

SVC for grid integration of wind power and damping of power oscillations in a 400 kV interconnector



A Static Var Compensator (SVC) rated at 300 Mvar inductive to 300 Mvar capacitive is operated in the 400 kV La Ventosa substation of the CFE (Comisión Federal de Electricidad) power transmission grid in Mexico. The SVC is required to provide high-speed dynamic reactive power generation and/or absorption during certain system outage and loading conditions. The SVC was installed and commissioned by ABB in 2010 as a turn-key commitment.

The SVC is located adjacent to a large wind farm cluster, with a generating capacity close to 2.000 MW at the time of commissioning the SVC. Subsequently, there are plans for additionally 1.900 MW of wind power to go into operation in the area. The wind power is fed to La Ventosa substation over a 230 kV collection grid. The SVC fulfils several tasks in conjunction to this:

- Control the 400 kV voltage under steady-state as well as transient conditions;
- Minimize voltage fluctuations in the grid;
- Provide damping of active power oscillations between wind farms as well as between wind farms and the grid. Also, provide damping of active power oscillations over the 400 kV interconnector between Mexico and neighbouring Guatemala.

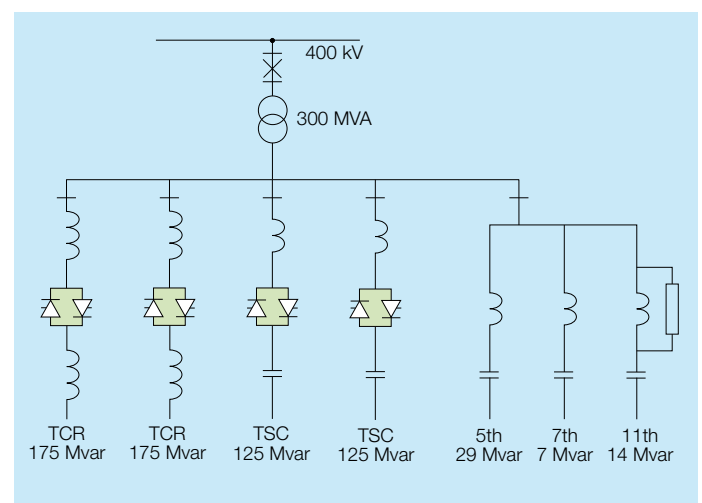
Main circuit design

The SVC consists of two thyristor controlled reactors (TCR), each rated at 175 Mvar, two thyristor switched capacitors (TSC), each rated at 125 Mvar, and three harmonic filters, rated together at 50 Mvar.

The SVC is connected to the 400 kV grid via three single-phase step-down transformers, with one spare single-phase transformer located close to the transformers in operation. The phase-angle control of the TCRs and switching of the TSCs result in a continuously variable reactive power control over the entire SVC operating range (- 300 / + 300 Mvar).

Thyristor valves

Each three-phase thyristor valve consists of three single-phase assemblies with PCTs (Phase Control Thyristor) vertically stacked in two anti-parallel stacks per phase. In parallel with each thyristor, a snubber circuit (series connected resistors and capacitors) is mounted. The thyristors are liquid cooled, using de-ionized water with low conductivity as coolant.



Single-line diagram, SVC

Control system

The SVC is controlled by a microprocessor based control system. The 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 information of the network parameters employed by the SVC.

The control system provides facilities for SVC control either from an Operator Work Station (OWS) in the SVC control room, via remote HMI (Human Machine Interface), or remotely via a conventional RTU/SCADA system. To achieve the highest possible availability of the SVC, the control system is structured in the following modes:

- Automatic voltage control, including the POD (Power Oscillation Damping) regulator
- Manual control.

In automatic voltage control, the control system is a closed loop system controlling the positive-phase sequence voltage at the 400 kV bus. In manual control mode, the SVC operates with open-loop control, with susceptance values set by the operator.

Power oscillation damping

Active power oscillations can appear in the grid system (local as well as inter-area oscillations) in the range 0.1 Hz - 2 Hz. The task of the SVC is to damp out such oscillations. After the power oscillations have vanished, the SVC automatically goes back into voltage control mode.

For flexibility, three identical POD regulators are implemented, each with different input signals:

- Bus frequency
- Active power sum of the transmission lines in the SVC node
- Active current sum of the transmission lines in the SVC node

Gain supervision

Changes in the 400 kV network may influence the fault level of the grid, thereby inducing oscillations of the SVC control if the regulator gain is not accordingly adjusted. For this reason, the control system is equipped with a gain supervision function to ensure stability in the closed loop voltage control during varying network conditions. In case of tendencies for system

For more information please contact:

ABB AB

FACTS

SE-721 64 Västerås, SWEDEN

Phone: +46 (0)21 32 50 00

Fax: +46 (0)21 32 48 10

www.abb.com/FACTS

oscillations, the gain supervision automatically reduces the voltage regulator gain until the SVC reaches stability. The voltage regulator gain can be manually reset from the OWS, via remote HMI, or remotely via the RTU.

Undervoltage strategy

For limited system voltage drops, e.g. due to remote transient faults, the normal voltage control will control the SVC to full capacitive output. However, if the voltage drops below a certain level, adjustable between 0.3 p.u. and 0.8 p.u., the TSCs are blocked and the SVC controlled to zero output. The objective is to prevent overvoltages from appearing at fault clearing in the 400 kV system.

Overvoltage strategy

For primary voltages between 1.1 p.u. and 1.3 p.u., the TCR will operate in the inductive region with TCR current limitation. For primary voltages above 1.3 p.u., the TSCs are blocked and protective firing occurs for the TCR. If the primary voltage remains above 1.3 p.u. for more than 1.0 second, the SVC is tripped.

Degraded modes of operation

The SVC can be operated even with individual reactive power branches temporarily out of operation. The control system is then activated according to the changed conditions.

Trips activated of TSC or TCR branches will first result in opening the 400 kV main SVC circuit breaker, followed by isolation of the faulted branch by opening its disconnect switch. The SVC breaker is reclosed thereafter for continued operation.

For single or multiple TSC failure, the maximum SVC susceptance value is automatically reduced by the control. For single TCR failure, the minimum SVC susceptance is automatically reduced by the control. Reactive power/voltage control will remain continuous with failure of one TCR.

Main technical data, SVC

Controlled voltage	400 kV
SVC rating	300 Mvar inductive to 300 Mvar capacitive, continuously variable
Control system	- Three-phase symmetrical voltage control by means of a closed loop voltage regulator; - Power oscillation damping
Thyristor valves	PCT (Phase Control Thyristors), water cooled, indirect light firing