

SVC for voltage support of a large pulsating load



A Static Var Compensator (SVC) has been commissioned by ABB for CERN's Super Proton Synchrotron (SPS) accelerator. The SVC was put into operation in 2002. The accelerator is fed directly from the 400 kV European grid via an 18 kV intermediate bus. Due to the sensitive nature of the pulsating power converter load for the SPS magnets, very strict requirements were imposed on the stabilization of the 18 kV accelerator bus voltage as well as mitigation of harmonic distortion.

The SPS accelerator is continuously pulsating with a cycle time of about 14 s. The load mainly consists of 12-pulse thyristor converters for bending and focusing magnets, RF cavities and injection tunnels for the Large Hadron Collider (LHC). There is a total power swing from about zero to 230 MW and 200 Mvar within two seconds. The large amplitudes and short rise times of the pulsating power call for rapid reactive power control for voltage stabilization. In addition, strict harmonic filtering is required to eliminate the harmonics generated by the thyristor converters.

Without the SVC, the 18 kV busbar of the SPS electrical network would suffer from periodic voltage variations of about 14% during each power cycle. In such cases, the operation of the SPS accelerator would be impossible. The primary mission of the SVC is to keep the voltage at the SPS bus close to its 18.0 kV set point. Permitted RMS voltage variations are $\pm 0.3\%$ for slow and $\pm 0.75\%$ for fast load changes.

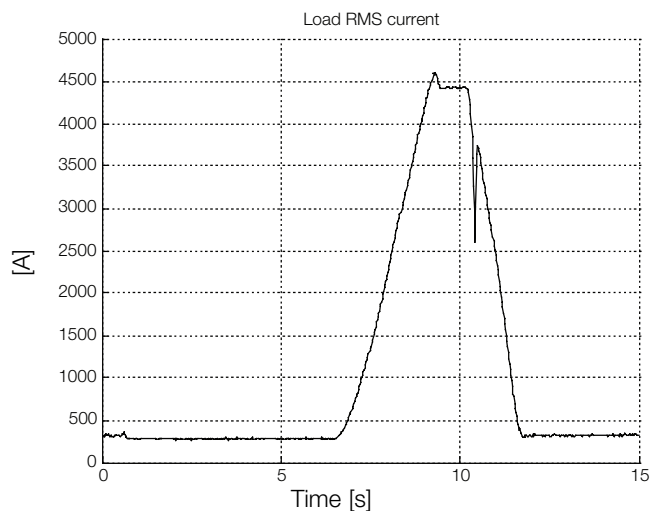
The adopted solution comprises an SVC rated at 20 Mvar inductive to 130 Mvar capacitive, consisting of a Thyristor-Controlled Reactor (TCR) rated at 150 Mvar and a comprehensive array of eight Harmonic Filters with a total reactive power of 130 Mvar.

A second TCR rated at 18 kV, 150 Mvar, also supplied by ABB, will replace an existing old saturable reactor of a second, existing large SVC in the SPS power network.

Main system design

The SVC consists of a TCR rated at 150 Mvar and eight Harmonic Filters together rated at 130 Mvar. The filters are of 2nd, 3rd, 5th, 7th, 11th, 13th, and damped high-pass types. The 5th, 7th, 11th and 13th Harmonic Filters are standard LC filters, while the 2nd and 3rd Harmonic Filters are C-type filters in order to minimize losses.

Accelerator load cycle

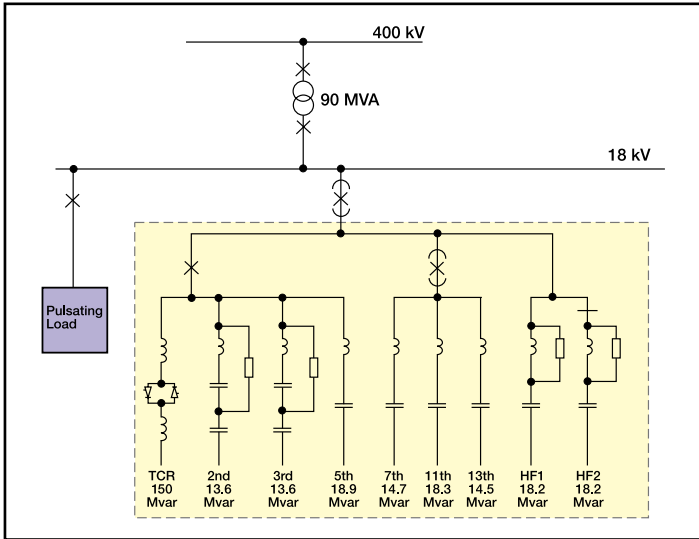


System studies performed prior to the SVC installation confirmed that eight harmonic filters were required in order to achieve a voltage THD (Total Harmonic Distortion) below a required value of 0.8%, with no individual harmonic exceeding the value of 0.5%. Without the SVC, the 18 kV voltage THD would be around 20%.

The thyristor valve consists of single phase assemblies. Each phase comprises two stacks of thyristors connected in anti-parallel. The thyristors are electrically fired, and the energy for firing is taken from the snubber circuits. Orders to fire the thyristors are communicated via optical light guides from a Valve Control Unit.

The SVC is able to operate continuously at voltages down to 0.8 p.u. (14.4 kV). At lower voltages, operation can be maintained for shorter periods of time. The SVC normally operates with all Harmonic Filters connected. To reduce SVC losses during periods of moderate network loading, one of the two high pass filters can be disconnected.

Single-line diagram



Control system

The SVC control system is based on the ABB MACH 2 concept, which is a system of both hardware and software specifically developed for power applications. It is built around an industrial PC with add-in boards and I/O racks connected through standard type field buses like CAN and TDM.

The voltage control system used is a closed loop voltage control with a feed forward path of measured active and reactive power of the load in parallel.

The control system is fully redundant. One of the systems will be active and perform the sequences, strategies and regulation, while the other system will be in stand-by mode. In case of control system malfunction, the SVC will switch over to the stand-by system and, without interruption, continue with the SVC's set values and strategies.

The SVC can be started and stopped from two different locations. Locally in the SVC control room there is an Operator Work Station (OWS/SER) based on a personal computer. The SVC can also be started and stopped from a remote location. Information from the SVC is also transferred to the CERN SCADA system through a Gateway Station in the SVC control system.

SVC performance

	18 kV bus voltage fluctuations	18 kV voltage THD
Without SVC	Up to 14%	Up to 20%
With SVC	Max +/- 0.3% for slow load changes Max +/- 0.75% for fast load changes	Below 0.8%

Technical data, SVC

Controlled voltage	18 kV
SVC rating	20 Mvar inductive to 130 Mvar capacitive.
Control system	Three-phase symmetrical voltage control by means of a closed-loop regulator.
Thyristor valve	Water cooled, with indirect light triggering.

Said about the project:

”This project shows the excellent SVC performance which can be achieved for fast changing loads”

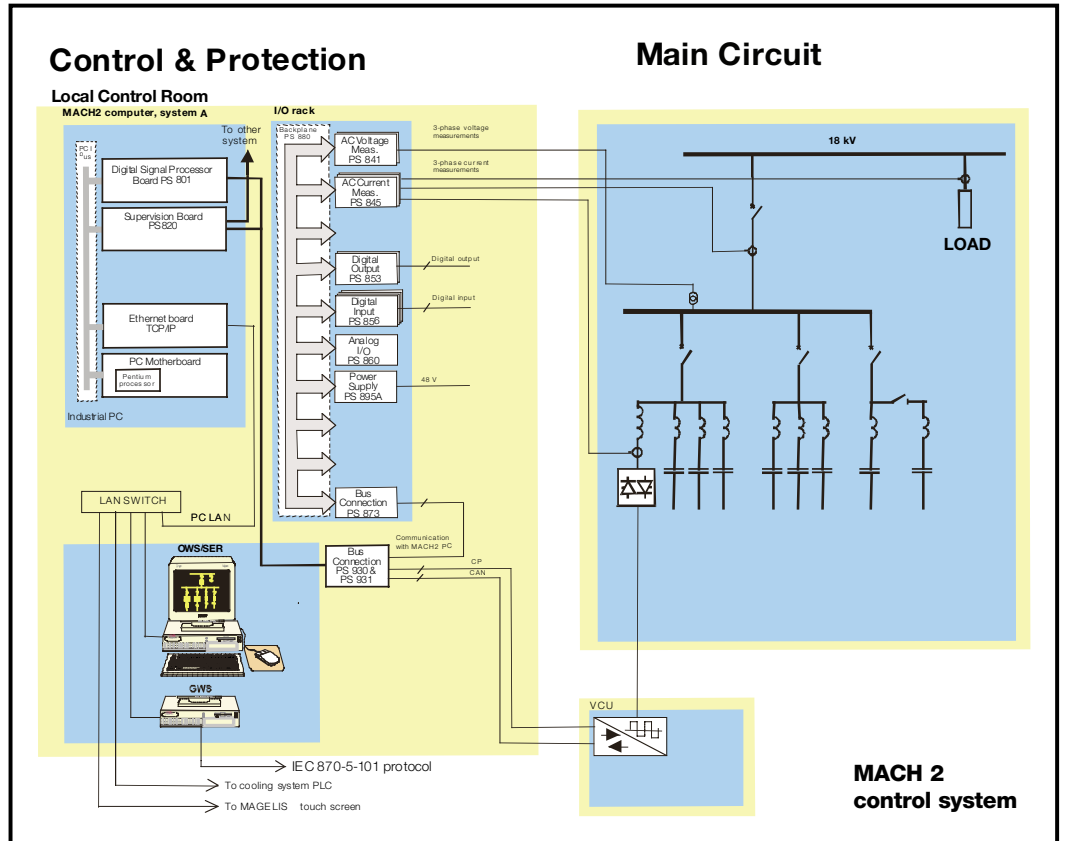


ABB Power Technologies AB FACTS

SE-721 64 Västerås
Sweden
Tel: +46 21 32 40 00
Fax: +46 21 18 31 43
E-mail: info.sepow@se.abb.com
www.abb.com/powersystems