FUSECO


*Unrivalled in its class.*

# Modular Active Harmonic Filters

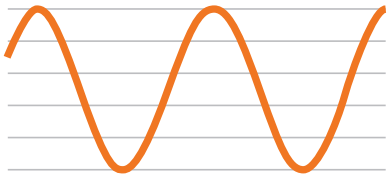
Sinexcel®

# The Need for Harmonic Mitigation

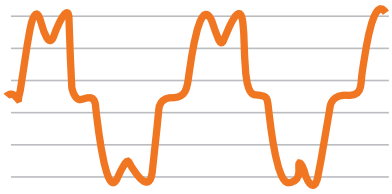
Harmonics are additional frequencies beyond the fundamental frequency (50Hz) and their presence in an electrical system distorts the clean shape of a sine wave.

A harmonic of a wave is a component frequency of the signal that is an integer multiple of the fundamental frequency. In the case of the Australian electricity supply, the fundamental frequency is 50Hz, so the frequencies of the harmonics are 100Hz, 150Hz, 200Hz, 250Hz, 300Hz, 350Hz and so on. 100Hz is called the 'second' harmonic (2 x 50Hz), 250Hz is called the 'fifth' harmonic (5 x 50Hz), etc.

The impact of harmonic pollution is an increasing problem given the growth of sophisticated power electronics and the proliferation of non-linear loads in power systems. Such loads are increasingly used in all industrial, commercial and residential installations.



*Sinusoidal AC Waveform*



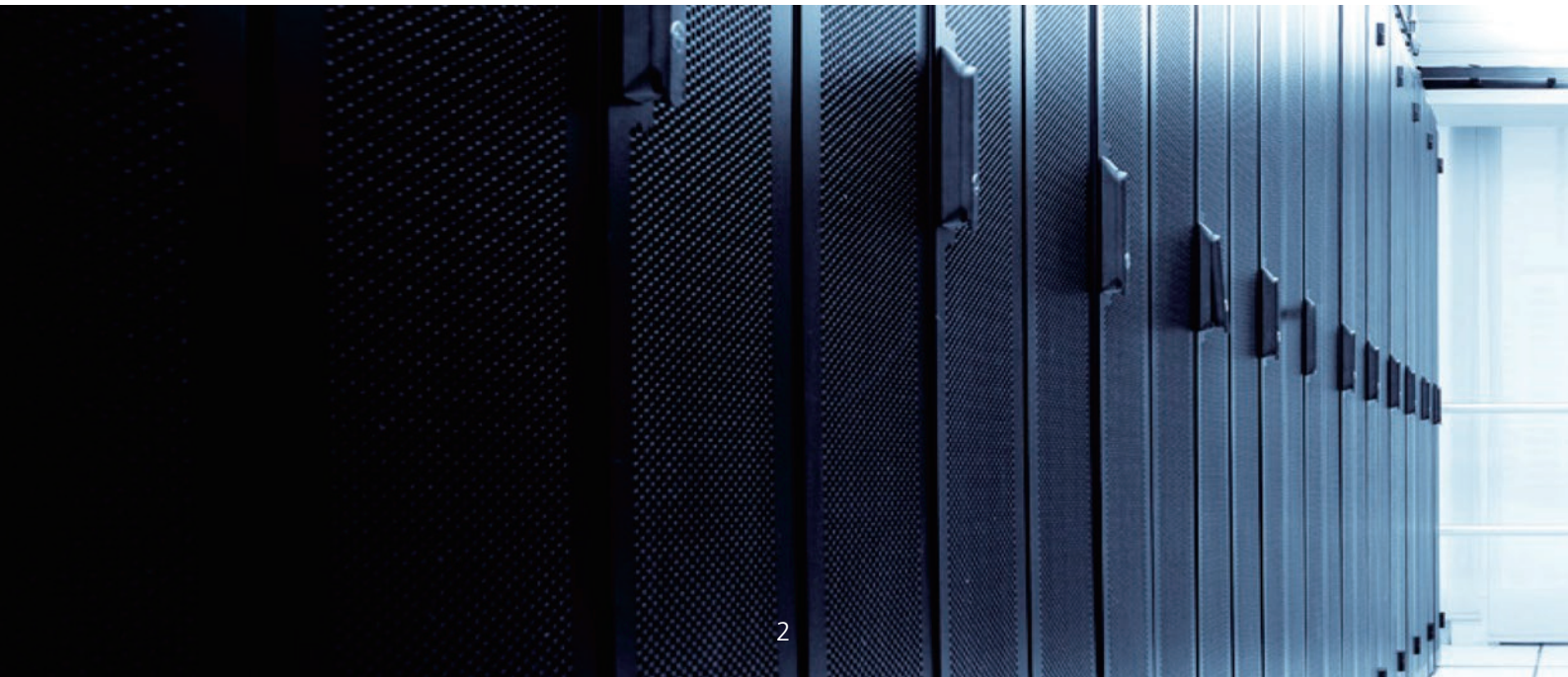
*Waveform influenced by harmonics*

## What are non-linear loads?

Non-linear loads change their impedance by conducting current only near the peak of the wave. Switching loads on and off during the waveform results in non-sinusoidal current pulses. These pulses introduce reflective currents (harmonics) back into the power distribution system. The resulting non-sinusoidal waveforms have the fundamental wave plus integral multiples of that fundamental wave.

Typical non-linear loads include:

- Variable speed drives for asynchronous and DC motors
- Industrial equipment (induction furnaces, static converters, welding machines)
- Uninterruptible power supplies (UPS) and saturated magnetic devices
- Office equipment (computers, servers, printers, photocopy machines)
- Switch-mode power supplies, fluorescent lighting, TV, light dimmers, microwave ovens, etc.



## What are the effects of harmonics?

The presence of harmonic currents increases the RMS current in power networks and creates voltage harmonics resulting in voltage distortions. Such adverse effects are often manifested in the following forms:

- Overheating (thermal losses) of cables, transformers, motors & distribution panels resulting in greater electrical & mechanical stress on the electrical system
- Costly downtime leading to higher operation and replacement costs
- Reduction in the lifespan of equipment, including motors and drives
- Premature degradation of a motor's bearings & insulation
- Overloading of neutral conductors
- Load imbalance
- Unstable network conditions
- Malfunction or premature failure of equipment
- Reduced safety levels of installations
- Logic faults or component failures in PLC's/SCADA/BAS systems or other sensitive loads
- Nuisance tripping of protective devices
- Poor power factor

## What is harmonic mitigation?

Harmonic mitigation is taking action to minimise the presence of harmonics in your electrical system and can achieve great cost savings as well as fulfil the requirement to comply with the Australian Standards for harmonic voltage distortion AS/NZS 61000.3.6 which is compatible with the world reference IEEE 519 recommendations.

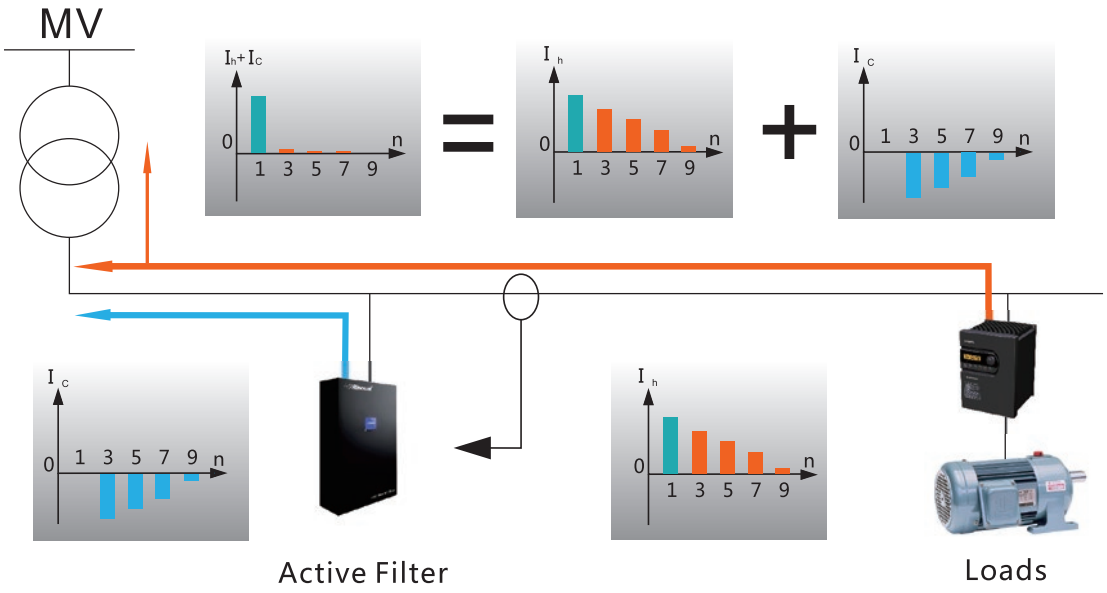
# Advanced Performance

## The 3-Level Topology Design Approach

Sinexcel have introduced their latest generation range of Active Harmonic Filters that incorporate many unique and innovative design features. Active Harmonic Filters are designed for mitigating harmonics that are injected into power networks by non-linear loads.

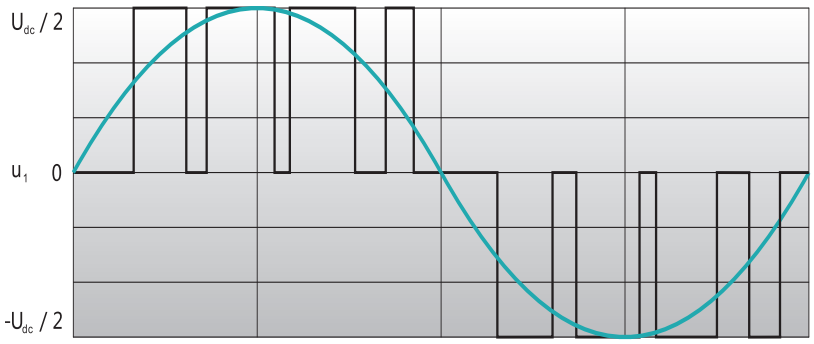
Generally installed in parallel to the polluting loads, the active filters analyse the line current harmonics drawn by the loads and generate a compensation current at the opposite phase angle, thereby "neutralising" the harmonic currents.

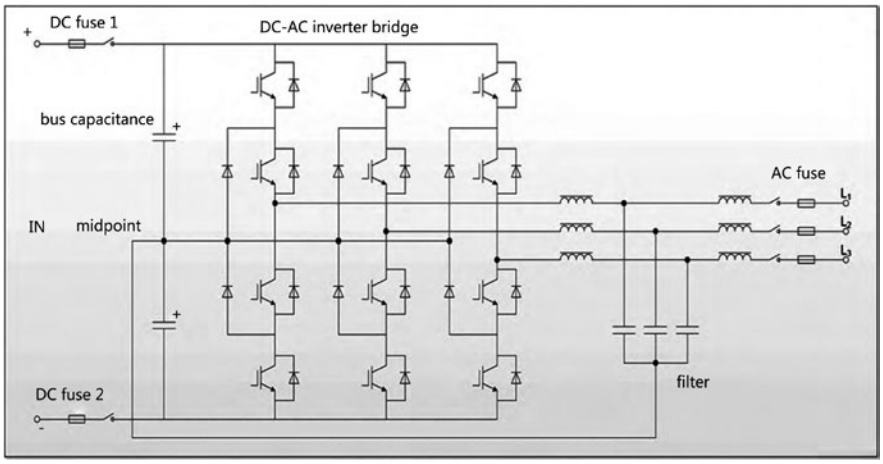
The unique technology incorporated within Sinexcel Active Harmonic Filters consists of the control current operating circuit and the compensated current generating circuit.




When harmonic mitigation is required, the operating circuit measures the load current and calculates the harmonic current spectrum via the advanced control algorithm programmed in the DSP. Sinexcel AHF series employs a Fast Fourier Transform (FFT) logic calculation method for the harmonic current spectrum from the 2nd to the 50th order. The logic then determines the amplitude of the compensated current control signal, to be injected at the opposite phase angle for each harmonic order selected for mitigation.

The compensated current generating circuit will then provide a control signal to the IGBT (semiconductor switch) via Pulse Width Modulation (PWM) and consequently a compensation current with perfect opposite phase for each harmonic is injected into the system. As a result, the harmonic currents at the supply side are significantly reduced.






3-level Topology Circuit Diagram

Owing to its 3-level topology design based on a zero level voltage transformation (comprising of IGBT's of lower voltage corresponding higher switching frequency). Sinexcel Active Harmonic Filters are capable of suppressing the undesirably generated ripple currents effectively and promote a high compensation precision for the output waveform with respect to the sinusoidal waveform.

## Harmonics Compensation Capability

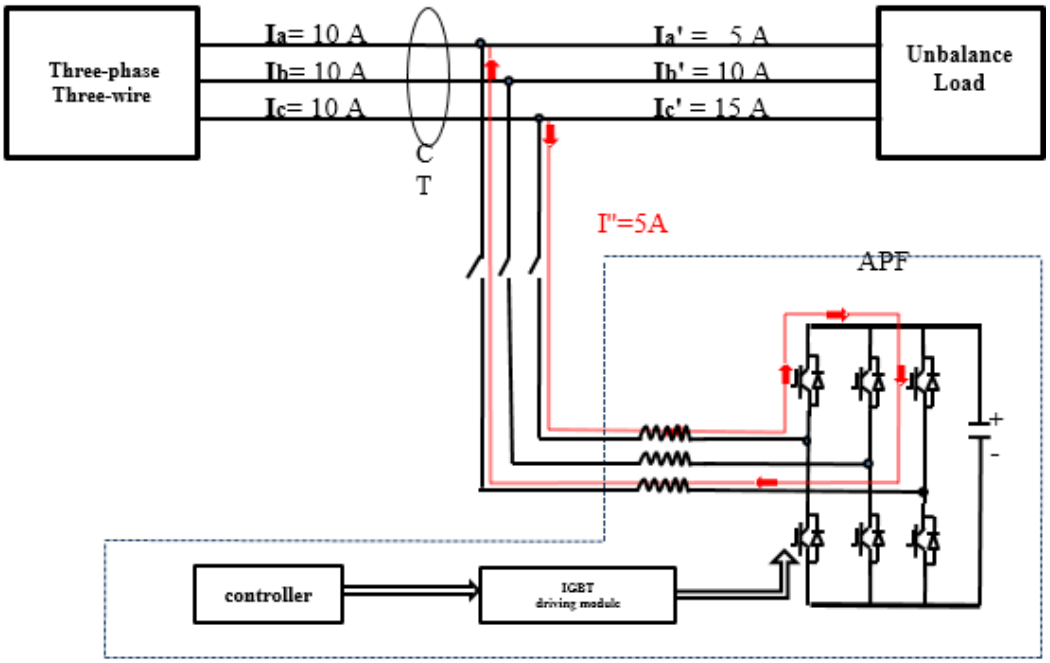
Compensates 2nd to 50th harmonic order or simultaneous compensation or all 50 harmonic orders.

## Algorithm Intelligence

Intelligent technology that integrates both FFT and Dynamic Compensation Modes, customised to the client's requirements

## Load Balancing and Reactive Power

During operation, Sinexcel Active Harmonic Filters are capable of measuring each phase and then redirecting the existing load current to balance the phases. They are also capable of using their remaining capacity to dynamically inject reactive power to correct the power factor. It is possible for the user to program the unit to prioritise load balancing or reactive power, depending on the application.



# Modular, Compact Size and Light Weight

Traditional Active Harmonic Filters are large and heavy, often taking up valuable floor space in switch rooms. Sinexcel have applied new generation thinking and innovative design principles to create a range of Active Harmonic Filters that feature a modular design and are available in wall-mount, rack-mount 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

## 25A & 35A Solutions


▲ 25A & 35A Rack-Mounted AHF – 18kg
440W x 470D x 150H (mm)

25A & 35A ▶
Wall-Mounted AHF – 18kg
440W x 150D x 470H (mm)


## 50A, 60A & 75A Solutions


▲ 50A & 60A Rack-Mounted AHF – 35kg
440W x 450D x 230H (mm)

50A & 60A ▶
Wall-Mounted AHF – 35kg
440W x 190D x 490H (mm)



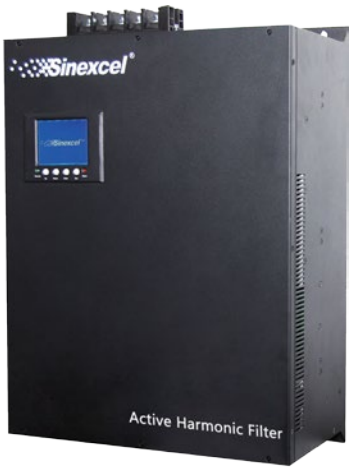
▲ 75A Rack-Mounted AHF – 35kg
500W x 600D x 191H (mm)

75A Wall-Mounted AHF – 35kg ▶
500W x 191D x 560H (mm)

# 100A Solutions


▲ 100A Rack-Mounted AHF – 36kg
440W x 630D x 230H (mm)

100A Wall-Mounted AHF – 36kg ▶
440W x 235D x 625H (mm)




# 150A Solutions


▲ 150A Rack-Mounted AHF – 48kg
500W x 520D x 270H (mm)

150A Wall-Mounted AHF – 48kg ▶
505W x 286D x 557H (mm)


# Cabinet Solutions

▲ 400V AHF Cabinet with
no centralised monitoring

▲ 400V AHF Cabinet with
centralised monitoring
and 500A capacity

▲ 480V/690V AHF Cabinet

# Key Features

## Easy to Use Graphical User Interface

The Sinexcel AHF series integrates a HMI including a graphical user interface. It offers direct control, configuration, monitoring and harmonics analysis of the AHF without the need of a PC. Communication options, detailed alarm events and fault reporting with real time stamp are also included.

## Backlit Display

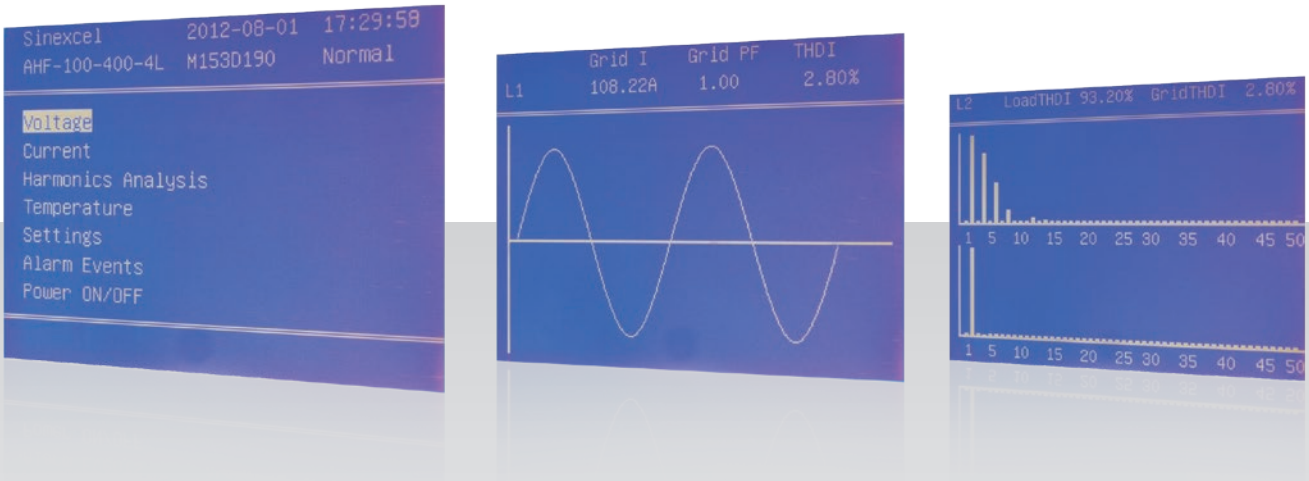
Incorporating a high level of readability and ease of menu navigation, the backlit LCD display offers:

- 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

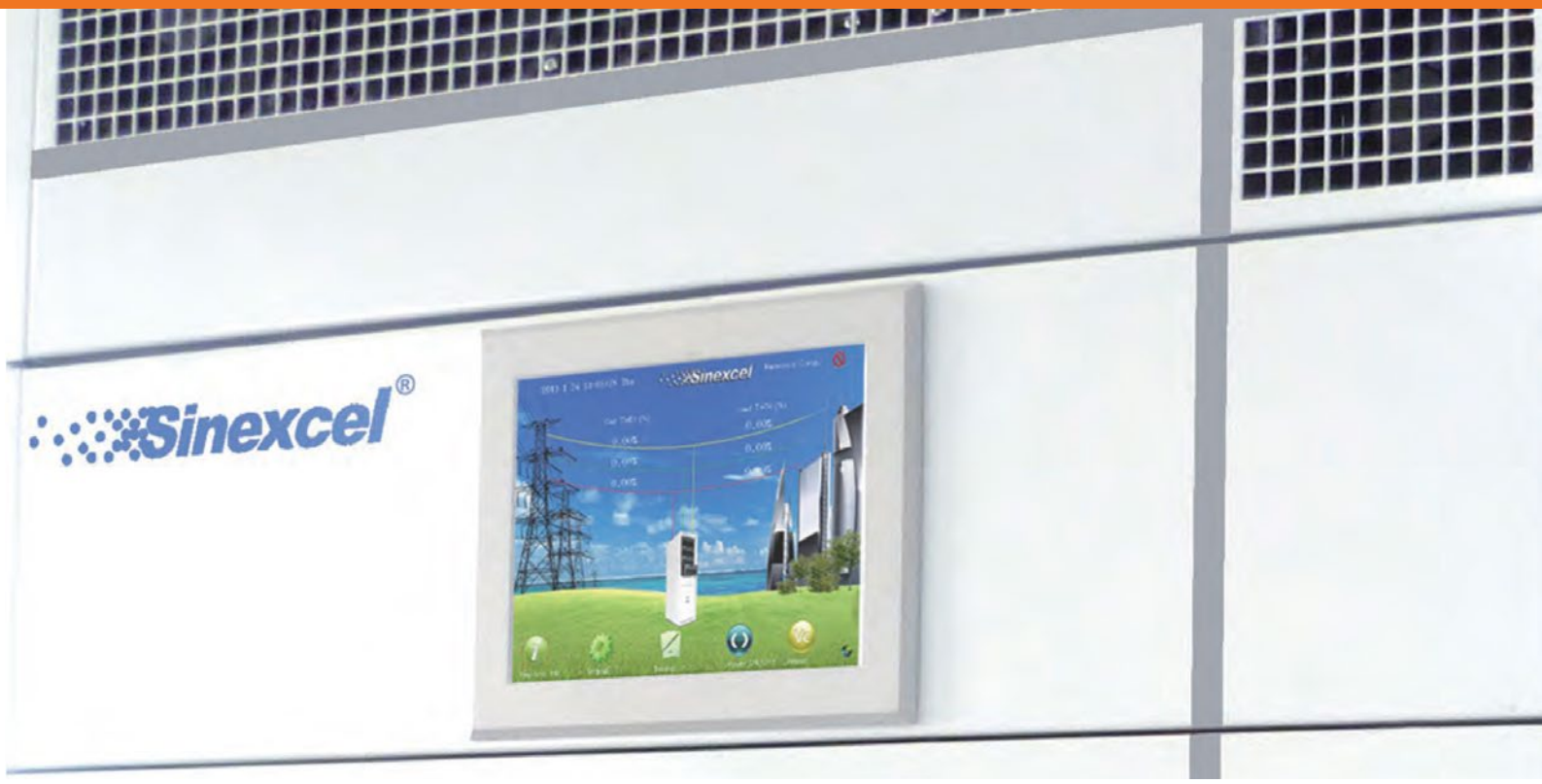
Provides a comprehensive set of measurement data for analysis, such as:

- 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)
- Graphical waveform of network voltages and currents, load and compensated currents
- Harmonic spectrum for network and load currents, from 2nd to 50th harmonic order






Sinexcel®




## Alarms and Fault Reporting

Detailed alarms and fault messages with real time stamping are provided for quick troubleshooting.

Modes of protection include:

- Over-temperature
- Inverter bridge in event of abnormal operations
- Over and under voltage
- Malfunction of ventilation fan
- Communication faults

## Ease of Installation & Commissioning

- Designed to be a 'Plug & Play' experience for the user
- Installation & Commissioning process is the industry benchmark for simplicity and ease of use.
- Fuseco provide comprehensive customer support from our Power Quality Consultants

## Available in Various Configurations

- 3-Wire and 4-Wire versions available
- Available in 690V
- Available in IP20, IP31 and IP54 versions to suit a wide variety of industry applications

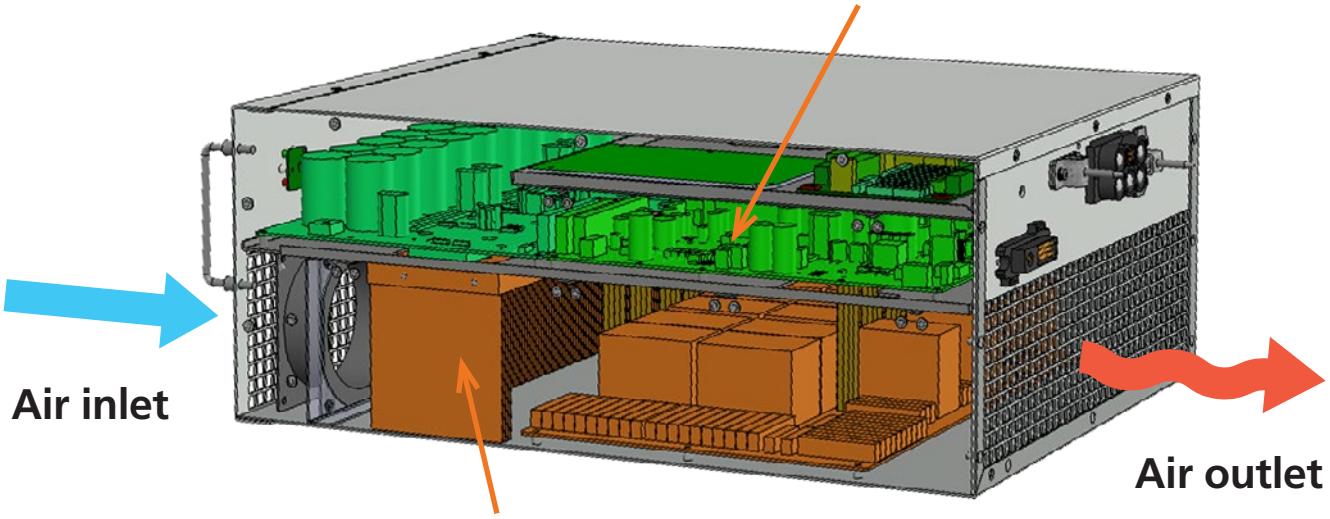
## 1 Year Warranty (conditions apply)

# Intelligent Design

## Designed for Efficiency & Minimal Maintenance

### Minimising Dust Ingress

Electronic components separated from heat producing components and housed in their own sealed compartment, resulting in greater protection from the effects of heat and dust ingress.




### Optimum Heat Dissipation

Heat sinks, IGBT's, inductors and other heat producing components housed in a separate compartment optimised for efficient ventilation and cooling.

## Protection Features

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

# Site Audit

A Power Quality Site Audit is a service offered by Fuseco to our customers. A Power Quality Consultant visits your site and conducts a power quality audit of your electrical system.

This involves setting up sophisticated measuring equipment on site that monitors and records all of the electrical activity that is occurring within the system over a period of time. The equipment is compact, easily transportable to most locations and can be set up indoors or outdoors.

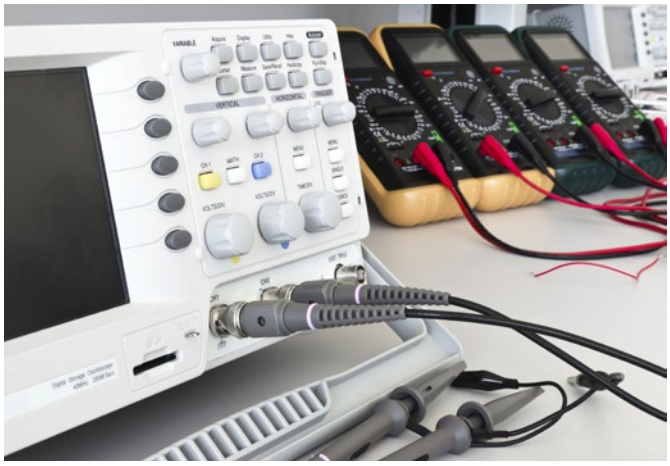
An analysis of the recorded data usually helps to reveal any harmful harmonics, voltage supply and power factor issues. Our power consultant will consider the data and present you with a power quality report, outlining the observed issues and suggesting solutions if required.

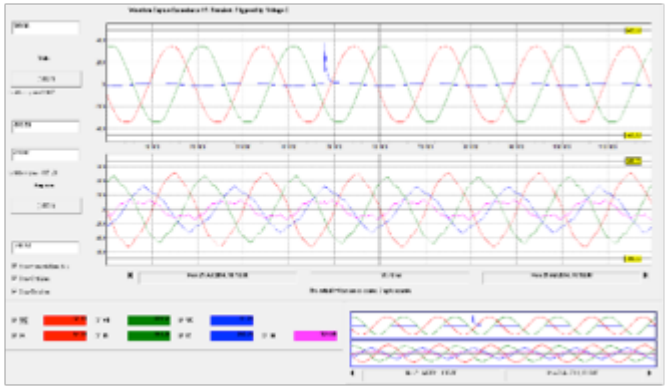
Audits are useful in determining electricity usage inefficiencies and identifying damaging harmonics which occur in electrical systems.

Even correctly functioning power systems require routine auditing to ensure early identification of any potential issues and proactive servicing requirements to keep power equipment operating to its full potential and the electrical environment complying to the Australian Standard AS/NZS 61000.3.6 and compatible with the IEEE519 recommendations.

A correctly functioning system could save you upwards of 30% off your power bills. In some industries and installations, that could translate to significant increases to your bottom line. By running an efficient system you also use less energy and therefore help the environment.

To discuss our site analysis service in more detail, please contact a power quality consultant at Fuseco.



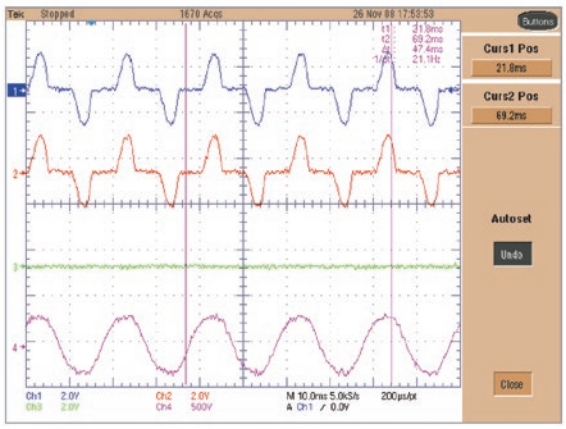


# Applications

## Waveform Analysis

The following example of a waveform analysis demonstrates the harmonic compensation effectiveness of introducing a Sinexcel Active Harmonic Filter into an electrical system.
Please note that the blue wave is the source current and the green wave is the compensation current created by the Active Harmonic Filter.

### Single Peak Wave

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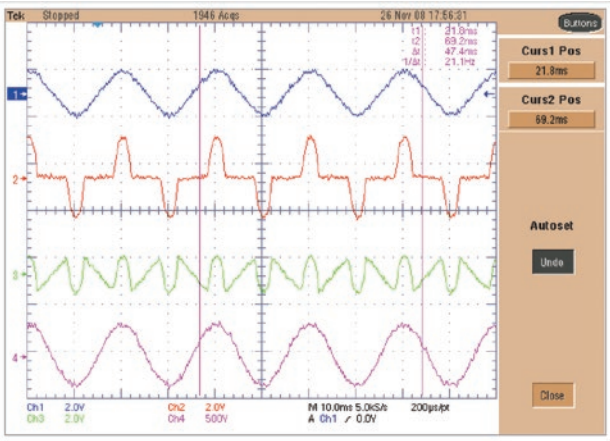
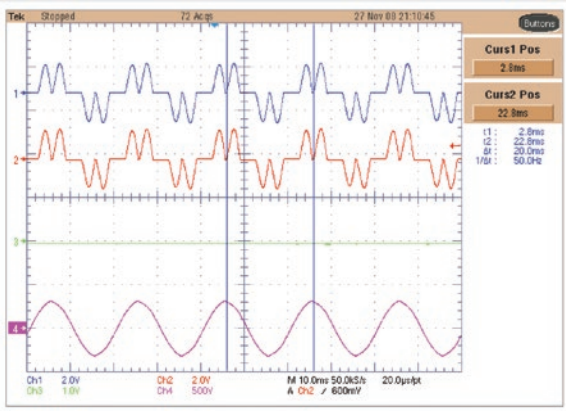



AFTER

### Double Peak Wave

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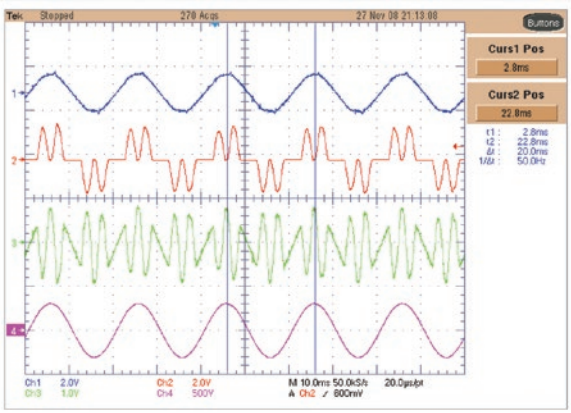


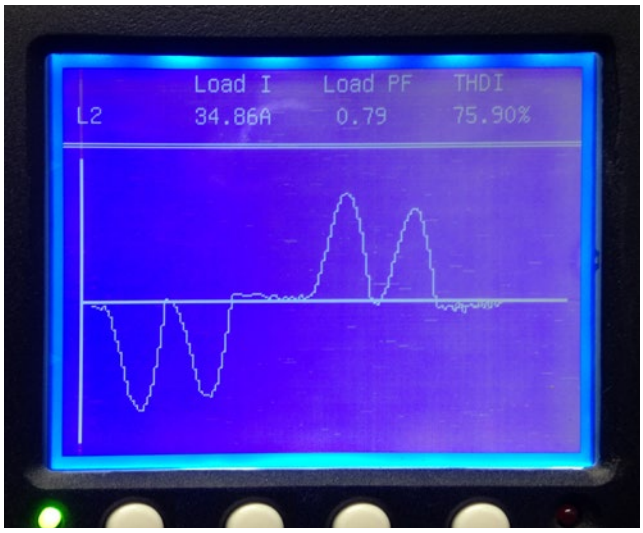

AFTER

## Common Applications for Active Harmonic Filters

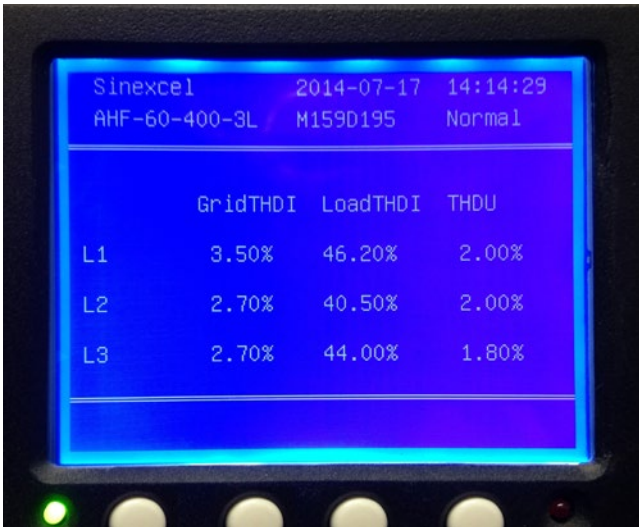
- Data Centres
- Water recycling
- Mechanical Services
- Hospitals
- Electrical Vehicles
- Multi-media
- Water reticulation
- Gas & Oil
- HVAC
- Building
- Water treatment
- Manufacturing
- Broadcasting
- Chemical
- Rail network

# Actual example


New installation had to comply with Australian Standards. The site engineers wished to achieve a THDi of <5%. A Sinexcel 60A Active Harmonic Filter was mounted onto a chiller.




This is the chiller load before harmonic compensation commenced.




This is the grid THDi after the Sinexcel AHF was installed. All phases are well under 5% THDi.


This post-AHF installation screen shot shows the THDi achieved (<5%) and with the injection of reactive power it shows the resulting Power Factor.

# Standards

## What is IEEE 519?

The IEEE is the Institute of Electrical and Electronics Engineers.

IEEE 519, "Recommended Practices and Requirements for Harmonic Control in Electric Power Systems," was published in 1981. The document established levels of voltage distortion acceptable to the distribution system. This document has been widely applied in establishing needed harmonic correction throughout the electrical power industry.

The new IEEE 519, published in 1992, sets forth limits for both harmonic voltages on the utility transmission and distribution system and harmonic currents within the industrial distribution systems.

**IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems** *Table 10-3 of IEEE Std 519-1992*

| ISC/IL | <11 | 11≤h<17 | 17≤h<23 | 23≤h<35 | 35≤h | Total Demand Distortion |
|---|---|---|---|---|---|---|
| **<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 |

NOTE:

• Current Distortion Limits for General Distribution Systems (120V through 69,000V) • Maximum Harmonic Current Distortion in Percent of I L • Individual Harmonic Order (Odd Harmonics) • Even harmonics are limited to 25% of the odd harmonic limits above • Current distortions that result in a dc offset, e.g. half-wave converters, are not allowed • All power generation equipment is limited to these values of current distortion, regardless of actual ISC/IL (ISC = maximum short-circuit current at PCC; IL = maximum demand load current, fundamental frequency component, at PCC)

## Australian Standards

The relevant standard for harmonic voltage distortion in Australia is AS/NZS 61000.3.6 and it is compatible with the IEEE 519 recommendations. If the supply authority is unsatisfied with the degree of voltage distortion at the point of common coupling (pcc), harmonic filtering may be specified to comply with the Australian Standards.

| Odd harmonics, non-multiples of 3 | | Odd harmonics, multiples of 3 (triplens) | | Even harmonics | |
|---|---|---|---|---|---|
| Order, h | % harmonic voltage | Order, h | % harmonic voltage | Order, h | % harmonic voltage |
| 5 | 5 | 3 | 5 | 2 | 2 |
| 7 | 5 | 9 | 1.5 | 4 | 1 |
| 11 | 3.5 | 15 | 0.3 | 6 | 0.5 |
| 13 | 3 | 21 | 0.2 | 8 | 0.5 |
| 17 | 2 | >21 | 0.2 | 10 | 0.5 |
| 19 | 1.5 | | | 12 | 0.2 |
| 23 | 1.5 | | | >12 | 0.2 |
| 25 | 1.5 | | | | |
| >25 | 0.2 + 1.1(25/h) | | | | |

NOTE: total harmonic distortion (TDHV) 8% max

# Technical specifications

| | | | |
|---|---|---|---|
| Rated Compensation Current | 25A-150A in wall-mount configuration<br>100A-600A in rack/cabinet configuration | Altitude Operating Limit | 1500m, 1% power reduction for each additional 100m, between 1500m & 4000m |
| Rated Voltage (V) | 380VAC -40% to 20%<br>(690V also available) | Operating Temperature Range (Ambient) | -5°C to 40°C |
| Rated Frequency (Hz) | 50Hz (45-63Hz) | Relative Humidity | Max <95% without condensation |
| Functions | (1) Harmonic Compensation<br>(2) Load Balancing<br>(3) Reactive Power | Neutral Filtering Capability | Yes |
| Network Configuration | 3P3W, 3P4W | Noise Level | <70dB |
| Parallel Operation | Unlimited (up to 600A per cabinet) | CT Rating Settings | 150/5-10,000/5 |
| Harmonic Compensation Efficiency | >97% | Topology Design | 3 Level |
| Harmonics Compensation Capability | THDi<5% | Neutral Compensation Capacity | 3 times rating |
| Harmonics Compensation Range | 2nd to the 50th Harmonic Order | Monitoring | Via centralised monitoring LCD Screen / PQ Software (included) |
| Reaction Time | <100µs | Resonance Protection | Yes |
| Full Response Time | <10ms | Power Loss | <3% of rated power |
| IGBT Frequency | 20kHz | Harmonics Spectrum | 2nd - 50th Harmonic Order |
| Self Protection | Yes | Digital I/O | 4 digital inputs |
| Communication Interface | RS485, Ethernet | Design / Approvals | IEC 61000-4-2, 4-3, 4-4, 4-5, 4-6, 4-8, 4-11, IEC 60146, EN 55011 Class A, EN 50091-1, EN 50178 |
| Filtering Degree | Programmable per harmonic from 10% to 110% | Complies with Standards | IEEE519, AS/NZS61000.3.6:2001, IEC61000-3-6, ER G4/5 |
| Communications Protocol | Modbus, TCP/IP | | |

| Model | 25A | 35A | 50A | 60A | 75A | 100A | 150A |
|---|---|---|---|---|---|---|---|
| Rated Compensation Current | 25A | 35A | 50A | 60A | 75A | 100A | 150A |
| Wall-Mount Dimensions (mm) | 440W x 150D x 470H | | 440W x 195D x 610H | | 500W x 191D x 560H | 440W x 235D x 625H | 505W x 286D x 557H |
| Rack-Mount LCD Dimensions (mm) | 440W x 490D x 150H | | 440W x 621D x 191H | | 500W x 600D x 191H | 440W x 630D x 230H | 500W x 520D x 270H |
| Rack-Mount LED Dimensions (mm) | 440W x 470D x 150H | | 440W x 621D x 191H | | 500W x 600D x 191H | 440W x 630D x 230H | 500W x 520D x 270H |
| Net Weight (kg) | 18 | | 35 | | 35 | 36 | 48 |
| Smart Air Cooling | 75L/Sec | 75L/Sec | 151L/Sec | 151L/Sec | 300L/Sec | 300L/Sec | 405L/Sec |
| Ingress Protection | IP20 | IP20 | IP20 | IP20 | IP20 / IP31 | IP20 | IP20 |

| Floor Standing Cabinet Model | 200A | 300A | 400A | 500A | 600A |
|---|---|---|---|---|---|
| Rated Compensation Current | 200A | 300A | 400A | 500A | 600A |
| Cabinet Dimensions (mm) | 1000W x 600D x 2200H | | 600W x 1000D x 2200H | | |
| Net Weight (kg) | 240 | 280 | 320 | 360 | 430 |
| Intelligent Air Cooling | 600L/Sec | 900L/Sec | 1200L/Sec | 1500L/Sec | 1500L/Sec |
| Ingress Protection | IP20 / IP31 / IP54 | IP20 / IP31 / IP54 | IP20 / IP31 | IP20 / IP31 | IP20 / IP31 |

## Selection guidelines

- Suitable for use in 3-Wire and 4-Wire systems
- For 3-Wire configuration, 2 CT's are required (at L1 & L3)
- For 4-Wire configuration, 3 CT's are required (at L1, L2 & L3)
- LED versions are used in stand alone cabinets that have a touch screen on the front door
- LCD versions are used where there is no touch screen required (eg. when 2-4 units are connected in parallel with each other)

Sinexcel®

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