Power Factor Correction

SVG Module based system

SVG - Static VAR Generator

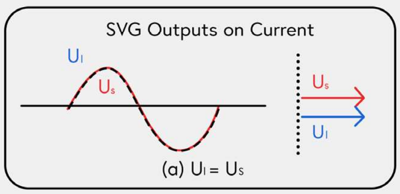
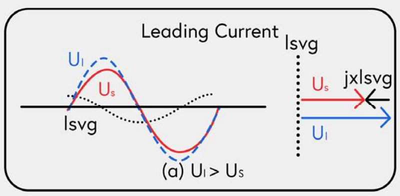
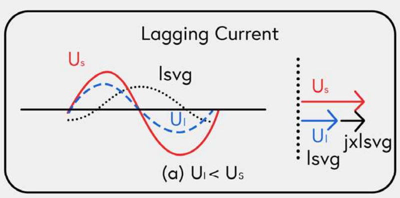
The EM Energy Solutions SVG represents the latest generation technology in the power factor correction field. It operates by detecting the load current on a real-time basis through an external CT (current transformer) and determining the reactive content of the load current. The data is analyzed, and the SVG's controller drives the internal IGBTs by using PWM signals to produce and inject the exact reverse reactive current of the corresponding load reactive content.

Key features

- Excellent power factor correction performance
- Maintains a PF of 0.99 lagging or unity if required.
- Compensates both inductive and capacitive loads
- Corrects lagging and leading power factor.
- Dynamic step-less compensation profiles the load and operates with a response speed of <15ms.
- No over or under-compensation only the kVAr that is needed in that moment.
- Corrects load imbalance
- User-friendly interface and monitoring
- Wall-mount & Rack-mount versions available
- Can operate at low voltages
- Can be used with existing PFC systems
- Modular design
- Available in 690V
- Simple installation and commissioning ('Plug and Play')
- Not affected by resonance

Operating Principle

The EMES SVG represents the latest generation technology in the power factor correction field. SVG technology is based on power electronics. It connects in parallel in front of the load that consumes reactive energy or produces harmonic currents, which in turn alters the power factor. The unit functions as a controllable current source supplying any form of current waveform in realtime. When the load draws inductive or capacitive current, the total load current turns either lagging or leading in respect to the voltage, depending on the total consumption. The SVG detects phase angle distortion and injects leading or lagging current into the distribution system, which brings power factor back to unity.

SVG Operating Mode	Waveform and Vector	Remark
No Load Mode		Ul = Us , Isvg = 0 , SVG outputs no reactive current
Capacitive Mode		Ul > Us , Isvg is leading the voltage, and its amplitude is continuously adjustable.
Inductive Mode		Ul > Us , Isvg is lagging the voltage, and its amplitude is continuously adjustable.

SVG Operation modes

For load balancing in 3- and 4- wire systems, the EMES SVG technology uses current control for rated load capacity. The unity senses the load's negative sequence current components and, based on this data, generates the same negative sequence current components in the opposite phase. The result will be a completely symmetrical load seen from the point of common coupling, which means the phase voltages and currents will be balanced without active power exchange between network and SVG.

Technological evolution

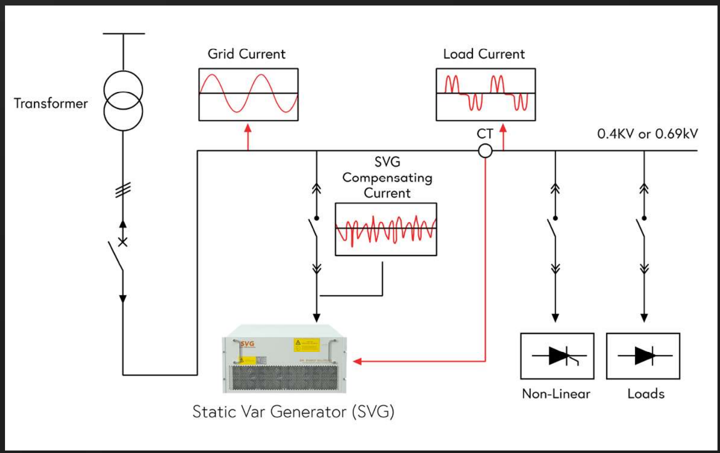
Power Factor Correction systems have come a long way in a short time. Most of the technological evolution has focused on switching performance of capacitor banks; however, in recent years, advances in technology have brought active units based on fast switching power electronics to the market. These units have a significantly faster performance and smaller cabinet footprint compared to conventional capacitor bank technology.

Fixed compensation

Automatic switching

Thyristor half controlled switching

IGTB intelligence controlled switching



Advanced Performance

Outstanding power factor correction capabilities

- Achieve a power factor of 0.99 lagging or unity if the system requires it

Performs both inductive and capacitive compensation

- Lagging and leading power factor correction between -1 to +1

No need for vulnerable capacitor banks

- With EMES SVG technology traditional capacitor bank for power factor correction is no longer necessary. Traditional systems comprised of switched capacitors are prone to failure caused by high temperature, over-voltage, or harmonic resonance, which can cause capacitors to rupture or ignite.
- The service life of switched capacitor banks depends on ambient operational temperature, requiring detailed planning in terms of cooling systems. This temperature vulnerability gives challenges when installing traditional systems in warmer climates. With the SVG technology, this is no longer a problem, and the operator does not need to worry about operational limitations, safety concerns, space requirements, and operational lifetime normally involved with capacitor-based systems.

3-phase operation

- In traditional system, each phase is individually compensated without regard to the other phases.
- EMES SVG measures and provides dynamic kVAr compensation throughout all three phases.

Increased service life

- Systems based on capacitor banks are controlled in a stepwise manner. The space requirement based on capacity is the same for either a 6kVAr or a 50kVAr capacitor. Besides, for fine adjustments, smaller steps are used to minimize the over or under-compensation; this causes much switching and severely reduced lifetime for the smaller steps. The power factor controller algorithm evenly distributes the workload between available steps, except when one or two of those steps are of small capacity. This extra strain on the smaller steps challenges the usable lifetime of the switching components as well.

Not affected by resonance

- EMES SVG does not cause dangerous resonance situations, which lead to large current, over-temperature, and even potential fire. This advantage removes the need for blocking reactors and increases your plant's safety.

Load balancing

- EMES SVG performs load balancing by sharing the load evenly between the phases. This causes large energy savings over time due to the fact that line losses will be reduced.

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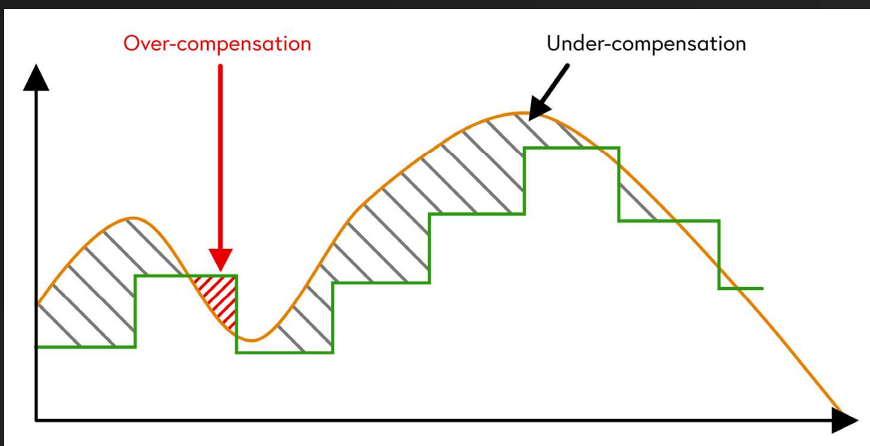
Comparison with conventional solutions

	Capacitor banks or reactor banks	Static VAR Generator (SVG)
	• The control system detects in realtime the total current drawn by the load with the use of external current transducers, and the controller determines the reactive component of the total current. The load-current data is analyzed by the controller, which in turn switches the stepwise amount of reactive current into the system based on available reactive current from the capacitor bank.	• The Static VAR Generator senses the total current drawn by the load with the use of external current transducers. The load current data is used to determine the reactive component of the current. The SVG controller analyzes the data and generates the PWM signal sent to the IGBTs, which in turn causes the inverter to generate a copy of the reactive current component in opposite phase.
Response	• Conventional technology based on contactors for switching often takes 30-40 seconds to react on changes in reactive power, while systems based on thyristor control use between 20-30ms.	• With an overall realtime response less than 50 micro seconds the SVG is able to mitigate reactive current without under or over compensation.
Output	• Realtime control not possible since only stepwise adjustment is possible • The functional use of capacitors & reactors is highly reliant on grid voltage	• Instantanious, continious, stepless and seamless • Grid voltage fluctuations have no influence on the output
Power Factor Correction	• Both capacitive and inductive energy banks are needed to compensate for leading and lagging power factors. These mixed systems cause additional system problems. • The stepwise control of inductive and capacitive energy makes it impossible to get unity power factor correction, which causes continuous over and under-compensation.	• Will correct both lagging (inductive) and leading (capacitive) power factor from -1 to 1 • No under or over compensation as the SVG will keep unity power factor at all times with step-less control
Imbalance	• Does not correct load unbalance	• Balanced system with load balancing functionality
Design & Sizing	• Plant reactive power analysis must be conducted to be able to determine the correct capacitor bank size. • Often the system will be oversized to be able to better follow changes in reactive power demand • Potential harmonic resonance situations must be taken into account • Custom-built for specific load and network conditions	• Time-consuming studies not necessary since the unit is adjustable • Capacity can match exact load demand • No danger of harmonic resonance situations • Will adapt to load and network conditions & changes
Maintenace & Lifetime	• Comprised of maintenance requiring equipment like circuit breakers, contactors, fuses, capacitors and reactors. • Resonance and transients caused by the switching operation give reduced equipment lifetime.	• Nearly maintenance free with close to 15 years service life as there is no electro-mechanical switching, transients or resonance potential.
Resonance	• Parallel or series resonance can amplify harmonic currents in the system	• No risk of harmonic resonance with the network
Overloading	• Possible due to slow response and/or variation of loads	• Not possible as current limited to max. RMS current
Footprint & Installation	• Larger footprint, especially in systems with a high amount of harmonic orders. • Difficult sizing since load situations often change over time.	• The space effective and compact modules have easy installation and have a small footprint. For installation, existing switchgear can be used.
Transients	• Caused by the switching of capacitor units or shunt reactors	• Not created (no switching of passive components)
Expansion	• Limited and depends on load conditions and network topology	• Simple (and not dependant) by adding modules

Advanced Performance

Dynamic step-less compensation

- Profiles the load and operates with a response speed of <15ms
- Dynamic reaction time is less than 50µs
- No possibility of over-compensation or under-compensation
- Only injects the kVAr that is needed in that moment



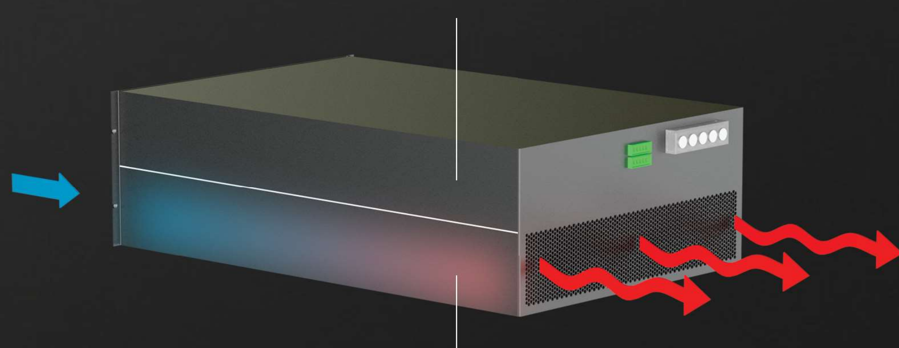
Over and under-compensation produced by conventional capacitor banks

The genius of simplicity

- Virtually maintenance free
- Can be used with existing PFC systems
- High reliability and safety

Prevention of dust contamination

Delicate electronics are separated from heat-generating power components, resulting in reduced dust ingress, heat, and prolonged lifetime.



Effective heat dissipation

Heat producing power electronics are housed separate compartment for optimum ventilation. Advanced calculations have been used for optimum ventilation airflow and component positioning.

Main SVG benefits

1. Capability to deliver instantaneous capacitive and inductive reactive power compensation.
2. Optimized for highly dynamic applications where conventional capacitor banks or reactor banks are unable to track the loads.
3. Allow compensation of loads fed by generators without risk of overcompensation.
4. Inject reactive power that is required by the load at each instant into the system.
5. Improve voltage unbalance on the phases and reduce neutral current, which increases the safety of the installation and allows sensitive loads to operate.
6. Avoids transformer saturation & overloading
7. Reduce power losses and voltage drop in neutral conductors
8. Reduces the oscillating torque in the rotating machines that appear because of load variations in the systems.
9. Over dimensioning not necessary: Compensation capacity equals the installed capacity.
10. Unaffected by network voltage drop. The SVG provides full reactive current to meet required demand under reduced network voltage level.
11. Avoids electrical equipment overheating and efficiency loss that causes premature failures
12. Simple dimensioning and installation.

ASVG module

ASVG - Advanced Static VAR Generator

The ASVG works as both a Power Factor Correction Unit and Harmonic Filter. The Advanced Static VAR Generator gives the same dynamic performance as the SVG but also has a harmonic mitigation capability. The SVG is available as 50/100kVAr wall-mounted solution, and 30/50/100kVAr cabinet mounted modules.

The most common harmonic orders in most installations are the 3rd, 5th, 7th, and 11th order harmonic. A properly sized ASVG will correct your power factor close to unity but, at the same time, also reduce the mentioned harmonics to <5% THDi. The size of the modules and cabinet is the same as the standard SVG unit.

Key features

- Superb power factor correction performance. Maintains a PF of 0.99 lagging or unity if required.
- Compensates for both inductive and capacitive loads. Capacitive and Inductive compensation: -1 to 1
- Dynamic step-less compensation. Profiles the load and operates with a response speed of <15ms.
- No possibility of over-compensation or under-compensation, will only inject the kVAr that is needed at any moment.
- Harmonic mitigation: mitigates 3rd, 5th, 7th, 11th harmonic orders
- The capacity of the unit can be shared 50/50 between power factor and harmonics correction
- Operates even at low voltages
- Can be integrated with existing power factor correcti-on systems
- Modular design
- Simple and fast installation and commissioning ('Plug and Play')
- Not affected by resonance
- Performs load balancing

Power Factor Correction

Advanced Performance

Improve the Power Factor Correction Performance of your facility
Low power factor is one of the most common power quality issue faced by the vast majority of industrial and commercial installations. The second largest power quality problem is harmonic mitigation. Common to both of these issues is that they create additional costs for both the consumer and grid supplier due to the extra strain they put on the distribution system.

- Power systems will often have large amounts of 3rd harmonic frequencies that accumulate in the neutral conductor. This harmonic order will often be caused by single-phase non-linear loads such as LED lighting, power supplies, Electronics lighting ballast, heat pumps etc.

- A data centre in combination with a UPS will often contain 5th, 7th and 11th harmonic orders.

- HVAC systems containing high amounts of variable speed drives will often further increase 5th, 7th and 11th harmonic orders.

- In general, industry contains large amounts of electrical motors controlled by variable speed drives for the increased precision, efficiency and productivity this gives. It is not unusual to see large amounts of current, and subsequent voltage harmonics caused by 6 pulse variable frequency drives producing 5th, 7th and 11th harmonic orders.

ASVG Control cabinet

The Advanced Static VAR Generator provides both power factor correction and harmonic mitigation in one compact, cost-effective unit. As an operator, you can address two of the most common power quality problems in the most cost-effective manner.

SPQ Smart Power Quality

Smart Power Quality

SPQ Control Cabinet

SPQ - Smart Power Quality

The SPQ is based on an upgraded SVG, or ASVG mounted inside a stainless steel enclosure complete with protections and built-in WiFi for easy diagnostics. The SPQ is specialized for the increased power quality issues found on distribution networks and has the following functions; three-phased unbalanced compensation, fast step-less regulation of reactive power, and system voltage stabilization. The SPQ can also be equipped with harmonic mitigation capacity if needed. The SPQ is ideal for mounting outside when there is no room left in a plant switchboard room or for mounting up a pole for electricity network applications. SPQ is available in 30/50/100kVAR in two cabinet size options. The SPQ offers all the features of the SVG / ASVG as a complete stand-alone system.

Key features

- Superb power factor correction performance that maintains a PF of 0.99 lagging or unity if required.
- Compensates both inductive and capacitive loads from -1 to +1 power factor.
- Dynamic step-less compensation profiles the load and operates with a reaction time of 50µs and a response time with full correction in less than 15ms.
- No possibility of over-compensation or under-compensation,
- Will only inject the kVAR that is required at any specific moment.
- Corrects load imbalance
- Harmonic mitigation (ASVG) of 3rd, 5th, 7th, 11th harmonic orders
- Unit capacity can be shared 50/50 between power factor and harmonics correction
- Operates at low voltages
- Can be used with existing PFC systems
- Suitable for mounting up a power pole
- Automatic voltage regulation
- Stainless steel IP44 outdoor rated enclosure
- MCB and class C overvoltage surge protection against indirect lightning discharge
- Not affected by resonance
- Parallel connected, so larger capacities are obtained

Advanced Performance

SPQ uses current control to deliver full rated load balancing functionality in 3- and 4- wire systems. The full rating load balancing is based on factors like load consumption and power factor. The unit works by injecting capacitive or inductive negative sequence current that is opposite in phase to the load negative sequence current. The result will be symmetrical load and phase voltage vectors together with balanced current consumption. This comes with no exchange of active power between the network and the SPQ.

Single-phase loads connected between phase to phase or phase to neutral will often result in unbalanced load conditions in the system.

If the load unbalances caused by single-phase loads are large enough, they will result in unbalanced voltages and also affect other loads connected at the common point of coupling.
An unbalance situation can also cause an excessive neutral current in a 4-wire system, which again can result in overheating of motors and transformers, power losses, and lower system efficiencies. By balancing the load, the overall power quality and efficiency will be improved

When the system is properly designed and rated, the unit can balance any load, as seen from the supply transformer.

The SPQ samples the voltage at the point of compensation and relays this data to the integrated DSP to determine if the voltage exceeds the setpoint.
When the upper limit is exceeded, the SPQ produces inductive reactive power, thus lowering the voltage. At the lower limit, the SPQ gives out capacitive reactive power to increase the voltage. The result will be stable voltages for each individual phase

The SPQ works as a controlled current source and supplies any type of current waveform in realtime. If the load draws inductive or capacitive current, the total load current will be either lagging or leading compared to the voltage. The phase angle difference is detected by the SPQ, and the unit will inject leading or lagging current in realtime into the power system. This compensation will give close to no phase shift between the voltage and current, resulting in a unity power factor. Operating with a low power factor gives increased energy consumption and will also affect the stability of the installation.
A low power factor is caused by inductive or capacitive loads that demand reactive power because their operation requires energy consumption by either the magnetic or electric field.
It can also be caused by harmonic currents produced by nonlinear loads.
SPQ compensates both inductive and capacitive reactive power in realtime. The fast response time gives accurate and stable power factor correction without the drawbacks of conventional technology like capacitor banks and reactor banks.