DATASHEET

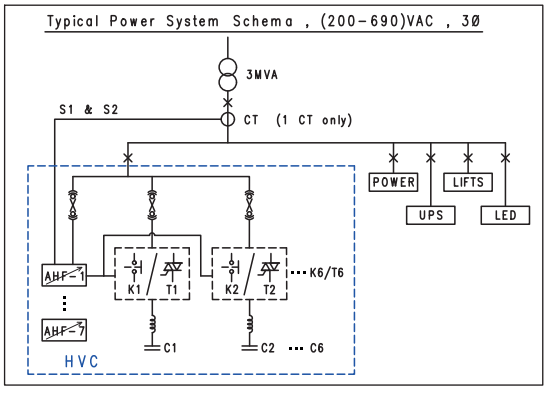
Hybrid var compensators

Hybrid var compensators (HVC) are the ultimate answer to power quality problems caused by waveform distortions, low power factor, voltage variations, voltage fluctuations and load unbalance 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.

HVC rated 400V 50/60Hz -144kvar to +984kvar

HVCs combine the technical advantages of active harmonic filters (AHF) or static var generators (SVG) with the cost-effectiveness of conventional contactor or thyristor switched detuned filter capacitor banks to form an economical stepless real-time compensator with a single controller. They combine different functions in a single device:

- Elimination of harmonic currents and voltages.
- Power factor correction (lagging or leading).
- Voltage variations (sags & swells) reduction.
- Voltage fluctuations (flicker) mitigation.
- Load balancing in three-phase systems.
- Controlled & selectable harmonic generation.



Typical design of an HVC

Highlights

- Full range: Specifications from -144kvar to +984kvar (200V-690V) in 3- & 4-wire systems can be covered by a single AHF or SVG module (unlimited amount 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.
- Global or selective compensation of harmonic currents up to the 50th order (odd and even).
- Load balancing and unloading of neutral wires.
- Not possible to over or under compensate the system and no risk of harmonic resonance.
- Compact and modular design optimized for installation, commissioning and maintenance.

Typical segments

HVCs 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

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

- Equipment using variable speed drives (VSD).
- Arcing devices: Electric arc furnaces (EAF), discharge-type lighting (fluorescent, sodium vapor and mercury vapor) and arc welders.
- Switch mode power supplies: Computers, TVs, battery chargers, LED lighting, PLCs, etc.
- UPS systems.
- Solar inverters and wind turbine generators.
- Modulated phase controllers, cycloconverters and thyristor-controlled AC voltage regulators.
- Saturable/rotating devices: Induction heaters, transformers, generators, reactors and motors.

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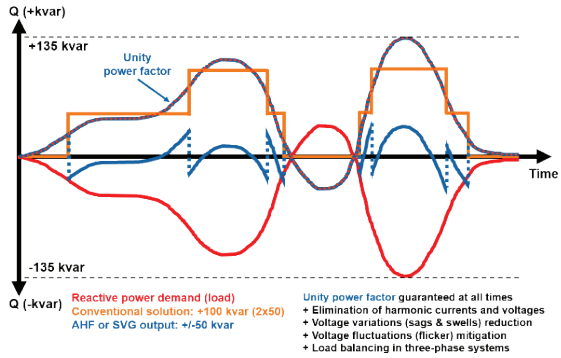
- Installations with fast changing reactive power demand or highly dynamic loads like ball mills.
- Correction of leading power factor like in data centers allowing back-up generators operation
- Railway electrification systems: Trains & trams
- Loads with low power factor: Motors, cables, lightly loaded transformers, lighting, etc.

Operating principle

An HVC is a power electronics-based device connected in parallel with the load that creates power quality problems. The HVC works as a controlled current source providing any kind of current waveform in real time.

HVCs use the capacitor bank steps to fulfil the most of the capacitive reactive power needs of the system while the AHF or SVG will take care of the extra continuous compensation needed (capacitive or inductive). At the same time, they can filter out the harmonics of the system, reduce voltage variations, mitigate flicker and balance the loads.

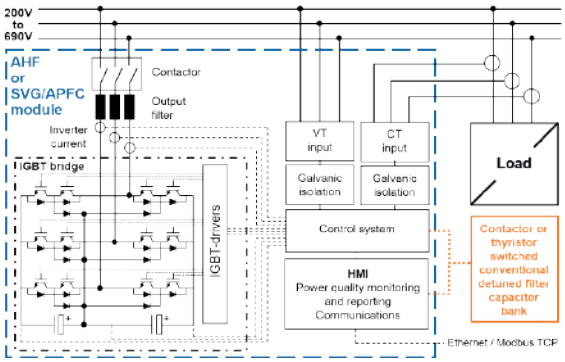


HVC operating principle

Benefits

Main benefits of HVCs can be summarized as:

- Protection of loads and equipment from waveform distortions, voltage variations and fluctuations, low power factor and unbalance.
- Capability to deliver instantaneous capacitive and inductive reactive power compensation.
- Optimized for applications where conventional capacitor banks, reactor banks or passive harmonic filters are unable to perform.
- No risk of harmonic amplification or resonance
- Unaffected by network voltage drop. Even at reduced network voltage levels, full reactive current can be provided to meet demand.
- Flexibility: Take care of individual disturbance patterns and automatically adapt to changing load conditions and network topologies.
- Simple dimensioning and installation.
- Compliance with the strictest power quality standards and grid codes including G5/4, IEEE519, IEC61000 3-2/3-4 and EN50160.



HVC connection

Comparison with conventional solutions

	Capacitor banks, reactor banks or passive harmonic filters	Hybrid var 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 •Steps inject extra capacitive reactive power in the system	•Instantaneous, continuous, stepless and seamless •Grid voltage fluctuation has no influence on the output •No injection of extra capacitive reactive power
Harmonic filtering	•One filter needed for eliminating each single harmonic order •Characteristics affected by network impedance and unbalance	•2nd to the 50th order simultaneously (odd and even) •Unaffected by network impedance or unbalance
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	•Extensive harmonic 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

HVC WITH 1 MODULE	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 415V using SVG module	-36 to +246kvar	-43 to +283kvar	-54 to +354kvar	-72 to +492kvar	-86 to +566kvar	-108 to +708kvar	-144 to +984kvar
Reactive power output at 415V using AHF module at 50%	-25 to +175kvar	-30 to +210kvar	-37.5 to +262.5kvar	-50 to +350kvar	-60 to +420kvar	-75 to +525kvar	-100 to +700kvar
Phase RMS current output at 415V using AHF module at 50%	35A	42A	53A	70A	85A	106A	141A
Neutral RMS current output at 415V using AHF module at 50%	150A	180A	225A	300A	360A	450A	600A
Reactive power output at high voltage (>1kV) with SVG and transformer (415V secondary)	-36 to +246kvar	-43 to +283kvar	-54 to +354kvar	-72 to +492kvar	-86 to +566kvar	-108 to +708kvar	-144 to +984kvar
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.						
Harmonic filtering	1st to 50th harmonic order (odd and even harmonics). Fully selectable and programmable per harmonic order.						
Operation modes	All harmonics / All harmonics but not fundamental / Selectable harmonics.						
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.						
Load balancing	Negative sequence current injected to balance fundamental current on the system (inherently corrects displacement power factor). Load balancing degree can be set from 0% to 100% of the output current of the module.						
Harmonic generation function	Controlled & selectable harmonic injection can be used for validating the performance of different components of the electric power system.						
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							
Number of steps and size	6 capacitor bank steps per module. One digital output can switch a step rated between 10kvar to 200kvar.						
Protection	Fuses or moulded case circuit breakers (MCCBs).						
Switching devices	Contactors or thyristor switch modules.						
Reactors	Iron-core detuned reactors 6%, 7% or 14%.						
Capacitor units	Single-phase capacitor units connected in star or delta, or three-phase capacitor units connected internally in star or delta.						
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 (module)							
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.						
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.						
HVC WITH FEW MODULES							
Electrical ratings							
Rated voltage	200-480VAC +/-10% (auto sensing). Connection to higher voltages through suitable step-up transformer.						
RMS current output	Any output is possible. Unlimited parallel operation of any rating combination of modules.						
Reactive power output	Any output is possible. Unlimited parallel operation of any rating combination of modules.						

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Technical specifications – 500-690VAC devices

HVC WITH 1 MODULE	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 690V using SVG module	-60 to +420kvar	-72 to +492kvar	-90 to +630kvar	-120 to +840kvar	-143 to +983kvar
Reactive power output at 690V using AHF module at 50%	-40 to +280kvar	-50 to +350kvar	-60 to +420kvar	-80 to +560kvar	-100 to +700kvar
Phase RMS current output at 690V using AHF module at 50%	35A	42A	53A	70A	85A
Neutral RMS current output at 690V using AHF module at 50%	150A	180A	225A	300A	360A
Reactive power output at high voltage (>1kV) with SVG and transformer (690V secondary)	-60 to +420kvar	-72 to +492kvar	-90 to +630kvar	-120 to +840kvar	-143 to +983kvar
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.				
Harmonic filtering	1st to 50th harmonic order (odd and even harmonics). Fully selectable and programmable per harmonic order.				
Operation modes	All harmonics / All harmonics but not fundamental / Selectable harmonics.				
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.				
Load balancing	Negative sequence current injected to balance fundamental current on the system (inherently corrects displacement power factor). Load balancing degree can be set from 0% to 100% of the output current of the module.				
Harmonic generation function	Controlled & selectable harmonic injection can be used for validating the performance of different components of the electric power system.				
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					
Number of steps and size	5 capacitor bank steps per module. One digital output can switch a step rated between 10kvar to 200kvar.				
Protection	Fuses or moulded case circuit breakers (MCCBs).				
Switching devices	Contactors or thyristor switch modules.				
Reactors	Iron-core detuned reactors 6%, 7% or 14%.				
Capacitor units	Single-phase capacitor units connected in star or delta, or three-phase capacitor units connected internally in star or delta.				
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 (module)					
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.				
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.				
HVC WITH FEW MODULES					
Electrical ratings					
Rated voltage	500-690VAC +/-10% (auto sensing). Connection to higher voltages through suitable step-up transformer.				
RMS current output	Any output is possible. Unlimited parallel operation of any rating combination of modules.				
Reactive power output	Any output is possible. Unlimited parallel operation of any rating combination of modules.				

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