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Passive Harmonic Filter Selections

Passive filter designs can be optimized for minimizing capacitance, DC bus voltage droop and harmonic correction levels. TCI offers several product families of passive filters that can be selected based on the system design and user needs. Many manufacturers offer one design which may not be suitable for all applications.

One area that causes considerable confusion is what some manufacturers call “generator compatibility”. Some manufacturers promote the improved generator compatibility of their passive filters without providing any information on the side effects on DC bus voltage or harmonic mitigation. In fact, depending upon the required total harmonic distortion (THD), the presence and size of generator, and the tolerance for reduced variable frequency drive (VFD) power output. At TCI, our approach is to provide a wide range of filtering solutions to cover any application and to assist in choosing the right one.

Passive Filter Basics

Passive filters are an effective solution to filter harmonic currents produced by 6-pulse VFDs and reduce the source current THD to 5% or less. Passive filters are typically constructed with a series line reactor and a shunt circuit made of a tuning reactor and capacitor, as shown in Figure 1.

The tuning circuit supplies the harmonic current needed by the VFD and the capacitor supplies leading current (or leading VARs) at the fundamental frequency of the power system. When the VFD is lightly loaded, these leading VARs flow to the voltage source – typically a utility transformer or generator. As the VFDs load increases it draws more lagging VARs, which consume the capacitor VARs and reduce the leading VARs that flow to the source.

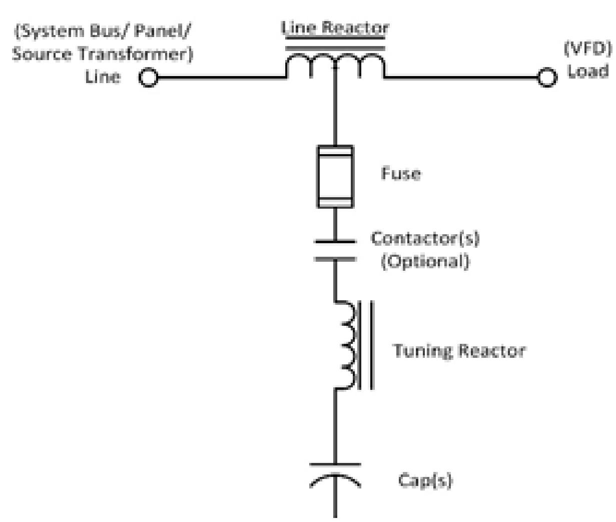

Figure 1: Simplified one-line of a passive harmonic filter.

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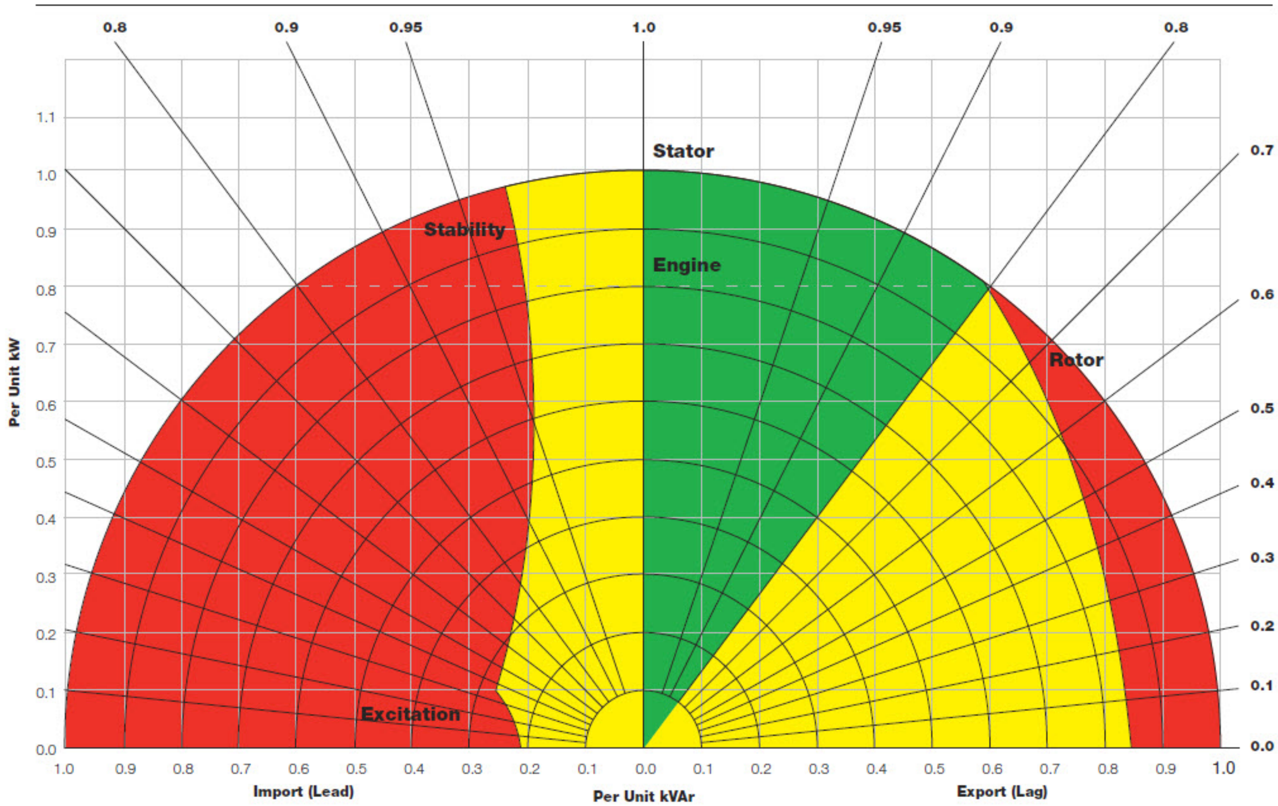

Figure 2- Generator Capability Chart and Passive Filter Load Curve[3].

Generator and Power Factor Guidelines

Synchronous generators have limited capability to provide either leading or lagging VARs. This is illustrated in the generator capability chart as shown in Figure 2. The green shaded area is the normal operating range of a typical generator, yellow indicates abnormal operating range, and red indicates the area of instability. Operating in the normal or abnormal regions of the generator capability curve should not cause damage. However, prolonged operation in the instability region can result in damage to the generator. The reverse or leading kVAR level at the boundary of the stability region is approximately 0.2 pu of rated KVAR. Some passive filter manufacturers have misunderstood the 0.2 per unit to be based on the generator rating and promote filters that are designed with 0.2 kVAR/KVA as generator compatible. The following example will show the pitfalls of this method.

A generator rated at 100kVA and a 0.8 PF is rated for 80 kW and 60kVAR. A leading kVAR limit of 0.2pu equates to 12kVAR. Thus, a generator rated for 0.8 PF, can support only about 12% of its rated kVA at no load. This level is detailed in application examples from generator suppliers [2], [3].

To examine compatibility of passive filters without contactors and small generators at no load, consider the generator from the example above in a passive harmonic filter application.

- Generator: 100kVA, 0.8PF. Rated for 80kW and 60kVAR
- Passive filter: 100HP with 15kVAR capacitance (0.15kVAR /HP)

The leading kVAR drawn by the filter at no load is 15kVAR. Since the generator is rated for 60 kVAR, the generator needs to produce 0.25pu leading kVAR (15kVAR / 60kVAR). This exceeds the maximum 0.2 p.u. capability level. See Figure 2.

As shown in Figure 2, even when using a ’generator compatible’ passive harmonic filter, a contactor must be used to keep the capacitors offline during light VFD loading conditions. While using a low capacitance style filter can help in a generator application, only the use of a contactor can ensure that the generator reverse kVAR limits are not exceeded under light VFD loads with tightly sized generators. This is true for all passive filters available today. Both TCI’s HarmonicGuard Passive (HGP) and HarmonicGuard Low Capacitance (HGL) are available with contactors.

If contactors are not used due to other system constraints, the generator oversizing is reduced by using the HGL.

	Minimum ratio of Generator Size (KVA)/VFD size (HP) with no contactor	THD Performance			
		% VFD Load			
		25%	50%	75%	100%
HarmonicGuard Passive	2.5:1	8%	5%	5%	5%
HarmonicGuard Low Capacitance	1.25:1	12%	10%	8%	5%
Harmonic Shield	2.5:1	8%	5%	5%	5%

Conclusions

All passive filters on the market today exceed generator reverse kVAR limits at no load. To achieve generator compatibility at no load without a contactor, the kVAR/HP levels must be below 0.12kVAR/HP as an absolute limit.

There have been no accounts of a passive filter utilizing a tuned circuit having kVAR/HP levels below the absolute limit while remaining in compliance with the IEEE-519 standard. However, TCI’s HGL has the lowest level of kVAR/HP rating and will still meet the IEEE-519 requirements.

TCI’s HGL and HGP filters are both generator compatible and come with contactors.The difference in trap circuit capacitance allows for a customer to choose to more tightly size a passive filter HP rating to generator kVA rating.

For more information on how to size and select a passive filter, please reach out to our Technical Support team at 800-824-8282.

References

[1] “How to size a genset: Proper generator set sizing requires analysis of parameters and loads”, Cummins Power Topic #7007. https://www.cumminspower.com/www/literature/technicalpapers/PT-7007-Sizing-Gensets-en.pdf

[2] “Synchronous Generators and Leading Power Factor Loads”, ePower News, Fall 2011, Issue 2, Toromont CAT Power Systems. http://www.toromontcat.com/powersystems/pdf/newsletter/Synchronous%20Generators%20and%20Leading%20Power%20Factors.pdf

[3] “Impact of leading power factor loads on synchronous alternators”, Cummins Power Topic #6001. http://power.cummins.com/sites/default/files/literature/technicalpapers/PT-6001-ImpactofPowerFactorLoads-en.pdf

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