SuperGrid Institute

An efficient and compact power converter to enable the supergrids of the future

speedgoat
real-time simulation and testing

The team at SuperGrid Institute have used Rapid Controller Prototyping to develop a new highly efficient and compact DC-DC power converter - an enabling technology for future supergrids which will allow greater use of renewable energy sources

SuperGrid Institute is a collaborative research platform in the field of low-carbon energy, bringing together the expertise of industry and public research, and promoting public-private investment and close cooperation between stakeholders.

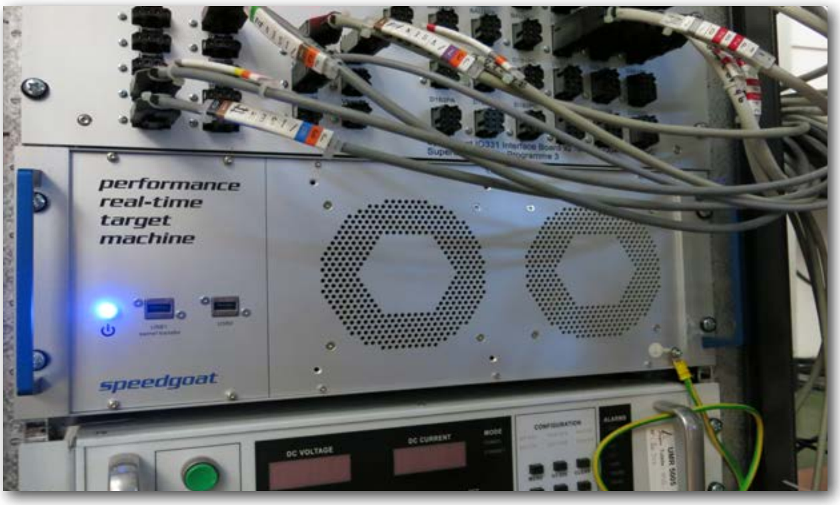
The institute develops technologies for supergrids - future electricity transmission networks for transporting gigawatts of energy over distances of up to several thousand kilometres. Supergrids will allow energy from renewable sources, which are often offshore or in remote locations, to be used where it's needed, in industrial zones and in cities. They will help to manage the intermittent nature of renewable energy and also to ensure the stability and security of the networks.

To transmit power as efficiently as possible supergrids will use direct current (DC) and alternating current (AC) at very high voltages (around one million volts). The institute is supporting this with research into conversion technologies, grid architecture, fault protection, cables and lines, and stabilisation and storage.

DC Transmission

DC transmission of power is more efficient than AC as there is no reactive power and transmission losses are much lower. However changing between voltage levels is much more difficult as classic transformers do not work.

The Power Converters team at SuperGrid Institute wanted to develop a new high voltage, high power DC-DC power converter which will be an enabling technology for DC transmission.



The research platform with Performance real-time target machine

Control

To be highly efficient, the new power converter was designed to operate at 20 kHz. Such a high frequency was only possible due to the very low switching losses of silicon carbide transistors. However controlling the nonlinear, fast switching converters posed significant challenges.

Rapid Controller Prototyping

The team wanted to use Model-Based Design for the development of the DC-DC converter to allow them to use fast and agile development cycles. They decided on a Speedgoat Performance real-time target machine as a controller as it enabled them to use MATLAB & Simulink to design, auto-generate and download real-time applications to the target machine with very fast iterations.

They used Simulink and HDL Coder to develop algorithms to run on the target machine's FPGA: power transistor firing order, analog measurement and processing, and power circuit protection. They also used the FPGA's on-board analog and digital I/O to achieve the very high sample rates needed.

The target machine's digital outputs were used to drive the power transistors via an interface board and a gate-drive. Digital inputs received feedback from power modules, and analog inputs measured current and voltage.

Success

The team successfully tested the compact 1 kV, 100 kW DC-DC power converter with an efficiency of 98% within one year of beginning the design. The converter is one of only a very few operational high efficiency, medium frequency DC-DC power converters in the world.

The team are now working on new concepts including multilevel converters using distributed control over fiber-optic networks.

Speedgoat's value Contribution

"Thanks to MathWorks and Speedgoat tools we can focus on our objective of designing control systems for power converters.

The transition from design model to real-time software was very fast thanks to the complete compatibility between MATLAB & Simulink and Speedgoat.

The Speedgoat target machine provides fast and robust control of the switching semiconductors in a difficult electromagnetic environment (E = 1V/m)."
- Mr. Dworakowski

The SuperGrid Power Converters team, left to right: Laurent Chédot - control engineer, Piotr Dworakowski - team leader, François Wallart - control engineer

Making measurements in the lab on the new 100kW DC-DC converter

SuperGrid Institute

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www.supergrid-institute.com

Speedgoat products used

- Performance real-time target machine
- IO331 Configurable FPGA I/O module with IO33X-6 analog I/O plug-in and IO3XX-21 rear I/O signal conditioning module

MathWorks software used

- MATLAB®
- Simulink®
- HDL Coder™
- Simulink Coder™
- Simulink Real-Time™

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