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Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
ROME TECHNOPOLE INNOVATION ECOSYSTEM

Seminario Online
25 Giugno 2024 ore 10:30

Introduzione al Digital Twin: Obiettivi e soluzioni

Digital Twin commerciali: settore energetico

Nome: Silvia Bardi
Azienda: Typhoon HIL GmbH
Email: silvia.bardi@typhoon-hil.com

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Who we are

- Spun off from MIT and ABB, funded by Ray Stata (Analog Devices), forged by power electronics industry.
- Laser focused on ultra-high fidelity **Hardware-in-the-Loop** (HIL) software testing for power electronics
  - Pure play Controller Hardware-in-the-Loop (**C-HIL**) solutions provider
  - Down to **25ns** (DC-DC) simulation time step (typically 250ns), **3.5ns** digital oversampling
  - Vertically integrated technology stack; best technical support in industry
  - Providing hardware, software, and engineering services
- Serving Power Electronics HIL customers for **10+ years**.
- **700+** drives, EV, and power electronics customers since **2009**
- **120+** employees across **7** offices

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Our Company

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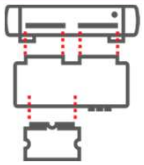
Unique Value Proposition

Typhoon HIL ecosystem. Vertically integrated.

- Complete integrated solution:
  - HIL simulator hardware, interfaces, software tools and services.
  - No 3rd party tools required.
- Highest digital power simulation fidelity on the market.
- Unprecedented ease of use.
- Short bring up time.
- Experienced support and engineering teams.
- Infrastructure for easy sharing of models
- Interfaces with major design toolchain and test frameworks.

Our Difference

SERVICES



Interfacing

Modeling

Test automation

SOFTWARE

Schematic Editor

HIL SCADA

TyphoonTest IDE

HARDWARE

HIL Simulators

Interfaces/signal processing

Emulators and signal amplifiers

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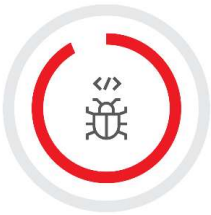
Typhoon HIL Testing Benefits

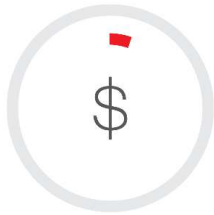


There are **11% less** software defects reported per year.

You can achieve the same results in **half the time**.

The required manpower for a job is **reduced five times.**

Risk to personnel and equipment is reduced to **nearly zero** and full safety guaranteed.



Testing cost per operating point is over **1000 times lower.**

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Testing in **PowerLab**

Testing with **HIL use**

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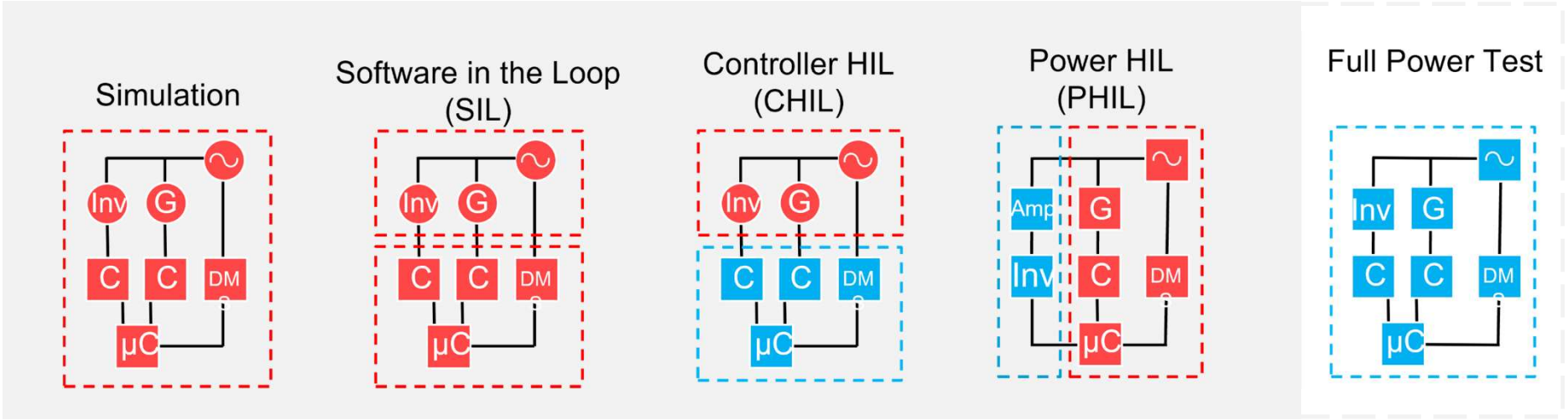
Model Based System Engineering

Definition according to International Council on Systems Engineering (INCOSE)

"Model-based systems engineering (MBSE) is the formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases.



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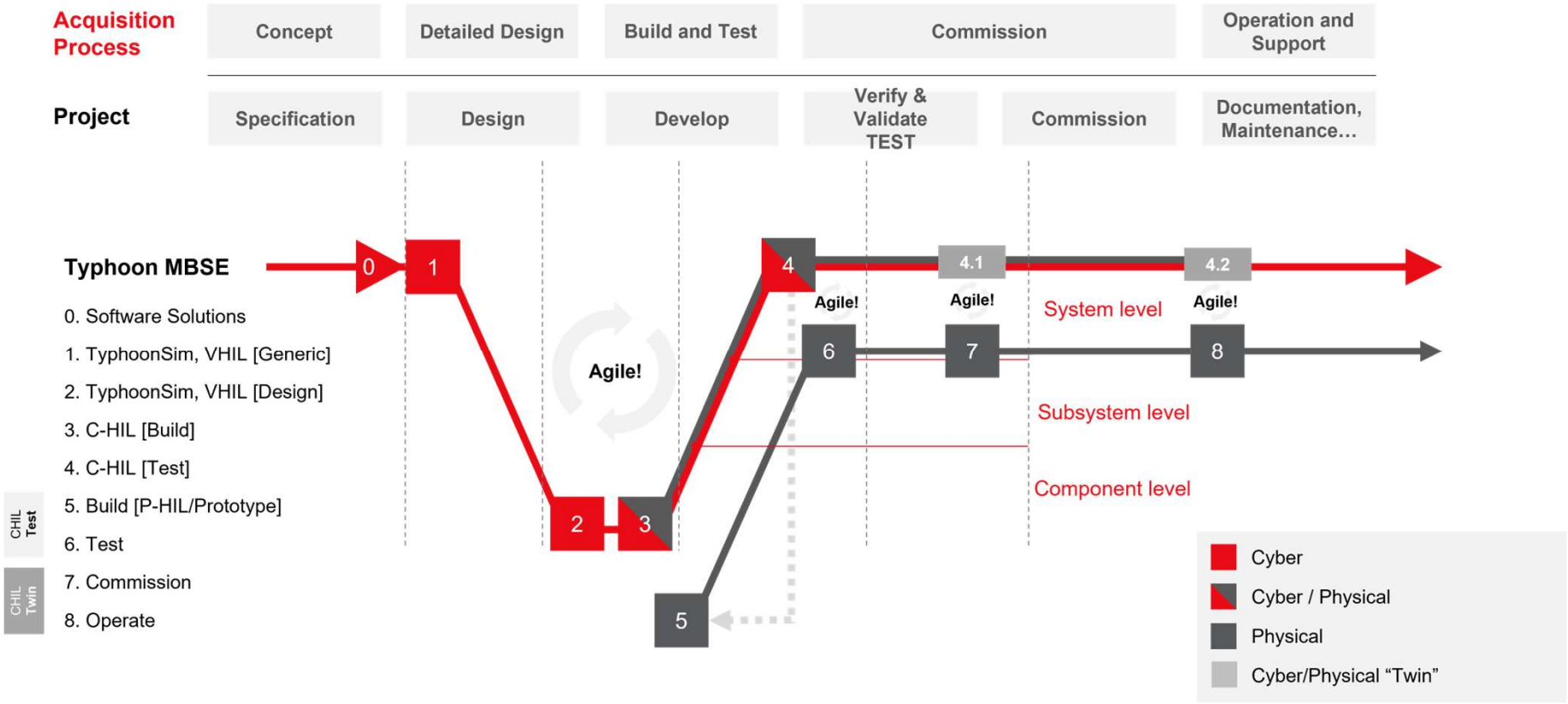
System Development Lifecycle ["V-Curve]



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Modeling Principles

Challenges of real-time and how to solve them

Piecewise linear approach

- Each switch states permutation is called a **mode** of the circuit
- For each circuit mode our model is LTI (switched LTI)
- Each circuit mode is discretized and represented by a state space matrix
- In order to reduce simulation runtime load, all state space matrices are pre-calculated and stored in the solver memory
- Number of modes (state space matrices) per circuit is $\mathbf{2^n}$ where **n** is the number of switch elements

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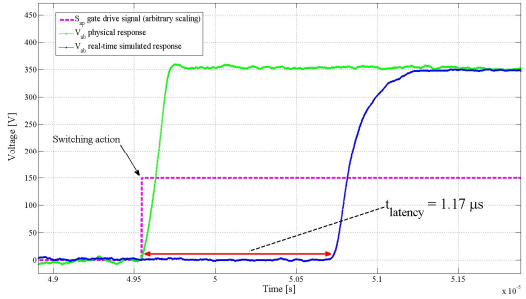
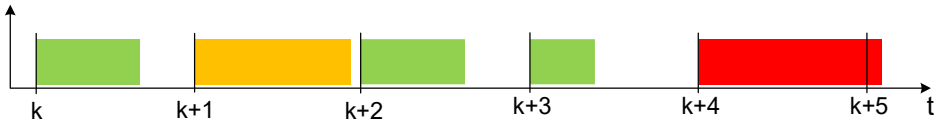
Modeling Principles

Problem definition: Real time constraints



- Discrete time with fixed simulation step
  - No time for iterations
- Strictly limited computation time for each simulation step
  - All the computations in every simulation step must be finished before the next simulation step starts to avoid overruns.



- Short response time required in PE HIL applications, comparable to the real power plant response time
  - Loopback latency

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Modeling Principles

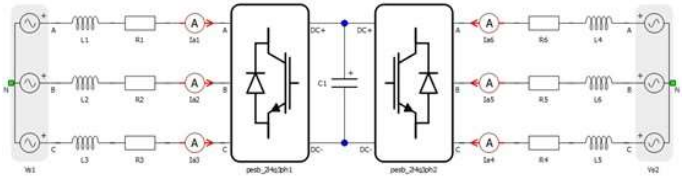
Real time simulation of power electronics and microgrid plants

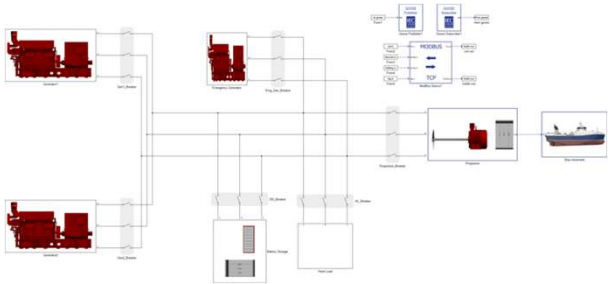
Power Electronics

- Large number of high frequency switching devices
- Highly nonlinear
- Fast dynamics

Microgrids

- Medium to fast dynamics due to converter-based generators
- Elements of primary and secondary control
- Interfaced with external controllers using communication protocols





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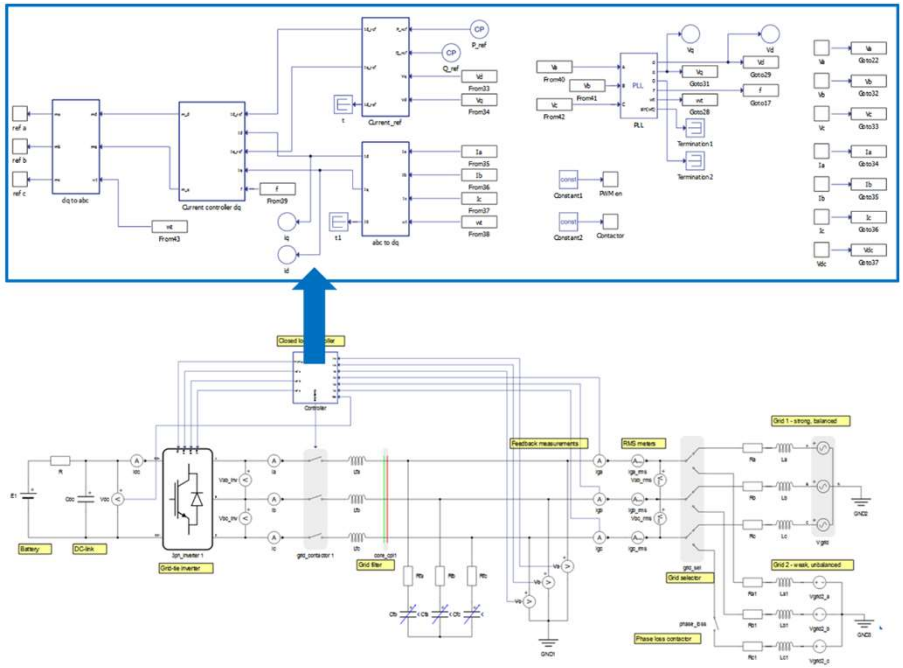
Modeling Principles

Signal processing components

- Typically used to simulate control or slow dynamics physical models
- Running on User CPU
- Multiple simulation rates supported
- Typically, slower than the electrical (FPGA solver) rate
- Implemented in C code
- User defined C functions
- Can interact with electrical domain components

User CPU



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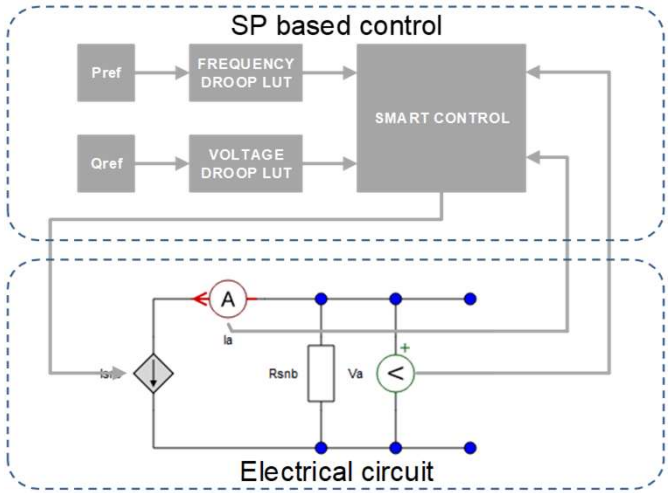
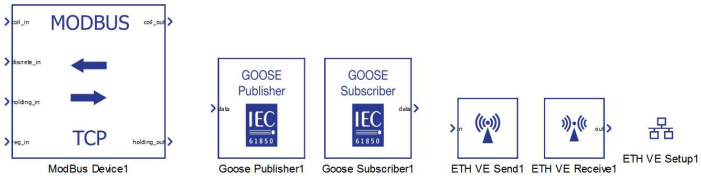
Modeling Principles

Hybrid and communications components

- Composed of both
  - electrical circuitry and
  - signal processing components
- Hybrid components
- Communication components
- Connecting internal signal processing components with external devices

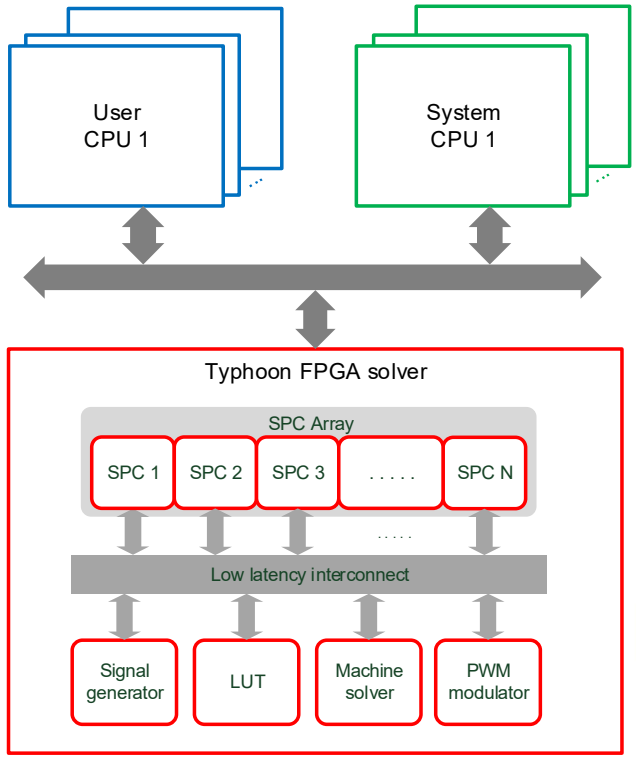




Model mapping

System architecture

- **Typhoon FPGA solver** – a specialized, proprietary FPGA-based multi-core processor optimized for time-exact simulation of electrical domain models.
- **System CPU** – one or more general purpose processors that are indirectly controlled by the user. Typically used to assist FPGA solver with certain low dynamics electrical domain components.
- **User CPU** – one or more general purpose processors that are under direct user control. They execute sub-models composed of signal processing components. Typically used to simulate controls or low dynamics physical models.



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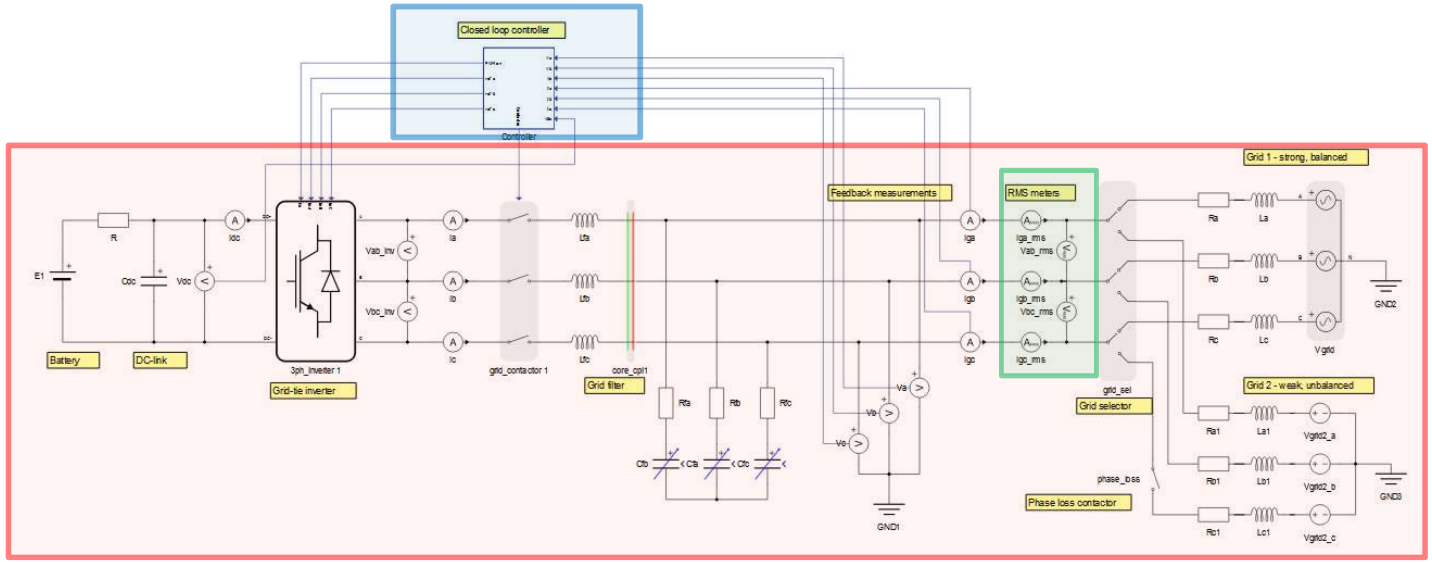
Model mapping

Example model



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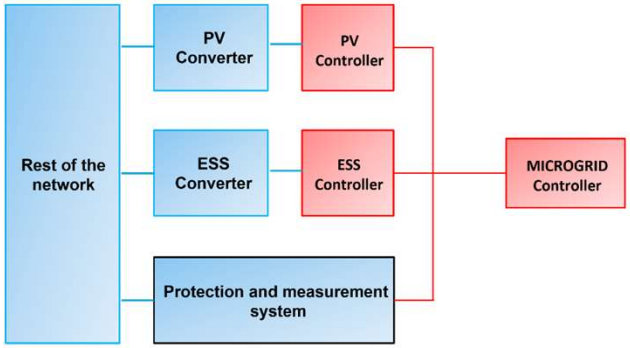
C- HIL Testbed

Fast track to grid digitalization

- Testing supervisory control
  - Testing supervisory control requires a focus on communication. Testing communication can be done in a virtualized environment with simulated DERs and products specific communication registry maps.
- Testing interoperability
  - Before deployment, we extend our test environment with HIL Compatible editions of DER controllers, with original control firmware and software versions.
- Testing protection
  - Finally, we can add a protection layer to our testbed together with high accuracy signal conditioners, and run multiple operational scenarios, especially faulty scenarios



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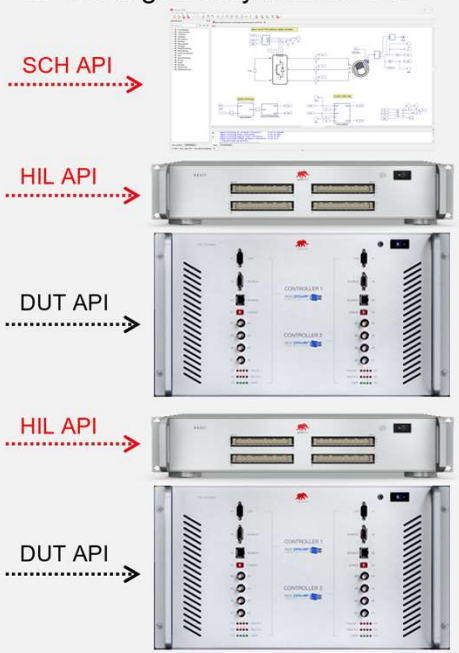
Typhoon HIL

Designed for HIL Test Automation and Integration

Typhon API, TyphoonTest, and Typhoon Test Hub

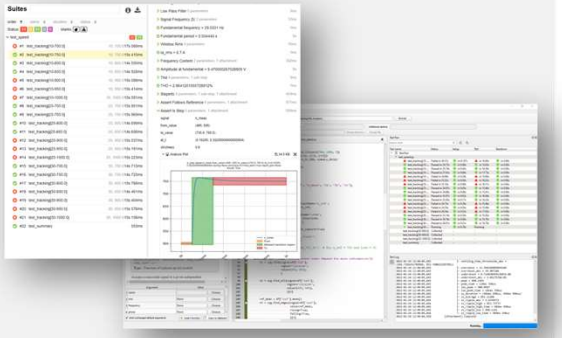
Typhoon API

Interfacing directly with devices



TyphoonTest

Test Framework: procedure and reporting



- ☐ Test framework tailored for HIL
- ☐ Automatic rich report generation
- ☐ Improved HIL API
- ☐ Assertion and Metric functions
- ☐ Test IDE with Wizard

Typhoon Test Hub

Test Integration, management, and execution

- ☐ Tailored and optimized for HIL
- ☐ Scalable, reproduceable, traceable
- ☐ Increased test results visibility
- ☐ Improved connection and integration
- ☐ Resource management and insight

Rest of your process

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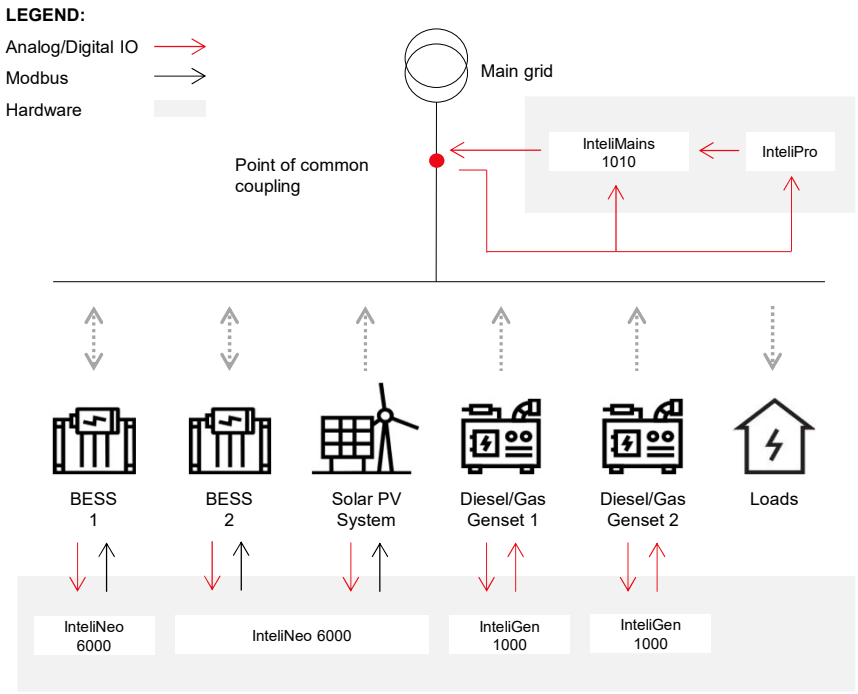
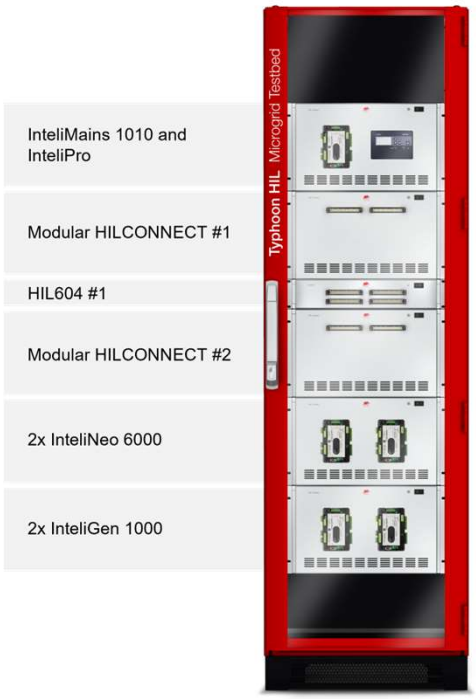
ComAp Microgrid Testbed



All ComAp controllers intercommunicate over a CAN bus



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Hitachi ABB: e-mesh PowerStore Digital Twin

Success Story:

Hitachi ABB Pushes the Limits of Testing e-mesh Controls with Typhoon HIL Solutions

"The controller Hardware-in-the-Loop is an excellent tool because we can show the real performance of our controllers."

Tilo Buehler

Global Product Manager, Grid Edge Solutions ABB Power Grids
Hitachi ABB

Read more on Typhoon HIL Blog

Spotlight video

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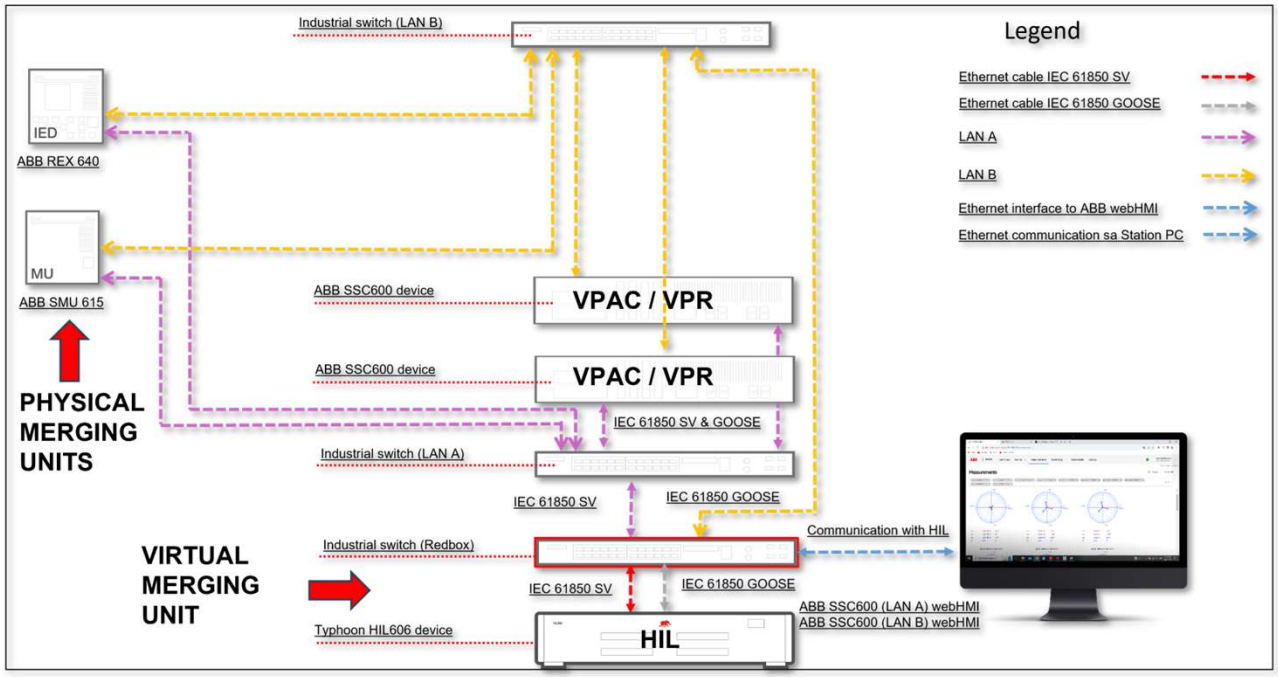
Centralised substation protection test panel:

Network Layout



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BESS Integration testing and lifecycle

for Value-adding Integrators

State-of-the-art model based technology
with product controllers and OEM-validated models from major Power Conversion System suppliers and OEM-specific models of battery packs, protection devices, etc.

Single-source solution for all stages of product and project lifecycle.
From plant controller development support, to vendor qualification, grid-code compliance testing and decades long operational maintenance support.

Universal environment
easy to reconfigure for every project.

Expert engineering and support.

Ultimate commercial flexibility
Rent*, Lease, Buy, or get a full scope as a Service (hosted in-house or accessed remotely).

Complementary grid-connection compliance studies.

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Nome: Silvia Bardi
Azienda: Typhoon HIL GmbH
Email: silvia.bardi@typhoon-hil.com

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