Static Var Compensators for Mining
Enhancing your process economy
Feeding safe and reliable power to a mine is a challenging task. Mines are often remotely located and fed by weak networks. This in combination with heavy and complex mining loads creates problems with both reliability and power quality. An SVC (Static Var Compensator) can increase the overall stability of the system, improve the power quality and also enhance your efficiency and productivity.
Enhance your process economy with SVC

Mining loads and the electrical grid
Operating a mine is a complex task which requires careful planning in order to secure a high availability of the equipment and a stable production rate without costly production outages. A difficult part is the mine’s electrical network. The network needs to support various loads with different requirements on power quality. As mines get larger and more remote, the need of voltage support becomes critical. The SVC will improve network stability and reliability resulting in a more efficient mine process.

You will experience benefits in terms of:
- Increased utilization of the equipment
- Power factor correction
- Mitigation of harmonics, unbalance and voltage variations
- Reduced risks of unnecessary tripping
- Grid code compliance
- Reduced transients at startup of heavy equipment
- Better voltage stability
- Increased transfer capacity

The Static Var Compensator
The ABB Static Var Compensator (SVC) provides dynamic voltage support and makes mining possible even in remote locations with weak grids. The SVC mitigates system disturbances and enables an increased productivity by stabilizing the system voltage.

In short, the SVC is a device which can dynamically control the reactive power flow and voltage in an electrical network. It is based on advanced semiconductor technologies in combination with harmonic filters. The heart of the SVC is the thyristor valve and the control system which are used to dynamically control the voltage. The control system constantly monitors the system and makes sure that just the right amount of reactive power exists in the network and that the voltage is kept at a constant level.

The SVC solves power quality problems for each application.

1. Mine hoists
   - Fluctuating load
   - Huge reactive power consumption at start up (DC-drive)
   - Harmonics

2. Grinding machines
   - Fluctuating reactive power demand
   - Dynamic harmonic spectrum (cycloconverter driven)
   - Very large dominating load (20–30 MW)

3. DC/AC Drives
   - Harmonics
   - Notching
   - Reactive power demand (DC)
   - Voltage fluctuations (DC)

4. Motor heavy load
   - Poor power factor (~0.75 p.u.)
   - Large inrush current
   - Over-voltages at load rejection

5. Smelters
   - Flicker
   - Unbalance
   - Harmonics
   - Reactive power demand

6. Incoming transmission line
   - Weak feeding network
   - Voltage dips
   - Voltage peaks
   - Voltage fluctuations

Close up view of SVC system
Optimizing your mine’s electrical network
Increasing both reliability and efficiency

Better voltage stability
An SVC reacts to external disturbances within milliseconds and will support the system during grid faults or in cases of load rejections in the mine. This provides a better voltage stability and the mine will be less prone to unnecessary tripping of equipment.

Higher efficiency and unity Power Factor
The SVC will stabilize the medium voltage bus of the mine and increase the power factor to unity. This will increase the efficiency of the equipment since this should always be operated at rated voltage.

Lower losses
By installing an SVC, no reactive power is drawn from the transmission system resulting in lower losses in the system and the transformers. Through a higher bus voltage, the motor losses will also be reduced.

Increased transfer capability
When no reactive power is taken from the grid, more active power can be transferred over long distances to the mine. This makes mining expansion possible, also in remote areas, without the need of new transmission lines.

SVC features

<table>
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<th>Feature</th>
<th>Benefit</th>
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<tr>
<td>1. Increased the stability margin</td>
<td>A mine more immune to grid faults. Thus, less trips of equipment!</td>
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<tr>
<td>2. Higher voltage at the point of operation</td>
<td>More power available for the mining equipment!</td>
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<tr>
<td>3. Increased maximum active power that can be consumed by the mine</td>
<td>More power available for the mining equipment!</td>
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The plot above illustrates the main bus voltage (U) as a function of the mine’s actual power consumption (P) at a given time. Without an SVC the bus voltage starts to decrease as soon as the loads start to consume power. With an SVC this voltage drop is reduced contributing to numerous advantages.

SVC versus Fixed filter banks
Traditionally, harmonic filter banks have been used to compensate for the inductive loads of the mine site. However, there are several limiting factors restraining the performance of such installations. The lack of dynamic response of the filter banks cannot counteract the fast variations in reactive power and the risk of over-voltages are restricting the size of the filters, leading to a low power factor and low utilization rate of the mining equipment.

Advantages of the SVC compared to fixed compensation
- Increased stability margin
- Increased active power transmission
- Phase-wise compensation and unbalance control
- No penalties from utility for poor power factor
- Higher utilization rate
- Mitigation effects of faults/disturbances
- Stable feeding voltage
- Reduced transformer size
- Less winding heating in motors
Power quality

A weak grid in combination with heavy loads, harmonic emissions and a complex cable network cause problems with power quality. By stabilizing the voltage and at the same time making use of harmonic filtering capabilities of the SVC, many of these problems can be solved. The SVC will enhance and safeguard the production capability.

With an SVC you can:

- Keep a constant power factor and voltage
- Reduce harmonics in the system
- Mitigate transients such as inrush currents and voltage dips/peaks
- Balance an unbalanced system (Negative phase sequence control)
- Damp flicker
- Improve power tariffs
- Comply with grid codes

Example of Voltage improvement at a large Iron ore mine in Sweden after installing an SVC:

Without SVC

The dynamic behavior of the loads causes severe voltage fluctuations without any dynamic support.

With SVC

An SVC mirrors the behavior of the loads, reducing the voltage fluctuations from ten to two percent.
Thyristor valve
The semiconductors are controlled on a millisecond basis in order to optimize the voltage profile on the bus and control the reactive power flow. The same technology is used for HVDC applications involving very high currents, ultra-high voltages and having the highest demands for reliability.

Cooling system
The cooling system is needed to cool the semiconductors. It can either use a cooling tower or, where available, industrial process water.

Control & protection system
The control system is the brain of the SVC, constantly monitoring the system to make sure it is operated under optimal conditions. ABB uses the same control system as in demanding HVDC applications. The control system has built-in redundancy to ensure highest availability.

TCR (Thyristor Controlled Reactor)
This reactor is in series with the semiconductor valve. It is by controlling the current through the TCR that the reactive power is controlled.
Connection of the SVC

An SVC can be connected to the medium voltage bus by either cables or busbar. If there is limited space in the substation, the SVC yard can be placed up to 1 km away and be connected by cable. Alternatively, the SVC can be connected on the high voltage system through a transformer.

Harmonic filters

The harmonic filters have two objectives. Firstly, to supply capacitive reactive power to the network. Secondly, to filter unwanted harmonics.

SVC building

The SVC building can be prefabricated in order to save time and cost during both civil works and installation.
Application example: Mine hoists
SVC enabling a 25–30 % increase of hoisting capacity.

The LKAB mine in Kiruna, Sweden, is one of the largest underground iron ore mines in Europe with an annual production of 25 million tons. Due to a weak network and strict power quality requirements, the full hoisting capacity could not be used. In order to limit the voltage variations and assure safe operating conditions only one of the seven mine hoists could be accelerated at a time.

In order to increase the hoisting capacity, LKAB installed an SVC to provide the reactive power needed to accelerate the mine hoists. The SVC stabilizes the 6.3 kV bus voltage reducing the voltage variations from about ten percent to less than two percent. The installation made it possible to accelerate three hoists simultaneously, enabling a production capacity improvement of 25 – 30 percent.

The SVC was designed for the mining environment and winter conditions in the north of Sweden with extreme temperatures (-40°C) and dust. To facilitate a quick installation and minimize the civil work, the building was delivered as a prefabricated container. After the first successful installation, ABB has now equally successfully delivered and commissioned a second SVC for LKAB.

Illustration of a mine hoist load cycle.
The sharp peak in reactive power during start-up of heavy equipment can lead to under-voltages and tripping of protections as well as system instability. The SVC rapidly responds to the peaks and counteracts the effect on the power system.

The SVC installed at LKAB in Kiruna, Sweden, improves power quality and enables a production increase.
Application example: General voltage stability
SVC facilitates a mine expansion through dynamic voltage support of a radial, weak grid.

Two SVCs were successfully installed to support the voltage at the Oyu Tolgoi Copper and Gold mine in Mongolia. The mine, owned by Rio Tinto, Ivanhoe Mines and the Mongolian government is expected to produce 170,000 tonnes of ore concentrate per day. The large complex fed over a 200 km long transmission line, was in need of reactive power compensation to facilitate its expansion.

The majority of the loads at the site are large mining loads including several 20 MW SAG-mills and Ball mills. The SVCs were installed to support the system in case one of the 220 kV lines is switched out of service and to prevent excessive over-voltages following system load rejections.

Another primary function of the SVCs is to support the system voltage in the event of a fault in the 220 kV transmission system or in the 33 kV mining distribution system. In these situations the SVCs will inject reactive power to support the system during restart of the many induction motors. Finally, in case of a single phase fault, the SVC will reduce the unbalance in the system enabling a swift fault recovery.

The Oyu Tolgoi SVC in Mongolia.
An important step in the refining of many ores is a pyro-chemical process. These smelters often require special attention and can cause problems in terms of:

- Voltage fluctuations and flicker
- Unbalanced operation
- Harmonics

SLN (Société Le Nickel) is operating three submerged Nickel arc furnaces in New Caledonia. The main power supply was composed of four generators and initially the furnaces were compensated by harmonic filter banks only. However, the unbalanced load stressed the generators and when starting to plan for a capacity increase, SLN realized that they required a dynamic solution to improve the power quality.

An SVC was selected as the most efficient solution to compensate the submerged arc furnaces and maintain the power quality in the feeding grid as well as in the plant itself. The resulting benefits were:

- Increased active power in the furnaces and increased productivity
- Reduced wear of power generators and other sensitive equipment reducing maintenance costs
- Phase-wise compensation and unbalance mitigation, critical for furnace operating with single-phase transformers
- Lower noise to other loads and consumers connected to the grid, increasing equipment life-span
- Harmonic reduction and Grid code compliance

The SVC nearly eliminates the negative phase sequence current and increases the power factor. In addition, the harmonic components are significantly reduced.

The arc furnace is a cause of many power quality disturbances in the power grid. The SVC mitigates these disturbances and not only does it stabilize the grid, but it also increases the plant productivity.
FACTS (Flexible AC Transmission Systems) is a term representing an entire family of devices for improved use and flexibility of power systems.

The SVC is a member of ABB's family of FACTS technologies. Other members are:
- SVC Light®/STATCOM
- TCSC (Thyristor Controlled Series Capacitor)
- Series Compensation
- DynaPeaQ® energy storage

ABB in the mining industry, it started in 1891...
ABB delivered its first steam generator for a mine hoist in 1891. Since then, ABB has delivered a wide range of products for the mining industry and has mining references in more than 75 countries. ABB has been delivering SVCs for more than four decades and with more than 500 SVCs installed world-wide, we are proud to be the leading company in reactive power compensation systems.

FACTS Care

ABB customer support assists you throughout all phases of the installation lifecycle. With our FACTS Online remote service, ABB offers service 24/7 globally and assists our customers with risk management to secure a continuous operation. Select from a wide range of service options that best fits your needs.