APQ,LLC. Low Pass Harmonic Filters vs. 18-pulse

There are two major technical benefits realized when using low pass harmonic filters in lieu of 18-pulse rectifier schemes:

- Improved harmonic distortion, especially when operating below 100% load
- Higher efficiency (lower total watts loss)

Power Loss Comparison (Full Load)

At minimum, 18-pulse schemes require an additional transformer and two additional bridge rectifiers (six diodes each). In some cases, balancing reactors are used to assure proper current sharing by the bridge rectifiers. In typical ratings of 18-pulse systems, the transformer is generally considered to have losses of about 2.5% to 4% when compared to the full load KW rating of the motor. The losses from the twelve additional rectifiers add to the transformer losses to arrive a total additional losses for converting to 18-pulse.

Low Pass Harmonic Filters using three reactors plus the appropriate capacitor cells typically experience losses of about 1% of the rated load. A typical comparison of the two methods is illustrated in the table below.

Table 1. Comparison of power losses for 18-pulse vs. Low Pass Harmonic filters

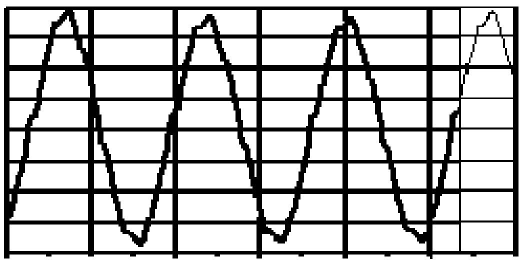
	18-Pulse Rectifiers				Low Pass Filters	
VFD Rating HP / KW	Transformer	Add'l Rectifiers	Total Losses	% Losses	Total Losses	% Losses
100 / 75	3680 W	330 W	4010 W	5.3%	805 W	1.07%
200 / 150	5660 W	540 W	6200 W	4.1%	1400 W	0.93%
400 / 300	9130 W	1200 W	10,330 W	3.4%	2358 W	0.79%

Transformer losses calculation is based on EQ 3.1, Clean Power Electronic Converters, Derek Paice. ISBN 0-9759274-1-8.

Harmonic Reduction

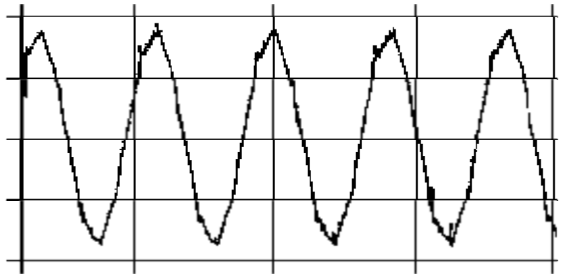
At 100% load, the performance of Type LPF harmonic filters and 18-pulse front ends is quite similar. Both can produce results of $\leq$5% under Full Load operating conditions. In either case, the actual measured distortion may be slightly higher due to voltage distortion on the power system. The major difference is when the drive system is operating at partial load. A major reason that drives are chosen over across-the-line started motors, relates to the power savings achievable while operating at light load. In a variable speed drive system, power consumption is inversely proportional to the cube of the speed. Operation at 75% speed uses only 42% as much power as operating at 100% speed. However, operation at full speed (this is also full load for fan and pump applications), does not offer any power savings. Thus, VFDs are often used in applications such as fans and pumps where frequent operation at partial load will realize some energy savings. With this in mind, one needs to consider the harmonic distortion not only at full load, but at reduced loads as well. The following data illustrates actual current waveforms and harmonic measurements for VFDs while operating at both full and partial load.

Low Pass Harmonic Filter Input Data:



input current waveform - **Full Load**

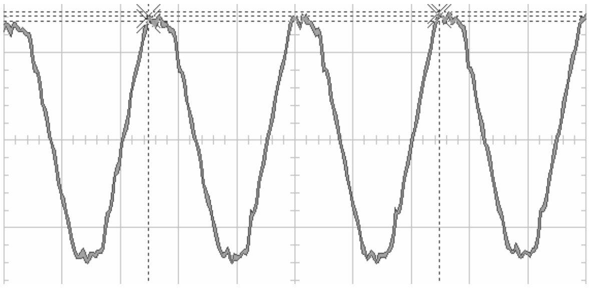
4.72% THD (current)
I5 = 2.2%, I7 = 2.8%, I11 = 2.0%, I13 = 1.2%



input current waveform – **Partial (33%) Load**

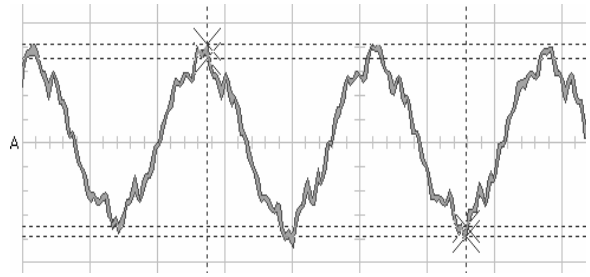
5.23% THD (current):
I5 = 2.75%, I7 = 3.8%, I11 = 2.7%, I13 = 1.9%

18-pulse Rectifier Input Data:



input current waveform – **Full Load**

5.1% THD (current)
(I5 = 3.0%, I7 = 1.6%, I11 = 2.1%, I13 = 0.8%)



input current waveform – **Partial Load (30%)**

13.6% THD (current)
(I5 = 8.9%, I7 = 6.8%, I11 = 6.4%, I13 = 2.6%)