CASE STUDY: HVDC & FACTS

DE-RISKING A REVOLUTION IN POWER FLOW CONTROL AT SMART WIRES

USER PROFILE: DELIVERING A NOVEL *FACTS* DEVICE TO TRANSFORM THE GRID

Smart Wires is the world's leading grid enhancing technology and services provider. The company solves grid issues and provides advice on the policies, market design, and solutions critical to creating the digital grid. Smart Wires' offering includes its flagship product, SmartValve™ – an innovative, digital power flow control technology; state-of-the-art software SUMO; and a range of advisory and consulting services whereby its power system experts use advanced software and modeling to develop solutions for generation and load connections, power system operation and planning constraints, and technology integration.

Real-time simulation lab at Smart Wires, USA

Image courtesy of Smart Wires Inc.

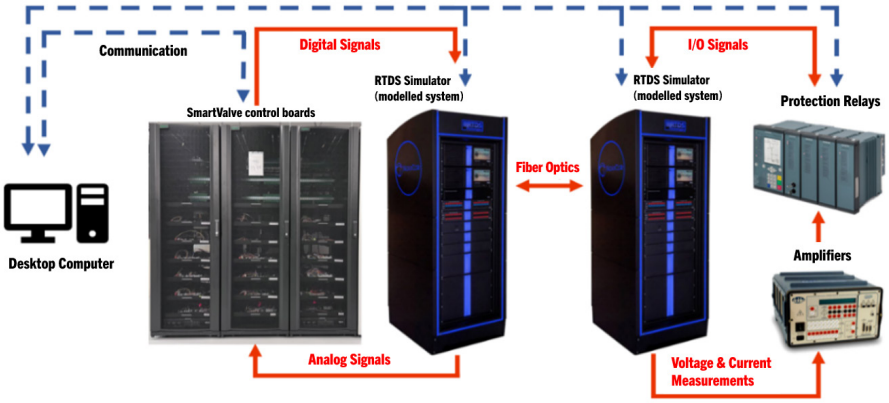
SmartValve is an innovative digital power flow control technology used by leading system operators worldwide to quickly solve bottlenecks by creating extra capacity on the existing network. It is a transformerless, modular Static Synchronous Series Compensator (SSSC) – a FACTS device – with an integrated fast-acting bypass and flexible deployment and control.

Smart Wires has adopted the RTDS® Simulator for the closed-loop factory testing of its power system products. Their North Carolina Headquarters houses their Hardware-In-The-Loop (HIL) laboratory, and their team of power system engineers, spread across the globe, remotely access the HIL setup to perform high-fidelity power system studies and device testing.

PROJECT FOCUS: DE-RISKING SMARTVALVE DEPLOYMENT VIA HIL TESTING

Smart Wires uses its HIL testing setup to validate several functionalities of the SmartValve system before the deployment date. In this project, the aim was to test the interoperability between the SmartValve and the protection relays that operate on the line. At the request of the system operator, the protection relays should be able to bypass the SmartValve. Two RTDS Simulator units were required to complete the testing, given the large network size under study.

In this project, the aim was to test the interoperability between Smart Wires' FACTS device and the existing protection relays that operate on the utility's transmission line.



Smart Wires' multi-chassis HIL tested setup

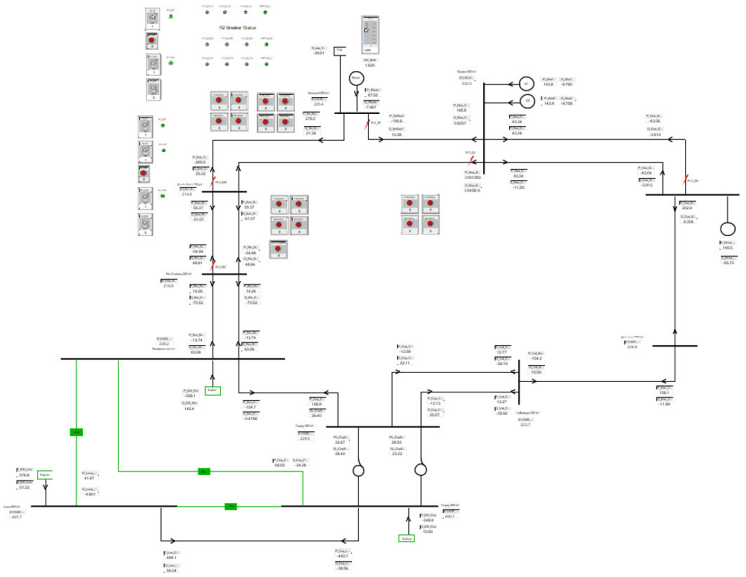
Image courtesy of Smart Wires Inc.

In this HIL setup, Smart Wires connected one NovaCor® chassis to the SmartValve control boards and the second chassis to protective relays. Both the SmartValve and the protection receive analogue output signals from the simulation and provide responses via digital inputs. A power amplifier is required to amplify the ±10 V_{peak} analogue signals from the RTDS Simulator to secondary-level signals for the relays.

THIS TEST SETUP WAS USED TO VERIFY A NEW FEATURE IN WHICH THE UTILITY COULD CHOOSE TO IMMEDIATELY REMOVE THE SMARTVALVE INJECTION FROM THE SYSTEM VIA A RELAY COMMAND.

MODELLING AND TESTING: AUTOMATION IS KEY

Smart Wires' team of power system engineers built a detailed model of the customer's grid in RSCAD®, reducing the peripheral network into voltage sources and linking impedances. The model included fault branches in 18 locations, with the ability to adjust the fault type, resistance, inception angle, duration, and position. Synchronous machine models included PSS and AVR controls, and a combination of PI section and frequency-dependent models were used for transmission lines. The model was tested against load flow and dynamic performance results to validate its accuracy.

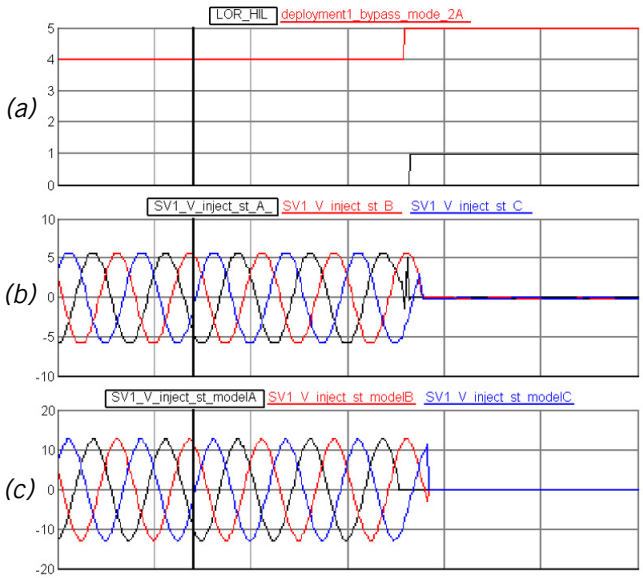


Test network layout in RSCAD's Runtime environment

Image courtesy of Smart Wires Inc.

Smart Wires used computer automation to enable efficient and replicable studies of hundreds of scenarios via RSCAD. They conducted several tests to validate the dynamic performance of the SmartValve and its integration with the customer protection schemes, including the following:

- **Verification of the SmartValve bypass operation during overcurrent scenarios**
- **Verification of protection relays behavior in different fault cases**
- **Verification of the SmartValve operating modes and behavior under different grid conditions**
- **Verification of the impact that different injection modes have on the power system operation**



Demonstration of low overcurrent ride through feature via RSCAD simulation

Image courtesy of Smart Wires Inc.

OUTCOMES: DEPLOYING WITH CONFIDENCE

The HIL configuration allowed Smart Wires to test the interface between the SmartValve and the line protection relays in the context of the utility's network. Low Current Ride Through (LOR) is a SmartValve feature that allows the device to stop its injection immediately and enter bypass mode after detecting an overcurrent event (or after receiving an external command). Plot (a) displays the LOR command and the state of the SmartValve's bypass mode. Plot (b) displays the three-phase voltage injection waveform of the SmartValve control board in the HIL testbed (1 device per phase) and plot (c) displays the same signals extracted from the SmartValve RSCAD models (2 devices per phase), summing up to a simulation of three devices per phase in total.

In this case, the LOR signal is being externalized by the protection relays according to their user-defined internal logic. After receiving the signal, all three phases of the SmartValve transition into bypass mode in less than 5 milliseconds. This feature is also triggered every time the line current falls into the user-selected overcurrent threshold. In that case, the SmartValve can re-establish the same injection level once the overcurrent event ends.

The RTDS Simulator allowed Smart Wires to validate the operation of a new product feature and demonstrate to the customer via hardware-in-the-loop testing that their technology would operate securely alongside the utility's existing protection and automation.

LEARN MORE ABOUT HIL TESTING FOR HVDC & FACTS SCHEMES AT RTDS.COM/APPLICATIONS