life industrial grade control systems, from the get go.

HIL400 Emulator

Provides a complete solution for power electronics control design, testing, and QA in a desktop size. Software toolchain is as intuitive, flexible, and easy to use as any state of the art non-real-time simulation software. 1μs emulation time step provides high-fidelity with completely realistic test and QA environment for your industrial controller platform. For example, our platform enables grid and PV emulation with dynamic fault injection and parameter variation.

TI DSP Controller

Our power electronics controller platform, supports a family of TI DSP controllers with one click controller application download, GUI interface to the controller application, JTAG port, and direct pin to pin compatibility with HIL400 and HIL600 devices.
Teaching modules.

Our teaching modules span a spectrum of applications from wind turbines, photovoltaics to motor control, hybrid/electric vehicle drives, and power supplies. From beginners to experienced professionals, users can adjust the level of technical detail and complexity, according to their needs.

Photovoltaic Converters

In photovoltaic systems, power electronics converter are one of the key components, as they directly interface one or multiple PV panels with the electrical utility grid. Design and testing of control SW/FW/HW for these converters is expensive and time consuming due to:

- direct power connection to the grid (high-voltage, high power);
- difficulty of emulating PV panels (including dynamic solar irradiation shading effects, PV faults etc.)

Typhoon HIL provides high-fidelity emulator system for design, testing, and test automation of PV converter control systems, that takes power hardware out of the picture for control designers. HIL enables fault injection including grid disturbances, islanding modes, and dynamically controllable solar illumination.

HIL400 system provides integrated, completely safe, and comfortable environment for students and engineers to learn, experiment and implement solar PV control and protection algorithms, no matter the power ratings; from kW to MW.
Variable speed drives are becoming ubiquitous. However, design and testing control systems next to a spinning machinery is neither safe nor pleasant experience. HIL400 system with Texas Instruments family of DSP controllers integrated in Typhoon HIL DSP Interface provides safe yet high-fidelity environment that can be used by novice students as well as experienced engineers.

Control algorithms

Our platform is geared for design and testing of different control layers, ranging from modulators, PLL, current and voltage loops, to torque and speed loops and estimators, all the way to slower protection functions i.e. contractors, pre-charging, temperature protection etc.

A range of induction machine control algorithms can easily be designed, optimized and tested, i.e.:

- V/f controls,
- Vector control, and
- Sensorless control.

In addition, we enable testing against different operating conditions, faults, and parameter variations, such as:

- Sensor faults
- Machine faults (open and short circuit)
- Converter switch faults
- Machine parameter variations.
Permanent magnet machines are widely deployed in high-power variable speed wind turbine systems, due to their high power density and performance. In addition, PM machines are used in automotive and industry automation applications. HIL400 system with Texas Instruments family of DSP controllers integrated in Typhoon HIL DSP Interface provides comprehensive and completely safe, yet high-fidelity environment that can be used by novice students as well as experienced engineers to develop, optimize, and test variety of control strategies.

Our platform is well suited for both high speed control tasks as well as slower ones. Testing application level control tasks is also straightforward. In addition, we enable testing against a spectrum of realistic operating conditions, faults, and parameter variations, often encountered in real life situations.

These operating scenarios include:

- Sensor faults
- Machine faults (open and short circuit)
- Converter switch faults
- Machine parameter variations
- Dynamic load torque specification, via drive cycle specification.
HIL400 laboratory in a Box

HIL400 laboratory consists of HIL400 real-time emulator, controller DSP Interface with TI DSP, oscilloscope, and accessories that all neatly fit into a small suitcase.

HIL400 Laboratory:
Complete design, test, and QA for power electronics:
- HIL400 real-time emulator
- DSP Interface for TI DSP’s
- Integrated software tool chain
- USB oscilloscope
- Set of converter/controller applications

HIL400 Emulator
- 1µs time step; two-core digital processor
- Ethernet and USB interfaces
- Two- & three-level converters, PV, motors
- Grid and PV emulation
- 32 Digital Inputs/32 Digital Outputs
- 16 Digital Outputs/8 Analog Inputs

HIL DSP Interface
- F2808, F28044, F2803x, F2806x, F28M35x TI DSP’s supported
- JTAG and RS232 programming interface
- HIL400 compatible analog and digital I/O
- 16 HIL AO connected to DSP ADC
- 12 HIL DI connected to DSP PWM output
HIL software toolchain.

Experience integrated HIL software with automated testing. Intuitive and easy to master, our software provides a unified environment for power electronics design, test automation and quality assurance.

Unified experience.
Model power electronics converters in our simple power electronics editor using a library of passive elements, converters, sources and machines. With only one click, rapidly compile the circuit into machine code that is executable on our HIL hardware. Open the HIL control panel to load the compiled model onto the hardware and launch the real-time simulation. Select signals you want to see on the scope and change sources and parameters for a fully interactive experience. With python script editor, automate your test processes and generate test reports, hands-off.

Discover simplicity.
- Vector graphics circuit editor with examples.
- Library of power electronics circuit elements.
- One click circuit compilation.
- Interactive control of real-time emulation.
- Dynamic routing of all signals.
- Waveform editor for source definition.
- Software control of digital inputs.
- Automatic testing via Python Scripts.
- Library of test scripts for testing grid compliance, protection etc.
- Python API.
- Automatically generate HTML test reports.

Typhoon HIL Hardware
Prepackaged Course Material for Grid Connected Converters.

We provide a complete teaching solution including a Lab Practicum with step by step exercises, detailed theory, and wealth of DSP code examples. It is easy, fun and real-time interactive.

Grid Connected Converter (GCC) Control Course Material

New methodological approach to teaching power electronics control applications of grid connected power electronics converters for distributed generation, renewable energy systems, active filters and smart grid applications.

Student operate converter systems under different operating conditions including grid disturbances and faults. Practicum covers open and closed loop control of three phase grid connected converters, including design of PWM modulation, PLL synchronization with the grid, grid currents control and DC link voltage control. From theory to real industrial application.
New power electronics lab paradigm.

Typhoon development and engineering team that develops industrial solutions perpetually distills gained experience into the teaching modules in collaboration with our academic partners thus providing wealth of knowledge and real life design examples.

Complete library of converters and controllers enables students to get machines, wind turbines, PV systems etc., running in 5 minutes and get oscilloscopes full of live signals. Multilayerd approach lets students choose the level of detail: from only changing controller and converter parameters all the way to the design and testing of modulators, PLL, protection schemes etc. all in all in C on real controllers. From undergraduate novice to graduate level students and professional engineers, everyone can immediately zoom in to the topic of interest and experience hands on interaction with the high fidelity system.
User experience
New Hardware-in-the-Loop Based Power Electronics Teaching Laboratory

“Typhoon HIL power electronics teaching laboratory provides engaging, hands-on, and intuitive learning environment which makes laboratory classes fun and effective for students while being in 100% safe environment”

Prof. Kaushik Rajashekara
The National Academy of Engineering Member
Distinguished Professor and Endowed Chair
University of Texas at Dallas

Introduction

Modern power electronics applications require increasingly complex, fast, flexible and robust control systems, hence the performance requirements for embedded controllers is continuously increasing. The need for well-equipped, effective, versatile, flexible, and safe digital power education platforms and laboratories, to educate the next generation of power electronics engineers and researchers, is becoming critically important.

An innovative digital signal processor (DSP) based power electronics and motor drives hands-on teaching lab enables students to rapidly and efficiently learn to program DSP and configure the peripherals for real-time applications and control/manage the power digitally. The core of the platform is the Typhoon HIL ultra-high fidelity Hardware-in-The-Loop (HIL) system and associated real-time power electronics emulation tools empowering students to easily create re-configurable real-time power plant models which are controlled by the industrial-grade DSP controller hardware. This hybrid approach to hands-on teaching provides an engaging, user friendly, and completely safe environment for students to experiment with advanced energy conversion systems, develop industrial quality controllers for a spectrum of energy conversion applications for virtually any power level, ranging from watts (W) to megawatts (MW).

Challenge

For most of the today’s power electronics practicing engineers solid knowledge of micro-controller or DSP is an imperative. However, learning the basics of such embedded systems is a grueling process due to the specialized architectures of the industrial grade embedded systems. Another key challenge for a truly hands-on digital power control course is the design stage of a hardware setup which requires a solid background in mixed signal circuit design, power topologies, pcb layout design, EMI, protection, component selection etc. In addition, the complex mixed signal designs can easily be damaged by the students during the experiments where they are required to reconfigure hardware and probe various test points. Maintaining complicated hardware based lab systems is another issue for instructors. Furthermore, the laboratory experiments are strictly limited with the hardware, and it is not feasible to make experiments using different plants, topologies, components, digital signal processors and keep the lab content up to date. Indeed, for an effective and engaging hands-on course, the teaching lab setups should be as flexible as possible to enable students to work on the cutting-edge technologies.

Solution

An alternative way to address these issues and effectively teach all aspects of DSP based power electronics is to use a ultra-high fidelity power electronics real-time emulators directly interfaced with the real digital controller systems. In the HIL configuration, a DSP controller can’t tell the difference whether it is controlling a real power stage or a real-time emulator due to the ultra-high fidelity of real-time emulation process. This approach allows students to design various power conversion systems such as motor drives, grid tied inverters, photo-voltaic converters, dc-dc converters etc., and optimize the system parameters and control it safely without being exposed to the risk of electric shock or mechanical accidents while working with realistic and ultra-high fidelity environment.
Teaching Modules

Implemented teaching modules span a spectrum of applications: from wind turbine drives, photovoltaic converters, active filter all the way to motor control, hybrid/electric vehicle drives, and power supplies, as illustrated in figures below.

Students can adjust the level of technical detail and complexity, according to their needs, starting with a fully working closed loop converters, exploring the performance of the closed loop system, fault tolerance and generally get familiar with the application. In the subsequent exercises students develop their control algorithms from ground up, usually starting with building their own modulators, closing current loops, developing and testing phase lock loops, all the way towards the application software and protection schemes.

Conclusion

Effective digital power education platforms and laboratories are ever so important to train the next generation engineers and researchers.

Ultra-high fidelity Typhoon Hardware-in-the-Loop based power electronics teaching laboratory enables students to rapidly learn how to configure the peripherals of a DSP for real-time applications and control/manage power digitally.

In order to ease the learning process, the combination of hardware in the loop system and digital signal processor has been used to teach the basics of digital power concept and the details of real time control. HIL real time emulator acts like an actual plant that is controlled using DSP platform enabling safer, easier and user friendly interactive platform.

The new Typhoon HIL based teaching laboratory at the University of Texas at Dallas.
Award winning senior design project

Controller Design for Three-phase Power Conditioner.

“Typhoon HIL is an ideal development environment for design and testing of grid connected converters. It enables students to focus on the design and testing of control systems without the need for expensive and dangerous high-power lab. HIL was the key in this project that helped undergraduate team win the best NCSU Senior Design Project.”

Prof. Subhashish Bhattacharya
ABB Professor of Electrical and Computer Engineering
North Carolina State University

The project proposed by Dr. Bhattacharya targets the application of Voltage Source Inverter (VSI) for load conditioning of industrial equipment. NC State University Senior Design Team investigated VSI control algorithms to achieve reactive power compensation, harmonic current filtering, and provide active power injection to enable peak power shaving. Simplified single node power system, VSI, and nonlinear load are modeled in a HIL400 real-time emulator, while TI DSP controller is used for closed loop control of VSI.

Modeling complete power system in Hardware-in-the-Loop (HIL) emulator enabled students to fully focus on the controller design and implementation of voltage source inverter (VSI) coupled with energy storage system (ESS). Controller was implemented in HIL DSP interface board with TI DSP.

HIL provided unprecedented level of flexibility in testing different real-life operational scenarios. For example, HIL programmable current sources were used to emulate nonlinear load with harmonics. Via Typhoon HIL API and Python scripting different load profiles and dynamic transitions were emulated in runtime. Indeed, the scripting provided automated and formalized way of doing repeatable testing and performance verification of the controller design.

Finally, HIL tested controller was directly ported to the NCSU MVDC Hardware Testbed which yielded same results as with the HIL. This demonstrated the effectiveness of Typhoon HIL models and the industrial design process: from rapid control prototyping with HIL; HIL automated test and verification; all the way to final hardware deployment.
NC State University uses HIL400 to develop new Convertible Static Transmission Controller (CSTC)

“Typhoon HIL400 proved to be invaluable research and development tool enabling us to rapidly develop, test, and verify novel utility scale converter system and its control.”

Prof. Subhashish Bhattacharya
ABB Professor of Electric and Computer Engineering
North Carolina State University

Introduction

Research team lead by Prof. Subhashish Bhattacharya at North Carolina State University FREEDM Center proposed a Convertible Static Transmission Controller (CSTC) that enables coordinated power flow control with emphasis on large penetration of renewable energy generators based transmission. CSTS can be connected across the substation transformer and configured for different modes of operation to perform as a versatile transmission controller: power flow control for transmission of renewable resources, and as a transformer back-up. Different connection configurations, i.e. shunt-shunt, series-shunt, and series-series can be obtained. Researchers demonstrated the proposed approach using Typhoon HIL400 ultra-high fidelity Hardware-in-the-Loop (HIL) emulator in three different modes of operation. HIL simulations were used to verify the validity of the proposed control strategy for CSTC operation for normal and unbalanced conditions.

Challenge

Transmission grid and its assets are getting older, and in particular power transformers. Available equipment failure data from 2008 to 2009 reveal an increasing outage trend due to transformer operational mechanisms. Key motivation for this work was to propose a unique power electronics solution that provides back-up in case of substation’s transformer failure or forced reduced transformer capacity. In addition, the CSTC can be designed to be portable and compatible with different voltage levels to operate as recovery transformer. In normal mode of operation, CSTC is deployed to extend the life span of existing transformers by partially bypassing and conditioning the substation throughput power. In case of transformer failure, CSTC can be deployed to meet power, voltage, and VAR requirements. Main challenge of the project was a control strategy development, implementation, and test and validation of the complete controller in a realistic environment. The CTSC control has to be optimized to provide:
- active power flow control;
- reactive power injection;
- robust operation under unbalanced conditions.

Solution

CSTC testing and verification is performed with Typhoon HIL400 real-time emulator, directly interfaced with AIX digital controller. CSTC power operational configuration.
stage comprising two back-to-back inverters, power transformer (230/138kV), and simplified model of the grid was simulated in HIL400. AIX controller was used to implement different control methods. Typhoon HIL400 covered essential requirements: 16 analog output for measuring simulated values, 8 analog inputs to change controlling values, 12 digital input for gate-drivers and contactors. Typhoon HIL400 was used for hardware-in-the-loop emulation of CSTC power stage in three distinct modes of operation: shunt-shunt, series-shunt, and series-series connection. HIL results were also verified using PSCAD off-line simulator. CSTS was tested with HIL for both balanced and unbalanced power system.

**Conclusion**

The Convertible Static Transmission Controller compared to existing FACTS solutions, provides the flexibility of full/partial utilization. This flexibility effectively increases the system spare capacity and operating margins, and provides back-up by providing real-time continuous power flow control and thereby, increased transfer capacity of existing transmission systems. Using HIL400 researcher were able to rapidly demonstrate the feasibility of CSTC under different operating conditions and extensively test and verify the performance of the complete system.
Typhoon HIL support.

Comprehensive online documentation, extensive examples, user forums, online videos, and highly technical support teams with local sales and distributor offices across Europe, North America, and Asia guarantee highest quality support.

International network of Typhoon HIL offices, broad distributor base, and number of value added resellers guarantee quick turnaround time and responsiveness to your specific needs and requirements. Our industrial customers and partners constantly drive our product development and customization providing constant feedback and product enhancement vectors.

Furthermore, Typhoon’s strong ties with academic research and teaching laboratories enable constant knowledge flow between teaching and research. As a company, we believe in building and supporting strong international power electronics innovation ecosystem that will benefit our society’s quest for green and sustainable energy future.