OPAL-RT TECHNOLOGIES

UBC Eng. Students Make Technology Integration Improvements for Renewable Energy Integration & Transmission

UBC THE UNIVERSITY OF BRITISH COLUMBIA

Application

- Modular Multilevel Converter (MMC)

Related Product

- MMC Test Bench

Type of Simulation

- Hardware-in-the-Loop (HIL)

SUCCESS STORY

INTRODUCTION

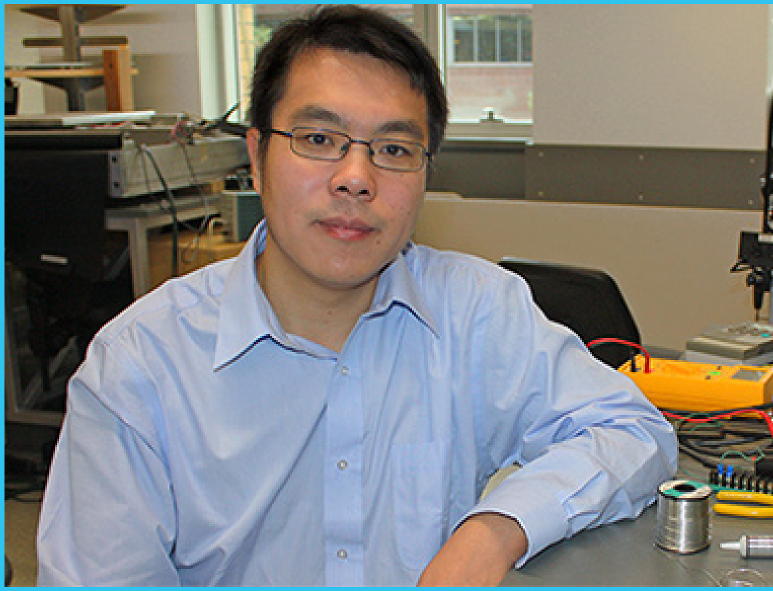
Researchers at the School of Engineering on the Okanagan campus of the University of British Columbia are used to pushing the envelope—and now they're modelling and simulating new power electronic converters for renewable energy integration.

With every incremental advancement in Distributed Energy Resources (DERs), conventional power transmission systems require further modification in order to route and deliver power derived from these same sources. DERs, in turn, rely on fluctuating and unpredictable atmospheric conditions (wind, sun: not always in predictable supply) to generate their renewable power. As a result, power transmission systems must incorporate new grid control devices (fast-switching electronic converters among them) to ensure efficient and reliable electricity distribution.

Renewable energy sources unavoidably experience cyclical variations in output based on the daily fluctuations in wind speeds and sunshine—and thus storage of the resulting energy is more important than ever before: a resource with unpredictable peaks and valleys must be warehousable to meet demand. As parts of the network are expanded with new devices with new purposes, energy storage technologies and larger-scale interconnected AC-DC power grids that enable renewable energy generation, transmission and utilization must be flexible, efficient, and reliable in order to assure success within this new framework.

"The complexity of the integration of variable energy sources makes the science, and specifically our modelling and simulation work, so interesting"

Dr. Liwei Wang, Assistant Professor, School of Engineering - UBC Okanagan



OBJECTIVE

Principal investigator and assistant professor Liwei Wang of the Flexible Power Transmission Laboratory for Renewable Energy Integration at UBC Okanagan and his team are discovering and testing groundbreaking methods to better connect power systems and to help make them more efficient.

OPAL-RT TECHNOLGIES, a global leader in developing power electronic and energy system simulators, hardware-in-the-loop testing equipment and rapid control prototyping systems, has partnered with Dr. Wang and his lab. Dr. Wang is further helping to design, test and optimize new components within these new systems that bridge the old grid and the new, evolving one: to integrate more recent renewable energy sources with pre-existing and legacy power transmission systems.

Dr. Wang's research interests, among others, include power system analysis, operation and simulation, electrical machine and drives, power electronic converter design, control and topology, power semiconductor modelling and characterization, utility power electronics applications, HVDC and FACTS, renewable energy sources, and distributed generation. It is through the diverse scope and variety of his knowledge and interests that he is helping, with his lab, to drive this valuable area of research further forward.

SOLUTIONS & DEVELOPMENT

Modular multilevel converters, which are able to control voltage sources enabling multiple and varying renewable sources to enter the power transmission system, require complex and exhaustive testing. Dr. Wang is developing universal modelling frameworks in an attempt to make the testing both faster and more accurate/reliable. The frameworks are expressly built in order to take into account the dynamic nature of the power electronic converters. They are then able to accurately accelerate the entire system simulation, in order to validate and to confirm the system design.

OPAL-RT TECHNOLOGIES and Dr. Wang are beginning to realize the fruits of their labors. Specifically, they have been making enormous headway on two specific frameworks:

- One greatly accelerates power system simulation speed by using average value models (AVMs) for modular multilevel converters (MMC) based on high-voltage direct current (HVDC) systems.
- The other one is a new hybrid modular multilevel converter with higher converter efficiency, a smaller footprint and better system fault resilience compared to the-best and most current state-of-the-art MMCs.

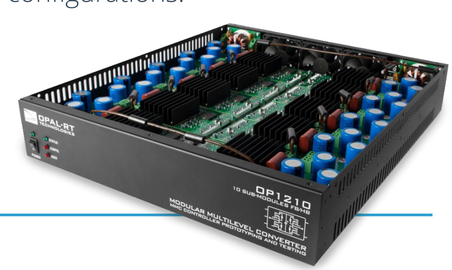
Experimental MMC setup (the cabinet houses the MMC hardware).

OP4510

Equipped with the latest generation of Intel Xeon four-core processors and a powerful Xilinx Kintex 7 FPGA, the OP4510 delivers raw simulation power for both CPU-based real-time simulation and sub-microsecond time step power electronic simulation.

OP1210

The OP1210 box is composed of 10 submodules (thus 11 levels), has a nominal voltage of 400V and can be operated as a half-bridge or a full-bridge topology. The rated power of the lab scaled MMC is 6 kW. The flexible setup of the system enables studies in both monopole and bi-pole network configurations.

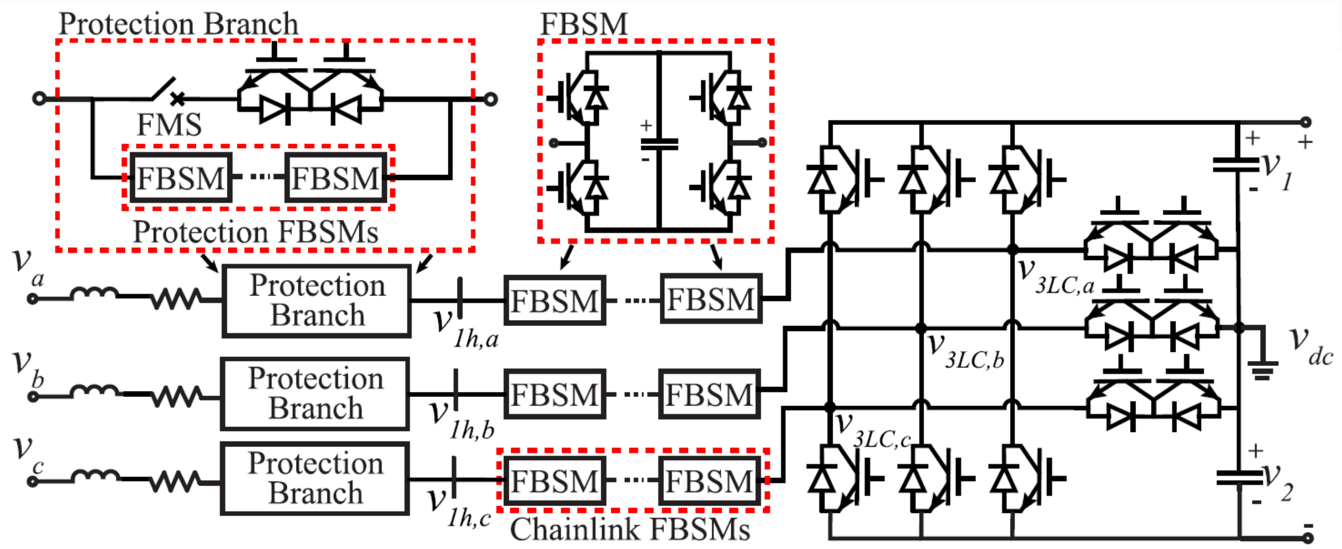


SOLUTIONS & DEVELOPMENT

"The success of simulation testing and scaled-down hardware converter prototypes based on these frameworks allows us to better design new components that are promising to be integrated into conventional power transmission systems," says Dr. Wang.

In addition to being major leaps forward in the quickly-developing scheme of things, these converters offer a significantly smaller footprint, less energy storage requirements, and improved converter efficiency.

Three-phase circuit configuration of H3LC



"A perfect example would be our proposed hybrid three-level converter (H3LC) with AC-side cascaded full-bridge submodules (FBSM) for HVDC transmission. The developed converter has new circuit topology and sophisticated controls. Although it sounds complex, the proposed converter reduces the previously-extablished minimum number of power electronics building blocks (or converter units and semi-conductors) required to have renewable energy harmoniously integrated with convention power transmission systems" explains Dr. Wang.

RESULTS

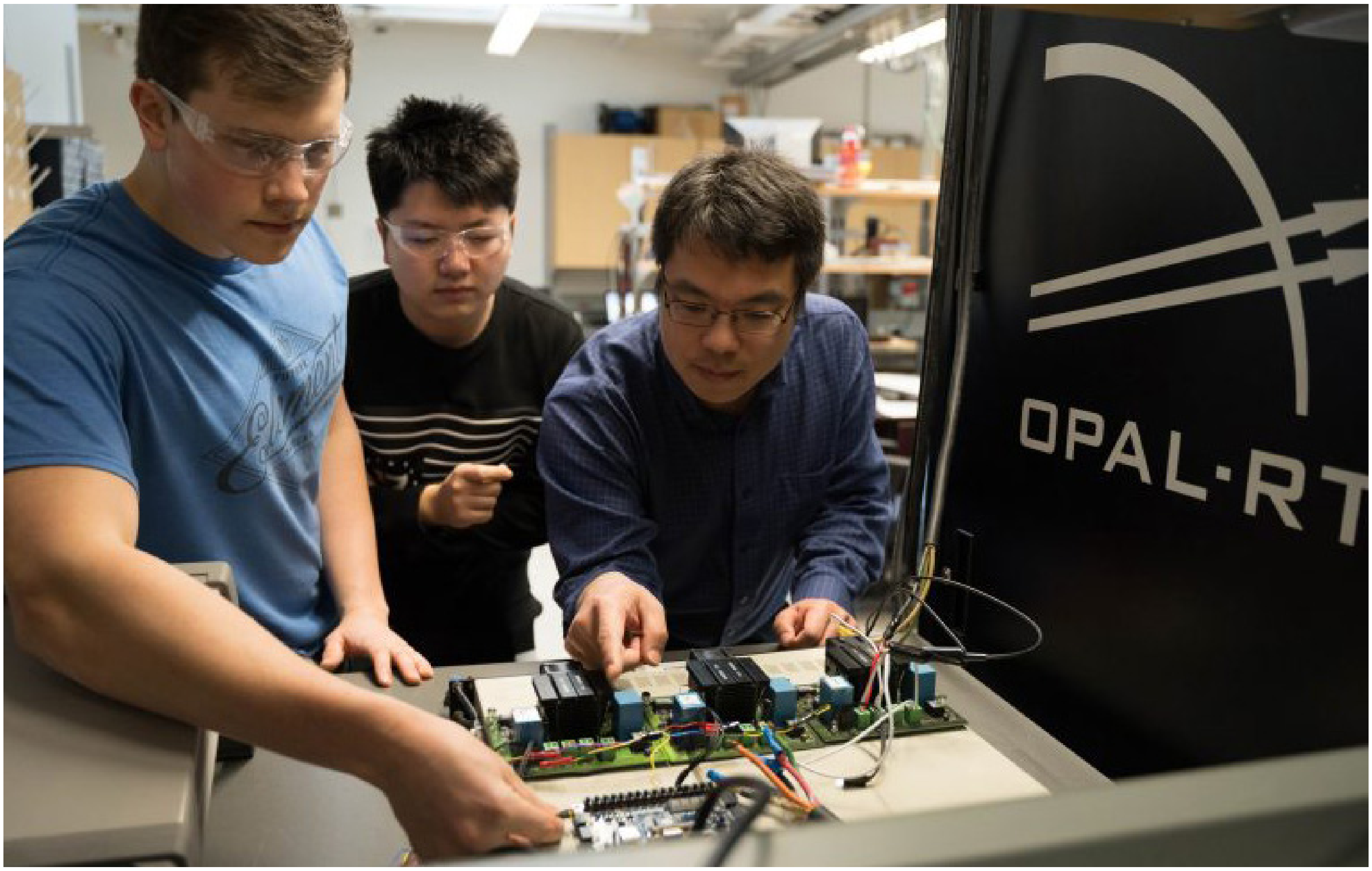
OPAL-RT has chosen to support development on these projects through both NSERC CRD and NSERC DG grants. The converter research, in an exciting and encouraging development, has recently been recognized by Institute of Electrical and Electronics Engineers (IEEE) with a Best Paper Award at the 10th IEEE Annual Information Technology, Electronics, and Mobile Communication Conference (IEEE IEMCON 2019).

In this context, both Dr. Wang and OPAL-RT are making an enormously important impact.

"Not only are we making advances in the science behind integrating renewable sources," says Dr. Wang, *"but our discoveries are being incorporated into real-time simulation software packages widely used to design the newer generation power grids around the world."*

OPAL-RT enjoys that a disproportionately large slice of its users and customers are students, researchers, and professors in groundbreaking labs such as the School of Engineering on the Okanagan campus of the University of British Columbia. The support has historically been in place since close to the company's founding date of 1997, and has proven to be advantageous for all involved: a true win-win situation. When OPAL-RT helps the engineers of the future early in their careers, we support and encourage change that is often applied in use for the wider betterment of all of us.

And as renewable energy sources continue to grow in both number and type, the solutions originating from the Flexible Power Transmission Laboratory for Renewable Energy Integration at UBC Okanagan will continue to make important contributions to their seamless integration into existing and new power transmission systems.



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