Typhoon HIL

4th Generation HIL.

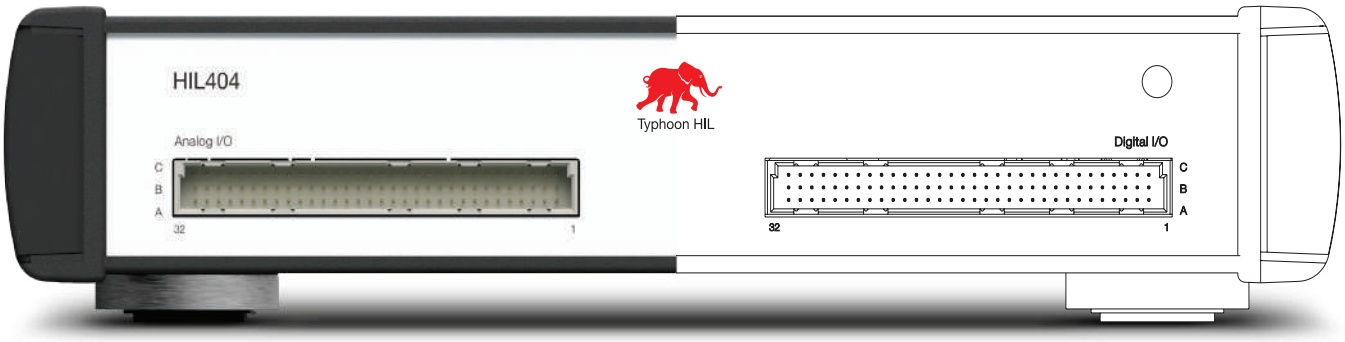
HIL404.

Deploy HIL in a day. It is the only way.

www.typhoon-hil.com

4th Generation HIL.

Ultra-high fidelity redefined.



Applications

While automotive and aerospace industries have already adopted model based HIL testing, power electronics industry is only playing a catch up. The good news is that the 4th generation HIL is delivering the unprecedented model fidelity needed for the most advanced motor drives and automotive power electronics applications.

Easy to use software tool-chain

User friendly and intuitive software is easy to use and master, even for first time users. Build your models and perform sophisticated test scenarios, in the comfort of your office.

What's new?

- Down to 200ns time-step
- Down to 200ns Analog Output update rate
- 3.5ns GDS oversampling on all Digital Inputs
- Up to 4 processing cores
- Real-time emulation of non-linear machines with spatial harmonics
- Real-time emulation of semiconductor power losses
- The most accurate Dual-Active Bridge (DAB) converter model.
- JMAG-RT FEM electric machine model import
- HIL connectivity exploded: USB3.0, Ethernet, Gb/s serial link, JTAG, General Purpose IO (GPIO)

Tailored for automotive drives with the most detailed inverter models, spatial-harmonic electric motor models, CAN connectivity, and plug and play interface towards 3rd party test automation tools.

Typhoon HIL404.

From HIL to Rapid Control Prototyping. The most versatile platform.

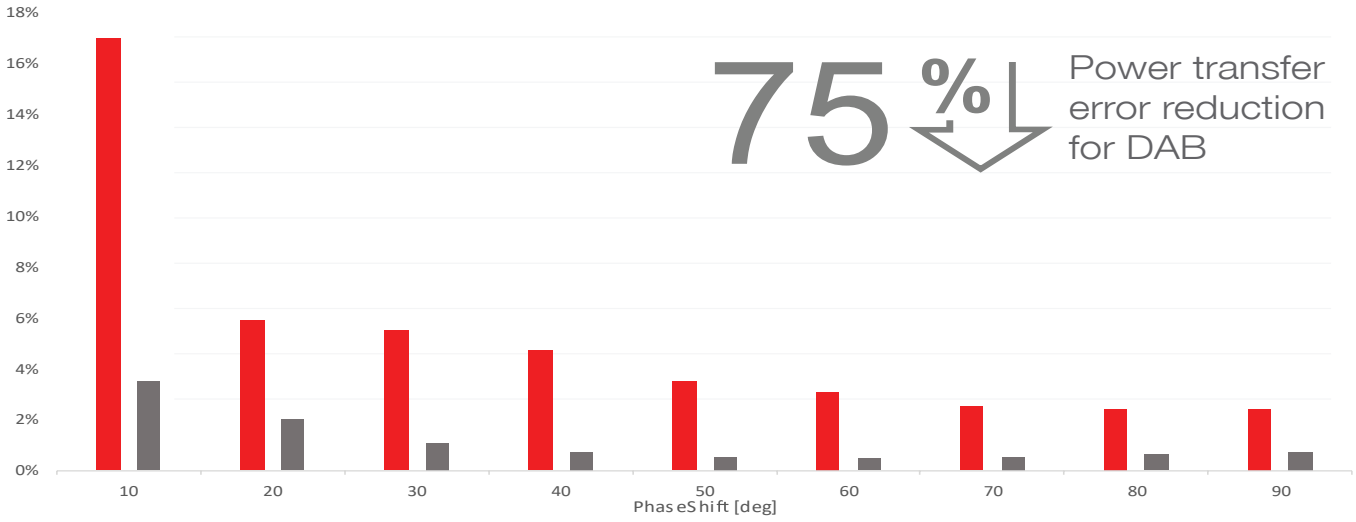
Ultra-high fidelity supercharged.

The most accurate 100kHz Dual-active bridge (DAB) model.

Probably the two most demanding power electronics applications for HIL testing are in the Electric Vehicle (EV) domain, namely: high performance motor drive, and battery chargers. Such applications pose a significant challenge for real time simulation fidelity. This is especially true for high switching frequency DC-DC converter applications (e.g. Dual Active Bridge (DAB)) where power transfer is carried out at high frequencies. For some practical applications of this type, even when the time resolution enhancement methods are employed, 500ns simulation step is simply not good enough leading to prohibitively high simulation errors.

HIL402, Ts= 500ns

HIL402, Ts= 250ns



The HIL404 is the fastest HIL product ever, with 200ns simulation time step and 3.5ns digital input sampling.

Our answer to the challenge is the 4th Gen HIL Device HIL404, our fastest HIL machine yet. With its ability to reach simulation time steps down to 200ns combined with input sampling resolution of 3.5ns it pushes the high-fidelity real-time simulation into a whole new dimension. To illustrate some of the benefits of HIL404, we did a comparative analysis of the relative power errors between the HIL402 and the HIL404 for a Dual Active Bridge (DAB) application.

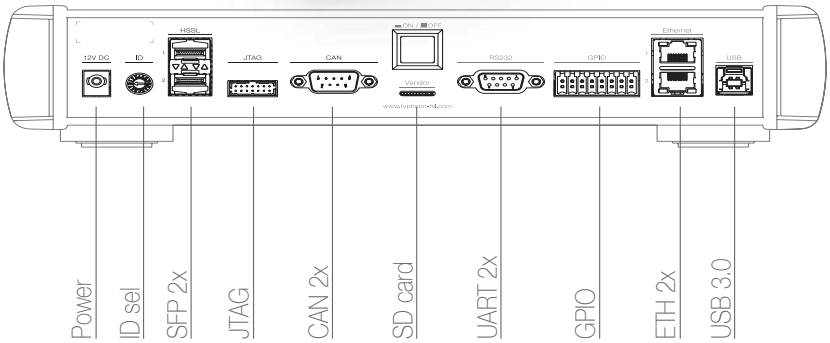
The model is controlled by an external open-loop controller switching at 100kHz and with the dead time of 50ns. Power transfer is measured and compared against the analytical model for a given phase shift. The error is mainly caused by the limited time resolution of the simulator. Here wpe can clearly see the benefits of the 2.5 times smaller simulation time step and higher frequency sampling provided by the HIL404.

The highest fidelity electric machine models. One click away.

However, HIL404 is so much more than just a faster HIL402 tuned for very-high frequency applications.It is a device that brings many advanced features to the 4-series, like 3.5 ns oversampling on all Digital Inputs, as well as functionalities of our industrial grade 6-series devices, such as:

- Nonlinear machine modeling
- Up to 16 cores FPGA processor configurations provided by paralelling capability.
- Accurate real-time converter power losses simulation; and
- Extended connectivity with out of the box support for CAN, RS232, USB 3.0, ETH protocols.

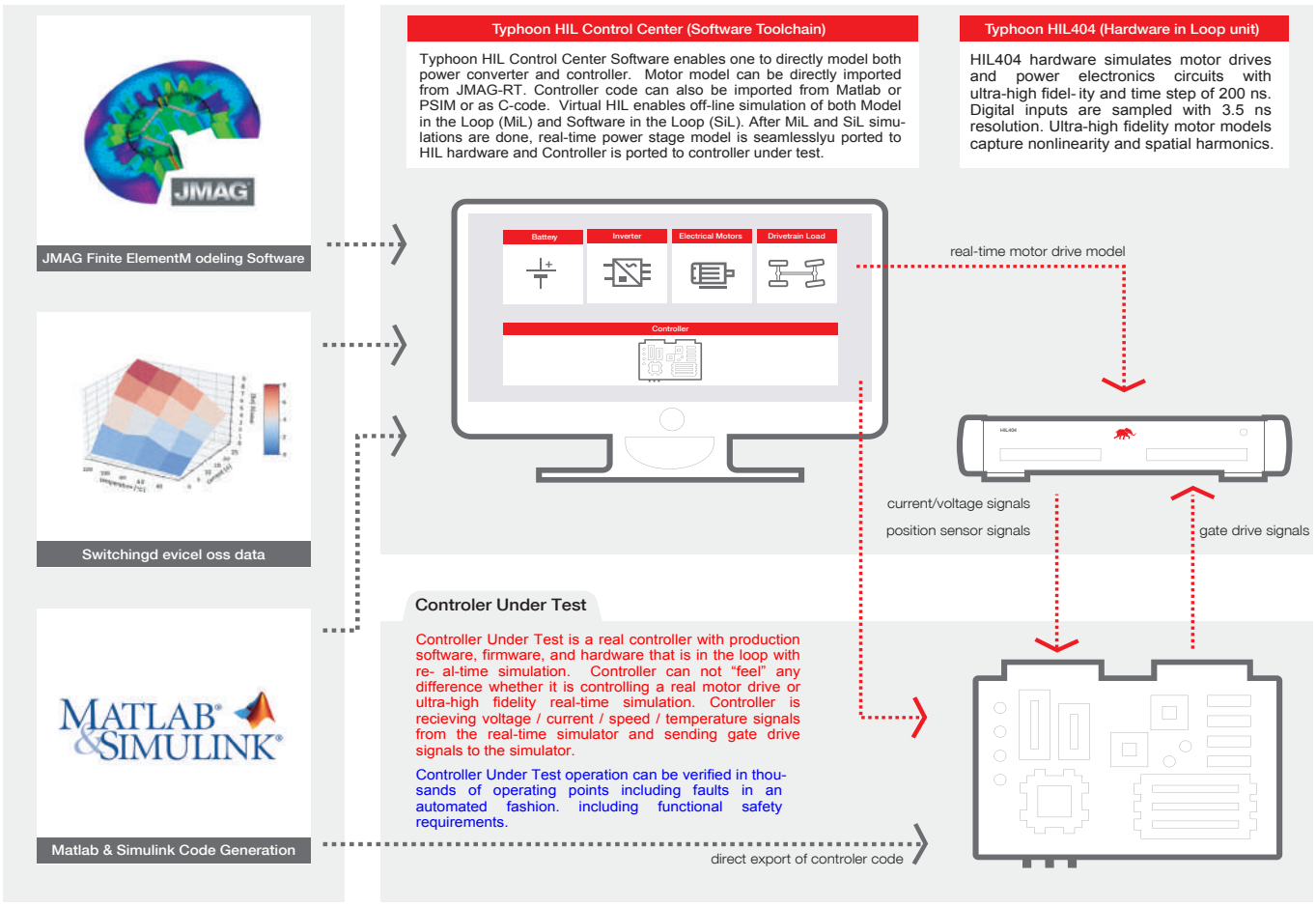
Indeed, HIL 404 supports direct import of high-fidelity JMAG-RT electric motor models directly obtained from JMAG's Finite Element models (FEM). With one click the nonlinear and spatially varying inductance FEM derived models run in real-time with unprecedented fidelity.



Seamless integration with Matlab/Simulink, JMAG, PSIM, and other model based and physics based

HIL 404 supports direct import of high-fdelity JMAG-RT electric motor models directly obtained from JMAG's Finite Element models (FEM). With one click the nonlinear and spatially varying inductance FEM derived models run in real-time with unprecedented fdelity. In addition, HIL404 supports one click import of power semiconductor switching and conduction losses directly from datasheet look-up tables. It has never been so easy to run high-fidelity and accurate thermal models in real-time.

By leveraging the ultra-high fdelity and ease of use of the existing Typhoon HIL solution, and by bringing the extra speed to the table, the HIL404 makes the HIL testing methodology truly applicable for the emerging high frequency power conversion applications.

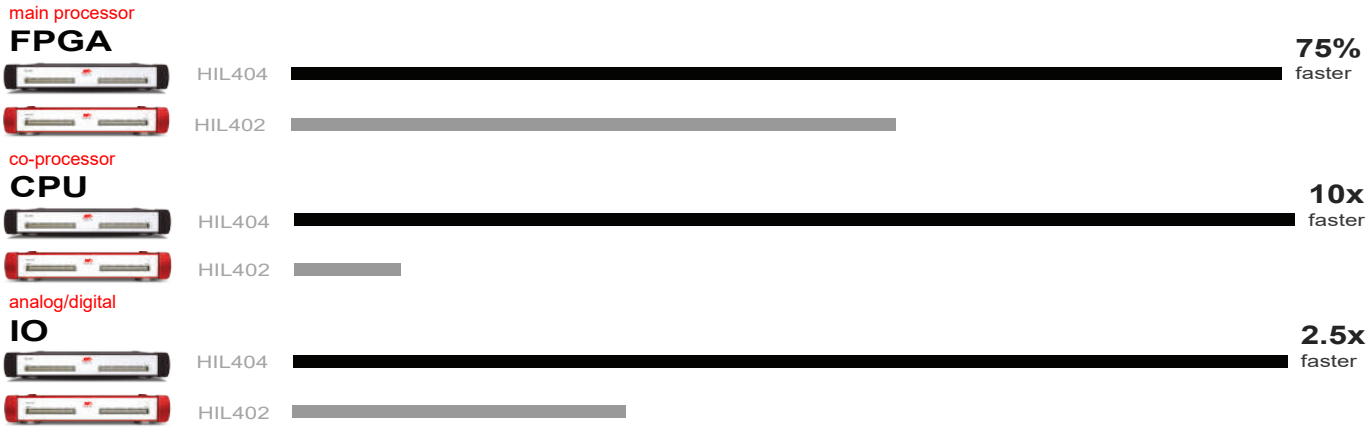


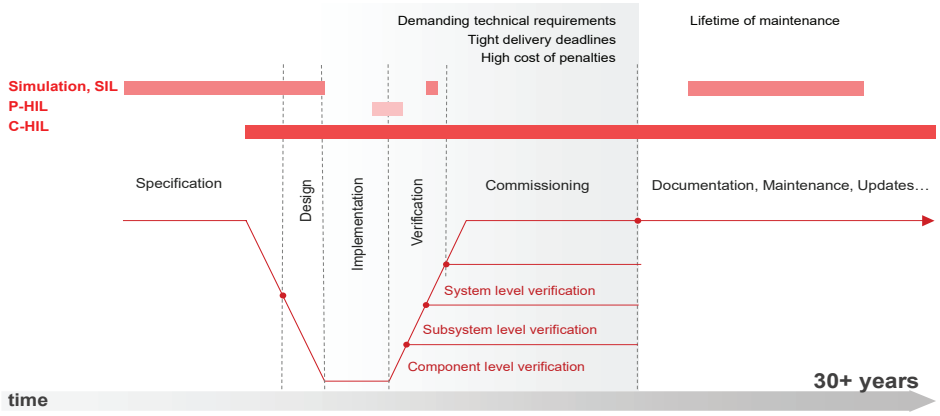
Rapid Control Prototyping Funcionality

A faster HIL means faster tests. Rapid Control Prototyping (RCP) is one of the key ways you can take profit of the high speed and fidelityof the HIL 404. Coupled with Typhoon HIL's software, RCP with the HIL 404 drastically accelerates your controller development cycle, saving you development time and cost, all while reducing investment risk.

The heart of this speed comes from the significant hardware upgrades to the HIL 404 over previous generations. With real-time datalogging, analog I/O resolution as low as 200ns, and digital I/O resolution as low as 3.5ns, you can have the confidence in the high-fidelity models you use. But don't just trust us: the diversity of connection ports in the HIL 404, plus Typhoon HIL's wide array of native communication protocol support, means you can connect your hardware connections directly to the model and perform Controller Hardware- In-the-Loop (C-HIL) tests yourself.

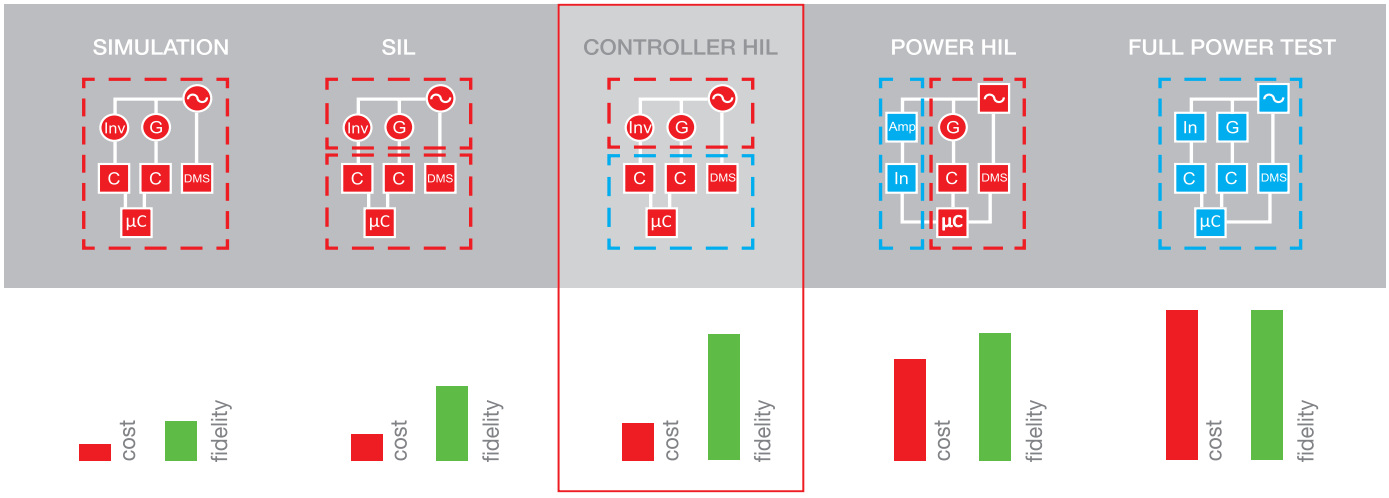
More CPU power for faster signal processing and time critical protocols.





With C-HIL in your RCP process, you can test the real unmodified controllers with its real hardware, software, and firmware. The controller under test cannot 'feel' any difference between controlling real equipment or the ultra-high fidelity, real-time simulation. It receives current/voltage signals, temperature signals, and position sensor signals from the real-time HIL simulator and sends the gate drive signals back to the real-time HIL simulator.

Typhoon HIL's software lets you use the same models from Model-in-the Loop (MIL), Software- in-the-Loop (SIL), and Controller Hardware-in- the-Loop (C-HIL) tests. This means that you can catch potential issues earlier in the development process and iterate new prototypes in your controllers before performing costly and potentially dangerous power lab tests. RCP and C-HIL testing also lets you have a greater test breadth, giving you greater confidence that new equipment will behave in the field as it does in the lab.



The comparison of testing approaches by test coverage and test fidelity.

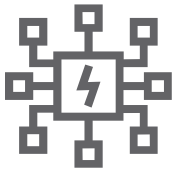
Microgrid library with 3-level fidelity components

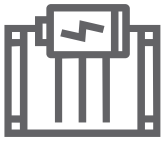
Typhoon HIL software comes with three types of built-in components designed for HIL 404 testing of specific real-world microgrid applications in its Microgrid Library:

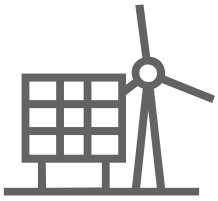
- **Switching Components**
  designed for system-level converter testing
- **Average Components**
  designed fo a realistic and hardware-efficient emulation of dynamics without the need for a PWM interface
- **Generic Components**
  designed for easy parametrization in grid stability and system integration studies)

The generic components in particular make it easy for you to build and parameterize your own microgrid model in Typhoon's software. The new built-in components include:

- Battery ESS
- PV Power Plant
- Wind Power Plant
- Diesel Genset







Generic Microgrid Components

Battery ESS

The generic battery model consists of two main sub-components: the Battery ESS component, which contains a high-level control subsystem and a low-level control subsystem with the power stage, and the Battery ESS UI component where all inputs and outputs are defined. The purpose of this component is to show characterise behaviour of a battery inverter, such as: different operation modes (e.g. PQ control, Droop, and VF control), imitations based on the nominal parameters, and fault detection.

PV Power Plant

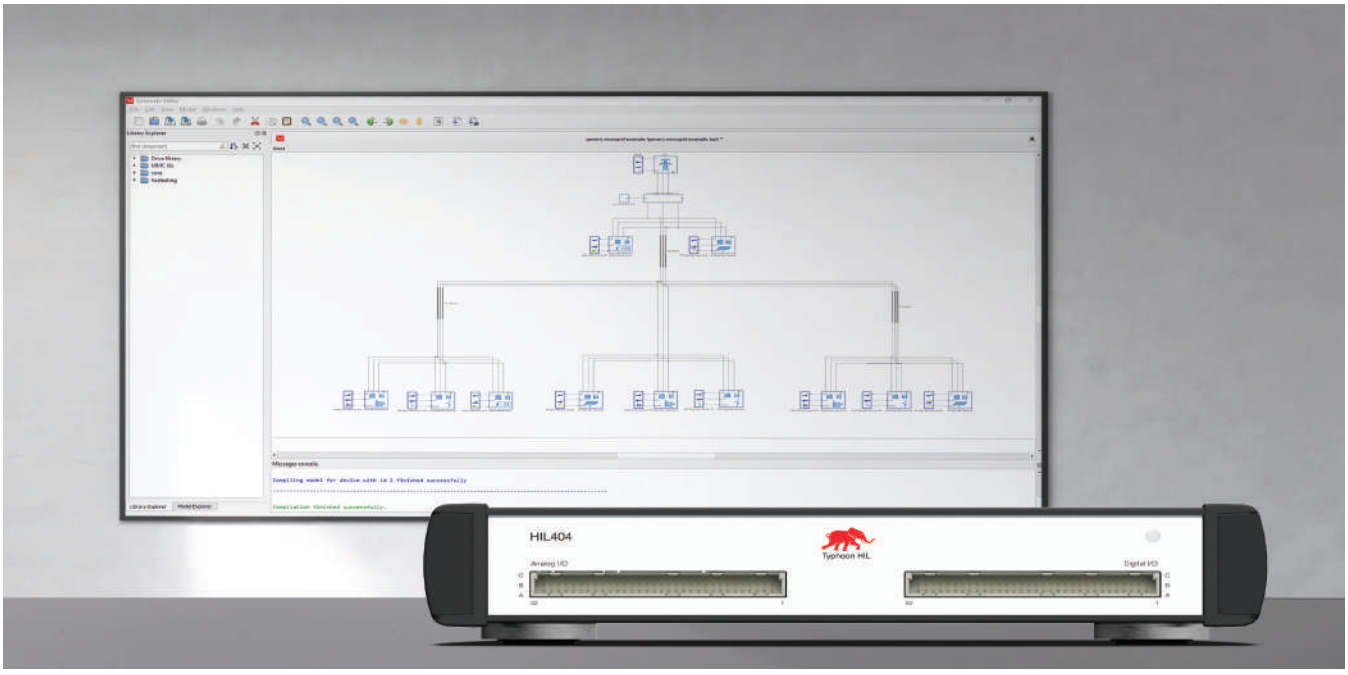
The main purpose of these components is to emulate the characteristic behaviour of the grid connected PV plant in the following scenarios: active power curtailment and reactive power control, plant state machine, faults detection and limits according to nominal values, and ramping functionalities for referent signals and MPPT.

Wind Power Plant

The component consists of two main parts: the high level control subsystem and the low - level control subsystem with the power stage and all measurements. Model inputs and outputs are clearly defined in corresponding User Interface subsystems. The turbines are easily parametrized with just a couple of nominal parameters (e.g. input voltage, nominal power).

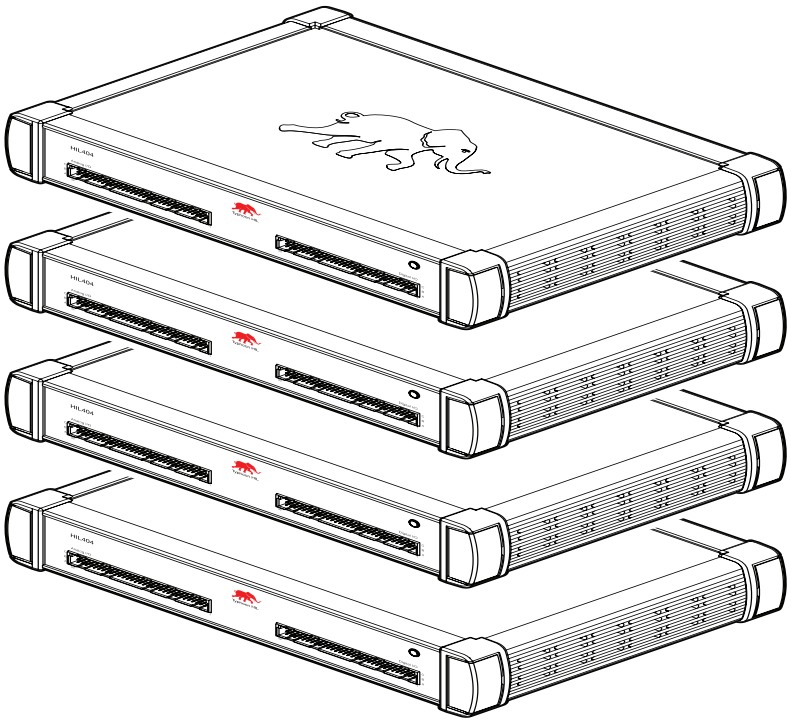
Diesel Genset

This component provides easier and more practical parametrization from a system integration point of view. Also, it includes new functionalities that are found in real- life (protection, frequency drift). Finally, it doesn't utilize the machine solver in HIL hardware resources, letting you create bigger models containing a larger number of generators (>4 per HIL device) are possible.



Device paralleling capability.Unparalleled.

Parallel HILs. Connect with amplifiers. Endulge.



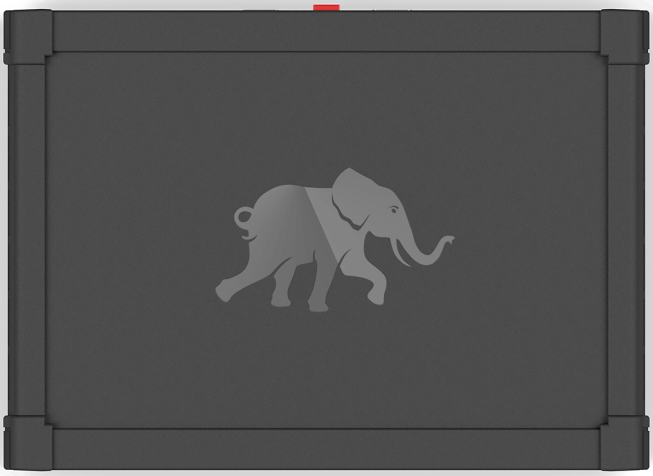
384

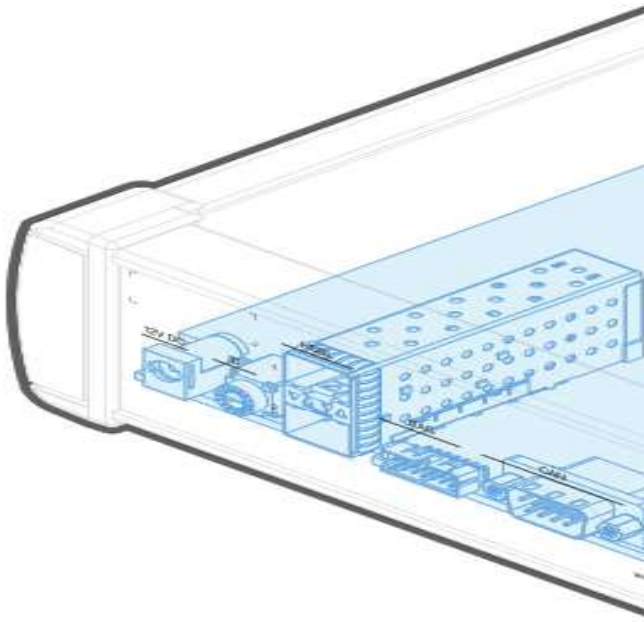
288

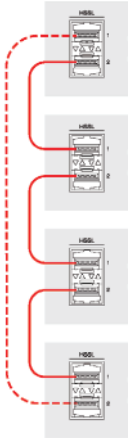
192

96

I/O







Use the high speed optical link to parallel your HIL404's while maintaining the small time step. The simulated model can grow, the simulation time step stays fixed. Whether you simulate a single motor drive or a complete microgrid, it is the same spiel.

Build a P-HIL testbed in a day. With the highest fidelity HIL on the planet and the optical link interface to any amplifier you can emulate an e-motor or a whole microgrid.

Two bidirectional SFP ports:

- Both can be used for paralleling
- One of the ports is multi-purpose and can be used for high-speed communication with other devices in the future

4th Generation HIL.




	HIL402	HIL404	HIL602+	HIL604
Generation	3rd	4th	3rd	3rd
Simulation capacity				
Detailed (switching) DER models (1ph / 3ph)	8 / 4	8 / 4	12/6	16/8
Average DER models with detailed control loops (3ph)	20	30	30	40
Distribution network simulation	✓	✓	✓	✓
Time resolution				
Minimal simulation step	500 ns	**200 ns**	500 ns	500 ns
DI sampling resolution	6.2 ns	**3.5 ns**	6.2 ns	6.2 ns
IO				
Analog I/O	16/16, +/- 10V, 16bit	16/16, +/- 10V, 16bit	16/32, +/- 10V, 16bit	32/64, +/- 10V, 16bit
Digital I/O	32/32	32/32	32/32	64/64
Connectivity				
USB	✓	✓	✓	✓
Ethernet	✓	✓	✓	✓
CAN		✓	✓	✓
RS232		✓	✓	✓
Time synchronization (PPS and IRIG-B)				✓
Paralleling		up to 4 units	up to 4 units	up to 16 units

CAN CANopen Modbus IEC 61850 SUNSPEC ALLIANCE DNP3 OPC UA

The ultra-high fidelity redefined.

Typhoon HIL

TYPHOON HIL REAL TIME EMULATOR
Model : HIL404

TECHNICAL SPECIFICATIONS

A. REAL TIME EMULATORS (HARDWARE)

1. **Processors :**
   - Main Processor : 4-Core FPGA for enabling short compilation time and low latency for small time-step, simulation.
   - Co-processors: 2x ARM, for simulation in signal domain.
2. **System Capability :**
   - Controller HIL and real-time simulation of maximum 4 switching converter models (3ph, 3 levels) with simulation time-step down to 200ns.
   - Controller HIL and real-time simulation of maximum 20 averaged converter models (3ph) with simulation time-step down to 200ns.
   - Real-time simulation of 80+ (3-phase) nodes/busses with full complexity at starting from 3µs to 1s simulation time-step.
   - Real time simulation of power electronic converters with switching frequency of up to 200 KHz.
3. **Option for External Interface *: In-built I/O***
   - 16 Analog outputs fully selectable with ± 10V range, 1 MSPS update rate, 16-bit resolution and 1% accuracy, ± 24V Tolerant ESD protection.
   - 16 Analog inputs fully selectable with ± 10V range, 1 MSPS update rate, 16 bit resolution, 1% accuracy, ± 24V Tolerant ESD protection.
   - 32 Digital outputs with at least 12 channels capable for PWM modulation with 7ns resolution, ± 24V Tolerant ESD protection.
   - 32 Digital inputs, 50MHz sample rate with 20ns sampling resolution on all channels, ± 24V Tolerant ESD protection.
4. **Academic Package Added Capabilities :**
   - The simulator supports multiple configurations without making any physical changes into hardware.
   - Free Firmware update is made available for all supported configurations by Simulator during support.
   - Connectivity: Ports for communication over standard communication protocols, including USB, Ethernet/IP, CAN, Modbus, RS232, GPIO, HSSL, JTAG.
   - Input Power supply is 230 Volts, 50Hz.

B. Simulation Software with Real Time Interface :

Simulator is not dependent on any third-party simulation Software. It has own simulation software with below mentioned specifications:

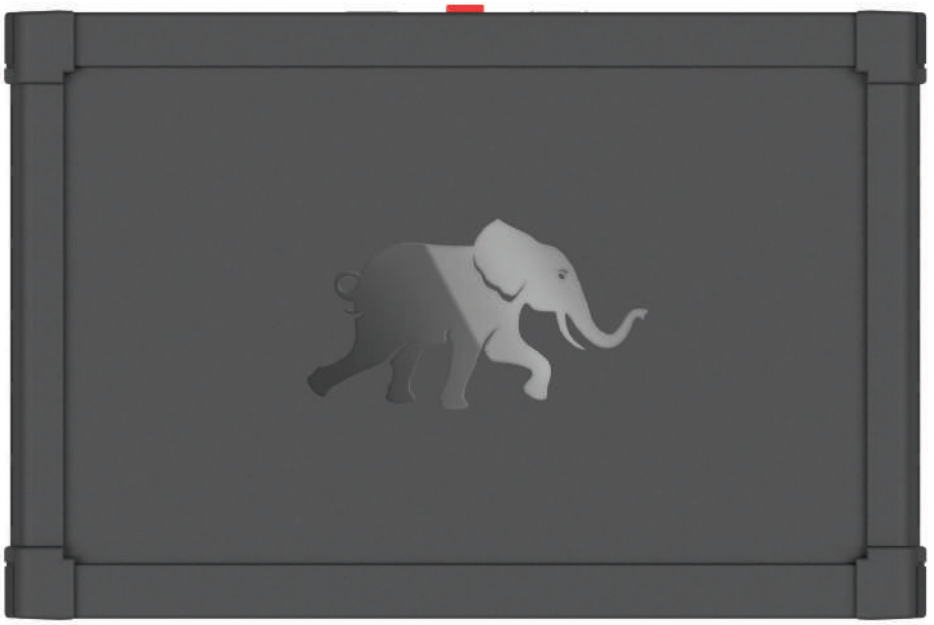
- Permanent software license for modelling as well as for Real-time Interface with free firmware updates and an unlimited number of software users.
- Academic premium toolbox package with Graphical User Interface (GUI/SCADA).
- Modeling environment for plant as well as Signal Processing with embedded library of components and toolboxes like, ***i) Converter toolbox, ii) Microgrid toolbox, iii) Power System toolbox, iv) Signal processing toolbox, v) Test Suite and vi) Communication toolbox having IEC61850, UL 1741, CAN Bus protocol, Ethernet, DNP3, MOD Bus protocol etc.***
- All the switching components in library have Internal (for simulation and real-time simulation) or external (HIL simulation) both control option during modeling.
- Ability to run Plant simulation without controller if required for feasibility testing of plant.
- High resolution built-in real time signal monitoring oscilloscope with 16 channels.
- Dedicated solvers for switching devices, machines, signal generators, LUTs, etc. are available with simulation software.
- Simulation of numerical signals with multiple execution rates
- Test environment for testing models and generating Test-Reports.
- Scripting Environment based on python. In-built API for automation as well as for communicating with other simulation software.
- Option for importing code generated for controller from simulation software like MATLAB, Simulink, LabView, PSIM etc.
- Option for importing .dll files generated from PSCAD, EMTP, PSSE-DigSilent etc.

C. The laboratory resources listed above is suitable for the following applications:

1. Grid connected converter applications.
2. Power System and its applications
3. Renewable energy applications.
4. Microgrid and Smart Grid applications.
5. Parallel and Multilevel converter topologies.
6. Electrical and industrial drives applications.
7. Electric Vehicle Application
8. Pre-certification of smart inverter controllers.

Specifications are subject to change without notice

Typhoon HIL



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