Typhoon HIL

4^{th} Generation HIL.

HIL404.

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

www.typhoon-hil.com

4^{th} 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 delivers the unprecedented model fidelity needed for the most advanced motor drives and automotive power electronics applications.

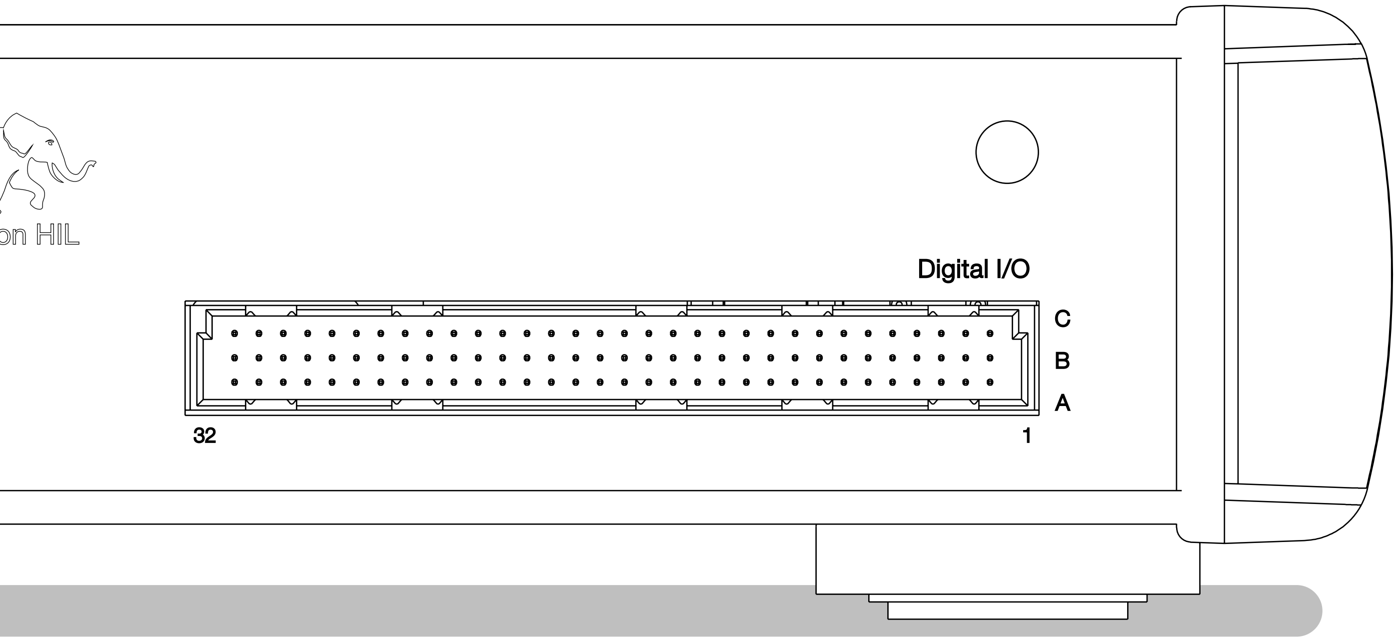
Easy to use software tool-chain

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), CAN and RS232.

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.



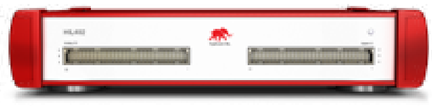
Typhoon HIL404.

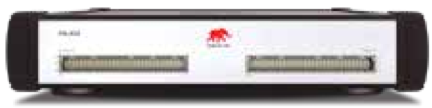
From HIL to Rapid Control Prototyping. The most versatile platform.

Ultra-high fidelity supercharged.

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

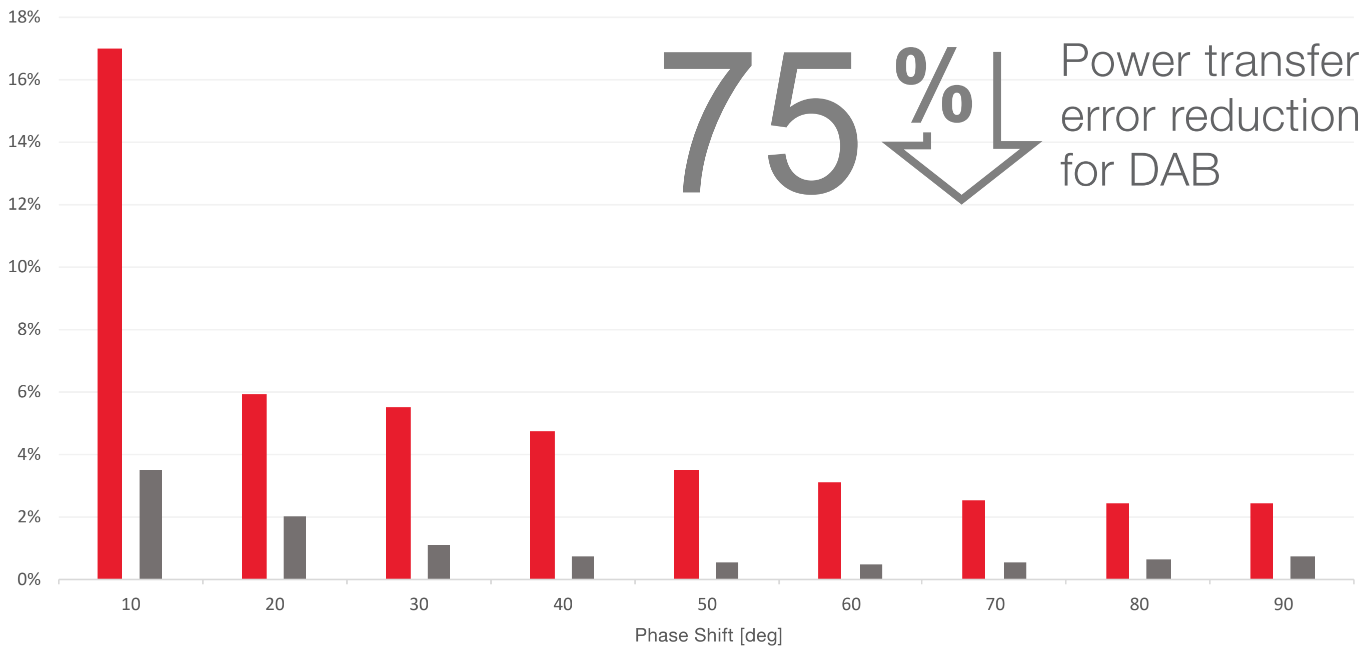
Probably the two most demanding power electronics applications for HIL testing are in the Electric Vehicle (EV) domain, namely: high performance motor drive, and battery chargers. Such applications pose a significant challenge for real time simulation fidelity. This is especially true for high switching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





HIL402, Ts= 500ns

HIL404, 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 we can clearly see the benefits of the 2.5 times smaller simulation time step and higher frequency sampling provided by the HIL404.

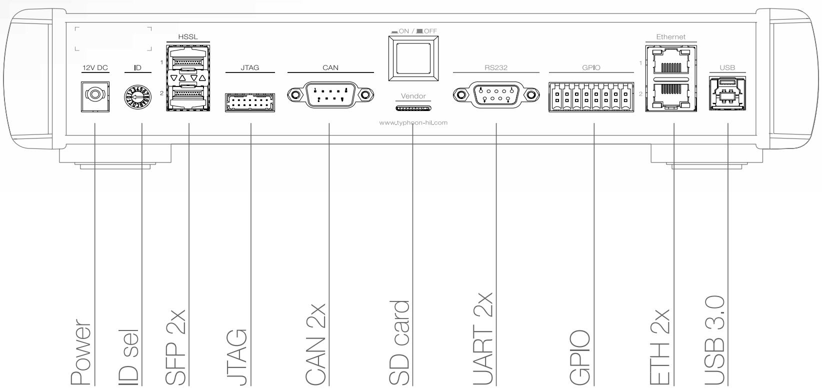
The highest fidelity electric machine models. One click away.

However, HIL404 is so much more than just a faster HIL402 tuned for very-high frequency applications.

It is a device from the same family of Typhoon HIL products, yet packed to the brim with latest technology that brings many advanced features of our industrial grade 6-series devices to the 4-series, such as:

- Nonlinear machine modeling.
- 3.5 ns GDS oversampling on all Digital Inputs.
- Up to 4 cores FPGA processor configurations.
- Accurate real-time converter power losses simulation.
- Extended connectivity with out-of-the-box support for CAN, RS232, USB 3.0, ETH protocols, including device paralleling support.

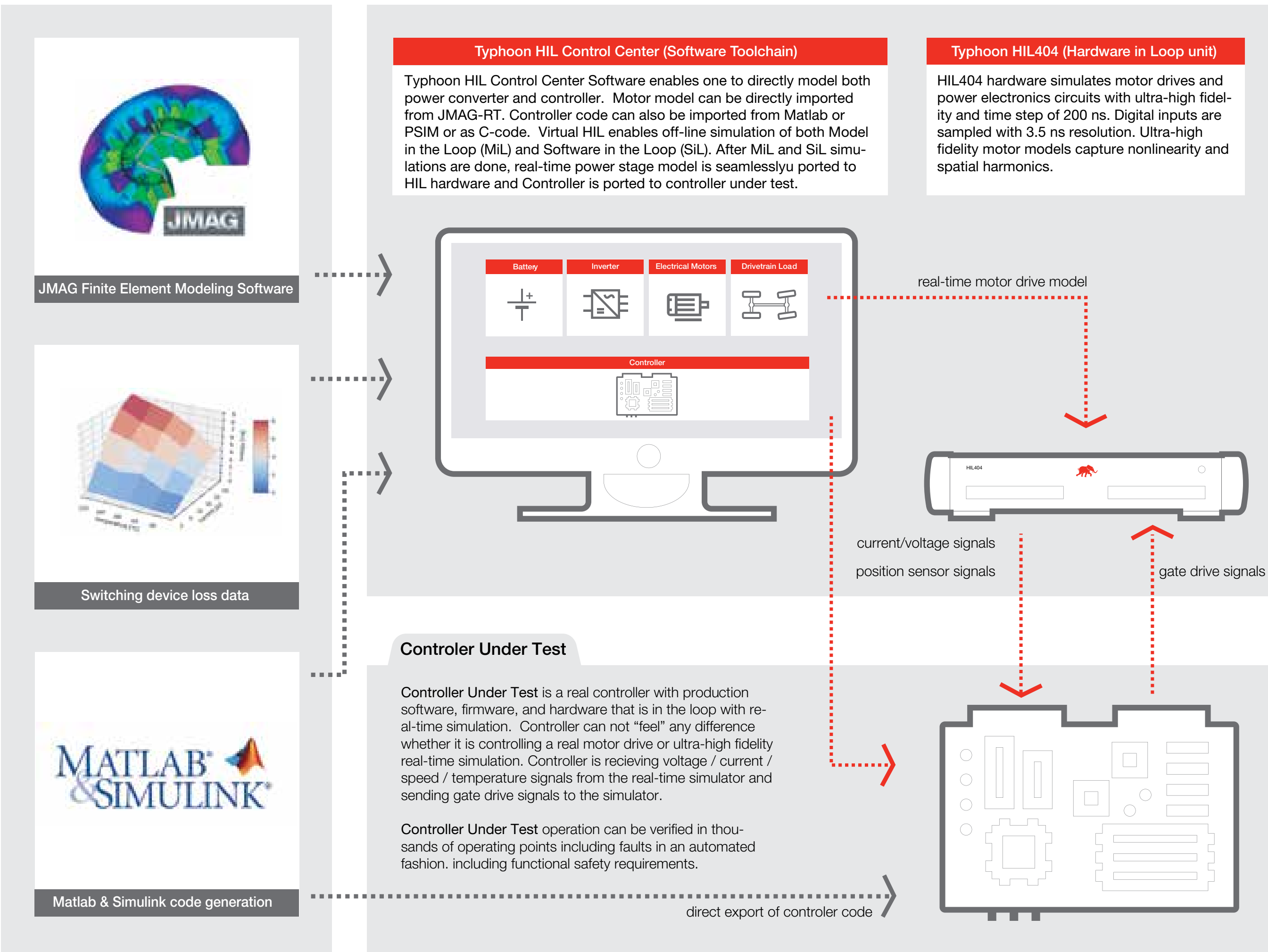
HIL404 has many connection possibilities.



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

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. 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 fidelity 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.

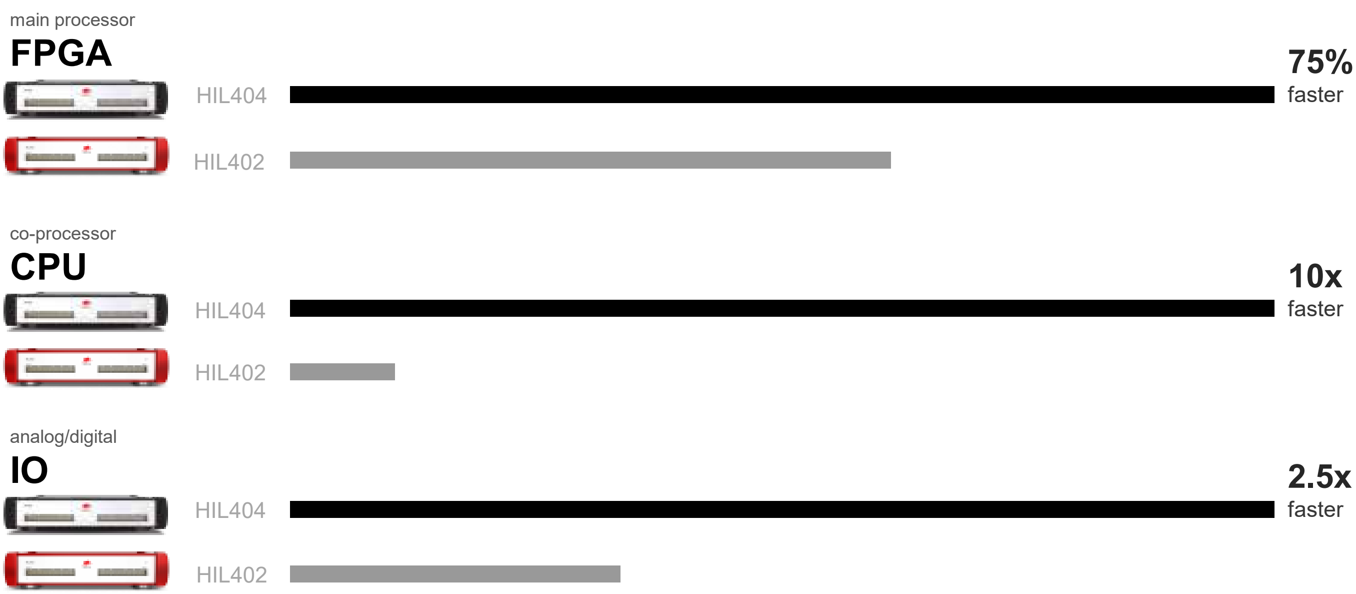


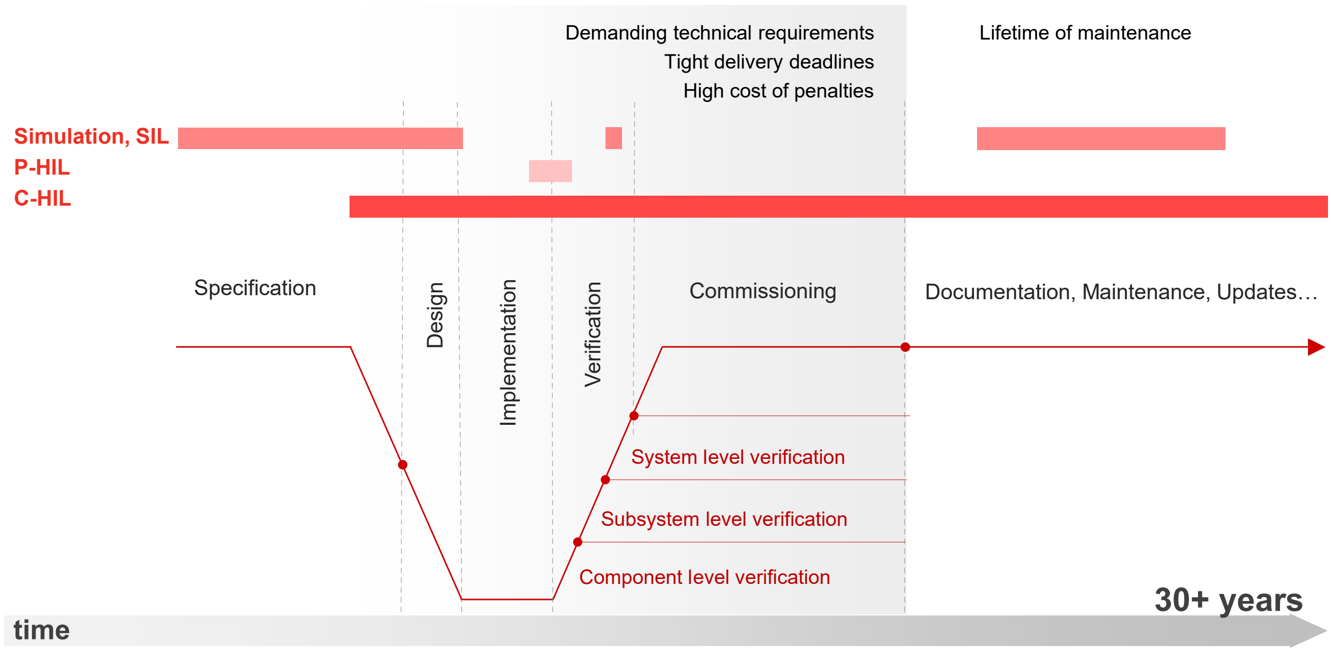
Rapid Control Prototyping Funcionality

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 fidelity of 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 source 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.

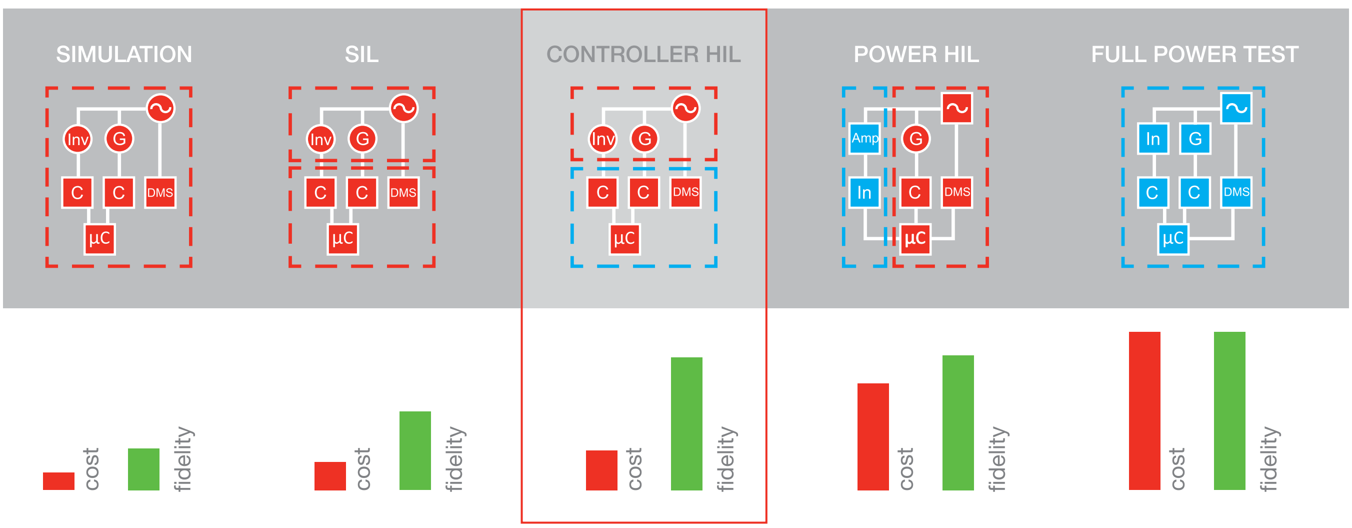




With C-HIL in your RCP process, you can test the real unmodified controllers with its real hardware, software, and firmware. The controller under test cannot 'feel' any difference between controlling real equipment or the ultra-high fidelity, real-time simulation. It receives current/voltage signals,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

Controller HIL maximizes fidelity while minimizing cost.



Microgrid library with 3-level fidelity components

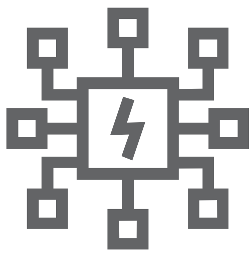
Typhoon HIL software comes with three types of built-in components designed for HIL 404 testing of specific real-world microgrid applications in its Microgrid Library:

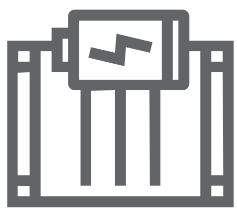
- **Switching Components** (designed for system-level converter testing)
- **Average Components** (designed for a realistic and hardware-efficient emulation of dynamics without the need for a PWM interface)
- **Generic Components** (designed for easy parametrization in grid stability and system integration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

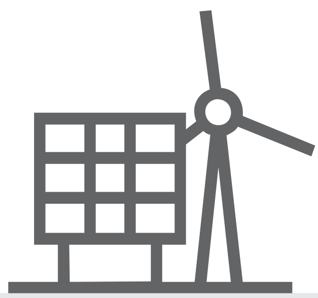
The generic components in particular make it easy for you to build and parameterize your own microgrid model in Typhoon's software. The new built-in components include:

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

Microgrid deployment is rapidly increasing, and this means it is necessary to have an efficient means to test them.







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 typical behavior of a battery inverter**, such as: different operation modes (e.g. **PQ control, Droop,** and **VF control**), **limitations based on the nominal parameters**, and **fault detection.**

PV Power Plant

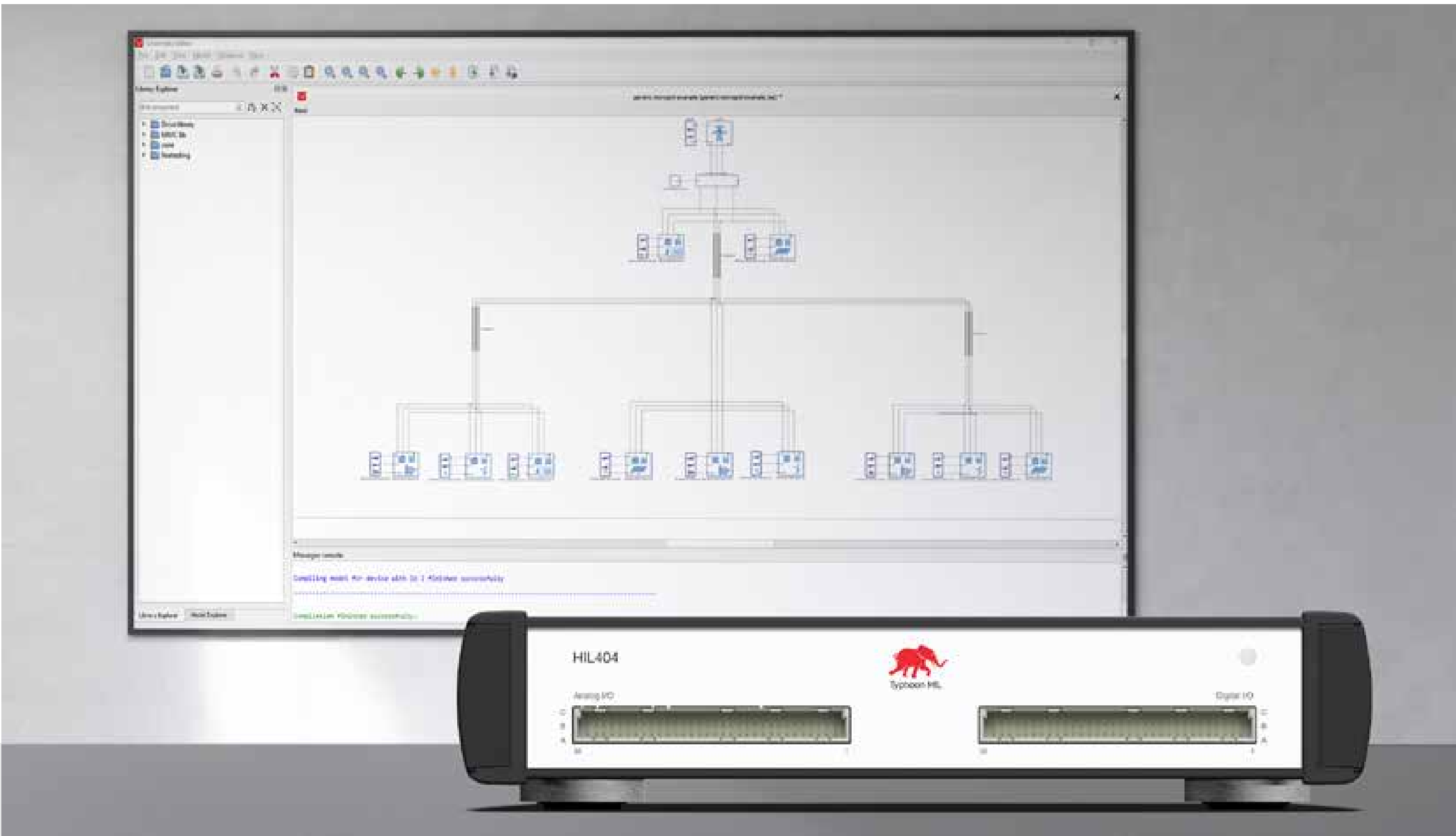
The main purpose of these components is to **emulate the characteristic behavior of a grid connected PV plant** in the following scenarios: active power curtailment and reactive power control, plant state machine, **fault detection and limits** according to nominal values, and **ramping functionalities for reference 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**).

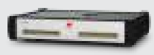
Diesel Genset

This component lets you **easily and practically parameterize a diesel genset** for system integration studies. 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).



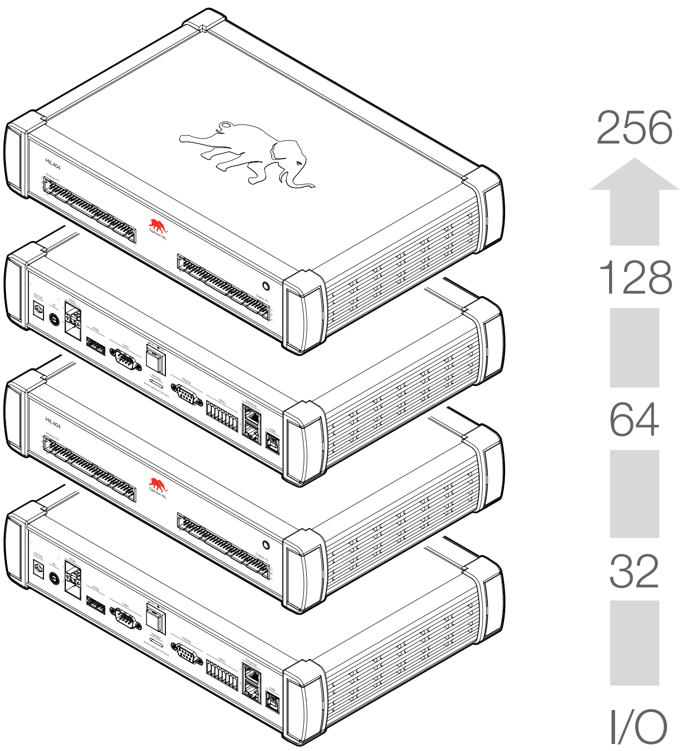
Device paralelling capability. Unparalleled.

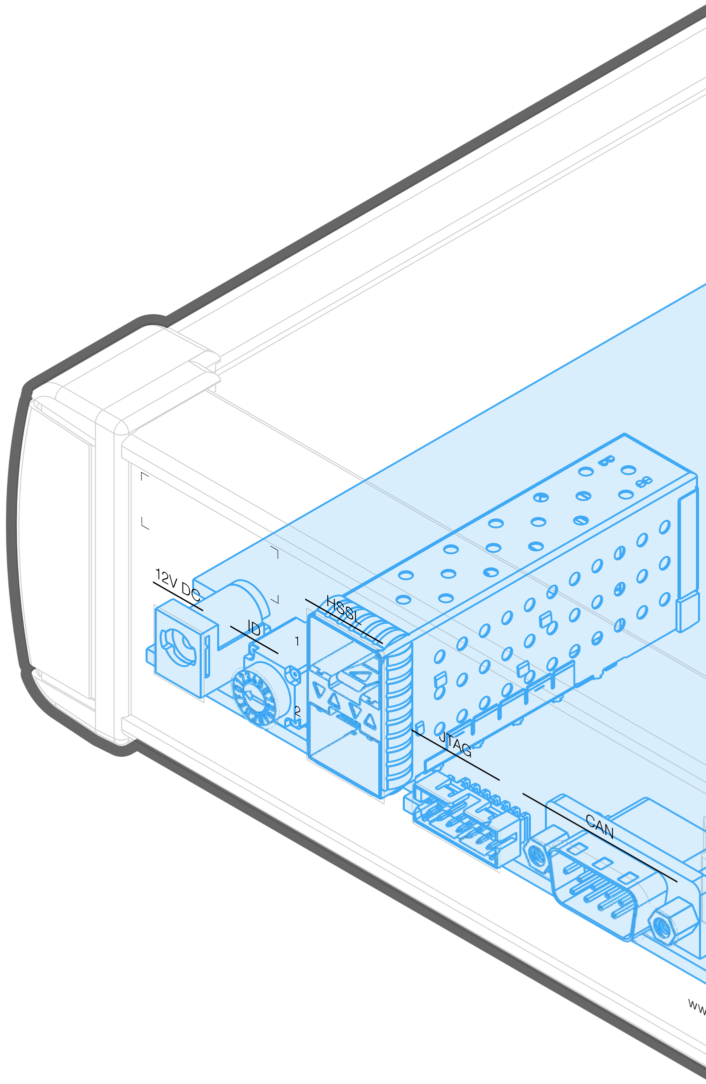
Next Generation HIL comparison.

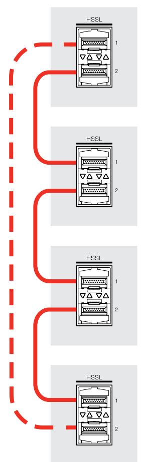
	 HIL101	 HIL404	 HIL506	 HIL606
Model capacity				
Detailed (switching) converter models (1ph / 3ph)	4 / 2	8 / 4	12 / 6	16 / 8
Average converter models (3ph)	8	12	18	24
Machine Solvers upported (max.)	1	2+	4	4
Distribution network simulation	✓	✓	✓	✓
Time resolution				
Minimal simulation step	250 ns	200 ns	200 ns	200 ns
DI sampling resolution	4.5 ns	3.5 ns	3.5 ns	3.5 ns
IO				
Analog I/O per unit	16 / 16	16 / 16	16 / 32	32 / 64
Digital I/O per unit	32 / 32	32 / 32	32 / 32	64 / 64
Connectivity				
Ethernet, USB 3.0, CAN, RS232, GPIO, HSSL	✓	✓	✓	✓
JTAG	✓	✓	✓	✓
Time synchronization (PPS and IRIG-B)			✓	✓
EtherCAT (master and slave)			✓	✓
CAN FD			✓	✓
SFP, QSFP			✓	✓
Paralleling	up to 4 units (HIL101)	up to 4 units (HIL404)	up to 16 units (HIL506 and HIL606)	up to 16 units (HIL506 and HIL606)

CAN CANopen Modbus IEC 61850 SUNSPEC ALLIANCE DNP3 OPC UA

Parallel your HILs.
Connect with amplifiers.
Endulge.







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

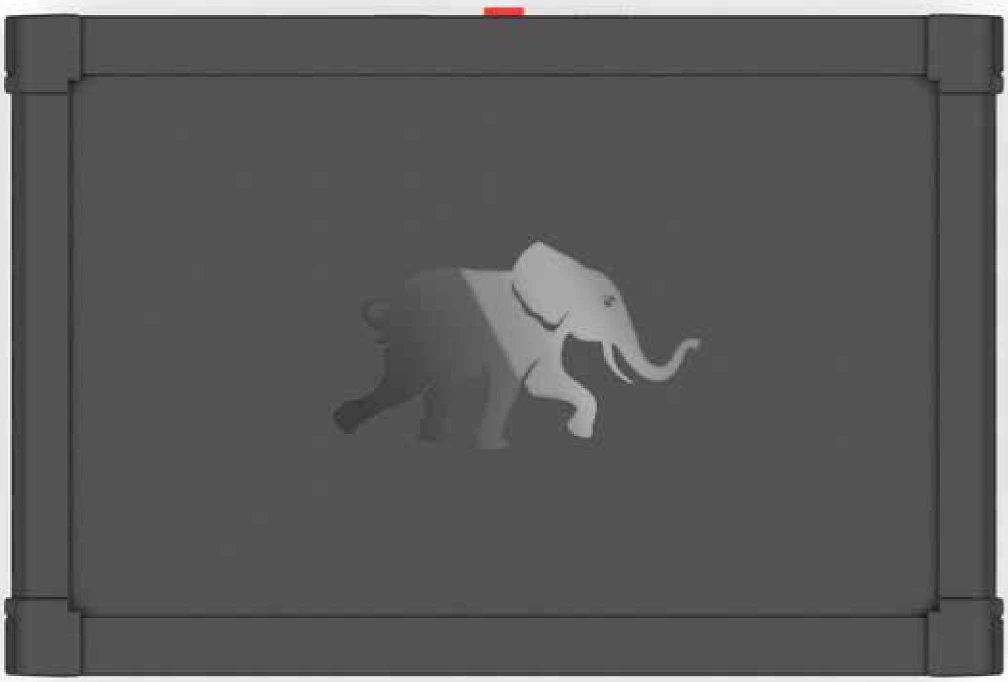
The ultra-high fidelity redefined.

HIL404
technical details.

Processor	Processor	ZU4EG Ultrascale+ Zync SoC
	Processor configurations	up to 4 processing cores;
Analog inputs (AI)	Channels	16 channels
	Resolution	16 bit ADC
	Input voltage range	±10 V
	Sample rate	up to 1 MSPS
	Linearity (DNL/INL)	1/2
	Gain error / offset error	0.01% / 1 mV
	Input resistance	25.5 kΩ
	Protection	±24V tolerant, ESD protection
Analog Outputs (AO)	Channels	16 channels
	Resolution	16 bit ADC
	Output voltage range	±10 V
	Sample rate	up to 5 MSPS
	Linearity (DNL/INL)	1/1
	Gain error; offset error	0.01%; 1 mV
	Output resistance	0 Ω
	Current capacity	4 mA
	Protection	±24 V tolerant, ESD protection
Analog IO connector	Connector	DIN 41612, type C 96 pin male connector

User Power Supply Unit (PSU)	±5 V analog	up to 1 A, resettable protection
	±12 V analog	up to 0.5 A, resettable protection
	+3.3 V digital	up to 1 A, resettable protection
	+5 V digital	up to 1 A, resettable protection
Digital inputs (DI)	Channels	32 channels
	Input voltage range Vi	-15 V < V_i < 15 V
	Output levels (low, high)	(V_{IL}(max) = 0.8 V; V_{IH}(min) 2 V)
	Input resistance	10 kΩ
	Protection	±24 V tolerant, ESD protection
	DI Sampling resolution	3.5 ns
Digital outputs (DO)	Channels	32 channels
	Output voltage range Vo	5 V
	Threshold voltages (low, high)	(V_{OL}(max) = 0.2 V; V_{OH}(min) 4.8 V)
	Output resistance	430 Ω
	Protection	±24 V tolerant, ESD protection
Digital IO connector	Connector type	DIN 41612, type C 96 pin male connector
Connectivity	Ethernet	2 x RJ45 connectors; 10/100/1000 Mbps
	USB2.0	1 x type B connector; 2.0 high speed
	CAN	2 x DB9 male
	RS232	2 x DB9 female
	High speed serial link	2 x SFP ≥ 5 GHz
	JTAG	Molex 87833-1420
	GPIO	12+ multi-purpose IO pins, terminal blocks
Housing	Dimensions	293 mm x 64 mm x 198 mm
	Weight	~5 kg
Power supply	Input voltage	100 - 250 VAC
	Output voltage	12 V
	Power	≥60 W

Typhoon HIL



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