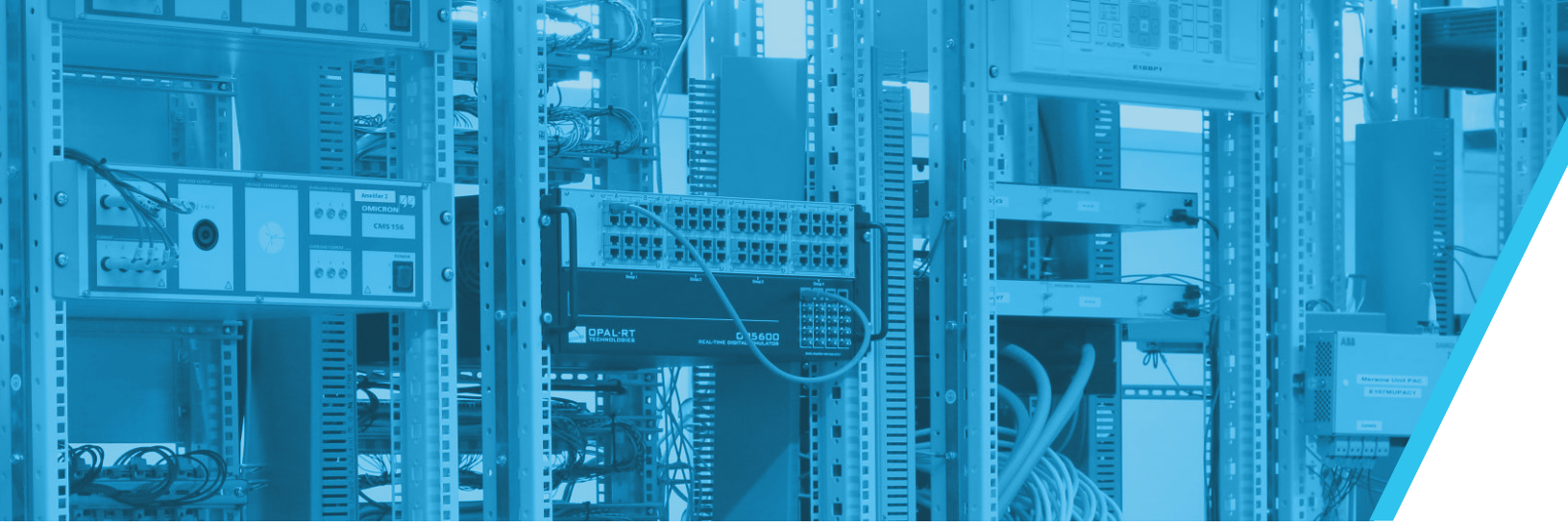


OPAL-RT TECHNOLOGIES

HIL SIMULATION FOR THE SUBSTATIONS OF THE FUTURE

R&D
NESTER

Application

- Smart Grids

Related Products

- HYPERSIM
- RT-LAB
- ARTEMiS
- ePHASORSIM

Type of Simulation

- Hardware-in-the-Loop (HIL)

SUCCESS STORY

INTRODUCTION

OPAL-RT's clients are widely diverse, and among them there are numerous respected research labs, intensive state-sponsored R&D efforts, and multi-partner collaborations that are changing the world we live in for the better through reaping the hard-earned benefits of modern engineering. Universities, industry, and local efforts are almost always involved in these efforts—and with the collaboration of various of our clients, these players co-navigate through and specialize in 21st century innovation, multi-lateral mega projects, and cutting-edge consulting.

R&D Nester counts themselves among these groups, and as such, have generously given presentations showcasing their research and development work, consultancies, and client solutions at several of OPAL-RT's 'Real Time' (RT) conferences over the years. Nester was incorporated in Lisbon, Portugal in 2013 and has among its stakeholders REN (the Portuguese TSO) and the SGCC (the State Grid Corporation of China) via CEPRI (China Electric Power Research Institute). Their fields of joint expertise include real-time power system simulation, research into renewable energy management, joint exploration of smart grid technologies and impact studies of energy markets and economics.

"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 leads 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.

CHALLENGES / SOLUTIONS

Energy producers and distributors find themselves in an ongoing and particular set of circumstances these days. The continuously growing integration of inverter-based energy resources (IBR), the persistent needs for a more environmentally friendly energy system, and the ceaseless increasing requirements for energy storage solutions—as well as, more generally, the deployment of the concept of smart grids—has changed almost entirely the context under which power systems are currently operated.

Simultaneously, the migration toward digitalization of power systems, i.e., the application and ongoing usage of digital solutions in power systems, is also taking place all around the world. And so interested parties of all stripes find themselves exploring not-before-seen scalability, processing power, co-simulation—in short, the same suite of problems is affecting the status quo, but persistently, and we are thus requiring new and evolving solutions.

The R&D Nester Real Time Power System Simulation (RTPSS) Laboratory

And so, R&D Nester—in Portuguese, the Centro de Investigação em Energia REN State Grid S.A.—undertook to acquire a laboratory for the real-time simulation of power systems, whose main workhorse assets ended up being two real-time power system simulators (RTPSS), one of them acquired from OPAL-RT.

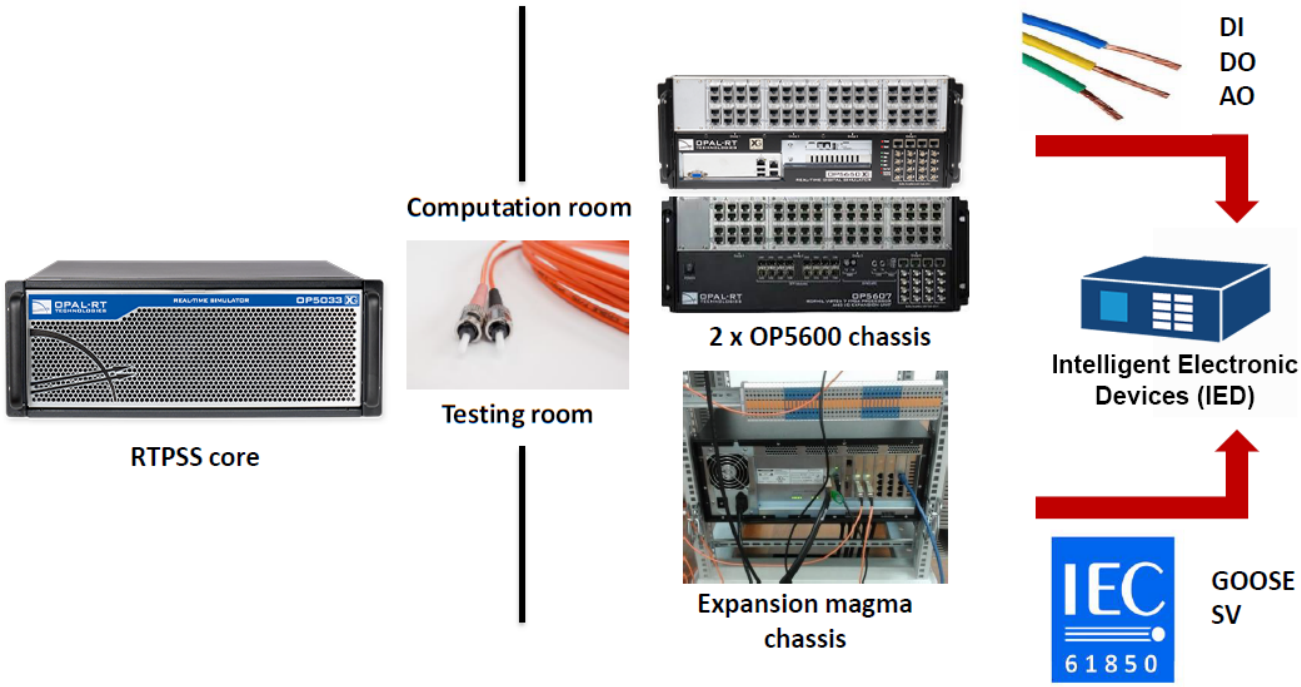
To complement these two RTPSS, various hardware and software tools were evaluated and used, together enabling both the simulation of power systems and communication networks (either in a standalone mode or through performing co-simulation).

CHALLENGES / SOLUTIONS

In this context, and to leverage the application of new products/solutions as they further evolved, R&D Nester has instituted and launched a Real Time Power System Simulation (RTPSS) Laboratory, providing a unique research and simulation infrastructure to analyze the behavior of different components of the power system.

Below, please see a simplified schema summarizing the solutions R&D Nester has in operation.

Simplified schema summarizing the Real Time Power System Simulation (RTPSS) Laboratory



The company is proud to be users of OPAL-RT's software platforms HYPERSIM and RT-LAB, and toolboxes CPU-based Electrical (ARTEMiS), and Electro-Mechanical Phasor (ePHASORSIM).

As a side benefit of this lab's inception, the housing of state-of-the-art equipment and multiple co-installed test tools renders possible the simulation of multifaceted scenarios featuring very complex power systems and the assessment of their performance in the same scenarios.

The introduction of digital solutions to power systems creates the vast and exciting opportunity for applications of new solutions and the Laboratory is also equipped with testing tools allowing co-simulation of power system and communication networks.

Software and hardware solutions have also been assembled for the simulation of communication networks running simultaneously with power system simulation solutions.

PROJECTS

One example of R&D Nester's projects is the "Substation of the Future", in which the RTPSS peformed HIL testing of protection, automation and control (PAC) systems. In this case, the RTPSS simulates the power system, allowing the execution of closed-loop (HIL) tests.

In the HIL testing, the RTPSS can be programmed, for instance, to simulate a fault in a transmission line. This fault will cause the protection relay to trip, but contrary to the open-loops tests, the RTPSS will acquire commands from physical devices, resulting in a new configuration of the power grid, then, it will reconfigure the power flow, which may cause other transmission lines to trip.

The HIL interfaces of the simulator are both hardwired and uses the IEC 61850 communication protocol, permitting the tests of legacy and state-of-the-art devices. With the simulator features it is also possible to automate tests using ScopeView, allowing convergence analysis of test results.

This period of intense and rewarding development allowed R&D Nester to migrate R&D forwards, including future use of their RTPSS for Smart Substation testing and implementation—and furthermore has allowed them in the recent past to contribute to national and international projects such as:

• ProtMPLS: project to assess the use of IP/MPLS communication for protection systems.

• Prot4HRES: project to assess the impact of the renewable sources in the design of the protection systems for transmission grids.

• OSMOSE: this H2020 project aims to identify and develop the optimal mix of flexibilities for the European power system to enable the Energy Transition.

TECHNICAL SPECIFICATIONS

Real Time Power Systems Simulation Laboratory (RTPSS)

• A 16-core UNIX based computer (OPAL-RT OP5600) which is the main equipment responsible for running real time simulations. This server has a total of 64 Gb of RAM memory, which also allows the running of highly complex processes

• Two expansion chassis (interfaces), each one providing a set of digital and analog inputs/ outputs, which enables the execution of HIL tests. The total number of ports per chassis is: 32 Analog Inputs, 32 Analog Outputs, 64 Digital Inputs and 64 Digital Outputs

Time synchronization

• Redundant Time Synchronization Servers, allowing the synchronization of laboratory equipment and devices under test, compatible with the following protocols: PTP, IRIG-B, SNTP, PPS and 10 MHz

IEC 61850 testing tools

• A protection test set dedicated to IEC 61850, allowing the generation of GOOSE and Sampled Values to be sent to the devices under test for open loop tests. This also translates GOOSE messages into hardwired outputs and vice-versa, for the testing of binary outputs of protection devices

• Four power amplifiers, to convert low voltage outputs of the RTPSS platforms and test set to 100 V, 1A to be used in protection devices

• A software package to check the IEC 61850 messages

• A software family to perform IEC 61850 conformity tests including data model and communication services of the devices under test

• An IED specification and configuration tool that allows the creation of IEC 61850 systems, and the test of interoperable solutions

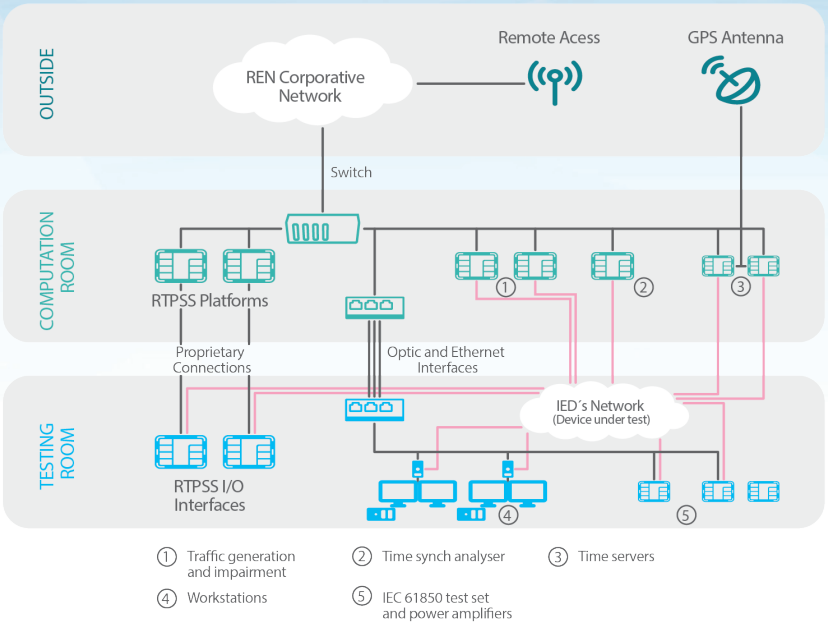
Communication Networks

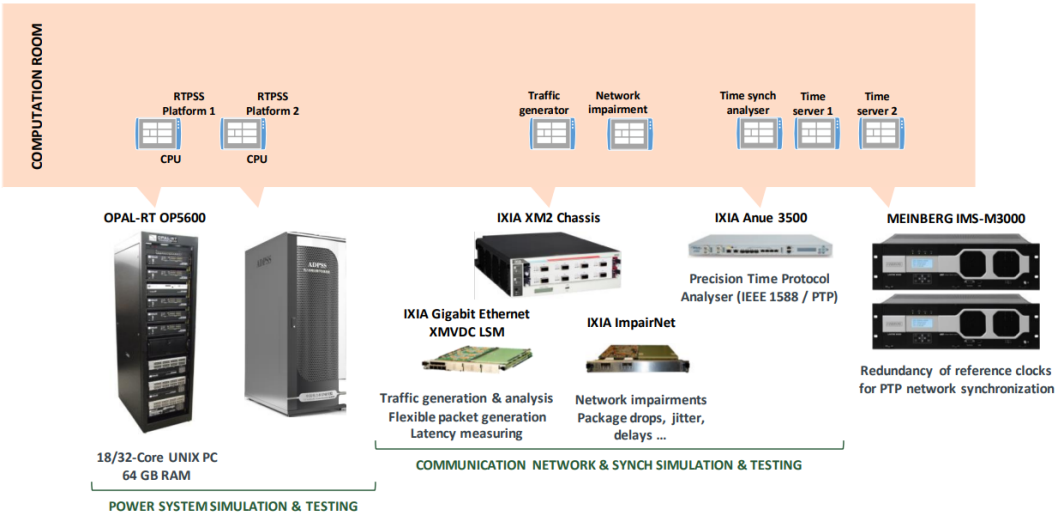
• A software package to simulate communication networks, permitting the execution of assessment studies without real devices or by performing HIL simulations

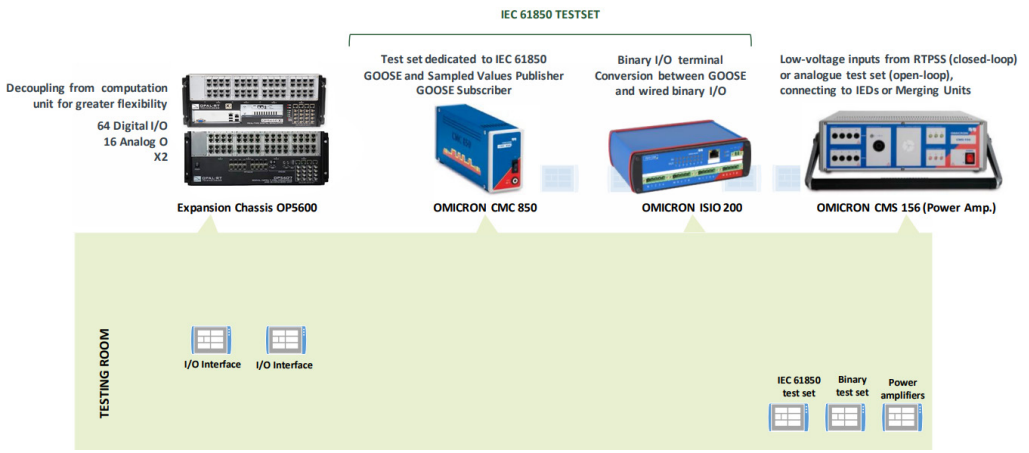
• Devices to inject simulated load into the network, and to impair, through simulated 'attacks', the circulating messages

TECHNICAL SPECIFICATIONS

Real Time Power Systems Simulation Laboratory (RTPSS) Architecture







RESULTS

The RTPSS center facility at R&D NESTER has been planned and executed specifically to allow an exceptionally large spectrum set of applications managing and overseeing power systems and communication networks.

It has allowed R&D Nester to work on projects heretofore untried and of staggering complexity, among them their so-called prototypical "Substation of the Future".

Some envisaged future applications of this technology include but are not limited to:

Testing

• Prototype development and product conformance testing; product type testing

• Testing of protection and automation systems

• Hardware-in-Loop (HIL) simulations (power network interaction in real time with prototypes, actual IEDs or other devices)

Modelling

• Model verification (e.g., linear element models, constant parameter transmission lines, pi-circuits, non-linear models, surge arresters, etc.) using field data and event records

Scenario Simulation

• Studies for the optimal integration of renewable energy sources; power system transient studies

• Power system performance assessment in line with European connection grid codes

• In-depth forensic analysis of power system events

Communications

• Performing iterative communication network studies, by means of simulations, to aid in their design

• HIL hybrid simulation of network communications using real devices in interaction with a simulated environment

• Testing communication network performance (measuring parameters and purposefully causing impairment, i.e., 'stress tests') to evaluate the impact to control and automation systems

Co-simulation

• Performing co-simulation (power system simulator and communication network simulator running simultaneously, interacting with each other)

  • The co-simulation of power systems and communication networks is crucial to evaluate the effect that failures in communication devices have in the power system

  • It consists in the joint simulation of both networks, running in parallel and performing synchronized actions

Training

• Staff training for control equipment operation.

The sky is really the limit for R&D Nester in terms of scope, scalability, and multiplying by a magnitude of several factors the work that can now be done in minutes and hours—as opposed to weeks and years.

The information included in this document was taken from R&D Nester website. Please visit www.rdnester.com for more information.