success story

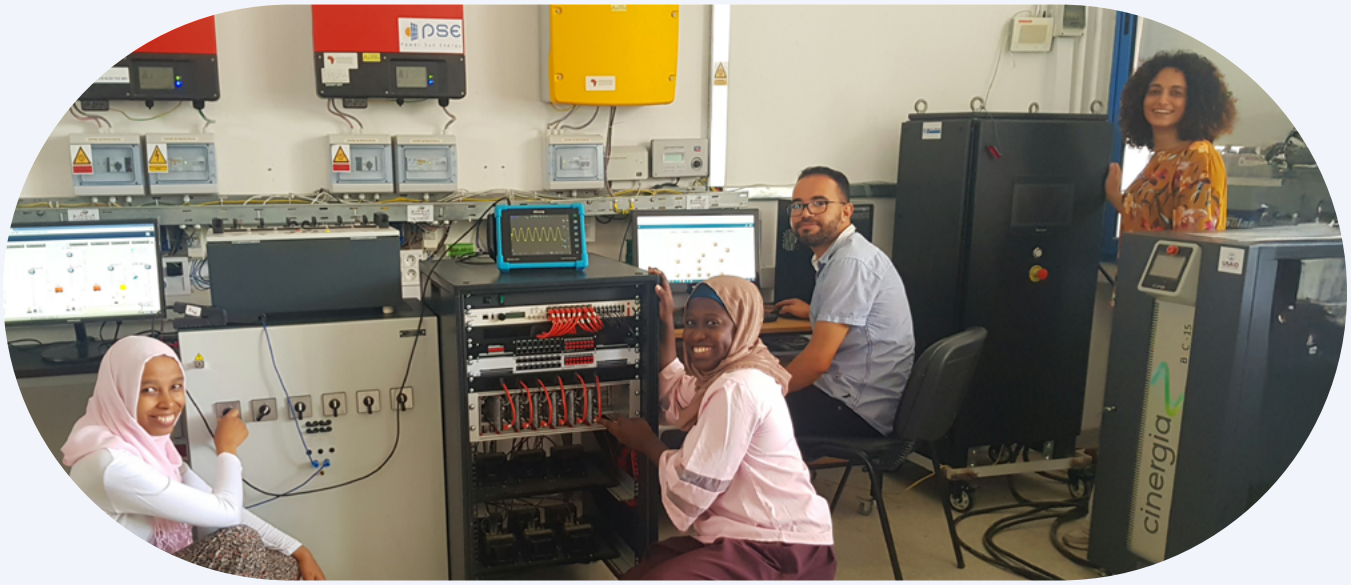
ENIT Enhances Renewable Hosting Capacity with Real-Time Simulation

A success story with the National Engineering School of Tunis (ENIT)

opal-rt.com

OPAL-RT TECHNOLOGIES

Executive Summary



The National Engineering School of Tunis (ENIT) is accelerating Tunisia's energy transition by advancing research into smart grids and renewable integration. By leveraging OPAL-RT's real-time simulation technologies, ENIT has developed a flexible and powerful platform to test inverter control, EV integration, and grid hosting capacity under realistic conditions, all without relying solely on expensive physical testing.

Customer Profile

ENIT is a leader in energy systems research and education. Its MICROGRID platform supports Tunisia's transition toward smart grids by enabling testing, validation, and innovation in renewable energy integration and power electronics.

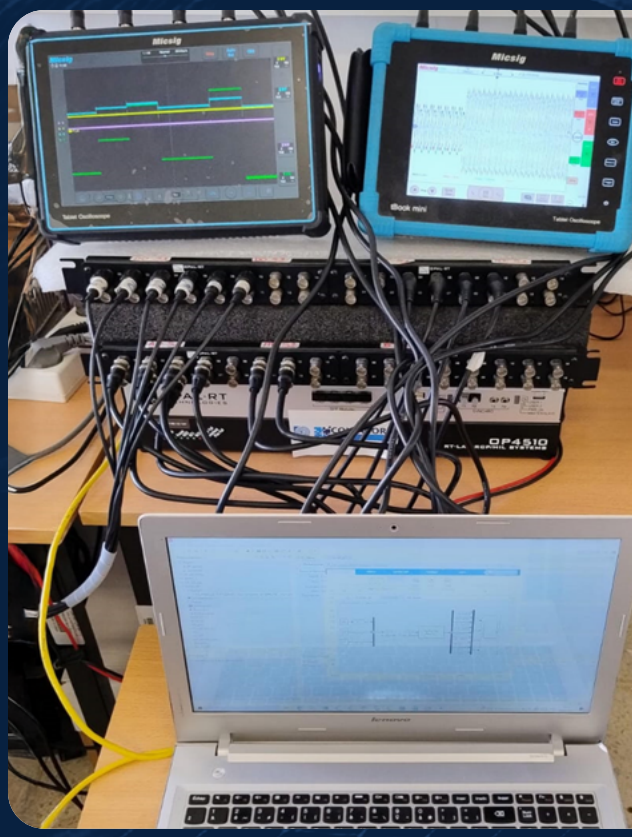
> ENIT chose OPAL-RT for its ability to Simulate complex systems with detailed switching behavior.

CHALLENGE

With photovoltaic (PV) and battery storage systems growing rapidly in Tunisia, the distribution grid faces new challenges:

- Understanding impacts of inverter-based resources (IBRs) on power quality and stability
- Increasing hosting capacity for renewables and electric vehicle (EV) chargers
- Developing advanced control strategies and validating them under realistic conditions

Physical testing alone was limited by cost, complexity, and flexibility. ENIT needed a scalable, precise way to simulate diverse scenarios—from LCL resonances to EV load surges—while accelerating prototyping.



> OPAL-RT's real-time simulator has been central to our research at ENIT since 2020. It enables rapid control prototyping and CPU-FPGA co-simulation, especially for power electronics and renewable integration in microgrids. The platform continues to drive our innovation in power systems.

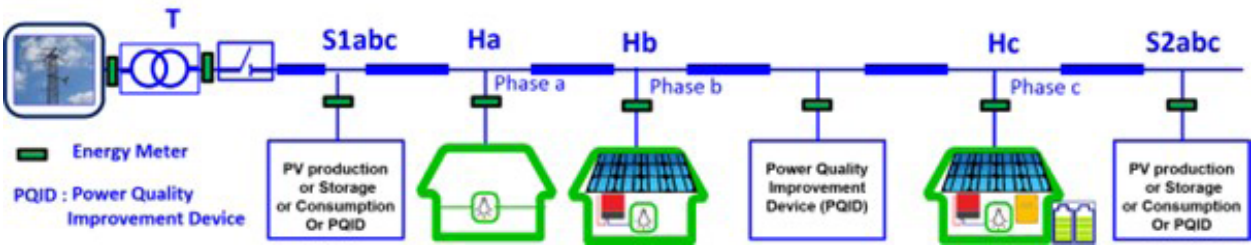
Dr. Manel Jebali Ben Ghorbal
Associate Professor at ENIT

MANEL JEBALI
BEN GHORBAL

SOLUTION

ENIT integrated OPAL-RT's OP4510 real-time simulator and eHS/ARTEMiS toolchains into the MICROGRID platform. This enabled:

- Real-time simulation, HIL, C-HIL, SIL, and PHIL testing
- FPGA-CPU co-simulation for high fidelity and low latency
- Modular platform with two 15 kVA microgrids (single- and three-phase), 16 kW
- PV, 7.2 kWh lithium-ion storage
- Load, PV, battery, and network emulators
- Integration with real hardware such as Imperix, Cinergia and TeknoCEA converters



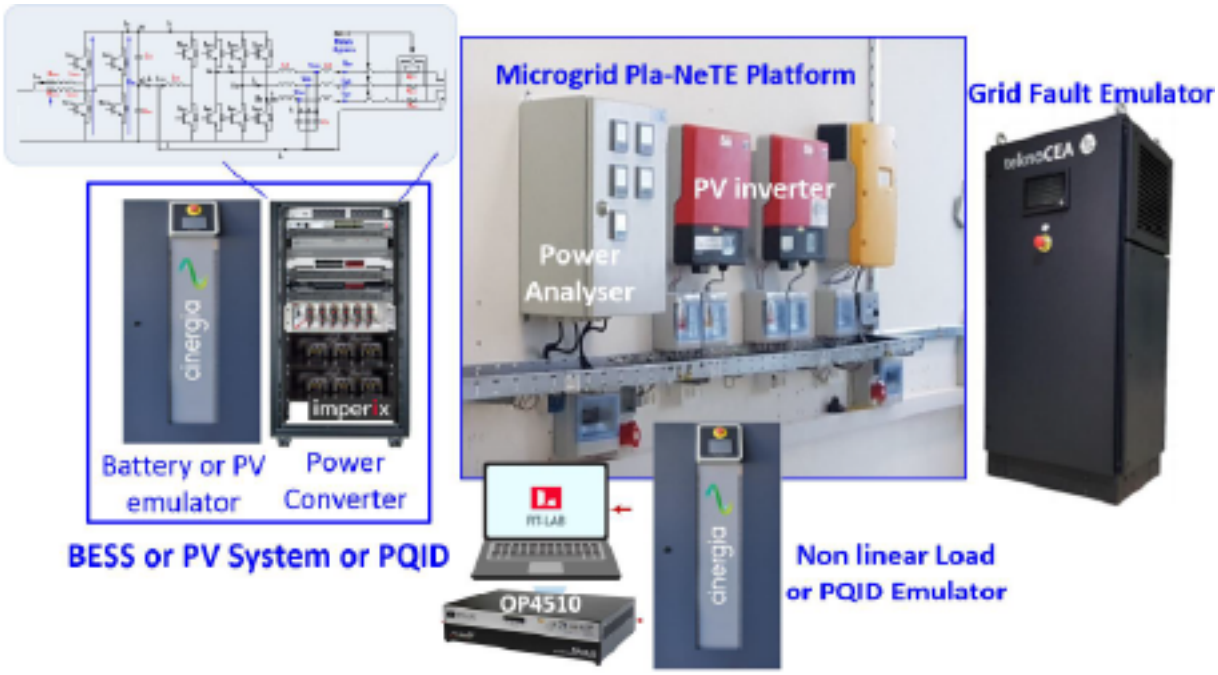
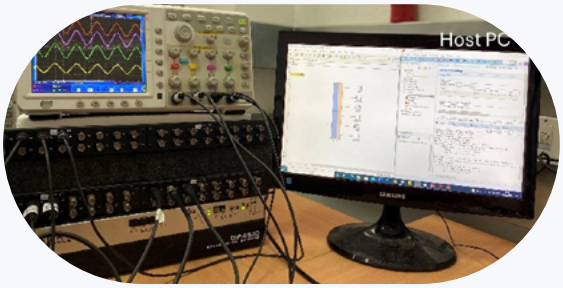


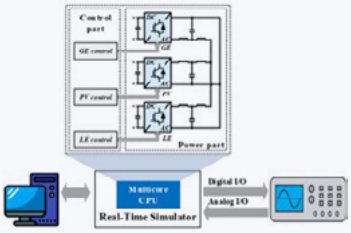
Figure 1. Pla-NeTE microgrid configuration showing modular integration of PV, storage, and emulators, powered by OPAL-RT

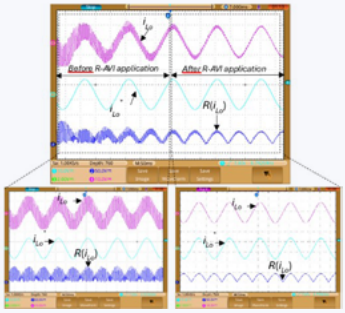
RESULTS

ENIT achieved impactful research outcomes across multiple use cases:

Case 1: Adaptive Inverter Control



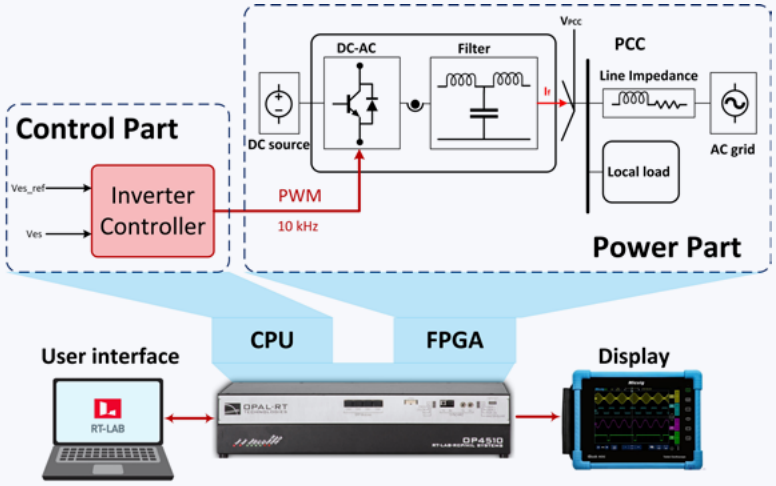


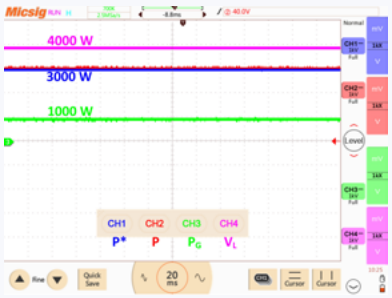


Developed adaptive virtual impedance control for mitigating LCL filter resonances, improving power quality and system stability.

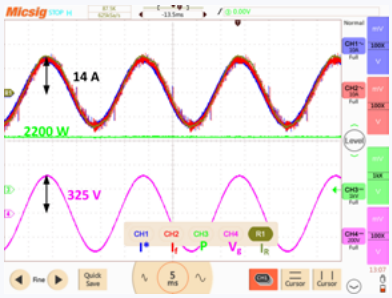
Case 2: Digital Twin for Prosumers

Created a SIL-based digital twin simulating a PV-powered prosumer microgrid, enabling rapid validation of control strategies.





Power flow considering resistive load



Comparison between real value and real-time simulation results

Figure 2. Real-time resonance mitigation using adaptive virtual impedance control in LCL filter configurations.

Case 3: Voltage Stabilization via Electric Spring (ES)

Modeled and validated ES devices to stabilize voltage under varying grid conditions, enhancing demand-side management.

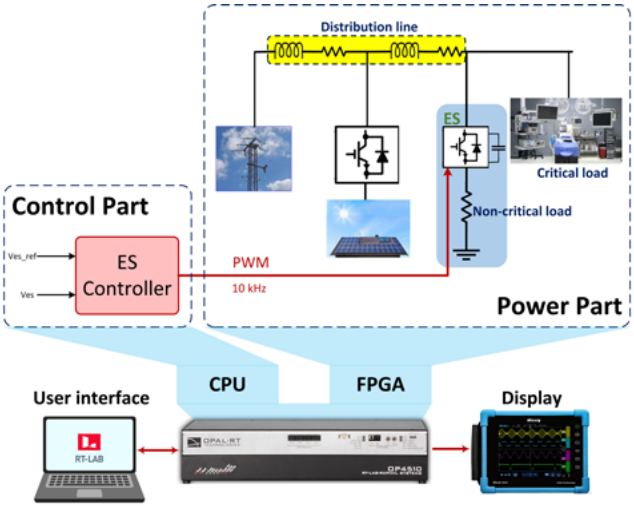
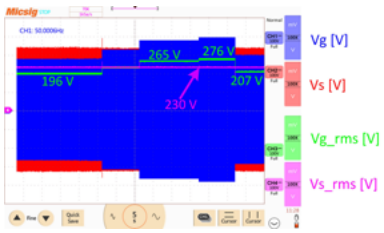
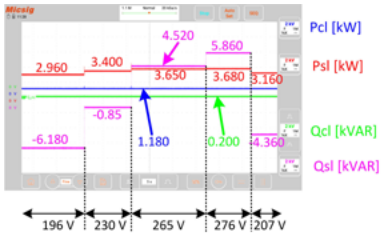


Figure 4. Voltage profile correction using Electric Spring (ES) control for demand-side voltage stabilization.



Voltage supply regulation with grid voltage variation



Smart load and critical load power variation

Case 4: EV Charger Co-Simulation

Simulated a 3.7 kW onboard EV charger with power factor correction, ensuring accurate transient behavior under variable loads.

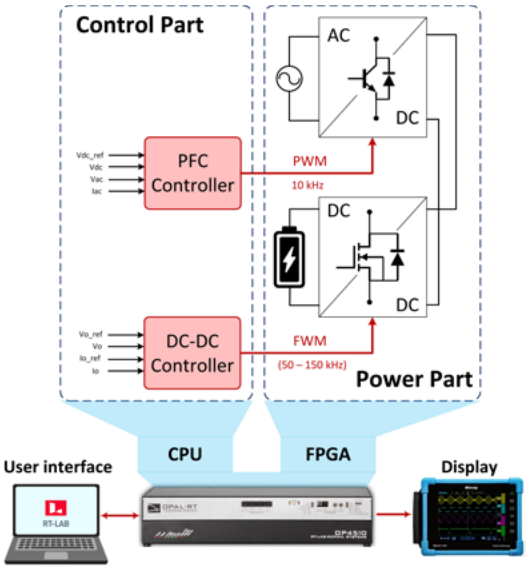
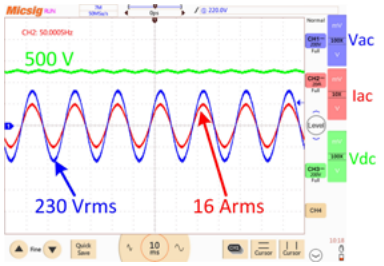
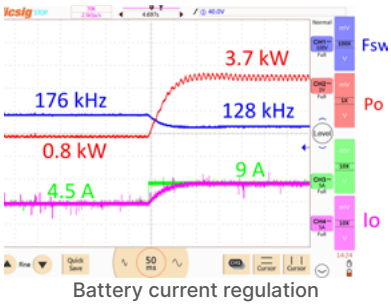


Figure 5. Real-time co-simulation of EV on-board charger with power factor correction under variable load.



DC bus voltage regulation and PF correction



Battery current regulation

Key research projects

ENIT's achievements were part of several national and international initiatives focused on smart grid transformation:

- PV-NeTE: A PHIL-based platform for exploring new PV technologies
- IRoN: Research on rooftop PV integration and its grid impacts
- N-TeQ: Development of microgrid strategies for dynamic power quality

Why ENIT chose OPAL-RT

ENIT chose OPAL-RT for its ability to:

Simulate complex systems with detailed switching behavior.

Model grid faults and multiple IBRs, EV chargers, and storage under varying scenarios

Leverage real-time co-simulation (FPGA + CPU) and flexible hardware-in-the-loop architectures

Integrate seamlessly with physical equipment (Imperix, Cynergia) for hybrid testing

Looking ahead

ENIT plans to deepen research by integrating Imperix 20 kVA converters with OP4512 for advanced PHIL experiments, testing configurations such as BESS (Battery Energy Storage Systems), PQID (Power Quality Improvement Devices), and PV emulators in real time within the Pla-NeTE plateforme.

Ready to innovate?

For over two decades, OPAL-RT TECHNOLOGIES has been a global leader in real-time simulation and hardware-in-the-loop (HIL) testing. Since 1997, OPAL-RT has empowered engineers and researchers with accessible, innovative, and customized simulation technology—bridging the gap between modeling and real-world applications. By leveraging high-performance computing, OPAL-RT accelerates the development of advanced solutions in energy, automotive, aerospace, and beyond. With our ISO 9001:2015 certification and a strong commitment to sustainable development, we're not just developing technology—we're building a better future, together.

Explore our other success stories

Discover how industry leaders achieve engineering excellence with OPAL-RT's solutions.

OPAL-RT TECHNOLOGIES

opal-rt.com