Real-Time HIL/RCP Laboratory

Study, design and test power electronics control algorithms using both OPAL-RT and Lab-Volt solutions.

Electric Motor Laboratory Curriculum Goals

The OPAL-RT real-time simulator is a multi-purpose platform that enables real-time simulation, Hardware-In-the-Loop (HIL) testing and Rapid Control Prototyping (RCP). Inspired from the industry, the HIL and RCP approaches make it possible to test, validate and reduce controller development in a secure environment.
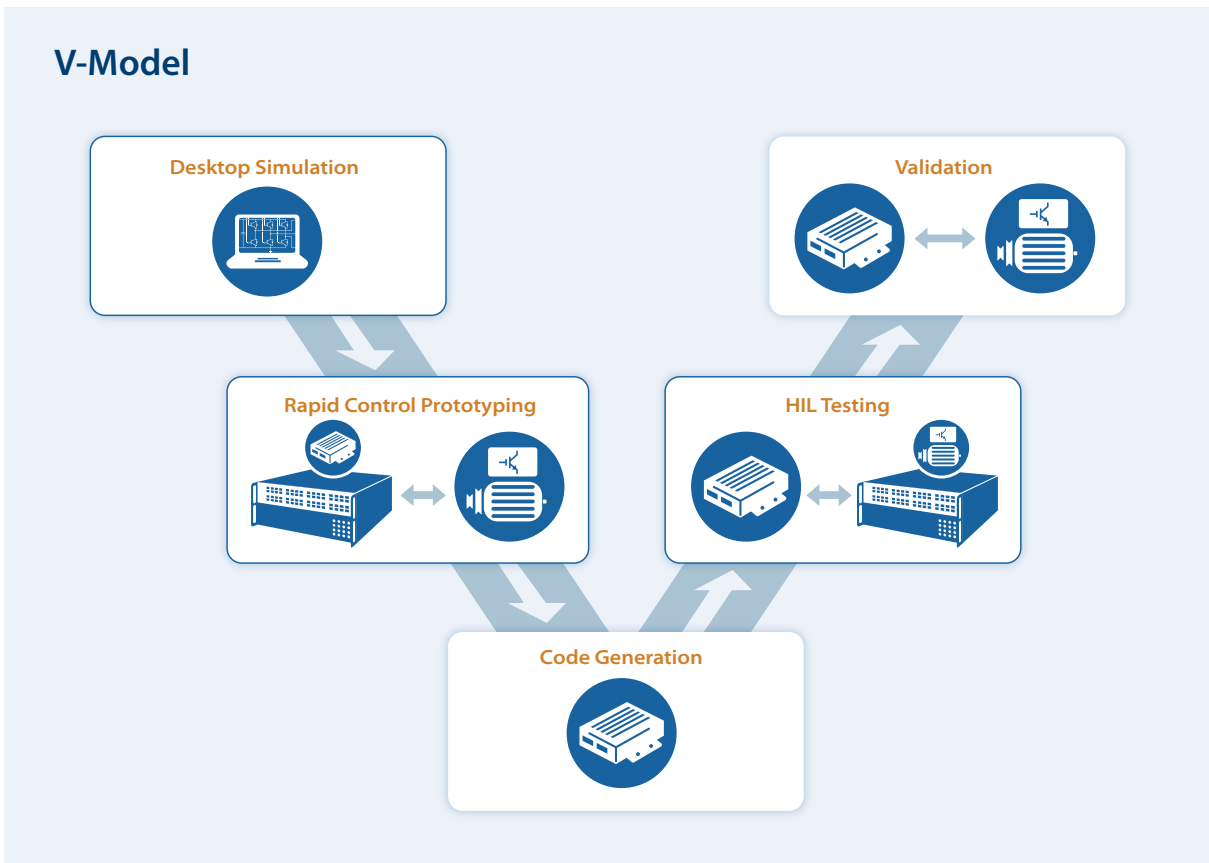
The OPAL-RT system, combined with Lab-Volt hardware, enables one to fully teach the V Cycle principles used in the industry. Students and researchers can build a model and then validate the same model against a real system. This way, they make sure that the parameters model are correctly identified and matches the ones from the real system. The real-time simulation platform allows one to connect directly the Simulink®/SimPowerSystems™ model to the real hardware through the simulator input and output channels.

With RCP, the plant is real (real IGBT or generators) and the controller algorithm is running inside the real-time simulator. This configuration enables one to quickly test different control algorithms without worrying about the controller's platform used, like DSP or FPGAs. Users can focus on the algorithms instead of spending a precious amount of time debugging and implementing the algorithm inside a proprietary platform (DSP). In short, the real-time simulator makes it easy to go from Simulink® models to a real working prototype in a few clicks.

With HIL, the controller is real and the plant is virtual. It is not always practical to do controller development on a real system for multiple reasons like security, availability and the high risk of damaging the equipment. HIL makes it possible to test the control against a safe and accurate virtual model before connecting to the real plant.

V-Model

Desktop Simulation

Validation

Rapid Control Prototyping

HIL Testing

Code Generation

Laboratory Highlights and Benefits

OPAL-RT's and Lab-Volt's Real-Time HIL/RCP Laboratory consists of seamlessly integrated hardware and software designed to conduct experiments in the fields of electrical machinery, power converters and wind energy generation. It is composed of an OPAL-RT real-time simulator, a signal conditioning interface, and a Lab-Volt hardware kit (0.2-kW or 2-kW).

Study, design and test

- Power electronics controls
- Validation of model against experimental results
- Integration of renewable energy sources into the grid
- System behavior under nominal and extreme condition

Highlights

- Design control strategies using RT-LAB and MATLAB/Simulink/SimPowerSystems/Stateflow
- Total integration of Lab-Volt laboratory with OPAL-RT OP4500 or OP5600 simulator and OP8660 HIL Controller.
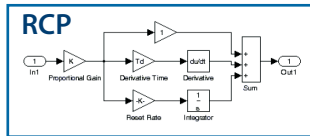- Step-by step tutorial and operational demonstration

Benefits

- Premium teaching solution
- Easy configuration and connectivity and short setup time
- Excellent coverage of experimental needs
- Customizable and scalable
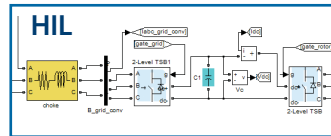- Reliable technical support and training
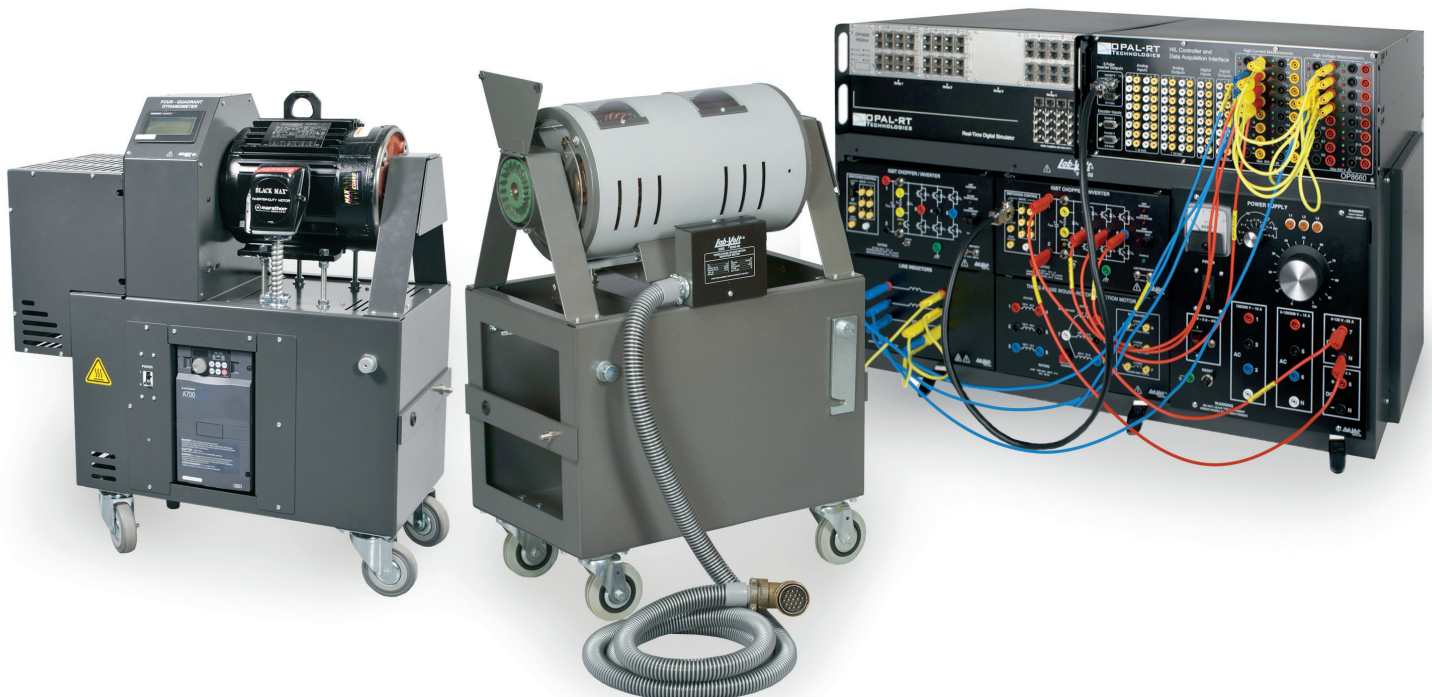
The Complete Solution
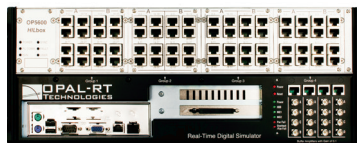
## Modeling Environment

RCP

Control Algorithms

and/or

HIL

Simulation Models

OPAL-RT Hardware

Automatic Real-Time Code Generation

2x 6-pulse
IGBT outputs

16x high current
inputs (15A)

2x encoder
imputs

16x high current
inputs (600V)

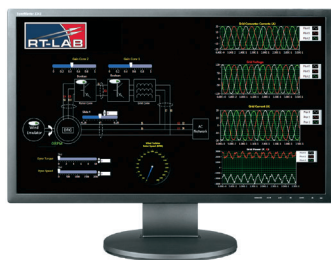### OPAL-RT Real-Time Simulator

OPAL-RT's real-time simulator lets you run MATLAB/Simulink and SimPowerSystems models on a dedicated real-time computing platform. Running real-time makes it possible to link the simulation or control models with external hardware components for Rapid Control Prototyping or Hardware-In-the-Loop development.
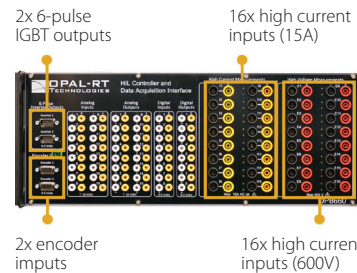
OP8660 Signal Conditioning Interface

The OP8660 signal conditioning interface extends the capabilities of the real-time digital simulator by providing multiple inputs and outputs channels tailored to power electronics and power systems applications. It simplifies the connectivity between a virtual environment (the real-time simulator) and real experimental systems by providing a secure, robust and easy to use interface ideal for training and academic environments.

Built-in User Interface

Thanks to OPAL-RT's core software RT-LAB, all models come with an intuitive visualization and control interface allowing users to easily operate, calibrate, change control parameters while simulation is running in real-time and even to program automatic testing and data recording.

Lab-Volt Hardware

The real-time simulator can be seamlessly interfaced with a Lab-Volt 0.2-kW or a Lab-Volt 2-kW kit depending on your research and teaching goals. The two Lab-Volt 6-pulse IGBT modules are controlled directly by the OPAL-RT simulator FPGA and the Simulink model can be modified easily to test various type of control algorithms. If you already have your own hardware like IGBT or motors, you can also interface them with the simulator easily.

The 0.2-kW Electromechanical Training System

Lab-Volt®

This experimental laboratory offers multiple electrical generators. Students and researchers can test multiple control algorithms on different motors with the same IGBT modules. The kit includes a large set of generators type such as Doubly-Fed-Induction, Permanent Magnet Synchronous Generator, Brushless DC and Induction Generator.

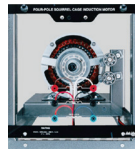**Motors / Generators**   **Components**

Dynamometer (8960)

Power Supply (8821)

PMSM (8245)

DFIG, Sync M/G, PMDC or SCIM (8231, 8241, 8213, 8221)

2x 6-pulse IGBT (8837)

Capacitive Load, Resistive Load or Line Inductors (8331, 8311, 8326-A)

The 2-kW DFIG Lab-Volt's "Renewable Energy" System

Lab-Volt®

The 2-kW kit provides more realistic and efficient generators to develop control algorithms for micro grid applications. The kit comes with a Doubly-Fed-Induction-Generator (DFIG) example that replicates a small scale DFIG wind turbine system. The four quadrant dynamometer can be fully controlled by the simulator in torque or speed mode to precisely emulate any wind variation. For example, it is possible to experiment and design reliable control algorithms to optimize the amount of active power pushed to the grid. Different types of generators, other than DFIG, are also compatible with the kit and are available upon request.

Motors / Generators   **Components**

Dynamometer (8540)

Power Supply (8525)

DFIG (8505)

Sync M/G, DC or SCIM (8507, 8501, 8503)

2x 6-pulse IGBT (8857)

Capacitive Load, Resistive Load or Line Inductors (8331, 8311, 8374)

Applications

This application example compares a simple IGBT simulation model connected to line inductors and resistive load against the same configuration using Lab-Volt hardware. OPAL-RT's HIL solution allows users to simultaneously run a control model and a simulation model at the same time.

Hardware Setup

Control & Simulation Model

Comparing Simulation Results with Hardware
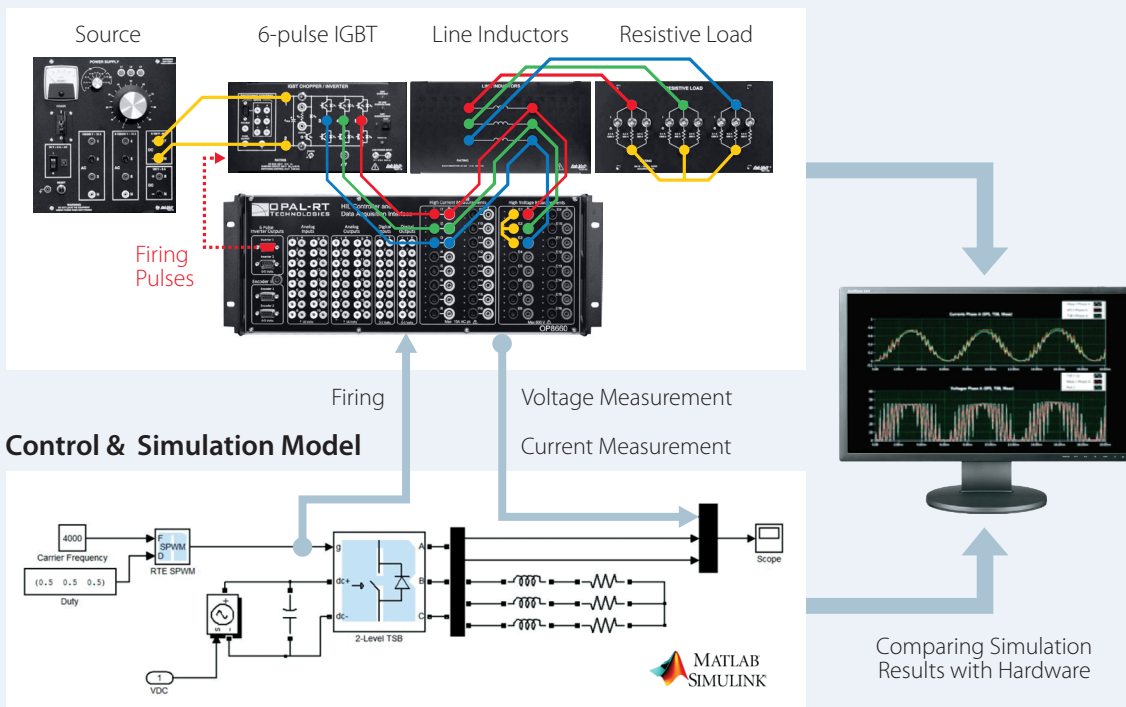
Easy integration with your curriculum

The kit is delivered with a series of working examples and case studies that easily integrate with your curriculum.

Renewable Energy

- Doubly fed induction generation
- Inverter control (6-pulse IGBT)
- Back-to-back inverter control
- DC bus active and reactive power control

Closed Loop Motor Control Models

- Permanent magnet DC motor speed control
- Squirrel cage induction machine speed Control
- Permanent magnet synchronous motor speed control
- Permanent magnet synchronous motor flux angle correction

Expand your Capabilities

At OPAL-RT, we have built our reputation on scalability, usability and competitive pricing. Furthermore, we have established strong technical leadership in the field of power grids and electrical drives. Our representatives can advise you on how to extend the capabilities of our solution for microgrid applications, large scale power system simulation, transmission & distribution, PMUs integration and even cyber security.

More CPU cores can be activated and added to the current system to enable larger model simulation.

- Various types of I/O channels can also be added
- It is also possible to convert the simulation package into an eMEGAsim or HYPERSIM package (power system simulation)
- Ask an OPAL-RT representative for more information about simulator capabilities
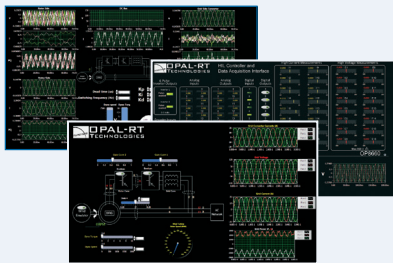
OPAL-RT's Ever-Evolving Software

OPAL-RT offers complete, open and high-performance power system real-time simulation solutions. Not only does it cover every need for traditional power grid simulation, it also offers an unsurpassed level of scalability to design, simulate and test complex power systems, thanks to a level of integration between products never seen before.

A Complete Line of Integrated Real-time Simulation Solutions

HYPERSIM
Large scale power system simulator for utilities & manufacturers

eMEGAsim
Power system & power electronics simulator based on MATLAB/Simulink & SimPowerSystem

ePHASORsim
Real-time transient stability simulator

eFPGAsim
High precision power electronics simulation on FPGA for controller testing

From Imagination... to Real-Time

OPAL-RT
Corporate Headquarters

1751 Richardson, Suite 2525
Montréal, Québec, Canada H3K 1G6
Tel: +1 514-935-2323
Fax: +1 514-935-4994

USA

OPAL-RT Corporation
26 Summit Street, Brighton
MI 48116, USA
Phone: +1 (734) 418-2961
Fax: +1 (866) 462-5120

EUROPE

OPAL-RT Europe S.A.
196 Houdan Street
92330 Sceaux, France
Phone: +33 1 41 73 40 80
Fax: +33 9 67 23 07 84

INDIA

OPAL-RT India Pvt Ltd
100 ft road, Binnamangala
Bangalore - 560 038, India
Phone: +91.80.2520.0305
Fax: +91.80.2520.0105

About **OPAL-RT TECHNOLOGIES**

OPAL-RT is the world leader in the development of PC/FPGA Based Real-Time Digital Simulator, Hardware-In-the-Loop (HIL) testing equipment and Rapid Control Prototyping (RCP) systems to design, test and optimize control and protection systems used in power grids, power electronics, motor drives, automotive industry, trains, aircrafts and various industries, as well as R&D centers and universities

www.opal-rt.com