



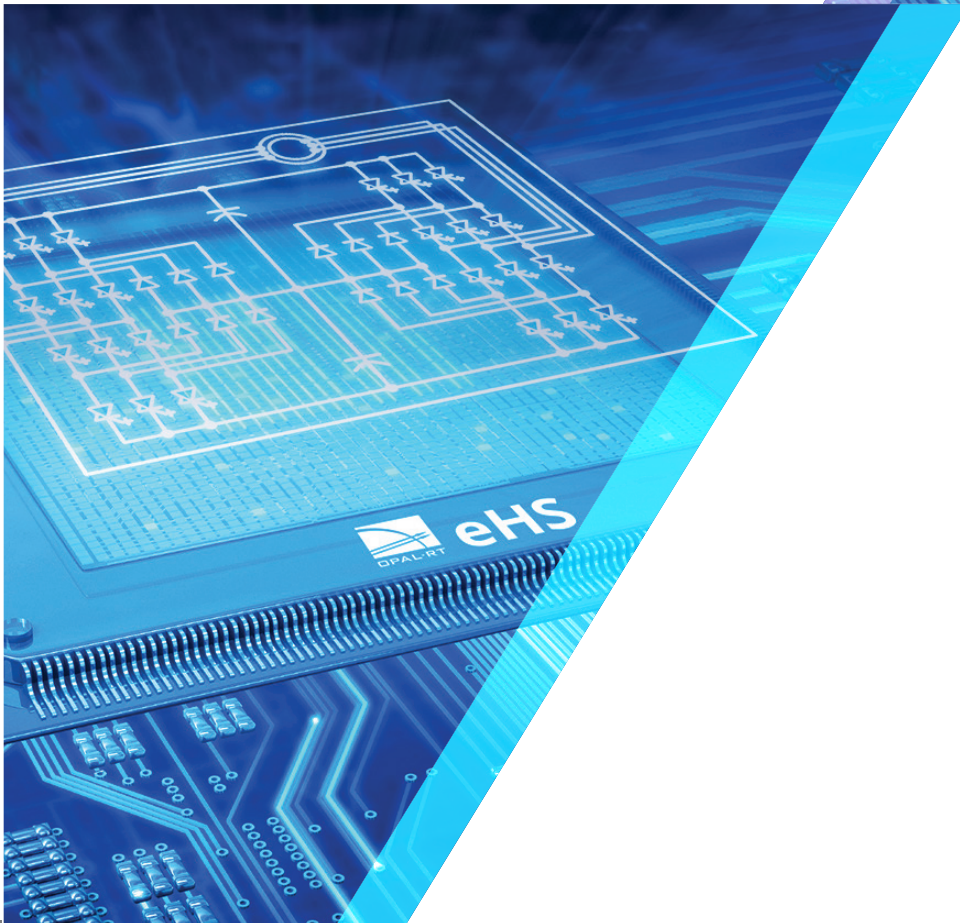
OPAL-RT
TECHNOLOGIES



Gold
Alliance
Partner

Hardware-in-the-Loop (HIL) Specialty

HIL FOR POWER ELECTRONICS AND POWER SYSTEMS WITH NATIONAL INSTRUMENTS



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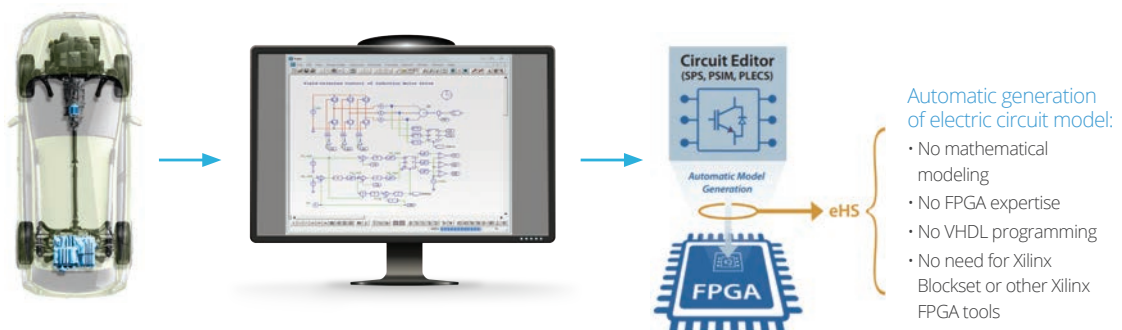
INTRODUCTION

For over 20 years, OPAL-RT HIL Simulators have been used by engineers and researchers at leading manufacturers, utilities, universities and research centres around the world. OPAL-RT is renowned for providing cutting edge HIL technologies for power electronic and power system applications.

Today, some of OPAL-RT's key technologies are available on the NI Platform.

NI Hardware, Labview & Veristand, combined with OPAL-RT's expertise in HIL and PHIL testing in Power Electronics and Power systems, enables NI users to overcome the greatest HIL engineering challenges using powerful NI FPGA-based systems that accelerate productivity and drive rapid innovation.

SIMULATION COMPONENTS



Power Electronics Solvers on NI FPGA

NI PRODUCT SOLUTION

 **NI VeriStand**

+



NI cRIO

CompactRIO is a real-time embedded industrial controller made by National Instruments for industrial control systems.



PXI

PXI is a rugged PC-based platform for measurement and automation systems. PXI combines PCI electrical-bus features with the modular, Eurocard packaging of CompactPCI and then adds specialized synchronization buses and key software features.

HARDWARE LIST:

NI cRIO-9068 / Zynq 7020 - CompactRIO (only for courseware)

NI-PXIe-7858R / K7 325T - R Series

NI-PXI-7971 / K7 325T - FlexRIO

NI-PXIe-7868R / K7 325T - R Series

NI-PXI-7972 / K7 325T - FlexRIO

NI-PXIe-7822R / K7 325T - R Series

NI-PXI-7975 / K7 410T - FlexRIO

NI-cRIO 9034 / K7 325T - CompactRIO

NI-PXI-7976 / K7 410T - FlexRIO

NI-cRIO 9039 / K7 325T - CompactRIO

FPGA Electric Motor & eHS for Hardware-in-the-Loop (HIL)

Field of applications



Microgrids



Electric Motors and Drives



Electric Ships



Electric Aircraft



Energy Conversion Controls

Real-time simulation of power electronics remains one of the greatest challenges to HIL simulation.

OPAL-RT's unique expertise in real-time simulation for EV and HEV electric motors, and experience in HIL engineering, have evolved to include a greater variety of field of applications, such as microgrids, electric motors and drives, electric ships and more electrical aircraft and any type of energy conversion controls.

OPAL-RT provides power electronic HIL firmware that can be loaded onto NI FPGA boards and managed through LabVIEW or Veristand.

Technology presentation:

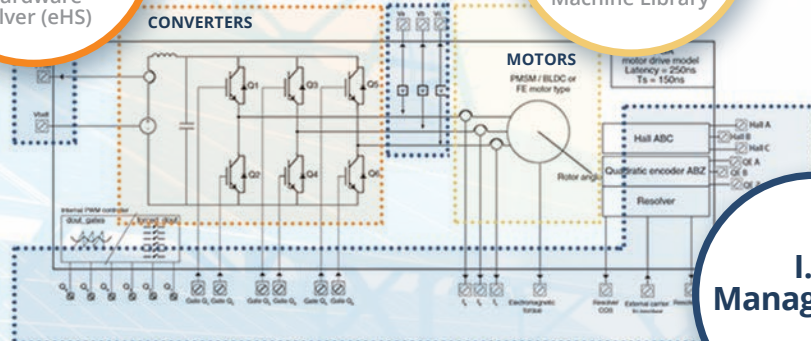
This diagram shows a technical representation of an electric motor and a converter, and combines two major OPAL-RT Technologies available to NI: eHS and FPGA Electric Motor libraries.



Electric Hardware Solver (eHS)



Electric Machine Library



I.O Management



eHS ELECTRICAL SOLVER

eHS, a generic and programmable FPGA-based electromagnetic transient (EMT) solver at the heart of the eFPGASIM suite, provides a convenient software environment that enables users to bring models into real-time in a matter of seconds.

- ✓ Facilitates the design cycle for complex circuit simulation by allowing a gradual simulation integration, from offline into FPGA simulation.
- ✓ Increases the simulation accuracy of complex and fast electric circuits and drives by achieving very small model time step updates.
- ✓ Compatible with National Instruments' Multisim, as well as other platforms such as Simscape's SimPowerSystems, PLECS Blockset and PSIM.



ELECTRIC MACHINE LIBRARY

The Electric Machine Library fits in the eFPGASIM suite as the ideal platform for designing and testing controllers.

The FPGA Electric Machine Library includes a power electronics and motor library that lets you simulate all components of the electric motor drive system. It includes detailed mathematical models of different types of electric motors, such as:



Permanent Magnet Motors (PMM)

- Brushless DC (BLDC)
- Permanent Magnet Synchronous Machine (PMSM)



Permanent Magnet Motors (PMM)

- Doubly Fed Induction Generator/ Machine (DFIG DFIM)
- Squirrel Cage Induction Generator/ Machine (SQIG SQIM)



Stepper Motor

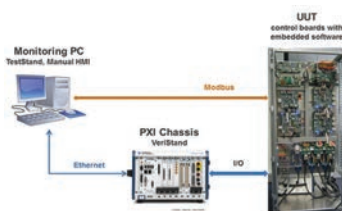
- Switched Reluctance Motor (SRM)



And More!

- Complex motors
- Multi-motor systems
- Resolvers
- Real-time scope
- Encoders
- Others

Success Stories



An innovative HIL test bench validates the software embedded in SOCMEC's inverters

"Thanks to NI and OPAL-RT, we now have a hardware and software solution to validate high-performance, real-time HIL, which will allow us to improve product quality and reduce time-to-market."

- Thierry Rohmer, SOCMEC SA

THE CHALLENGE:

Have an HIL simulator for our power electronics converters that would allow us to validate all the operations that have strict real-time constraints and to test product reliability in all types of use.

THE SOLUTION:

Use the National Instruments PXI Express chassis and FPGA boards that support the OPAL-RT eHS64 solver, with the NI software suite with LabVIEW and VeriStand for the real-time node and TestStand for test automation.



Advancing Subaru Hybrid Vehicle Testing Through Hardware-in-the-Loop Simulation

"By adopting FPGA-based simulation using the NI hardware and software platforms, we achieved the simulation speed and model fidelity required for verification of an electric motor ECU. We reduced test times to 1/20 of the estimated time for equivalent testing on a dynamometer."

- Mr. Tomohiro Morita, FUJI Heavy Industries, Ltd.

THE CHALLENGE:

Using automated testing to develop a new verification system that satisfies the control quality level required for the motor electronic control unit (ECU) in Subaru's first production model hybrid vehicle, Subaru XV Crosstrek Hybrid, and creating strenuous test conditions that are difficult to achieve using real machines.

THE SOLUTION:

Building a verification system with the NI FlexRIO platform that makes automatic execution of all of the test patterns possible and replicates the most severe testing environments to ensure the highest level of safety to the user, while obtaining the required control rate and meeting critical timelines.

NI Preferred Configuration

The simulator includes a power electronic and motor library that includes a detailed mathematical model of motors, power electronic converters and inverters and also devices such as resolvers, encoders and Hall Effect sensors. The electric circuit represented below provides an overview of the type of motor drive model that can be simulated.

TYPICAL CONFIGURATION



NI CRIO-9034 OR 9039 K7 325 T



**NI PXIe 7868R - R Series
with NI PIXle-1078 chassis 9 slots**

Processors	1.91 GHz Quad-Core Intel Atom	2.6 GHz Quad-Core Intel Core i7-5700EQ
Number of I/O slots	4 or 8	8
OPAL-RT eHS version	eHSx64	eHSx64
SIGNAL TYPE	I/O BOARD EXAMPLES	I/O BOARD EXAMPLES
Digital outputs used for PWM Out, Digital Out, Gate Firing, Hall Effect Sensor, Quadrature Encoders, ...	NI 9477 32-Ch, 5 V to 60 V, Sinking DO module	PXIe-7868 Multifunction reconfigurable I/O module 18AO/6AI
Digital inputs used for PWM In, Digital IN, Firing Pulse, ...	NI 9425 Spring terminal, 32 Ch, 24V, 7 us, Sinking digital input	PXIe-7868 Multifunction reconfigurable I/O module 18AO/6AI
Analog inputs used for Current & sensor inputs, Resolver carrier input	NI 9229	PXIe-7868 Multifunction reconfigurable I/O module 18AO/6AI
Analog outputs for Current & Voltage sensor outputs, Resolver, Sensor, ...	NI 9264	PXIe-7868 Multifunction reconfigurable I/O module 18AO/6AI



ABOUT US

Founded in 1997, OPAL-RT TECHNOLOGIES is the leading developer of open Real-Time Digital Simulators and Hardware-In-the-Loop testing equipment for electrical, electro-mechanical and power electronic systems.

OPAL-RT Simulators are used by engineers and researchers at leading manufacturers, utilities, universities and research centres around the world.

OPAL-RT's unique technological approach integrates parallel, distributed computing with commercial-off-the-shelf technologies.

The company's core software, RT-LAB, enables users to rapidly develop models suitable for real-time simulation, while minimizing initial investment and their cost of ownership. OPAL-RT also develops mathematical solvers and specialized models for accurate simulation of power electronic systems and electrical grids. OPAL-RT's RT-LAB solvers and models are integrated with advanced field programmable gate array (FPGA) I/O and processing boards to provide complete solutions for RCP and HIL testing.



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