# USE OF HIGH PERFORMANCE HEMP POWER LINE FILTERS WITH VARIABLE FREQUENCY DRIVES

Where a variable frequency (VFD) drive is used in conjunction with a power line filter, special considerations are required.

Variable frequency drives work by rectifying the mains ac power to dc, then chopping the dc in an inverter at a higher frequency using a pulse width modulation technique to produce a new sine wave supply of variable frequency and voltage which is then used to drive an ac motor. The switching frequency of the variable frequency drive is known as the carrier frequency. Because the new sine wave supply is formed by chopping, it will be somewhat distorted rather than a clean waveform.

Variable frequency drives have carrier frequencies in the region of 250Hz – 14kHz with newer technologies using higher switching speeds with the aim of improving the quality of the sine wave output waveform and hence reducing the total harmonic distortion.

As specific examples,

Older SCR drives had a carrier frequency in the region of 250-500Hz
BJT drives have a carrier frequency of 1-2kHz
Latest IGBT drives have a carrier frequency of 3kHz to 14kHz

Because of the technology used, the sine wave will contain many harmonics, with typically the most problematical ones being 5$^{th}$, 7$^{th}$, 11$^{th}$, 13$^{th}$ and higher harmonics of the mains frequency and also harmonics of the switching frequency, but these will all depend on the design of the VFD.
The total harmonic distortion of the sine wave output may be expected to be within 5% with individual harmonics being up to 3%.

Although the harmonic content of newer drives running at higher frequency is lower than the older ones, because the carrier frequency and harmonics are at a higher frequency, their effect on filters can be just as significant.

The problems arise due to the carrier frequency and/or harmonics being within the pass band of the filter.

If, for example, a filter having an insertion loss of 100dB at 14kHz is used with a carrier frequency of 14kHz, the filter will try to filter out the carrier frequency and this will generate extra heat within the filter capacitors, and/or inductors. In practice, because the filter insertion loss is quoted in an impedance of 50 ohms, rather than the impedance of the VFD which will be a fraction of an ohm, the filter will not actually get rid of all the carrier frequency but it may attenuate part of it causing the filter to run hot. The design margins and materials used for the capacitors and inductors within the filter will affect how hot they get.

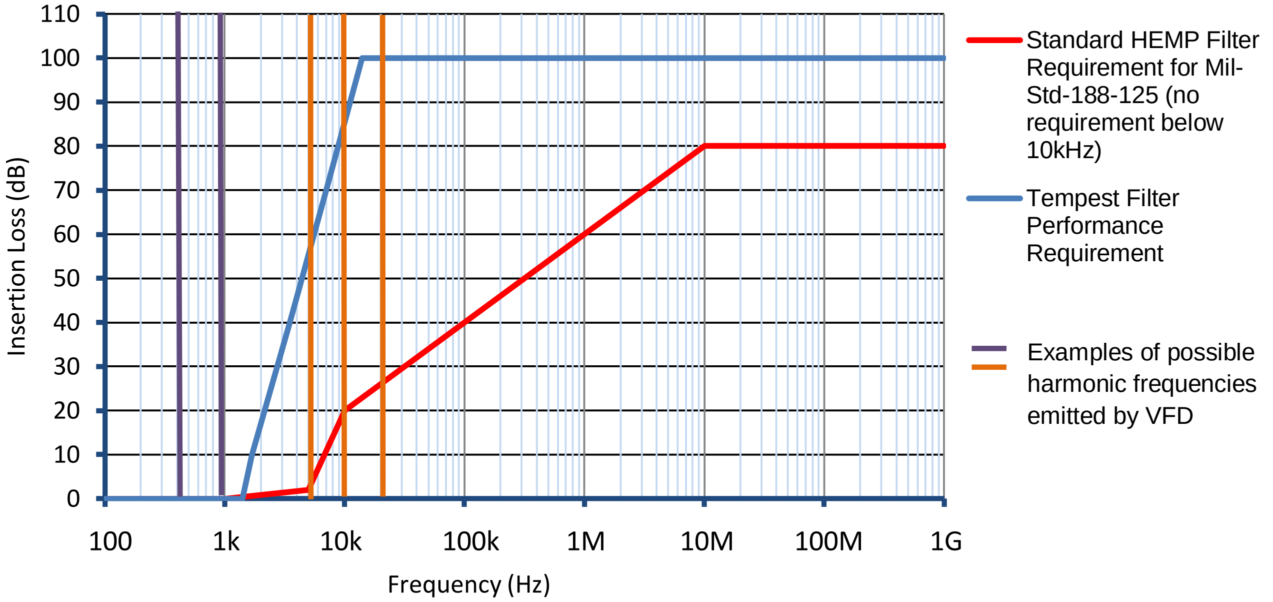
The graph on page 2 shows typical HEMP power filter insertion loss performance. The red graph shows the minimum filter insertion loss to meet the requirements of Mil-Std-188-125, which only requires a comparatively low performance filter. The blue graph shows the higher (usually unnecessary) performance often offered for HEMP filters. It can be seen that any VFD carrier or harmonic frequencies up to 1 kHz (e.g. purple lines) should not cause either filter type any significant issues. VFD frequencies above 1kHz (e.g. orange lines) will have some effect on both filter types but much more significantly on the higher performance filters.





MPE Limited
www.mpe.co.uk
sales@mpe.co.uk
+44 151 632 9100

These comments are necessarily general and specific applications must be considered in detail.




**Summary**

In the case of high performance HEMP power line filters, the carrier frequency and/or harmonics of a variable frequency drive may be within the stop band of the filter, and the filter will try to attenuate any power present at these frequencies. This will manifest itself as overheating of the filter. The extent of the overheating will depend on the filter performance and design, the carrier frequency and the magnitude of harmonics. In the worst case, this could lead to thermal runaway and failure of the filter.

A higher performance filter such as those with a specification of 100dB insertion loss from 14kHz upwards will be more prone to overheating than a lower performance filter with a specification of say 20dB or 60dB from 10kHz upwards.

It follows that MPE standard performance HEMP power filters, which are fully compliant with and tested to Mil Std-188-125 and have an insertion loss performance of 20dB at 10kHz are likely to be more suitable for VFD applications than higher performance filters having an insertion loss of 100dB from 14kHz.

In general, great care should be exercised when selecting power filters for use on systems containing variable frequency drives. The selection of filter should be made on a case by case basis by considering the characteristics of both the variable frequency drive and the filter.

We can provide more detailed information against specific applications.



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www.mpe.co.uk
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