OPAL-RT TECHNOLOGIES

Success Story

NR Electric Uses RT-LAB Real-time Simulator to Test the Control and Protection System for the Zhoushan Multi-terminal MMC-HVDC Project

Located in Zhoushan, Zhejiang Province, China, the Zhoushan MMC-HVDC project is the first five-terminal MMC-HVDC project in the world. Three of the five stations have a capacity of 100MW, with the remaining two at 300MW and 400MW respectively, all with DC voltages at ±200kV. Each MMC valve consists of 270 sub-modules. This enormous project involves many applications of VSC-based HVDC systems, such as islands interconnecting, island power supply, and wind power output. NR Electric provided the entire five-terminal control and protection system for the project.

1. Challenge

The control and protection (C&P) schemes in the five-terminal MMC-HVDC system are more complex than are found in a two-terminal HVDC system. They need a precise and coordinated strategy among stations to guarantee the system can continue operating after a failure. In normal operating mode, the Zhoushan station is the only terminal that provides power to the rest of the system. However, a total of 27 operation modes have been designed, considering that one or more terminals may trip due to a temporary fault or because of scheduled maintenance. The full C&P system must be validated for each of these designed operation modes, as well as under fault conditions during the factory acceptance test (FAT). Given the large number of test cases and safety constraints, a Hardware in the Loop (HIL) platform is the most effective and efficient tool to perform the FAT for the actual C&P system of this five-terminal MMC-HVDC project. However, multi-terminal MMC-HVDC is still a new technology, especially in the design of HIL simulation models and the interface of multi-terminal MMC C&P systems. There was very little mature experience to reference when embarking on this pioneering work.

2. Solution

The MMC sub-module model is implemented in field-programmable gate array (FPGA) boards with a computation cycle of 500 ns, while the rest of the power system is simulated on the central processing unit (standard multi-core CPU) with a time-step of 30 µs. The State-Space Nodal (SSN) interface is used to couple the models simulated on FPGA and on CPU. In addition, a communications protocol based on Giga-bit Ethernet was designed to connect the actual valve balancing controller with the real-time simulator.

3. Achievement

In 2013, NR Electric built up an RT-LAB real-time simulation system consisting of C&P and valve control prototypes (Figure 1), and accomplished a series of verifications on the functionalities and performances of C&P devices. This system passed KEMA witness test using the RT-LAB HIL platform in September 2013 (Figure 2). From September to December 2013, with the RT-LAB HIL simulation system, the C&P and valve control system developed by NR Electric accomplished and passed all test cases in the FAT. KELIANG, OPAL-RT's exclusive distributor in China, teamed up with the OPAL-RT Asia-Pacific Technical Center to finish the development and commissioning of the HIL platform under pressure of short deadlines.

Mr. Gang LI, NR Electric's engineer in charge of the RT-LAB real-time simulation platform, said: "The OPAL-RT real-time simulation platform played a key role in the C&P system commissioning of the Zhoushan project. Especially because of the timely technical support of OPAL-RT in both China and Canada, the project deadline was met." "Such complex system commissioning highlights the advantage of OPAL-RT's local technical service in China," said Weihua WANG, chief representative of OPAL-RT Technical Center Asia-Pacific.

The Zhoushan five-terminal MMC-HVDC project was officially put into operation in July 2014.

Figure 1 VSC HVDC Control and Protection System frame diagram

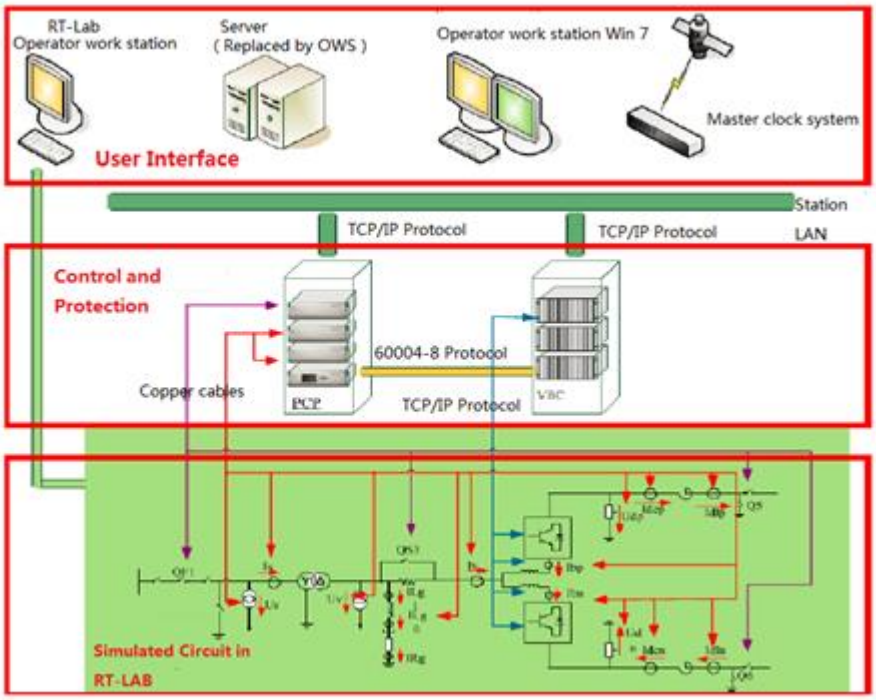

Figure 2 KEMA Test Certificate

CONCLUSIONS ON WITNESSED AND REVIEWED TESTS:

Above performed and witnessed tests with mentioned main test parameters passed in accordance with SGCC's control & protection equipment technical specification for Zhoushan five terminals VSC HVDC transmission project, and NR Electric's company standards for HVDC control & protection equipment. Detailed test conditions and results are described in the next part of this report.

WITNESSED BY Dr. Yanny Fu, KEMA Nederland B.V.

DATE AND SIGNATURE Arnhem, 30 September 2013

KEMA
KEMA Nederland B.V.
Utrechtseweg 310, 6812 AR Arnhem
P.O. Box 9035, 6800 ET Arnhem
The Netherlands
T +31 26 3 56 24 00
F +31 26 3 89 24 77
www.kema.com