Technical & Scientific Profile Sheet

OPAL-RT OP4610XG Real Time Simulator (Smart Grid Controller & HIL Platform)

Category	Real-Time Simulation and Hardware-in-the-Loop (HIL) System
Equipment Name	OPAL-RT OP4610XG Real Time Simulator
Domain	Smart grids, renewable energy integration, control systems, microgrids, and intelligent building energy management
Location	Concordia University – Future Buildings Laboratory (Solar House) Montreal, Quebec, Canada
Responsible	Prof. Luiz A. C. Lopes, PhD Department of Electrical and Computer Engineering
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Access	Upon request. Requires discussion and approval for academic or research use.

Equipment Description

The OPAL-RT OP4610XG Real Time Simulator is a high-performance platform designed for real-time modeling, simulation, and Hardware-in-the-Loop (HIL) applications in advanced energy systems. Serving as the *brain* of the Concordia Solar House, the simulator collects, processes, and transmits reference signals to multiple components such as photovoltaic inverters, stationary batteries, electric vehicles, loads, and the hydrogen loop.

The equipment is powered by an **AMD Ryzen 5 processor (6 cores, 3.8 GHz) and a Xilinx Kintex-7 410T FPGA**, which together provide the computational power needed for accurate

real-time simulations. It is primarily programmed using MATLAB Simulink, although alternative coding languages (e.g., C++) can also be applied.

- Processing of instantaneous local parameters (irradiance, load demand, state-of-charge).
- Integration of historical data and predictive weather inputs.
- Real-time emulation of components for experimental validation of smart energy strategies.

Operational Modes & Safety Features

The Real Time Simulator enables multiple operational configurations to support a wide range of research scenarios:

- Centralized energy management of the Solar House.
- Hardware-in-the-Loop (HIL) emulation of devices such as batteries, inverters, and controllable loads.
- Flexible configuration for experiments based on local, historical, or forecasted data.

Operating Conditions

- Indoor installation (room temperature: ~18–25 °C).
- No calibration required (non-measuring equipment).

Safety

- Operated under standard laboratory conditions.
- No additional safety certifications required beyond the manufacturer's guidelines.

Integrated Safety Mechanisms

Although the OP4610XG Real Time Simulator does not handle hazardous gases or pressurized systems, it incorporates several operational safeguards:

- Software-Based Protections: Fault detection and emergency stop features built into the OPAL-RT environment prevent unstable simulations from propagating to connected hardware.
- Hardware Isolation: Dedicated FPGA interfaces and communication ports provide galvanic isolation to reduce risks during Hardware-in-the-Loop (HIL) experiments.
- Error Logging & Monitoring: Continuous monitoring through MATLAB Simulink/OPAL-RT software allows immediate identification of system faults.
- Safe Operating Environment: Designed for indoor, room-temperature operation, eliminating risks from extreme environmental conditions.
- Manufacturer's Guidelines: Operation follows OPAL-RT's recommended safety procedures, ensuring compatibility and secure connections with third-party equipment.

Possible Analyses or Experimental Applications

- Real-time emulation of energy system components.
- Energy flow coordination between renewable generation, hydrogen storage, and loads.
- Integration and validation of smart grid control strategies.
- Optimization studies of microgrid performance using predictive algorithms.
- Hardware-in-the-Loop studies for PV systems, batteries, and electro-thermal storage units.

Associated Projects and Uses

- **Mr. Mohammad Ali Ghaderi (MSc, 2025):** Conducted a preliminary investigation of the connection between the Real-Time Simulator (RTS) and the SMA equipment at the Solar House. A PhD student will follow up on and extend this work.

- Potential use by undergraduate students for capstone projects on energy management, microgrid control, and renewable integration.

Accessibility

Available upon request for academic research, student projects, industry-academic collaborations, and demonstrations. Training in MATLAB, Simulink, and OPAL-RT software is recommended before operation.

Contact Informations

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