A Static Var Compensator (SVC) rated at 75 Mvar inductive to 150 Mvar capacitive (-75/+150 Mvar) at 230 kV, supplied and installed by ABB, has gone into operation at the Extremoz substation belonging to Chesf, a Brazilian transmission and generation utility located in the state of Rio Grande do Norte in Northeastern Brazil. This equipment is part of a transmission system expansion required to facilitate the integration of renewable energy from more than 1.000 MW collected from a multitude of wind turbine generators located in that region.

The wind energy is first collected at two major points in the grid, João Câmara and João Câmara II, and from there further transmitted to the National Interconnected System (NIS) through the Extremoz 230 kV substation and 500/230 kV transformers.

The Extremoz SVC has been designed to enable the following actions:

- To perform 230 kV busbar voltage control for steady state and contingencies;
- To provide dynamic, fast response reactive power following system contingencies (e.g., network short circuits, line and generator disconnections);
- To enhance first swing stability by maintaining system voltages within the established limits during large disturbances in the power grid.
Main circuit design
The SVC comprises two thyristor controlled reactors (TCR), each rated at 60.6 Mvar, two thyristor switched capacitors (TSC) each rated at 64.2 Mvar, a 3rd harmonic filter rated at 16 Mvar, and a 5th harmonic filter rated at 22 Mvar. A step-down transformer rated at 150 MVA is connecting the SVC busbar to the 230 kV grid.

By phase-angle control of the TCRs and switching the TSCs, continuously variable reactive power control is achieved over the entire SVC operating range (-75/+150 Mvar).

Control system
The reactive power of the Extremoz SVC can be continuously varied by means of symmetrical control of the three phases for voltage control.

The SVC is controlled by a microprocessor based control system. The control system is based on the 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 network variables employed in the SVC control.

The control system provides facilities for SVC control either from the Operator Work Station (OWS) in the SVC control room or remotely via a GWS to a conventional SCADA system.

The SVC control system is structured in the following modes:

- Automatic Voltage Control
- Manual Control

In Automatic Voltage Control, the control system is a closed loop system with control of the positive-phase sequence voltage at the 230 kV busbar. The voltage regulator is required to be fast enough to counteract voltage variations and disturbances but also retain an adequate stability margin. The voltage regulator output is the SVC susceptance reference, $B_{svc}$, which is used to determine the firing angles of the TCRs and the switching instants of the TSCs.

In Manual Control mode, the SVC operates with open-loop control, with susceptance values set by the operator.

Thyristor valves
Each three-phase thyristor valve consists of three single-phase units. Each unit is equipped with a vertical stack of BCT (Bi-Directional Control Thyristors). A BCT is formed by two anti-parallel high power thyristors integrated onto one single silicon wafer and assembled into a housing. In parallel with the thyristor, a snubber circuit (series connection of resistors and capacitors) is mounted. The thyristors are liquid cooled using de-ionized water with low conductivity as coolant. Nickel-plated aluminum heat sinks, providing double side thyristor cooling, also serve as electrical connection between the thyristors.

The TCR snubber resistors are liquid cooled and the TSC snubber resistors, which are of wire wound ceramic type, are air-cooled.

Main technical data

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
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<tbody>
<tr>
<td>Controlled voltage</td>
<td>230 kV</td>
</tr>
<tr>
<td>SVC rating</td>
<td>75 Mvar inductive to 150 Mvar capacitive, continuously variable</td>
</tr>
<tr>
<td>Control system</td>
<td>Three-phase symmetrical voltage control by means of a closed loop voltage regulator</td>
</tr>
<tr>
<td>Thyristor valves</td>
<td>BCT (Bi-Directional Control Thyristors), water cooled, indirect light firing</td>
</tr>
</tbody>
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