DYNAMIC
Measurement & Control Solutions, LLC

APF Module

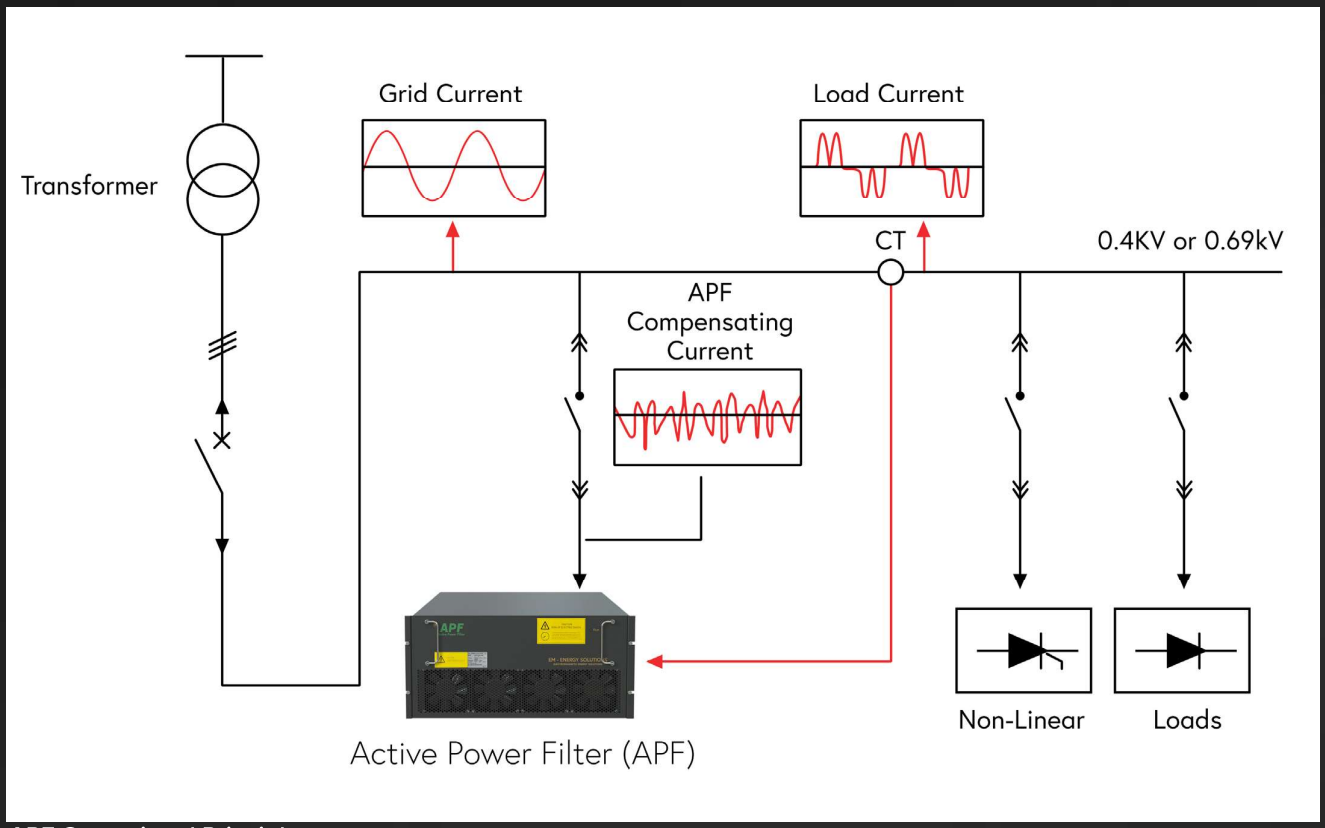
APF - Active Power Filter

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

APF Active Power Filter — Harmonic Filtering



APF Operational Principle

APF Control Cabinet

IP54 APF Control Cabinet

APF Active Power Filter Harmonic Filtering

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

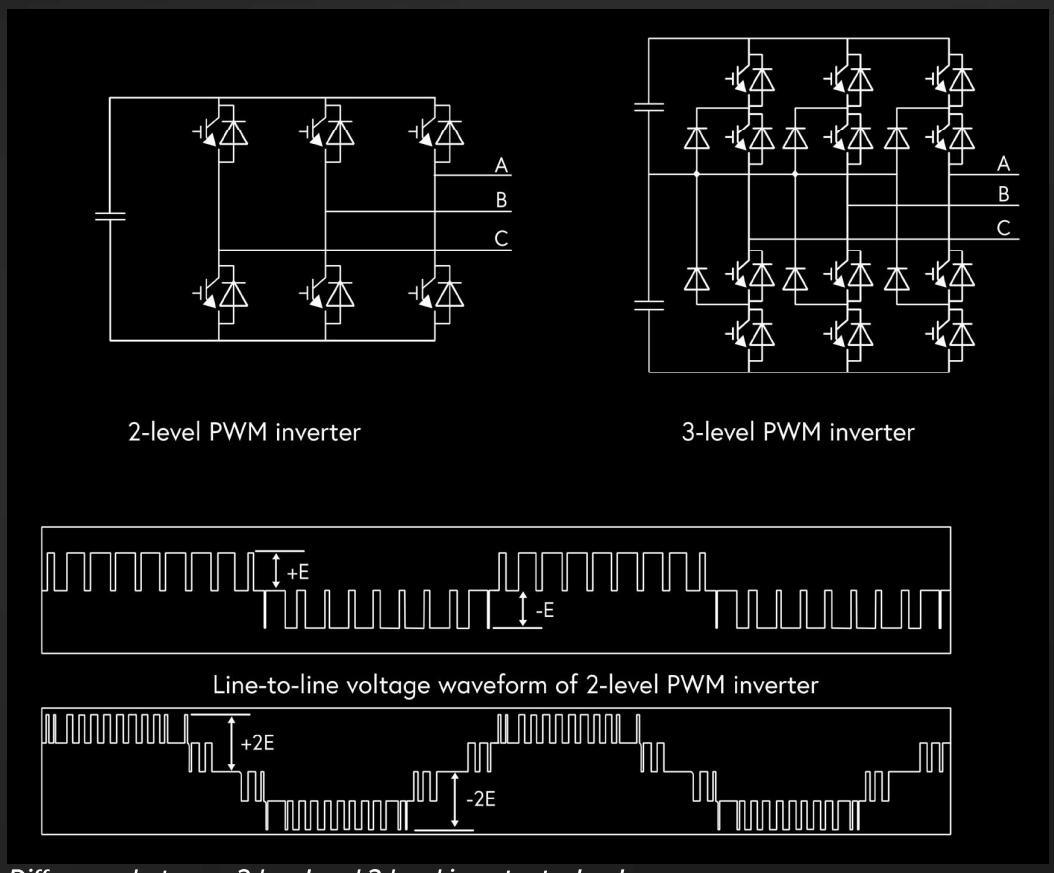
- Internal short-circuit protection
- Temperature monitoring
- Over-voltage protection
- Under-voltage protection
- Abnormal frequency protection
- Output overload protection
- Busbar over-voltage protection
- CT installation detection
- Inverter bridge abnormal operation protection
- Inverter over-current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

APF Active Power Filter Harmonic Filtering

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.

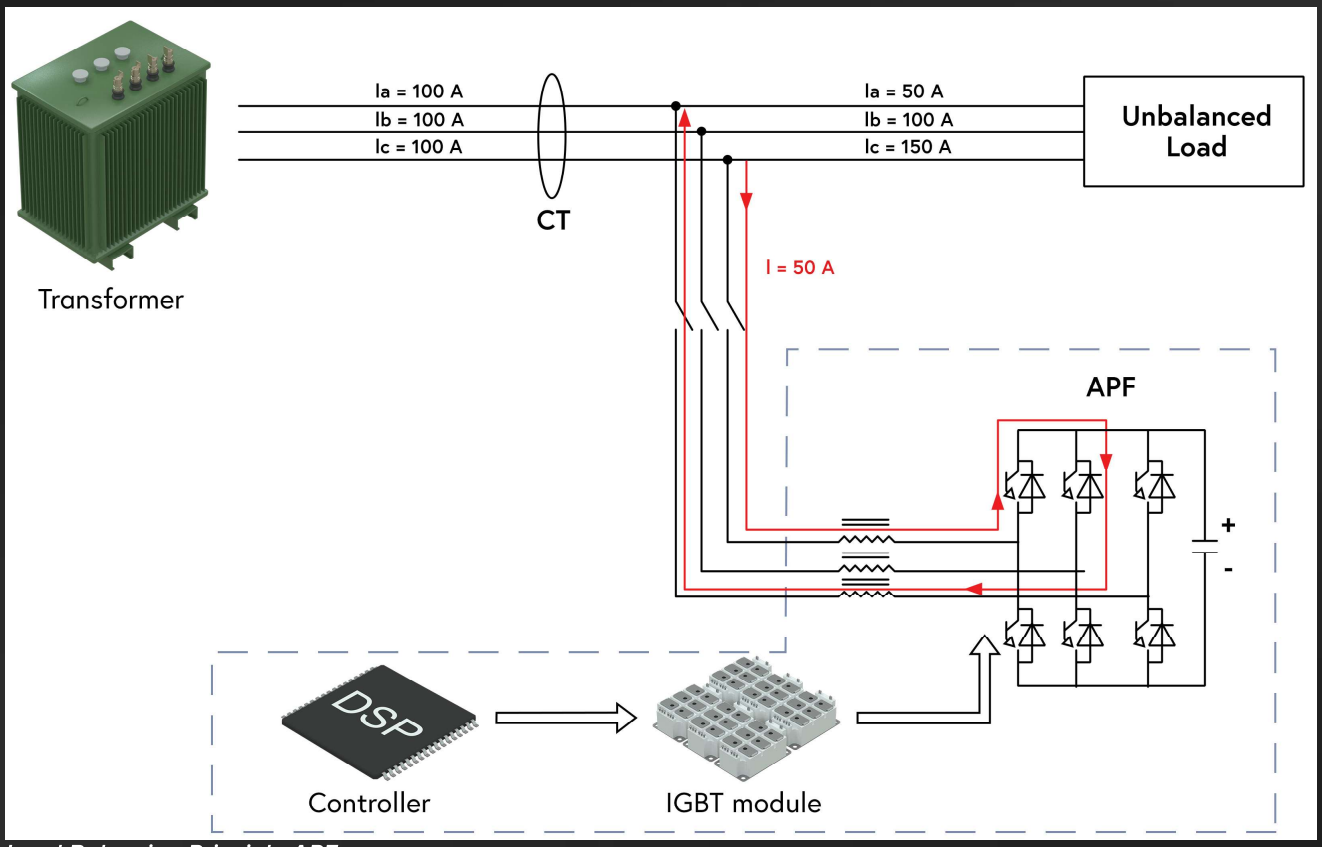
- Keep THDi below 5%
- Selectable odd and even harmonic mitigation up to 50th harmonic order
- Advanced Fast Fourier Transform for accurate correction of all harmonics up to the 50th order
- Efficiency higher than 97%
- Less than 50 microseconds reaction time with less than 5ms response time
- System 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

Harmonic Filtering

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

Harmonic Filtering

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)

APF Active Power Filter — Harmonic Filtering

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

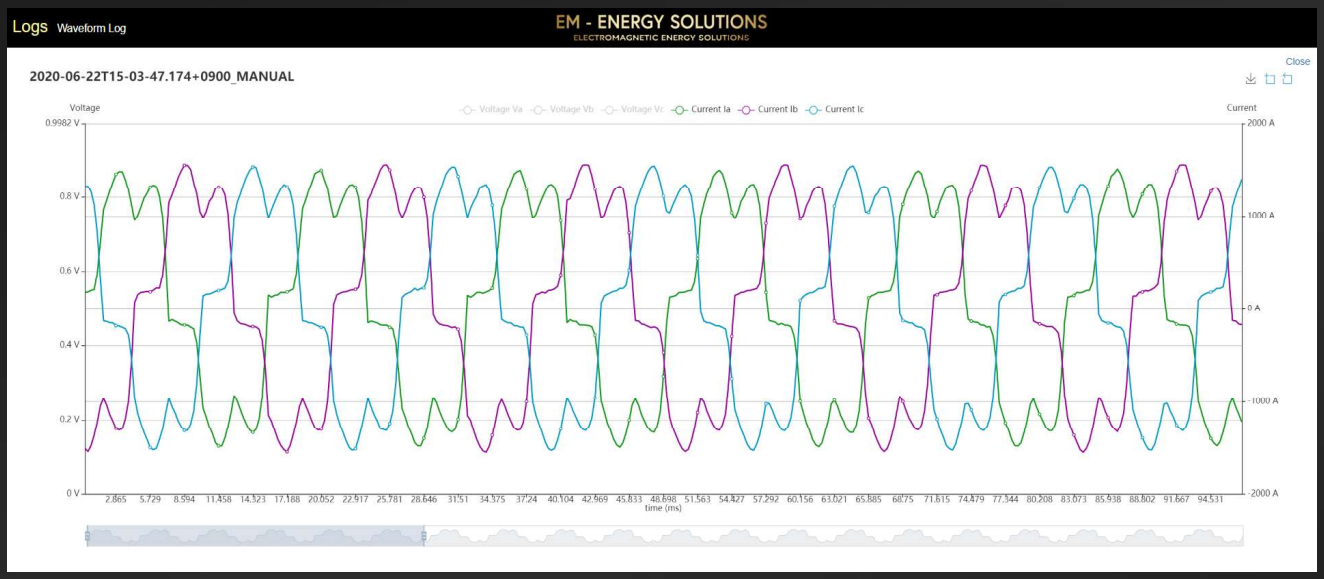
EMES APF technology is suitable for many industrial or commercial areas where optimal power quality is a crucial factor for safe and secure operation. The APF technology gives an advantage in today's modern industry comprised of variable frequency drives, rapid fluctuating loads such as welding robots,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

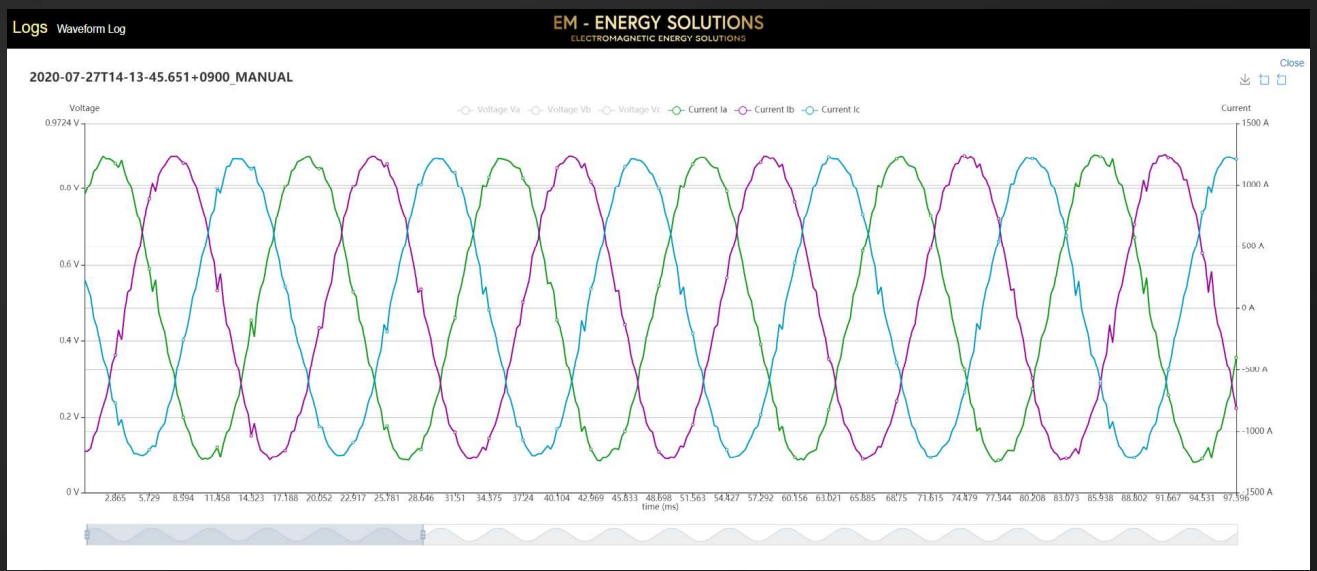
Harmonic Filtering

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

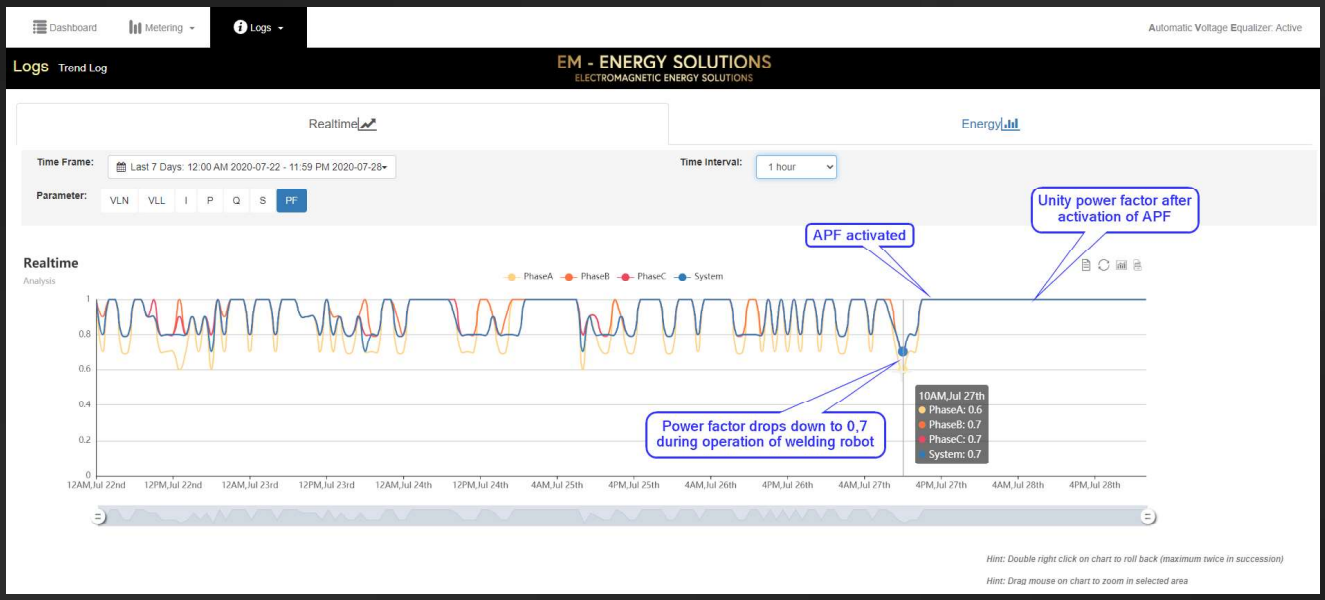


Waveform log of current when APF is active. THDi is now at only 3%, well within any power quality standard

Harmonic Filtering

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