FACTS for grid voltage stabilization and increased power transmission capability in Chile

SVC Light, Cerro Navia

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In 2011, a FACTS undertaking comprising a STATCOM (Static Compensator) and an SVC (Static Var Compensator) was supplied and commissioned by ABB in the power transmission system of Transelec S.A. in Chile. The purpose of the installations was to bring about increased power transmission capability over the Central Interconnected System by means of raising the system stability for steady-state as well as contingency conditions in the grid.

Background

The Central Interconnected System serves the central part of Chile and supplies power to about 90% of the Chilean population. Transelec S.A. is the main transmission operator and owns and operates transmission facilities at voltages from 500 kV down to 66 kV.

In Chile, as in other parts of the world, there is growing opposition to the construction of new transmission infrastructure. As a consequence, Transelec S.A. has been investigating optimal ways to exploit existing facilities to a higher degree. To this end, after completion of feasibility studies, it was decided to install FACTS devices at critical points in the grid with the aim of increasing the dynamic stability of the system and thereby allow more power to be transmitted through the grid.

The undertaking comprises the following items:

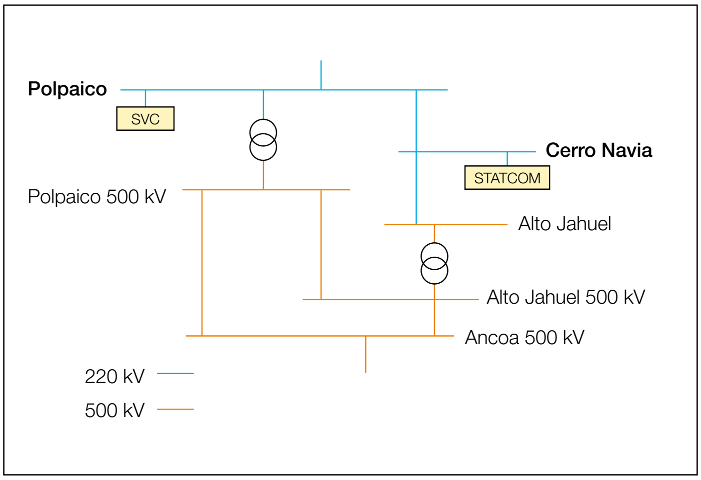
- A STATCOM located at the Cerro Navia 220 kV substation, rated at 65 Mvar inductive to 140 Mvar capacitive (-65/+140 Mvar);
- An SVC located at the Polpaico 220 kV substation, rated at -65/+100 Mvar.
- Control of an MSC (Mechanically Switched Capacitor) located at the Polpaico 220 kV substation, and rated at 100 Mvar.

The common tasks of the FACTS devices are the following:

- Regulate and control the 220 kV grid voltage under normal steady-state and contingency conditions;
- Provide dynamic, fast response reactive power following system contingencies, such as network short circuits and line or generator outages, particularly during high power flow from Ancoa northwards.
- Enable an increase of the power transfer capability of the grid.

Both Cerro Navia and Polpaico substations are located in the capital of Santiago de Chile, where the greatest part of the load of the Central Interconnected System is concentrated. Together, the devices increase the power transmission capacity from previously 1.400 MW to 1.600 MW over the 500 kV corridor between Ancoa and Alto Jahuel, and Ancoa and Polpaico, a transmission corridor exceeding 300 km of length (Fig. 1).

Fig.1: FACTS locations in the Central Interconnected System.



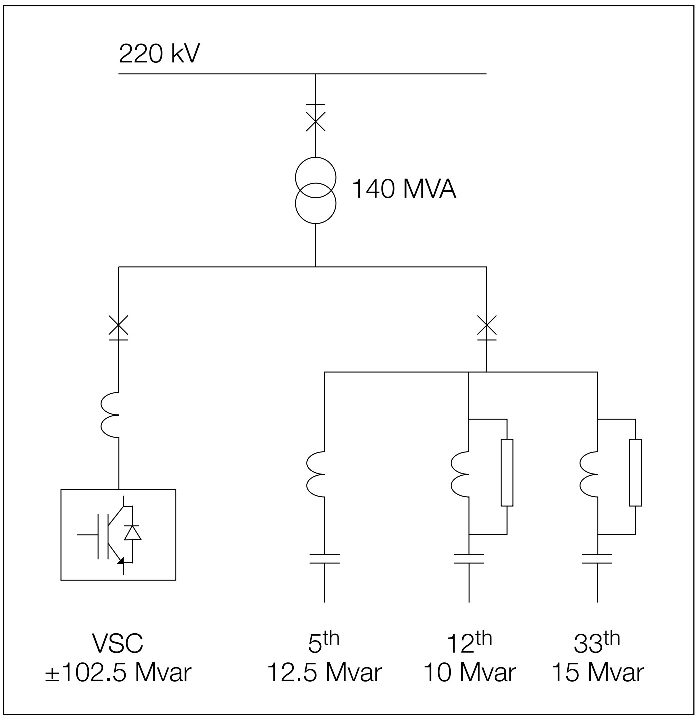


Fig. 2: Single-line diagram, Cerro Navia SVC Light.

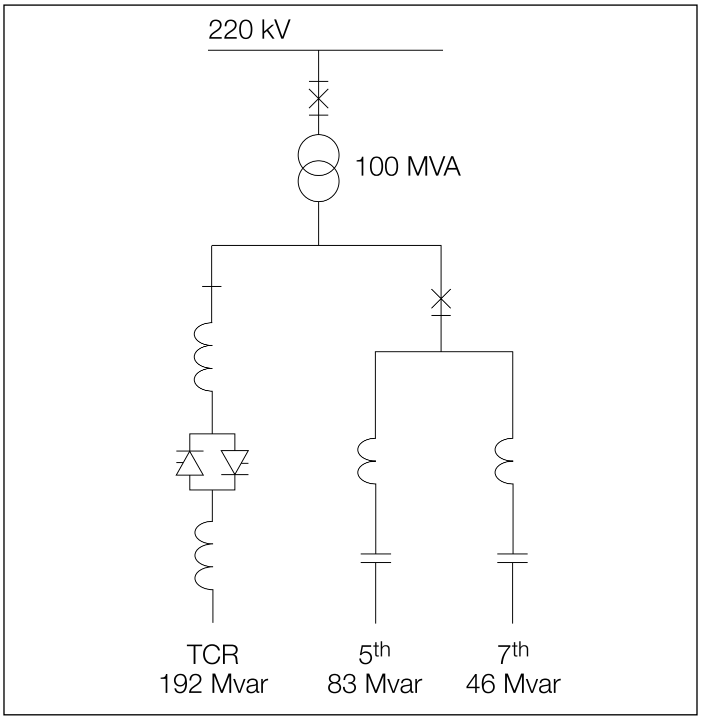


Fig. 3: Single-line diagram, Polpaico SVC.

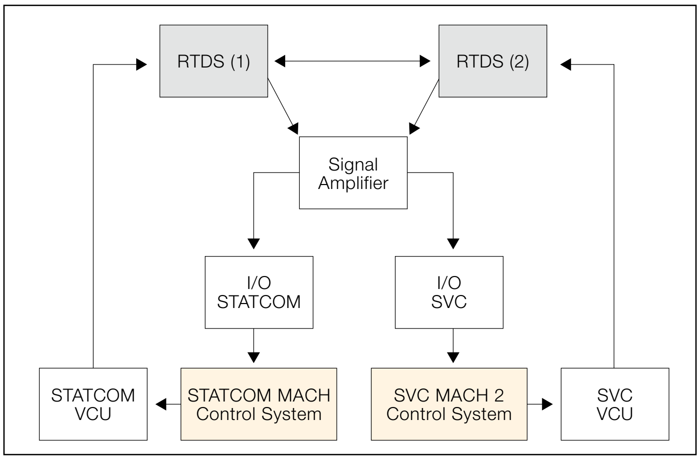


Fig. 4: Test setup of the two FACTS devices in RTDS tests.

SVC, Polpaico.

STATCOM: main circuit design
ABB's trade name for STATCOM is SVC Light®, based on a pulse-width modulated voltage source converter (VSC) design, utilizing IGBTs (Insulated Gate Bipolar Transistors) for switching. The nominal rating of the SVC Light for continuous operation is from 65 Mvar inductive to 140 Mvar capacitive reactive power at 1 p.u. voltage at the 220 kV PCC (Point of Common Connection).

The SVC Light comprises (Fig. 2):

- One VSC branch rated at ± 102.5 Mvar
- One Harmonic Filter branch tuned to the 5th harmonic and rated at 12.5 Mvar
- One Harmonic Filter branch tuned to the 12th harmonic and rated at 10 Mvar
- One Harmonic Filter branch tuned to the 33rd harmonic and rated at 15 Mvar.

SVC: main circuit design
The SVC comprises (Fig. 3):

- One TCR branch (Thyristor Controlled Reactor), rated at 192 Mvar
- One 5th Harmonic Filter branch rated at 83 Mvar
- One 7th Harmonic Filter branch rated at 46 Mvar

The SVC is connected to the 220 kV bus via a three-phase step-down transformer rated at 100 MVA. The phase-angle control of the TCR yields continuously variable reactive power control over the entire SVC operating range (- 65/+ 100 Mvar). In addition, the SVC controls a 100 Mvar MSC located in the Polpaico substation. This way, dynamic reactive power support can be provided by the SVC and SVC Light.

Control system
Both FACTS devices are controlled by microprocessor based control systems, based on the ABB MACH 2 concept, built around an industrial PC with add-in circuit boards and I/O racks connected via standard type field buses. Dedicated voltage and current transformers provide the control system with information on the network parameters employed by the SVC Light and SVC.

The normal mode of operation is automatic voltage control. The voltage control comprises a closed-loop system with control of the positive-phase sequence voltage at the 220 kV bus.

To prevent oscillations in the reactive power output of the SVC, a control strategy allowing gain adjustment of the voltage regulator is included. This control function is essential during weak system operation conditions as well as during system contingencies that could excite oscillations in the reactive power output of the SVC.

RTDS tests
In a system with independent FACTS devices regulating the voltages in locations electrically close, it is of great importance to verify that the control strategies are working well both individually and together. Since the SVC Light and SVC are located close to each other (~30 km), tests were performed to establish that no unfavourable control interaction occurs between the devices. Using RTDS (Real Time Digital Simulation) at the project implementation stage, the controllers of both devices were put to full test simultaneously, whereby correct performance of both FACTS devices was verified. Detailed dynamic tests with network equivalents of both the 500 kV and the 220 kV systems close to the SVC and the SVC Light were performed. The performance of the devices and the control functions were verified during different scenarios, including faults in different locations, transformer energizations, by-pass of existing series capacitors etc. A connection diagram of the test setup is shown in Fig. 4.

Main technical data, FACTS

	SVC Light	SVC
Controlled voltage	220 kV	220 kV
Dynamic rating	65 Mvar inductive to 140 Mvar capacitive	65 Mvar inductive to 100 Mvar capacitive
Control system	Three-phase, closed-loop voltage controller	Three-phase, closed-loop voltage controller
Switching device	IGBT (Insulated Gate Bipolar Transistor)	PCT (Phase Controlled Thyristor)

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