

# Harmonic Absorption Filters

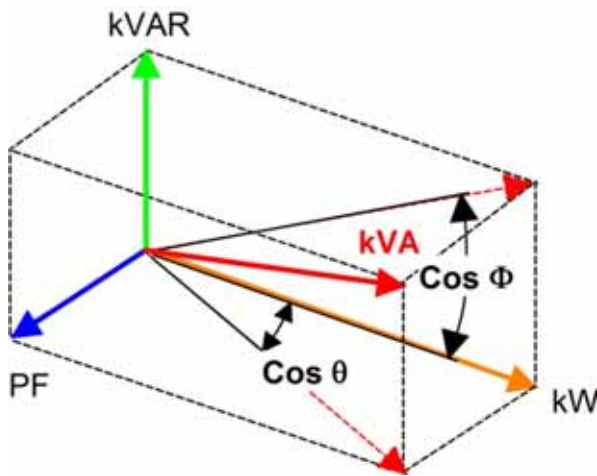
(for Six-pulse Converters)

Whoever stops trying to be better  
has stopped being good.



## Scope of this document

Power factor correction is becoming a more important issue because of the extra current demand which it places on the public supply network and the distortion which it causes to the mains sine-wave.



There are two non work-producing power elements involved, displacement power factor (otherwise referred to as kVAR or  $\text{Cos } \Phi$ ) and the harmonic power factor PF as can be seen in the vector diagram on the left.

Stricter regulations are being introduced for connection of electrical equipment to the mains network and it is the responsibility of industry to ensure that harmonic limits are complied with. This document provides details of one method using passive filters that can be applied to frequency inverters which have a 6-pulse converter to provide DC.

The filters are specially designed each application the components are selected to reduce orders of harmonics that are particularly troublesome.

## Introduction

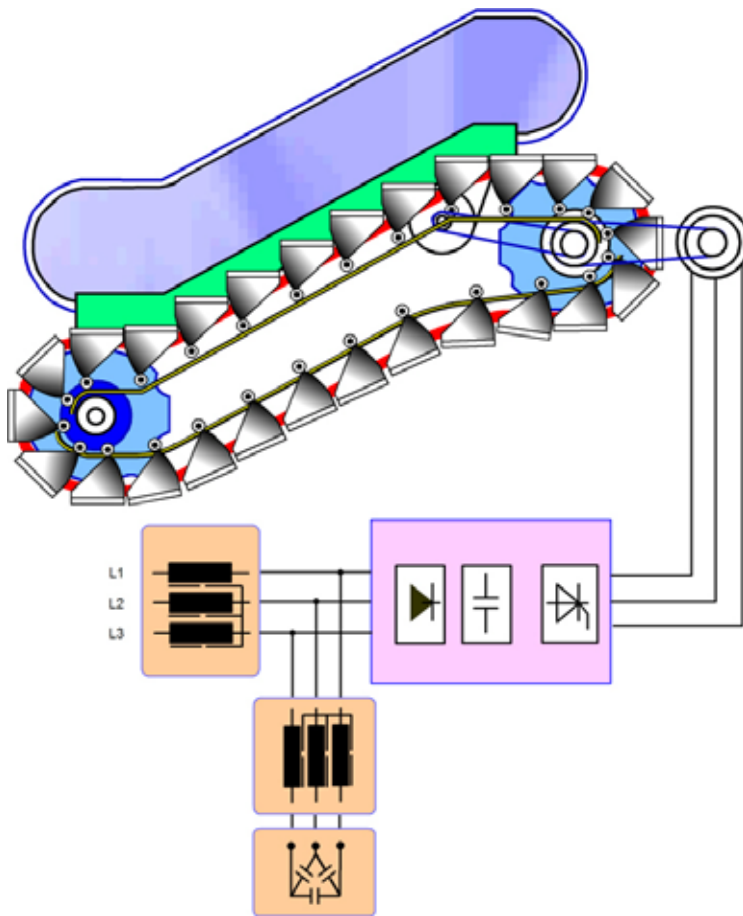
Harmonic absorption filters are used with frequency inverters which use a six-pulse converter in industrial applications where there is a fairly predictable, or definable, load, for instance escalators, lifts, cranes UPS's and welding equipment. The filter components are tuned so that they absorb only the most troublesome harmonics and offer very low impedance to all other frequencies; and so they have lower losses. Essentially they are passive filters based on series/parallel connection of inductors and capacitors which are connected to the power input side of an inverter. At full load the Total Harmonic Distortion can be reduced to as low as 5%.

There are also other benefits to be gained by using harmonic absorption filters which include:

- Commutation interference eliminated
- Reduced power consumption
- Longer operating life for the frequency inverter and motor
- Improved power quality
- Improved Displacement Power Factor ( $\text{Cos}\Phi$ )
- Improved Harmonic Power Factor

One single harmonic absorption filter can be used with several frequency inverters providing they start and stop simultaneously and not in sequence.

## Application Example



The diagram on the left shows a typical motor-powered escalator which is used in public buildings. The REO harmonic absorption filter components are selected by the REO design team after testing the motor and frequency inverter combination and deriving measurements for the harmonic spectrum up to the 40<sup>th</sup> harmonic.

The filter was then designed to reduce harmonics according to the Lifts Directive 95/16/EC which states that a manufacturer may apply harmonised standards in order to satisfy the essential requirements of the EMC Directive:

EN 12016:2004 – Immunity

EN 12015:2004 – Emissions

(which include tables for RFI and harmonic distortion limits).

It was important that the filter fitted in the available under floor space adjacent to the motors and this was achieved by building inductors with low profiles.

## Harmonic Distortion Limits

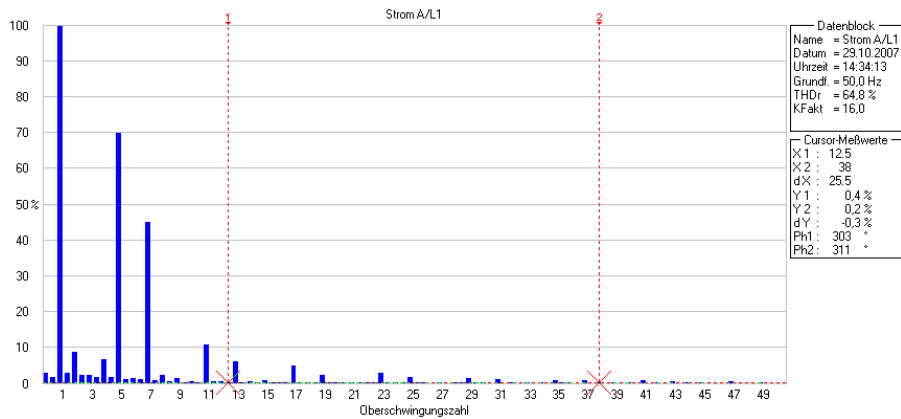
Standard EN 12015 calls up IEC/TR2 61000 – 3 – 4 for the test methods

Table 4 — Harmonic distortion

Environmental Phenomena	Test set-up	Units	Limits for permanent emission <sup>a</sup>	Limits for short duration <sup>b</sup>
Harmonic distortion	IEC/TR2 61000-3-4	$I_5/I_1$ [%]	30	45
		$I_7/I_1$ [%]	18	27
		$I_{11}/I_1$ [%]	13	19
		$I_{13}/I_1$ [%]	8	12
Harmonic distortion factor	IEC/TR2 61000-3-4	THD [%]	35	52
		PWHD [%]	39	58
NOTE 1 The relative value of even harmonics should not exceed 16/n [%].				
NOTE 2 The relative value of odd triplen harmonics should not exceed 9/n [%].				
<sup>a</sup> The given limits are based on IEC/TR2 61000-3-4:1998 for $R_{sc} = 250$ (balanced three phase equipment).				
<sup>b</sup> Harmonic currents with a duration of up to 10 s maximum, in the case that the system is manually or automatically switched on for the first time or is definitely switched off.				

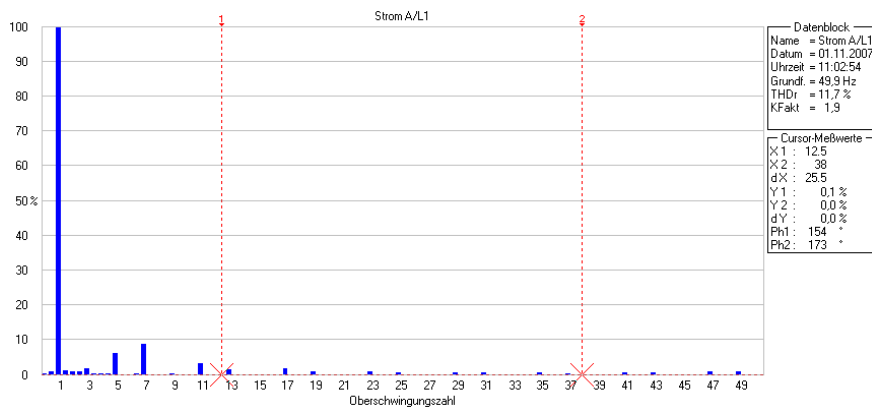
## Results

### Harmonic spectrum without any filter fitted



h5 = 9.974 A  
h7 = 6.314 A  
h11 = 1.359 A  
h17 = 0.601 A  
THDI = 79.78%  
PWHD = 26.61%

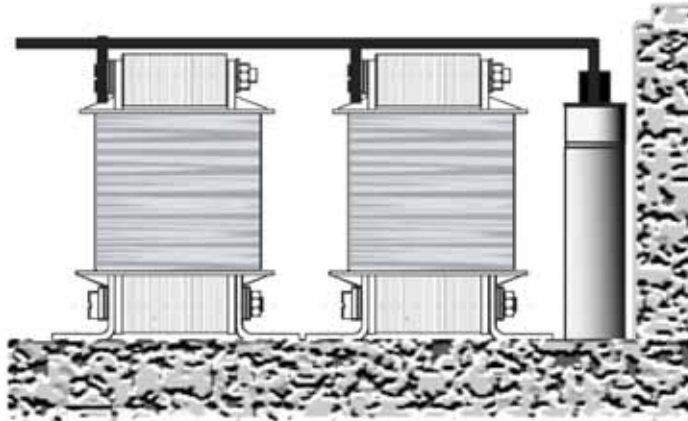
### Harmonic spectrum with the REO Harmonic Absorption Filter (HAF) fitted



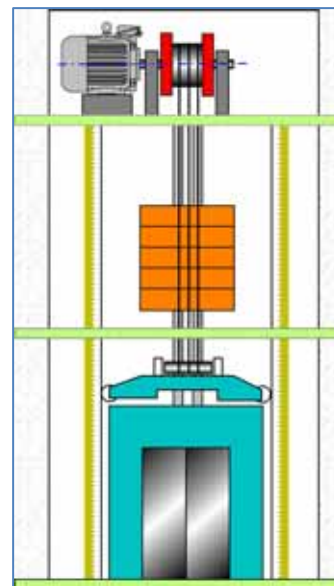
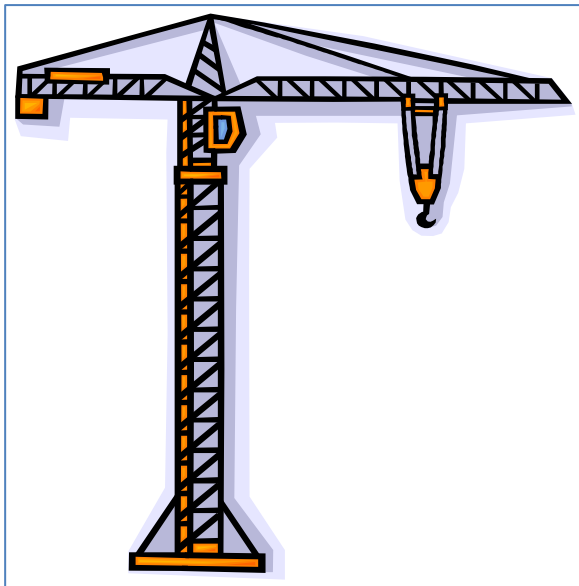
h5 = 0.897 A  
h7 = 1.190 A  
h11 = 0.308 A  
h17 = 0.150 A  
THDI = 13.80%

## Installation details

The REO Harmonic Absorption Filter comprises two chokes and three capacitors. In this instance dimensions of the inductor's core laminations were selected to give a low profile so that the whole filter could fit inside the floor cavity adjacent to the motor and drive gear.



## Other applications



Harmonic absorption filters can be used with electrical loads which have a predictable and fairly constant harmonic distortion with one or two predominant harmonic frequencies such as the fifth and seventh (250 Hz and 350 Hz with a 50Hz nominal fundamental frequency).



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