Real-time Simulation Solutions for Power Grids and Power Electronics

From Imagination... to Real-time
Over the years, OPAL-RT TECHNOLOGIES has become the world leading developer of open Real-Time Digital Simulators and Hardware-In-the-Loop (HIL) testing equipment for electrical, electro-mechanical and power electronic systems. Simpler, we help engineers develop, test and validate faster.

Our software enables users to rapidly develop models suitable for real-time simulation, while minimizing initial investment and their cost of ownership.

We offer a complete line of integrated real-time simulation solutions: the ePOWERgrid product family that simulates everything from fast electromagnetic phenomena to the transient stability of large power systems allowing power system engineers and scientists to optimize the security, efficiency and performance of micro grid, renewable energy sources and large interconnected power grids.

We partner with power utilities and research laboratories worldwide. In 2012, following an agreement with IREQ from Hydro-Quebec, OPAL-RT launched HYPERSIM; a powerful and intuitive power system simulator for Utilities, R&D Centers and Manufacturers, based on decades of research by Hydro-Quebec.

According to our vision, we provide powerful, versatile and cost-effective solutions, thus optimizing return on investment through high-quality engineering services.

Powering reliable solutions for you

Jean Bélanger
CEO & CTO

Our Customers

Other Customers (partial list)

Bharat Heavy Electricals Ltd, Delta Electronics, Denso, EDF; EPGH Singapore, Fraunhofer IWES, GE Energy, GE India Technology Centre, Hitachi, Indian Central Power Research Institute, Mitsubishi, Nari-Relays Electric, Panasonic, Senvion, Rockwell Automation Canada, Sandia National Laboratories, Schneider, TMEIC Japan, XJ Group China and several other manufacturers, R&D centers and universities worldwide.
OPAL-RT’s solutions cover every need for traditional power grid and power electronics real-time and as fast as real-time simulation, and also offer an unsurpassed level of scalability to design, simulate and test complex new generation power systems. Indeed, OPAL-RT real-time systems help perform feasibility studies, develop new concepts, design and test controllers for a wide variety of applications including small power converters, hybrid electric drives, large power grids and renewable energy systems.

Choose the technology that is right for you by looking at the frequency of the transient phenomena simulated as well as the numbers of nodes.

**Number of Single-phase nodes**

- ePHASORsim: Real-time transient stability simulator
  - 10 ms time step
- HYPERSIM: Large scale power system simulation for utilities & manufacturers
  - 10 μs to 100 μs time step
- eMEGAsim: Power system & power electronics simulation based on Matlab/Simulink & SimPowerSystem
  - 10 μs to 100 μs time step
- eFPGAsim - eHS & eMMCsim: Power electronics simulation on FPGA
  - 100 ns to 1 μs time step

**Applications**

- Smart Grid & Renewable Energy
- Large transmission & distribution systems
- SCADA & Automation Systems
- PMUs & Protection Devices
- More Electric Aircraft, Trains & Ships
- Power Electronics Controller Development
- MMC, HVDC and FACTS Simulation

**Multiple Hardware Platform**

It is possible to run those solutions on OPAL-RT open hardware, from portable systems to large scale super computer architectures, depending on real-time simulation requirements.
HYPERSIM Power Systems Real-time Simulator

HYPERSIM is the only real-time digital simulator with the power to simulate and analyze very large-scale power systems with more than 2000 three-phase buses. It is used for factory acceptance and system integration testing, as well as for R&D works and commissioning tests. This solution relies on open architecture, high-speed parallel processing and modular scalability to deliver standard real-time simulators designed to meet the evolving needs of the most demanding utilities and manufacturers. Its intuitive and convenient interface allows engineers to create complex power system topologies and tackle operational and reliability issues within a single day.

Based on decades of research by Hydro-Quebec on one of the world’s most complex transmission power systems, HYPERSIM is an ever-improving solution with a proven track record. As a result, it is rapidly becoming the new standard for very large power systems.

Who needs HYPERSIM

Utilities
Power utilities equipment manufacturers
Research centers
Electrical engineering department of universities
Industries with large electric infrastructure
Protection system testing laboratories
Clients like: HQ, CEPRI, NIPA, Siemens, RTE

Applications

Everything related to generation, transmission and distributions power systems, including:

- MMC, HVDC, FACTS, SVC, STATCOM

- Micro grid: PV, wind turbine, generator, fuel cells, capacitor banks

- Smart grid

- PMU and SCADA (C37.118)

- Relay and protection systems (IEC61850, DNP3, and more)

- Energy storage

- Power HIL, Hardware-In-the-Loop and Controller-In-the-Loop (CHIL)
### Benefits

- Unmatched power and scalability (very large grids)
- Extreme reliability developed and validated by a world-renowned power system simulation laboratory at Hydro-Quebec’s research institute (IREQ), and selected by french TSO RTE, State Grid Corporation of China (SGCC) and several utilities for critical projects
- Increased productivity for factory acceptance and integration tests
- Faster testing speeds with flexible and intuitive features

### Features

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<th>Feature</th>
<th>Description</th>
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<tr>
<td><strong>Extreme scalability using off-the-shelf computers</strong></td>
<td>Power systems with thousands of three-phase buses integrated with several HVDC and FACTS systems can be simulated with hundreds of high-end INTEL™ processors sharing the same memory. Such capability, available with off-the-shelf technologies, is beyond the reach of competing solutions that use custom-made computer and communication boards.</td>
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<td><strong>Ease-of-use with fully automated processor allocation</strong></td>
<td>Large scale power grid simulation is made easy since available processor cores are automatically allocated to simulate each network subsystem without any manual intervention.</td>
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<td><strong>Real-time parameter modifications</strong></td>
<td>Users can easily modify and set the power system and control circuit parameters, even while the simulation is running in real-time or in offline mode. Most competing solutions do not allow to modify impedance RLC values on-the-fly.</td>
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<td><strong>Accelerated simulation on the same hardware</strong></td>
<td>HYPERSIM can be used on a standard laptop, workstation server, supercomputer, and even on the cloud to accelerate large simulation for offline optimization and MonteCarlo analysis.</td>
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<td><strong>Validated power LCC and MMC converter models</strong></td>
<td>HYPERSIM includes thyristor-based LCC HVDC and FACTS models validated against field tests, as well as MMC HVDC system models.</td>
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<td><strong>Rich library of transmission line, transformer, load and arrester models</strong></td>
<td>Validated models of all power system components are supplied with the ability to modify parameters manually or from the test management software while the simulation is running.</td>
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<td><strong>I/O server for easy management of connections</strong></td>
<td>HYPERSIM provides an I/O server that allows for easy management of connections between the simulator and I/O signals coming from real equipment, such as protection equipment and control systems.</td>
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<td><strong>FPGA-based I/O and simulation system with sub-micro second time step</strong></td>
<td>HYPERSIM is integrated with OPAL-RT real-time simulator and I/O system, enabling the use of multi-FPGA boards to implement fast power electronics models running with sub-microsecond time steps to reach maximum accuracy. Such a feature is useful in the simulation of very fast voltage source converters installed in micro grids and industrial systems.</td>
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* Compatible with eFPGAsim. Talk to one of our sales person.
eMEGAsim is the only MATLAB™/Simulink™/SimPowerSystems™ based real-time digital simulator for the development and testing of protection and control systems using HIL simulation. Used for teaching, R&D works and HIL tests, eMEGAsim accurately simulates the electromagnetic transients required by power grids and very complex and fast power electronic and converters systems.

**Who needs eMEGAsim**

Universities and research laboratories  
Power manufacturers including industrial and transportation systems  
All SimPowerSystems™ users who want to accelerate the simulation of complex systems or perform HIL simulation and tests  
Clients like: ABB, Alstom, EDF, KTH, Mitsubishi Electric, Nari Relay

**Applications**

Everything related to the development and testing of control and protection equipment  
Large scale power systems simulation requiring up to 32 processors  
Line commutated HVDC transmission system – controller development and testing  
Modeling and rapid control prototyping of wind turbine controller  
Power HIL testing, Hardware-In-the-Loop and Controller-In-the-Loop (CHIL)  
IEC 61850 relay and protection equipment testing  
MMC, FACTS, STATCOM  
Complete power grid of electric ship
Benefits

- Best performance to cost ratio as compared to any available commercial real-time simulator
- High simulation accuracy with simulation time steps as low as 10 microseconds
- Very open solution enabling modular scalability

Features

The highest accuracy and speed for simulation of grids and power electronics systems on FPGA
eMEGAsim uses the unique ARTEMiS and SSN solvers developed by OPAL-RT to increase speed, accuracy and numerical stability for the simulation of critical systems. The highest performance is achieved by taking advantage of parallel processing and advanced techniques to eliminate errors caused by artificial delays used with conventional solvers for parallel simulations

Fully integrated with the Mathworks™ products for the best inter-connectivity
eMEGAsim is fully compatible with MATLAB™, Simulink™ and SimPowerSystems™ and several other commercial software for modeling, test automation, and report generation

RT-LAB™ Integrated Simulation Environment
RT-LAB™ is OPAL-RT’s flagship integrated simulation environment for real-time applications. It enables engineers to conduct distributed parallel computing for real-time simulation of large and complex models for HIL and RCP applications. With its interactive interface, RT-LAB™ provides all the required functionalities to configure and manage simulator functions and interact with running simulations, making model development and test easier. RT-LAB™ also allows several commercial software to quickly interface with the eMEGAsim simulator

Rich library of power systems components
Validated models of all power systems components are supplied including frequency-dependent line and cables, loads, machines and motors

Validated MMC converter models
eMEGAsim includes thyristor-based LCC HVDC and FACTS models. HIL simulation of an MMC HVDC system with more than 1000 MMC cells per arm is also possible using standard processors or FPGA chips

Real-time parameter modifications
Users can easily modify and set the control system parameters and other mechanical models implemented with Simulink™ and Simscape™ even while the simulation is running in real-time or in offline mode

Automatic Test Control
Automatic tests and optimization studies can be implemented using NI TestStand™, LabVIEW, Java, C and Python™ scripts

Interfaced with ePHASORSim
eMEGAsim is fully interfaced with ePHASORSim transient stability simulation. The ePHASORSim phasor-mode simulation module is interfaced with Simulink™ and can be executed simultaneously with SimPowerSystems™/ARTEMiS electromagnetic transient simulation

Simulation of large distributed systems with up to 600 nodes
eMEGAsim enables the simulation of distribution systems with more than 600 nodes or less than 100 microseconds. Such performance is out of reach of competitive solutions, as achieved using the unique SSN parallel solver
ePHASORsim Real-time Transient Stability Simulator

ePHASORsim performs real-time and faster than real-time transient stability simulation for transmission and distribution grids with thousands of buses. Its Phasor domain solver with a typical time-step of few millisecond allows to compute the RMS and angle values of voltage and current, as well as active and reactive powers, machine frequency, reference values, and etc. for every spot in a system. It is perfectly suited for interactive simulation in real-time and operation studies.

Who needs ePHASORsim

Power utilities to:
• Train operators
• Test SCADA systems
• Predict system responses faster than real-time

Research facilities with focus on:
• Transient stability simulations for systems in range of 30,000 nodes
• Wide area control/protection/state estimation algorithms
• EMS tools and algorithms such as AGC and load shedding,
• PMU streams and PDC applications
• System studies with massive number of renewable penetration
• Design and test local controllers such as voltage regulators
• Advanced metering and information network
• Impact of load profiles in distribution networks

Clients like: TNBR (Malaysia), Fraunhofer IWES (Germany), GE Energy (US), IIT (India), CEPRI (China), University College Dublin (Ireland), University of Lille (France)

Applications

Design and test wide area control and protection systems on SCADA systems using PMU measurements for voltage and power control

Operator training simulator for transmission systems using balanced positive-sequence network models and for distribution systems using unbalanced phase-by-phase network models

Testing of interaction between FACTS and HVDC transmission systems on system stability of interconnected systems using fundamental-frequency simulation before making detailed EMT simulations

Test and optimization of machine controls on system stability (voltage regulators, speed regulators, power system stabilizers)

Educational and research works
Benefits

- High efficiency solution for the simulation of electro-mechanical transient stability phenomena of very large power grids
- A test automation platform that speeds up testing and contingency analysis
- Best third-party connectivity and integration
- Automatic Parallel processing based simulation
- Extensible library of models through Modelica based interface (FMU)

Features

**Large-scale power system simulation in real-time**
Simulate power grids with up to 30,000 node distribution systems including more than 70,000 in-ports and out-ports, as well as thousands of generators, transmission lines, cables, loads and transformers. Simulate also synchronous generators with power system stabilizers, excitation systems, turbine governors and various voltage- and machine-speed regulators

**Test automation platform**
Perform test automation using Python™ scripts, use ScopeView to record, display and analyze the results and modify parameters while the simulation is running

**Rich and expandable library of models**
Built-in library includes generator, voltage source, load, transmission line, power system stabilizer, reactor, external Simulink™ blocks, etc. Moreover, a modelica based library of models that includes various type of generators and controllers is available

**Third-party connectivity**
ePHASORsim is interfaced with Simulink™, SimPowerSystems™ and SimScape to enable users to develop their own load, control and protection models. It is also interfaced with the Excel™ spreadsheet and with PTI™s PSS/e to import the network data files

**Third-party integration through Ethernet protocols**
ePHASORsim is becoming an standard tool where user wants to interact with the simulation engine via various types of communication protocols. This application includes both sending commands and monitoring features that are required for testing the SCADA, EMS tools, and wide area control algorithms. Some of user stories includes integration with AGC toolbox of ETAP for load-frequency control, and RTDMS package from EPG for PMU-PDC streams and visualization applications
eFPGAsim Power Electronics FPGA-based Real-time Simulator

eFPGAsim combines the performance of high fidelity digital simulators with very low communication latency to provide power electronics engineers with an easy-to-use HIL platform for the development and testing of control and power electronics systems that require sub-microsecond time step capacity.

Who needs eFPGAsim

- Research centers
- Electrical engineering department of universities
- Electric motor drive manufacturers
- PV converters system manufacturers
- Manufacturer of power transmission and distribution systems
- Clients like: AEG, APERT, FORD, GE, National Instruments

Applications

- Simulate power electronics systems and electrical motors for feasibility studies, design and testing
- Protection and control system development and testing
- HIL simulation and testing of industrial and traction motor drives, industrial power converters, solar power conditioners, multilevel converters and inverters
- More electrical aircraft, electrical trains and ships
### Benefits

- Increased simulation accuracy of complex and fast electric circuits, as well as, drives, by achieving very small model time step updates between 200 ns and 1 μs
- Easy model development by using the electrical schematic editor of SimPowerSystem™, PSIM™ and PLECS™
- Detect errors at earlier stages of the design
- Increased development speed and implementation of new control algorithms

### Features

**Automatic FPGA model generation from the circuit with eHS**

The innovative eHS technology, a generic electrical FPGA Hardware Solver, is at the heart of the eFPGA_sim solution. It is intended to facilitate the design cycle of complex circuit simulation on the FPGA by allowing a gradual simulation integration set-up from off-line simulation to FPGA on-chip simulation.

**Reliable HIL implementation of new generation of controllers for electrical drives**

Users can test motor controllers simulating test fault conditions, as well as perform virtual fault injection on converters, bridges and electrical motors and Finite Element Analysis.

**Generate custom, application specific models that can be implemented on an FPGA device with RT-XSG**

RT-XSG is a Simulink™ toolbox that provides a convenient way to build models. It offers greater flexibility by allowing users to implement their own calculations and models on FPGA.

**MMC model implementation on FPGA**

MMC FPGA models include up to 6000 MMC submodules, and run at 250ns

#### Automatic FPGA model generation from the circuit with eHS

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Automatic generation of electric circuit model:
- No mathematical modeling
- No FPGA expertise
- No VHDL programming
- No need for Xilinx Blockset or other Xilinx FPGA tools
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Our Presence Worldwide

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