

Improved power quality and productivity in an iron ore mine by means of SVC



In 2009, an SVC supplied by ABB was commissioned in the LKAB iron ore mine at Kirunavaara in the north of Sweden. The SVC, rated at 0-35 Mvar at 6.3 kV, has the purpose of improving power quality at the 145 kV Point of Common Coupling (PCC) as well as inside the mine by reducing voltage fluctuations and harmonics. As a direct benefit, with the SVC in operation, the ore hoisting capacity has risen, as well, making the extracting process more efficient than before.

In the demanding environment of an iron ore mine, special focus was given to creeping distances of support insulators of outdoor equipment due to iron dust. Likewise, as the mine is situated north of the Arctic Circle, focus was given to snow clearance in winter time, as well as surrounding temperatures down to -50 C.

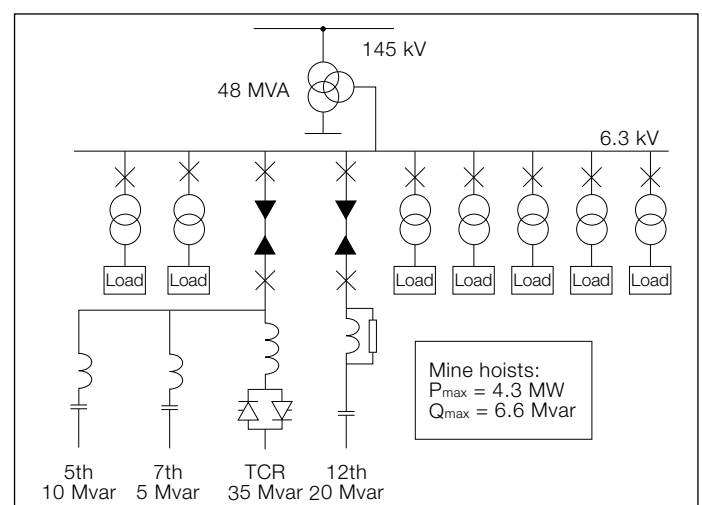
Mine loads

In the underground mine of LKAB, iron ore is brought to the surface by a total of seven mine hoists, each driven by a 4.3 MW thyristor equipped 6-pulse DC drive and representing a fast varying load affecting the whole supply system. The load cycle consists of 3 different phases: acceleration, full speed operation and retardation. A typical load cycle duration is about 90 sec.

Before the advent of the SVC, due to insufficient strength of the feeding grid, simultaneous operation of the drives was seriously restricted, preventing the full capacity of the hoists to be utilized. Only 3% of voltage variations are permitted at the 145 kV PCC. Thus, to limit the voltage variations at the PCC to an acceptable level, only one mine hoist could be started at a time, resulting in reduced productivity. With a planned extension of production capacity from 25 Mtonnes annually to 35 Mtonnes, the situation was aggravated further.

Due to the rapid load variations, conventional mechanically switched capacitors (MSC) were ruled out for voltage control of the drives.

With the SVC in operation, the voltage feeding the drives is supported at all times, with voltage sag never exceeding 3% at the 6.3 kV bus. Under these conditions, the mine hoists can be utilized more efficiently, cutting the total load cycle from previously 96 seconds to 72 seconds, an improvement of hoisting capacity by some 30%. One year of operational experience has corroborated this result, with a noted increase in hoisting capacity by 25-30%.



Single-line diagram, SVC and mine hoists

Main design features

The SVC consists of a Thyristor Controlled Reactor (TCR) rated at 6.3 kV, 35 Mvar, in parallel with three harmonic filters tuned to the 5th, 7th, and 12th harmonics. The total reactive power yield of the filters is 35 Mvar at 50 Hz, giving the SVC an overall control range of 0-35 Mvar capacitive, continuously variable. For proper design of the harmonic filters, not only the grid impedance was taken into consideration but also the reactance of a 250 m cable connection between the feeding switchgear and the SVC. The 12th harmonic filter has a high-pass character, enabling it to damp the 11th, 13th and higher harmonics, as well.

Control system

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

There are two SVC control modes available:

- Closed loop control, based on power factor control, Mvar control or voltage control on the 6.3 kV bus;
- Open loop reactive power control.

Operating experiences

The main goal of the SVC installation is to reduce voltage variations on the 6.3 kV and 145 kV bus bars. A comparison between the voltage variations on the 6.3 kV busbar without the SVC as well as with the SVC in operation at approximately 30 MW hoist load is shown in the graphs. It can be seen that the voltage variations have been reduced from typically $\pm 10\%$ down to $\pm 2\%$. An increase of hoisting capacity by 25-30% has been noted.

	Required values		Measured values	
	6.3 kV	145 kV	6.3 kV	145 kV
Max voltage variations	3%	3%	3%	1.3%
Power factor	0.98	-	0.998	-
Total harmonic distortion, voltage	4.8%	1.5%	3.2%	0.8%
Total harmonic distortion, current	5%	5%	2%	2%

For more information please contact:

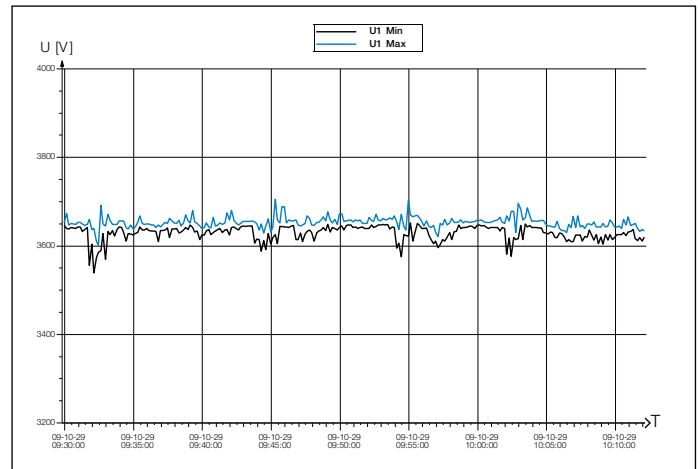
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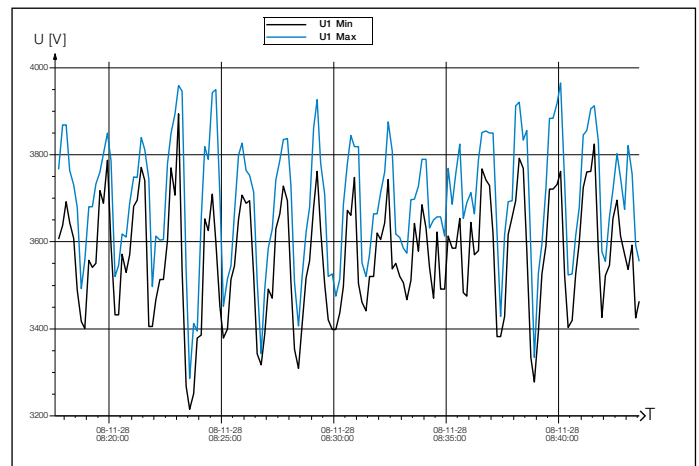
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Performance results

The contractual requirements on the performance of the SVC are listed in the left column below, together with the actually measured values with the SVC in operation. As can be seen, the SVC fulfils its tasks, as well as actually surpasses them.



Bus voltage variation with SVC
(Blue: maximum values; black: minimum values)



Bus voltage variation without SVC
(Blue: maximum values; black: minimum values)

Main technical data, SVC

Controlled voltage	6.3 kV
Dynamic rating	0-35 Mvar (capacitive)
Harmonic filters	5 th harmonic / 10 Mvar 7 th harmonic / 5 Mvar 12 th harmonic / 20 Mvar
Control system	- Closed loop control, based on power factor control, Mvar control or voltage control on the 6.3 kV bus; - Open loop reactive power control
Thyristor valve	Water cooled, PCT type thyristors, indirect light firing