DATASHEET

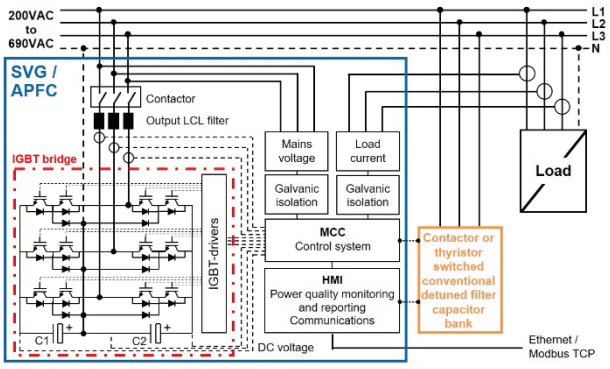
Static var generators

Static var generators (SVG), also known as active power factor compensators (APFC) or instantaneous stepless reactive power compensators, are the ultimate answer to power quality problems caused by low power factor and reactive power demand for a wide range of segments and applications. They are a high performance, compact, flexible, modular and cost-effective type of active power filters (APF) that provide an instantaneous and effective response to power quality problems in low or high voltage electric power systems. They enable longer equipment lifetime, higher process reliability, improved power system capacity and stability, and reduced energy losses, complying with most demanding power quality standards and grid codes.

SVG/APFC module rated 400V 50/60Hz -69kvar to +69kvar

Low power factor increases the active energy losses of installations and affects their stability. It is typically caused by inductive or capacitive loads that demand extra reactive power to perform properly. Other contributors to low power factor are harmonic currents produced by nonlinear loads and the change of load in the electric power system.

SVGs deliver real-time inductive or capacitive reactive power compensation. Rapid response time provides stable and accurate power factor correction without the drawbacks of conventional solutions like capacitor banks and reactor banks.



Typical design of an SVG/APFC

Highlights

- Full range: Specifications from +/-17kvar to +/-152kvar (200V-690V) in 3- and 4-wire systems can be covered by a single module. Unlimited amount of SVG modules can be paralleled.
- Simple connection to high voltage systems.
- 3-level NPC inverter topology reduces losses, noise, size and extends module's lifetime.
- Overall response time <100 microseconds.
- Instantaneous, precise & stepless power factor correction of inductive and capacitive loads.
- Not possible to over or under compensate the system and no risk of harmonic resonance.
- Suitable for networks with harmonic distortion.
- Capability of switching contactors or thyristor switches of detuned filter capacitor bank steps.
- Compact and modular design optimized for installation, commissioning and maintenance.

Typical segments

SVGs can be applied to small, medium or large applications in a wide range of segments.

Markets	Segments	Applications
Smart grid	Renewable generation	
	Non-renewable generation	
	Transmission & distribution	
	Microgrids	
Raw material extraction & processing	Mining	
	Oil & gas	
	Minerals & cement	
	Steel & metals	
Manufacturing & infrastructure	Conventional manufacturing	
	Critical process industries	
	Transport	
	Water & wastewater	
Green buildings & smart cities	Healthcare facilities	
	Critical process facilities	
	Industrial & office facilities	
	Retail & leisure facilities	

Applications: Green - primary, yellow - secondary, red - none.

Typical applications

SVGs have many low and high voltage potential applications where their use offers many benefits.

- Installations with fast changing reactive power demand: Electric arc furnaces, ball mills, etc.
- Highly dynamic loads (power factor fluctuates rapidly or in big steps): Cranes, shredders, sawmill machinery, welding machines, etc.
- Correction of leading power factor like in data centers allowing back-up generators operation
- UPS systems.
- Solar inverters and wind turbine generators.
- Railway electrification systems: Trains & trams
- Loads with low power factor: Motors, cables, lightly loaded transformers, lighting, etc.

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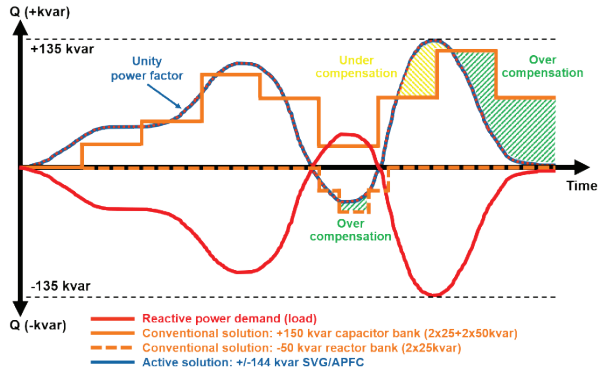
Operating principle

An SVG is a power electronics-based device connected in parallel with the load that requires power factor correction. The SVG works as a controlled current source providing any kind of current waveform in real time.

When the load generates inductive or capacitive current, it makes load current lagging or leading the voltage. An SVG detects the phase angle difference and injects in real time leading or lagging current into the electric power system, making the phase angle of the current almost the same as that of the voltage, bringing fundamental power factor to unity.



SVG/APFC operating principle

Benefits

Main benefits of SVGs can be summarized as:

- Capability to deliver instantaneous capacitive and inductive reactive power compensation.
- Optimized for highly dynamic applications where conventional capacitor banks or reactor banks are unable to track the loads.
- Allow compensation of loads fed by generators without risk of overcompensation.
- Only inject in the system the reactive power that is required by the load at each instant.
- No need for over dimensioning: Compensation capacity equals the installed capacity.
- Unaffected by network voltage drop. Even under reduced network voltage levels, full reactive current can be provided to meet required demand.
- Simple dimensioning and installation.
- Compliance with the strictest power quality standards and grid codes.

SVG/APFC rated 415V 50/60Hz -288kvar to +288kvar

Comparison with conventional solutions

	Capacitor banks or reactor banks	Static var generators / Active PF compensators
Response time	•Contactor-based solutions take at least 30s to 40s to mitigate the problem and thyristor-based solutions 20ms to 30ms	•Real-time mitigation of power quality problems as the overall response time is less than 100µs
Output	•Depends on step sizes, cannot match load demand in real time •Depends on grid voltage as capacitor units & reactors are used	•Instantaneous, continuous, stepless and seamless •Grid voltage fluctuation has no influence on the output
Power factor correction	•Capacitor banks needed for inductive loads and reactor banks for capacitive loads. Problems in systems with mixed loads •Not possible to guarantee unity power factor as they have steps, system will be having continuous over and undercompensation	•Corrects simultaneously from -1 to +1 power factor of lagging (inductive) and leading (capacitive) loads •Guaranteed unity power factor at all times without any over or undercompensation (stepless output)
Unbalance	•Do not correct load unbalance	•Can correct by selecting the amount of load balancing
Design & sizing	•Reactive power studies needed to size the proper solution •Usually oversized to better adjust to changing load demands •Need to be designed taking into account system harmonics •Custom-built for specific load and network conditions	•Not required extensive studies as it is adjustable •Mitigation capacity can be exactly what load demands •Unaffected by harmonic distortion in the system •Can adapt to load and network conditions & changes
Resonance	•Parallel or series resonance can amplify currents in the system	•No risk of harmonic resonance with the network
Transients	•Caused by the switching of capacitor units or shunt reactors	•Not created (no switching of passive components)
Overloading	•Possible due to slow response and/or variation of loads	•Not possible as current limited to max. RMS current
Footprint & installation	•Medium to large footprint, especially if several harmonic orders •Not simple installation, especially if loads upgraded frequently	•Small footprint and simple installation as modules are compact in size. Existing switchgear can be used
Expansion	•Limited and depends on load conditions and network topology	•Simple (and not dependant) by adding modules
Maintenance & lifetime	•Using components that need extensive maintenance like fuses, circuit breakers, contactors, reactors and capacitor units •Switching, transients and resonance reduce lifetime	•Simple maintenance and service life up to 15 years as there is no electro-mechanical switching and no risk of transients or resonance

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Technical specifications – 200-480VAC devices

LOOSE MODULES	A2-50	A2-60	A2-75	A2-100	A2-120	A2-150	A2-200
Electrical ratings							
Rated voltage	200-480VAC +/-10% (auto sensing). Connection to higher voltages through suitable step-up transformer.						
Rated frequency	50/60Hz (auto sensing).						
Reactive power output at 200V	-17 to +17kvar	-21 to +21kvar	-26 to +26kvar	-35 to +35kvar	-42 to +42kvar	-52 to +52kvar	-69 to +69kvar
Reactive power output at 220V	-19 to +19kvar	-23 to +23kvar	-29 to +29kvar	-38 to +38kvar	-46 to +46kvar	-57 to +57kvar	-76 to +76kvar
Reactive power output at 380V	-33 to +33kvar	-39 to +39kvar	-49 to +49kvar	-66 to +66kvar	-79 to +79kvar	-99 to +99kvar	-132 to +132kvar
Reactive power output at 400V	-35 to +35kvar	-42 to +42kvar	-52 to +52kvar	-69 to +69kvar	-83 to +83kvar	-104 to +104kvar	-139 to +139kvar
Reactive power output at 415V	-36 to +36kvar	-43 to +43kvar	-54 to +54kvar	-72 to +72kvar	-86 to +86kvar	-108 to +108kvar	-144 to +144kvar
Reactive power output at 440V	-38 to +38kvar	-46 to +46kvar	-57 to +57kvar	-76 to +76kvar	-91 to +91kvar	-114 to +114kvar	-152 to +152kvar
Reactive power output at high voltage (>1kV) with step-up transformer (415V secondary)	-36 to +36kvar	-43 to +43kvar	-54 to +54kvar	-72 to +72kvar	-86 to +86kvar	-108 to +108kvar	-144 to +144kvar
Electrical features							
Reaction / response time	Reaction time <50 microseconds / Overall response time <100 microseconds (1 network cycle if working in selectable mode).						
Electrical system compatibility	3-phase 3-wire and 3-phase 4-wire.						
Inverter features	3-level NPC inverter topology (IGBT). Switching frequency 20kHz.						
Controller / redundancy	Each module has an independent controller. In parallel operation of several modules, if any module fails, the rest will continue in operation.						
Power factor correction	Optimized, stepless and continuously adjustable power factor correction, leading (capacitive) and lagging (inductive).						
Voltage support	Reduction of voltage variations (sags and swells) and mitigation of voltage fluctuations (flicker) via reactive power injection.						
Protection functions	Overcurrent, overvoltage, undervoltage, overtemperature and ripple circuit overload.						
Stand-by & AutoStart	Stand-by stops the IGBTs if required compensation current is below a certain limit. AutoStart allows automatic start after a network failure.						
Remote discrete control	Remote run/stop.						
Capacitor bank steps control (HPQ functionality)							
Operation	Dedicated digital outputs can switch contactors or thyristor switch modules of conventional detuned filter capacitor bank steps.						
Number of steps and size	6 capacitor bank steps per module. One digital output can switch a step rated between 10kvar to 200kvar.						
Connections							
Digital inputs	3 potential free inputs 15-48VDC or up to 277VAC. Any input can be programmed as trigger for stand-by, trip or alarm.						
Digital outputs	6 potential free outputs DC or up to 277VAC. 4 can be programmed for trip, alarm, running & force, or all can be used for capacitor bank steps.						
Current transformers (CT)	Any primary ratio with 1A or 5A secondary (5A preferred). Class 1 accuracy or better.						
CT location	Open loop (current transformers in the load side) and closed loop (current transformers in the supply side) connections possible.						
CT polarity	If one or more CTs are connected with inversed polarity, it is possible to change the load current polarity from normal to inversed in the HMI.						
Number of CTs required	Open loop connection: 3 CTs. Closed loop connection of 1 module: 3 CTs. Closed loop connection of several modules in parallel: 6 CTs.						
Connection of parallel modules	Unlimited scalability. Parallel operation of any rating combinations up to 7 modules per one HMI. Unlimited amount of HMIs.						
Interfaces							
HMI / display	7" touch screen multilingual graphical HMI (new languages can be added on request).						
Monitoring and reporting	On-site and remote monitoring capabilities. Reports data of power quality events up to 30 days.						
Communication capability	Ethernet and Modbus TCP.						
Software update	Via Ethernet or USB drive.						
Mechanical features							
Mounting arrangement	Loose module ready for cubicle or wall installation.						
Enclosure features	Compact IP20 galvanized steel enclosure in black colour.						
Cooling method	Forced air by easy to service automatically controlled DC cooling fans adjusted by module temperature via PWM.						
Losses	<2.3%						
Noise level (ISO 3746)	60dB	60dB	64dB	64dB	65dB	67dB	68dB
Dimensions WxHxD	225x850x500mm	225x850x500mm	225x850x500mm	225x850x500mm	225x850x500mm	225x1150x500mm	225x1150x500mm
Weight	70kg	70kg	70kg	70kg	70kg	110kg	110kg
Installation and operation							
Temperature (without derating)	+5°C to +40°C.				+5°C to +30°C.	+5°C to +40°C.	
Humidity	Maximum 85% RH, non-condensing.						
Altitude (without derating)	Up to 1000m.						
Needed airflow for the module	350 m³/h	350 m³/h	400 m³/h	450 m³/h	500 m³/h	750 m³/h	1000 m³/h
Ventilation requirements	300mm free space below and above the module required for air ventilation.						
Main circuit fuses	NH00 gL/gG 63A	NH00 gL/gG 80A	NH00 gL/gG 100A	NH00 gL/gG 125A	NH00 gL/gG 160A	NH00 gL/gG 200A	NH00 gL/gG 250A
Cable entry	Top or bottom.						
Standards and certifications							
Electrical safety	EN 50178						
Electromagnetic compatibility	Emissions: EN/IEC 61000-6-4. Immunity: EN/IEC 61000-6-2.						
Third party approvals	CE, UL.						
ASSEMBLED MODULES	**Modules installed in cubicles**						
Electrical ratings							
Rated voltage	200-480VAC +/-10% (auto sensing). Connection to higher voltages through suitable step-up transformer.						
Reactive power output	Any output is possible. Unlimited parallel operation of any rating combination of modules.						
Electrical features (cubicle)							
Power frequency voltage test	2.5kV/1min						
Impulse withstand voltage	6kV						
Short-circuit current	65kA rms (3 seconds) / 143kA peak.						
Power circuit protection	MCCB or fuse-switch. General design rule is to select the protection level 1.3 times the nominal current of the device.						
Earthing	According to local regulations, 16mm² Cu conductor is the minimum recommended.						
Mechanical features (cubicle)							
Mounting arrangement	Free-standing cubicle.						
Enclosure IP class	IP20 to IP42 for indoor installation (other classes or outdoor installation cubicles on request).						
Enclosure material and colour	Galvanized steel, light grey RAL7035 (other materials or colours on request).						
Panel thickness and treatment	2mm. Epoxy powder coating.						
Cooling method	Forced air or heat exchanger.						
Cable entry	Top or bottom.						
Door locking system	Handle without lock, lock with key, electrical lock or special safety lock.						

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Technical specifications – 500-690VAC devices

LOOSE MODULES	A2-50-E	A2-60-E	A2-75-E	A2-100-E	A2-120-E
Electrical ratings					
Rated voltage	500-690VAC +/-10% (auto sensing). Connection to higher voltages through suitable step-up transformer.				
Rated frequency	50/60Hz (auto sensing).				
Reactive power output at 500V	-43 to +43kvar	-52 to +52kvar	-65 to +65kvar	-87 to +87kvar	-104 to +104kvar
Reactive power output at 600V	-52 to +52kvar	-62 to +62kvar	-78 to +78kvar	-104 to +104kvar	-125 to +125kvar
Reactive power output at 660V	-57 to +57kvar	-69 to +69kvar	-86 to +86kvar	-114 to +114kvar	-137 to +137kvar
Reactive power output at 690V	-60 to +60kvar	-72 to +72kvar	-90 to +90kvar	-120 to +120kvar	-143 to +143kvar
Reactive power output at high voltage (>1kV) with step-up transformer (690V secondary)	-60 to +60kvar	-72 to +72kvar	-90 to +90kvar	-120 to +120kvar	-143 to +143kvar
Electrical features					
Reaction / response time	Reaction time <50 microseconds / Overall response time <100 microseconds (1 network cycle if working in selectable mode).				
Electrical system compatibility	3-phase 3-wire (500-690VAC modules) and 3-phase 4-wire (500-525VAC modules).				
Inverter features	3-level NPC inverter topology (IGBT). Switching frequency 20kHz.				
Controller / redundancy	Each module has an independent controller. In parallel operation of several modules, if any module fails, the rest will continue in operation.				
Power factor correction	Optimized, stepless and continuously adjustable power factor correction, leading (capacitive) and lagging (inductive).				
Voltage support	Reduction of voltage variations (sags and swells) and mitigation of voltage fluctuations (flicker) via reactive power injection.				
Protection functions	Overcurrent, overvoltage, undervoltage, overtemperature and ripple circuit overload.				
Stand-by & AutoStart	Stand-by stops the IGBTs if required compensation current is below a certain limit. AutoStart allows automatic start after a network failure.				
Remote discrete control	Remote run/stop.				
Capacitor bank steps control (HPQ functionality)					
Operation	Dedicated digital outputs can switch contactors or thyristor switch modules of conventional detuned filter capacitor bank steps.				
Number of steps and size	5 capacitor bank steps per module. One digital output can switch a step rated between 10kvar to 200kvar.				
Connections					
Digital inputs	3 potential free inputs 15-48VDC or up to 277VAC. Any input can be programmed as trigger for stand-by, trip or alarm.				
Digital outputs	5 potential free outputs DC or up to 277VAC. 4 can be programmed for trip, alarm, running & force, or all can be used for capacitor bank steps.				
Current transformers (CT)	Any primary ratio with 1A or 5A secondary (5A preferred). Class 1 accuracy or better.				
CT location	Open loop (current transformers in the load side) and closed loop (current transformers in the supply side) connections possible.				
CT polarity	If one or more CTs are connected with inversed polarity, it is possible to change the load current polarity from normal to inversed in the HMI.				
Number of CTs required	Open loop connection: 3 CTs. Closed loop connection of 1 module: 3 CTs. Closed loop connection of several modules in parallel: 6 CTs.				
Connection of parallel modules	Unlimited scalability. Parallel operation of any rating combinations up to 7 modules per one HMI. Unlimited amount of HMIs.				
Interfaces					
HMI / display	7" touch screen multilingual graphical HMI (new languages can be added on request).				
Monitoring and reporting	On-site and remote monitoring capabilities. Reports data of power quality events up to 30 days.				
Communication capability	Ethernet and Modbus TCP.				
Software update	Via Ethernet or USB drive.				
Mechanical features					
Mounting arrangement	Loose module ready for cubicle or wall installation.				
Enclosure features	Compact IP20 galvanized steel enclosure in black colour.				
Cooling method	Forced air by easy to service automatically controlled DC cooling fans adjusted by module temperature via PWM.				
Losses	<2.8%				
Noise level (ISO 3746)	67dB	67dB	67dB	67dB	68dB
Dimensions WxHxD	225x1150x500mm	225x1150x500mm	225x1150x500mm	225x1150x500mm	225x1150x500mm
Weight	120kg	120kg	120kg	120kg	120kg
Installation and operation					
Temperature (without derating)	+5°C to +40°C.				
Humidity	Maximum 85% RH, non-condensing.				
Altitude (without derating)	Up to 1000m.				
Needed airflow for the module	350 m³/h	350 m³/h	400 m³/h	450 m³/h	500 m³/h
Ventilation requirements	300mm free space below and above the module required for air ventilation.				
Main circuit fuses	NH00 gL/gG 63A	NH00 gL/gG 80A	NH00 gL/gG 100A	NH00 gL/gG 125A	NH00 gL/gG 160A
Cable entry	Top or bottom.				
Standards and certifications					
Electrical safety	EN 50178				
Electromagnetic compatibility	Emissions: EN/IEC 61000-6-4. Immunity: EN/IEC 61000-6-2.				
Third party approvals	CE, UL.				
ASSEMBLED MODULES	**Modules installed in cubicles**				
Electrical ratings					
Rated voltage	500-690VAC +/-10% (auto sensing). Connection to higher voltages through suitable step-up transformer.				
Reactive power output	Any output is possible. Unlimited parallel operation of any rating combination of modules.				
Electrical features (cubicle)					
Power frequency voltage test	2.5kV/1min				
Impulse withstand voltage	6kV				
Short-circuit current	65kA rms (3 seconds) / 143kA peak.				
Power circuit protection	MCCB or fuse-switch. General design rule is to select the protection level 1.3 times the nominal current of the device.				
Earthing	According to local regulations, 16mm² Cu conductor is the minimum recommended.				
Mechanical features (cubicle)					
Mounting arrangement	Free-standing cubicle.				
Enclosure IP class	IP20 to IP42 for indoor installation (other classes or outdoor installation cubicles on request).				
Enclosure material and colour	Galvanized steel, light grey RAL7035 (other materials or colours on request).				
Panel thickness and treatment	2mm. Epoxy powder coating.				
Cooling method	Forced air or heat exchanger.				
Cable entry	Top or bottom.				
Door locking system	Handle without lock, lock with key, electrical lock or special safety lock.				

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