

Karavia: SVC for dynamic voltage control of a 220 kV transmission system fed by the Inga-Kolwezi HVDC link



A Static Var Compensator (SVC) rated at 75 Mvar inductive to 75 Mvar capacitive (-75/+75 Mvar) at 220 kV supplied by ABB came on line at the end of 2013 as a Turn-key installation at the Karavia substation of the state utility SNEL (Société Nationale d'Electricité) of the Democratic Republic of Congo. Three MSC (Mechanically Switched Capacitors), each rated at 30 Mvar at 220 kV are part of the installation, as well.

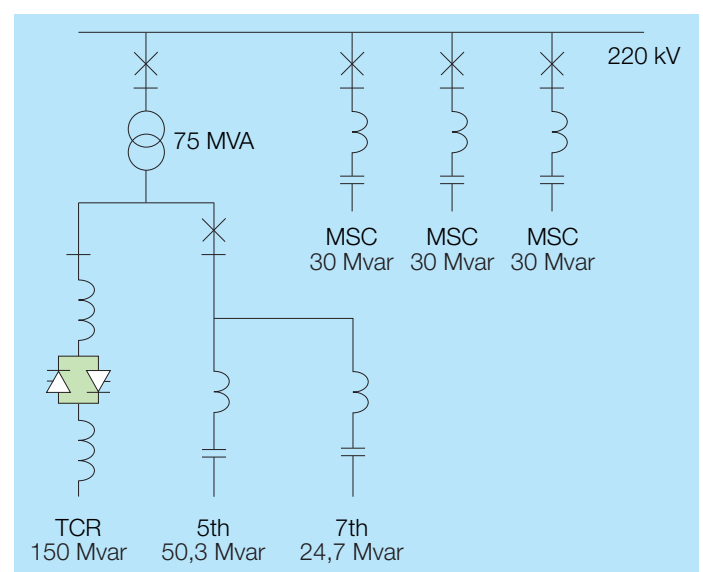
The SVC is part of the rehabilitation of the 220 kV HVAC corridor for power export into the mineral rich Katanga province in the south, holding among other things some of the largest deposits of copper and cobalt in the world. The 220 kV corridor receives large amounts of environmentally friendly hydro power from the Inga Falls on the Congo river over the 1.700 km long Inga-Kolwezi HVDC link. The Karavia 220 kV substation is located approximately 290 km from the Kolwezi converter station at the receiving end of the HVDC link.

The SVC has the following tasks:

- Improve the voltage and angular stability of the 220 kV AC network of Katanga;
- Compensate the deficit of reactive power of the grid, otherwise to be imported from neighboring Zambia;
- Enhance the first swing stability by maintaining the system voltage during large disturbances.

Main circuit design

The SVC is connected to the 220 kV network via a three-phase power transformer rated at 75 MVA. It consists of a Thyristor Controlled Reactor (TCR) rated at 150 Mvar and two Harmonic Filters tuned close to the 5th and 7th harmonics and rated at 50.3 Mvar and 24.7 Mvar respectively. The phase-angle control of the TCR results in continuously variable reactive power over the entire -75/+75 Mvar operating range of the SVC.



Single-line diagram, Karavia SVC

Control system

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 RTU/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 220 kV bus. 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 TCR.

In Manual Control mode, the SVC operates with open-loop control. The desired reactive power output is obtained by manually changing the SVC primary susceptance reference.

External bank control

There are three MSC at the Karavia substation, controlled by the SVC control system. The primary purpose of this control function is to manage the available reactive power sources to maintain a steady voltage level and minimize the number of circuit breaker operations while preserving the dynamic range of the SVC.

Thyristor valve

The three-phase thyristor valve consists of three single-phase units with PCTs (Phase Control Thyristor) stacked vertically in two anti-parallel stacks per phase. Snubber circuits (series connected resistors and capacitors) are mounted in parallel with each thyristor. The thyristors are electrically fired, with energy for firing taken from the snubber circuits. Thyristor firing orders are communicated via optical light guides from the valve control unit located at ground potential (indirect light firing). The thyristors are liquid cooled, with de-ionized, low conductivity water as coolant.

Main technical data

Controlled voltage	220 kV
SVC rating	75Mvar inductive to 75 Mvar capacitive, continuously variable (-75/+75 Mvar)
Control system	Three-phase symmetrical voltage control by means of a closed loop voltage regulator
Thyristor valve	PCT (Phase Control Thyristor) type, water cooled, indirect light firing

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