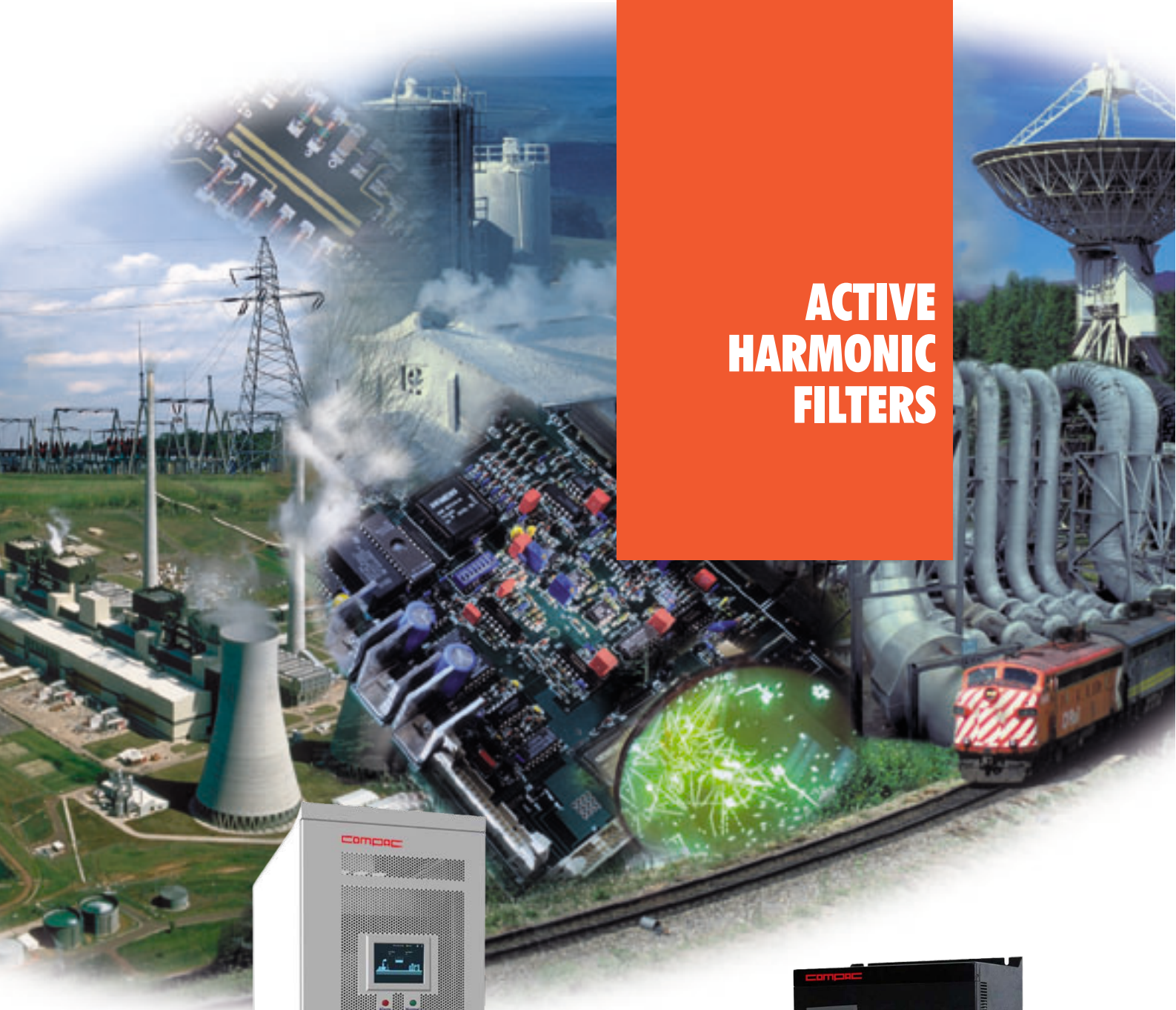
ACTIVE HARMONIC FILTERS



compac
ELECTRIC

Our Power Quality Services

For many companies, the electricity is an important cost element, and a part of the amounts is due to the consumption of reactive energy and poor Power Quality.

With proper assistance and maintenance you can avoid wasting money and unnecessary power dissipation in the electric plant cables and transformers that undergoes premature aging.

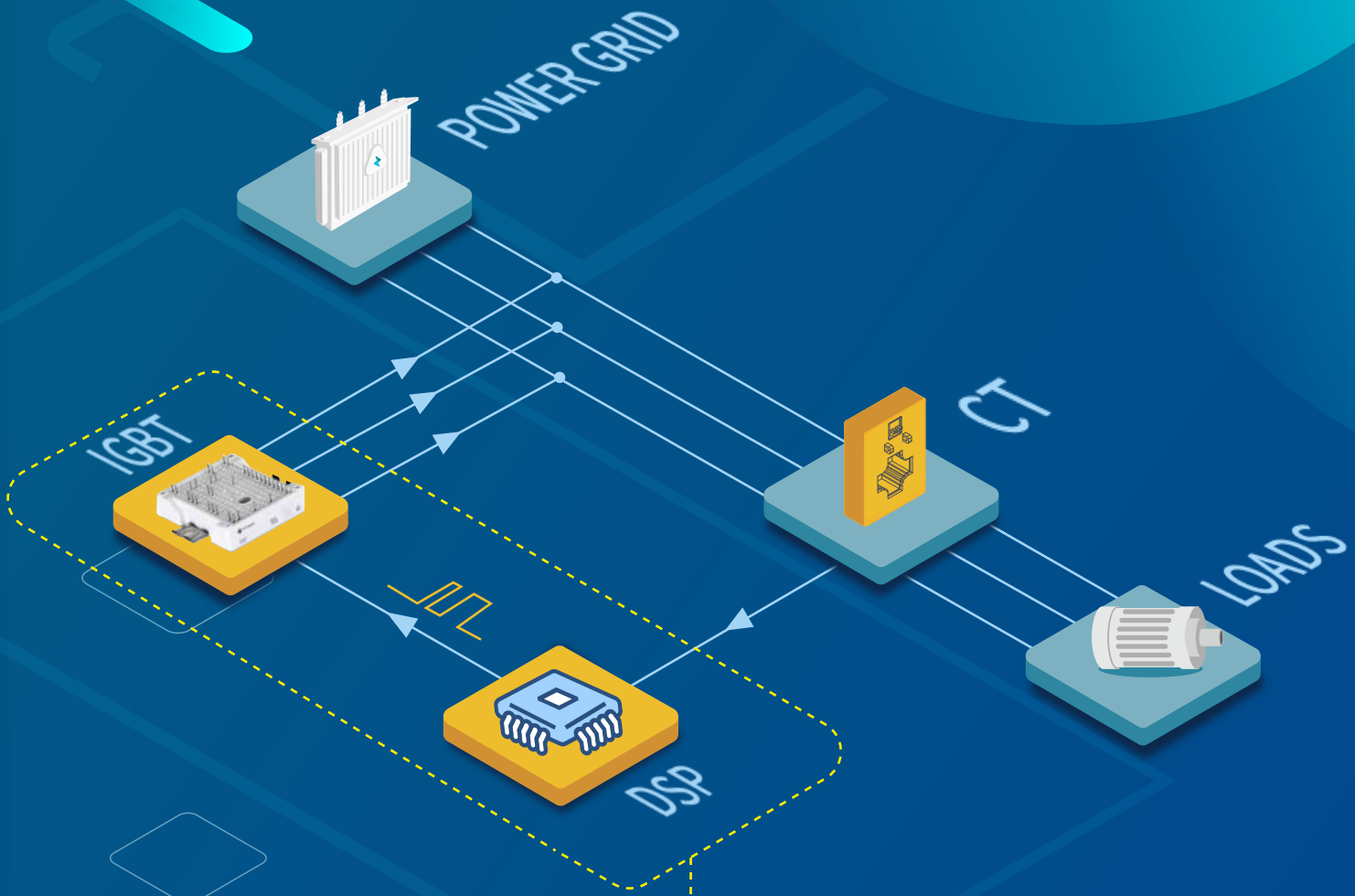
Startup and commissioning

Sheduled maintenance

Power Quality analysis for specific issues, including ongoing analysis

Make your own measurement and let us know

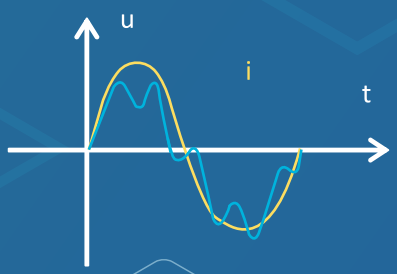
Power Quality Assessment



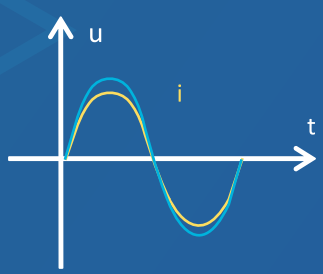
WAVEFORM

Voltage
Current

LOAD



SOURCE

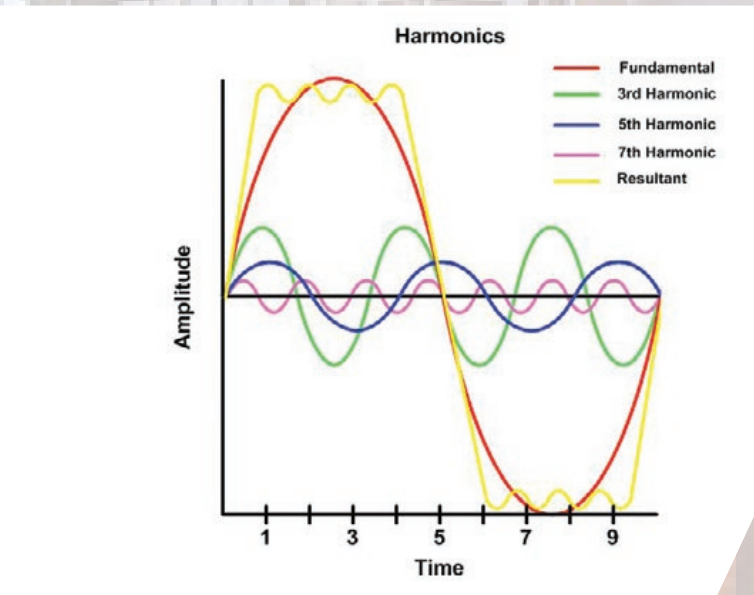


INTRODUCTION TO HARMONICS

Harmonics are 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 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 at frequencies that are at multiples of the fundamental frequency (50 or 60Hz). These additional components are referred to as harmonic currents. If a high enough level of harmonic current is being drawn from the supply then this results in distortion of the voltage waveform.
The measurement of the distorted voltage wave form is described as the Total Harmonic Distortion Voltage or THDV. The measurement of the current waveform, including the fundamental and harmonics, is described as the Total Harmonic Distortion Current or THDI.

Typical Non-Linear Loads:

- 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 IMPROVE MY HARMONICS?

Harmonic currents increase the level of current being drawn from the supply and negatively impact on the quality of the supply voltage. Most electrical networks have been designed to operate at the fundamental frequency only and the presence of currents outside of this frequency often stress distribution equipment and can disrupt normal power supply operation. Some typical effects of harmonics are:

- Overheating of transformers, switchboards, cables, motors due to increased current requirements
- 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 Harmonic Filtering (AHF) equipment. AHF equipment simply adds currents 180^0 out of phase with the existing harmonic currents, but that are equal in magnitude and frequency.

THE BENEFITS OF ADDRESSING HARMONICS

- Lower operating costs by using power efficiently, lowering distribution costs, and avoiding network penalties.
- Reduces the threat of operational downtime from nuisance tripping, overloading, and premature plant failure.
- Eliminates the risk of electrical system resonance caused by harmonic currents.
- Reduces the risk of overloaded neutrals, transformer windings,and premature power factor correction capacitor failures,and other sensitive electronic equipment.
- Reduced failure rate of electronic hardware.
- Compliance with electrical network standards.

Harmonics Standard

The foundation of many of these local network companies regulations are based on international standard IEEE 519 which has been recognised as the international benchmark for acceptable harmonic current levels . IEEE 519 takes supply impedance or prospective short circuit current of the supply into consideration, as well as harmonic current levels.

Based on "IEEE Recommended Practice and Requirements for Harmonic Control in Electrical Power Systems" (IEEE 519-2014) , the grid voltage distortion limits are:

Bus Voltage ***V*** at PCC	Individual harmonics (%)	Total harmonics distortion THD (%)
V ≤ 1.0kV	5.0	8.0
1kV < ***V*** ≤ 69kV	3.0	5.0
69kV < ***V*** ≤ 161kV	1.5	2.5
161kV < ***V***	1.0	1.5

Cument Distortion Limits for Systems Rated 120V through 69kV

Maximum harmonic current distortion in percent of I_L						
Individual harmonic order (Odd Harmonics)						
I_{sc}/I_L	3 ≤ h < 11	11 ≤ h < 17	17 ≤ h < 23	23 ≤ h < 35	35 ≤ h < 50	TDD
<20*	4.0	2.0	1.5	0.6	0.3	5.0
20<50	7.0	3.5	2.5	1.0	0.5	8.0
50<100	10.0	4.5	4.0	1.5	0.7	12.0
100<1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0
Even harmonics are limited to 25% of the odd harmonic limits above.						
Current distortion that results in a DC offset, such as half-wave converters, are not allowed.						
* All power generation equipment is limited to these values of current distortion, regardless of actual I_{sc}/I_L.						

where
I_{sc} = maximum short-circuit current at PCC.
I_L = maximum demand load current (fundamental frequency component) at PCC.

Major function of AHF

AHF is a harmonic generator to analyze and remove the harmonics generated from a nonlinear load.
This enhances the power factor by improving the reactive power, improves the unbalanced load, reduces the load capacity(kva),reduces the voltage harmonic distortion rate(THDV), reduces the voltage drop in transformers and cables, and reduces heating. Inaddition, these can be easily installed in parallel, and two or more ones can be operated in parallel to enable selection of capacity necessary for the improvement of power quality.

Feature of AHF

COMPAC AHF provides real time responsewith constant correction to plant harmonics.The virtually instantaneous response ensuresyour plant power quality is at the highest possible level even with varying harmonic loads.

- THDi < 5%.
- Selection of odd and even harmonics up to the 51th order.
- Intelligent Fast Fourier Transform(FFT) for automatic correction of all 51 harmonic orders.
- High harmonic filtering rate: Up to 97%.
- Reaction time <100us. Response time of<5ms.
- Control Algorithm: FFT, Intelligent FFT and instantaneous reactive power
- Reactive control modes.
- System impedance at each harmonic is learnt by the AHF.
- On initial system connection compensation current is slowly increased with system stability closely monitored.
- Should resonance be detected at any point the intelligent FFT can skip the problematic area.
- Simple wall mount for 30/50/75/100/150 amp sizes.
- Simple rack mount for 30/50/75/100/150 amp sizes.
- Cabinet Type up to 600 Amps.
- Neutral filtering capability 3 times the rated filter current (in case of 4 wire device).
- Increase your capacity as your plant grows. Simply add as many units in parallel as required.
- Complete protection: Automatic current limit protection for power grid over-voltage and under-voltage, power grid over-frequency and under-frequency, inverted sequence of input voltage, over-current, over-heating and over-load, and busbar short-circuit.. All faults are recorded in the event log, which is convenient for failure analysis.
- Multifunctional: Harmonic, reactive power and imbalance compensation.
- Excellent reactive compensation: High speed, Precise (-1.0≤PF≤+1.0), Step-less, Bi-directional (capacitive and inductance) compensation.

Feature of AHF

- Excellent imbalance correction: Both negative and zero sequence, mitigates neutral current.
- Wide input voltage & frequency range, adapts to tough electrical environments.
- Low thermal loss, efficiency ≥ 97%.
- High stability: Infinite impedance to grid, avoids harmonic resonance problems.
- Flexible application: Modular design, embedded in standard or customized cabinet.
- Easy installation and maintenance: Plug-in installation for AHF module replacement and expansion.
- Environmental adaptability: -10~45°C temperature, compatible with diesel generator.
- Improvement of 3P unbalance
  - Improvement of unbalance between phases depending on the use of 1P load in a 3P 4-wire system.
- Modular design, easy to expand, up to 8 modules can beconnected in parallel.
- Plug-in frame or wall-mounted installation, adapt to variousenvironments.
- The CT installation position is flexible, which can be connected close to the power supply side or the load side.

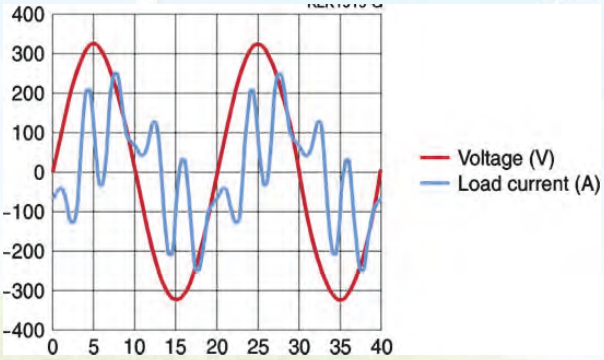
High reliability of AHF

• Integrated intelligent FFT calculation method
- Compensation of harmonics to realize stabilization of a system by monitoring the power system in real time
• Protection of resonance through a high-class control algorithm
- AHF is designed to "shut-down" to prevent damage to the equipment in case of parallel resonance with the load change.
• Protection mode
- Can diagnose the internal temperature to prevent overheating of internal components
- Internal short circuit
- Protection from overloads
- Cooling system (Cooling design)

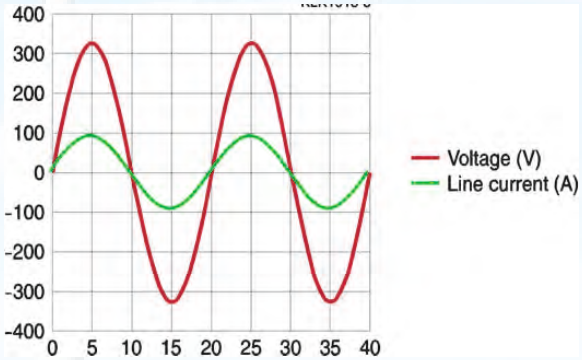
*Dust protection function and natural cooling system
*Ventilation fan effective for heat loss

Active harmonic filter

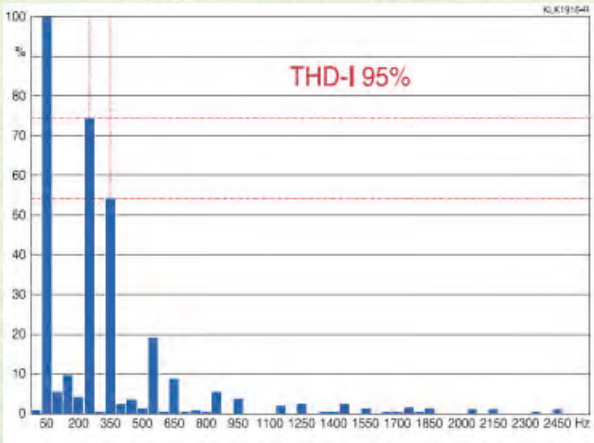
Without COMPAC AHF Harmonic disturbances caused by e.g. actively non-linear loads



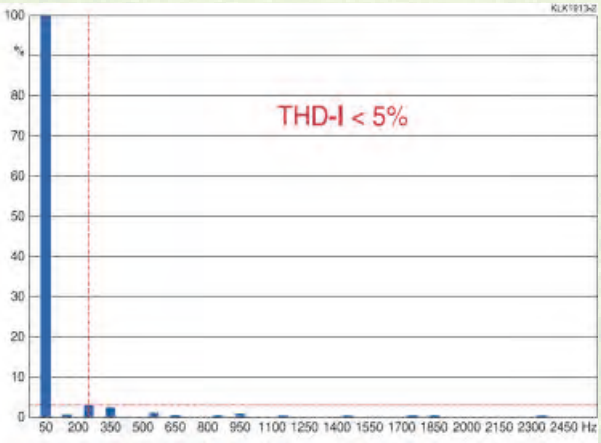
With COMPAC AHF Reactive power harmonic oscillations are compensated



Total harmonic current distortion without active filter

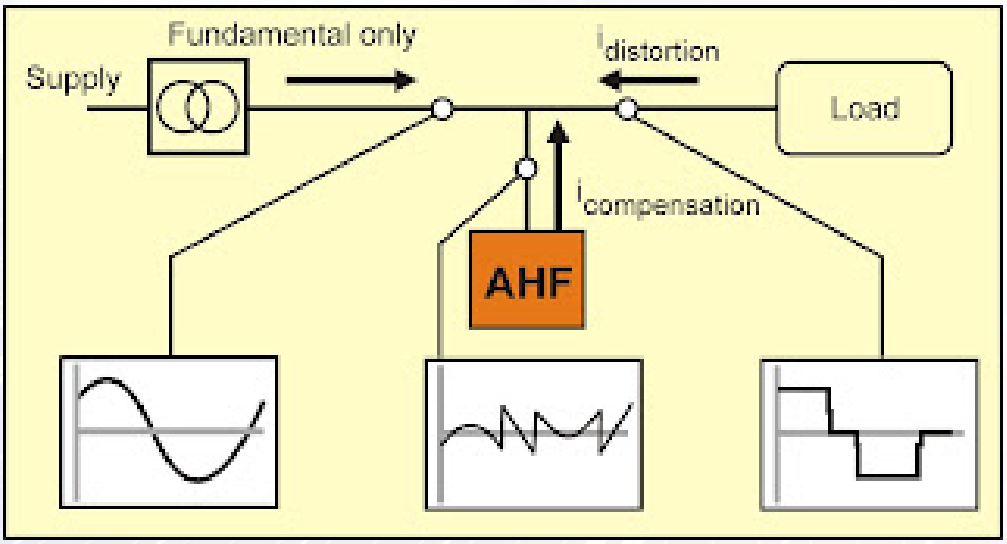


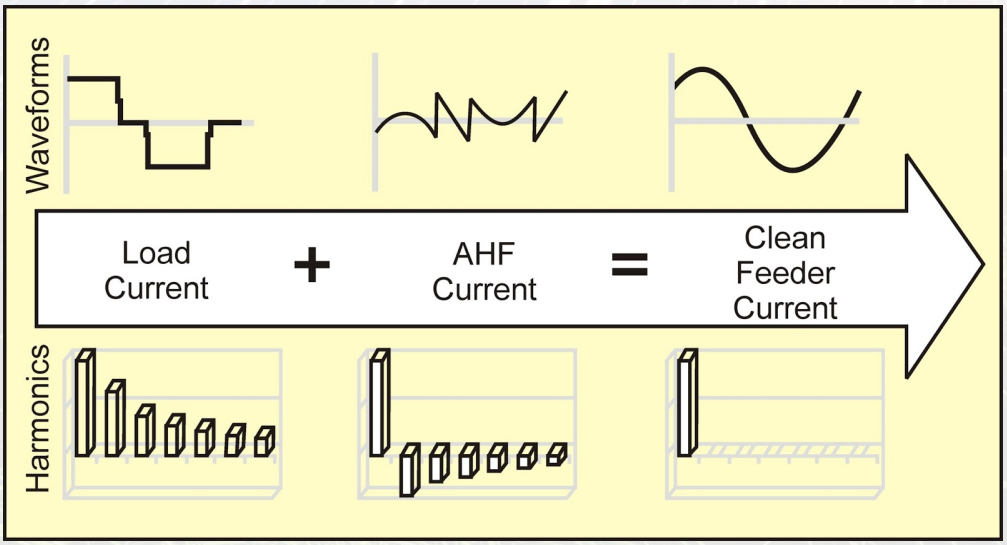
Current harmonics distortion



COMPAC AHF
OPERATING PRINCIPLES

Load current, including harmonics, are detected through external CTs and, are fed to the internal DSP and CPU where an intelligent FFT algorithm separates the harmonic currents from the fundamental current. A compensating harmonic current, of equal magnitude but 180° out of phase, is dynamically and accurately calculated and sent to the IGBT control. At the same time, the internal CT's detect the output current and provide negative feedback to the DSP which then makes adjustments to achieve a more accurate and stable system.



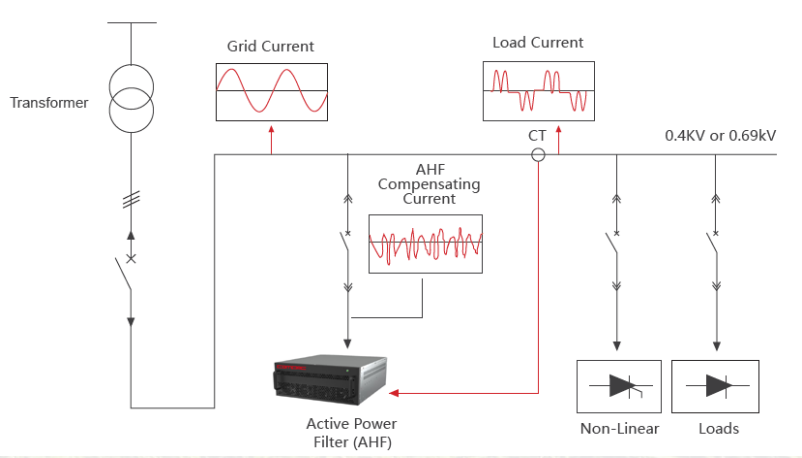


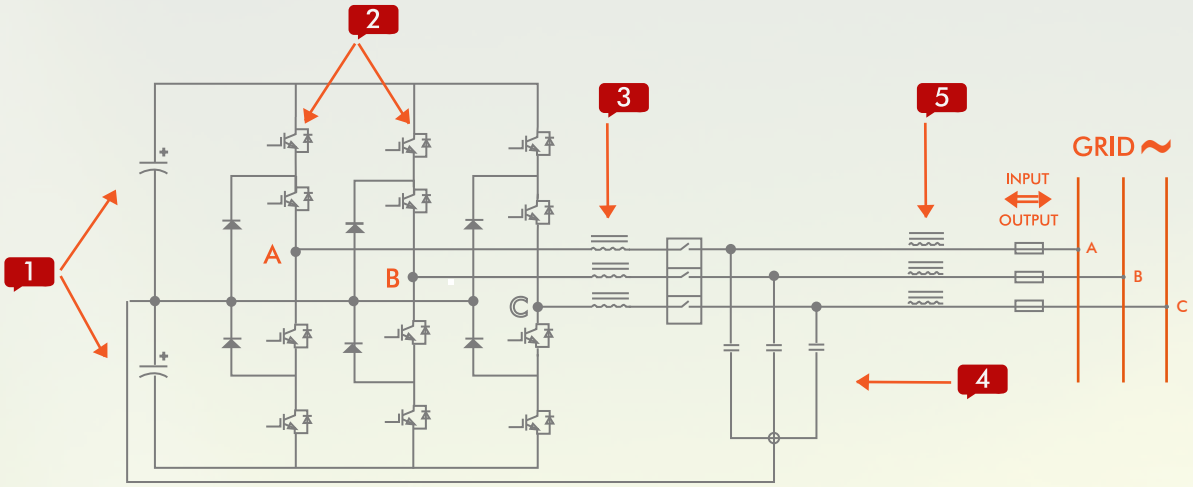
PROTECT YOUR SYSTEM FROM RESONANCE

Maintaining a reliable supply free from resonance and instability is the biggest challenge for an active harmonic filter. The COMPAC AHF utilises the very latest digital control technology and applies a unique Intelligent FFT (Fast Fourier Transform)algorithm.
AHF avoids resonance by effectively learning each individual harmonic system impedance when first turned on. Compensation current is slowly increased for each harmonic frequency with the AHF constantly monitoring the stability of the network. Should resonance occur at any point on any harmonic then AHF IFFT skips the problematic point.
Even stable electrical systems change –loads change, impedance values change – so resonance points change too. AHF constantly monitors for resonance and will avoid new resonance points as they occur.

The 3-Level Topology Design Approach

COMPAC's innovative three level inverter is the foundation of every AHF unit. The modular three level inverter uses 12 IGBTs so reduces the switching loses and permits higher switching speeds. The need for small filter components provides for an ultra-compact, modular design with an improved waveform resulting in very low harmonic distortion and low levels of electromagnetic interference. Multiple COMPAC AHFs can be configured to operate together simply by connecting the external CTs in series through all the units.





Three-level topology circuit:

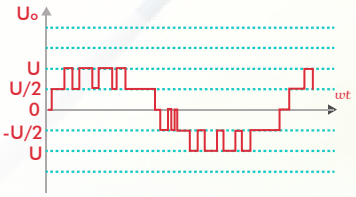
DC BUS CAPACITOR 1

AC to DC rectifier storage

IGBT 2

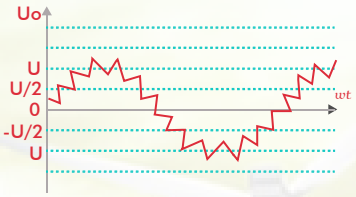
Controlled by DSP software algorithm, IGBT on-off timing selection and length could control inverter to generate a harmonic current.

IGBT generates square wave, it's outline is like sinusoid.



INVERTER INDUCTION 3

The square wave will convert into triangular wave, which is more like sinusoid after inverter inductor.



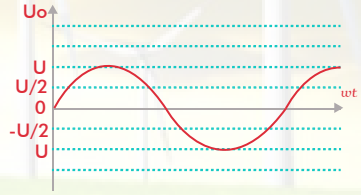
LCL FILTER CIRCUIT

LC FILTER CIRCUIT 4

LC filter circuit filter out impurities of the harmonic. High frequency inductor The rest of high frequency harmonic will be filtered by the high frequency inductor.

HIGH FREQUENCY INDUCTOR 5

Both for filtering. The combination of LC filter circuit and high frequency inductor are called LCL filter circuit



AHF Structure

COMPAC AHF has a modular design. the Active Power Filter system consists of one or several AHF modules and a display.

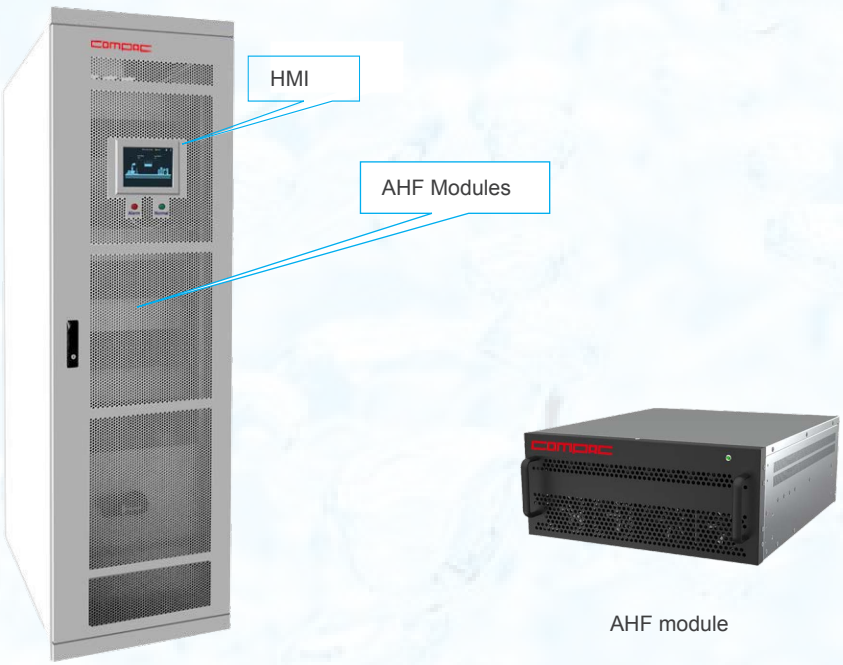
- Cabinet based systems come complete with 7-Inch/10-Inch LCD touch screen (optional) so you can see exactly what is happening with your complete system. In addition to the information available on the standard unit display you can view individual module temperatures, THDv, THDi, voltage waveforms, harmonic spectrum.
- RS485, RJ45 network port
- Modbus RTU protocols supported

Each AHF module is an independent harmonic filtering system, and users can change the harmonic filtering system rating by adding or removing AHF modules. According to the mounting type, AHF can be divided into Modular AHF (rack mounting) and Wall-mounted AHF.

modular AHF

Module display Interface 10-Inch LCD touch screen(rack-mounted) ; 4.3-Inch LCD touch screen(wall-mounted).
AHF modules and HMI can be embedded in COMPAC standard AHF cabinet or a customized cabinet. There are breakers, cable terminals and Surge Protection Device (SPD) in the AHF cabinet.

- cabinet type AHF



AHF module

Wall-mounted AHF /Rack-Mounted AHF

Wall-mounted AHF can be installed on a wall, which is suitable for low rating applications, and wall-mounted type HMI can be installed on the wall-mounted AHF module, along with a mounting bracket to provide support and protection.

Rack-Mounted AHF module

Wall-mounted AHF with HMI and Bracket

AHF Compensation Performance

COMPAC AHF can perfectly mitigate harmonic current, and suppress harmonic voltage caused by the harmonic current. When the AHF capacity is sufficient and background harmonic voltage is low, the AHF ensures excellent compensation performance at full load condition, as below.

- THDu (Total Harmonic Distortion of Voltage) < 3%
- THDi (Total Harmonic Distortion of Current) < 5%
- PF (Power Factor) ≥ 0.99 (improves both leading and lagging PF)
- Neutral Current Attenuation Ratio ($\frac{I_{N(Before)} - I_{N(After)}}{I_{N(Before)}}$)>95%

Power Quality Viewer

- AHF provides a power quality viewer integrated with HMI including a graphic user interface. The PQ viewer provides the harmonic analysis, type monitoring and direct control of an active harmonic filter without PC.

PQ measurement

- Comprehensive provision of measurement data on the analysis of average values

– RMS of voltage and current

– It displays the electric parameters (IS&IL) connected currently, and the sum (IO) of output current of all equipment.

– Displays the real-time measured data of the module including the output current, active power, reactive power, apparent power, power factor, temperature, degree of unbalance and bus voltage.

– It displays the voltage and current waveform of grid. The zoom-in and zoom-out button realizes the function of zooming in and zooming out the waveform, and the menu bar can switch between voltage and current curves.

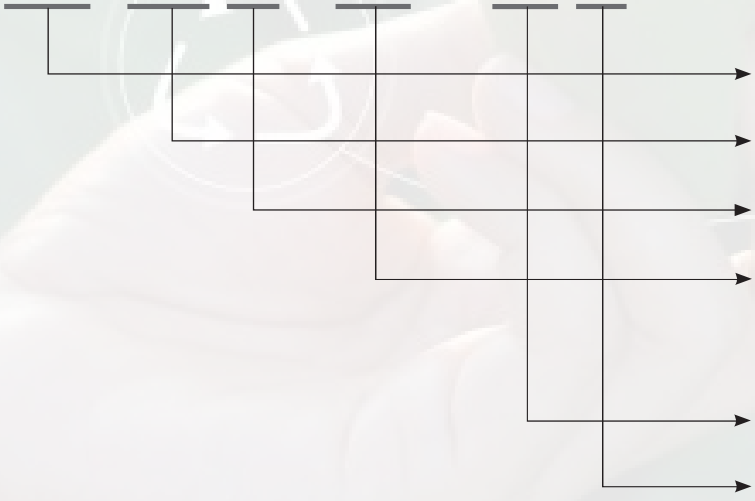
– The data of harmonic waves can be viewed. The menu bar on the right can be switched between the data and the bar chart.

– The bar chart of harmonic waves can be viewed.

– Can check the harmonic content in the load current through spectrums up to 2 ~ 51 degrees

Model Code Selection

CEM AHF 3 - 100 / 0.4 B



- COMPAC
- Active Harmonic Filter (AHF)
- 3 : 3P3W, 4 : 3P4W
- AHF Compensation Capacity:
  30 : 30A, 50 : 50A, 75 : 75A,
  100 : 100A, 150 : 150A Up to 600A
- Line Votage (kV)
- M-Rack type
  B-Wall-mounting type
  G-Cabinet type

Specification

· (B-Wall-mounting type)							
MODEL (3P3W)(3P4W)	Rated Voltage	Rated Current	Module	Power efficiency	Noise level	Dimension W x H x D	Weight
CEM - AHF 3 (4) - 30 / 0.4B	380VAC (400V LL ±15%)	30A	1EA	97%	≤65dB	444 x 609 x 149 mm	24kg
CEM - AHF 3 (4) - 50 / 0.4B		50A	1EA			444 x 609 x 149 mm	24kg
CEM - AHF 3 (4) - 75 / 0.4B		75A	1EA			444 x 609 x 149 mm	24kg
CEM - AHF 3 (4) - 100 / 0.4B		100A	1EA			520 x 759 x 237 mm	51kg
CEM - AHF 3 (4) - 150 / 0.4B		150A	1EA			520 x 759 x 237 mm	51kg
· (M-Rack type)							
MODEL (3P3W)(3P4W)	Rated Voltage	Rated Current	Module	Power efficiency	Noise level	Dimension W x H x D	Weight
CEM - AHF 3 (4) - 30 / 0.4M	380VAC (400V LL ±15%)	30A	1EA	97%	≤65dB	501 x 142 x 609 mm	24kg
CEM - AHF 3 (4) - 50 / 0.4M		50A	1EA			501 x 142 x 609 mm	24kg
CEM - AHF 3 (4) - 75 / 0.4M		75A	1EA			501 x 142 x 609 mm	24kg
CEM - AHF 3 (4) - 100 / 0.4M		100A	1EA			581 x 230 x 729 mm	51kg
CEM - AHF 3 (4) - 150 / 0.4M		150A	1EA			581 x 230 x 729 mm	51kg
· (Cabinet - 50A Module)							
MODEL (3P3W)(3P4W)	Rated Voltage	Rated Current	Module	Power efficiency	Noise level	Dimension W x D x H	Weight
CEM - AHF 3 (4) - 50 / 0.4G	380VAC (400V LL ±15%)	50	1EA	97%	≤65dB	600 x 800 x 1400mm	150kg
CEM - AHF 3 (4) - 100 / 0.4G		100	2EA				190kg
CEM - AHF 3 (4) - 150 / 0.4G		150	3EA			600 x 800 x 2000mm	280kg
CEM - AHF 3 (4) - 200 / 0.4G		200	4EA				320kg
· (Cabinet - 75A Module)							
MODEL (3P3W)(3P4W)	Rated Voltage	Rated Current	Module	Power efficiency	Noise level	Dimension W x D x H	Weight
CEM - AHF 3 (4) - 75 / 0.4G	380VAC (400V LL ±15%)	75	1EA	97%	≤65dB	600 x 800 x 1400mm	160kg
CEM - AHF 3 (4) - 150 / 0.4G		150	2EA				220kg
CEM - AHF 3 (4) - 225 / 0.4G		225	3EA			600 x 800 x 2000mm	280kg
CEM - AHF 3 (4) - 300 / 0.4G		300	4EA				320kg
· (Cabinet - 100A Module)							
MODEL (3P3W)(3P4W)	Rated Voltage	Rated Current	Module	Power efficiency	Noise level	Dimension W x D x H	Weight
CEM - AHF 3 (4) - 100/0.4G	380VAC (400V LL ±15%)	100	1EA	97%	≤65dB	800 x 900 x 1400mm	186kg
CEM - AHF 3 (4) - 200/0.4G		200	2EA				246kg
CEM - AHF 3 (4) - 300/0.4G		300	3EA			800 x 900 x 2000mm	296kg
CEM - AHF 3 (4) - 400/0.4G		400	4EA				336kg
· (Cabinet - 150A Module)							
MODEL (3P3W)(3P4W)	Rated Voltage	Rated Current	Module	Power efficiency	Noise level	Dimension W x D x H	Weight
CEM AHF 3 (4) - 150 / 0.4G	380VAC (400V LL ±15%)	150	1EA	97%	≤65dB	800 x 900 x 1400mm	186kg
CEM AHF 3 (4) - 300 / 0.4G		300	2EA				246kg
CEM AHF 3(4) - 450 / 0.4G		450	3EA			800 x 900 x 2000mm	296kg
CEM AHF 3 (4) - 600 / 0.4G		600	4EA				336kg

TECHNICAL PARAMETER

COMPAC-AHF				
Grid	400V		690V	
Mounting Type	Wall-mounted Rack-mounted	Cabinet	Floor type	Cabinet
System				
Rated Input	400V LL ±15%		690V LL ±15%	
Power Grid Frequency	50/60Hz ±5%			
Parallel Operation	8 modules, customizable			
Overall Efficiency	≥97%(laboratory data)			
Power Grid Structure	3P3W,3P4W		3P3W	
Circuit Topology	3-level			
Performance Indicators				
Rated Capacity	30A/50A/75A/100A/150A	Up to 600A	100A/125A/150A	Up to 500A
Compensation Mode	Harmonic, reactive power, unbalance			
Filtering Range	2 to 51 orders			
Filtering Order	Selectable from 2 to 51			
Filtering Degree	Adjustable from 2 to 51			
Reaction Time	<100μs			
Response Time	<5ms			
Target Power Factor	Adjustable from -1 to +1			
Control Algorithm	FFT, Intelligent FFT and instantaneous reactive power			
Switching Frequency	20kHz/60kHz			
Cooling Mode	Forced air cooling			
Noise Level	≤65dB			
Communications and Monitoring Capabilities				
Communications Port	RS485 and network port(RJ45)			
Communications Protocol	Modbus-RTU			
Module Display Interface	4.3in LCD/ LED indicator	7in/10in LCD touch screen(optional)	LED indicator	7in/10in LCD touch screen(optional)
Protection Function	Automatic current limit protection for power grid over-voltage and under-voltage, power gridover-frequency and under-frequency, inverted sequence of input voltage, over-current,over-heating and over-load, and busbar short-circuit.			
Monitoring Alarm	Available			
Monitoring	Independent monitoring and centralized monitoring			
Environment Requirements				
Altitude	1,000m, for every increased 100m, the power is reduced by 1%.			
Operating Temperature	-10℃~45℃			
Relative Humidity	5% to 95%,non-condensing			
Protection Class	IP20			
Related Standards				
Directive	2014/30/EU 2014/35/EU			
Standards Compliance	EN 61000-6-2:2005+AC:2005 EN 61000-6-4:2007+A1:2011 EN 50178:1997			

COMPAC ELECTRIC MFG. CO., LTD.
info@compacelectric.eu