SVC Light®: a powerful flicker mitigator

An SVC Light, rated at 33 kV, 0-164 Mvar has been installed in the melt shop of Outokumpu Stainless Oy in northern Finland, based on a very large Electric Arc Furnace (EAF), rated at 140 MVA, +20% short-time overload capability. The EAF takes its power from a 110 kV grid. Due to a modest short-circuit level at the Point of Common Coupling, the EAF would become a formidable source of disturbances, which, if not properly remedied, would spread through the grid to other consumers of electric power. The EAF is also a heavy consumer of reactive power. The task of the SVC Light is to remedy these disturbances in order to maintain proper power quality in the feeding grid as well as in the plant itself. In fact, the SVC Light is a prerequisite for operation of the EAF at full power.

With the SVC Light in operation, a flicker reduction factor > 4.5 is achieved.

Grid code

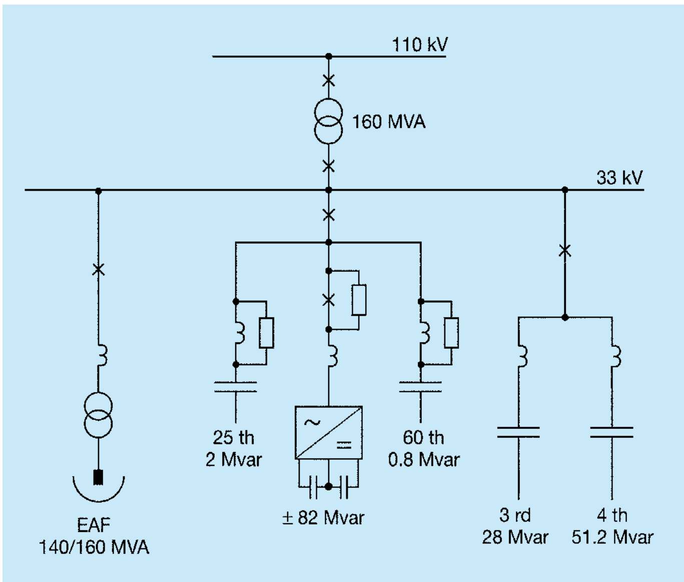
The European Union has firm regulations on power quality issues such as flicker: acceptance levels, methods for measurement, and flicker meters. As a consequence, the Finnish Transmission System Operator and grid owner, Fingrid, imposes strict requirements on power subscribers connected to its grid system, in order that proper power quality in the grid is maintained at all times. This fact, in the case of the steel plant, gave rise to a need for measures to neutralize the grid-polluting effects from the EAF. As an extra benefit, increased power into the EAF was achieved, enabling an improvement of process economy for the plant.

EAF: a demanding load

The EAF is a generator of several kinds of disturbances, which, unless remedied, add up to more or less severe deterioration of power quality. Large and stochastic variations in reactive power consumption give rise to large and rapid grid voltage fluctuations, which show up as illumination flicker, a particularly annoying sensation for people exposed to it.

Furthermore, the EAF is an asymmetrical load on the three-phase feeding grid, giving rise to current and voltage unbalance in the grid. Normally, only very limited levels of asymmetry can be allowed without causing deterioration of power quality for other consumers connected to the same grid.

And last but not least, the EAF is a generator of harmonics, odd and even, as well as interharmonics.



Single-line diagram

Electric arc furnace.

Installation benefits

- The installing of the SVC Light at the steel plant brings benefits not only to the steel plant, but also to the grid owner:
- A low flicker level at the Point of Common Coupling.
- Low amounts of harmonic distortion.
- A low negative-phase-sequence voltage level.
- Load balancing between phases of the 110 kV grid.
- A high and constant power factor at the feeding point of the plant, with no feedback of reactive power into the grid.
- Keeping grid reinforcements at a minimum.

Benefits to the steel plant:

- Increased production capacity.
- Lower electricity consumption per steel weight.
- Reduced specific electrode consumption.
- No reactive power fees.

SVC Light®

SVC Light is ABB's trade name for STATCOM, based on a three-level Voltage Source Converter (VSC) design, utilizing IGBTs (Insulated Gate Bipolar Transistors) as switching elements and a control concept based on PWM (Pulse Width Modulation). The Outokumpu SVC Light is rated at 33 kV, 0 to 164 Mvar (capacitive), continuously variable over the entire range.

The main building blocks of the SVC Light are the VSC, rated at -/+ 82 Mvar, an air-core phase reactor for coupling of the VSC to the 33 kV EAF bus, and an array of parallel harmonic filters together rated at 82 Mvar. The task of the harmonic filters is multiple: shifting the operating range of the SVC Light wholly into the capacitive range (0-164 Mvar); filtering low-order harmonics from the EAF; and filtering high-order harmonics from the VSC.

In the VSC, there are four IGBT valves and two diode valves in each phase leg. The valves are built up of stacked devices with interposed coolers and with external pressure applied to each stack.

One side of the VSC is connected to a capacitor bank, which acts as a DC voltage source. The converter produces a variable AC voltage at its output by connecting the positive pole, the neutral, or the negative pole of the capacitor bank directly to any of the converter outputs.

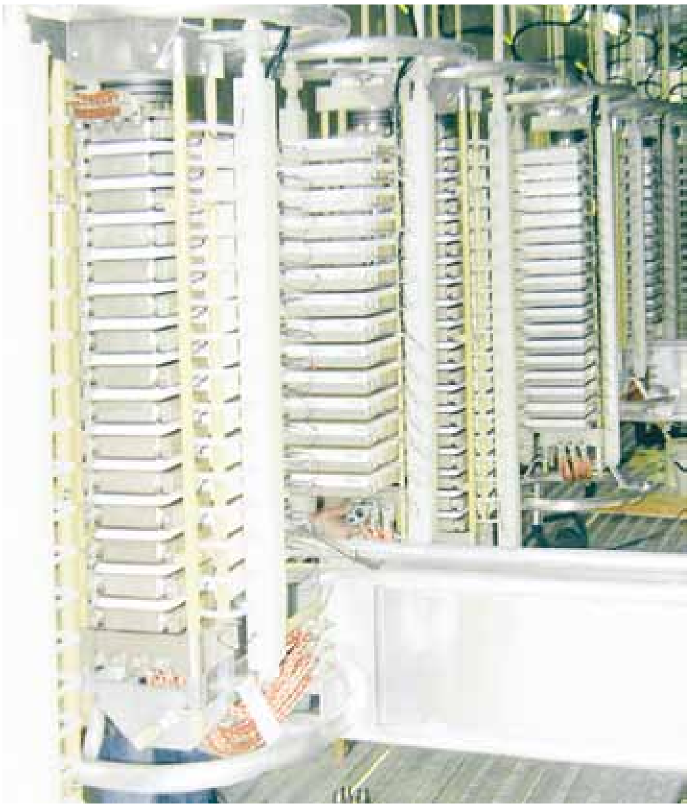
The EAF load changes very rapidly even within the cycle and is a source both of harmonics and asymmetry between phases. By means of PWM, SVC Light is capable of coping with the demand to compensate distorted and asymmetrical currents within the cycle. The result is a total AC current of nearly sinusoidal shape, requiring only very limited harmonic filtering. This contributes to the compactness of the design, as well as to robustness from a harmonic interaction point of view.

Valve voltage

The valve voltage rating has undergone considerable increase since the first installation of SVC Light. Thus, in the first SVC Light, the VSC was connected directly to a bus voltage of 10.5 kV. The next development stage enabled the direct connection of the VSC to 20 kV. And now, a VSC directly connected to a bus voltage of 33 kV is in commercial operation. In none of the cases has there been a need for a large, complicated intermediate transformer.

Dry-type capacitors

The DC link is built up from DryHED®, a novel ABB design of compact, high voltage, dry-type capacitors. By the use of metallized film, insulated by means of polymers instead of impregnated materials, the design of the capacitors is dry, making them very environmentally friendly. In manufacturing, they require neither impregnating fluids nor the use of paint solvents. They have high energy density, which together with their cylindrical shape, enables a very compact DC capacitor bank to be built.



SVC Light® valve assembly.

Control and protection scheme
To fulfill the requirements of the plant on control and protection, a fully computerized control and protection system known as MACH 2 has been implemented. It uses state-of-the-art computers, microcontrollers and digital signal processors. High performance industrial standard buses and fiber-optic communication links are utilized.

Electronics is a rapidly developing field. The best way to make sure that designs can follow and benefit from this development is to build all systems based on open interfaces. The MACH 2 platform is built around an industrial PC, equipped with high-performance add-in boards. It also includes a whole family of I/O circuit boards for sampling and signal conditioning.

The system also includes a human-machine interface (HMI). This serves as the interface between the operator and the control system. The HMI communicates with the control system via the LAN. The system can be controlled from several different locations, locally in the control room or by connecting a remote OWS (operator workstation) using RAS (remote access service).

FACTS Online: A Web Interface and Service: Improves the service level and increases availability
The system also includes a web interface. This makes it possible to access the system via the Internet, allowing remote supervision of the station. This interface is also capable of notifying service personnel via SMS and e-mail in the event of a fault generated by the system.

The hardware realization of the web interface for a FACTS system comprises a web server, a software or hardware firewall and the necessary connections to the FACTS internal LAN and ISP (Internet service provider) connection. The web server contains several web pages that present dynamic data from the FACTS installation, such as indications for breakers, disconnectors, analog values, etc., as well as several lists.

Verification of flicker mitigation
A flicker mitigation study was performed at the design stage, evaluating the flicker reduction factor that could be expected with the SVC Light in operation. To evaluate the flicker level, the voltage variations were computed at the PCC, i.e. at the 110 kV bus. The flicker level was then estimated according to the IEC 61000-4-15 recommendation (Pst). After that, field measurements were performed to validate the flicker improvement performance.

As it was not practically possible to run the EAF at full power without the SVC Light in operation, the flicker improvement factor could not be found by means of flicker meter measurements without and with SVC Light in operation. Instead, an indirect flicker measurement procedure was utilized, in which two currents were used as inputs: the EAF current alone, and the EAF plus SVC Light currents together. The first current then represented the uncompensated case, and the second current represented the compensated case. The corresponding fluctuating voltages were then calculated, utilizing models of the grid impedance. Finally, flicker levels were calculated by means of the IEC 61000-4-15 algorithm (“Flickermeter – functional and design specifications”).

After that, using only the EAF current, the no-compensation flicker was calculated. Using the EAF plus SVC Light current, the mitigated flicker level was calculated. From that, the flicker improvement ratio was calculated. The procedure was verified by parallel recording on an officially certified flicker meter, and shown to be correct and accurate.

Technical data

Grid connecting voltage	110 kV
Furnace bus voltage	33 kV
Rated EAF power	140 MVA +20%
SVC Light rating	33 kV, 0-164 Mvar (capacitive)
Flicker reduction factor	> 4.5

Dry-type DC capacitors for SVC Light®.

MACH 2 constituents: Valve Control Unit and HMI.

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

A02-0199 E, 2011-01, Elanders Sverige AB

Power and productivity
for a better world™