OPAL-RT TECHNOLOGIES

Success Story

Center for Power Electronics and Drives

www.c-ped.org

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Electrical Grid Simulator for Testing Power Quality Analysis Systems

1. Context

Hardware-in-the-loop (HIL) Real-Time simulators can provide important advantages in electrical engineering applications. It allows users to simulate power electronics converters, electrical drives or grids and to fully test the developed control software, thus avoiding the need for or risk to any physical hardware. Safety from both electrical and mechanical risks is a key benefit of real-time simulators.

Speed is another benefit: real-time (HIL) testing simplifies workflows and shortens time-to-market.

C-PED, a joint research center founded by the ROMA TRE University and University of Rome Tor Vergata, decided to start using HIL platforms for both research and teaching activities.

2. Challenge

C-PED is involved in power electronics, electrical drive and electrical grid research projects. A remote grid monitoring system was developed and needs to be tested. The monitoring systems acquires and evaluates the main grid voltage and current parameters, and outputs power quality information such as analysis and reports of voltage and current distortion due to non-linear loads, voltage unbalances caused by unbalanced loads.

Testing and validating such a system requires a real grid with real loads. However, such a setup requires resources, space and time, especially during the software development stage.

3. Solution

The HIL simulator selected is a mixed OPAL-RT, National Instruments platform. National Instruments LabVIEW is the official software used at C-PED for control and general software development. The HIL platform should be fully controlled by LabVIEW to avoid using new development environments.

The selected real-time simulator selected uses the NI cRIO-9039 hardware with the powerful and efficient OPAL-RT eHS-64 solver. The eHS solver is installed on the cRIO FPGA and is fully controlled using well-known LabVIEW real-time and FPGA techniques. In addition, the FPGA can also execute additional LabVIEW user code and allows to develop additional simulation model features. Furthermore, users can access all variables, change and configure hardware, deploy the model to be simulated, directly from the cRIO real-time target (microprocessor).

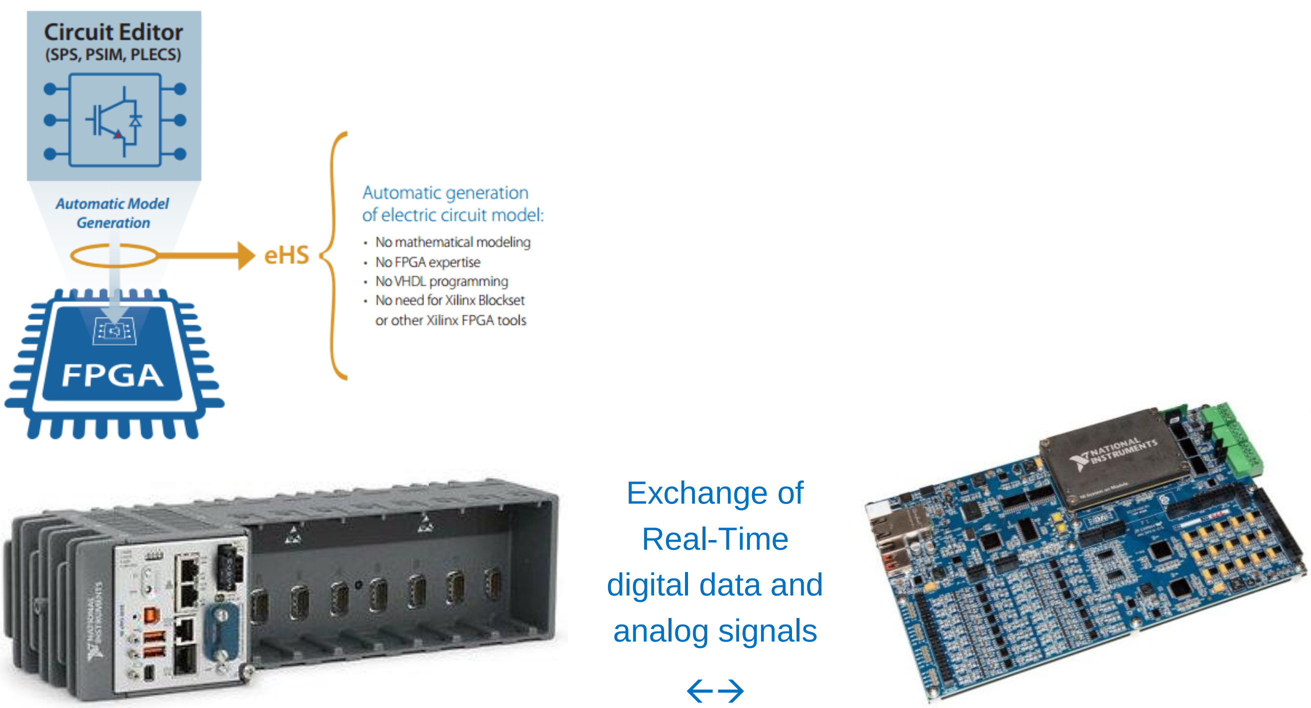
According to C-PED, this solution did not increase the complexity and did not require any additional training for students, researchers and staff.

In regards to model development, OPAL-RT offers a different solution. Simulink, PLECS, PSIM software can be used to graphically describe the system sent to the eHS solver. C-PED already uses the Matlab/Simulink environment for simulating electrical systems, hence, it is well accepted and straightforward.

In this specific case, the grid power quality monitoring system was developed by the PED-Board® platform (www.ped-board.com), which is based on the NI sbRIO-9651, fully programmable by LabVIEW.

The cRIO-9039 can be configured according to the user's needs, and is able to host up to 8 NI modules. HIL simulator peripherals, such as digital I/O, analog outputs (DAC) and analog inputs (ADC) can be accessed through a LabVIEW program as a common cRIO platform. The grid model created by Simulink must be saved in .mdl format and then uploaded to the cRIO by the *gen_eHSgen3_mtx.vi* in the *open_eHSgen3_cRIO9039.lvlib/eHS_gen3_Host.lvlib* library provided by OPAL-RT.

The electrical grid model was defined using Simulink, as illustrated in **Figure 1**. It includes the sinusoidal voltage generators, the cables and some loads, which can be linear and non-linear, single-phase and three-phase. Each load can be connected and disconnected acting on a dedicated switch. Each switch is controlled by the HIL and externally triggered by the control board. Hence, the implemented software can be tested in different operating conditions.



OPAL-RT eHS64 solver on NI cRIO-9039

PED-Board

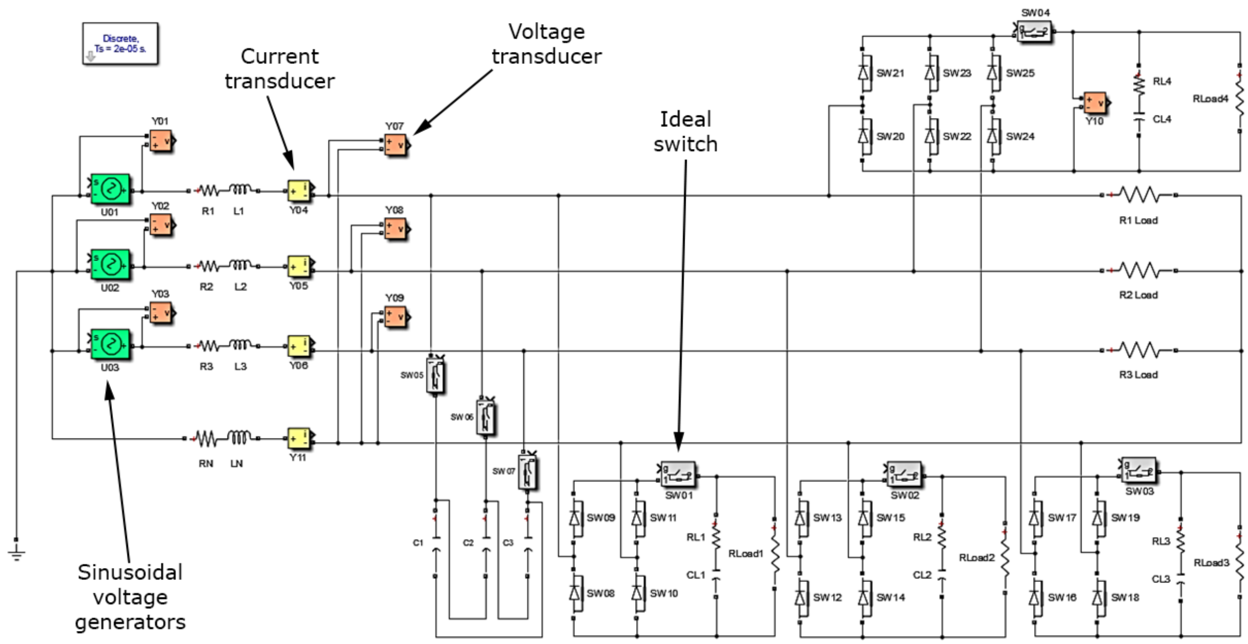


Figure 1. Simulink model for the electrical grid.

4. Results

Thanks to the HIL simulator, the power quality monitor was tested and verified in a very simple and effective way. Software for grid parameters analysis was developed and fine-tuned in a safe, fast, reliable and cost effective setup. The total time required is significantly less than with a traditional approach, considering the final experimental test on the real system (i.e. electrical grid). Different loads can be used to fully verify the grid analyzer.

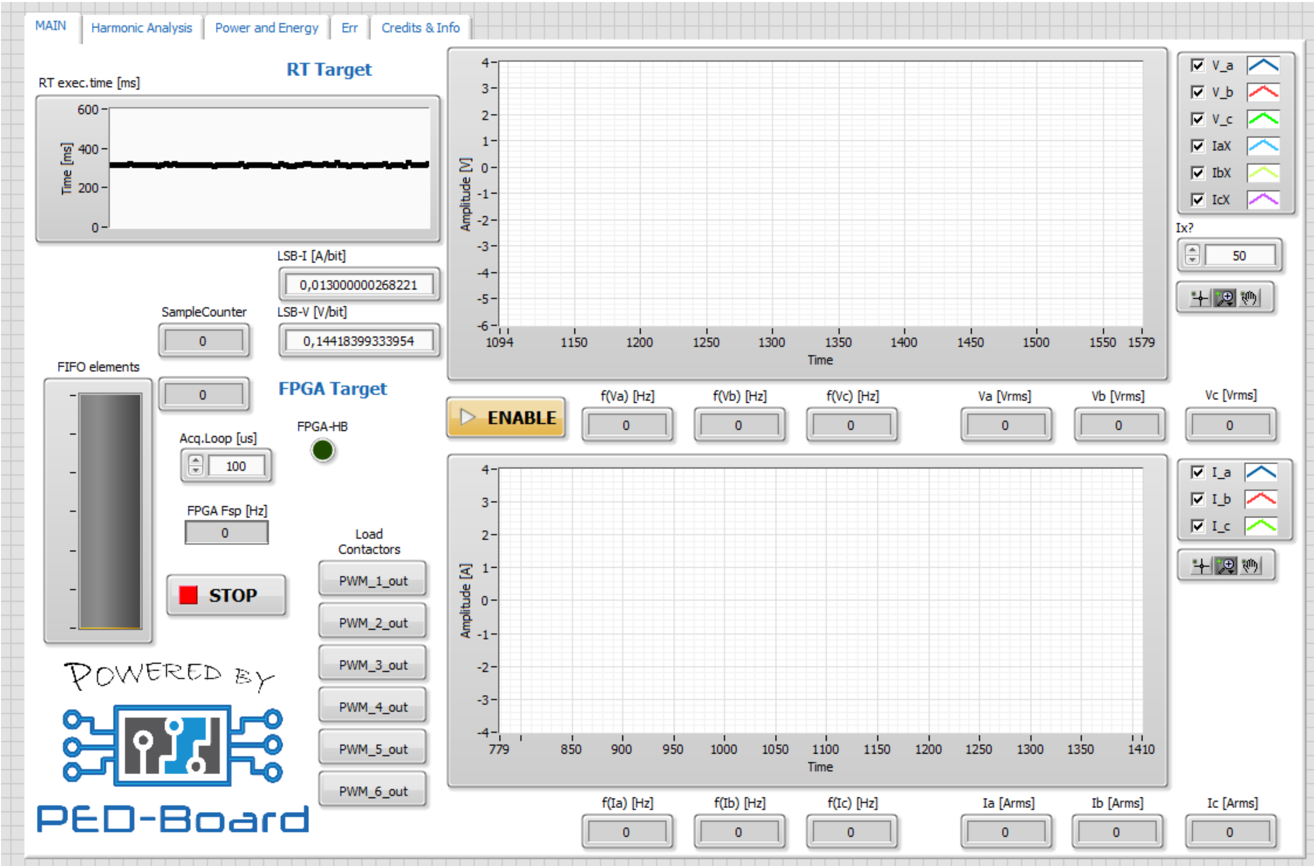


Figure 2. Front panel of the PED-Board based power quality analysis software.