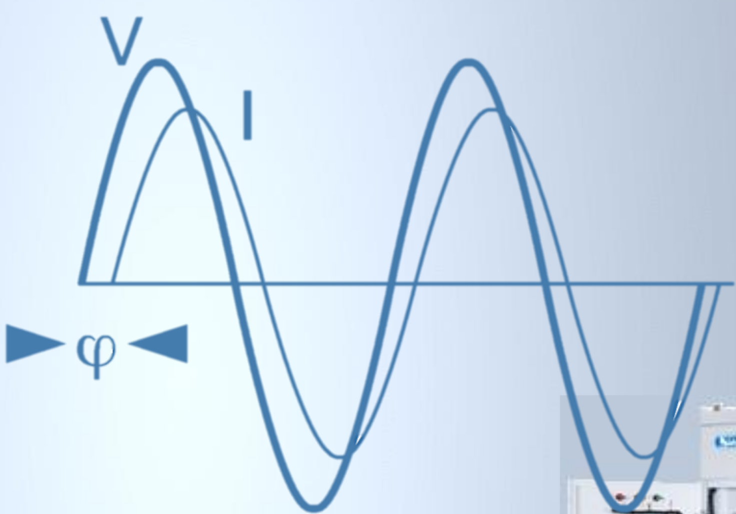
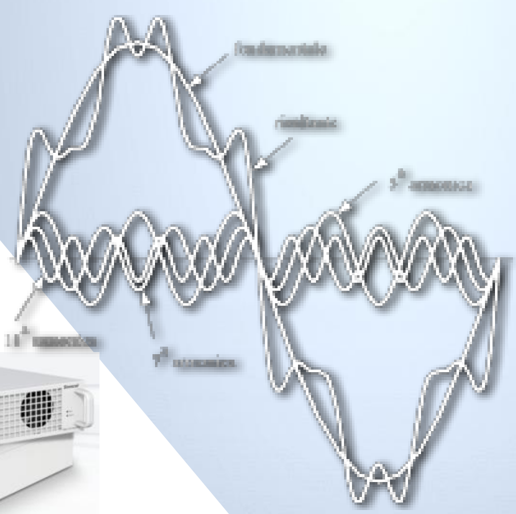
Power Quality

Dynamic and Hybrid Power Factor Correction
Active Harmonic Filters





COMAR Condensatori

Save your **Energy.**

Since some years, many types of applications have been showing an increasing focus on **power quality** where the loads used in the production process can adversely affect the electrical system, reducing - even drastically - the quality of the power itself.
Insufficient power quality therefore has an impact on the efficiency of systems, their availability, the quality of processing, the reliability of machinery, safety, and finally operating costs.
'Energy quality' means:

- Continuity of supply: the absence of interruptions in the provision of electricity service
- The characteristic of voltage and current, intended as the quality of the waveform (amplitude, frequency, variations, etc.).

The increasing popularity of microprocessor-based equipment and power electronics components used in production machinery has contributed greatly to the occurrence of disturbances of electrical variables in networks. Power quality problems range from untimely tripping of circuit breakers, overheating of the neutral, flicker, blocking of electronic equipment, overloads

Harmonics are disturbances, in voltage and current, that distort the original shape of the sinusoid, and have a frequency multiple of the fundamental frequency a (e.g. n x 50Hz).

These unwanted frequencies cause numerous symptoms, including overheating of the neutral conductor and of the power transformers supplying these circuits. (see third harmonic effect) .

Harmonics originate from the action of non-linear loads, such as static converters, variable speed drives, arc welders, diode controlled power controls, etc.

In overall terms, current harmonics can reduce the efficiency of an electrical system, damage its insulators - on lines and machines - and create malfunctions on various components. When symptoms related to harmonics occur, it is necessary to carry out a measurement campaign by observing the total harmonic distortion (THD).

A significant increase in THD under varying load conditions makes it possible to establish a comparison in percentage terms of the current level of each harmonic with respect to the total current flow of the fundamental in the system. Knowing the effects caused by each harmonic current and comparing them with the identified symptoms helps in troubleshooting. The origin of the harmonic must then be isolated and resolved through the appropriate installation of harmonic filters.

The **power factor** is crucial for power quality as it regulates excessive reactive power and reduces unnecessary currents as well as voltage drops.
This implies a reduction in joule losses and thus an immediate improvement of the lines and components that make up the system: in fact, the load on the transformers and lines is reduced, and over-dimensioning can be avoided at the design or expansion stage.
Installing appropriately sized capacitor banks is therefore the first action to consider, requiring power factor correction equipment with tuning reactor in the presence of harmonics.

Frequency variation is an alteration of the mains frequency from the nominal frequency. As an average value, the Regulations takes the one measured within a 10-second interval.
The European frequency of 50 Hz must be maintained for 95 % of the year within a tolerance of ±1 %, while at no time it must exceed an increase of 4 % or a decrease of 6 %. What causes a frequency variation are faults in the generation and transmission system, or even sudden shutdowns of large generators. Negative effects occur in terms of speed variation of motors and possible functional faults on electronic equipment.

A **transient** (impulsive/oscillatory) is a temporary change in voltage of an electrical circuit, due to a disturbance, caused by shunting surges or currents in series inductances.
Voltage transients can cause symptoms ranging from computer crashes and damage to electronic equipment, to the occurrence of discharges and damage to the insulation of distribution equipment. They are manifested by significant voltage increases, lasting only a few microseconds, and are often caused by lightning strikes and the abnormal switching of capacitor banks, or by the return of systems to operation after a power failure, the switching of loads consisting of motors, the switching on or off of loads consisting of fluorescent lamps or high-intensity discharge lamps, the switching of transformers, or the sudden shutdown of certain types of equipment.

In presence of transients, it is necessary to monitor the load in order to associate operating problems or equipment failures with events occurring in the distribution system.

Power Quality Problems & Solutions

Flicker is a phenomenon produced by sudden and repetitive voltage variations. The causes can be varied: from the switching on and off of large loads to the starting of motors, from the presence of arc furnaces to high-power crushers, as well as the use of welding systems or converters.
Depending on how dynamic the load variations are, correction can be obtained with dynamic or hybrid correction systems, and/or active filters. In any case, the dimensioning of flicker compensation requires a measurement of short-term load trends.

Voltage unbalance is one of the most common problems in electrical networks and occurs when one phase is overloaded by assuming a different voltage value than the other phases.

As they are often overlooked, imbalances can become the cause of serious damage to electrical and electronic equipment, especially to transformers and three-phase motors which, in the presence of asymmetries, may be subject to problems of overheating, abnormal noise, excessive vibration and premature failure. In fact, in a 400V motor, apparently small voltage imbalances (2-3%) cause a current imbalance that can exceed 20%, with a temperature rise of more than 30 °C. In these cases, it is necessary to have a voltage stabiliser, which detects and compensates voltage imbalances automatically and independently on each phase.

Voltage fluctuations include voltage drops or voltage rises and are solved by installing a voltage stabiliser that guarantees an output voltage around the rated value.

Voltage sags are responsible for most power quality problems and occur when the voltage drops below 90% and up to 10% (below becomes interruption) of its nominal value. Common symptoms of dips include dimming of incandescent lights, freezing of computers, shutdowns of sensitive electronic equipment, loss of data (memory) of programmable controllers and problems in the control of relays.

Voltage surges above 110% of the nominal value) occur less frequently, but

may cause the equipment to break down, often resulting in the power supply of the electronics.

Some failures may not occur immediately, causing components to fail prematurely.

The main causes of surges include the sudden switch-off of large loads and the abnormal switching of power factor correction capacitors.

COMAR invests in Power Quality

The experience gained in the energy efficiency sector, as a leader in the design of the best correction solutions, allowed COMAR to get in touch with industrial realities with high energy requirements, such as the steel, petrochemical, paper, packaging, cement and automotive industries.
Thanks to this experience and strategic agreements with specialised partners, COMAR has been able to complement its power factor correction systems with solutions for active harmonic filtering, dynamic power factor correction and to develop the hybrid power factor correction line in-house.

The value proposition is further extended by the establishment of a <u>dedicated Power Quality team</u> capable of supporting companies with a range of tailor-made services, such as:

<u>Power Quality Measurements and Network Analysis</u>
Voltage and current harmonics
Compatibility curves
Unbalanced loads and tension
Active, reactive and distorting power
Identification of anomalies, sources of disturbance, definition of solutions

<u>Power Quality test measurements</u> EN50160
Frequency analysis
Voltage variations
Flicker severity
Tension imbalance
Voltage harmonics
Voltage events, interruptions, dips and surges
Report EN50160

Instrumentation used, depending on the type of analysis: class S or class A analyser, according to IEC61000-4-30.

PATENT PENDING

Hybrid Power Factor Correction

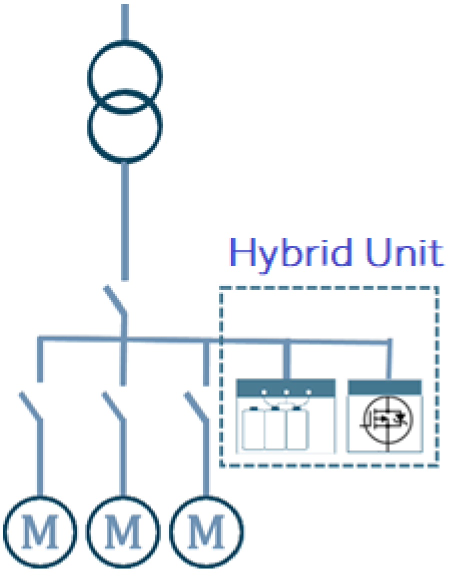
The integrated solution for Power Quality and Energy efficiency

What is hybrid active correction?

Traditionally, poor power quality has been addressed through the integration of more dedicated and targeted device to solve the specific problem.

- A power factor correction unit is used if the power factor is inadequate.
- A harmonic filter (active or passive) is used if harmonics are identified as a problem.

Advances in diagnostic technology have led to the recognition that power quality problems arise from a combination of different problems and that a more flexible - **hybrid** - solution is needed, integrating troubleshooting into a single equipment.



How does it work?

Hybrid active power factor correction (**HSVG**) combines the technological advantages of dynamic generation with the discrete power of classical capacitor banks, driven by contactors or thyristors.

Connected in parallel to the load supply, the hybrid unit provides a dynamic and controlled current source that can adapt in real time to the changes in the grid.

Thanks to its logic, the system is able to simultaneously manage the steps of the capacitor banks providing the fundamental capacitive reactive power, and the dynamic power (both capacitive and inductive) provided by the integrated active system

The integration of the two technologies within the hybrid unit enables the simultaneous correction of reactive power, reduction of voltage fluctuations, flicker mitigation and phases unbalance in a single device.

Benefits

The hybrid correction solution solves a number of additional problems compared to conventional PFC equipment or passive filters:

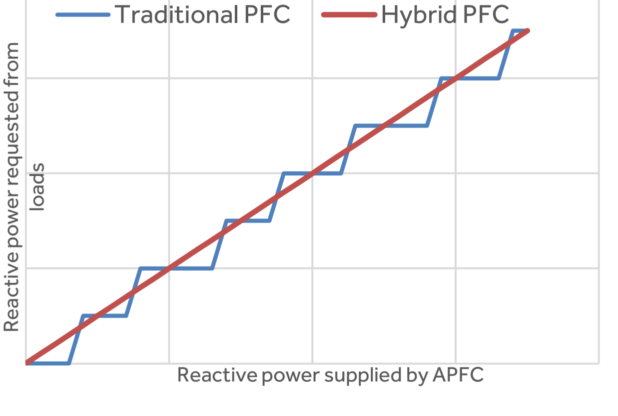
- voltage variations and fluctuations
- Injection of reactive energy into the grid both capacitive and inductive
- Unbalance between phases.
- Low costs compared to a 'pure' dynamic system due to conventional technology for reducing reactive power withdrawal from the grid

With the efficiency provided by electronic control

- Continuous, linear dynamic output: the typical 'steps' of systems with only capacitor banks or inductor banks are eliminated by the SVG component.
- Immediate reaction time
- The Human-Machine-Interface display allows intuitive and simple control.

Where is it needed?

- Highly variable loads
- Unbalance and power factor correction of lines with single-phase loads
- Voltage compensation (flicker)



General technical data common to all hybrid series

Hybrid correction can be implemented on all current COMAR power factor correction series.

The installation is similar to that of conventional power factor correction units, with the only additional need to carry the amperometric (CT) signals of all 3 phases.

The equipment leaves the factory already fully configured and therefore does not require any setting by the installer

The AAR/100 hybrid series configurations is given as examples

GENERAL TECHNICAL DATA COMMON TO ALL SERIES

Enclosure	Made of steel sheet, protected against corrosion by phosphating and epoxy powder coating. Colour RAL 7035. External degree of protection: IP31 Internal degree of protection: panels with interlocked switch-disconnector IP20 live parts; IP 20 protection in additional modules Capacitor banks are assembled on drawers that can be pulled out from the front of the cabinet for quick maintenance Cabinets are equipped with eyebolts for lifting
Installation	Indoor installation, in a well ventilated position free from solar radiation. Pollution degree 1 Working temperature: -5 / +40 °C; Relative humidity RH50% @40°C (EN61435-1) Altitude: <1000 asl
Main Disconnector	Three-phase off-load disconnector with door interlock.
Wiring	Internal connections are made with FS17-450/750V insulated, flame-retardant low smoke emission cables. On non-preinsulated cable lugs, the connection point is covered with a durable heat-shrink sleeve. Auxiliary circuits are appropriately identified in accordance with current standards.
Bank insertion	The banks are driven by three-phase contactors (Class AC6-b). Series without tuning reactor have contactors with a pre-insertion resistor to limit peak inrush current Static insertion series are fitted with thyristor insertion modules controlled by microprocessor such that switching on/off occurs when the potential difference between the mains and the capacitors is zero. (zero crossing). The switching time for the insertion of the capacitor banks is approximately 200 ms.
Fuses	The capacitive banks are protected by high breaking capacity fuses (100kA). The protection system for the power circuits uses NH-00 curve gG fuses; for the auxiliary circuits sectionable fuse holders and 10.3x38 fuses.
Auxiliary circuits	230 Vac Internal transformer
Capacitors	Single-phase capacitors made of self-healing metallised polypropylene (MKP), equipped with over-pressure device and discharge resistance. Impregnated with PCBs-free vegetable oilf. Delta connection. Continuous duty type. - overvoltage: 1.1 x Un (8h / 24h) - current overload: 1.3 x In - capacitance tolerance: -5% / +10%. - Dielectric losses: ≤0.2 W/kvar; total dissipation losses: ≤0.4 W/kvar - temperature category: -25 / D In the higher-performance series, '**Heavy Duty**' capacitors made of high thickness film and multiple elements in series are installed to reduce the effect of high currents on the element heads
Tuning reactor (where present)	Iron core with oriented crystals; aluminium windings Resin impregnation Dissipation loss (average): 6W/kvar Over-temperature control probe
SVG	• Mosfest SiC technology • Real-time correction of reactive power and unbalance 99% efficiency • Connection: 3-phase (3-phase + neutral connection on request) Response time: 20ms
Controllers	• HPR+HMI 7" interconnected controllers with three-phase measurement • amperometric signals: by means of 3 current transformers with 5A secondary (not included) • response time: 20ms
Safety	Automatic unit shut-down for high THDi, THDu, loss of capacitance of the banks, over-temperature >50°C, under and overvoltage. bank block for inductance overtemperature (where present), low capacitance Dry contact NC for extreme internal temperature (>70°C)
Testing	100% of the equipment undergoes visual inspection, phase-to-phase and phase-to-ground insulation tests, bank efficiency and ventilation circuit checks.
Standards	Capacitors: IEC/EN 60831-1 / 2 certified by IMQ (V1927) Equipment: IEC/EN 61439-1 / 2, IEC/EN 61921; 2014/35/EC Electromagnetic compatibility: 2014/30/EC.

Hybrid Active Harmonics Filters

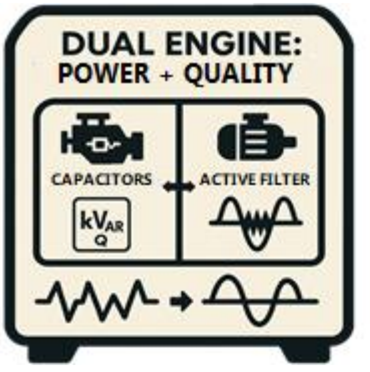
The all-in-one solution for Power Quality and Energy efficiency.

Hybrid Active Harmonics Filters

What is hybrid active filtering?

Traditionally, poor power quality has been addressed through the integration of different dedicated and targeted device to solve the specific problem:

- A power factor correction unit is used if the **power factor** is inadequate.
- A harmonic filter (active or passive) is used if **harmonics** are identified as a problem.



Advances in diagnostic technology have led to the recognition that power quality problems arise from a combination of different causes and that a more flexible - **hybrid** - solution is needed. A device that can solve the different problems into a **single equipment.**

How does it works ?

The **HAHF (Hybrid Active Harmonic Filter)** system acts on the power supply of the loads, selectively mitigating harmonics from the 2nd to the 50th order in real time.
Power factor optimisation is handled by traditional capacitor banks.

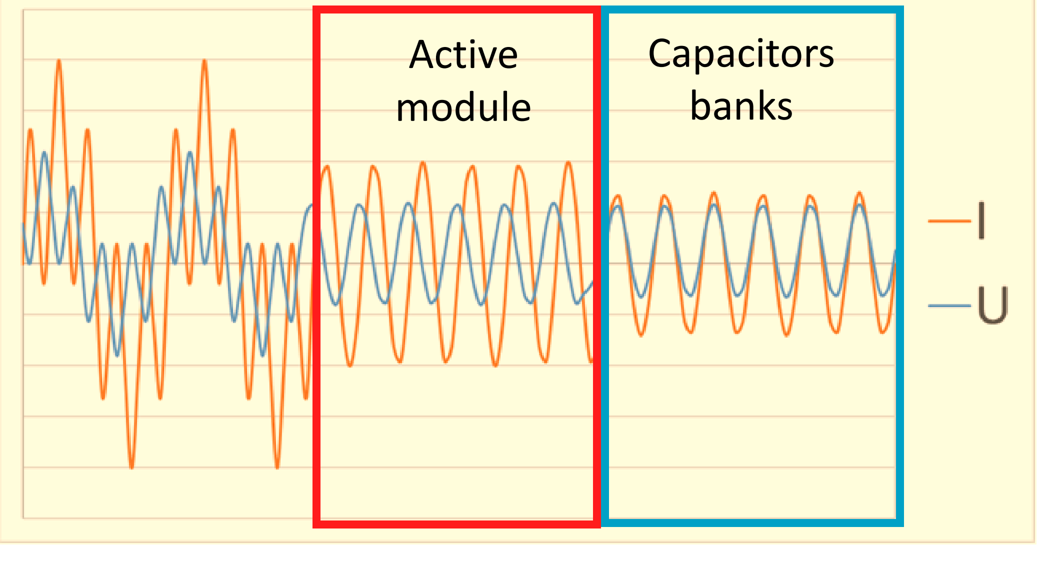
The HAHF unit integrates three functions within a single device:

- an **active module** that filters harmonics and, with the residual power, can fine-tune the reactive power drawn or fed in;
- **capacitor banks**, managed by contactors or thyristors, which provide the capacitive reactive power required by the loads;
- an integrated logic that coordinates the two systems, ensuring optimal performance in every situation.

The result is improved power quality through simultaneous, real-time compensation of **harmonic disturbances, voltage fluctuations, flicker and low power factor**.

Highlights

Versatility: corrects harmonics, reactive power, current unbalance, and flicker in a single system.
Efficiency: the fundamental reactive load is corrected by the traditional capacitor banks, while rapid variations are managed in real time and with maximum precision by the active module.
Flexibility: the modular concept can adapt to different scenarios of growth or implementation of the system.



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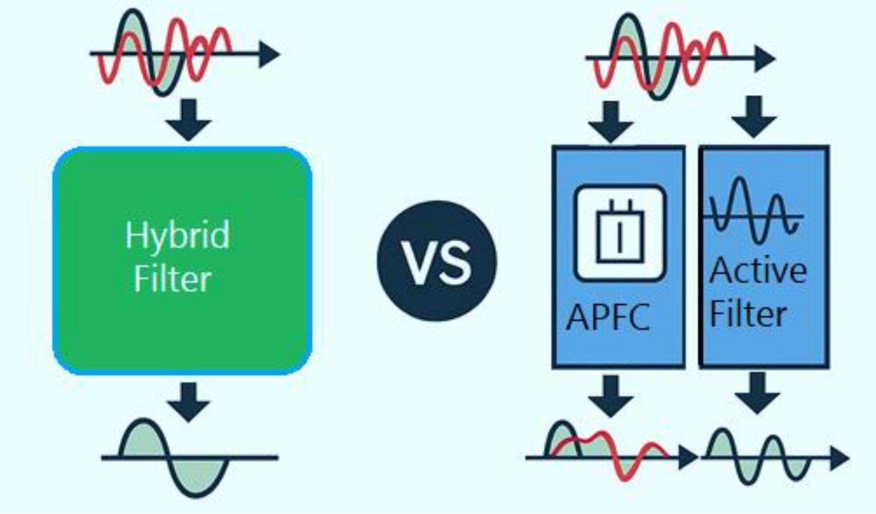
Hybrid Active Harmonics Filters

Benefits

Hybrid technology offers the following additional advantages compared to a "pure" active filter

- Reduced purchase costs. It is not necessary to oversize the filter to fully correct the power factor
- Reduced operating costs: dissipation losses in capacitor banks are lower than in active equipment
- Compactness: a single machine doesn't only means less space, but also lower installation costs: power cables and amperometric signals do not need to be duplicated on multiple machines.
- The residual power of the active module can be used to compensate the inductive or capacitive energy during periods of low production.
- The Human-Machine-Interface display allows for intuitive and simple consultation.



Where is it necessary?

- Industry with highly variable and non-linear loads

inverter driven machines, welding machines, induction furnaces, robotics, automated production lines.
Advantages: the active filter manages harmonics and phase unbalance and quickly adjusts the power factor, capacitors banks supply the reactive power base need.

- Tertiary sector installations with mixed and variable loads

airports, shopping centres, hospitals, data centres.
Advantages: the active part dynamically compensates for unpredictable disturbances, the capacitors are designed to compensate for slowly varying loads.

- Energy-intensive industries subject to penalties from the energy provider

cement factories, paper mills, steelworks.
Advantages: improves cosφ even in the presence of harmonics and phase unbalances, avoiding overcurrents and reactive power penalties.

- Revamping of existing electrical systems

Advantages: compact and versatile system that replaces or integrates existing power factor correction devices, adapting to the new loads requirements.

Hybrid Active Harmonics Filters

HAHF are available in the Comar detuned equipment series AAR/138, AAR/600, AAR/D20.

The installation is similar to that of conventional power factor correction units, with the only additional need to carry the amperometric (CT) signals of 2 phases; L1(R) and L3(T)

The equipment leaves the factory already fully configured and therefore does not require any setting by the installer

GENERAL TECHNICAL DATA COMMON TO ALL SERIES

Enclosure	Made of steel sheet, protected against corrosion by phosphating and epoxy powder coating. Colour RAL 7035. External degree of protection: IP31 Internal degree of protection: panels with interlocked switch-disconnector IP20 live parts; IP 20 protection in additional modules Capacitor banks are assembled on drawers that can be pulled out from the front of the cabinet for quick maintenance Cabinets are equipped with eyebolts for lifting
Installation	Indoor installation, in a well ventilated position free from solar radiation. Pollution degree 1 Working temperature: -5 / +40 °C; Relative humidity RH50% @40°C (EN61435-1) Altitude: <1000 asl
Main Disconnector	Three-phase off-load disconnector with door interlock.
Wiring	Internal connections are made with FS17-450/750V insulated, flame-retardant low smoke emission cables. On non-preinsulated cable lugs, the connection point is covered with a durable heat-shrink sleeve. Auxiliary circuits are appropriately identified in accordance with current standards.
Bank insertion	The banks are driven by three-phase contactors (Class AC6-b).
Fuses	The capacitive banks are protected by high breaking capacity fuses (100kA). The protection system for the power circuits uses NH-00 curve gG fuses; for the auxiliary circuits sectionable fuse holders and 10.3x38 fuses.
Auxiliary circuits	230 Vac Internal transformer
Capacitors	Single-phase Heavy Duty double element capacitors made of self-healing metallised polypropylene (MKP), equipped with over-pressure device and discharge resistance. Impregnated with PCBs-free vegetable oilf. Delta connection. Continuous duty type. - overvoltage: 1.1 x Un (8h / 24h) - current overload: 1.3 x In - capacitance tolerance: -5% / +10%. - Dielectric losses: ≤0.2 W/kvar; total dissipation losses: ≤0.4 W/kvar - temperature category: -25 / D
Tuning reactor (where present)	Iron core with oriented crystals; aluminium windings Resin impregnation Dissipation loss (average): 6W/kvar Over-temperature control probe
Active module	• High efficiency Mosfest SiC technology • Real-time correction of harmonics and reactive power. 99% efficiency • Connection: 3-phase Response time: 20ms
Controllers	• HPR+HMI 7" interconnected controllers with three-phase measurement • amperometric signals: by means of 2 current transformers with 5A secondary (not included) • Settable response time
Safety	Automatic unit shut-down for high THDi, THDu, over-temperature >50°C, under and overvoltage. Capacitor bank shut-down for reactor overtemperature, low capacitance Dry contact NC for extreme internal temperature (>70°C)
Testing	100% of the equipment undergoes visual inspection, phase-to-phase and phase-to-ground insulation tests, filtering efficiency, capacitor bank power and ventilation circuit checks. Capacitors undergoes capacitance, tan(δ), insulation tests in 3 times during manufacturing process
Standards	Capacitors: IEC/EN 60831-1 / 2 certified by IMQ (V1927) Equipment: IEC/EN 61439-1 / 2, IEC/EN 61921; 2014/35/EC Electromagnetic compatibility: 2014/30/EC.

PATENT PENDING

Active equipments

Static Var Generator

Active Harmonic Filter

SVG

Static Var Generators are part of the new electronic power factor correction equipment capable of generating leading or lagging current in response to the load capacitive or inductive current generation.
The main characteristics are

- Compensation of inductive and capacitive current on the 3 phases
- Immediate response time to load variations
- Current balancing on the 3 phases

There are different size available that can be assembled in parallel to reach the desired power

PERFORMANCE DATA

Operating voltage	228V- 456V (up to 690V on request)
Reactive Power modules	30 – 50 – 100 – 200 kvar
Rated frequency:	50/60Hz auto selection (45Hz÷ 62Hz)
Inverter type:	Silicon Carbide Mosfet
Efficiency:	99%
Switching frequency	40kHz (average)
Response time:	<50us (full correction <15ms)
correction level:	>97%
Power supply	Three-phase, 3-wire or 4-wire (3-phase+neutral)
Rated neutral current	3In (4-wire type only)

TECHNICAL DATA

Power factor correction	inductive and capacitive correction
Unbalance compensation	phase-by-phase compensation of unbalanced loads
Communication protocol	RS485 port, RJ45; MODBUS RTU protocol, TCP/IP
Protections	overvoltage, undervoltage, overtemperature
TA Report	150/5 ÷ 30.000/5 A
Degree of protection	IP20
Power losses	≤1%
Assembly	wall or cabinet
Operating temperature	-20 to 40°C (downgraded for temperature > 40°C).
Relative humidity	<95% without condensation formation
Storage temperature	-20 ÷ 70°C
Noise level	< 65 dB
Altitude	≤ 1,500m (from 1,500m to 4,000m, 1% downgrade per 100m)

AHF

Active Harmonic Filters are electronic equipment able to correct power factor and harmonic currents. The principle is similar to the SVG but moreover they can reduce harmonics currents in the grid by injecting a current equal and opposite to the harmonic one . The main characteristics are

- Compensation of inductive and capacitive current on the 3 phases
- Immediate response time to load variations
- Current balancing on the 3 phases
- Harmonic current reduction

There are different size available that can be assembled in parallel to reach the desired power

DATI DI PERFORMANCE

Operating voltage	228 - 456Vac (up to 690V on request)
Current modules	25 – 35 -50 - 60 – 75 -100 - 150 – 300 A
Frequency	45Hz÷ 62Hz (auto)
Inverter type:	Silicon Carbide Mosfet
Efficiency:	99%
Switching frequency	40kHz (average)
Response time:	<50us
Power supply	Three-phase, 3-wire or 4-wire
Rated neutral current	3In (4-wire type only)
Residual THDI	< 5% (at full load)

TECHNICAL DATA

Power factor correction	inductive and capacitive correction
Unbalance compensation	phase-by-phase compensation of unbalanced loads
Harmonic current compensation	Up to the 50th harmonic (both odd and even order)
Communication protocol	RS485 port, RJ45; MODBUS RTU protocol, TCP/IP
Protections	Abnormal voltage/frequency; Inverter short-circuit; Abnormal output current; Inverter overload; Overtemperature
TA Report	150/5 ÷ 30.000/5 A
Degree of protection	IP20
Power losses	≤3%
Assembly	wall or cabinet
Operating temperature	-20 to 40°C (downgraded for temperature > 40°C).
Relative humidity	<95% without condensation formation
Storage temperature	-20 ÷ 70°C
Noise level	< 65 dB
Altitude	≤ 1,500m (from 1,500m to 4,000m, 1% downgrade per 100m)

Any other question ?

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