OPAL-RT TECHNOLOGIES

VOL. 4
SUMMER 2023

Power in Mind

NEWS, INNOVATION & BREAKTHROUGHS

A Word from the Editor

Advancing Electrification through Real-Time Simulation

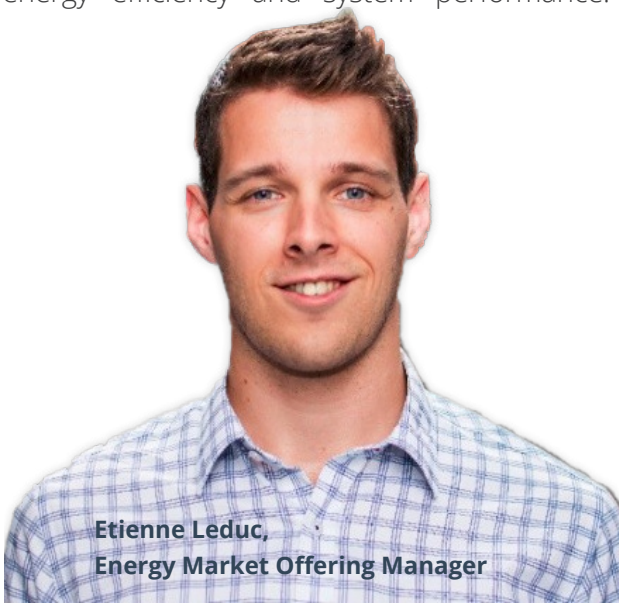
In this edition, we delve into real-time simulation and its profound impact on the energy sector. It revolutionizes the design, operation, and optimization of energy systems by creating dynamic models that capture complex dynamics and time-varying factors. Real-time simulation accurately captures energy system dynamics, allowing decision-makers to assess performance, identify vulnerabilities, and enhance reliability. It also drives energy efficiency by optimizing energy flows, reducing waste, and streamlining operations. This technology empowers operators to fine-tune control strategies and explore innovative energy management techniques.

We present articles showcasing the transformative potential of real-time simulation in various energy domains. From smart grid optimization to renewable energy integration, our contributors explore cutting-edge research and practical applications that advance energy efficiency and system performance.

We express gratitude to the esteemed authors who have contributed their expertise, shedding light on state-of-the-art advancements and paving the way for future innovations in the energy sector.

Real-time simulation stands as a cornerstone technology that enables us to forge a sustainable, reliable, and efficient energy future. We hope the knowledge shared in this magazine inspires further exploration and implementation of real-time simulation techniques to accelerate the transition to a greener and more resilient energy landscape.

Enjoy discovering the limitless possibilities that real-time simulation offers in the realm of energy.

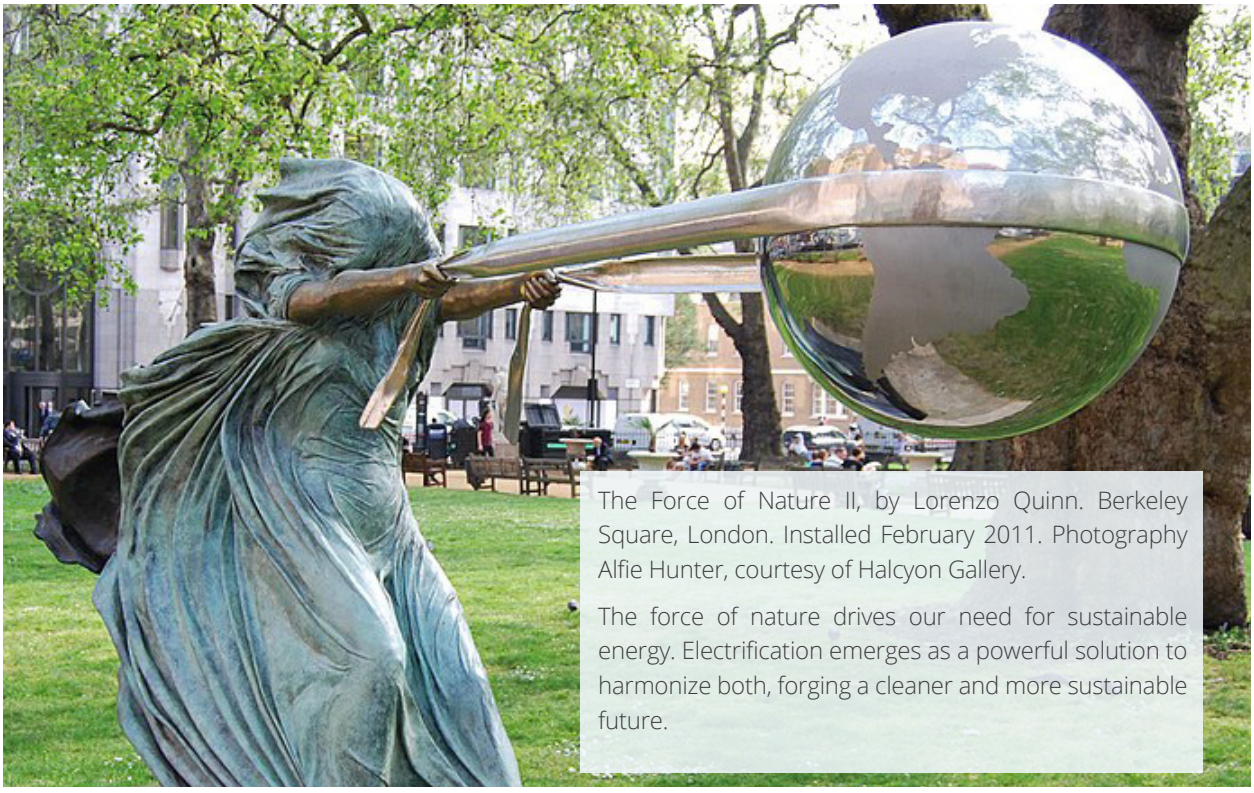


Etienne Leduc,
Energy Market Offering Manager

Etienne Leduc is a highly accomplished professional in electrical engineering and power systems at OPAL-RT TECHNOLOGIES. With expertise in real-time simulation and hardware-in-the-loop testing, Etienne has made significant contributions to power system simulation and control technologies. He is dedicated to promoting green energy solutions, particularly in renewable energy integration and grid modernization.

In this Edition of Power in Mind

Behind the Cover



The Force of Nature II, by Lorenzo Quinn. Berkeley Square, London. Installed February 2011. Photography Alfie Hunter, courtesy of Halcyon Gallery.

The force of nature drives our need for sustainable energy. Electrification emerges as a powerful solution to harmonize both, forging a cleaner and more sustainable future.

Electrifying the World Through Innovation

Over a century after the discovery and harnessing of electricity, the world is finally taking advantage of this power source throughout all parts of life. No longer just powering lights, and electronics, but now powering the cars on the road, the boats in the sea, and the planes in the sky. As electricity reaches out and connects to new areas, the means for how electricity is generated continues to evolve and advance as well with the continued ubiquitousness of renewable energy.

As the world becomes electric, powered by renewable energy, the world becomes green again, with the reduction of CO2 emissions driven by traditional and now outdated fossil fuels.

Grounded in the reality that the world must become electric, this sparks new challenges. OPAL-RT has its roots in power systems and has continued to extend its leading simulation technology to other areas of electrification including EV, aero, maritime, etc. OPAL-RT knows the simulation is what will power the acceleration of an electrified and greener world.

OPAL-RT's commitment to developing cutting-edge real-time simulation technologies becomes paramount. Our primary objective is to empower engineers and researchers to tackle the complexities of power systems and power electronics with unwavering confidence and unwavering precision.

Advanced real-time simulation tools like our fifth generation eHS Gen5 platform, we enable the rapid progress of research, development, and implementation of electrification projects.

We should be excited, but we should be cautious. Powering the future of electrification and protecting the surge of threats is where simulation shines.

With the rapid development of the smart grid and increasingly integrated communication networks, power grids are facing serious cyber-security challenges. The integration of renewable energy production on existing electrical networks further compounds these challenges, requiring more testing and computational complexity. This means that simulators with greater computational power are necessary.

Amidst the escalating demand for EMT simulation on large power systems OPAL-RT stands ready to tackle this significant challenge.

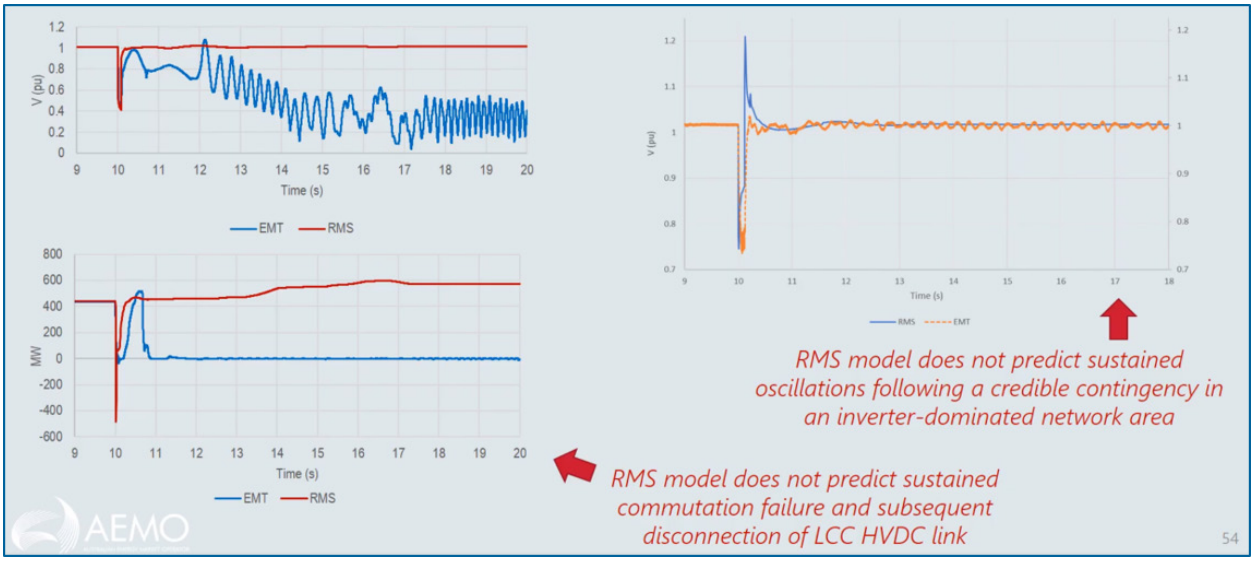
Increased research on energy storage and artificial intelligence projects in the energy and mobility sectors shaped our focus on developing advanced simulation technologies that can accurately model and analyze these complex systems.

To address the need for scalability and efficiency, we have developed a solution that enables parallel execution of simulation tests on multiple cloud simulators. This capability allows engineers and researchers to efficiently handle the computational requirements of large-scale electrification projects and expedite the development and deployment of innovative solutions.

As the world progresses towards a sustainable future driven by electrification, OPAL-RT remains steadfast in its dedication to providing innovative real-time simulation solutions that propel the industry forward. We take immense pride in being a driving force in this transformation, supporting engineers and researchers as they navigate the intricacies of electrification and contribute to shaping a greener and more efficient world.

Addressing the Pipeline of New Renewable Grid Connections

As the renewable energy sector continues to expand, the need for robust testing and simulation methods becomes increasingly critical. RMS-based modelling continues to fulfill the needs it was designed for in utility planning and operations, but the increasing complexity of fast switching power electronics leads to additional needs that can only be addressed by Electromagnetic Transient (EMT) simulations to ensure the reliability and stability of renewable power networks.



AEMO system strength workshop | https://aemo.com.au/en/learn/energy-explained/system-strength-workshop

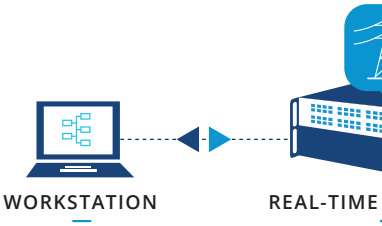
Solar PV Tripping and Modeling Capabilities and Practices		
Cause of Tripping	**Can be Accurately Modeled in Positive Sequence Simulations?**	**Can be Accurately Modeled in EMT Simulations?**
Erroneous frequency calculation	No	Yes
Instantaneous* ac overvoltage	No	Yes
PLL loss of synchronism	No	Yes
Phase jump tripping	Yes	Yes
DC reverse current	No	Yes
DC low voltage	No	Yes
AC overcurrent	No	Yes
Instantaneous* ac overvoltage—feeder protection	No	Yes
Measured underfrequency—feeder protection	No	No**

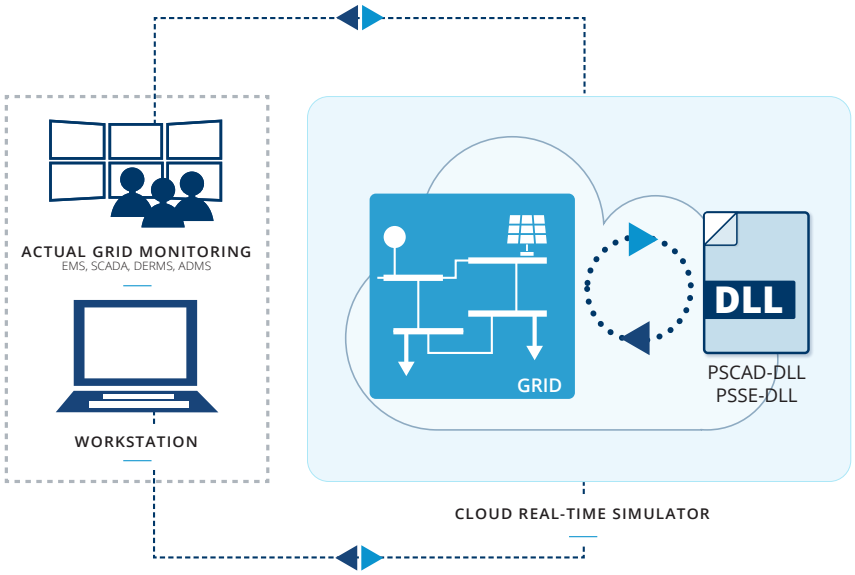
** Sub-cycle* ***Due to very limited protective relay models in EMT today*

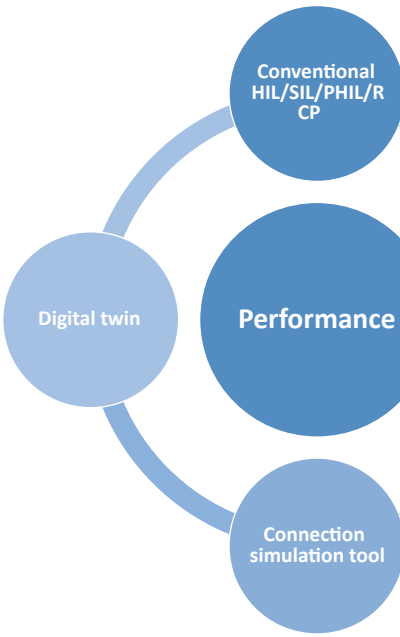
This was well supported by real-life examples in the System strength workshop hosted by the Australian Energy Market Operator (AEMO) in November 2020, as shown in table 1. It was further analyzed and reinforced by the North American Electric Reliability Corporation (NERC) in its Odessa Disturbance Report in September 2021, where they provided information over a series of inverter tripping causes that had been identified in the Odessa events and could not properly be modelling with RMS-centric tools.

Addressing the Pipeline of New Renewable Grid Connections (continued)

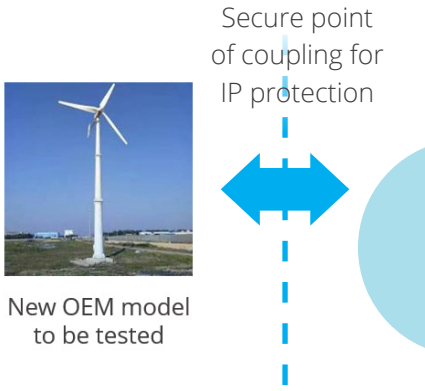
Many free-to-use and commercial tools exist to execute EMT simulations, but most pose challenges to efficiency due to their slow processing speed, lack of real-time capability, poor scalability and ease of use, or cover only a narrow range of applications. Only one simulation tool can pride itself on delivering performance in any of these aspects, offering fast and accurate accelerated and real-time simulations: HYPERSIM.

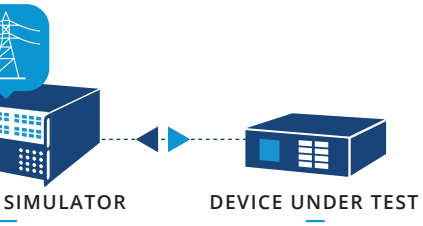




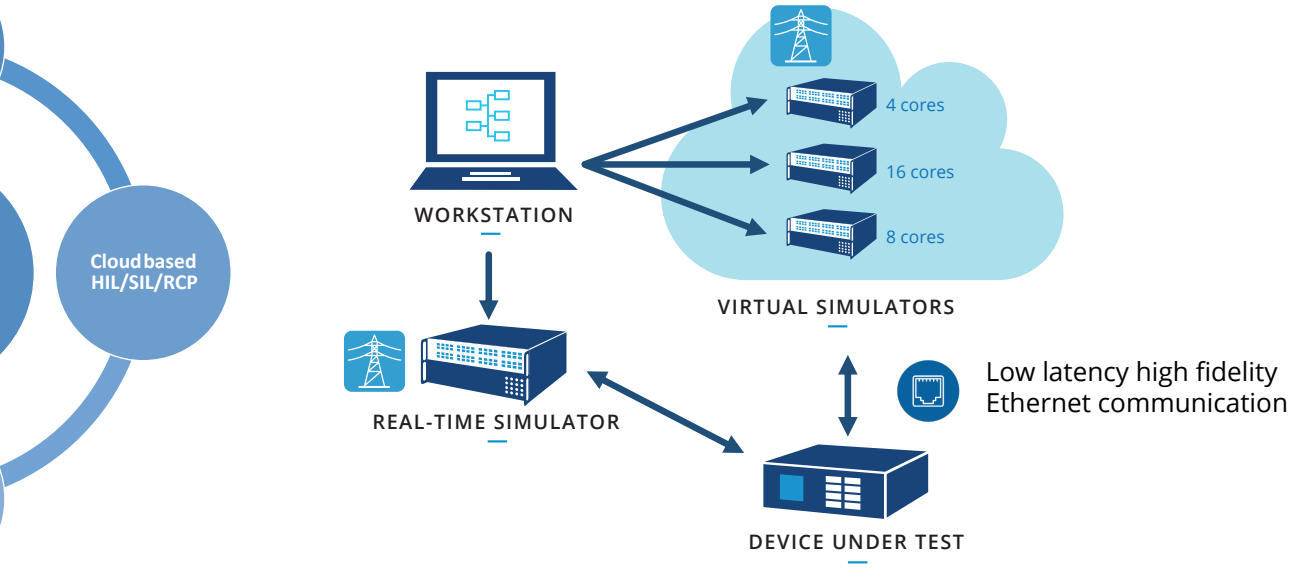


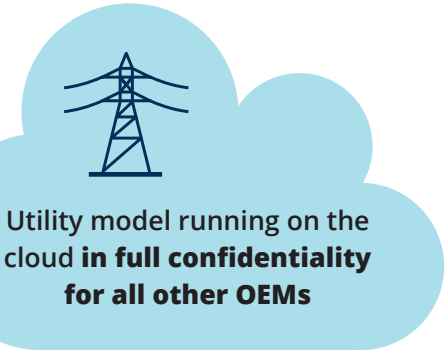
From its inception over 30 years ago at Hydro-Quebec research center (IREQ), HYPERSIM was designed to achieve an unequaled performance and has remained the undisputed leader throughout the years. This performance is what allows us now to push the boundaries of simulation beyond the conventional Software/Hardware-in-the-Loop, to help more engineers across all aspects of renewable design and integration, from converter topology and control validation, all the way to multi-vendor control interactions testing and large grid-scale studies.





The same performance will enable, among other things, cloud-based Software/Hardware-in-the-Loop, real-time and faster-than-real-time simulations for planning, and the full-scale digital twin to support grid operations, even including some or all manufacturer real code in the form of blackbox static/dynamic libraries. By leveraging cloud resources, engineers gain access to cutting-edge hardware technology and can perform simulations from anywhere in the world. This flexibility ensures that engineers are not limited by hardware availability or constrained by geographic boundaries.





As the renewable energy sector continues to evolve, the importance of robust testing and simulation cannot be overstated. HYPERSIM's disruptive approach aligns with its mission to revolutionize simulation and democratize access to high-end tools, providing engineers with fast and accurate results and paving the way for innovation in renewable energy testing. With its commitment to excellence and dedication to customer success, HYPERSIM plays a crucial role in ensuring the reliability and efficiency of future renewable power networks.

Product News | XG Series Upgrade

Check our HYPERSIM benchmark: Click here

Check our ARTEMiS benchmark: Click here

THE XG SERIES FOR UNMATCHED PERFORMANCE

Upgrade your real-time simulation experience with OPAL-RT's XG series. **Our cutting-edge OPAL-RT Linux 3.x 64-bits operating system, powered by Intel® and AMD latest technologies.** This powerful combination delivers an unmatched performance, empowering engineers to push the boundaries of development, testing, integration, and validation.

EXPERIENCE SIMULATIONS UP TO 2.5 TIMES FASTER!

The new XG series system can efficiently simulate larger and more complex power systems, power electronics, or microgrid models using fewer cores.

Scalable

Increase processing power, flexibility, and scalability. Experience higher accuracy with reduced time steps and benefit from up to 44 cores on a single simulator.

Performant

Experience high-fidelity simulations with exceptional accuracy and speed, advanced parallel processing, and maximum reliability with the latest motherboard and CPU.

Versatile

Seamlessly integrates with power electronics devices, control systems, and communication networks for comprehensive HIL and CHIL systems.

opal-rt.com/contact-sales-team/ for system assessment and upgrade recommendations.

Microgrid PHIL Test Bench (OP1420)

Real Power to Test Microgrid Applications

Quickly bring real-time simulated microgrids to the real world and extend their power busses into the lab to connect and test real power devices with Power Hardware in the Loop (PHIL). Don't know where to start? No problem. Each OP140 Real-Time Microgrid PHIL Test Bench comes with a validated generic microgrid model, detailed DER models and a generic microgrid controller, readily configured for PHIL emulation.

Trustworthy

Made to ensure closed-loop stability, accuracy and high bandwidth PHIL.

Turnkey

Save time and money with an intuitive, ready-to-use solution.

Safe

Turnkey PHIL systems designed with user safety in mind.

SOFTWARE

Compatible with RT-LAB (Simulink® based) and HYPERSIM software platforms, users are able to bring complex microgrid models to life in their lab in a few easy steps.

REAL-TIME SIMULATOR

The OP1420 operates with a Real-Time Simulator featuring a generic microgrid model to help users get started as quickly as possible. Simulators contain multiple processors and a powerful FPGA capable of digitally simulating complex microgrids and power converter systems.

MICROGRID BUS BAR & POWER METER PANEL

Safely interface various equipment to a PHIL node. It supports three-phase interfacing via laboratory 4 mm banana plugs/sockets. In addition, it comes with an accurate power meter panel with integrated on-board LCD display that gives users a realtime visual of the electric quantities of the busbar branches.

PHIL 4Q POWER AMPLIFIER

It includes up to 3 three-phase, high-frequency amplification units of the 4Q power amplifiers designed for PHIL applications involving grid, energy source and/or DER emulation. The Power Amplifiers connect directly to the Real-Time Simulator via optical link for low latency operation.

Check our PHIL web app:
Click here

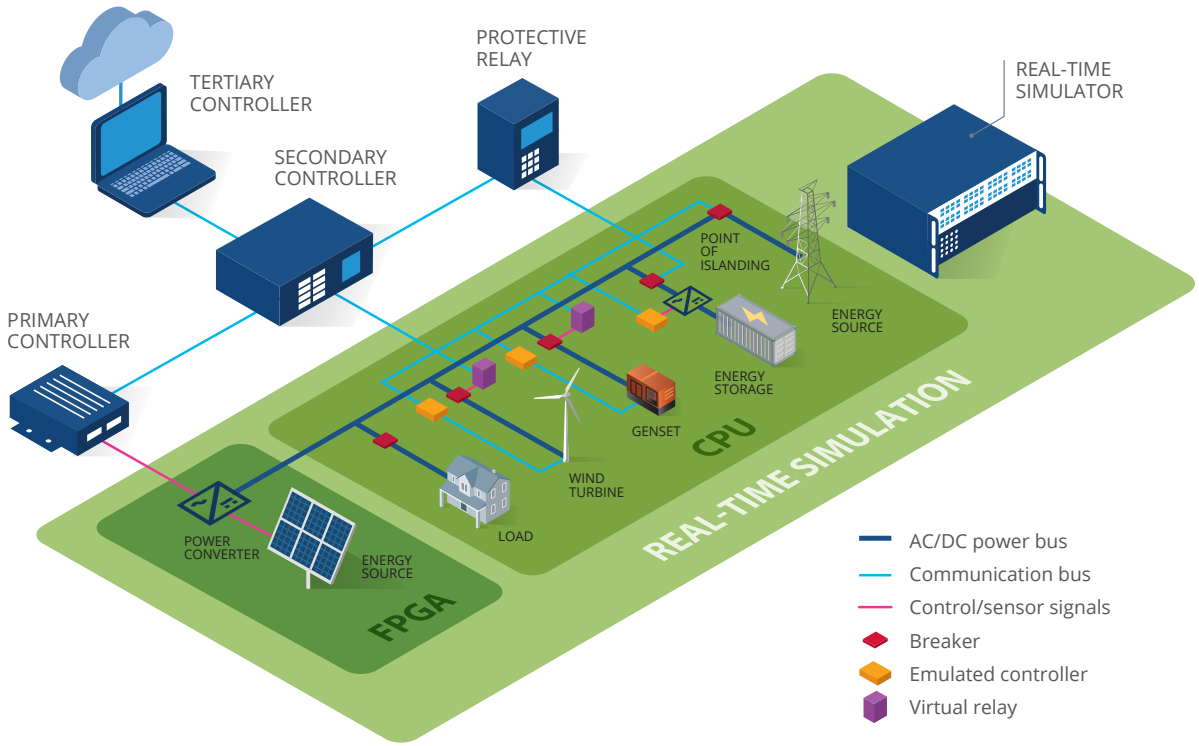
Assessing the Effectiveness of Grid-Forming Smart Inverters in Islanded Microgrids

The emergence of renewable energy sources has paved the way for the development of microgrids, which offer localized power generation, improved reliability, and increased resilience. In islanded microgrids, where the connection to the main grid is intentionally severed or unavailable, the challenge lies in maintaining stable and reliable power supply. To address this, grid-forming smart inverters have emerged as a promising technology.

One of the most significant challenges in islanded microgrids is maintaining stable voltage and frequency. Grid-forming smart inverters tackle this challenge by employing advanced primary and secondary control algorithms that can for instance emulate the behavior of conventional synchronous generators. Proper microgrid design can combine both grid-forming and grid-supporting inverters to provide the necessary grid stability, with voltage and frequency regulation, reactive power control, and fault ride-through capabilities.

Watch the demo "Innovative Software-in-the-Loop (SIL) Testing Tools for Grid-Forming Converter Control" Click here

Grid-Forming Inverters: The Key to Islanded Microgrid Stability



Challenges and Considerations

While grid-forming smart inverters offer significant benefits, their integration in islanded microgrids comes with challenges. Compatibility issues with existing infrastructure, standardization of control protocols, and cybersecurity concerns are some of the factors that need to be addressed for widespread adoption. Additionally, thorough testing and validation are essential to ensure the effectiveness and reliability of these inverters under various operating conditions.

OPAL-RT's Innovative Smart Inverter Control Library

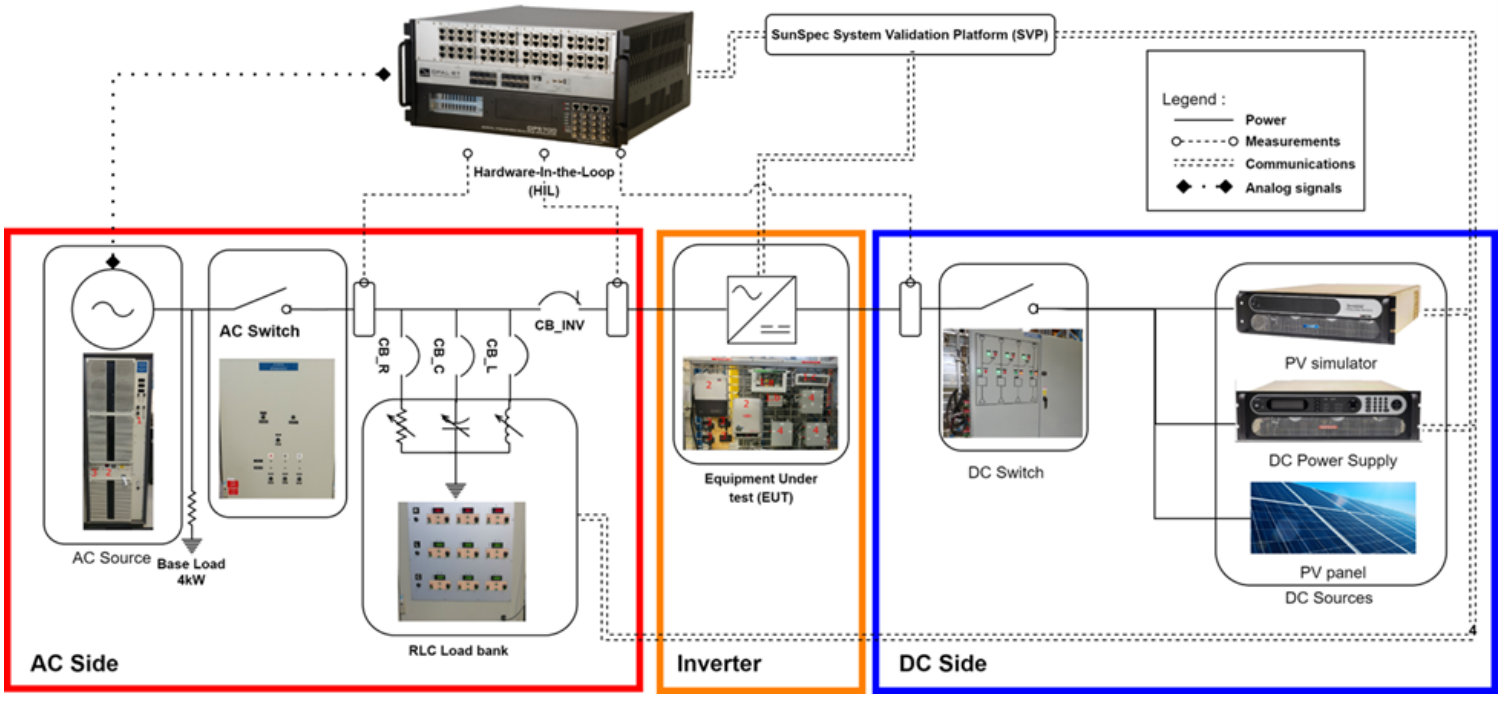
The simulation world facing a lack of standardized modular control and protection capability, OPAL-RT was proud to partner with CanmetENERGY to be the first to provide engineers with a cutting-edge solution to these challenges, a MATLAB-Simulink-based Smart Inverter Control Library, available through RT-LAB and ARTEMiS. Based on the requirements of IEEE Std. 1547-2018, it enables the development of control and protection algorithms for both grid-forming and grid-support inverters, and can be used both for offline and real-time simulations.

LIBRARY CONTENT

- Wave reference
- Secondary control
- Protection system
- Primary control
- Signal conditioning

APPLICATIONS

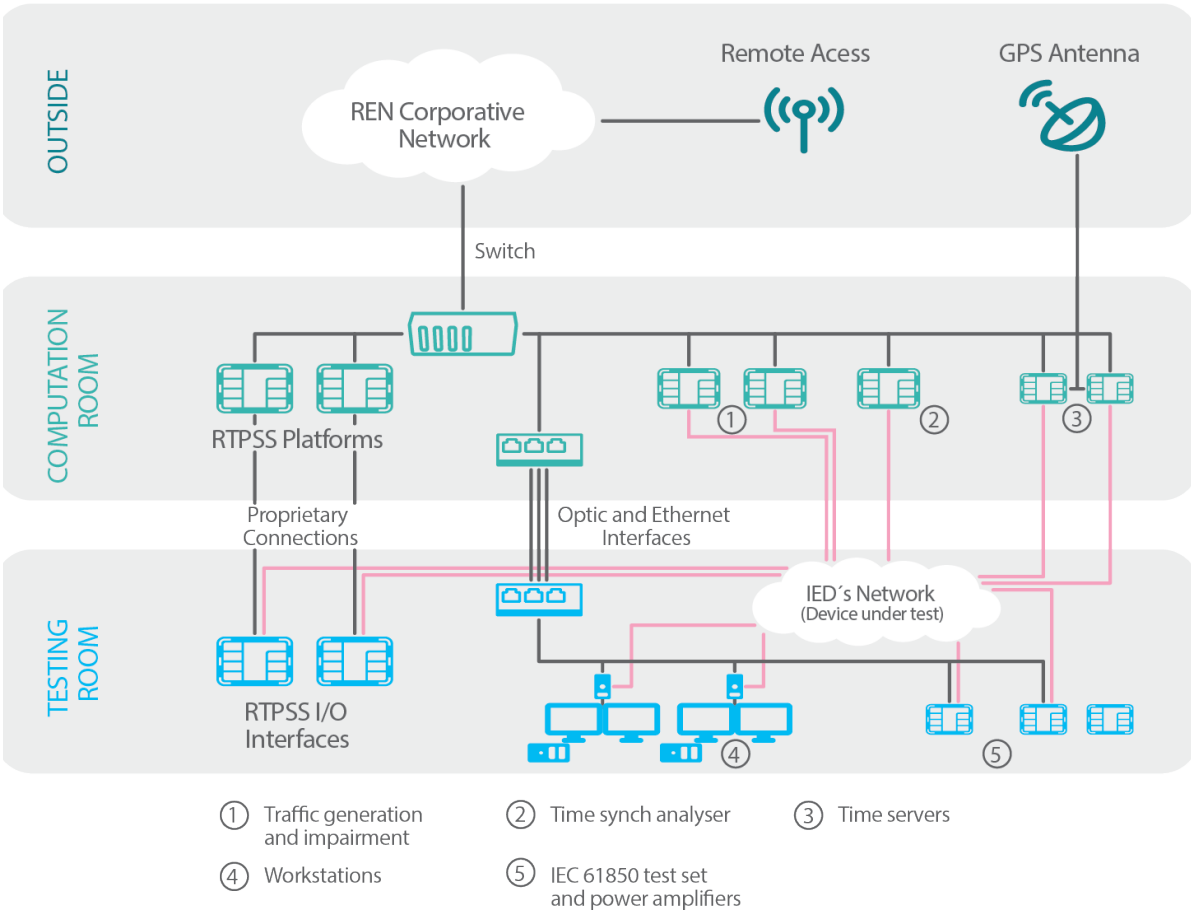
- Rapid control prototyping and validation of islanded microgrids
- Interaction studies
- Frequency/voltage stability assessment in islanded microgrids
- Transient response
- IEEE 1547-2018 standard compliance



Success Story R&D Nester - Revolutionizes Power Systems through Real-Time Simulation

R&D Nester, in collaboration with OPAL-RT, is at the forefront of innovation in power systems. By harnessing real-time simulation technology, R&D Nester addresses the challenges posed by the integration of inverter-based energy resources, the need for environmentally friendly systems, and the demand for energy storage solutions. Their partnership has resulted in the establishment of a Real-Time Power System Simulation (RTPSS) Laboratory, enabling comprehensive research and analysis.

In the ever-evolving power system landscape, energy producers and distributors face continuous challenges. The integration of digital solutions, smart grids, and the demand for eco-friendly and efficient systems require new solutions. Additionally, the digitalization of power systems necessitates scalability, processing power, and co-simulation capabilities. Recognizing these needs, R&D Nester established the RTPSS Laboratory—a state-of-the-art facility equipped with real-time power system simulators. Supported by diverse hardware and software tools, this laboratory enables simulation of power systems and communication networks. By analyzing complex scenarios, it facilitates the development of innovative solutions to address these challenges.



"We at R&D Nester have been very satisfied not only with their software and hardware, but also with their support. We have been using OPAL-RT real-time solution for many years, and their knowledge, responsiveness and commitment are very professional."

Nuno de Souza e Silva, currently Executive Board Member at R&D Nester, the Research Center for Energy from REN and State Grid working under the motto "Creating a Smart Energy Future", dealing mainly with international project on Renewable Energy integration, Smartgrids, Power Systems simulation and Energy Markets.

The establishment of the RTPSS Laboratory has revolutionized R&D Nester's capabilities in power system research. Through the use of real-time simulation technology, R&D Nester has successfully tackled complex projects. The laboratory's applications include prototype development, product testing, protection system evaluation, modeling, scenario simulation, and co-simulation of power systems and communication networks. This accelerated pace of research and development propels the industry towards a smarter and more sustainable energy future.

In conclusion, R&D Nester's partnership with OPAL-RT and the RTPSS Laboratory positions them as leaders in power system innovation. Through real-time simulation, they address challenges in integrating renewable energy and developing environmentally friendly systems. The RTPSS Laboratory enables groundbreaking research and comprehensive testing. Join us at RT23 in Lisbon this November to visit R&D Nester's installations and witness their contributions to an efficient and sustainable energy landscape. Details at the end of the magazine.

Recent contributions to national and international projects

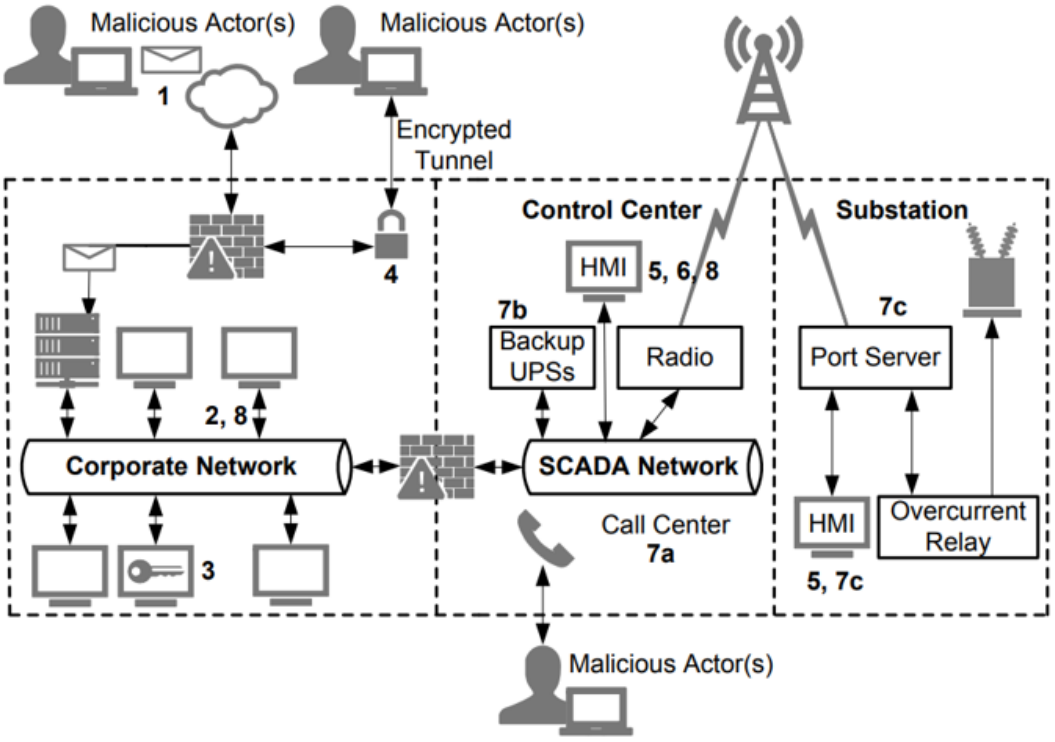
ProtMPLS: assess the use of IP/MPLS communication for protection systems

Prot4HRES: assess the impact of renewable sources in the design of the protection systems for transmission grids

OSMOSE (Horizon 2020): identify and develop the optimal mix of flexibilities for the European power system to enable the Energy Transition

Ukraine Power Grid Attack: Unveiling Cyber Resilience through Network Digital Twins

In today's relentless era of cyber warfare, organizations across diverse sectors are increasingly targeted by high-profile attacks. Ukraine has experienced several high-profile cyber-attacks in recent years, with one notable example being the 2015 attack on its power grid that caused widespread power outages lasting up to six hours. Operators faced difficulties regaining control over 50 affected substations. Simultaneously, the attackers initiated a denial-of-service attack on the telephony system, further hampering communication.



"Ukraine Cyber-Induced Power Outage: Analysis and Practical Mitigation Strategies"

by David E. Whitehead, Kevin Owens, Dennis Gammel, and Jess Smith Schweitzer Engineering Laboratories, Inc

SEQUENCE OF EVENTS

1. Email phishing
2. Reconnaissance and enumeration of the network to provide an initial backdoor
3. Discovery and access to servers containing user accounts and credentials
4. Encrypted tunnel to get inside control system networks
5. Discovery and access to SCADA HMI due to improperly configured firewall
6. Control override of HMI operators and breaker opening command
7. Several other actions complicating the responses of control operators
8. KillDisk malware attempting to wipe out the control center workstations.

Watch the webinar: Click here

This attack showcased the attackers' high levels of sophistication and expertise, demonstrating a coordinated effort. Restoring power required manual intervention by technicians at the substations. Investigation of the incident revealed corrupted firmware in serial-to-Ethernet converters, remote deactivation of uninterruptible power supplies, and corrupted hard drives in multiple computers. This event serves as a landmark case, emphasizing the need to address vulnerabilities and enhance critical infrastructure security.

Together, Keysight's EXata CPS and OPAL-RT's RT-LAB and HYPERSIM electrical grid simulators remain the first and only comprehensive modeling and simulation platform designed to address both malicious and accidental cyber-threats. Leveraging network digital twins, this partnership provides organizations with invaluable insights into both malicious and accidental cyber threats. Research could be conducted to strengthen cyber defenses and effectively manage the risks associated with persistent cyber-attacks. This collaboration marks a significant step towards achieving a new era of cyber resilience, where knowledge becomes power and preparedness is paramount.

ACCIDENTAL THREATS

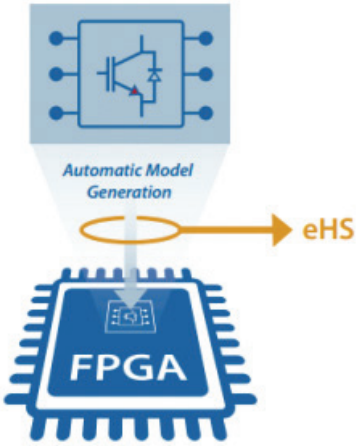
- Software and hardware failures (crashes, bugs)
- Human errors:
  - Misconfiguration of server hardware, OSes, applications and devices
  - Failure to upgrade or right-size servers to accommodate more data and compute intensive workloads
  - Failure to upgrade outmoded applications that are no longer supported by the vendor
  - Failure to keep up to date on patches and security
  - Overburdened IT departments, lack of training, etc.

KEYSIGHT TECHNOLOGIES

Pioneering Real-Time Power Electronics Simulation for the Electrified World

In an era where power system electrification is on the rise, the requirements for power electronics have become increasingly demanding, encompassing aspects such as efficiency, loss reduction, and power density. OPAL-RT has been at the forefront of FPGA simulation for over 20 years and continues to innovate to meet the demands of the power system industry.

eHS leverages FPGA technology to enable high-fidelity Hardware-In-the-Loop (HIL) simulation with sub-microsecond time steps. By eliminating the complexities associated with FPGA coding, eHS allows users to transition seamlessly from circuit modeling to FPGA implementation in a matter of seconds. This eliminates the need for mathematical modeling, VHDL programming, or FPGA expertise on the part of the user.



Redefining speed, power and accuracy of real-time FPGA simulations

The latest fifth generation of eHS introduces significant improvements in speed and resolution, resulting in faster and more accurate outcomes, pushing the boundaries of FPGA computational performance to achieve maximum resolution. With a minimum time step of 90 ns and a resolution of 625 ps on the gating events, it stands as the world's fastest real-time simulation platform for grid and power electronics applications.

No decoupling

Avoid instabilities and the manual struggles of artificially decoupling networks. Run up to 21 3-phase converter models (128 switches) or 250 grid nodes @ 500 ns on the same FPGA core.

FPGA cores scaling

Have larger models or need to run faster? Efficient parallelization algorithms ensure you can connect multiple FPGA-based simulators.

Picosecond Oversampling

625ps oversampling with interpolating converter models ensures the highest sampling resolution and accuracy available.

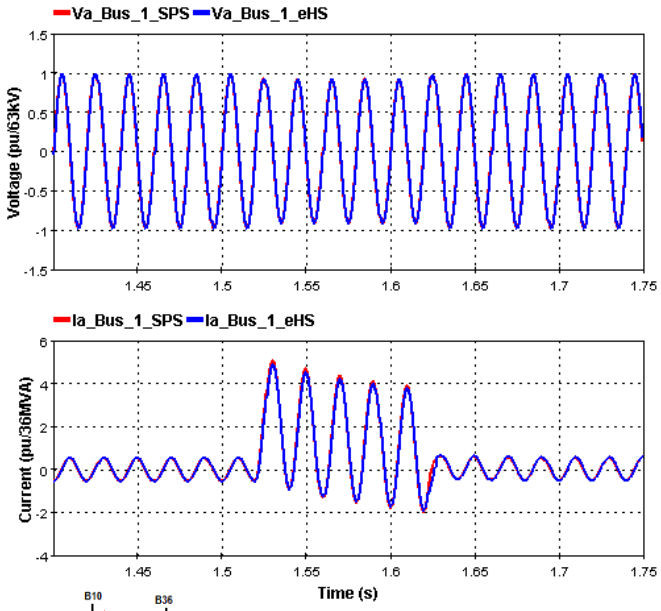
Co-simulation ready

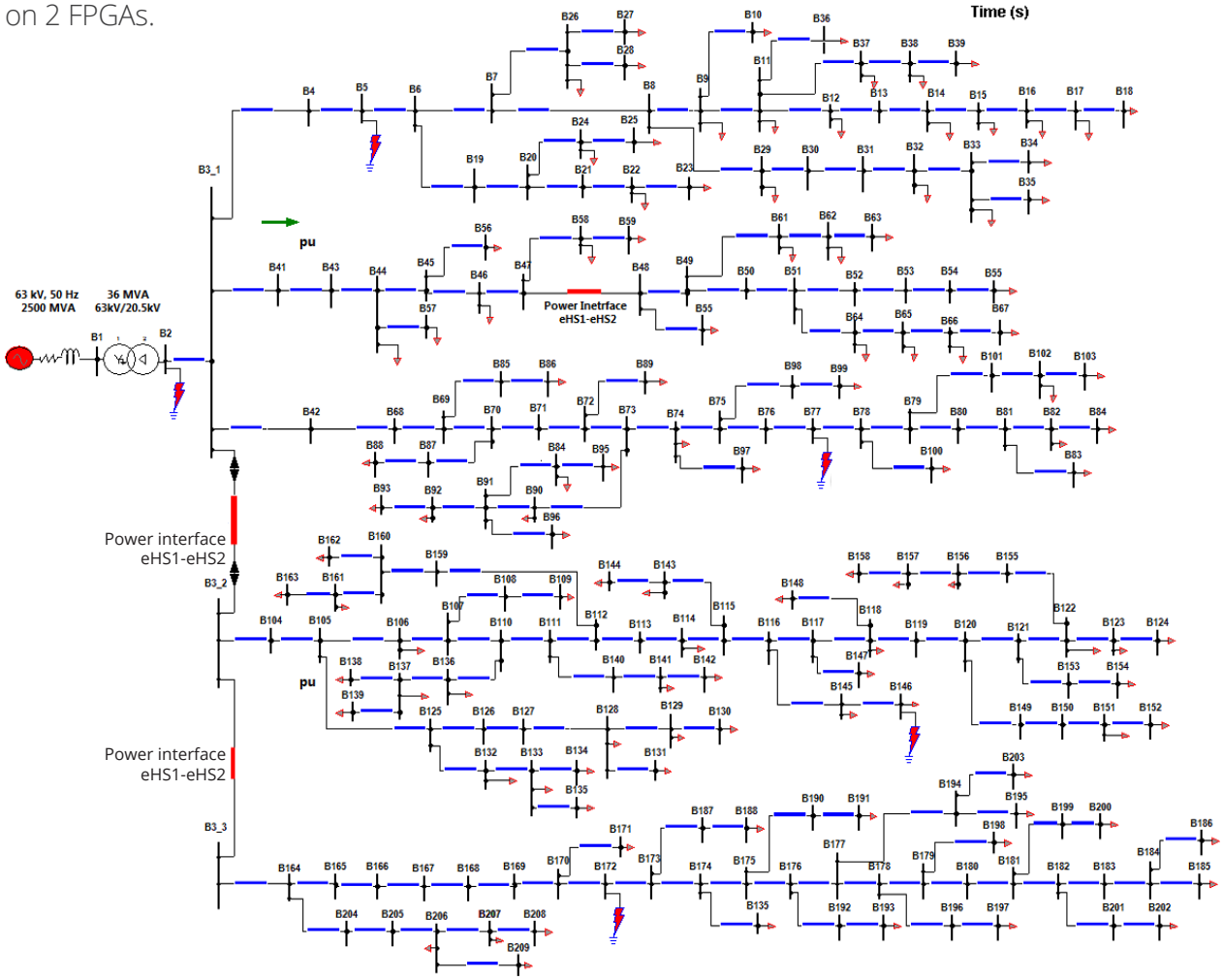
Combine performance and capability, reserving the FPGA for high-frequency switching modeling, and CPU for larger network system simulation.

eHS Gen5 not only excels in simulating user-defined resonant converter topologies with switching frequency up to 250 kHz in real-time, but it can also easily achieve up to 500 kHz for user-defined VSC applications. Furthermore, the platform's performance can surpass real-time capabilities through parameter scaling.

For users looking for scalability beyond power electronics, eHS supports efficient parallelization algorithms, facilitating the connection of multiple FPGAs using high-speed optical cables without compromising time step or performance. This remarkable capability sets eHS apart, especially when compared to competitors utilizing eight cores per FPGA, requiring extensive decoupling. In the 630-node circuit example below, eHS Gen5 surpasses its predecessor by a factor of 6x, bringing the time step down to only 500 ns on 2 FPGAs.

SPS offline simulation vs eHSx128





RT23

YOUR IDEAS
OUR ENERGY

INFORMATION AND REGISTRATION

opal-rt.com/rt23

NOV | 13-16 | 2023

Lisbon, Portugal

Join us at OPAL-RT's 15th annual conference on real-time simulation.

FEATURING

- Hands-on workshops
- Keynotes & Technical Presentations
- Galas
- Activities to discover the city of Lisbon

CO_2 REDUCTION CONTEST

A chance to win a trip to Lisbon, Portugal and a ticket to the RT23 conference

Apply by July 31st, 2023
opal-rt.com/co2-reduction-rt23

Scan the QR code and
REGISTER

OPAL-RT TECHNOLOGIES

Empowering a Greener Future through Electrification

In the quest for a sustainable future, electrification plays a pivotal role in reducing carbon emissions and fostering a greener world. Electrification is not just a trend but a transformative force driving environmental sustainability. The company has wholeheartedly embraced this vision and made it an integral part of everything we do and build. Our expertise lies in providing cutting-edge real-time simulation solutions for electrification-based systems, such as electric vehicles, renewable energy integration, and smart grids. By focusing on these critical areas, we actively support the electrification revolution that is reshaping our energy landscape.

Innovation is one of our most defining values. By harnessing advanced technologies, such as high-performance computing and real-time simulation, we enable the development and testing of electrification solutions with unmatched accuracy and efficiency. These innovative tools allow engineers and researchers to model, simulate, and optimize complex electrified systems in a virtual environment. This simulation-driven approach not only accelerates the development process but also reduces costs and minimizes the need for physical prototypes, thereby fostering a more sustainable and resource-efficient approach to electrification. This capability is especially vital in the rapidly evolving landscape of electric mobility, renewable energy, and smart grid integration. By leveraging real-time simulation, we facilitate the development and deployment of advanced control algorithms, energy management systems, and grid integration strategies that are essential for a sustainable and resilient energy future.

Looking ahead, we anticipate even greater integration of electric vehicles into our transportation systems, with improved powertrain efficiency, longer battery life, and expanded charging infrastructure. Furthermore, as renewable energy sources continue to gain traction, we envision seamless integration into existing grids, enabling a more robust and resilient energy infrastructure. With real-time simulation as our guiding force, we are proud to help shape a future where electrification drives sustainable development and paves the way towards a cleaner, greener, and more sustainable world.

Be part of the change by participating in our CO2 reduction contest for a chance to win a trip to Lisbon, Portugal (only for people in the academic sector): Click here

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 and HYPERSIM, 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 models specialized for accurate simulation of power electronic systems and electrical grids. RT-LAB, HYPERSIM and OPAL-RT solvers and models are integrated with advanced field programmable gate array (FPGA) I/O and processing boards to create complete solutions for RCP and HIL testing.

OPAL-RT TECHNOLOGIES

OPAL-RT CORPORATE HEADQUARTERS

1751 Richardson, Suite 2525 | Montréal, Québec, Canada | H3K 1G6
Tel: 514-935-2323 | Toll free: 1-877-935-2323 | Fax: 514-935-4994

U.S.A.
OPAL-RT Corporation
2532 Harte Dr
Brighton, MI
48114, USA
Phone: 734-418-2961
Toll free: 1-877-935-2323
Fax: 1-866-462-5120

EUROPE
OPAL-RT Europe S.A.
196 Houdan Street
Sceaux, Hauts-de-Seine
92330, France
Tel: +33 1 75 60 24 89
Fax: +33 9 70 60 40 36

GERMANY
OPAL-RT Germany GmbH
Bucher Straße 100
Nürnberg
90408, Germany
Tel: +49 911 38 44 52 02

INTELLIGENT TRANSPORTATION SYSTEMS
OPAL-RT Intelligent Transportation Systems
10 Boulevard Vivier Merle
Lyon
Auvergne-Rhône-Alpes
69393, France
Tel: +33 7 60 80 36 14

INDIA
OPAL-RT Technologies India Pvt. Ltd.
648/A-4/5, 2nd Floor,
OM Chambers,
100 Feet Road
Indiranagar 1st Stage
Bangalore, Karnataka
560038, India
Tel: 080-25200305

BRAZIL
OPAL-RT Brazil
Alameda Rio Negro
503. 23º andar
Barueri, São Paulo
06454-000, Brazil
Tel: +55 11 2110-1833

U.S.A.
OPAL-RT Corporation USA – Colorado:
10200 W 44th Avenue,
Suite 239
Wheat Ridge, Colorado
80033, USA
Tel: +1 877 935 2323

POLAND
OPAL-RT Poland
E. Plater 28, 00-688 Warsaw,
Poland
Tel: +48 12 429 41 01

CHINA
OPAL-RT China
Unit 608, 6/F Zhongyu Mansion
No. 6 North Workers' Stadium Road,
Chaoyang District,
Beijing 100027, China
Tel. 0086 10 56617026

WWW.OPAL-RT.COM