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Generic modularity for reactive power control implementation

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Real-time power system simulation is vital for reactive power controller development and testing. Although commercial solutions exist, the uniqueness of their project prompted New Zealand's Transpower to commission a tailor-made solution from Alstom Grid.

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On February 22, 2011, an earthquake of magnitude 6.3 struck Canterbury on New Zealand's South Island, killing more than 100 people and causing extensive destruction. Underground power cables were badly damaged. Overhead lines and substations suffered too, but less. Seismic activity is the aspect of New Zealand's physical geography that has the most dramatic impact on the power sector. Major catastrophes are rare, but the country's shape poses systemic problems for electricity transmission. As Alstom Grid Australia's Project Engineering Manager Dr Ping Wang explains, "the network is long and skinny with major loads connected to generation centres by relatively long transmission lines. To maximise asset use, these lines are increasingly loaded to the point where they're approaching their thermal capability."

« The real-time simulator proved to be a key success factor »

Voltage stability limits the maximum utilisation of transmission line thermal capability. Planning studies by the national grid owner-operator, Transpower, show that the most cost-effective means of dealing with voltage stability and dynamic reactive power issues in New Zealand is to use dynamic shunt compensation, such as Static VAr Compensators (SVC), Static Synchronous Compensators (STATCOM) or synchronous condensers. However, this means that the number of reactive power devices will increase in major load areas, and coordinating numerous dynamic and static devices is difficult. A Reactive Power Controller (RPC) can be employed to ensure optimal coordination, but no suitable equipment existed for the New Zealand configuration. So Transpower commissioned Alstom Grid to design and develop an RPC that would be installed first in Christchurch and subsequently throughout the whole national network.

The final configuration will involve multiple systems hierarchically grouped by region and area, communicating with the national SCADA system. For Dr Wang's design team, the main challenge was to "devise a generic principle in both control concept and engineering implementation so that the design can be rolled out easily to other parts of Transpower's network without major hardware and software reengineering." The control algorithm has to be independent of a given substation's physical topology to be readily applicable to a wide range of installations.

« Customer satisfaction is the best gauge of a project's success. »

At the same time, control priorities have to be configurable to easily address the particular requirements of a given substation or area, or changed control strategies. In other words, what's needed is what Dr Wang describes as "generic modularity".


Islington HMI cubicles at the Christchurch substation.

1 __Real-time simulator

The stringent performance requirements and the critical role the RPC is required to play meant that the design and the control system had to be tested extensively with a power system interface that simulates the South Island system in real time. Buying or renting a commercial simulator would have been expensive; and it would have required considerable effort to tailor an off-the-shelf product to the needs of the project. So Dr Wang and his team decided to develop their own simulator. Their simulator contains detailed models of the substations, including all static and dynamic plant, transformers with on-load tap changers, switchgear and loads. It also includes a model of the South Island network reduced to a level where the simulator can run in real time but retains all crucial system characteristics. The final model closely matches the complete South Island system with regard to fault levels at the substations, reactive power and behaviour of dynamic plant, which was verified by detailed PSCAD/EMTDC® modelling.

The real-time simulator proved to be a key success factor for the RPC project. Due to the requirement for generic design and implementation, the RPC was type tested to prove its generality, expandability, changeability, and capacity to handle all types of plant, station topologies, system configurations and control strategies. After the successful completion of type tests, the simulator was then used to factory test the specific functionalities of the RPC for Christchurch production, and to fi ne-tune the control strategy and parameters. The tests lasted about six months. The simulator was particularly useful for testing the RPC under abnormal system conditions because, as Dr Wang says, "many tests cannot be repeated during RPC commissioning due to power system security concerns and potential conflicts with Transpower's principal performance obligations." Customer satisfaction is the best gauge of a project's success. Dr Ping Wang and his team are justifiably proud that Transpower is keeping the simulator – even after RPC commissioning is completed – as part of an RPC testing and development platform that can also be used to provide operator training, evaluate new control strategies before deployment, and support the addition of new substation equipment into the RPC scheme.

2__Improving the RPC simulator through factory testing

Apart from verifying that the RPC met contract specifications and was fit for site installation, factory acceptance tests revealed unforeseen issues such as little-known characteristics of the firmware, and also allowed changes to be made that will improve

RPC performance. For example, because of unnecessary capacitor switching during voltage excursions, it would have taken four seconds for the RPC to return substation 220 kV voltage to within the dead-band. The solution was to reduce the slope of the Static VAr Compensator local controller (not part of the RPC system) so that its dead-band was lower than the RPC's. This ensures that the SVC will always use its full range in output to control the 220 kV voltage following voltage excursions, without having to first wait for the RPC to issue raise or lower commands.

For minor voltage excursions, the voltage will still return to within the normal RPC dead-band after a few hundred milliseconds. For major voltage excursions the capacitor would be switched to assist voltage control after four seconds via the RPC voltage control loop.

EXPERTS

Dr Ping Wang

Alstom Grid Australia's Project Engineering Manager

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