Smart Grids: KTH uses Opal-RT Simulators to Conduct Groundbreaking Research and Education

"The *Smart Transmission Systems-Laboratory*, built using Opal-RT's eMEGAsim Real-Time Digital Power Grid Simulator, enables us to conduct research in many areas of the future "Smart Grid".
e*MEGA*sim provides us with access to versatile, high performance hardware technology. In addition, eMEGAsim is tightly integrated with MATLAB/Simulink, a modeling environment that our students are very familiar with. This reduces training requirements, simplifies our research and increases our opportunities for international research cooperation."
Dr Luigi Vanfretti, KTH
The Royal Institute of Technology,
School of Electrical Engineering.

Smart electricity grids will contribute to making energy systems more energy efficient. KTH participates in EIT, an EU cooperation initiative which aims to make Europe a global leader in smart grid innovation.

Researchers and students at Sweden's **Royal Institute of Technology (KTH)**, have a unique opportunity to conduct pioneering research into the development of innovative control, protection and communication technologies for electric power Transmission and Distribution Networks that will pave the way for the widespread introduction of "Smart Grids".

KTH is building **SmarTS-Lab** (Smart Transmission Systems-Laboratory) using OPAL-RT's **eMEGAsim Real-Time Power Grid Simulator**. SmarTS-Lab will allow the assessment of research ideas by testing them within a "near-real-world" power network.

SmarTS Lab
Smart Transmission Systems Laboratory

By using a completely configurable **highly-detailed real-time simulation environment**, researchers and students can use SmarTS-Lab to conduct research projects under a completely controlled, accurate and reproducible environment, including:

- New power system operations methods;
- Control methods, strategies, and algorithms;
- Advanced techniques for protective system coordination with system controls;
- Communication network paradigms and computer system architecture paradigms;
- And determine information and communication technology design specifications.

"SmarTS-Lab will provide solid test simulation facilities for Research, and lead to major education improvements at KTH ", says Dr. Luigi Vanfretti, Assistant Professor at The Royal Institute of Technology, KTH.

CHALLENGE

The Royal Institute of Technology, KTH, is responsible for one third of Sweden's capacity for engineering studies and technical research at the post-secondary level.

To support its research and educational activities in the areas of Smart Grids and HVAC & HVDC power grids, the Electric Power Systems (EPS) Division and Industrial Information and Control Systems (ICS) Division of KTH's School of Electrical Engineering joined forces to build an innovative test and simulation platform based on real-time digital simulation.

To reach their objective, KTH needed tools sophisticated enough to design and perform highly detailed simulation of power systems, and to emulate the behaviour of power system devices in different time-scales, the smallest of which being electromagnetic transients. The simulator was also required to simulate large AC and DC grids.

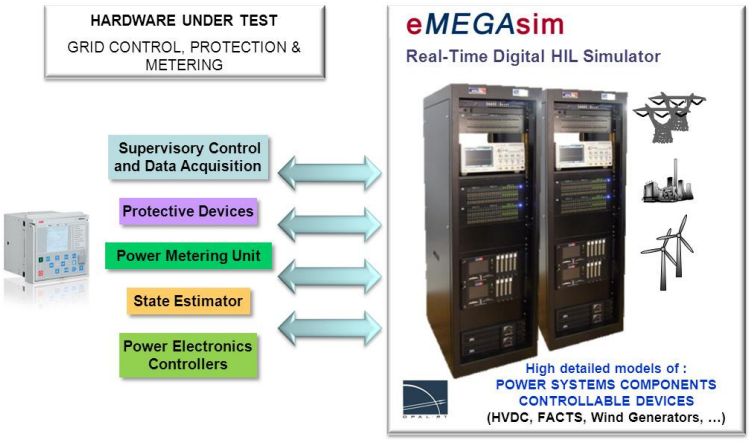
Fast Input and Output (I/O) interfaces were also required to test real control and protections in closed-loop with the simulator. The introduction of Smart Grids implies the intensified use of distributed control and information exchange, with Ethernet-based protocols (for example, IEC61850), and the capability to address, develop and test such protocols using the simulator.

With more than 12 researchers directly involved in the use of simulator, in addition to its use in classroom situations, KTH needed to be able to access the simulator from multiple workstations. At the same time, the simulator needed to be intuitive enough for students to learn quickly, and new colleagues to become quickly involved in research efforts. *"For students to get up to speed takes way too long when using specific programming tools"* , Vanfretti explains.

"Opal-RT's simulator technology allows us to develop a collaborative R&D platform for use by different research divisions. From the start, the flexibility and openness of the eMEGAsim simulator allows the EPS and ICS divisions to conduct joint research on Smart Grids. This common platform will allow us to bring different research aspects together and evaluate them as a whole" says Vanfretti.

SOLUTION

Royal Institute of Technology (KTH) acquired a **powerful eMEGAsim Power Grid Real-Time Simulator** from Opal-RT Technologies. (www.opal-rt.com)



The eMEGAsim simulator delivered to KTH is comprised of:

- **Two real-time supercomputers, with a total of 24 CPU cores,** integrated in two separate racks for independent operation;
- A high-speed link to connect the two supercomputers and form a single system with doubled capacity
- **RT-LAB, Opal-RT's real-time simulation software environment**, including software libraries and toolboxes that allow direct and accurate hard real-time simulation of power system models designed in Simulink and SimPowerSystems;
- More than **350 fast IO channels**, interface panels and 250V high voltage interface;
- **IEC 61850** compliant communication with IEDs including GOOSE messaging and Sampled-Value messaging
- **User-programmable FPGA** coprocessors for ultrafast simulation (Xilinx Virtex-6 based)
- Automated Test Sequencer
- Floating licences to equip as many workstations as required

High Detailed Simulation

The eMEGAsim simulator is **optimized for large and accurate simulation**.

RT-LAB real-time simulation software environment and a powerful **parallel computing platform** enable the simulation of large, highly detailed power system models. The eMEGAsim installed in SmarTS-Lab allows HIL simulation of up to 450 3-phase node distribution networks, HVDC, detailed VSC-based systems, transmission systems, distribution networks, HVDC/HVAC interconnection with offshore wind farm, distributed generation. The Simulink "phasor mode" simulation is also compatible with eMEGAsim and extends the application possibilities.

Low computation time-steps and IO management timing permit **enhanced precision**. The complete simulation cycle time can be as low as 10 microseconds, which is 5 times faster than conventional real-time simulators, which yields for the accurate simulation of fast power electronic transients. Through the use of FPGA coprocessors, models can be executed 200 times faster than conventional real-time simulators.

Open

The RT-LAB eMEGAsim simulator is entirely programmed under MATLAB/Simulink and SimPowerSystems, with OPAL-RT libraries and toolboxes. RT-LAB includes an **Application Programming Interface** (API) and gateways with common COTS (Commercial-off-the-Shelf) tools and programming languages. This enables a variety of third-party software and systems to be used with the RT-LAB environment, including LabView, automation systems, OPC, and openPDC.

Cost-efficient

In many industries, digital real-time simulators have superseded analog simulators and physical test stands. This is due to the increased precision, productivity, flexibility, and reduced cost available from digital simulation. With eMEGAsim simulator, the use of a **standard PC computing platform** and compatibility with COTS software and hardware yields a **very high performance/price ratio**. *"For the same cost, the system is much more powerful than other solutions based on proprietary software and hardware"* says Vanfretti.

Local support

The close proximity of Opal-RT Europe engineers ensures that all installation, training and technical support issues are handled quickly, eliminating the need to deal with overseas technical support.

RESULTS

- **Accelerated Research.** "*The eMEGAsim Real-Time Digital Power Grid Simulator is extremely powerful, very versatile and open for customization and integration with third party software and hardware. This helps in wide ranging research activities, to unleash innovation, permit maximum reuse, and accelerate development,"* Vanfretti says. *"eMEGAsim, through its tight integration with MATLAB/Simulink and SimPowerSystems, provides a state-of-the-art modeling environment that makes it easy to communicate with other researchers."*

- **Costly hardware prototypes avoided.** "*A traditional alternative to using digital simulators has been to use physical test stands, which are expensive, take a long time to setup and require a lot of hardware"* , says Vanfretti. *"The eMEGAsim simulator lets us make changes through the available software of through developing our own."*

- **Research and teaching integrated.** *"It is an excellent collaborative environment that carries over into the classroom"* Vanfretti says. *"We are expecting a significant return on investment in the form of graduate students who can contribute to research efforts right away because they are already familiar with MATLAB/Simulink tools."*

- **Career opportunities in leading organizations**. *"We believe that the experience gained through the development of the SmarTS-Lab program, and the impact of Opal-RT's products on relevant electrical engineering projects, will produce engineering graduates with advanced analytical, design and implementation skills that will transform today's power delivery system into 'Smart Grids'"* says Vanfretti.

Opal-RT Europe
Parc d'affaires SILIC- 1 rue Traversière
94150 RUNGIS
Tel. : +33 (0)1 41 73 40 80 – Fax. : +33 (0)1 41 73 08 49
www.opal-rt.com