OPAL-RT TECHNOLOGIES

Success Story

Imperial College London

Rapid Control Prototyping enabling development of control for novel converter topologies and HVDC networks at Imperial College London

The Control and Power research group at Imperial College London are interested in developing the technology to enable future electricity networks, including multi-terminal HVDC systems. Efficient and reliable transmission through HVDC requires low-loss AC-DC converters and effective and robust control strategies for both the converter and the network.

A DC network is under construction including modular multilevel style converter topologies, allowing rapid control prototyping on representative scaled hardware demonstrators of HVDC converters and networks. This allows the testing and validation of novel converter topologies and strategies for network control on actual hardware.

1. Challenge

Novel converter topologies and control strategies…

Modular Multilevel Converters, and other hybrid multilevel converter such as the Alternate Arm Converter (AAC) have a significantly higher requirements in terms of control complexity and the number of IO channels than previous generations of voltage source converters. Building lab-scale demonstrators of such converters thus poses a serious challenge, not just in terms of initial implementation of the controller, but also in ensuring the controller can be used by other researchers after the original researchers on the project have moved on.

… Validated using power hardware demonstration.

Hardware results are an important part of validating concepts in the power electronics world. Simulation work alone may not capture sufficient real-world effects, such as noise and measurement error.

2. Solution

Rapid control prototyping for novel converter and network control

Several hardware modular multi-level style converter demonstrators are under construction, each able to represent either an MMC or an Alternate Arm Converter (AAC). Some of the first experimental validation on the AAC has been carried out in order to verify the feasibility of the novel topology. A range of operating points and fault conditions have been evaluated on the converter, as shown overleaf. A modular multi-level DC-DC converter is also under test. Whilst the converter power hardware has been designed and built in-house, each converter is controlled by an OPAL-RT OP5600 system. This receives numerous voltage and current measurements from the converter and outputs control signals to each sub-module through 200 optical fibres, all at 10kHz.

Picture 2: Multi-level Converter

Experimental verification of simulation

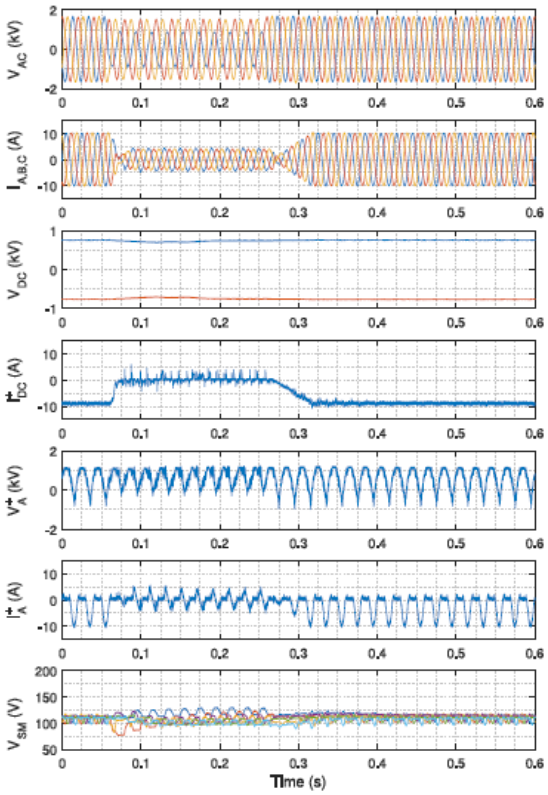
Using the OP5600 HIL systems and RT-Lab, a new control algorithm can be taken from a Matlab/Simulink/SimPowerSystems simulation model and quickly compiled for use on the hardware demonstrator. This use of OPAL-RT allows time-efficient hardware implementation of new control mechanisms.

A lab-scale multi-terminal HVDC network

The existing and planned converters will be connected together using a hardware emulation providing the equivalent of 220km HVDC cable. This flexible hardware arrangement is capable of evaluating a variety of network topologies, however the network is nominally a four terminal network. DC-side fault studies have already been conducted using the network, and will continue to be tested as more converters are commissioned.

3. Conclusion

Several lab-scale modular multilevel type converters have been constructed, allowing for the hardware verification of novel control algorithms for existing and novel power electronic converter topologies. In the future a four terminal DC network will be in operation, allowing for further experimental work on converter interactions and network control. The application of OPAL-RT systems for rapid control prototyping allows for a rapid transition between software simulation and hardware demonstration. This scaled DC system allows for the continuing of research into novel HVDC converter topologies and networks, helping to enable future HVDC networks and interconnection of renewable energy resources.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V_{DC} (kV)
I^{+}_{DC} (A)
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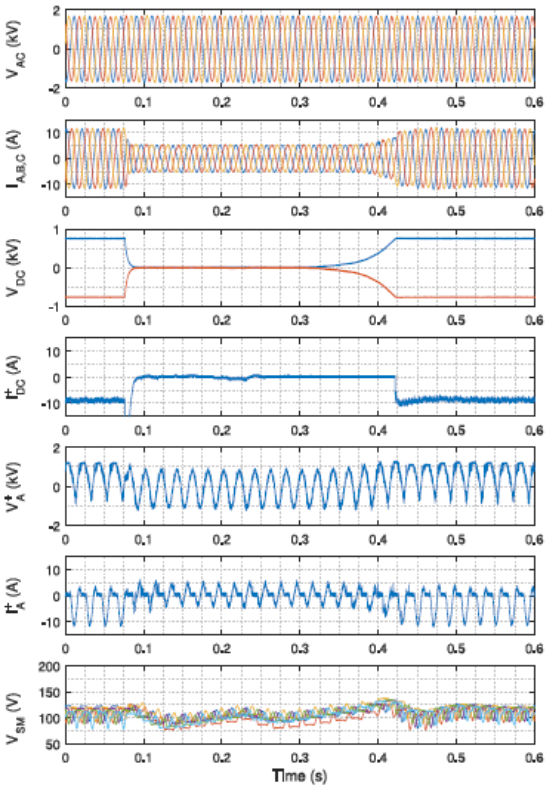
V_{SM} (V)
Time (s)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