SVC to Increase Reliability and Reduce Congestion over Multiple 500 kV Lines

A very large Static Var Compensator (SVC) supplied by ABB was commissioned at the end of 2007 at Allegheny Power's Black Oak substation near Rawlings, Maryland. The installation enhances the reliability on Allegheny Power's 500kV Hatfield-Black Oak-Bedington transmission line – one of the most heavily-loaded lines in the PJM (Pennsylvania, Jersey, Maryland) Interconnection area – by quickly changing reactive power levels to control the line's voltage. In addition to improving reliability, the SVC will enable increased transmission capacity across the PJM region. Enabling more power to flow on existing lines is an efficient use of resources and an important step in keeping pace with the region's increased demand for electricity.

The SVC is a midline SVC and constructed to stabilize the voltage at the point of connection during network operation events and contingencies.

The project was initiated as part of PJM's Regional Transmission Expansion Plan, which identifies upgrades and additions to ensure the reliability of the electric transmission system throughout its multi-state region.

The Black Oak SVC is rated at 145 Mvar inductive to 575 Mvar capacitive (-145/+575 Mvar). The turnkey project was completed in 14 months, a record time given its scope, size and complexity. The Black Oak SVC is equipped with an advanced control system capable of controlling not only the operation of the SVC itself, but also the switching of two 500kV Mechanically Switched Capacitor banks (MSC) connected at Black Oak. ABB type PM 550 gas circuit breaker equipment for one of these banks was also part of ABB´s scope of supply.

Purpose of the SVC

The purpose of the SVC is to provide voltage stability to the power system under the following conditions:

1. The SVC restores the 500 kV bus voltage to normal after a system disturbance (fault or load rejection). With heavy west to east transfers across Allegheny Power´s transmission system, the SVC is needed to restore the bus voltage to an acceptable or near normal level for loss of the Pruntytown-Mt. Storm 500 kV line.

2. The SVC increases the power transfer capability of a circuit (Hatfield-Black Oak-Bedington-Doubs 500 kV line) that is otherwise limited by low voltage at the receiving end upon the outage of a parallel 500 kV circuit (Pruntytown-Mt. Storm 500 kV line). The SVC is now capable of continuously providing this reactive power support.

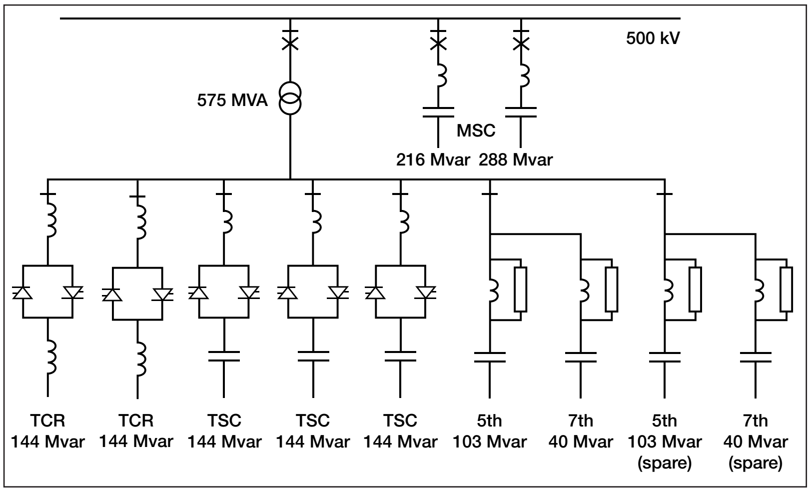
Furthermore, the SVC control system incorporates automatic connection and disconnection of two 500 kV MSC in the same substation.

Main circuit design

The main SVC design is a 6-pulse configuration with two TCR branches (Thyristor Controlled Reactor), three TSC branches (Thyristor Switched Capacitor), and two harmonic filter pairs, one redundant, each tuned to the 5th and 7th harmonics. Redundant filters have been installed for the sake of availability.

The TCRs and TSCs are rated at 144 Mvar each. The harmonic filter pair is rated at 143 Mvar. This gives the SVC a dynamic range from 145 Mvar inductive to 575 Mvar capacitive (-145/+575 Mvar). The spare filters will be connected not only at a failure in one of the main filters but also in case of a TSC failure. With this design approach, the loss of a TSC or a TCR branch will not cause a reduction in the SVC capacitive range, thus keeping the SVC availability at high levels.

Another concern was the occurrence of Geo-magnetically Induced Currents (GIC) verified in this region during solar storm activity, and their possible effect on SVC components. The SVC design took into account harmonic measurements provided by the customer before the installation of the SVC.



Single line diagram.

Control and protection system

The SVC is controlled by a micro-processor based control system, based on the ABB MACH 2 concept, built around an industrial PC with add-in circuit boards and I/O racks connected through standard type field busses. 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 an Operator Work Station (OWS) in the SVC control room or remotely via a Gate Way Station to a conventional RTU/SCADA system.

The SVC control system is structured in the following modes:
- Automatic Voltage Control, including a Power Oscillation Damper (POD) regulator and switching control of two 500 kV MSC.
- Manual Control.

The normal mode of operation is Automatic Voltage Control, operated in a closed loop.

A POD control is implemented to enhance future power transfer capabilities.

Thyristor valves

Each three-phase thyristor valve consists of three single-phase units with PCTs (Phase Control Thyristor) stacked vertically 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.

Main technical data

Controlled voltage	500 kV
SVC rating	145 Mvar inductive to 575 Mvar capacitive
Control system	Voltage control by means of a closed loop system with control of the positive-phase sequence voltage around a dead-band and switching control of external MSC
Thyristor valves	PCT type thyristors, water cooled, indirect light firing

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