CASE STUDY: DISTRIBUTION AUTOMATION

TESTING CENTRALIZED AUTOMATION FOR DIGITAL SUBSTATIONS AT ABB

USER PROFILE: A GLOBAL TECHNOLOGY GIANT DEVELOPING INNOVATIVE POWER SYSTEM PRODUCTS

ABB is a leading global technology company with a long history of excellence in power system solutions. Their protection and control products are trusted by transmission and distribution system operators worldwide.

ABB was an early adopter of the RTDS® Simulator — one of the first institutions in history to use real-time digital simulation for the closed-loop factory testing of their power system products. Today, ABB continues to apply the RTDS Simulator in several different divisions, where hardware-in-the-loop (HIL) testing is used to validate the dynamic performance of devices prior to customer deployment.

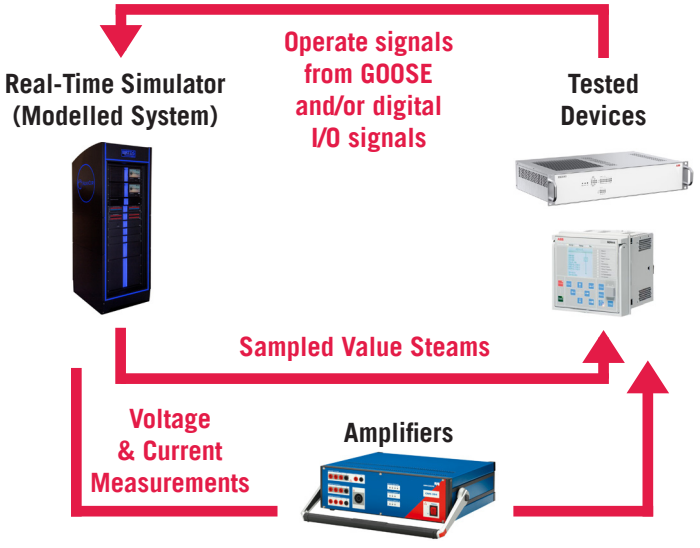
Though ABB has been an RTDS Technologies customer since the mid-1990s, their Distribution Solutions laboratory in Vaasa, Finland first acquired a Simulator in 2019. They quickly went through multiple expansions, increasing the capability of their system and improving the scope of testing for their projects.

The real-time simulation testbed at ABB Finland
Image courtesy of ABB

PROJECT FOCUS: VALIDATING THE SSC600 PRIOR TO A UTILITY PILOT PROJECT

ABB's SSC600 represents a novel approach to protection and control in distribution networks — centralizing all protection and control functionality within a single device at substation level. This centralized approach increases the flexibility, reliability, and speed of deployment for protection and control systems in the distribution network, while reducing network complexity and optimizing asset management and engineering for the digital substation. SSC600 is IEC 61850 and IEC 60870-5-104 compliant.

ABB performed HIL testing with the RTDS Simulator to validate several functionalities of the SSC600 system prior to deployment by a utility. The interoperability of the SSC600 and a REF615 feeder protection relay was also verified.



Both conventional and IEC 61850-based I/O are used to interface the SSC600 and REF615 to the simulated network
Image courtesy of ABB

Voltages and currents from the simulation were sent to the SSC600 via IEC 61850 Sampled Values. The SSC600 then sent operate signals back to the simulated circuit breakers via GOOSE Messaging.

In one scenario, the REF615 was tested in a merging unit role, receiving amplified analogue signals from the simulated network and passing them to the SSC600 for operation via Sampled Values.

HARDWARE-IN-THE-LOOP TESTING ENABLES A COMPREHENSIVE, SYSTEMS-LEVEL UNDERSTANDING OF THE DYNAMIC BEHAVIOUR OF PROTECTION AND CONTROL SCHEMES, PROVIDING A NEW LEVEL OF CONFIDENCE TO BOTH EQUIPMENT MANUFACTURERS AND THEIR UTILITY CUSTOMERS

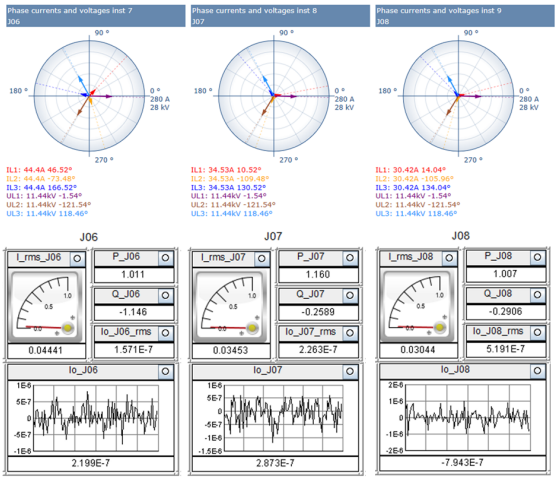
MODELLING AND TESTING: CONSIDERING THE CUSTOMER'S NETWORK AND NEEDS

A simplified model of the customer's substation and the surrounding network was developed in the RTDS Simulator's software. The real-time distribution network model had the following characteristics:

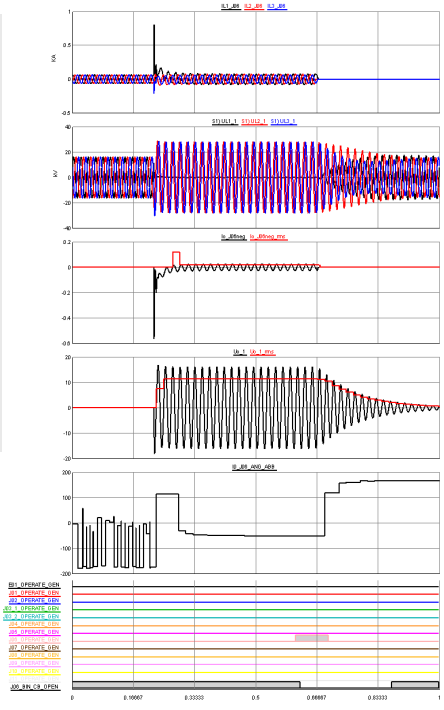
- Outgoing feeders modelled as simple radial lines with no branches, using PI section models with parameters based on provided earth fault current data
- Earth fault compensation modelled with arc suppression coils
- Fault branches in ten locations throughout the network, with the ability to adjust the fault type, resistance, inception angle, duration, and position

Real-time simulation allows for many operating scenarios and contingencies to be represented conveniently and efficiently. ABB conducted several tests in order to validate proper functionality of the SSC600, including the following:

- Comparing Sampled Values and GOOSE messages measured/ issued by device to theoretical system values
- Verification of Multi-Frequency Admittance earth fault protection operation for various fault positions, types, and severities
- Verification of transformer differential protection operation with faults on both HV and MV sides of transformer
- Verification of busbar differential protection operation
- Verification of load shedding operation after system frequency decay



Steady-state feeder current and voltage values measured by the SSC600 (top) are compared to theoretical values from the real-time simulation (bottom)



Simulated feeder phase currents (top), Bus 1 phase voltages (second), residual current including calculated RMS value (third), calculated Bus 1 neutral voltage (fourth), residual current angle with respect to Bus 1 neutral voltage (fifth), operate commands of SSC600 and REF615 (bottom)

OUTCOMES: DEPLOYING WITH CONFIDENCE

Interfacing the SSC600 with a simulated network allowed ABB to comprehensively validate the dynamic behaviour of the system in various scenarios. Closed-loop testing with a real-time simulator also enables the testing of multiple devices simultaneously, allowing ABB to verify the operation of the SSC600 in conjunction with a REF615 feeder relay.

The graph to the left shows the operation of the SSC600's earth fault protection element in a test scenario where an A-phase-to-ground fault was placed on one feeder, 7 km from the substation. The SSC600 received the feeder current and voltage values via Sampled Values from the REF615 and issued an operate command back to the feeder relay via GOOSE Message. The REF615 then issued a circuit breaker open command to the simulated breaker via a binary I/O channel.

LEARN MORE ABOUT HIL TESTING FOR DISTRIBUTION AUTOMATION SYSTEMS AT RTDS.COM/APPLICATIONS

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