OPAL-RT TECHNOLOGIES

Success Story

CONECTA

Successful deployment of the OP4500 at CONECTA S.A.

1. Challenges and reasons to purchase a real-time simulation platform

CONECTA is an integrated company offering monitoring, protection and control solutions for the Chilean and Latin American electricity sector, and has been present in Chile since 1991. CONECTA specializes in the development of SIPS (System Integrity Protection Schemes), which ensure the availability of electrical systems in the event of the emergence of contingencies, with such contingency propagation preventing an overall blackout. SIPS are systems that are classified as mission critical, or rather, their malfunctioning compromises human life and safety. In addition, CONECTA has specialized in developing SIPS, transforming this product into one of the company's main business lines. Consequently, CONECTA decided to increase the reliability, safety and strength of its SIPS by purchase in January 2014 of an OPAL-RT OP4500 real-time simulation platform, allowing PHIL (Power Hardware in the Loop) tests to be executed.

Since then, CONECTA has been implementing OPAL technology to run all FATs (Factory Acceptance Tests) for its products. Currently, and considering the success of OPAL technology, CONECTA has upgraded its OP4500 platform and replaced it with an OP5600 platform, significantly increasing simulation potential and testing. The following is a description of one of the first successful deployments of CONECTA using OPAL-RT's real-time simulation tools.

2. Success Story

To allow the maximum energy output of photovoltaic and wind power farms in the far northern territory of Chile's electrical system, CONECTA S.A. developed and implemented an EDAG/ERAG (Detached Equipment/Generation Reduction) SIPS protection scheme on the 180-km 220 kV double circuit transmission line of the CIS (Central Interconnected System) between Diego de Almagro and Paposo. In addition to protection features, SIPS offers a feature to increase the power transmission of such lines up to its thermal transmission limit, relaxing the N-1 safety criterion and maximizing the injection of renewable energy to maintain the electrical power system's operation and safety standards.

This protection scheme is shown in Figure 1 below and consists of:

- A Monitoring Cell at the Diego de Almagro busbar, responsible for monitoring the voltage, current and status of the switches at that point.
- A Monitoring Cell at the Paposo busbar, responsible for monitoring the voltage, current and status of the switches at that point.
- A Control Cell located in the Tap-off substation (NCRE [Non-Conventional Renewable Energy] plant and SIC connection point), responsible for receiving information from the monitoring cells and NCRE[1] through communication networks, processing information, and sending control commands (power outage/reduced of power supply) to the farms, if necessary.

[1] The control cell communicates with SCADA of the NCRE plant through Ethernet networks by IEC-104 communication protocol.

Figure 1 shows the unilineal diagram of the SIC plot where the SIPS will be implemented.

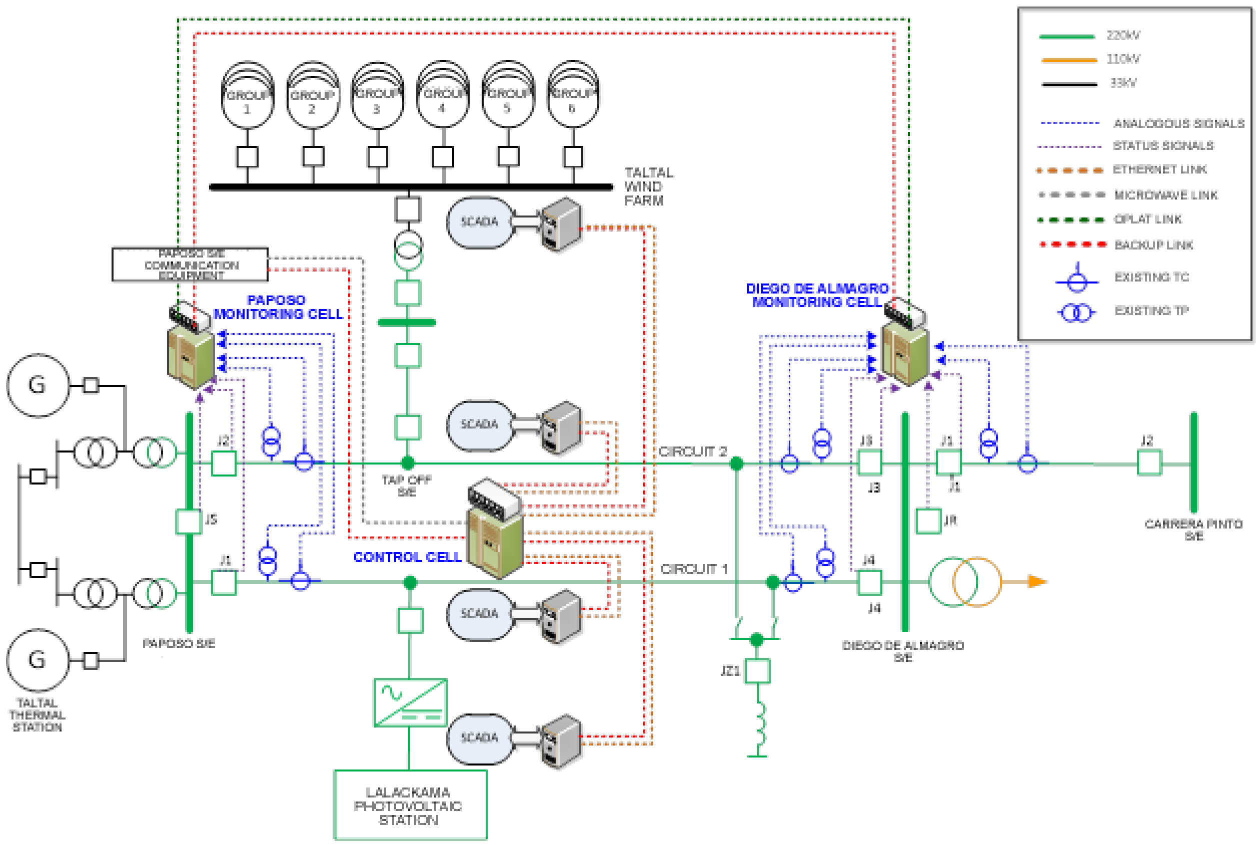

Figure 1: SIPS Scheme of Diego de Almagro - Paposo

When implemented in this way, SIPS must be able to reduce and/or disconnect power generated by the NCRE plants in cases of contingencies (disconnection of any line circuit) that cause an overload in any of the circuits (or plots) along the Diego de Almagro –

Paposo line. SIPS control action and protection must be fast enough to act before the protections located in this stretch are activated, thereby avoiding loss of any other element (circuit or generator) or compromising the integrity of the remaining system is compromised.

Since the functions programmed in the SIPS protection schematics may significantly impact the availability and integrity of the electrical system (or part of it), it is vital to submit such schematics to exhaustive FATS in which as many conditions of the electrical system are emulated to the greatest extent possible, thereby verifying that all requirements for which the SIPS was designed are adequately fulfilled.

During the FATs, the operation of the SIPS schematics must be verified (already fully built) in an environment that emulates the actual conditions under which such schematics would be installed. Therefore, all the applicable voltage and current signals (values of the measuring transformers) of the electrical system between Diego de Almagro and Paposo, switches statuses, and communication signals for SCADA of NCRE farms should be simulated based on a simulated model of an electrical system (equivalent to SIC) that faithfully represents dynamic phenomena and can also be run in real time.

3. Deployed solution

Using a real-time OP4500 digital simulator, the electrical system section (SIC) was simulated in detail where the SIPS will be installed, i.e., the section between the Paposo and Carrera Pinto busbars, to which an equivalent model was added to represent the remaining SIC to the south. All the elements and functions that would be related to SIPS operations were simulated: SVC, SCADA and control activity of NCRE plants, disconnection logic and points of analogous and digital measurements.

To emulate the actual interconnection conditions, the following experimental resources were used:

1. Current and voltage to emulate the analogous signals of the field equipment registered by the monitoring cells, as if they were measurement transformers.
2. Relay circuits: to obtain the status values of the monitored switches.
3. Communications switch: to enable an Ethernet communications network representing the SCADA communication of the NCRE plants through the IEC-104 protocol.

The simulated electrical model and the entire associated control system allowed us to generate an automated testing design which uses a processing time of 120 μs, 15 analogous output signals, 16 digital output signals, and 4 IEC-104 slave modules.

SIPS is constantly monitoring the condition of the electrical system and, at the same time, it is directly connected to the OP4500 simulator to issue the control actions (when appropriate) that may interfere with the simulated electrical system. This methodology is called Power Hardware in the Loop.

The testing schematics used are shown in Figure 2 below.

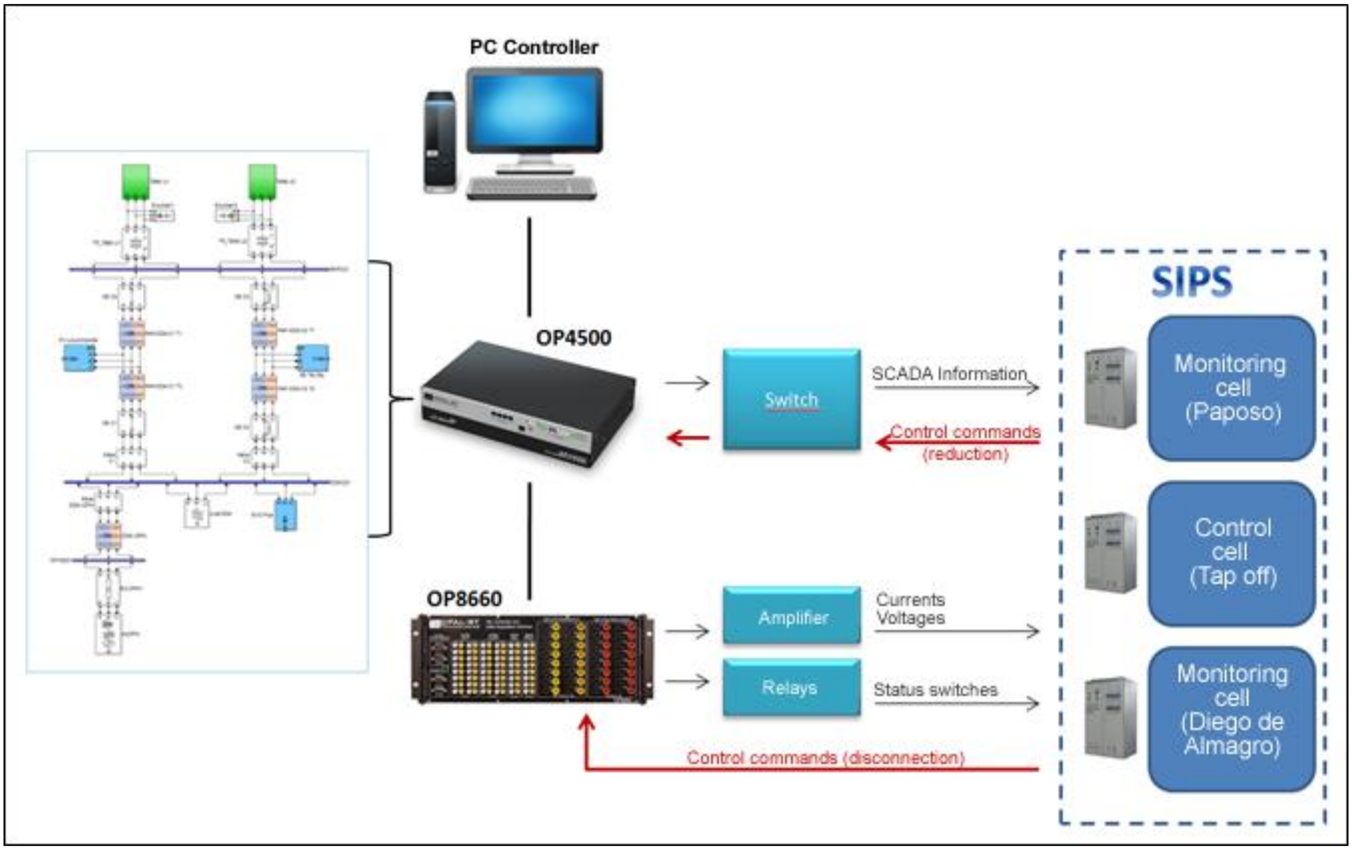

Figure 2: Architecture of SIPS FATs DdA-Paposo - Power Hardware in the Loop

4. Main results (including statistics)

Once the system was implemented, the SIPS protection schematics were tested fully and comprehensively based on the documentation of conceptual, basic and detailed engineering, allowing verification of the logic of control in different situations of the electrical system such as: opening of switches, failures in lines (short circuits), oscillations, congestion in the line due to a generation increase, and load disconnection, among others. In addition, tests were performed to validate SIPS subsystems: verification of correct reception of input variables, recognition of digital status, and tests of high and low probability of anomalies in situations of failures and abnormalities.

Approximately 85% of the tests performed were successful the first time they were run, detecting as main error the portion of logic that did not consider situations of electromagnetic transients in the system. In this case, the SIPS issued unnecessary control actions.

The problems detected were quickly corrected and improved, and the programmed logic was improved so that the SIPS would be capable of detecting the system's dynamic phenomena. All of this was verified a second time using the same method as outlined above.

Before preparing the RTS OP4500 platform, CONECTA ran its FATs by using multiple test boxes (Omicron type), as well as a specialized team of engineers for both the development of test files (Comtrade) and implementation of the testing itself. A SIPS of the scale as described above requires the use of three Omicron testing boxes and three to five specialist engineers, requiring approximately 3 to 4 weeks to be fully tested and received by our client.

The main results obtained by using the RTS OPAL platform are the following:

- Significant decrease in the preparation and running times of the FATs, from approximately three to four weeks to no more than five days.
- Significant reduction in the use of experimental resources, to the point that the use of Omicron test boxes was not required virtually.
- Reduction in the use of specialized human resources by requiring the participation of only one specialist engineer.

- Important detection and correction of problems and programming errors in SIPS which are impossible or very difficult to detect with conventional testing methodologies. This involved the development of more durable solutions.
- Significant increase in the number of tests run on SIPS without impact on the delivery times to the client.
- Significant reduction in SIPS delivery times (of almost three weeks).
- Reduction in the number of SATs (Site Acceptance Test) and consequential reduction in the time invested in such testing due to the thorough and comprehensive development of FATs.
- Significant reduction in the use of human and experimental resources for preparing and developing the SAT.

5. Final comments, conclusions & recommendations

Using the digital simulator in real time and the Power Hardware in the Loop method, SIPS was rigorously tested by increasing the number of tests and decreasing running time relative to the conventional method.

Carrying out exhaustive FAT testing in which real operating conditions were emulated led to the development of a more durable and reliable protection scheme by considerably reducing the possibilities of failure at the time of installation, thereby reducing the work time of field engineers. This reduces costs and boosts client satisfaction thanks to faster testing and installation of the protection scheme.

CONECTA has verified that using an RTS platform significantly reduces costs, increases profits and boosts competitiveness.