VLT® Advanced Harmonic Filters more effective than 12-pulse converters

Passive harmonic filters offer a practical solution to harmonic mitigation on power systems with a large concentration of non-linear loads connected to the distribution transformer or supply generator.
The performance of passive filters like the VLT® Advanced Harmonic Filter AHF010 or AHF005 is much better compared to 12-pulse or 18-pulse solutions at reduced loads on a power supply with a significant amount of voltage imbalance and distortion.
The graphs to the right illustrate the performance of an VLT® Advanced Harmonic Filter in comparison to its 12-pulse counterpart on voltage supplies with a significant amount of imbalance or pre-distortion.
It shows that the current distortion level for the AHF filters are lower than those resulting from the use of a 12-pulse input converter.

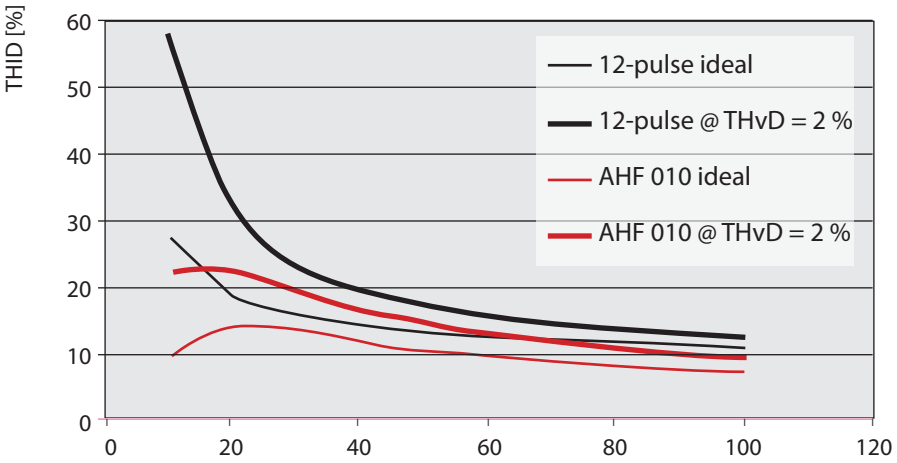


Fig.1: *THD Performance of VLT® filter and 12-pulse converter on power supply with 2% voltage distortion.*

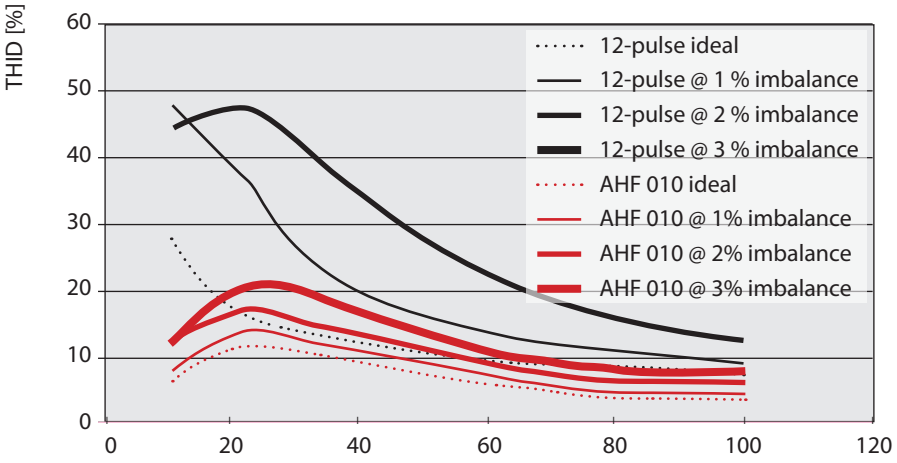


Fig.2: *THD Performance of VLT® filter and 12-pulse converter on unbalanced power supply*

Filter selection
The selection of an AHF Filter depends upon the following parameters:

- Specification for the distortion figure at the Point of Common Coupling (PCC). For a stand-alone drive panel, this will mean the point at which the drive module or panel gets connected to the power supply. It will mean the secondary of the distribution trans-

former for a set of drives fed from this supply when a group filter design is involved. Distortion is specified by VTHD and ITHD values.

o Drive Motor full load current. For a stand-alone drive panel, the connected motor FLC becomes the basic parameter for the current rating of the filter. The current rating of the filter is given by the following equation:

If = 1.1*Im*Cos (Ø) where
Im - Rated motor current in amperes.
Cos (Ø) - Motor PF at full load.

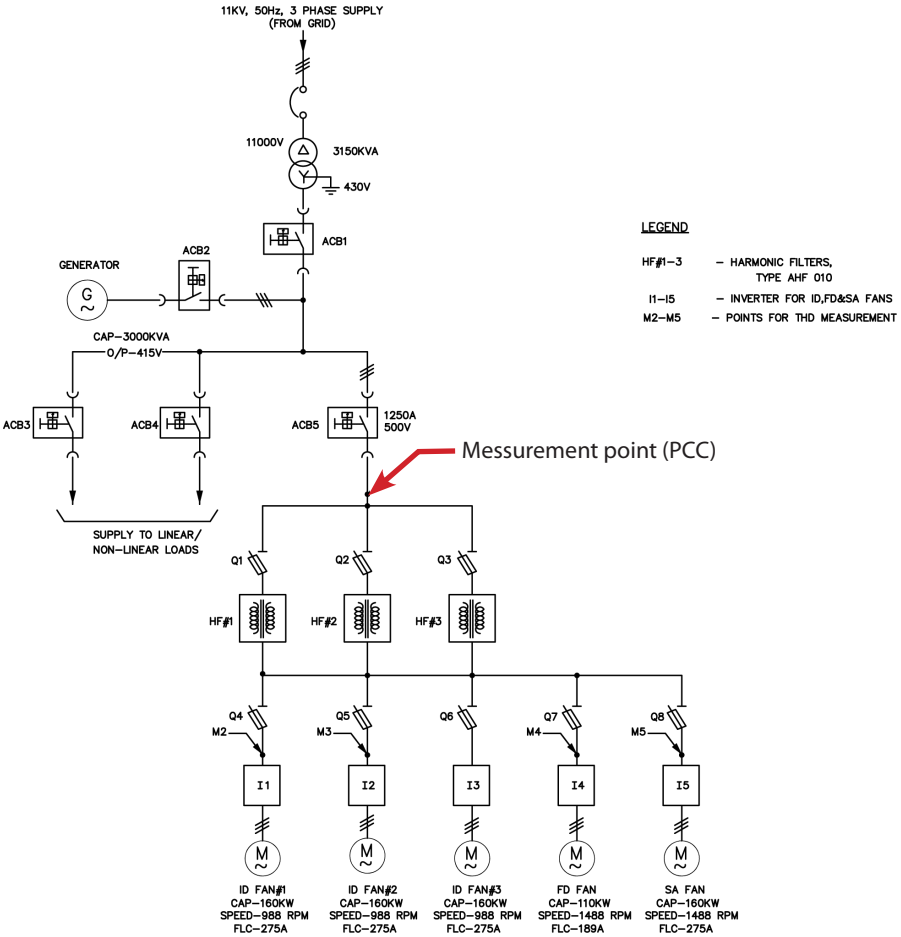
We will illustrate the design with a practical example of selection of Advanced Harmonic Filter AHF010 filters for drives installed at the sugar plant **Pandurang Sahakari Kaarkhaana Limited** (PSSKL), in Shirpur, District Solapur, Maharashtra, India.

Danfoss has supplied drives in the Sugar Plant for energy saving application for the following equipments:

ID Fans Three drives, out of which two are running and one is standby.

FD Fan One running drive with DOL bypass.

SA Fan One running drive (not Danfoss)



Reference to the figure below shows that the above mentioned group of drives derives feed from the downstream side of the main breaker.
This becomes the Point of Common Coupling (PCC) for the measurement of VTHD and ITHD.
The filter can therefore be selected to minimize the ITHD at the PCC.
The total motor current at the PCC at full load is 2 x 275 + 189 +275 = 1014 A.
If the full load power factor (PF) is 0.85, the design filter current becomes:
If = 1.1 x 0.85 x 1014 = 948 A

The requirement can be satisfied by connecting three units VLT® AHF 010 filters, model 175G6633, in parallel. This model has therefore been selected for harmonic mitigation.

Measurements at PSSKL site
To study the effectiveness of the filter solution, measurements have been made on the power system having the configuration as shown in the drawing to the left..
The test conditions for measurement are as defined below:

Measuring device
- Power Harmonics Analyzer, type Fluke Instruments, Model 434, suitable for measurement of 3Ø Power with 3 Nos. sensing CT's for each of the phases and line-line voltage sensing.

Load condition
- ID Fans 1 & 2, FD Fan & SA Fan running at part load.

Supply Source -
Sugar Plant Generator, Capacity-3000KVA, Output Voltage-3Ø, 415V, 50Hz.

Points for THD measurement
- MI (PCC), M2, M3, M4 & M5.

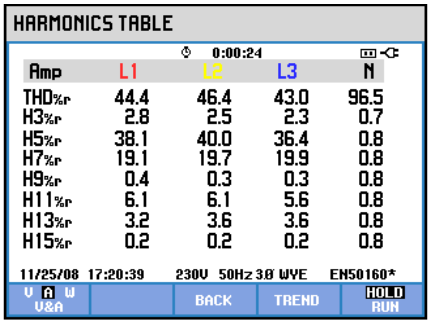
Power supply imbalance -
Voltage imbalance < 2 %,
Supply frequency 50 Hz ± 1 **%.**

The running load conditions for each of the equipments are summarized in Table 2 below:

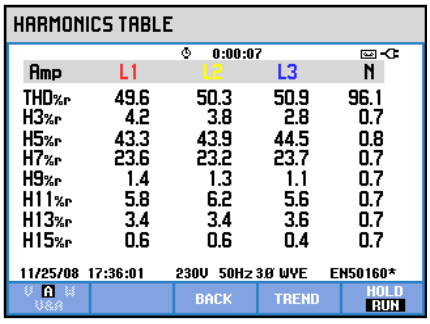
Equip-ment	Average load current (A)	Motor load (%)
ID Fan#1	150	54.5
ID Fan#2	140	50.90
FD Fan	115	60.84
SA Fan	152	55.20

Equipment	Motor data		
	CAP (KW)	VOLTS (V)	FLC (A)
Induced draft fans no's 1-3	160	415	275
Forced draft fan	110	415	189
Secondary air fan	160	415	275

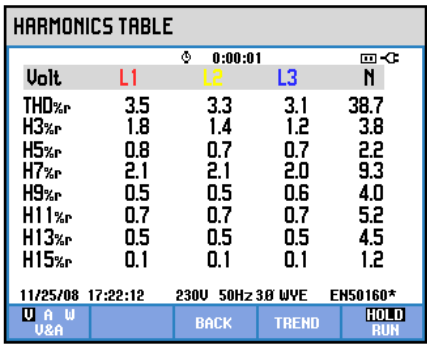
Current and voltage THD measurements ID fan 1 and ID fan 2:



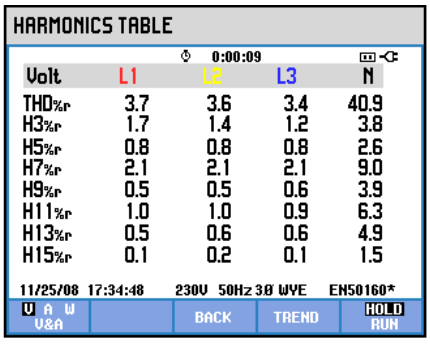
CURRENT HARMONICS OF ID FAN#1 DRIVE-MEASURING POINT M2



CURRENT HARMONICS OF ID FAN#2 DRIVE-MEASURING POINT M3

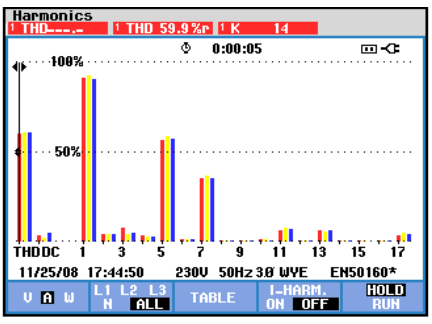


VOLTAGE HARMONICS OF ID FAN#1 DRIVE-MEASURING POINT M2

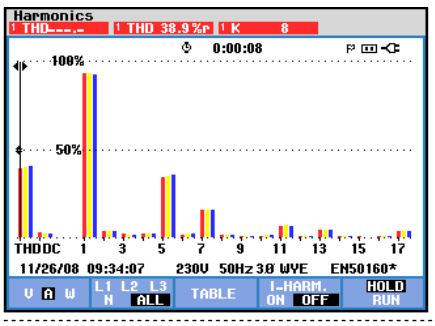


VOLTAGE HARMONICS OF ID FAN#2 DRIVE-MEASURING POINT M3

Current THD measurements, FD fan and SA fan

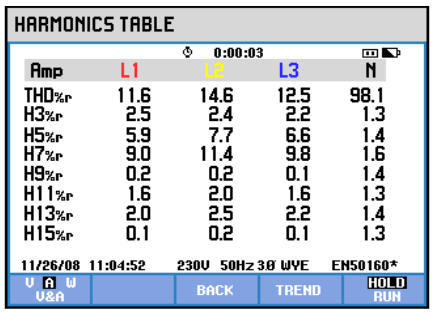


BAR GRAPH OF CURRENT HARMONICS OF FD FAN DRIVE-MEASURING POINT M4

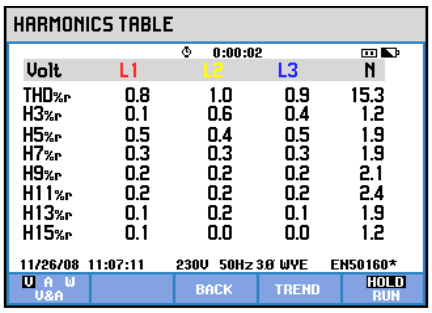


BAR GRAPH OF CURRENT HARMONICS OF SA FAN DRIVE-MEASURING POINT M5

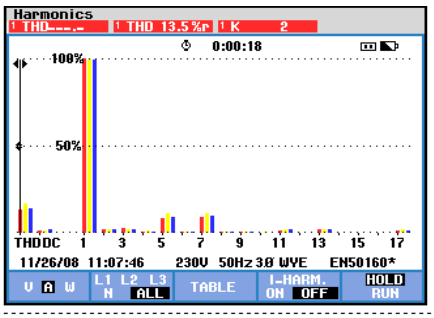
Voltage and current THD measurements at PCC



CURRENT HARMONICS AT PCC-MEASURING POINT M1



VOLTAGE HARMONICS AT PCC- MEASURING POINT M1



CURRENT HARMONIC SPECTRUM AT PCC-MEASURING POINT M1

The results of the THD measurement are summarized in Table 3 below:

EQUIPMENT	VTHD (%)	ITHD (%)
ID Fan#1	3.3	44.6
ID Fan#2	3.56	50.26
FD Fan	2.93	59.90
SA Fan	2.93	38.90
PCC (Point M1)	0.90	13.5

Conclusions:

The observations made above can be summarized as:

1. The ITHD figures are, as expected, high at the respective drive power inputs. This is due to the fact that the drives are running at part load.
   Under this condition, although the load current is less than100 %, the proportion of current harmonics is still significant and hence the RMS harmonic current has not reduced in the same proportion as the fundamental current. Lower THiD levels can be expected when the fan motors are fully loaded. This was, of course, not possible in a running plant.
2. At the PCC, there is a significant reduction in the ITHD value (ITHD =13.5%) due to the attenuation of the 5th and 7th harmonics. The behaviour of the filter assembly at this reduced load is on expected lines and in agreement with the performance chart on page 1. An ITHD value of 10 % or less can be realised if, as mentioned earlier, the drive motors are fully loaded.
3. The VTHD value at the respective drive terminals is < 5 % in all cases due to the supply source having a low output impedance and the reduction of the THiD at the PCC.
4. Power measurements at the PCC show that the input PF is leading, with the filter units supplying reactive power to the supply (PF depends on the load factor and is at 50 % around 85% leading). This is a direct consequence of the drives being lightly loaded and is not a problem for this installation, since there are other loads which can absorb this reactive power without a supply grid voltage increase.
   In case this excess reactive power is not capable of being absorbed by the grid, contactors may have to be installed to disconnect the capacitors in the filter unit under light load conditions.
5. The reduction in the VTHD figure at the PCC is on expected level.