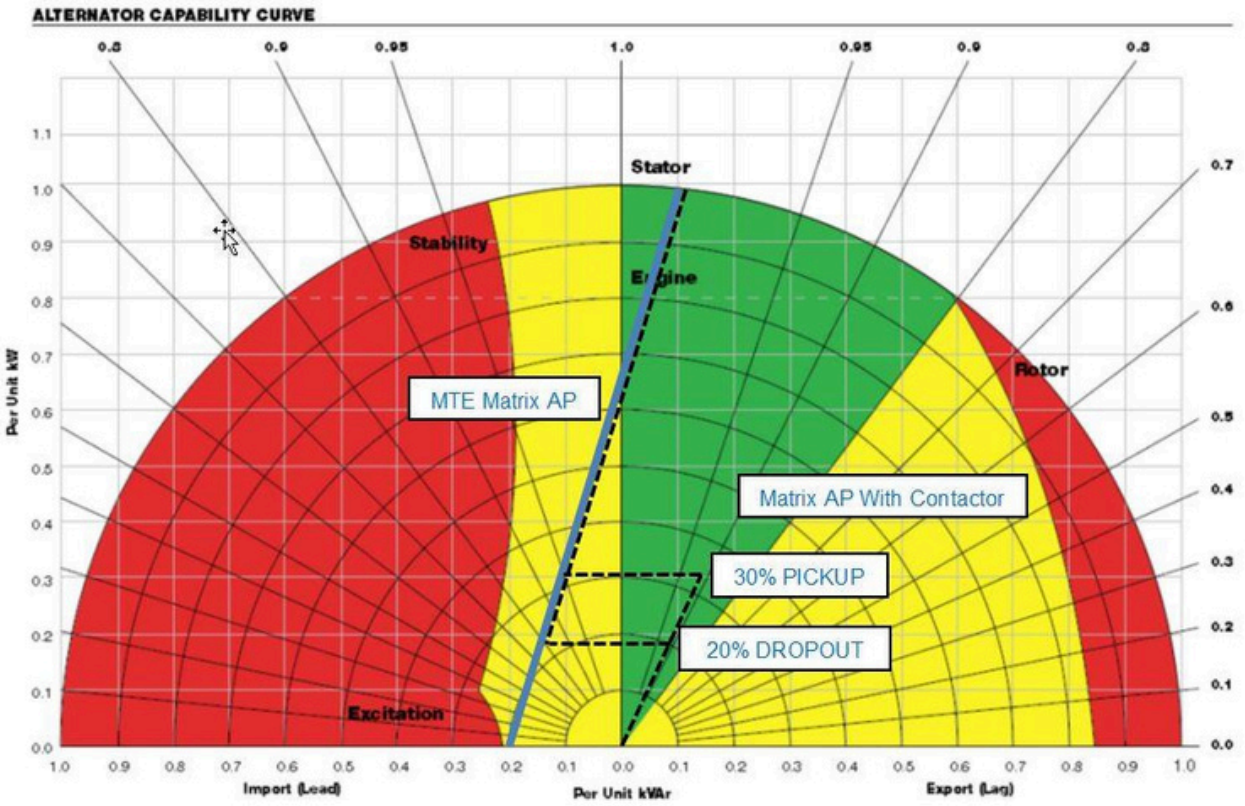
Generators and Matrix filters

Six pulse filtered VFD loads have characteristics that can impose a leading power factor (KVAR) onto the power source. While these loads are typically not a problem for utility power sources, leading power factor can cause a generator to shutdown or prevent certain loads from operating properly under generator power. This paper will help you understand how to best use a matrix filter with generator power.
Synchronous alternators used on generators have a limited ability to absorb capacitive KVAR from applied loads, and exceeding this limit will result in generator shutdown on overvoltage

Over time generator manufacturers have improved their equipment designs to include the use of (AVR) automatic voltage regulators, permanent magnet excitation systems, and using PWM-type controls to enable the gen set to produce stable voltage and frequency allowing for operation of non-linear loads. At the same time, VFD manufacturers which have non-linear load characteristics have begun to use filters to limit harmonic current distortion onto the power source. Capacitive KVAR compensation has become automated into facilities to improve the power factor when operating on the utility source to avoid higher energy charges. While passive harmonic filters provide positive impacts on the overall power system, they can be very disruptive to generator operation.

Harmonic filter equipment is sized for operation at the expected maximum load. At light loads there may be excess filter capacitance, causing a leading power factor on the generator. During normal operation the AVR monitors generator output voltage and controls alternator field current to maintain a constant output voltage. A relatively low AVR current is required to maintain generator no-load voltage. Since AVR's are designed to ramp on from NL to FL the presence of leading or reverse KVAR during light loads negates the AVR field control and will force the generator to shut down on overvoltage. A utility supply simply absorbs the reactive power because it is extremely large relative to the filter system plus it has many loads that can consume this energy. The Cummins "Alternator capability curve" shows, the Green area is normal operating range of a typical generator, yellow is abnormal but not damaging, and operating in red regional will cause damage or mis-operation. The MTE AP harmonic filters' KVAR is graphed to see how they could impact generator operation. To work with generators the harmonic filters' capacitance must not exceed the alternators' ability to absorb reverse KVAR loading.



Conclusion:

Generators are limited power sources with much higher source impedances and are physically limited both in their ability to supply power to linear loads and absorb reverse KVAR. Proper generator sizing and load management techniques must be used for successful operation of motor drives on standby power.

To ensure proper generator operation with VFD applications the following steps need to be considered as guidelines for successful operation:

Generator / Alternator sizing

VFD loads on a generator must be less than approximately 50 percent of generator capacity to limit total harmonic voltage distortion to less than 15 percent some are 11%. Cummins and other generator manufacturers use alternator sizing programs which account for harmonics and adjust alternator size for harmonic filtering for active solutions and passive filters or multi pulse drives as the load. In the Generac program the alternator shrinks by 33% if the THID harmonics are reduced from 30 to 5%.

Load step sequencing

In many applications the generator set is sized to pick up all loads at once. In some applications it is advantageous to start up the loads which cause the largest starting surge first and then the rest in multiple steps —the “largest motor first” rule. Codes may require sequenced load starting to start

emergency and life safety loads within as little as ten seconds, while allowing other loads longer periods of time. Start linear loads first then the filtered VFDs to allow for these loads to absorb some of the reverse KVAR of the filter capacitors. In general, sequenced startup allows the smallest generator set in relation to the steady state load. When cycling motor loads exist, it will still be necessary to size the generator set to start the largest cycling motor last, with all other loads connected.

Choice of a harmonic filter

Choose a harmonic filter that will not adversely affect the generators voltage regulation. The choice should be one that has low KVAR, 15% of its KW rating, such as the MTE AP filter. AP harmonic filter alternator loading is shown with a blue line on the above chart and will always be in the generator acceptable yellow/green operating area.

A contactor may be used with the AP Matrix to switch in the capacitors where the generator is closely sized to the KVA rating of the Matrix filter. The effect of the contactor added to an MTE Matrix AP can be seen on the above figure with the black dashed lines showing an example with the filter reactive current becoming more lagging if the cap switching is delayed to the 30% load point; to add 10% hysterias the contactor drops the capacitors at 20 percent load.

The following Matrix options are available to support capacitor removal to ensure successful generator operation:

Option -002 ***Capacitor Contactor*** (***Please note that a 120 volt 60 Hz power source is required for this option***.)

Option -012 ***Capacitor Contactor*** (***Powered***) ***This option is only available for enclosed units***

These options provide a contactor to disconnect the filter capacitors when the drive is not running or to allow a generator to start without any reverse KVAR loading. The contactor coil and auxiliary contacts are wired to a customer terminal block. The customer wires the run output of the VFD and programs the drive to control the contactor activation switch points, typically 30 to 50% of full load or as best meets the generator load requirements.

Option -009 ***Capacitor Contactor with adjustable pick up and drop out***

This option provides a powered contactor to disconnect the filter capacitor bank based on the motor load current. Two current operated switches provide independent adjustment of the pickup and drop current levels. The switches are preset at the factory for pick up at 35% and drop out at 20% of the filter output current rating. The switches are each field adjustable over a 0 – 100% current range. ***This option is only available for enclosed units***.