# EM - ENERGY SOLUTIONS

# POWER QUALITY

## Product Line 2020


AVE - Automatic Voltage Equalizer

APF - Active Power Filter

SVG/ASVG - Static VAR Generator


*SVG wall mounted module*

*IP54 APF Control Cabinet*


*SVG Module based system*

EM ENERGY SOLUTIONS
+47 414 45 616
contact@emenergysolutions.com
Ferjemannsveien 4, 7042 Trondheim, Norway

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- Based on unique electromagnetic technology
- Eliminates transients and surges
- Voltage balancing
- Prevent Arc-Flash
- Reduced energy consumption
- Extended lifespan of electrical components
- Reduce voltage harmonics (Phase – Ground)


## AVE Hybrid

- Ultimate solution - Controls both voltage and current
- Mitigates harmonic current and voltage
- Current and voltage balancing
- Reactive power compensation (PFC)
- Eliminates transients and surges
- Compliance with IEEE519 , IEC61000+++
- Reduced supply sags & swells

## APF - Active Power Filter

- Eliminate harmonic distortion
- Power factor correction
- Sags & Swells reduction
- Load balancing
- Flicker mitigation
- Energy savings
- Extended equipment liftetime


## Static VAR Generators

- Dynamic step-less compensation
- Power factor correction of 0.99 lagging or unity if required
- Eliminates the need for switched capacitors
- Corrects load imbalance
- Eliminates transients and surges
- Mitigation of 3rd, 5th, 7th, 11th harmonic orders (ASVG)
- Unit capacity can be shared 50/50 (PFC/THD) (ASVG)

# Power Quality

## General

The term 'Power Quality' is used to describe the quality or 'fitness' of electric energy that drives an electrical load, and the power quality dramatically affects the load's ability to function properly. Without adequate power quality, an electrical device may malfunction, fail prematurely, or not operate at all.

The power grid's ability to supply a clean, continious, and stable power flow together with the amount of noise the load creates defines the power quality situation of the plant. The voltage and current flow should ideally have a pure sinusoidal waveform while remaining within specified amplitude and frequency tolerances. Unfortunately, no real-life power source is ideal, and power quality related problems are always present to some extent.

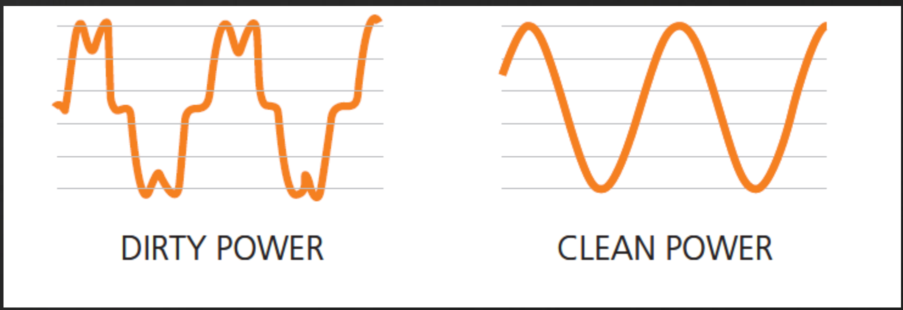
In today's electrical networks, substantial deviations from ideal conditions are frequent due to internal factors like an increased amount of non-linear loads or external factors like a weak power grid, among many more. Power generation is also becoming more involved with new players and technologies entering the business, which adds new challenges to power grid operators.

The consequences of insufficient power quality can be severe losses on business and economy. In a worst-case scenario, it may even pose a threat to human life in mission-critical applications and highly sensitive environments, such as hospitals.

Does poor power quality contribute to additional costs other than just an increased electricity bill?

Yes,  and these additional costs are a reality in many industries. The cost of power quality problems can be directly related to increased energy consumption but also hidden costs such as downtime, loss of production, equipment damage, idling personnel, data losses, negative impact on cash flow, customers, and marketing value.

Even though we think that the power quality is within recommended standards in most European countries and the United States, poor power quality is, in fact, a severe, increasing problem.
The direct and hidden costs of poor power quality are high, and the annual cost is estimated to be 119$ – 188$ billion for U.S. companies and 150€ billion for European industry.



## Examples of power quality problems:

### Power Outages:
The expense of a power outage implies more than just the cost of lost kWh during normal operation. One 60 min outage during a year is usually much cheaper than 1 min outage 60 times a year.

### Dips, sags, swells, surges:
If the voltage decreases or increases below/above a specific limit for a short time, it causes interruptions and damages in control systems, which leads to problems in electrical systems.

### Harmonics:
Harmonic distortion can cause sporadic problems. Harmonics have different impacts such as voltage waveform distortion, efficiency losses, failures in compensation systems, failures in sensitive electronic devices, overheating in electric motors, and transformers.

### Power imbalance:
The current imbalance has two main effects: a higher peak demand in one phase, which can lead to heat losses, and over dimensioning of the feeder. At the same time, a current imbalance creates voltage unbalance when going through the feeder. Voltage imbalance can make, e.g., VSD control system unstable.

### Arc-Flash:
Arc-Flash is one of the most dangerous electricity-related incidents for both personnel and equipment. It is an electrical explosion/discharge that results from a low-impedance connection through the air to ground or another high voltage phase in the electrical system. It can be initiated through accidental contact, underrated equipment compared to available short circuit current, contaminated insulated surfaces, as well as other causes. According to Industrial Safety and Hygiene News report, there are on average 30 000 Arc-Flash incidents every year with an estimated 7000 burn injuries, 2000 hospitalizations, and 400 fatalities.

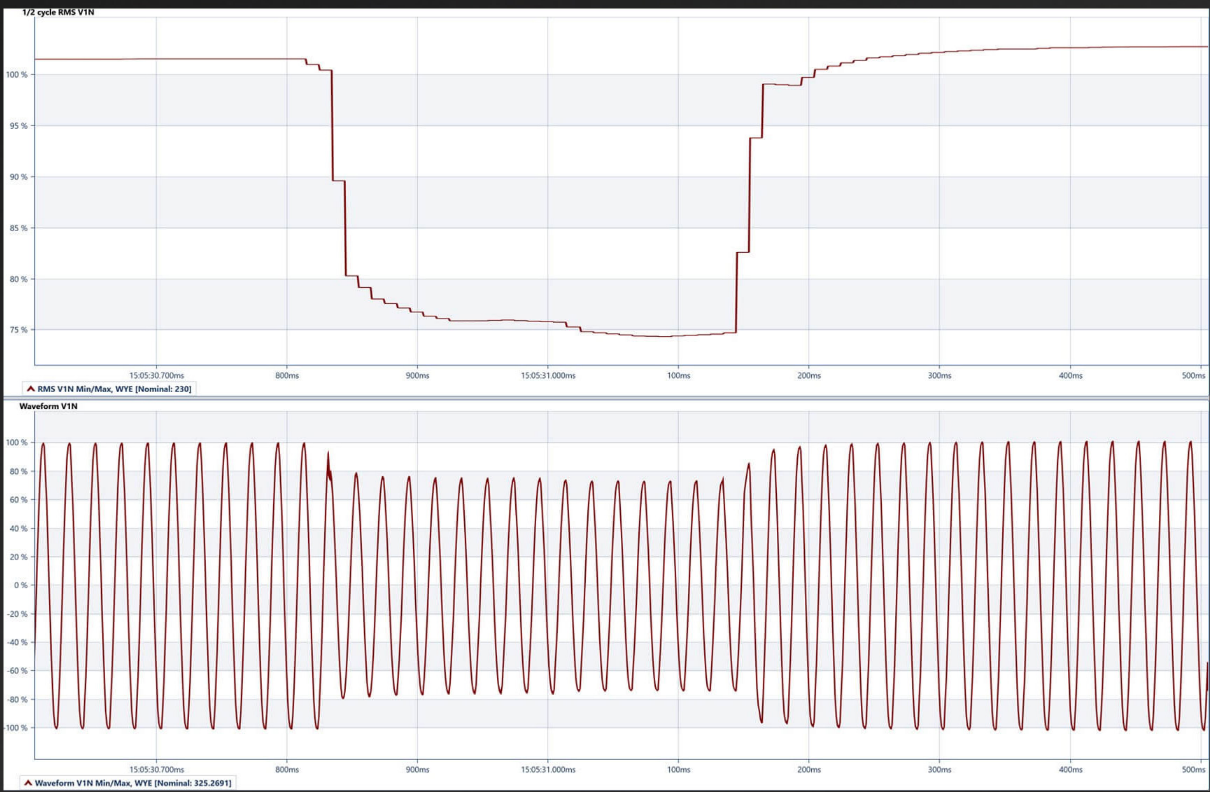
### Ground fault:
Ground fault is an unintentional contact between a live conductor and ground potential, that will result in a fault current flowing through either the grounding system or any other personnel or equipment. Ground faults are potential life threatening dangers when they are left untreated and become a live hazard for personnel and animals.

### Transients:
A transient event is a short lived burst of energy in the power system, often seen as voltage spikes with various amplitudes. These Spikes will, depending on their size and time duration, damage or even destroy electrical equipment.

## Examples

### Voltage sags

The definition of a voltage dip according to the IEC 61000-4-30 standard, is a slight reduction in RMS voltage of 10 percent or more below the nominal voltage for a period of more than ½ cycle to one minute. Voltage dips are a common power quality occurrence several times per year at an industrial plant's common point of coupling or other locations in the plant's power system. Recent years power quality standards like the IEEE 1668 published in 2017 (recommended Practice for Voltage Sag and Short Interruption Ride-Through Testing for End-Use Electrical Equipment Rated less than 1000V), have brought on requirements for electrical equipment to ride through short voltage dip events.




*Graph displaying voltage sag in both RMS and Waveform value*

### What is causing voltage Sags?

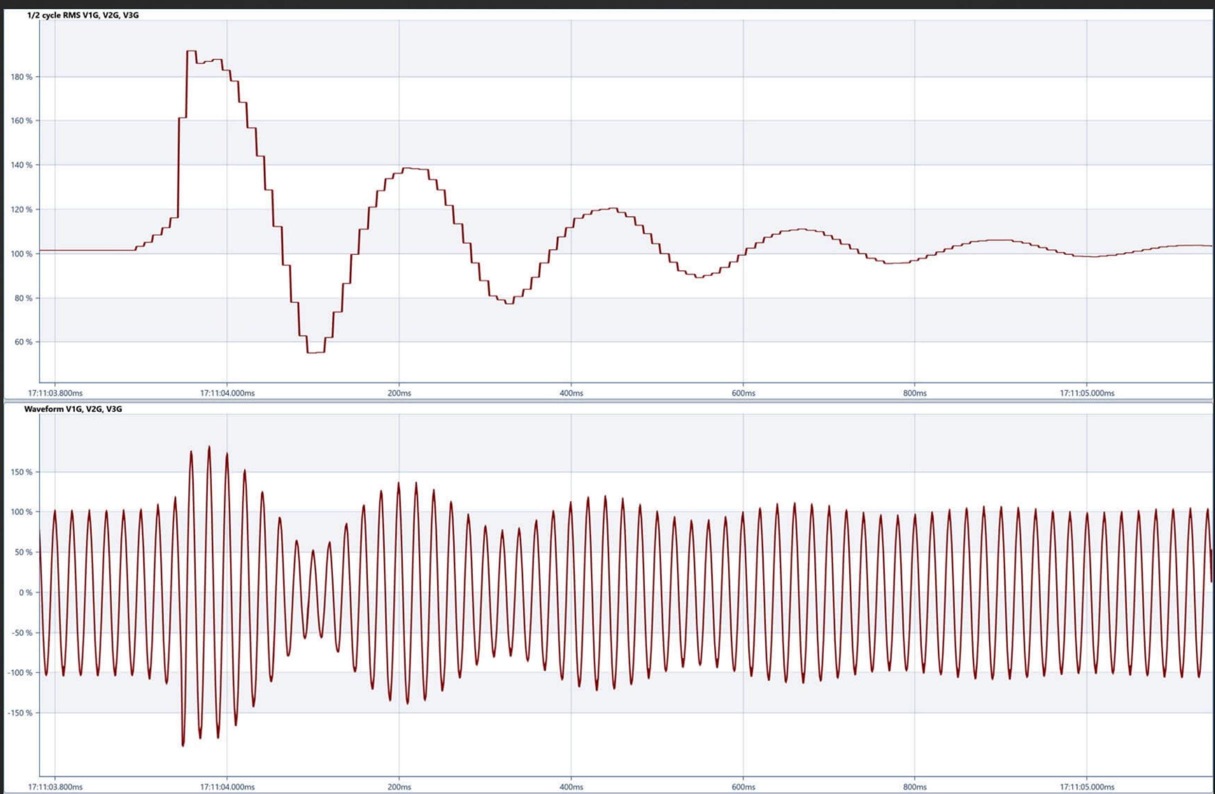
The major cause of voltage Sags on a supply system is a fault on the system, that is sufficiently remote electrically that a voltage interruption does not occur. Other sources are the starting of large loads (especially common in industrial systems), and, occasionally, the supply of large inductive loads. Faults on a supply network occur, and in industrial systems it is often practiced to specify equipment to ride-through voltage dips of up to 0.2s. The most common exception is contactors, which may well drop out if the voltage dips below 80% of rated voltage for more than 50-100ms.
Other network-related fault causes are weather-related (such as snow, ice, wind, salt spray, dust), causing insulator flashover, collisions due to birds, and excavations damaging cables. The impact on consumers may range from the annoying (non-periodic light flicker) to the serious (tripping of sensitive loads and stalling of motors). Where repeated dips occur over a period of several hours, the repeated shutdowns of equipment can give rise to serious production problems.

## Voltage swells:

As the name implies, this is the opposite of voltage dips, defined by the IEC 61000-4-30 standard as a brief increase in RMS voltage of 10 percent or more above nominal equipment voltage for a period of ½ cycle to one minute. Voltage swells are usually associated with system fault conditions - just like voltage sags, but are much less common. This is particularly true for ungrounded or floating delta systems, where the sudden change in ground reference results in a voltage rise on the ungrounded phases. In the case of a voltage swell due to a single line-to-ground (SLG) fault on the system, the result is a temporary voltage rise on the healthy phases, which last for the duration of the fault.

Voltage swells can also be caused by the de-energization of a very large load. The abrupt interruption of current can generate a large voltage, per the formula: $V = L\ di/dt$, where L is the inductance of the line, and di/dt is the change in current flow. Moreover, the energization of a large capacitor bank will also cause a voltage swell, though it more often causes an oscillatory transient.

Although the effects of sag are more noticeable, the effects of a voltage swell are often more destructive. It may cause a breakdown of components on the power supplies of the equipment, though the effect may be a gradual and accumulative effect. It can cause control problems and hardware failure in the equipment due to overheating that could eventually result in a shutdown. Also, electronics and other sensitive equipment are prone to damage due to voltage swell.




*Graph displaying voltage swell in both RMS and Waveform value*

## Harmonic Distortion

Harmonic distortion is an increasing problem in today's modern electrical system. The rapid uptake of sophisticated power electronics devices and non-linear loads has resulted in electrical networks that are rich in harmonic currents and voltage distortion.

Non-linear loads draw current from the electrical supply that is non-sinusoidal. These currents contain additional components referred to as harmonic currents, which are at frequencies multiples of the fundamental frequency. In situations with significant current harmonics in conjunction with a high impedance weak distribution system, significant voltage harmonics also occur.

The total harmonic distortion voltage THDv is the measurement of the distorted voltage waveform. The measurement of the current waveform, including the fundamental and harmonics, is described as the Total Harmonic Distortion Current or THDi.

### Typical Non-LinearLoads:

- Uninterruptable Power Supplies (UPS)
- Induction Furnaces & Welding Machines
- AC and DC Variable Speed Drives
- Battery Chargers and other DC Supplies
- LED and Fluorescent Lighting Circuits
- Computers and other devices containing Uncontrolled Rectifiers

### WHY REDUCE HARMONICS?

Harmonic currents increase the level of current drawn from the supply and affect the quality of the supply voltage. Electrical networks operate at the fundamental frequency, and the presence of currents with a frequency different from the fundamental stresses distribution equipment and can disrupt normal power supply operation. Some typical effects of harmonics are:

- Overheating of transformers, switchboards, cables, and motors due to increased current flow.
- Nuisance tripping of thermal protection devices such as overloads and circuit breakers
- Overloading of neutral conductors
- Poor Power Factor & premature failure of PFC capacitors
- Failure of PLC, DCS, computer, and other sensitive low voltage power supplies
- Premature failure of motors and poor motor performance

Harmonic currents can be improved by installing Active PowerFilter (APF) equipment. APF equipment simply adds currents 180 degrees out of phase with the existing harmonic currents, but that are equal in magnitude and frequency.

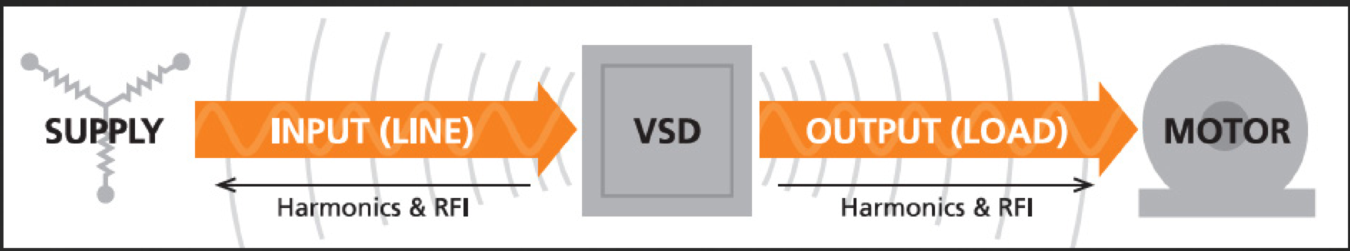
## Harmonic Distortion

High precision process control in today's modern industry relies on electromotors controlled by variable frequency drives, otherwise known as VFDs. These VFDs contain state of the art IGBT (Insulated Gate Bipolar Transistors), that together with a controller, enable accurate speed/frequency control of the motor and subsequent machine.

A VFD works by having a rectifier section at the input that generates DC voltage supplying an internal DC bus. The inverter section at the output side provides the Pulse Width Modulated (PWM) waveform. A VFD changes the speed of the motor by altering the frequency of the voltage supplied to the motor.

PWM is employed to control the voltage and frequency supplied to the motor drive. DC voltage is applied to the motor by controlled pulses at high frequency, which results in a voltage that approximates a sine wave of the chosen frequency.

This PWM method creates harmonics in the system. The switching also creates radio frequency interference (RFI) and voltage spikes that can be up to 1200V at the motor terminals. The high switching frequency can also lead to 'capacitive bearing currents' that flow through the motor bearings and can damage the bearing surfaces. A portion of the harmonics is reflected in the VSD by the motor, creating further issues in the electrical environment.




Harmonics in an electrical system can cause:
- Degradation of motors, especially the bearings and insulation = higher costs
- Significant reduction of the lifespan of equipment due to excessive heat = higher costs
- Although you get billed for the supplied power, a large percentage of that power may be unusable = higher costs
- Unusual events such as flickering lights, alarms going off, or MCBs, MCCBs, RCDs and Earth Leakage devices tripping for no apparent reason = more downtime = higher costs

VFDs are prolific creators of harmonics in electrical systems, and as a result, most of the harmonic mitigation effort focuses on the input side and output side of a VFD. For the mitigation of harmonics on the input side (line side) of a VFD, we recommend Active Power Filters. For the mitigation of harmonics on the output side (load side) of a VSD, we recommend our AMO/AMO-SF units.

## Power losses due to low power factor

If the plant is operating with a power factor of 0,6, it means just 60% of the consumed power is used effectively and that 40% is being wasted. The 40% that is being wasted consists of reactive power. Many industrial loads have inductive characteristics bringing the power factor away from unity. The lower the power factor, the larger the apparent power drawn by the system. The increased apparent power draw causes an increased current draw. The increased current draw puts extra load on the utility system, transformers, and the plant itself. This additional current draw causes additional energy costs and limits the utilization of available grid capacity.

## Why improve the power factor?

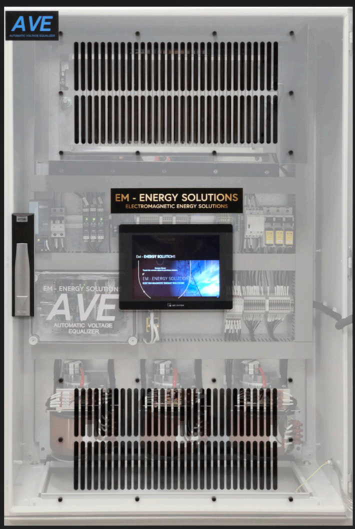
Low power factor gives penalties to you as a consumer, because of the extra strain and costs it gives the utility supplier. By improving the power factor, less current is consumed by the system and plant operator, and utility suppliers benefit from it in terms of reduced energy consumption, and costs.

## What is Power Factor Correction technology?

Conventional power factor correction technology has been based on capacitor banks for storing and supplying reactive power. These are inaccurate systems in terms of adapting to the actual reactive power consumption of the plant. Also, they are large in size and not very space-effective. EMES provides the latest high-performance technology with simple installation & commissioning. Our units have a compact design and are very space-effective.

## What will you achieve with unity power factor?

An electrical system with an unsatisfactory power factor consumes more current than a system with improved power factor for the same amount of useful power transferred. This additional consumption causes unnecessary load on the electricity distribution network. By optimizing the power factor, your electricity bill is reduced due to lower monthly demand and capacity charges. Typically payback time for our power factor technology is between 1-3 years. Taking into account the life expectancy of the power factor correction equipment and potential savings, it is a cost-effective investment.
Low power factor results in energy losses and voltage drops, which in turn contributes to excessive equipment heating and malfunction of motors and other electrical equipment. If the electrical system has reached its maximum capacity, installation of power factor correction equipment would help avoid costly upgrades by reducing the existing system demand and improving efficiency.




*AVE control cabinet*

# AVE - EMP protection

Problems related to frequency distortion are complex and is in most situations generated in the end user's power system. These issues can vary from harmonics, transients, notching, voltage sags & swells, to other power quality-related issues that alter the frequency away from the fundamental frequency.

End-users connected to weak distribution systems with high impedance and low short circuit capacity are more prone to these internally generated harmonic distortions, especially wye distribution systems containing a neutral conductor.

In terms of vast interconnected grid failure caused by frequency distortion, the cause can either be natural events like solar storms or an enemy attack (EMP). Solar storms can be hard to predict and can cause massive blackouts throughout a grid and subsequent collateral damage by damaging key power infrastructure components.

Solar storms vary in severity and direction and are a release of high amounts of magnetic energy from the sun's surface that propagates through space and collides with the earth's magnetosphere. A solar storm massive enough in scale could cause billions of dollars' worth of damage to radio communication, satellites, or power grids, that could take weeks or months to repair.

Similarly, an EMP can have the same effect as a solar flare but initiated by an enemy attack generated by a high-altitude nuclear explosion. By targeting key infrastructure components, a vast amount of populated areas can suffer power grid blackouts, causing massive havoc. The nuclear explosion creates a high-frequency electromagnetic field within the vicinity of the detonation point. This field can be strong enough to produce transient voltage spikes of thousands of kilovolts. These transients can severely damage or even destroy transformers, generators, radios, radars, computers, and other electrical equipment.

## EMP Theory

These EMP induced voltage spikes are not unlike the effects of a lightning strike, and computer based processing, communication, automotive, communication, electronic flight control, satellite, and warfare communication systems are all vulnerable to the EMP effect. Modern technology is even more vulnerable to EMP attack since solid-state equipment used today is more susceptible to damage by large, brief voltage and current surges compared to older vacuum-tube based equipment.

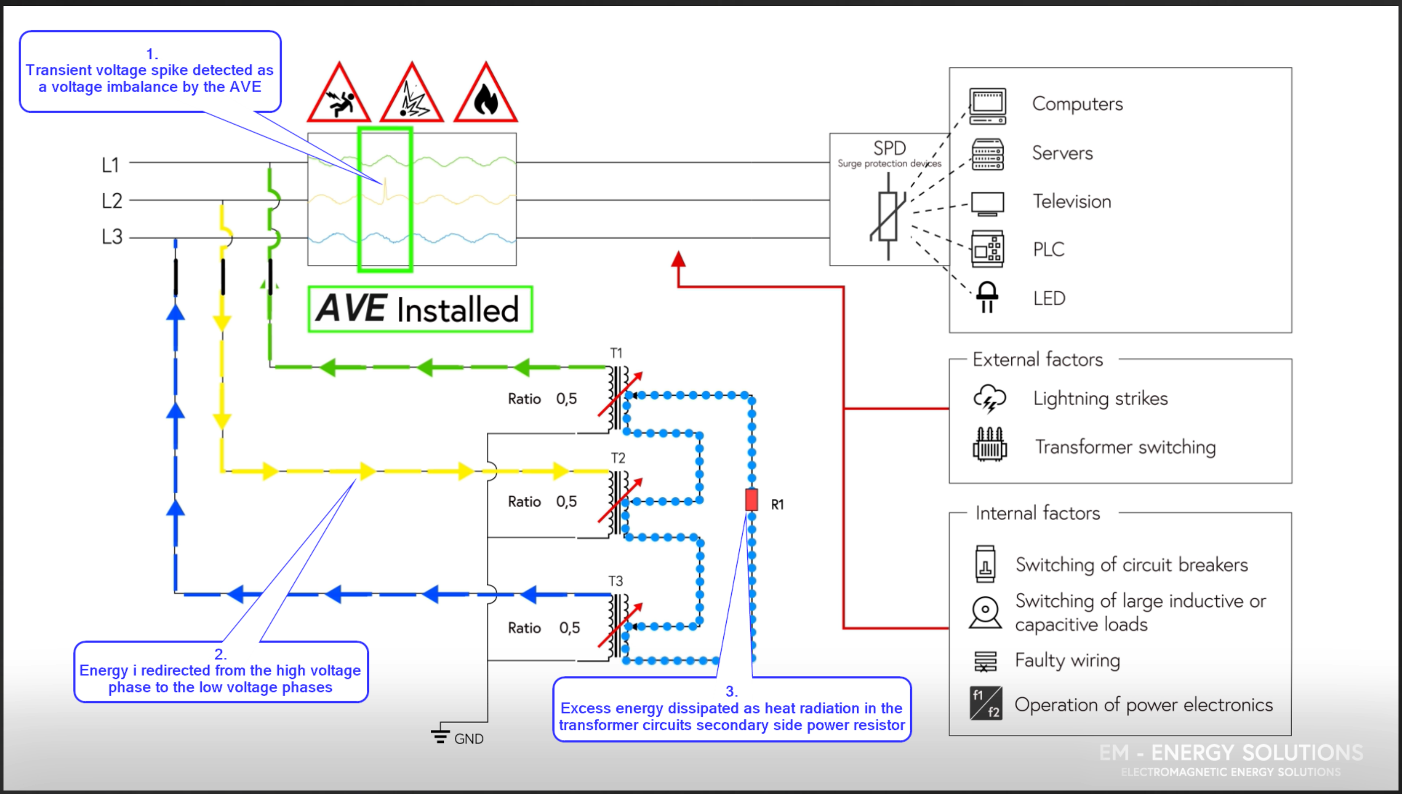
In terms of military equipment, which contains a vast amount of electronic equipment, an EMP attack can severely reduce their functionality or even destroy them without sufficient safety measures.

The AVE mitigates these high-frequency disturbances, which present themselves as zero sequence components in the power grid. The AVE filters the harmonic components with the square of the order of the harmonic. This square factor implies that a 7th order harmonic is filtered 49 times. The unique design of the AVE makes it capable of reducing harmonic components from the 2nd order up to very large orders by merely beating the noise against itself. The AVE is not limited to specific frequencies or amplitudes, unlike today's technology for mitigating high-frequency noise or harmonics, like passive and active filtering systems.

## AVE transient mitigation

AVE mitigates harmonics with the speed of the electromagnetic field, which makes it extremely useful in mitigating EMP induced transient, which often lasts for only a few microseconds. The figure below describes how the AVE mitigates transient voltage spikes. A voltage imbalance can present itself as a transient voltage spike, zero-sequence harmonic, steady-state voltage imbalance, notching, or any other power-quality related event that alters the phase to ground voltage. In theory, the events can occur at many different frequencies up to the EMP frequency range area.

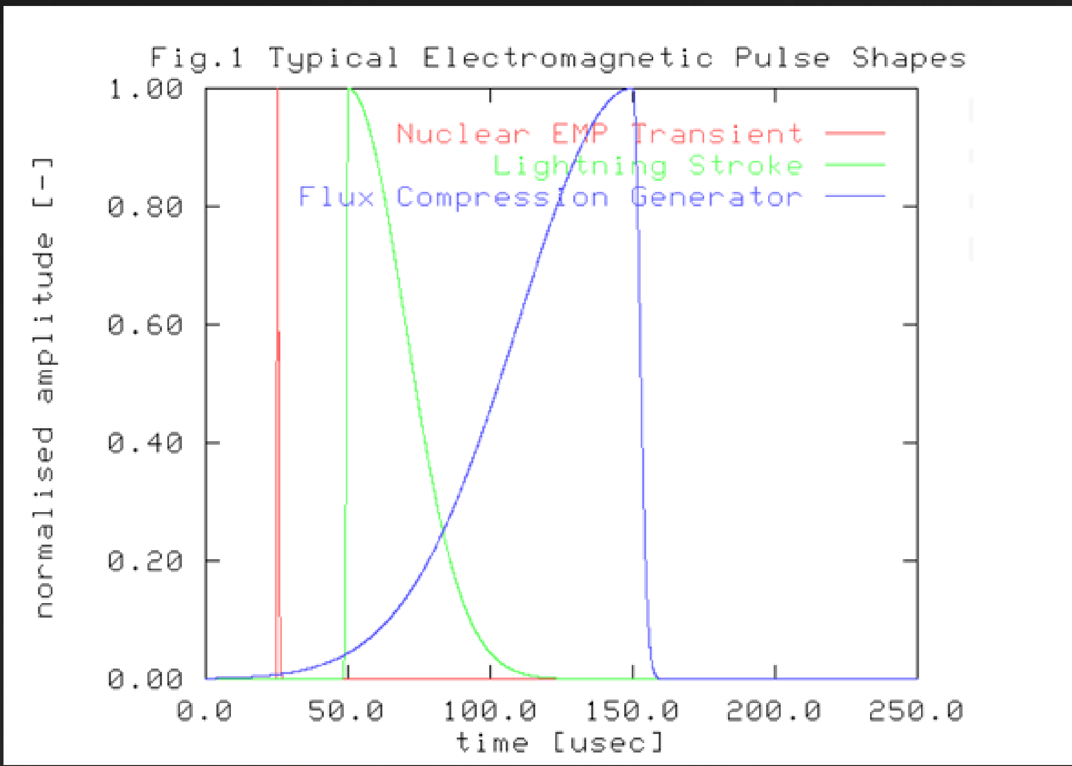
A voltage potential is set up across the circuit's secondary side steel grid resistor when an imbalance in the voltage occurs. This potential means a current starts to flow, and energy from the transient dissipates in the steel grid resistor. Also, energy is redirected back into the low voltage phase to even out the phase to ground voltages. The amount of energy redirected back into the low voltage phases is dependent on system impedance.




*The figure visualises how the AVE mitigates transient voltage spikes*

## EMP Pulse

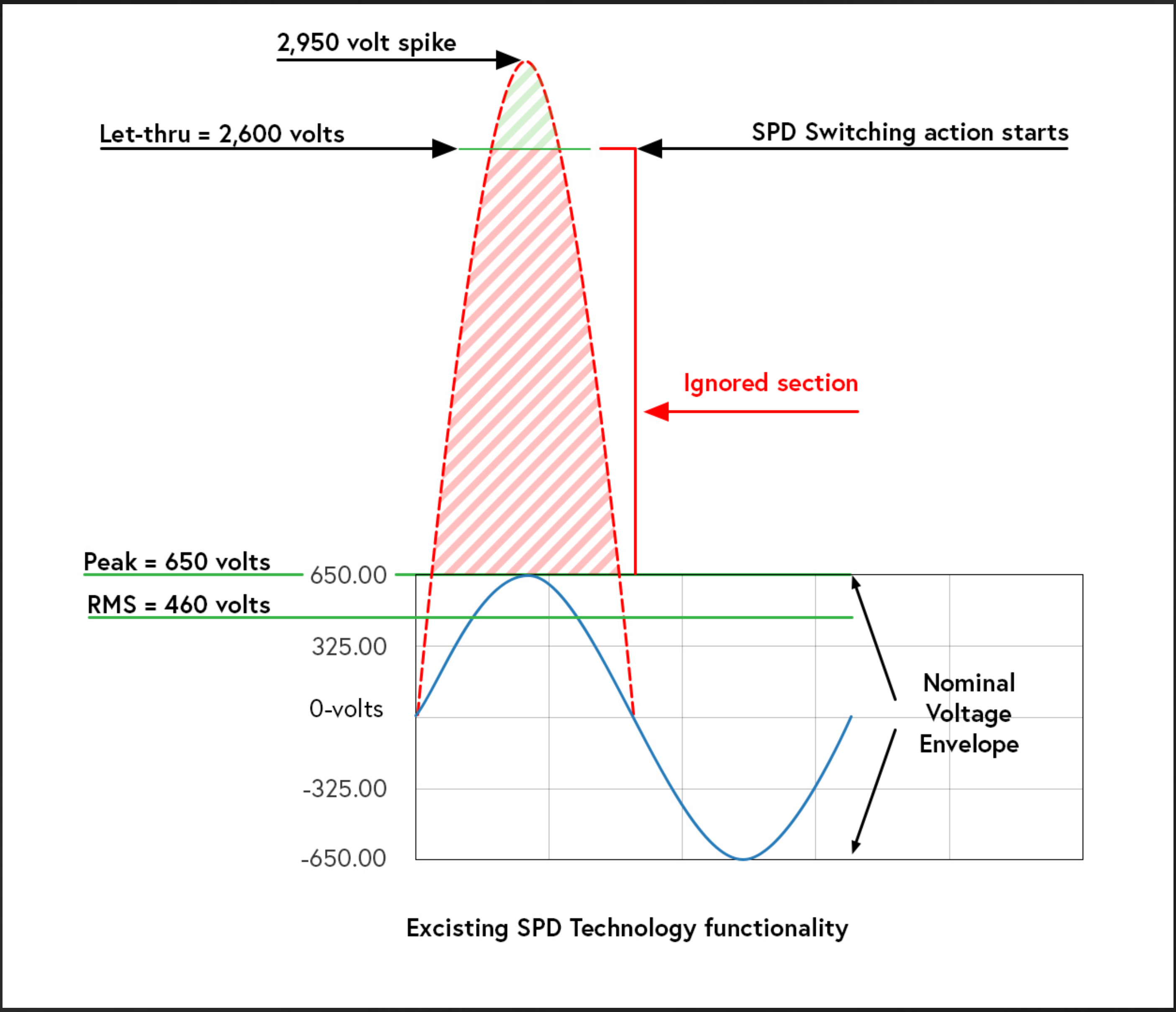
If we look at typical electromagnetic pulse shapes, we see that a nuclear EMP transient is exceptionally brief in time, lasting only a few microseconds. The figure below clearly shows how fast an EMP transient is compared to a lightning strike or flux compression transient.




*Timespan and amplitude of EMP, ligthning and flux compression transient event*

## MOV based technology

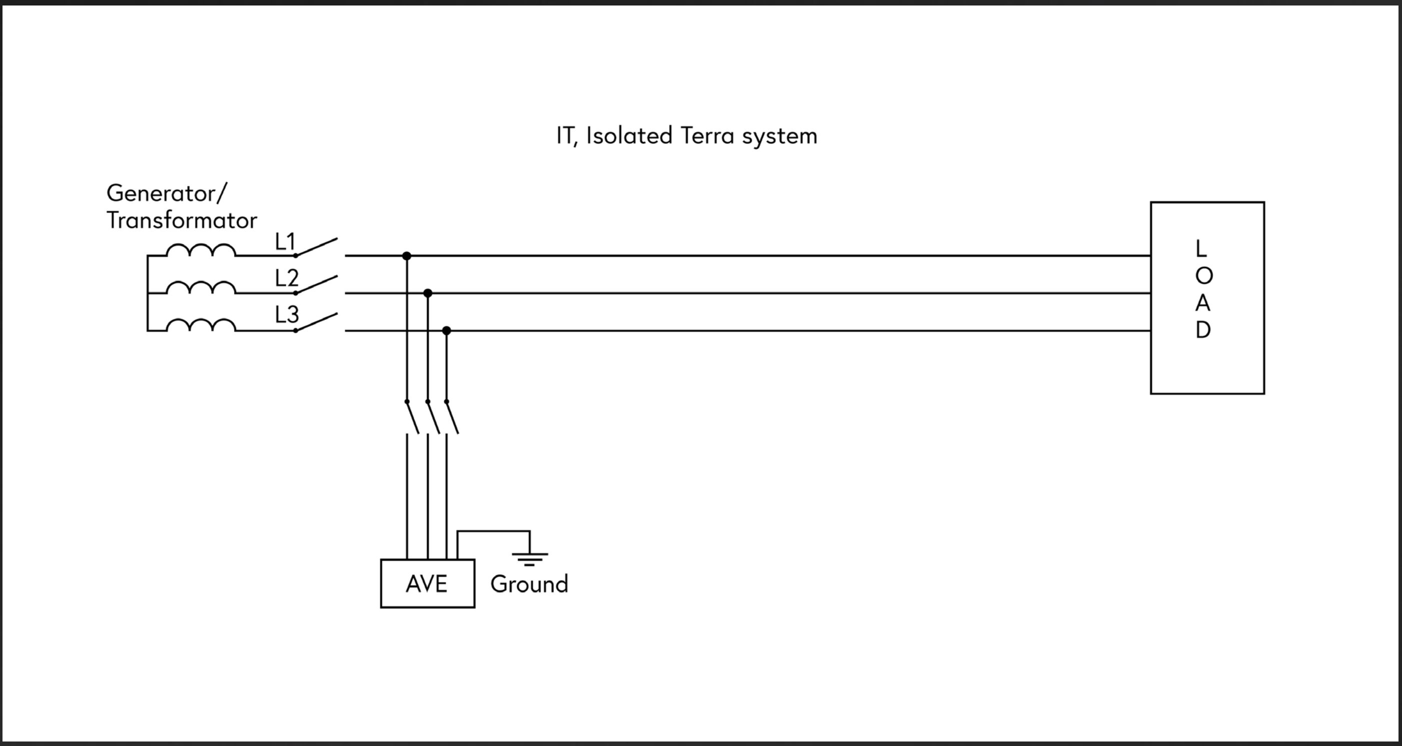
Conventional protection technology based on metal oxide varistors often referred to as surge protection devices, better known as SPDs are very sensitive to high voltage transients, and are easily damaged. Also, they are too slow to react and allow voltages 4-5 times the nominal voltage rating into the equipment they are meant to protect. The graph below shows how semiconductor protection technology is too slow to stop transient voltages before they can do damage to the equipment.




*MOV based technology allows 4-5 times nominal voltage onto equipment it is meant to protect*

## AVE installation location

To protect your power system from all of the power quality related problems mentioned in this document, one AVE per distribution system is sufficient. The AVE is placed on the secondary side of the distribution transformer, with no more than 15 meters of wire between connection points. The connection diagram below shows how the AVE is connected to a TN-C-S distribution system.




*AVE connects in parallel on distribution transfomers secondary side*

# Automatic Voltage Equalizer


*AVE control cabinet*


## AVE - Automatic Voltage Euqalizer

EM Energy Solutions’ revolutionary patented technology for voltage stabilizing ensures an optimal phase voltage balance on both grounded and ungrounded distribution systems.
AVE is an EHRGS (Electromagnetic High Resistance Grounding System) that reacts to any voltage imbalance and equalizes the voltage between all phases with the speed of the current.
By constantly logging the supply transformers’ phase to ground voltages and using this to control single-phase variable or multitap transformers, one can achieve optimal phase voltage balance. A state-of-the-art controller controls the variable transformers. The system has an operator panel for control functions and display of operational status together with a comprehensive alarm system that will notify operators about various events like ground faults, transients, and high harmonic distortions.
AVE serves as a surge suppressor, voltage regulator, and zero-sequence harmonic filter. It is easy to install and is connected as close as possible to the transformer secondary side. It will protect all downstream equipment, thus making other power quality technology such as MOV based devices unnecessary and obsolete. By having the AVE installed, the result will be substantial cost savings and increased electrical safety.

### Key features

- Balanced Voltage; AVE will keep the voltage balanced and phase vectors perfectly 120 degrees offset
- Mitigates transient events; The larger the transient, the more AVE will counteract it
- Reduction in Zero-Sequence harmonics
- Reduction in energy consumption
- Increased plant safety
- Simple and fast installation
- Arc-Flash mitigation; AVE will reduce Arc-Flash potential by more than 85 percent
- EMP protection
- Reduced CO2 emissions

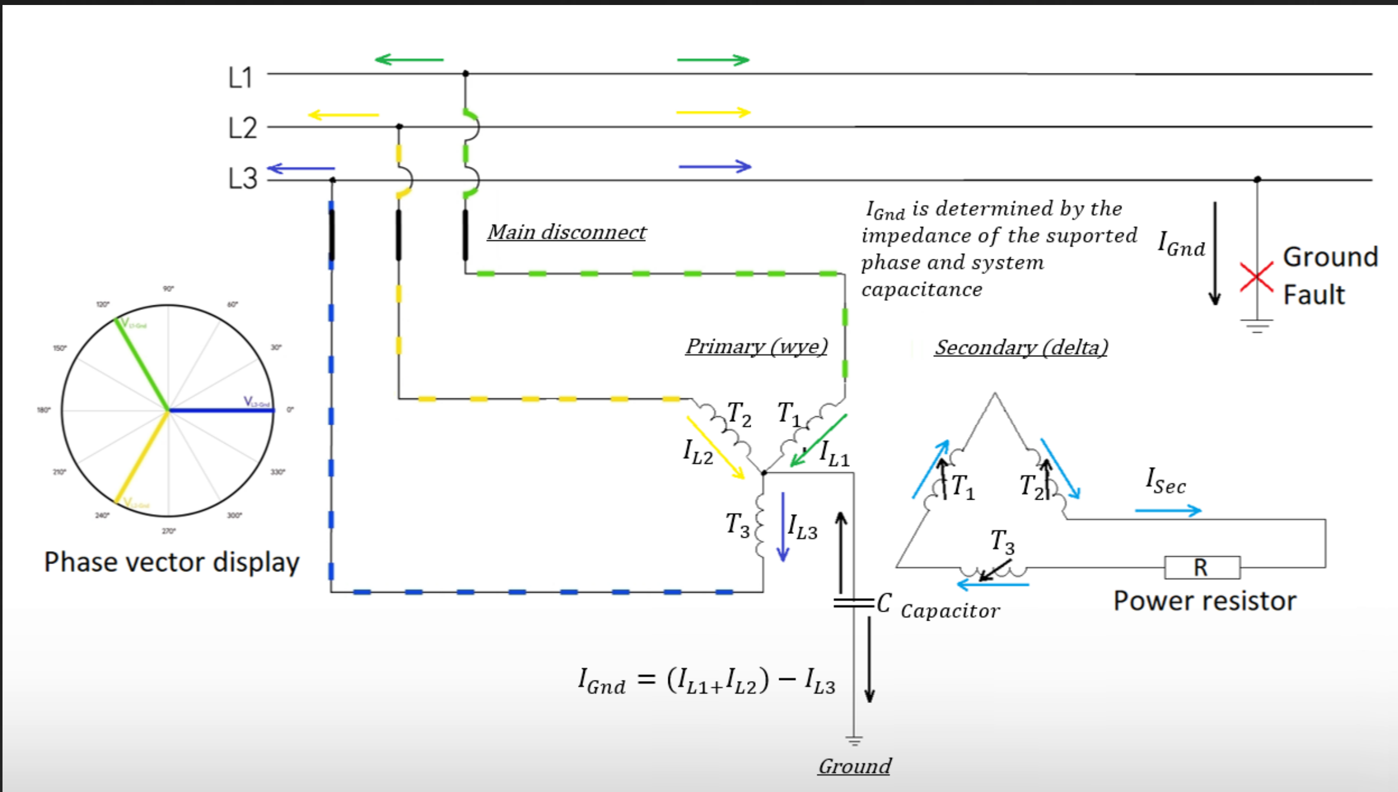



*Diagram showing working principle of the AVE*

Here you can see a simplified schematic of AVE's main circuit. The variable transformers are connected in wye configuration on the primary side with neutral connected to ground, while the secondary sides of the variable transformers are connected in delta-series with a stainless-steel grid resistor. The schematic visualizes the current flow in the AVE during a ground fault. The working principle will be the same for any other voltage imbalance related problem.

If we look at the phase vector display, we see that the voltages are ideally 120 degrees offset during the fault. The two healthy phases (L1 and L2) support the low voltage/faulted phase (L3). Energy is redirected from the healthy phases to the low voltage phase through the transformer circuits' secondary side and will cause an increase in voltage on the low voltage phase.
During the fault, all phase currents will be in phase, making us able to use simple mathematics to calculate the ground current (See equation for I_gnd in the schematic).

# Automatic Voltage Equalizer



*AVE Fixed control cabinet*

## AVE - Fixed

AVE Fixed is a more cost friendly solution but can still pack a punch. It uses fixed high-quality isolation transformers with variable tapping regulated by a controller. It will make an instantaneous correction to any phase voltage imbalance. Any steady-state voltage imbalances will be corrected with the variable tapping functionality, making it capable of correcting 100% voltage imbalances (fault condition).
Due to its robust design transformers, the unit requires very little maintenance. It comes with an integrated power quality meter with access through a remote web server and cloud solution. Control and status information from the unit can also be obtained from the local HMI panel.

| | |
|---|---|
| **Voltage class [Vac]** | 250/480/690 |
| **kVA rating [kVA]** | 1200/3000/6000 |
| **Current rating $I_{sec}$ [A]** | 1000-13800 |
| **Power quality meter** | ✓ |
| **Web interface** | ✓ |
| **Cloud solution** | Optional |
| **Floor mounting** | Optional |
| **Weight [lbs/kg]** | 364/165 |
| **Size [Inch/mm] w x h x d** | 31,5×47,2×15,8/800x1200x400 |
| **Distribution system** | 3ph Grounded/Ungrounded |
| **Display size [Inch/mm]** | 10/254 |


*AVE mini control cabinet*

# AVE - Mini

AVE-mini is a more cost and space-effective solution for lower range transformers between 400 to 1200 kVA. The same electromagnetic principles as used on the standard AVE are applied. The compact design reduces the challenge in terms of available space. It is fitted with high-quality single-phase transformers utilizing controller regulated variable tapping to achieve voltage balancing to a high degree of accuracy.

The unit has the integrated power quality meter as optional. The operator can obtain necessary system information from the HMI panel located in the front door. AVE-mini also comes in single phase solutions, making it suitable for smaller housing areas.

| | |
|---|---|
| **Voltage class [Vac]** | 250/480 |
| **kVA rating [kVA]** | 400/800/1200 |
| **Current rating $I_{sec}$ [A]** | 480-1400 |
| **Power quality meter** | Optional |
| **Web interface** | Optional |
| **Cloud solution** | Optional |
| **Floor mounting** | Optional |
| **Weight [lbs/kg]** | 198/90 |
| **Size [Inch/mm] w x h x d** | 23,6×39,37×15,8/600x1000x400 |
| **Distribution system** | 1ph/3ph Grounded/Ungrounded |
| **Display size [Inch/mm]** | 4,3/109 |


*AVE High Voltage Control Cabinet*

# AVE - High Voltage

AVE High Voltage is designed for voltages up to 15000 volts. The unit is fitted with single-phase isolation transformers with controller regulated variable tapping. The AVE High Voltage will be custom sized for each installation, ensuring optimal sizing for the specific transformer energy rating and voltage class.
Due to its robust design, the unit requires very little maintenance. When installed in front of a smaller sized transformer, it will protect downstream transformers from external events like lightning strikes, short circuits, and phase voltage imbalances.

| | |
|---|---|
| **Voltage class [Vac]** | 1500/5000/7500/15000 |
| **kVA rating [kVA]** | - |
| **Current rating $I_{sec}$ [A]** | - |
| **Power quality meter** | ✓ |
| **Web interface** | ✓ |
| **Cloud solution** | ✓ |
| **Floor mounting** | ✓ |
| **Weight [lbs/kg]** | - |
| **Size [Inch/mm] w x h x d** | - |
| **Distribution system** | 3ph Grounded/Ungrounded |
| **Display size [Inch/mm]** | 10/254 |

*AMO in conjunction with VFD and motor*

# AMO - Automatic Motor Optimizer

The Automatic Motor Optimizer is designed for protection of frequency-controlled motors. Harmonics and voltage spikes from frequency drives create a wide range of problems like reduced motor efficiency and drastically shortened motor life expectancy. These problems also limit the allowed cable length between motor and VFD.
With the AMO installed, a significantly increased cable length is allowed between VFD and motor. The AMO extends motor life by balancing phase to ground voltages, allowing the drives and control system to operate reliably. The AMO is also suitable for use on smaller-scale distribution transformers up to 400kVA. In situations where available space for installation is a challenge, and the transformer sizes are small, the AMO is the perfect match.

| | |
|---|---|
| **Voltage class [Vac]** | 250/480/690 |
| **kVA rating [kVA]** | 100//200/400 |
| **Current rating $I_{sec}$ [A]** | 100-920 |
| **Power quality meter** | x |
| **Web interface** | x |
| **Cloud solution** | x |
| **Floor mounting** | Optional |
| **Weight [lbs/kg]** | - |
| **Size [Inch/mm] w x h x d** | - |
| **Distribution system** | 3ph Grounded/Ungrounded/VFD |
| **Display size [Inch/mm]** | - |

Hybrid Control Cabinet


AVE Control Cabinet

# AVE - Hybrid

AVE Hybrid is the ultimate solution to any power quality related problem. Combining the AVE technology with our active units ensures optimal power quality in your plant. The active part of the hybrid solution ensures the removal of system harmonics, load balancing, and a power factor close to one. The AVE part mitigates fast switch transients and protects the installation against voltage surges. The unit also reduces voltage dips and its effects together with reducing zero-sequence harmonics, ensuring a clean and stable ground reference, which again will reduce the risk of control system lockups. The AVE - Hybrid gives 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.

## Key Features

- The ultimate solution to ensure an optimal power quality by controlling both current and voltage.
- Provides Reactive Power (PFC) & Load Balancing
- Transient and Surge suppression
- Harmonics Compensation Capability: Compensates 2nd to 50th harmonic order or simultaneous compensation of all 50 harmonic orders.
- Algorithm Intelligence: Intelligent technology that integrates both FFT and Dynamic Compensation modes, customized to client's requirements.
- Simple Installation & Commissioning ('Plug and Play')
- Unique 3-level topology based on a zero voltage transformation design and incorporating high-frequency inductor technology results in more than 97% efficiency.
- User-Friendly Interface and Monitoring
- Very easy to operate. Online monitoring and programming available. Presents information in terms of numerical data, waveform analysis, etc.
- Modular, Compact Size and Light Weight
- Can be wall mounted and installed in small spaces.
- Standards: IEC61000 / IEC60146 / EN55011 EN50091 / IEEE519

AVE HYBRID

# AVE - Hybrid

## Combined functions AVE / Active Units

By combining the AVE and Active unit technology, the AVE-Hybrid is capable of controlling both current and voltage, making it capable of addressing almost all known power quality related problems we see today.

### AVE-Technology

The AVE is an EHRGS (Electromagnetic High Resistance Grounding System) that reacts to any voltage imbalance and equalizes the voltage between all phases with the speed of the current.
By constantly logging the supply transformers’ phase to ground voltages and using this to control single-phase variable or multitap transformers, one can achieve optimal phase voltage balance. A state-of-the-art controller controls the variable transformers. The system has an operator panel for control functions and display of operational status together with a comprehensive alarm system that notifies operators about various events like ground faults, transients, and high harmonic distortions.

AVE serves as a surge suppressor, voltage regulator, and harmonic filter. It is easy to install and is connected as close as possible to the transformer secondary side. It protects all downstream equipment, thus making other power quality technology, such as MOV based devices unnecessary and obsolete. By having the AVE installed, the result is substantial cost savings and increased electrical safety.

### Key features AVE

- Balanced Voltage; AVE keeps the voltage balanced and phase vectors 120 degrees offset
- Mitigates transient events; The more extensive the transient, the more AVE counteracts it
- Reduction in Zero-Sequence harmonics
- Reduction in energy consumption
- Increased plant safety
- Simple and fast installation
- Arc-Flash mitigation; AVE reduces Arc-Flash potential by more than 85 percent
- EMP protection


*AVE control cabinet*

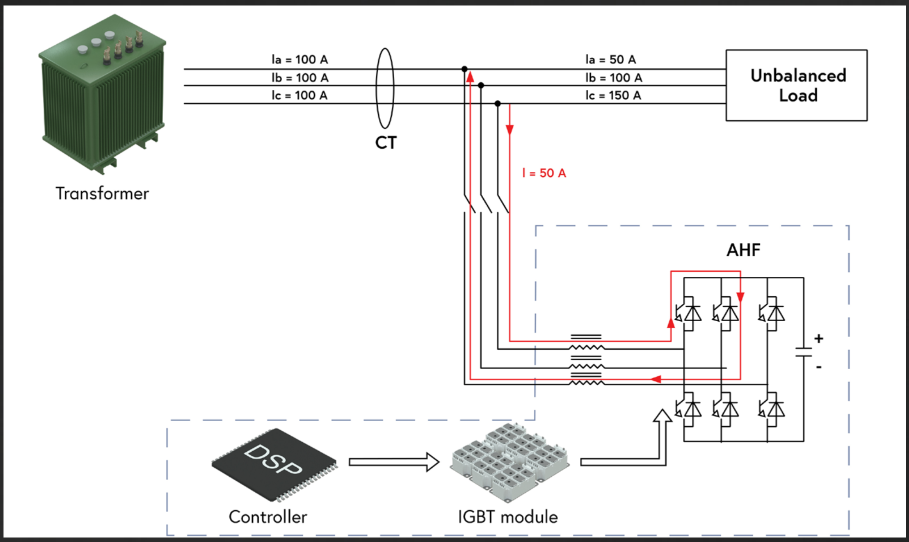
## Combined functions AVE / Active Units

### Active unit technology

The active part of the AVE-Hybrid either contains APFs, SVGs, ASVGs, or a combination of these units, enabling a tailor-made solution for optimal performance and cost-effectiveness.

EMES Active units are the ultimate answer to power quality problems caused by waveform distortion, low power factor, voltage fluctuations, and load unbalance. It is a high performance, compact, flexible, modular, and cost-effective solution that provides an instantaneous and effective response to power quality problems in both low and high voltage power systems. The unit connects in parallel with the power grid and detects the harmonic components with the help of current transformers. An advanced algorithm generates a reverse-phase compensation current, which by the help of IGBTs are injected into the power system to cancel out the harmonic distortion.

The EMES Active Units contains an algorithm that balances the load current on the individual phase by redirecting excessive load current back into the phases with less load. This function keeps a balanced loading on the supply side. The unit uses excess capacity for additional reactive power compensation and power factor improvement. Configurable priority mode is also available, which enables the operator to choose if the remaining capacity is used for load balancing or power factor improvement.




*Load balancing principle SVG*

### Key functions APF

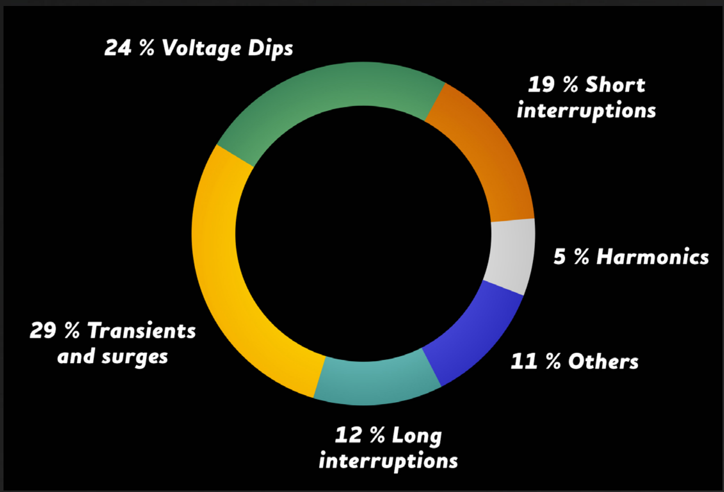
- Elimination of harmonics
- Lagging or leading power factor correction
- Voltage sags & swells reduction.
- Voltage fluctuations (flicker) mitigation.
- Load balancing in three-phase systems.
- Selectable harmonic mitigation

### Customer benefits

- Energy savings
- Higher productivity
- Reliable operation at reduced maintenance costs
- Longer lifetime of electrical and process equipment
- Additional capacity in an existing electrical network
- Compliance with IEEE 519, G5/4, IEC 61000 3-2, 3-4 or any other power quality standard
- Quick return on investment

## Benefits

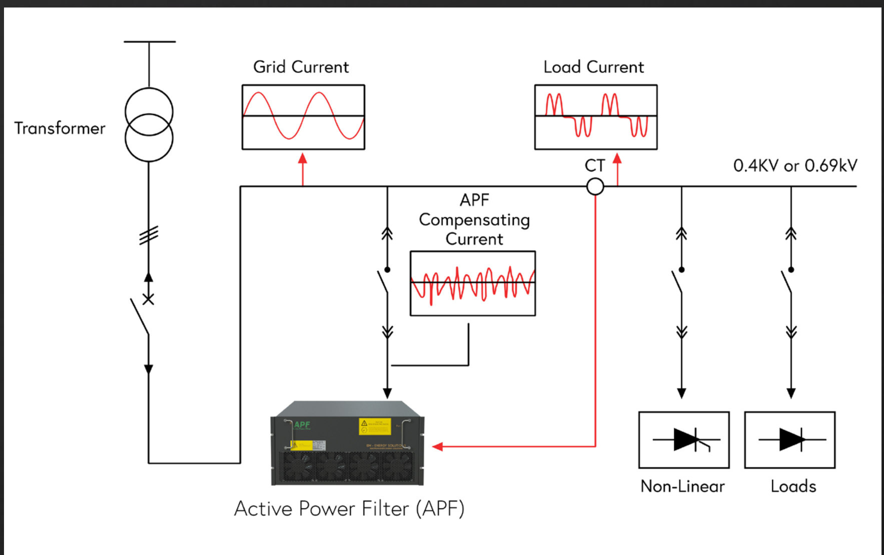
According to a European study made by Manson & Roman Targosz, the total cost of bad power quality in Europe alone is 150B euros per year. The diagram below displays the various causes and their part of the total cost.




29% Transients and surges
24% Voltage dips
19% Short interruptions
5% Harmonics
11% Others
12% Long interruptions

*Study done by Manson & Roman Targoz estimates 150B euros in power quality costs per year in Europe alone*

By having the AVE Hybrid installed, you can protect your plant against more than 88% of these problems and subsequent costs (AVE Hybrid AVC). Depending on the power quality situation, the hybrid solution can be delivered with either APF, SVG, ASVG or a capacitor bank in conjunction with an APF solution.




*APF Operational Principle*

*APF Control Cabinet*

## Standard hybrid models

Here is a brief summary of the various standard hybrid models available. Other variants are also available based on what will be the optimal solution for your plant.

### AVE Hybrid SVGC

The AVE Hybrid Static VAR Generator Capacitor is a more cost-effective solution. The cost reduction is achieved by using a capacitor bank to take the central portion of the VAr compensation. At the same time, the active filter compensates for the intermediate steps and the inductive reactive power. Also, the active filter works as a load balancer and a harmonic filter. The integrated AVE technology protects against transient voltage surges and dips together with zero-sequence harmonics.
In combination with our revolutionary AVE technology, this is an all-in-one, cost-effective solution for optimized power quality and:

- Cost-effective and fast power factor correction
- Harmonic current and zero-sequence harmonic voltage mitigation
- Load balancing
- Voltage surges and dips protection

## AVE Hybrid AVC RTS/DVR

The AVE Hybrid Active Voltage Conditioner unit combines filter technology, AVE hybrid technology, UPS technology, or voltage regulator technology into one package. The unit comes with two options in terms of blackout prevention; either an energy storage system that allows for higher power outage ride-through times (AVC RTS) or with voltage vector control for smaller voltage ride-through times (AVC DVR).

The AVC DVR is a more cost-effective solution than the AVC RTS but still compensates for up to 40% voltage variation for up to 30 seconds. The RTS is based on thyristor controlled ultra-capacitor banks with superior power density, cycle life, and life-expectancy for higher ride-through capacity. Both units protect your installation from power outages, interruptions, and voltage dips, while the AVE and filter technology protect against transient voltage surges, harmonic current distortion, zero-sequence voltage harmonics, and flicker. The units also perform load balancing.

The Hybrid AVC has the possibility for two operational modes (optional). During a stable power supply, it operates in power quality mode performing harmonic current mitigation, load balancing, and flicker mitigation. When a power outage or voltage sag is detected, the unit switches from power quality mode to power supply mode, securing power to the plant and preventing the effects of the voltage sag or power outage. The units are available in load capacities between 150kVA to 3000kVA, with higher ratings available on request.

With AVC RTS hybrid installed, the power system can ride through power outages for up to 3 seconds as standard. The 3-second limit is based on common industry standard, but other compensating time frames are possible based on system load and capacity of the energy storage system. The unit has high efficiency due to its intelligent switchover between the operation modes and provides substantial cost savings compared to conventional technology. The AVE technology will, at all times, protect against transient voltage surges, zero-sequence harmonics, and is not affected by the operational mode.

Compared to the AVC RTS, the AVC DVR is not relying on capacitors to counteract voltage sags & Swells. The lack of capacitors makes this is a more cost-effective solution, but it still compensates for up to 40% voltage variation for up to 30 seconds, which prevents the effect of sags & swells in most cases. During regular operation, the AVC DVR optimizes the output power. During a voltage sag, the AVC boosts the output voltage by altering the voltage vectors to compensate for the reduced voltage.

## Network Analyzer and Remote Access

The AVE - Hybrid is equipped with one of the most advanced power quality analyzers on the market today. Data from the unit is reachable through a SCADA network or remotely through a webserver. There is also a local HMI display for both AVE and active unit for"in the field" troubleshooting and power analysis.

AVE-Hybrid is standard equipped with industrial Modbus TCP/IP communication protocol wired or wireless for seamless integration into any existing SCADA system. Other communication protocols are also available HTTP/HTTPs Post, FTP, sFTP, BACnet-IP, DNP3 V2, SNMP V3, IEC61850 2nd edition, SMTP.

### WEBSERVER

The PQA`S Ethernet module supports HTTP protocol and has a Web Server function making the PQA accessible through Ethernet or 4G router anytime from anywhere. (4G Router is optional) Fully encrypted and authentic data communication between PQA and data server. Leading HTTP web security standard TLS v1.2 and SSL HTTPS encryption. WPA or WPA2 enterprise security protocol authenticates the WIFI communication. The PQA also has inbuilt storage for realtime energy logs, waveform capture, and data logs.

### WAVEFORM & FAULT RECORDER

The PQA (Power Quality Analyzer) allows trigger point waveform recording. This function enables operators to go back and look at any situation that has taken place to understand the sequence of events in the power system. The meter supports a waveform capture function that allows users to capture and record 10 cycles before and after the triggering point, whether it be a voltage sag, swell, or over current. The waveform log on the web interface allows users to view these waveforms whenever a power quality event has occurred. The log displays a table that includes waveform files, timestamps, and file sizes. The waveform file name includes the timestamp when the event occurred as well as the parameter name/event name that triggered the power quality event.


*Trend log taken from Power Quality Analyser*

## Network Analyzer and Remote Access

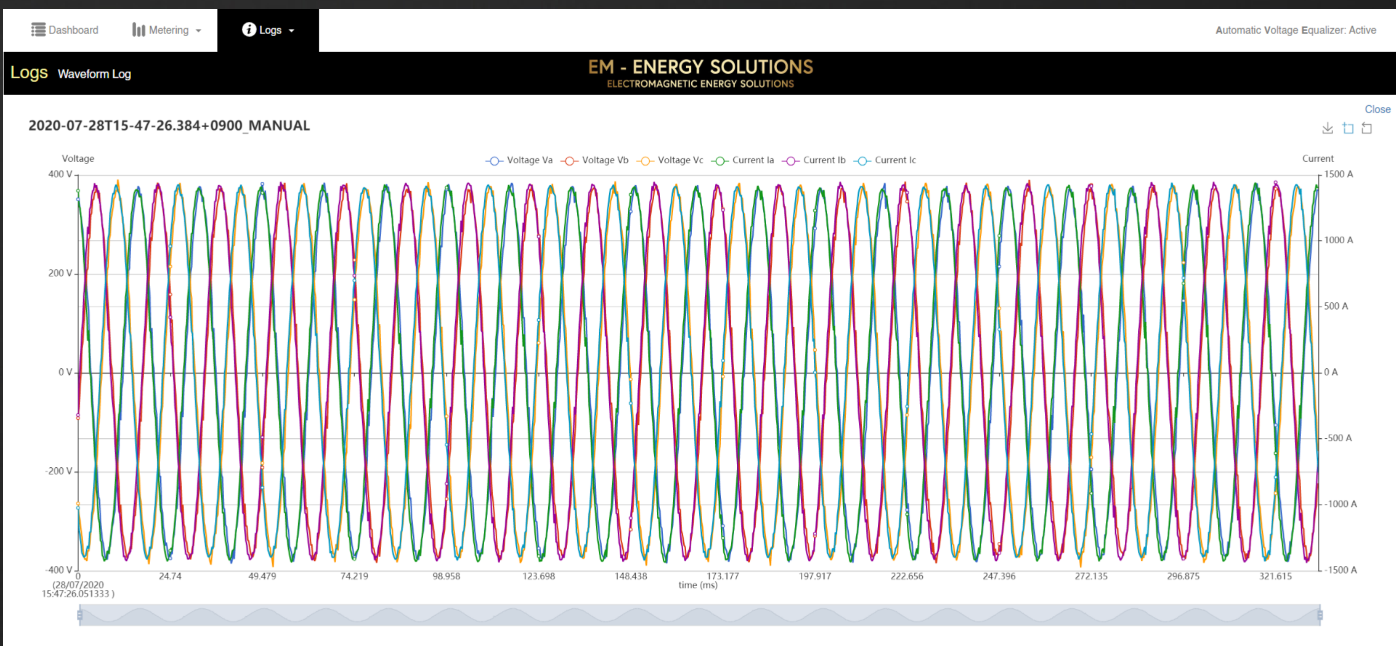
### Functionality

- Harmonic mitigation
- Transient and Surge protection
- Load balancing
- Flicker mitigation
- Leading and lagging power factor correction
- Reduction of voltage sags & Swells
- Ground fault detection
- Reduce zero-sequence harmonics
- Prevent Arc-Flash
- Prevent phase voltage imbalance & instability
- Prevent arcing ground faults
- Provide a good and stable ground reference for power system stability to ensure optimal operation of control systems without interruption.

### Customer benefits

- Energy savings
- Higher productivity
- Reliable operation and reduced maintenance costs
- Extended lifetime on electrical equipment
- Higher utilization of available capacity
- Compliance with IEEE 519, G5/4, IEC 61000 3-2, 3-4 or any other power quality standards, and recommendations
- Quick return on investment
- Increased revenue
- Increased plant safety


*EMES Power Quality Analyzer*




*Waveform log of voltage and current taken from EMES PQA*


*APF Module*

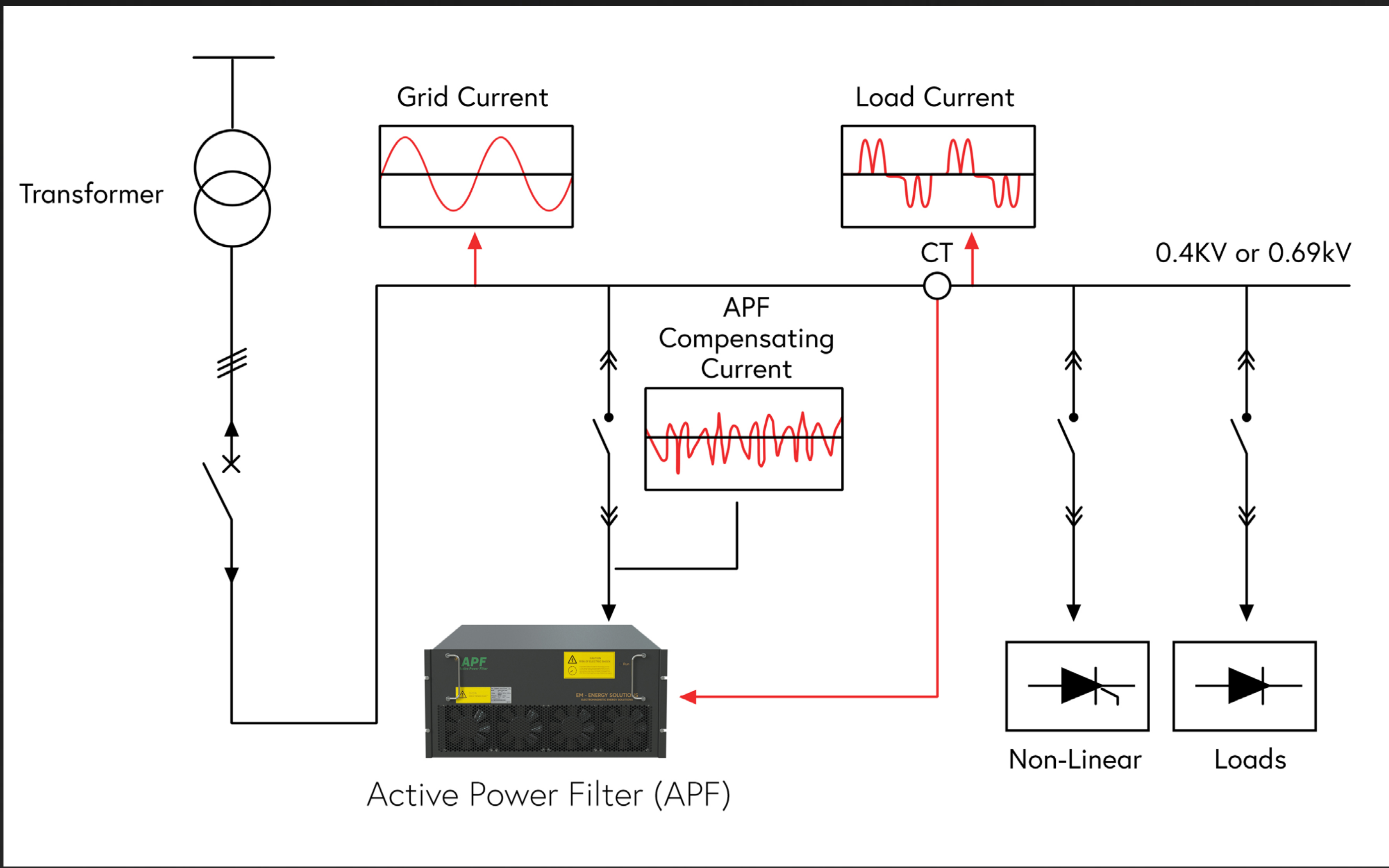
# APF - Active Power Filter

EMES Active Power Filter is the ultimate answer to power quality problems caused by waveform distortion, low power factor, voltage fluctuations, and load unbalance. It is a high performance, compact, flexible, modular, and cost-effective solution that provides an instantaneous and effective response to power quality problems in both low and high voltage power systems. The unit connects in parallel with the power grid and detects the harmonic components with the help of current transformers. An advanced algorithm generates a reverse-phase compensation current, which by the help of IGBTs is injected into the power system to cancel out the harmonic distortion.

## Key features

- Mitigates harmonic distortion and keeps THDi <5%
- Superb power factor correction capabilities maintaining a power factor of unity if required.
- Compensates both lagging and leading power factor.
- Dynamic step-less compensation
- Profiles the load and operates with a response speed of <15ms.
- No possibility of over-compensation or under-compensation, injects only the kVAR that is needed in that moment
- Corrects load imbalance
- Not affected by resonance
- 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’)
- Comply with Standards: IEC61000 / IEC60146 / EN55011 EN50091 / IEEE519

# Harmonic Filtering




*APF Operational Principle*


*APF Control Cabinet*


*IP54 APF Control Cabinet*

## Key Features

Current transducers measure the total current draw, including current harmonics from the transformer. The data is transmitted to an internal DSP and CPU, which contains an advanced FFT algorithm that extracts the various harmonic current components from the fundamental current. The IGBT controller uses the data to produce a PWM signal with a switching frequency of up to 35kHz. This data is used in the IGBT controller to produce a PWM signal with a switching frequency of up to 35kHz. In realtime, internal current transducers register the output current and feed the signal back to the DSP, and the regulator performs corrections to optimize the harmonic mitigation.

### ULTRA-COMPACT FOOTPRINT

EMES' innovative three-level inverter technology is the foundation of every APF unit. The modular three-level inverter uses 12 IGBTs to reduce the switching frequency losses and to permit higher overall switching speed. The three-level inverter technology requires small filter components in comparison with conventional technology, which provides for an ultra-compact, modular design with a resulting improved waveform, low levels of harmonic distortion, and electromagnetic interference. Multiple EMES APFs can be configured to operate together by simply connecting the external CTs in series through all the units.

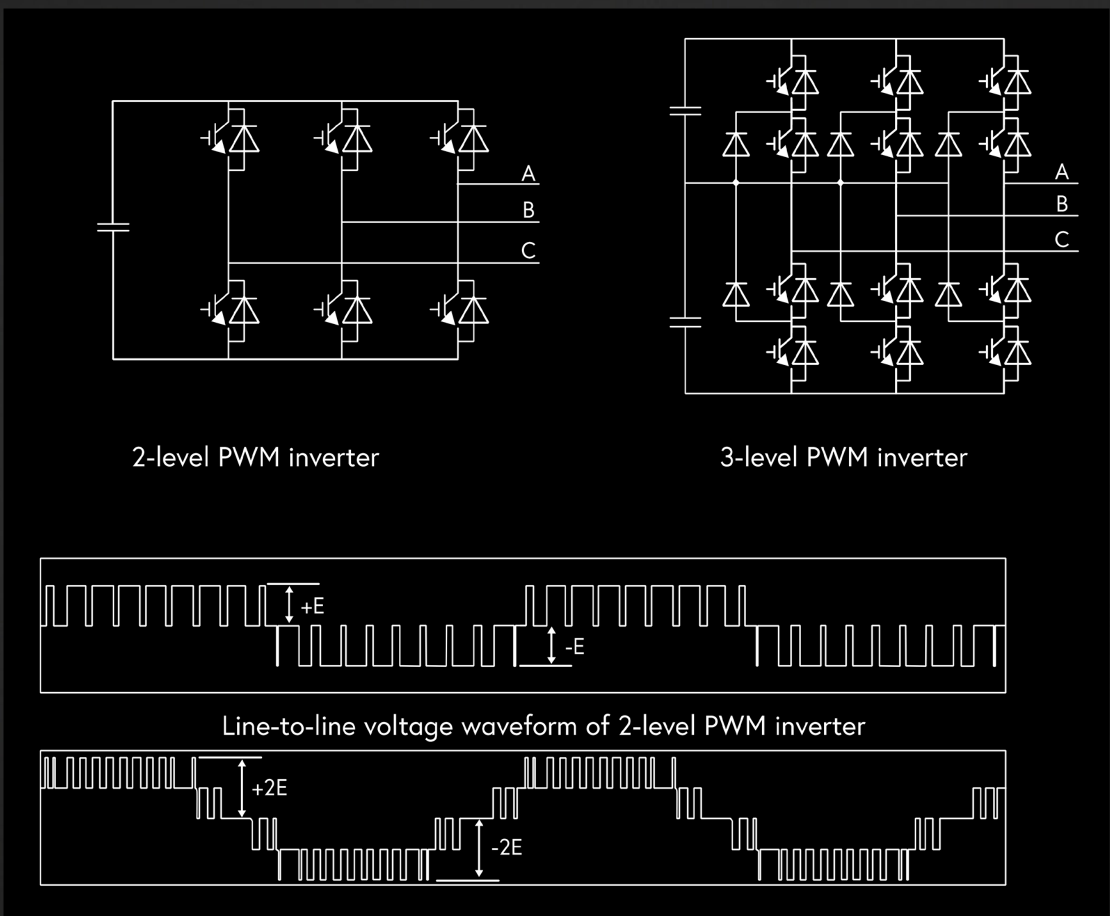
### Protection Features

- Internal short-circuit protection
- Temperature monitoring
- Over-voltage protection
- Under-voltage protection
- Abnormal frequency protection
- Output overload protection
- Busbar over-voltage protection
- CT installation detection
- Inverter bridge abnormal operation protection
- Inverter over-current protection
- Over-compensation capacity
- Component capacity redundancy
- Fan fault protection
- Fuse protection

## Intelligent System

EMES APF provides a real-time response with a constant correction to plant harmonics. The virtually instantaneous response ensures that your plant's power quality is at the highest possible level, even with varying harmonic loads.

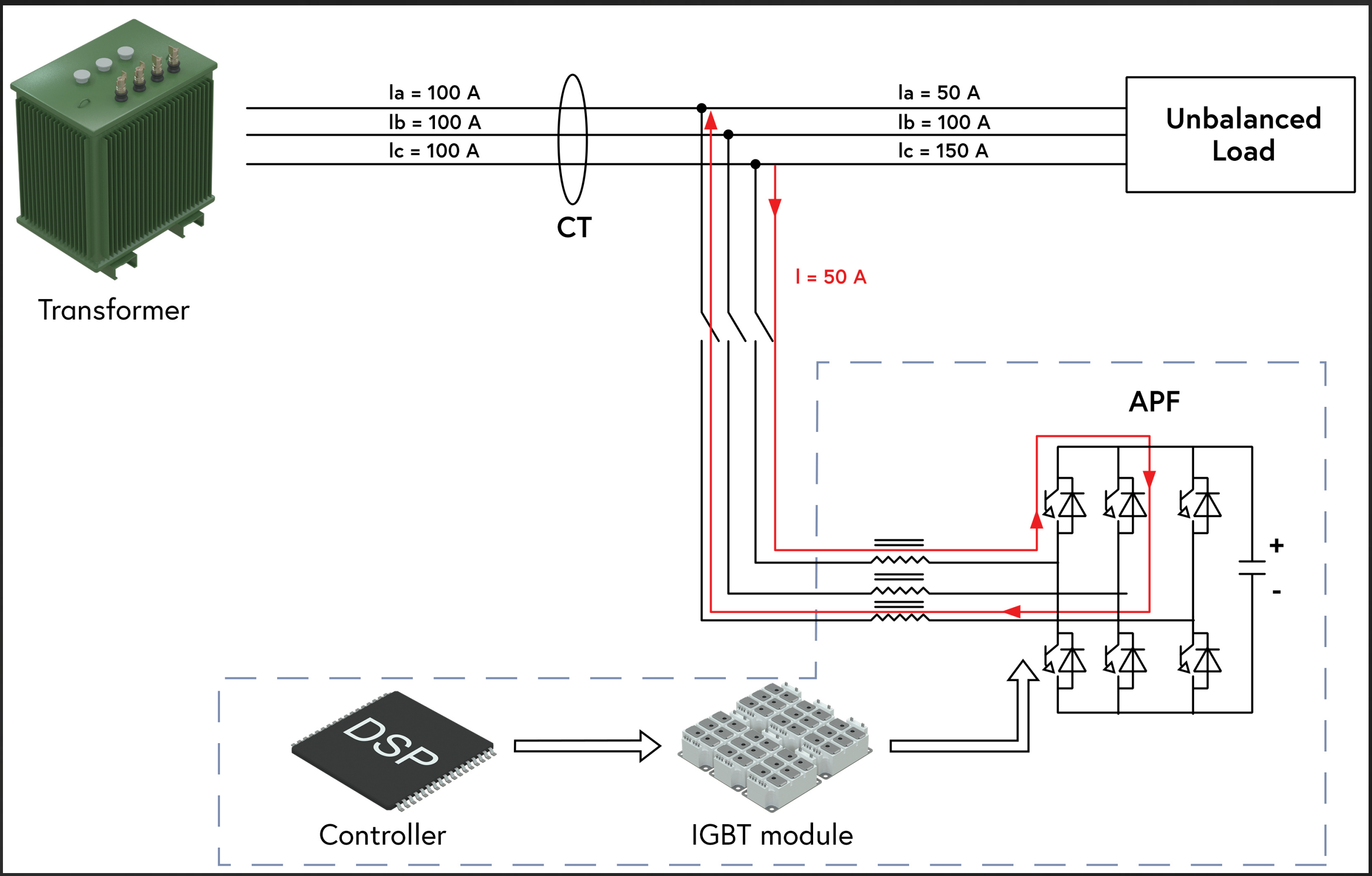
- Keep THDi below 5%
- Selectable odd and even harmonic mitigation up to 50th harmonic order
- Advanced Fast Fourier Transform for accurate correction of all harmonics up to the 50th order
- Efficiency higher than 97%
- Less than 50 microseconds reaction time  with less than 5ms response time
- System impedance at each harmonic component is "learned" by the APF
- Automatic safe-self test mode during the first time startup that gradually increases current magnitude to check system stability.
- Automatically detects resonance frequencies and skips the problem areas.
- Fast and secure wall mount for 5/10/15/25/35/50/60/75/100/150 amp sizes
- Pluggable rack mount option available in 75 amp
- Cabinet mount options for 25/35/50/60/75/100/150 amp sizes
- One cabinet can fit up to 750 amps utilizing any combination of sizes. It is also possible to combine APF and SVG modules to achieve a more cost-effective solution.
- Increase your capacity as your plant grows, add as many units in parallel as required




*Difference between 2-level and 3-level inverter technology*

## Load Balancing and Power Factor Correction

The EMES APF contains an algorithm that measures the load current on the individual phase and redirects excessive load current back into the phases with less load. This function keeps a balanced loading on the supply side. Excess capacity is used to compensate for reactive power and improve the power factor. Configurable priority mode is also available, which enables the operator to choose if the remaining capacity should be used for load balancing or power factor improvement.




*Load Balancing Principle APF*

## Control and Monitoring

### Easy to Use Graphical User Interface

- User friendly graphical user interface
- Direct configuration, monitoring, control, and harmonics analysis
- Communication options, detailed alarm events and fault reporting with real time stamps

### Backlit LCD Display

- Incorporates a high level of readability and ease of menu navigation, the LCD display offers:
- Access and configuration of operating parameters
- Measurement data in numerical, graphical and spectrum formats
- Operation status inclusive of detailed alarms and fault messages
- Password protected for critical settings

### Measurements

- Provides a comprehensive set of measurement data for analysis, such as:
- Network RMS voltages and currents
- Network Voltage and current distortions (THDu and THDi)
- Total RMS load currents and THDi
- System frequency
- Load factor
- Compensated RMS currents
- Comparison of PF (before and after)
- The graphical waveform of network voltages and currents, load and compensated currents
- Harmonic spectrum for network and load currents, from 2nd to 50th harmonic order


*APF HMI layout*

## Modular design

Traditional APFs are large and heavy, often taking up valuable floor space in switch rooms. EMES have applied new generation thinking and innovative design principles to create a range of Active Power Filters that feature a modular design and are available in wall-mount, rackmount and rack/cabinet configurations. This flexibility gives engineers multiple options to cater for all situations and ultimately save valuable space and 'floor real-estate'

- Up to 150A capability from a wall-mount solution
- Up to 150A capability from a single rack-mount module
- Up to 500A capability from a single cabinet solution

### Plugable Cabinet

*Plugable APF control cabinet*


*APF wall mounted module*

**NOTE:** Contact EMES for other available cabinet options

### Flexible Cabinet – hardwired modules

- Up to 750 Amps in
- 25/35/50/60/75/100/150A modules
- Includes MCCB top or bottom mount.
- 600/800/1000 W x 800D x 2200H (mm)
- Weight approx. 280kg (empty)

### Pluggable Cabinet - plugged modules

- 75A modules only
- up to 525 Amps
- includes MCCB top or bottom mount
- 630W x 851D x 2200H (mm)
- Weight: 210kg (empty)

## Functions and customer benefits

### Key functions

- Elimination of harmonic currents
- Lagging or leading Power Factor correction
- Voltage sags & swells reduction.
- Voltage fluctuations (flicker) mitigation.
- Load balancing in three-phase systems.
- Selectable harmonic generation

### Customer benefits

- Energy savings
- Higher productivity
- Reliable operation at reduced maintenance costs
- Longer lifetime of electrical and process equipment
- Additional capacity in existing electrical network
- Compliance with IEEE 519, G5/4, IEC 61000 3-2, 3-4 or any other power quality standard
- Quick return on investment

### Applications

EMES APF technology is suitable for many industrial or commercial areas where optimal power quality is a crucial factor for safe and secure operation. The APF technology gives an advantage in today's modern industry comprised of variable frequency drives, rapid fluctuating loads such as welding robots, uninterruptable power supplies, unbalanced systems due to single-phase loads, and arc furnaces.

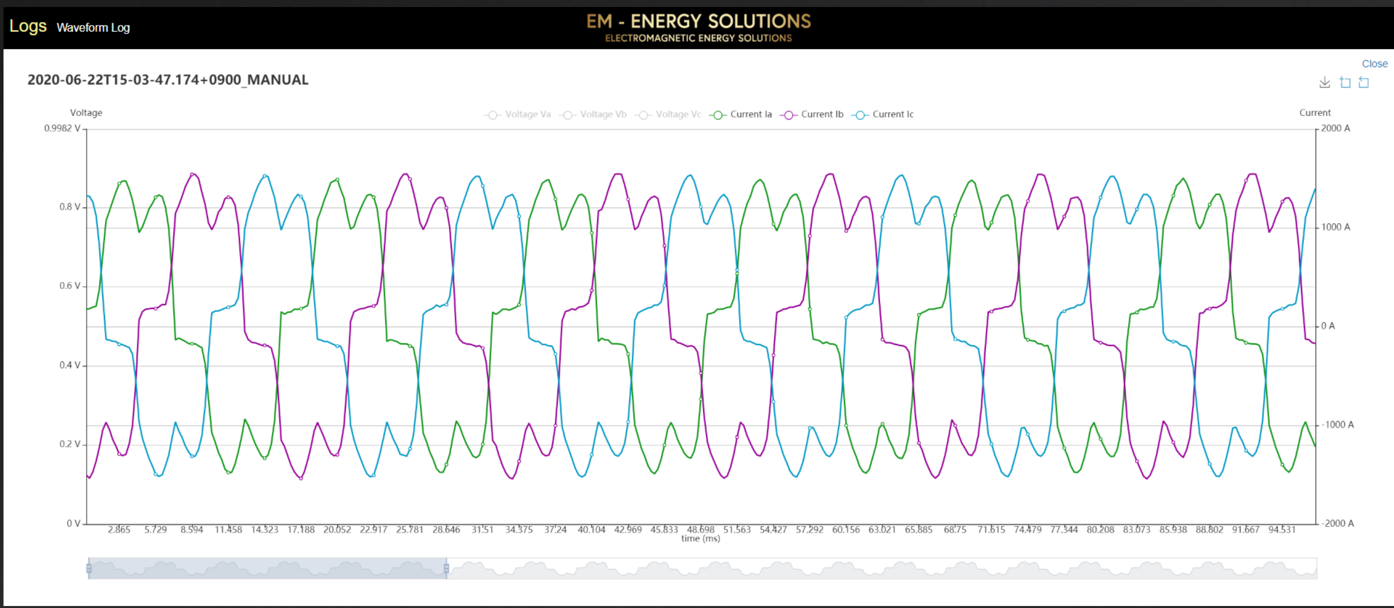
- Commercial buildings
- Data centers & IT
- Airports
- Hospitals and laboratories
- Residential buildings
- Shopping malls
- Financial institutions
- Ski resorts
- Amusement parks
- Marine vessels

- Renewable energy
- Water and wastewater treatment plants
- Heating, ventilation and air conditioning systems (HVAC)
- Wind and solar farms
- Traction
- Metro stations
- Cranes
- Lifts
- Package sorting facilities

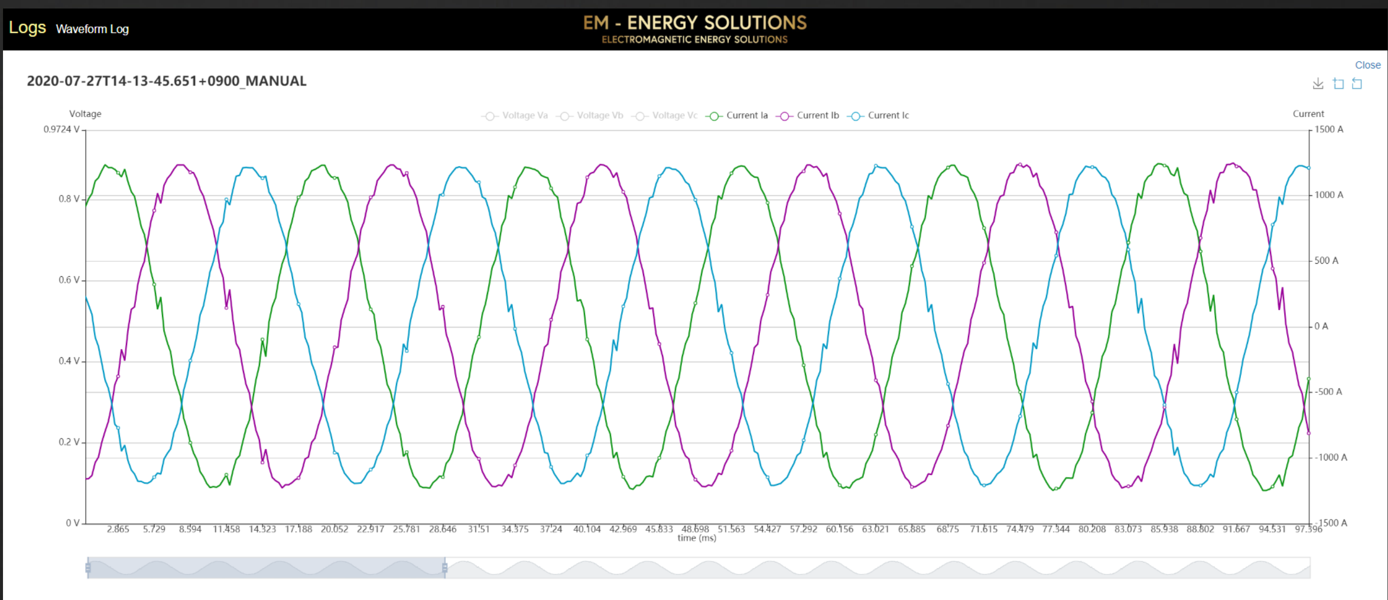
- Welding processes
- Automotive industry
- Printing industry
- Chemical Industry
- Steel industry
- Cement industry
- Food and beverage industry
- Oil and gas industry
- Pulp and paper industry
- Textile and clothing industry
- Pharmaceutical industry
- Electronics manufacturers

## Case Study

The following screenshots display the power quality in terms of harmonic distortion and power factor in a welding facility at one of the most advanced shipyards in the world. The welding plant was experiencing excessive harmonic distortion and low power factor caused by the power electronics in the welding robots. They had previously tried to counteract the problems with conventional capacitor bank technology with unsatisfactory results. We at Electromagnetic Energy Solutions are proud to say that we were able to bring the power factor close to unity and bring the harmonic distortion levels to well below the requirements in any power quality standard. THDi dropped from 34% down to 3%, while the power factor improved from 0,2 (inrush) to near unity. Also, the APF performed load balancing, causing additional energy savings.



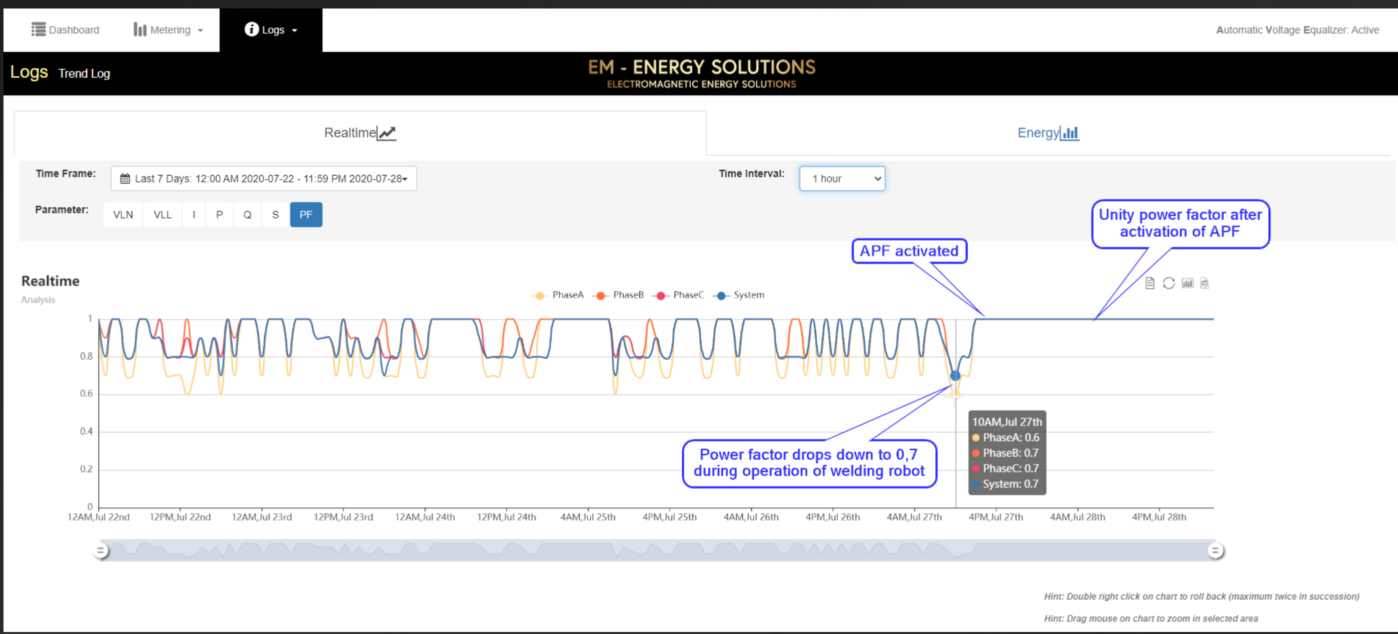

*Current waveform distorted by 3rd (4%), 5th (29%), 7th (11%) and 11th (6%) current harmonics. THDi is at 34%, APF is not active*




*Waveform log of current when APF is active. THDi is now at only 3%, well within any power quality standard*

## Case Study

The illustration below shows the power factor trend from a welding factory. Due to the sampling rate, the power factor only seems to be dropping down to 0,7, but in reality, due to the fast acting reactive consumption of the load, power factor drops all the way to 0,2 during welding operation. During initial startup of each welding sequence, the extreme inrush current draw causes significant voltage drop, which in turn affects the welding machine and welding quality. After activation of our APF unit, we clearly see that the power factor remains close to unity and also the voltage drop during startup is no longer present. This is achievable due to the outstanding response time of the APF unit. The market leading 35kHz switching frequency, reaction time of 50 microseconds, and overall response time of 15 milliseconds, makes the unit capable of realtime response.




*7 day trend log showing power factor without APF activated and unity power factor when APF is active*


*SVG Module based system*

# SVG - Static VAR Generator

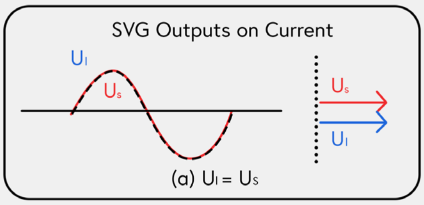
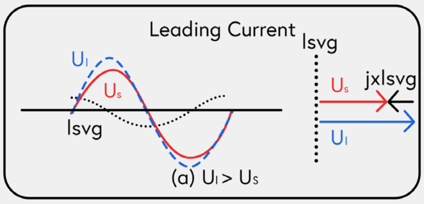
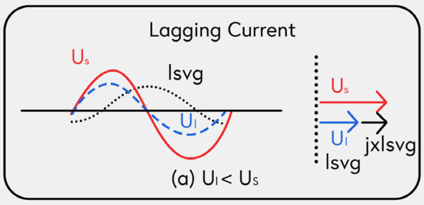
The EM Energy Solutions SVG represents the latest generation technology in the power factor correction field. It operates by detecting the load current on a real-time basis through an external CT (current transformer) and determining the reactive content of the load current. The data is analyzed, and 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

↓

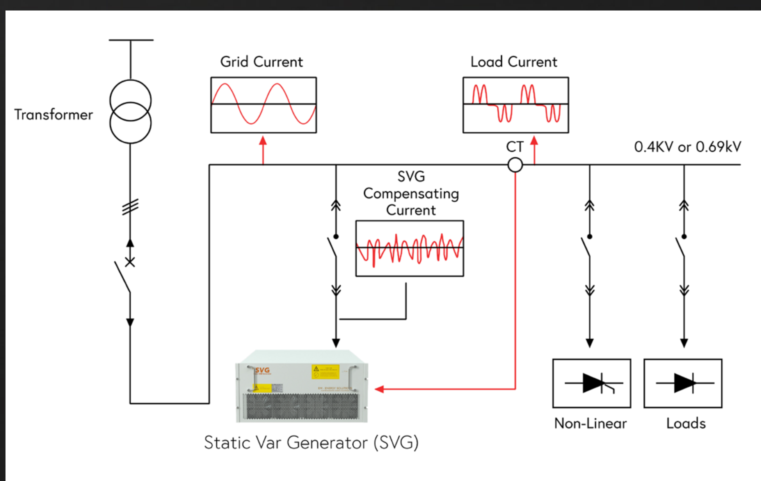
Automatic switching

↓

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, overtemperature, 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.

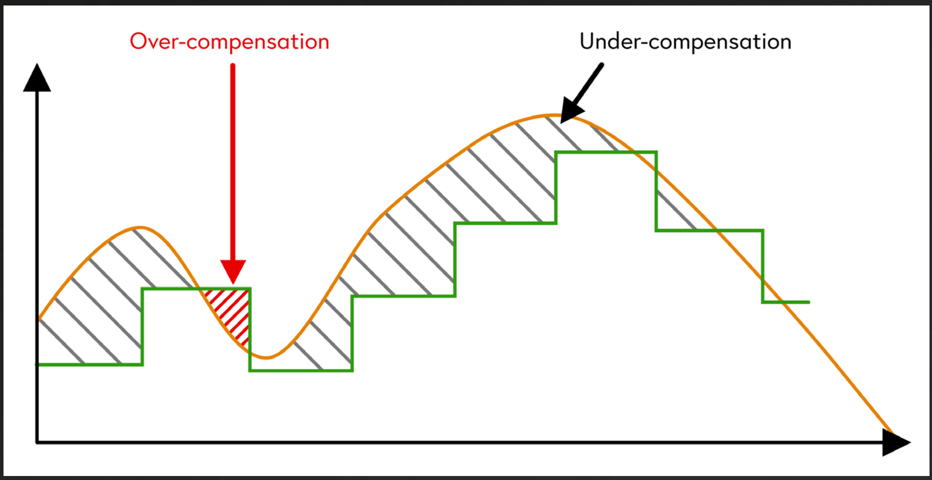
## Comparison with conventional solutions

| | 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<br>• The functional use of capacitors & reactors is highly reliant on grid voltage | • Instantanious, continious, stepless and seamless<br>• 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.<br>• 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<br>• 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.<br>• Often the system will be oversized to be able to better follow changes in reactive power demand<br>• Potential harmonic resonance situations must be taken into account<br>• Custom-built for specific load and network conditions | • Time-consuming studies not necessary since the unit is adjustable<br>• Capacity can match exact load demand<br>• No danger of harmonic resonance situations<br>• Will adapt to load and network conditions & changes |
| Maintenace & Lifetime | • Comprised of maintenance requiring equipment like circuit breakers, contactors, fuses, capacitors and reactors.<br>• 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.<br>• 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



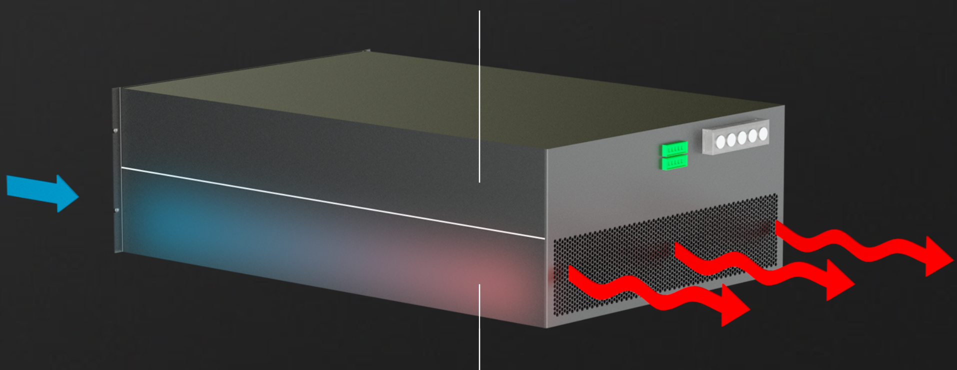

*Over and under-compensation produced by conventional capacitor banks*

### 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.

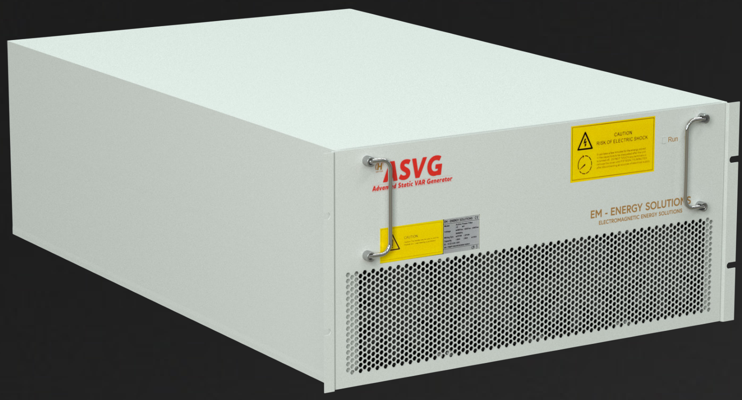
## Advanced Performance

### 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 Advanced Static VAR Generator

# Power Factor Correction




*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 correction systems
- Modular design
- Simple and fast installation and commissioning (‘Plug and Play’)
- Not affected by resonance
- Performs load balancing

## 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 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.

*UPSQ Control Cabinet*

# UPSQ - Uninterruptible Power Supply

The EMES UPSQ handles voltage-quality related problems such as abnormal grid voltage, frequency fluctuations, and flicker. It protects your business against the damaging effects these events have on both equipment and production output. The unit has two operational modes: High efficiency and online mode. The high-efficiency mode allows for efficiency up to 99%, while the online mode allows for 97% efficiency. The UPSQ provides a continuously high-quality power supply when operated in online mode. When a transient event like a voltage sag or a power outage occurs, the unit shifts from power quality priority to power supply priority.

## Key features

- High Efficiency of up to 99%
- High Grid voltage adaptability from 138-465V
- Frequency range between 40 - 70 Hz
- High power quality output with a voltage accuracy up to 0,1V
- Compact design with main cabinet dimensions of 600x830x2000 mm (WxDxH)
- User-friendly 12-inch operator panel
- Intelligent control system with wave-form recovery, fault finder, self-test functionality, recovery functionality, cooling control, and fan fault alarm function.


*AVC RTS Control Cabinet*

# AVC-RTS Ride Through Storage

AVC-RTS is the ideal solution for voltage sag correction in commercial and industrial applications. AVC-RTS is available in load capacities from 150 kVA to 3000 kVA, with higher ratings available on request. Momentary power outages and voltage sags are a common and expensive occurrence in the power distribution system. The power system can ride through outages up to 3 seconds in duration with the AVC-RTS installed; other duration capabilities are also available based on customer's requests. The 3-second standard is based on what is most common in industry and provides voltage sag and blackout protection. Other compensating time frames are possible based on system load and capacity of the energy storage system. The AVC-RTS is capable of full 0-100% voltage sag compensation with a response time of 2-5 ms and is not reliant on any peripheral equipment due to its super-capacitor energy storage system. The unit has a superior efficiency higher than 99%. Energy storage consists of ultracapacitors due to their high energy density, cycle life, and life expectancy. The AVC-RTS can also be used for continuous voltage regulation, voltage balancing, flicker reduction, voltage sag mitigation, peak shaving, and wind farm storage.

## Key features

- Up to 30 seconds of ride-through for voltage sags or loss of power
- Ultra high efficiency < 99% - Low operation cost
- No reduction of fault capacity. Support DOL motor start and guaranteed protective fuse protection.
- Small footprint design
- Protects against utility recloser events and other short outages
- Provides back-up during generator start-up following utility supply failure
- Low investment and maintenance costs
- Modular system from 300 - 3000KVA
- Custom storage solutions available
- Maintenance-free solution; Super capacitors with more than 1 million charge cycles.
- Rugged industrial design
- Resilience against grid disruptions
- An investment in productivity

# Blackout Prevention

## Functions, Applications and customer benefits

### Key Functions

- Power outage prevention
- Active mitigation of harmonic distortions
- Voltage sag mitigation
- Voltage stabilization
- Power factor improvement
- Flicker mitigation
- Load balancing

### Customer benefits

- Complete protection from power outages, voltage sags, harmonic distortions, flicker, load imbalance and other power quality problems in a single, cost-effective, and robust solution.
- Excellent protection of critical processes in commercial and industrial applications, reducing downtime cost
- Reduced breakdown of electrical equipment and longer plant life
- Compliance with IEEE 519, G5/4, IEC 61000 3-2, 3-4 or any other power quality standards, and recommendations
- Energy savings
- Higher electrical capacity from the existing electrical network
- Quick return on investment

### Applications

- Commercial buildings
- Financial institutions
- Scientific laboratories
- Telecommunication centers
- Remote radar locations
- Data centers
- Hospitals
- Airports
- Semiconductor industry
- Glass industry
- Automotive industry
- Printing industry
- Chemical industry
- Food and beverage industry
- Pharmaceutical industry
- Other process industries


*AVC DVR Control Cabinet*

# AVC - DVR Dynamic Voltage Regulator

Short voltage dips in the electrical power supply can result in unplanned production downtime. As a result, product quality can suffer, and companies can incur significant economic losses. EMES DVR (Dynamic Voltage Regulator) is a system for stabilizing voltage to protect sensitive systems and processes.

Compared to the AVC-RTS, the AVC-DVR does not rely on capacitors to counteract voltage sags & swells. The lack of capacitors makes this a more cost-effective solution, but it still compensates for up to 40% voltage variation for up to 30 seconds, which will prevent the effect of sags & swells in most cases. During normal operation, the AVC-DVR optimizes the output power. During a voltage sag, the AVC will boost the output voltage by altering the voltage vectors to compensate for the reduced voltage. The unique features of the DVR make it ideal for handling voltage fluctuations.

## Key features

- Voltage drops of up to 30% or 40% are increased to the desired value on the output side.
- Overvoltages of up to 20% are reduced to the nominal voltage.
- Voltage correction in less than 1ms
- Protection against overvoltage
- In the event of overloads and short circuits, the system protects itself without interruption by means of an electronic by-pass switch.
- Ease of Installation and Commissioning (‘Plug and Play’)
- Low investment and maintenance costs
- Modular system from 150 - 3000KVA
- Can operate at low voltages
- Efficiency of over 98%
- No energy accumulator required
- Compact design and small footprint
- Resilience against grid disruptions
- An investment in productivity

# Blackout Prevention

## Functions and customer benefits

Voltage fluctuations can result in unplanned and costly production downtime and can also negatively impact the quality of the products. Furthermore, they increase the wear on the machines, which in turn reduces the service life.

**Causes of voltage drops**

- Short circuit in the supply network
- Lightning strike
- Power plants switching on and off
- Volatile energy sources (wind or solar parks)
- Extreme load changes
- Switching operations at the power supply company

**Direct consequences**

- Disruption of contactors and relays
- Crash of computers and control systems
- Failure of frequency converters
- Spread of errors on the network

**Effects**

- Interruption of manufacturing processes
- Failure to comply with quality standards
- Financial losses due to lower productivity

**EMES DVR**

Prevent production disruptions:
To safeguard production processes, EMES DVR connects in series between the distribution transformer and the load. The DVR has close to no impact on the short-circuit capacity of the grid. Already installed protection measures can remain as they are. EMES DVR protects against voltage sags & swells. Voltage correction happens in realtime (< 1 ms) when the input voltage deviation is between 30% to 120% of the nominal voltage.

Optimizing quality costs:
EMES DVR is compact and can be expanded with modular components, making it suitable to everything from individual systems to entire grid sections and factories. The system does not require a battery for power storage and is easy and inexpensive to operate.

DVR connects between the supply transformer and the load to ensure disruption-free production processes. The DVR can be expanded with modular components and installed in everything from individual systems to entire grid sections.

# Medium Voltage Units

EM Energy Solutions deliver flexible solutions for low and medium voltage power systems for all our active units, including APF, SVG, and ASVG. The EMES active units can easily connect to any voltage level up to 38.5kv utilizing specially designed step up - step down transformer solutions. Such flexibility allows designing of an economically viable power quality solution at any voltage level up to 38.5kv utilizing our standard units and industry-proven technology.

Modern power systems need a balanced supply and demand for active and reactive power in order to ensure proper power quality. The presence of heavy and fast fluctuating loads can disturb the balance, and create power quality challenges to both supply grid and end customers.
Common power quality problems are voltage variations, flicker, harmonic distortions, and poor power factor. Unsatisfactory power quality means reduced productivity, low reliability, and higher operating costs for the end customer. The supply system suffers from compromised reliability and low transmission capacity. Conventional technologies are too slow to control capacitive or inductive powers. They are often not sufficient to ensure a stable power system

EM Energy Solutions active units are an extremely fast and reliable solution for power quality challenges. The active units can guarantee the stability of a power system with response time less than a millisecond. EMES active units are highly flexible, allowing a combination of different units into one control cabinet, ensuring the optimal cost-performance solution. This flexibility also allows the same unit to solve a wide range of power quality issues, including dynamic reactive power compensation, load balancing, and active harmonic filtering functionalities, which can solve a variety of customer challenges.

# Medium Voltage Units

## Applications

Large industrial loads, such as arc furnaces, welding equipment, rolling mills, and large induction motors used in various industries, significantly affect the stability and operation of the power system by causing flicker, voltage unbalance, and harmonic distortion. With an ultra-fast response time of less than one millisecond, EMES active units ensure superb compensation of reactive power and harmonic distortion even for rapid varying large loads. The compensation increases the plant's productivity and removes damaging power quality challenges like flicker and harmonic distortion.

Wind and solar farms must meet regulatory power quality standards. By installing EMES active units, you resolve the problems with unstable voltage and harmonic distortion caused by renewable energy plants.

Demand from rapid fluctuating loads requires a fast response from the transmission and distribution grid. This fast response results in notable voltage variations that may even cause a complete voltage collapse under certain severe conditions. EMES active units are an excellent and scalable solution for grid voltage stabilization due to its fast reactive power compensation with varying loading conditions.

Application areas include:

- Steel industry (Electric Arc Furnaces – voltage stabilization reduces tap-to-tap time and electrode consumption.)
- Mining and heavy industry – dynamic reactive power compensation stabilizes the power system, especially on large motor start-up, ensuring a reliable power system.
- Shredders and crushers
- Welding (Shipyards)
- Cement plants
- Cranes
- Renewables markets like solar farms, wind farms, solar panel installations
- Regulating voltage and reactive power in transmission and distribution lines

## ELECTRIC ARC FURNACES

Arc furnaces create substantial power quality challenges to a supply system. The arc furnaces create voltage variations, which are seen as flicker by adjacent customers. EMES active units deliver excellent flicker reduction which conventional technologies are unable to offer. The result is stable grid operation with minimum voltage variations.

Customer Benefits: Voltage stabilization brings a number of benefits to the end-customer. It increases plant productivity by reducing tap-to-tap time and lower electrode consumption and carbon charges.

### Rolling mills
Large frequency drives are an essential part of the operation of rolling mills. The downside with these large drives is the reduced power factor they create due to the harmonic distortion and voltage dips. EMES active units provide real-time harmonic filtering, power factor correction, and eliminate voltage dips. The fast response to harmonic distortion ensures any plant is able to meet the power quality standards.

**Customer Benefits**: Mitigation of harmonics and voltage distortion with EMES active units brings several advantages to rolling mills. By controlling the power factor, system losses and reactive power consumption are reduced together with the improved capacity of the electrical system. The overall result will, in any case, be increased production.

### Mining and large loads

Mining and other large industrial segments normally rely on large and sensitive loads such as mining hoist, shovels, pumps, cranes, conveyor belts, and crushers. These large inductive loads consume high amounts of reactive power, especially during the startup phase. When these loads are connected to weak grids with low short circuit capacity, the reactive power consumption can induce voltage dips and fluctuations on the supply grid. The voltage dips and fluctuations can disturb other consumers on the same feeder and cause a less reliable power system. By having a fast and dynamic reactive power compensation, smoother operation of large inductive loads, and a more stable power system is achieved.

**Customer Benefits**: Improved power quality brings several benefits to the end customers. The payload on the hoist applications increases, and jams are avoided in crushers and shredders applications. The production capacity and capital equipment lifetime are enhanced, and smooth plant operations are secured.

## What we offer

EM Energy Solutions offers a wide spectrum of energy management services involving power factor correction, energy optimization, harmonic mitigation, and overall power quality improvement.

Our team of experts have broad experience and provide support to our customers during the formulation, management, and implementation of energy management projects.

EM Energy Solutions' first priority is to supply our customers with cost-effective, self-funding energy optimization solutions that meet relevant power quality standards, reduce energy consumption, improve production output, reduce emissions, and ensure an overall improved plant performance.

### What we offer

System studies and in-depth analysis
Proven and industry-leading technology
Engineering, simulation, and design
Factory tests for validation of required criteria
On-site delivery, installation, and commissioning
Training and after-sales support
Modernization and system upgrades

## Other Products & Services

We at EM Energy Solutions take pride in providing our customers with excellent service before, during, and after installation of our power quality optimizing units. We can perform detailed analysis on our customer's behalf to determine the actual state of the power system in terms of power quality and to find the most optimal solution. Our team of experts assist during the engineering and installation & commissioning phase to ensure a safe and secure startup. With our integrated power quality analyzer and remote support solution, we are just a phone call away if any assistance is needed.

### What we offer

- Power Quality Analysis
- Technical Support
- Integrated Power Quality meter with remote support capability
- Installation & commissionign Support

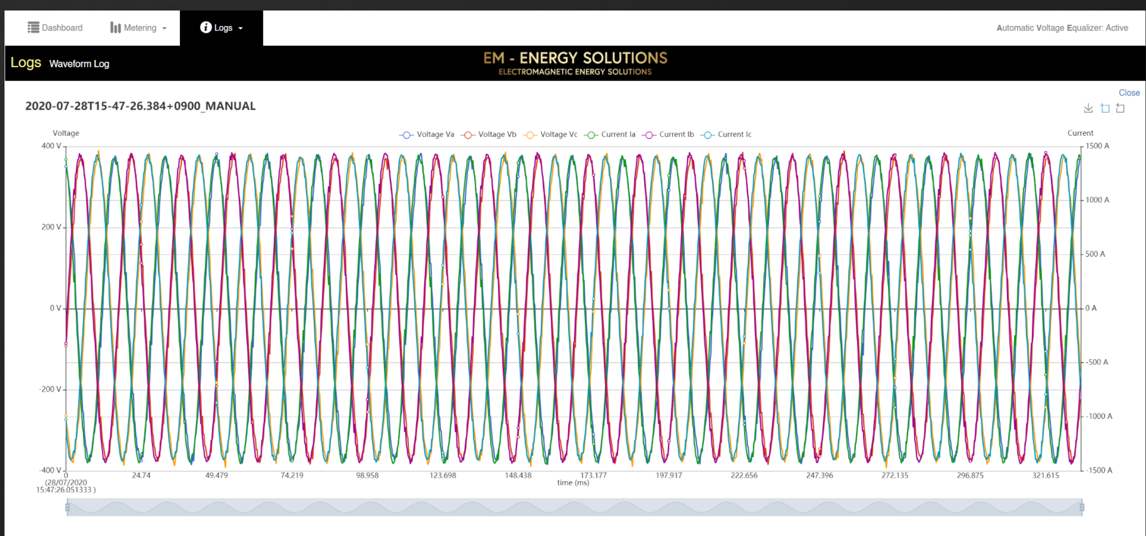
## Power Quality Analyzer


*EMES Power Quality Analyzer*

Comprehensive energy management and power monitoring program is the key to success for any energy provider/consumer regardless of their size. Our units can be equipped with one of the most advanced power meters on the market today.

### WAVEFORM & FAULT RECORDER

The PQA (Power Quality Analyzer) has integrated trigger point waveform recording, which enables operators to go back and look at any situation that has taken place. With detailed trends and waveform logs, the operator can understand the sequence of events in the power system fully. The meter supports a waveform capture function that allows users to capture and record 10 cycles before and after the triggering point, whether it be a voltage sag, swell, or overcurrent. The waveform log on the web interface allows users to view these waveforms whenever a power quality event has occurred. The waveform log displays a table that includes the waveform files, time of recording, and file size. The waveform file name includes the timestamp when the event occurred as well as the parameter name/event name that triggered the power quality event.




*Waveform log of voltage and current taken from EMES PQA*

## Power Quality Analyzer

**INTERACTIVE DATA COMMUNICATION**

Data from the unit is reachable through a SCADA network or a mobile application. There is also a local HMI display for "in the field" troubleshooting and power analysis.
AVE is standard equipped with industrial Modbus TCP/IP communication protocol wired or wireless for seamless integration into any existing SCADA system. Other communication protocols are also available HTTP/HTTPs Post, FTP, sFTP, BACnet-IP, DNP3 V2, SNMP V3, IEC61850 2nd edition, SMTP.

**WEB SERVER**

The PQA`s Ethernet module supports HTTP protocol and has a Web Server function making the PQA accessible through Ethernet or 4G router anytime from anywhere.
Fully encrypt and authenticate data communication between PQA and data server with HTTP web security standard TLS v1.2 and SSL HTTPS encryption. WiFi communication authentication with WPA or WPA2 enterprise security protocol.
The PQA has inbuilt storage for realtime and energy logs, waveform capture, data logs.
8GB onboard memory with 1-second interval data logging capabilities.

**EM CLOUD**

EM Cloud is a cloud-based metering platform that provides users access to data from PQA. The data is available to our customers to view, import, export, and analyze.

**Data Storage:**

The integrated EM Cloud Solution stores data such as system voltage, current, power, energy, power-factor, demand, and transients in five-minute intervals. Also, it provides users an unparalleled granular level into historical metering data.

**Data Analytics:**

The cloud solution also offers a quick and straightforward data analysis tool that includes trending, energy profile analysis, comparison, consumption trends, heatmaps, demand analysis, realtime data trends, and verification.

**Reports:**

Offers the ability to download and email reports directly to your colleagues for collaborative analysis and insightful decision making  You can send all or select report dashboards. These reports cover key energy management areas such as Facility Energy Consumption Trend Analysis, Top Consuming Meter Points, Deployment, Meter Point Energy Consumption Trend Analysis, Meter Point Operations Analyzer, and Meter Point Active Power & Weekdays Analysis.

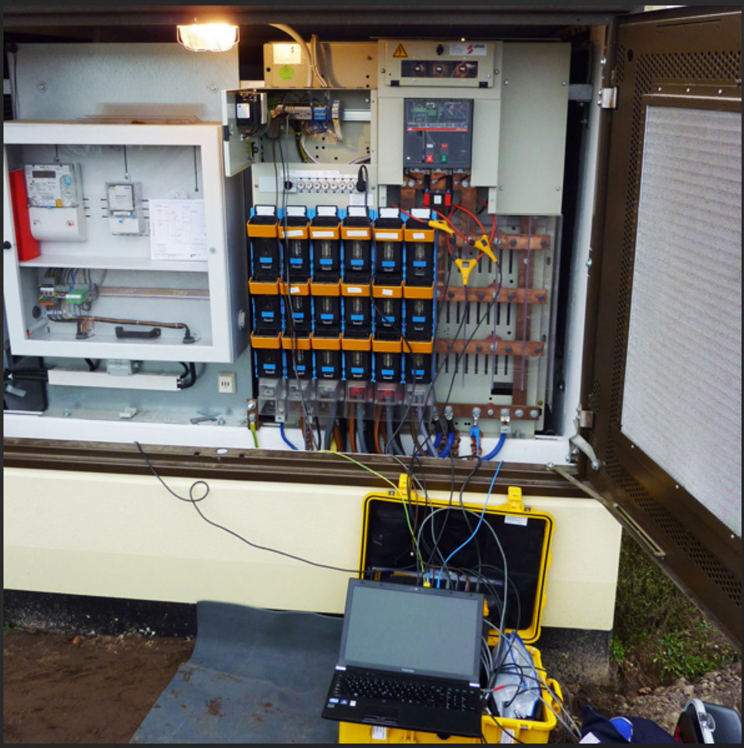
# Other Products & Services

## Power Quality Measurement Services

EM Energy Solutions' power quality measurement services provide you an opportunity to assess the current status of various power quality parameters in your facilities and benchmark them against applicable power quality standards. The findings of the power quality measurements and recommendations for possible solutions, if so required, are presented in a post-measurement power quality report.

Power quality measurement services are delivered to our clients outside of Norway, typically by our global expert network of distribution partners. In Norway, or in countries where we don't have a partner trained to do measurements, EM Energy Solutions arranges these services. As a specialized company in the field of power quality, EM Energy Solutions gives you unmatched expertise from problem definition to solution identification and implementation, together with our global distribution network.

Measurements are the basis for troubleshooting, verification, or sustainable optimization of power quality. We check your power supply network for voltage fluctuations, reactive power, harmonic oscillations, and other network disturbances, and by doing so, uncover potential ways to optimize costs and detect potential disturbance factors.



*Power Quality Analysis can be performed by EMES personnel*

## Installation & Commissioning

Buyers of our products are provided with necessary installation and commissioning services as required. For larger projects, installation supervision and commissioning are conducted by EM Energy Solutions engineers.

*EMES personnel are available for installation and Commissioning*

## Technical Support

EM Energy Solutions are committed to providing high-quality support to our customers through service and application engineering.

### 24/7 Support

EMES guarantee 24/7 support through either phone or directly through one of our sales and engineering staff. After hours installation & commissioning support is also available.

### Onsite assistance

In the unlikely event of equipment issues, we are committed to assisting our clients with support for all our products.

### Engineering support

EMES engineers are available to give technical advice and support on our products and the plants where they are serving. Our customers have our projects department and factory-based software at their disposal. Our projects department is comprised of highly skilled experts in our product portfolio.


During the warranty period, technical support and maintenance are available free of charge to customers and partners. We also offer the following options:

- Individual case post-warranty support
- Individual case post-warranty maintenance
- Technical support contracts available
- 24/7 support with a monthly fee
- Yearly maintenance contract
- Remote support