FACTS

SVC Light®
The next generation

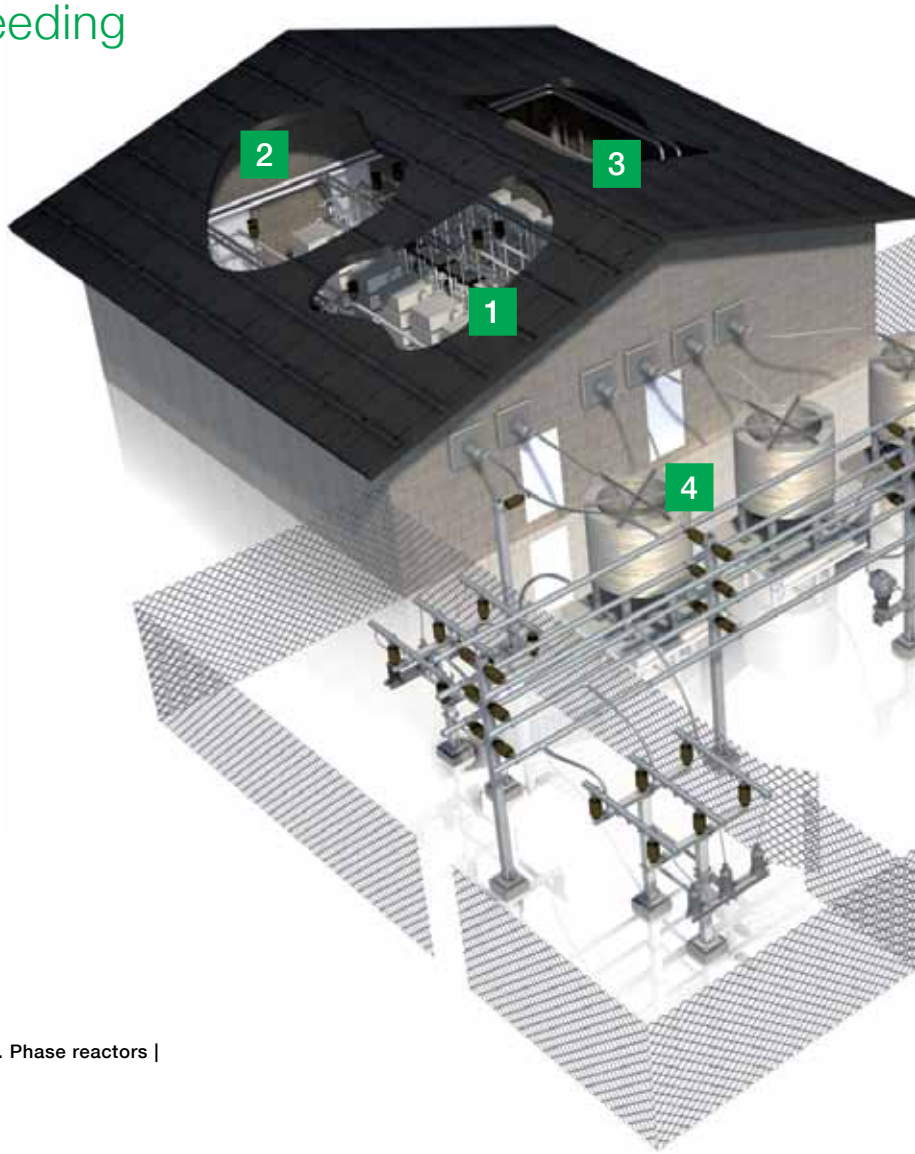
Power and productivity
for a better world™

Proven superiority
and leading edge technology

SVC Light® solves the troublesome problem of electric arc furnace generated flicker. SVC Light also improves arc furnace economy by supplying high quality power to the furnace. The heart of SVC Light is the high power Insulated Gate Bipolar Transistor, IGBT.
With SVC Light there are no limitations. You can build your melt shop where it suits you the best, even where the strength of the feeding grid is limited.

With ABB SVC Light you get:

- World class flicker mitigation
- Direct connection
- Unlimited range
- Excellent process economy
- Unrivalled experience



1. VSC | 2. Control and protection system | 3. Cooling system | 4. Phase reactors | 5. High pass filter | 6. Harmonic filter (optional)

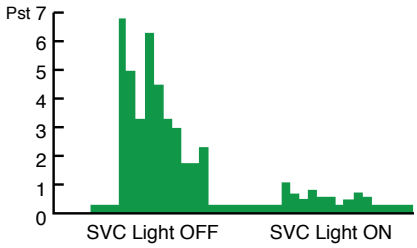
World class flicker mitigation

SVC Light radically reduces flicker

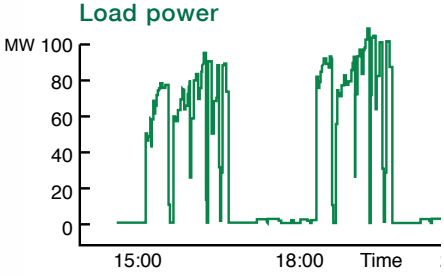
The most common source of flicker is electrical arc furnaces (EAF). The violent forces released in the furnace process impose a wide band of disturbances on the power supply. This “electrical pollution” can be reduced by controlled reactive power compensation. However, these disturbances are not fixed, but comprise a mixture of amplitudes and frequencies and phase unbalance which change over time as a function of mechanical resonances, electrical supply, operation modes, and other process parameters. This wide variety of process conditions results in behavior of a truly stochastic nature.

The only way to stabilize voltage and reduce disturbing flicker successfully is to continuously measure and correctly counteract rapid changes in currents and reactive power flow by extremely fast reactive power compensation. Through dynamic compensation the voltage on an arc furnace bus can be stabilized and disturbing flicker practically eliminated.

Flicker mitigation



Load power



Direct connection

No transformer between furnace bus and SVC Light

SVC Light is directly connected to the EAF bus all the way up to 69 kV, avoiding all converter transformer drawbacks. This, in particular, is important for achieving the best possible flicker reduction by compensating the furnace current including DC components. DC components in the EAF current are common during EAF energizing and bore down period of the melt. To make things even worse, it is in these parts of the cycle that flicker will be at its heaviest.

No transformer saturation – full flicker reduction

With a converter transformer saturation can happen due to DC components in the current, and flicker reduction will suffer as a saturated transformer does not allow for fast and accurate reactive compensation. This, of course, will not happen with a directly connected SVC Light.

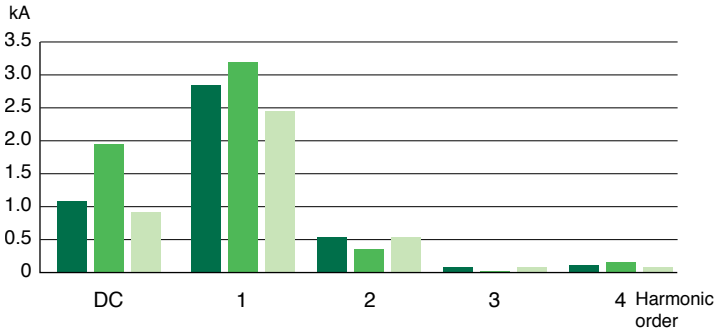
Harmonic reduction

Furthermore, the latest power quality standard such as IEC/TR 61000-3-6 recommends a relatively low level of inter-harmonics (<0.2%) to avoid interference with other equipment. To comply with the standard, SVC Light must actively damp the harmonics and inter-harmonics. This can be achieved by controlling the SVC Light current to mirror the load current. To accomplish this task, it is important that the SVC Light is directly connected to the furnace bus through a linear reactor (air-core reactor). Use of an intermediate transformer to connect the valve to the furnace bus would not be desirable as a saturated transformer generates harmonics.

Avoiding the converter transformer brings:
Direct, quick and unaffected control
Superior flicker mitigation
Efficient harmonic reduction

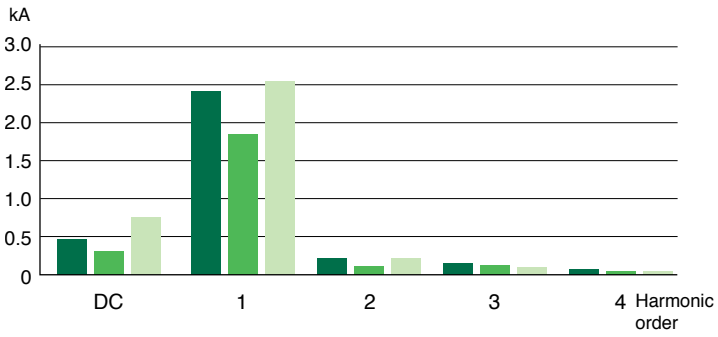
...plus, of course, a number of additional benefits:
No environmental hazard from oil
No fire hazard
No transformer losses
Less noise
Smaller footprint
A saving of transportation and installation costs
Less maintenance

Initial bore-down



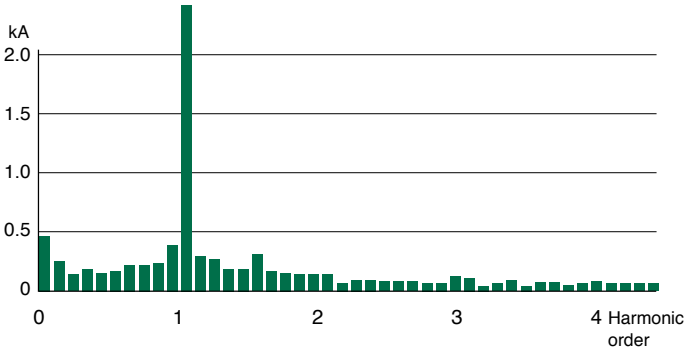
Initial bore-down: Very large DC current (phase-wise).

Melting



Melting: Harmonic spectrum (phase-wise).

Compensating currents



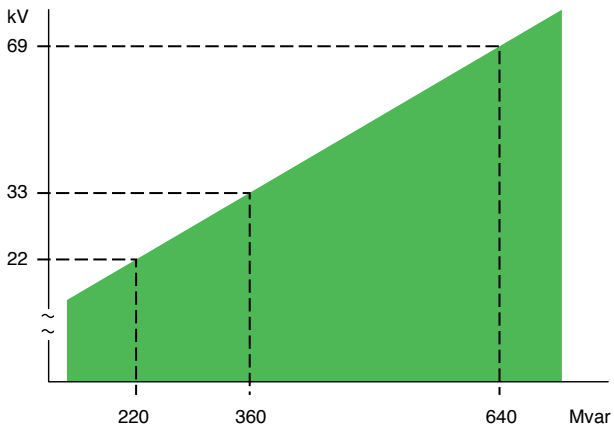
Compensating currents from SVC Light (mirror load current).

Unlimited range
SVC Light can successfully be used with any EAF in any environment

Unlimited: Mvar ratings are available for all EAF sizes, ie with SVC Light, the reactive power compensators available are no longer a limitation on EAF rating. No electric arc furnace specification is too tough for SVC Light, not even in a very weak grid.

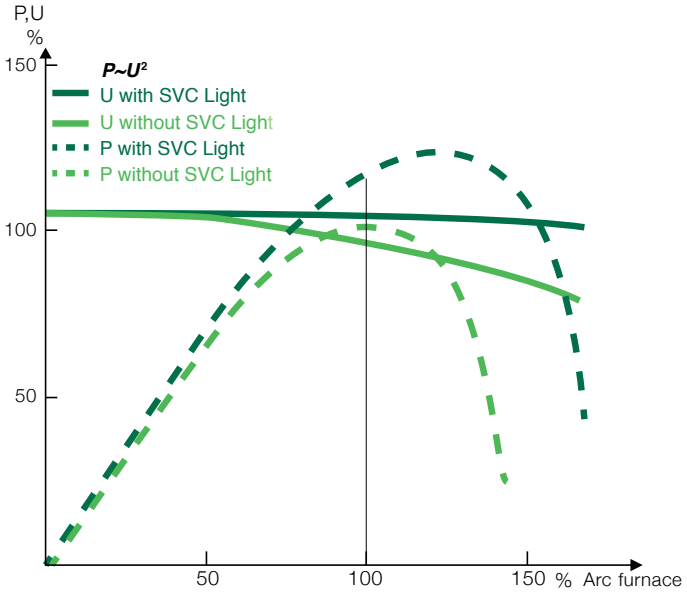
SVC Light is scaleable and functional in all feeding grids for steel plants, including the very weak ones. Simultaneously, it can be rated to accommodate the highest EAF bus voltages as well as the largest MVA ratings. The result: with SVC Light, the steel plant can be installed wherever it suits the builder, owner, investor, and be sure to cope with the severest demands from the grid operator, without risking disputes over power quality issues.

Operation range, SVC Light

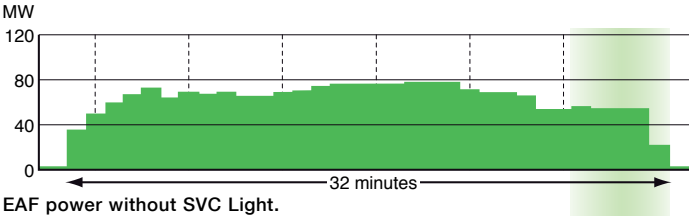


Excellent process economy

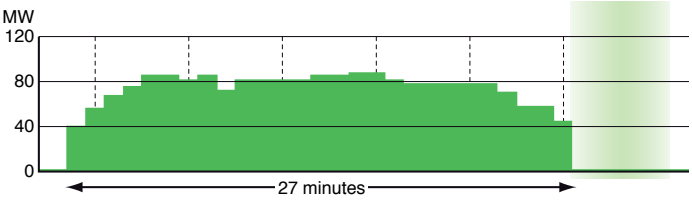
With SVC Light, better plant utilization results in better operational economy. SVC Light helps to maintain a high and constant furnace bus voltage, thereby enabling high power input to the EAF.



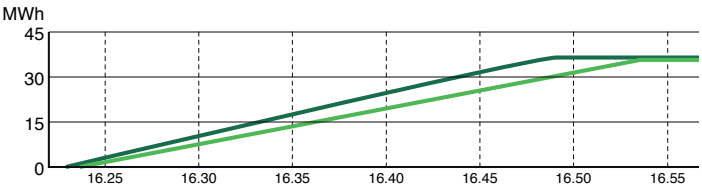
P=Arc furnace power. U=Voltage at arc furnace bus.



EAF power without SVC Light.



EAF power with SVC Light. As the melting power increases with SVC Light the melting cycle can be shortened.



EAF energy:
With SVC Light.
Without SVC Light.

You can build your melt shop where it suits you the best, regardless of network strength.

The resulting EAF power increases with SVC Light during the melt cycle, and thereby increases energy yield per time unit. This can be utilized either to increase the output of molten steel, or to attain a certain steel output in a shorter time than would be possible without SVC Light.

Reactive power compensation through SVC Light gives you the following benefits:

- Shorter melt down times
- Lower energy losses
- Reduced electrode consumption
- Refractory savings

Improved power factor:

- Lower utility tariff
- More efficient use of existing electrical plant

Optimized melting profiles

- Excellent flicker suppression → no limitation of choice in melting profile.

Unrivalled experience

“SVC Light is a prerequisite for the operation of the EAF.”

An example: An SVC Light rated at 35 kV, 0-164 Mvar has been installed in a green-field steel plant, based on a very large EAF, rated at 140 MVA. The EAF is taking its power from a 220 kV public grid. Due to very strict flicker demands at the point of common coupling, the plant could neither be operated nor even started without corrective measures taken to ensure that the grid code is fulfilled with the EAF in operation. What is of concern is maintaining proper power quality in the grid.

The primary task of the SVC Light is to suppress flicker to acceptable levels, but also to yield a high and constant power factor, as well as limit harmonic distortion and negative phase sequence componenets generated by the EAF.

ABB has SVC Light experience since more than a decade
With ever-growing ratings of modern electric arc furnaces, their non-linear characteristics as loads on the network, as well as their strongly stochastic behavior, EAFs present a formidable challenge as power system loads. Mitigating their impact such as active and reactive power fluctuations, flicker generation, harmonics and unbalance between phases is a task for SVC Light which has no parallel in other fields of application.

With more SVC Light installations on EAFs than any other manufacturer, ABB has cemented its lead in the field.

How is this achieved?

The reactive power can be controlled very fast. As a result, outstanding flicker reduction is achieved.

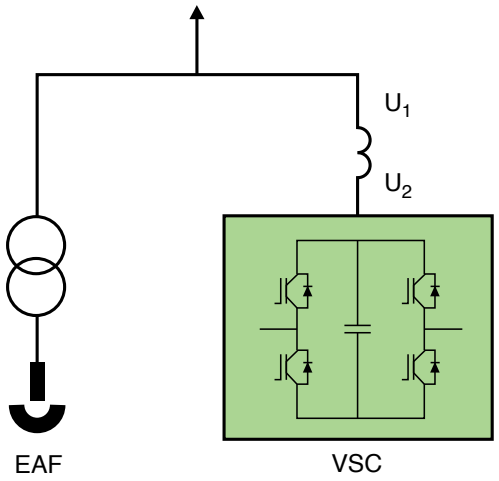
VSC – a fully controllable voltage source

The function of a VSC (Voltage Source Converter) is a fully controllable voltage source matching the system voltage in phase and frequency, and with an amplitude which can be continuously and rapidly controlled, so as to be used as the tool for reactive power control. In the system, the VSC is connected to the system bus via a small reactor.

By choosing zero phase-shift between the bus voltage and the VSC voltage, the VSC will act as a purely reactive element. With the VSC voltage and the bus voltage denoted U_2 and U_1 respectively, if $U_2 > U_1$, the VSC will act as a generator of reactive power, ie it will have a capacitive character. If $U_2 < U_1$, the VSC will act as an absorber of reactive power, ie it will have an inductive character.

The EAF has an inductive character, ie to compensate its demand for reactive power, capacitive generation is needed. The VSC has a symmetrical inductive/capacitive range on either side of zero Mvar. By means of a harmonic filter, capacitive reactive power is generated, in order to shift the overall range of SVC Light into the capacitive region. Some inductive reactive power is needed, as well, to enable the SVC Light to suppress unbalance between the phases of the furnace load.

SVC Light: principle diagram



SVC Light versus SVC

Only part of the MVA needed

SVC Light is based upon a VSC, while SVC is based on a TCR (Thyristor Controlled Reactor). In both cases, harmonic filters are utilized to provide capacitive reactive power for shifting the overall working range partly or fully onto the capacitive side.

As the VSC has its dynamic range symmetrically around zero Mvar while the TCR can only go inductive, the VSC only needs half the rating of the TCR, and only half the amount of Mvar in filters to achieve a certain overall dynamic range on the capacitive side.

For example, to build a dynamic compensator with the range 0 – 100 Mvar capacitive, the following is required:

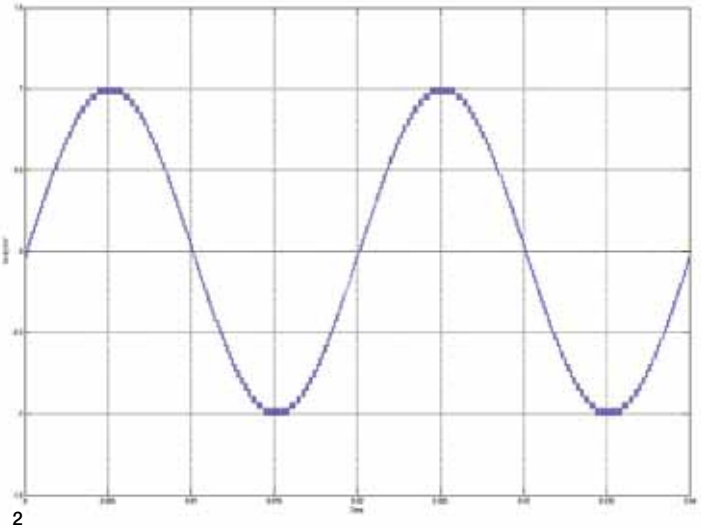
SVC		SVC Light	
TCR	**Filters**	**VSC**	**Filters**
100 Mvar	100 Mvar	±50 Mvar	50 Mvar

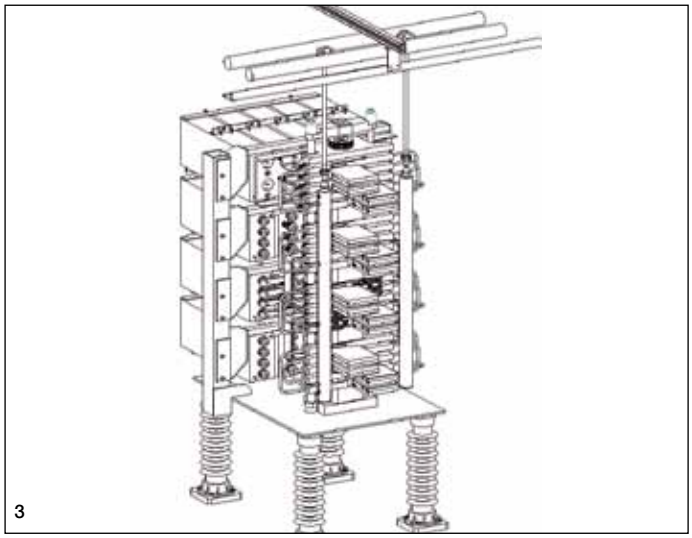
Less footprint

In other words, SVC Light can typically be built more compact than SVC for the same dynamic range, ie in the majority of cases, SVC Light has a smaller footprint.

Superiour flicker mitigation

SVC Light utilizes IGBTs, which can be switched thousands of times per second. This leads to superiour flicker mitigation properties.





1 ABB MACH2, for control and protection, is specially designed to meet the highest demands of high speed power applications. | 2 A smooth output voltage. | 3 The converter valve. | 4 ABB StakPak IGBTs have passed rigorous failure mode and safety tests.

Control and Protection

ABB's MACH2, for control and protection, is specially designed to meet the highest demand of high speed power applications. Fibre optics ensure safe feed back and control of the high voltage bridges. The MACH2 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 converter valve

The VSC of SVC Light is a Multi-Level Chain Link converter, with single-phase units consisting of a number of series connected chain link cells, forming the converter phase legs. Each chain link cell module consists of four IGBT positions, each consisting of an IGBT module with a corresponding Gate Unit, and a DC capacitor.

A smooth output voltage

Pulse Width Modulation (PWM) is utilized with an effective switching frequency in the tens of kHz range, giving a smooth output voltage shape.

IGBT

The IGBT utilized in SVC Light is of the type ABB StakPak™, rated at 4.5 kV. Each IGBT is built up in a modular housing comprising a number of sub-modules, each containing a number of semiconductor chips. ABB StakPak IGBTs have passed rigorous failure mode and safety tests.

Power quality
A key issue

Flicker – a power quality problem
Flicker is caused by stochastic variations in the mains voltage which affect lighting sources. Light flicker is extremely irritating to the human eye and can also cause disturbances in sensitive production equipment. Flicker can affect wide geographical areas, especially when the power grid is weak. By definition, flicker is a power quality problem for both power suppliers and industrial process enterprisers, as well as annoying to the private consumer.

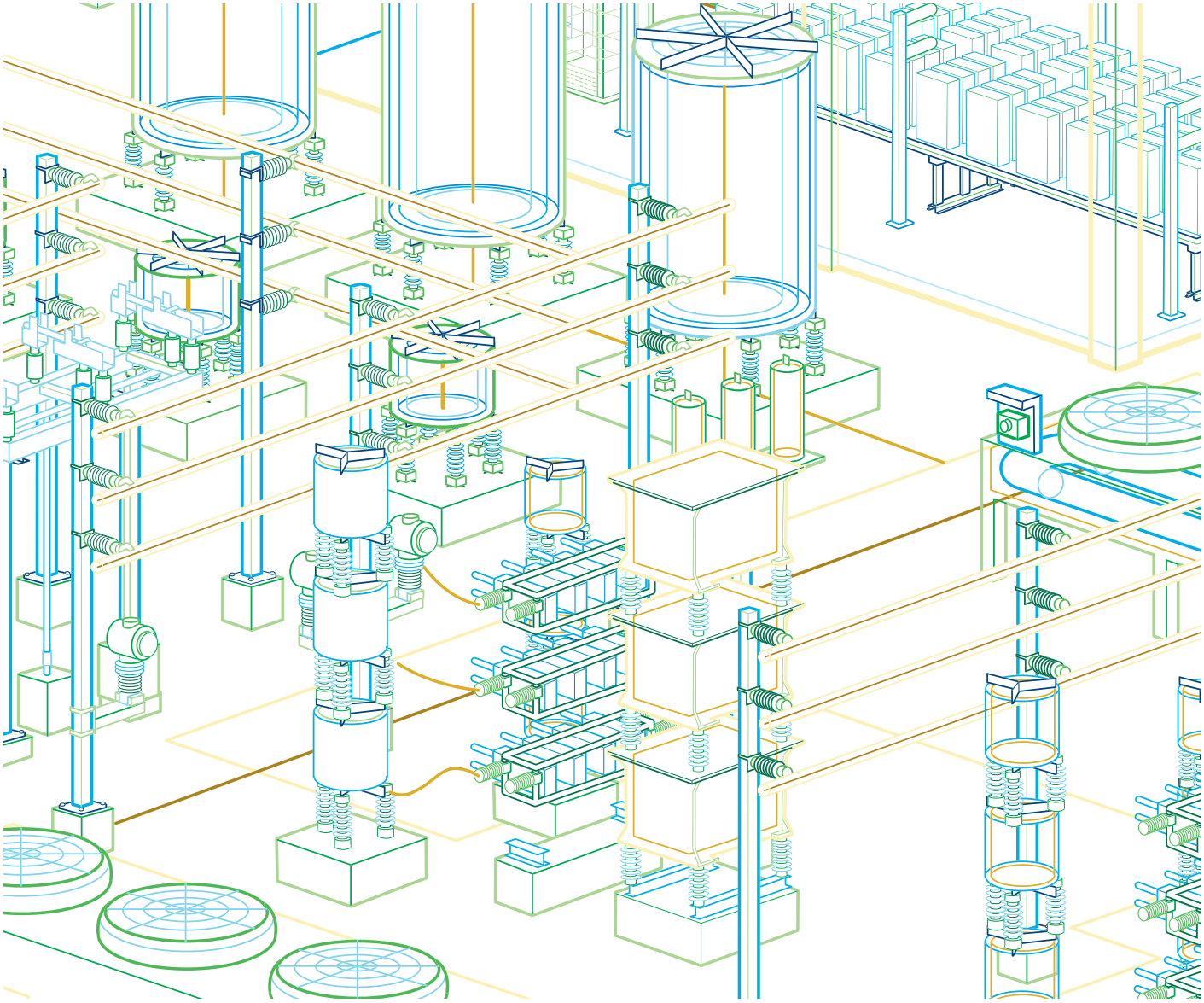
Process industry standards for clean power
The process industry must meet requirements not to disturb the grid, set out in Grid Codes. It will also have to set its own standards for clean power. Increased deregulation together with tougher legislation is speeding up this process.

SVC Light – a bridge between the power grid and industrial processing
In a global economy, a reliable supply of cost effective energy is essential. Deregulation gives consumers a choice of supplier. This, in turn, will increase the grid operator's need for clean process industry on the network to increase their competitive strength as a premium power quality supplier. In this context SVC Light is serving as a bridge between the power grid and industrial processing.

Not only flicker
Power quality is a natural concern today. Along with flicker, other disturbances such as unbalanced voltage, harmonics and voltage variations also need to be addressed. Grid owners regulate this by issuing their Grid Codes, stipulating the permitted levels of grid disturbances from each individual power subscriber connected to the grid.

SVC Light mitigates asymmetrical voltage variations
Unbalanced voltages are caused by asymmetrical loads which lead to unwanted heating of machine windings. Voltage variations can cause problems for sensitive process equipment and computers. These problems can be mitigated by SVC Light.

Active filtering
Electric arc furnaces, due to their non-linear characteristics, are strong sources of harmonics, displaying a spectrum of all kinds of harmonics: even, odd, and even inter-harmonics. SVC Light works as an Active Filter, enabling low THD at the Point of Common Coupling, without any need to install area demanding filter branches. Furthermore, inter-harmonics in particular cannot easily be suppressed by means of discrete LC filters. Active filtering by means of SVC Light is a superior solution to this problem.



FACTS and SVC Light

FACTS (Flexible AC Transmission Systems) is a term denoting an entire family of devices for improved use and flexibility of power systems.

SVC Light is a member of ABB's family of FACTS technologies. Other members are:

- SVC (Static Var Compensator)
- Series Capacitor
- TCSC (Thyristor Controlled Series Capacitor)
- DynaPeaQ® energy storage

SVC Light is in itself a highly useful, well-proven concept and is in operation at many locations around the world and more systems are being installed.

ABB has extensive experience with SVC Light for high power applications.

FACTS Customer support

FACTS customer support enables you to rest assured throughout all phases of the installation lifecycle. ABB's FACTS customer support team offers you service 24/7 globally. With our FACTS Online remote service we can help our customers to improve risk management and increase grid stability. Select from a wide range of service options that best fits your needs. Read more about our FACTS customer support services on www.abb.com/FACTS

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