

SVCs for maintaining power quality in a 400 kV grid feeding a steel plant



Since 1998, two Static Var Compensators (SVC) supplied by ABB have been in operation at Saldanha Steel in Cape Town, South Africa. The purpose of the SVCs is maintaining power quality in the 400 kV grid supplying the plant.

One of the SVCs, rated at 0/+165 Mvar at 33 kV intermediate bus voltage, compensates a meltshop load comprising an Electric Arc Furnace (EAF) rated at 115 MVA and a Ladle Furnace (LF) rated at 25 MVA. The other SVC, rated at 0/+60 Mvar likewise at 33 kV bus voltage, has the purpose of compensating a Hot Strip Mill. By the compensating procedure, disturbances emanating from the operation of the steelplant such as voltage flicker, voltage fluctuations, phase unbalance and harmonics are confined to the plant and thereby prevented from entering into the feeding grid and propagating further down the line.

The rolling mill is equipped with cycloconverter drives, posing particularly demanding challenges on harmonic filtering. This has been taken into consideration in the design of the SVC, to safeguard proper filtering at all possible operating conditions.

Another important task of the SVCs is to keep a high and stable power factor in spite of the strongly varying loads of the plant.

Required performance

With the SVCs in operation, the following required performance is met

Flicker reduction factor at the 400 kV point of connection:	≥ 1,8
Power factor at the 400 kV feeder:	≥ 0,99
Voltage unbalance at the 400 kV point of connection:	≤ 1%
Voltage fluctuations at the 33 kV rolling mill bus:	≤ 3%
Harmonic voltage distortion at the 33 kV rolling mill bus:	≤ 3,8%-individual harmonics ≤ 2%-non integer harmonics

Load characteristics

The EAF and Rolling Mill have some distinct characteristics as loads on the network, making SVC a necessity for upkeeping of power quality in the feeding system:

EAF

The EAF is of high power type. It is a heavy absorber of reactive power, and a large generator of voltage flicker, phase unbalance as well as harmonics. For stabilizing purposes, the EAF is equipped with a series reactor.

Rolling Mill

The Rolling Mill consists of a two stand Roughing Mill, rated at 21 MW, as well as a five stand Finishing Mill, rated at 41 MW. All drives are of cycloconverter type. As a load on the network, the Rolling Mill is characterized by

- 1) Large consumption of reactive power, the magnitude of which is variable with the speeds of the drives;
- 2) Strong harmonic generation, with a frequency content varying with drive speeds.

SVC configurations

The EAF SVC comprises a Thyristor-Controlled Reactor (TCR) rated at 165 Mvar, a 2nd Harmonic Filter rated at 35 Mvar, a 3rd Harmonic Filter rated at 65 Mvar, and a 4th Harmonic Filter rated at 65 Mvar. The overall rating of the SVC is 0-165 Mvar (capacitive), continuously variable.

For compensation of unbalanced loads, the SVC has to be shortly operable in the inductive region, as well. The TCR is therefore rated to be operated at a higher load in such situations. Thus, it has been designed with a 10 seconds rating of 1,1 pu, i.e. 182 Mvar.

The 2nd Harmonic Filter is of C-type design, for enabling adequate damping with low losses at fundamental frequency.

The Rolling Mill SVC comprises a TCR rated at 60 Mvar at nominal system voltage, a 3rd Harmonic Filter rated at 12 Mvar, a 5th Harmonic Filter rated at 24 Mvar, and an 11th Harmonic Filter rated at 24 Mvar. The overall rating of the SVC is 0-60 Mvar (capacitive), continuously variable.

Control systems

The EAF SVC control system contains two different regulators. The primary regulator is an open-loop, unsymmetrical three-phase reactive power regulator, and the secondary regulator

is a closed-loop reactive power regulator. The task of the secondary regulator is to keep a desired power factor in the 33 kV EAF bus feeder. The control system also comprises a secondary voltage limiter with the task of preventing the voltage on the SVC bus to exceed a preset voltage level.

The Rolling Mill SVC control system comprises a main, open-loop var control for control of the reactive power consumption of the load, as well as a secondary, closed-loop reactive power control of the 33 kV bus.

Sequence and var control functions are built up in a programmable microcomputer system (VarMACH), using standardized program modules for the different control functions of the SVC. The SVCs are operated and controlled from a Station Control and Monitoring (SCM) system located in the SVC building.

Technical data	EAF SVC	Rolling Mill SVC
Rated voltage	33 kV	33 kV
Dynamic range	0-165 Mvar (capacitive)	0-60 Mvar (capacitive)
Harmonic filters	35 Mvar / 2nd harmonic	12 Mvar / 3rd harmonic
	65 Mvar / 3rd harmonic	24 Mvar / 5th harmonic
Control system	65 Mvar / 34th harmonic	24 Mvar / 11th harmonic
	Open-loop, phase-wise var control, plus closed-loop power factor control. The control system also includes a secondary voltage limiter.	Open-loop var control, plus closed-loop power factor control.

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Single-line diagram

