

## Clarification Bulletin for Harmonic Filter Capacitive kVAR Draw at VFD No Load Condition

### Executive Summary

Passive harmonic filters contain capacitors which draw reactive power (kVAR) whenever they are energized. When under load, this capacitance in combination with the filter inductance is used to filter out harmonics drawn by the nonlinear load (ie. VFD). But when the load is not running, this will appear on facility metering as a current draw. It is understandable that this might make operators and end users nervous, thinking that this current draw will mean that they are paying for energy usage when their load is not running. The intent of this technical bulletin is to provide an explanation on the technical reasons for this effect and to show that end users will not be charged for this capacitive current draw. In fact, this capacitive kVAR draw will usually have a positive effect on the power system. This is because inductive loads are often the cause of low power factor issues in a facility, and the capacitors in the Lineator will act to offset the power factor effects from these loads.

Mirus has installed tens of thousands of filters over the past decades and has never been made aware of a situation where a customer was charged for capacitive kVAR draw from our harmonic filters.

### Power Factor and Utility Billing

Electrical power consists of apparent power (kVA), active power (kW), and reactive power (kVAR). Active power provides energy for real work to be done, such as turning a motor or powering a light bulb. Power generation and distribution is expressed in kVA. kVAR is the portion of the power that is drawn by equipment but is not usable.

The first thing to understand is that utilities charge their customers for usage in terms of kW and kWhr, not kVAR or kVA. The utility then takes a snapshot at the point of highest consumption for a given period (usually a month) and calculates the power factor at that time. If power factor is below a certain level, a penalty is often applied in various ways depending upon the utility's policy but always only effects the 'peak demand' charge. This method acts to reduce the total kVA that a utility must provide to a facility (by encouraging the customer to lower their peak kVA draw) without penalizing them for being at a low power factor when all their loads are off and they have no effect on the peak demand of the grid. It is also an easier way for utilities to manage their billing. Consumption charge remains as kWhr so is unaffected.

So consumers are never charged for kVAR directly but the power factor penalty will increase the demand charge when power factor is low during peak demand.

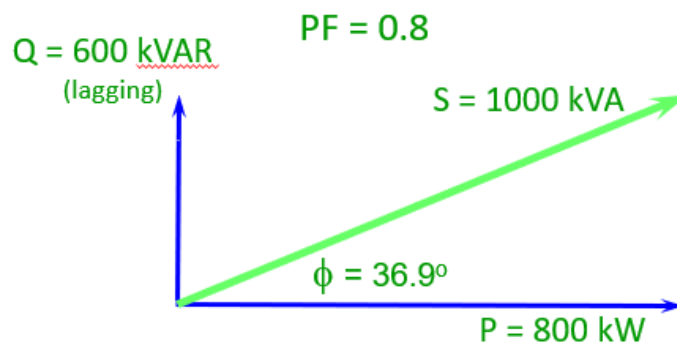
The net effect is that kVAR when not at the highest consumption point for a given period has no negative effect on the electrical charge. Therefore, at light load levels there is no need to worry about kVAR draw.

Capacitors draw reactive power (kVAR), rather than the real power (kW) that is used to do work, like turn a motor. Reactive power can be inductive or capacitive. Since the overwhelming majority of power systems are inductive (due to the proliferation of induction motors), capacitors are often installed on a power

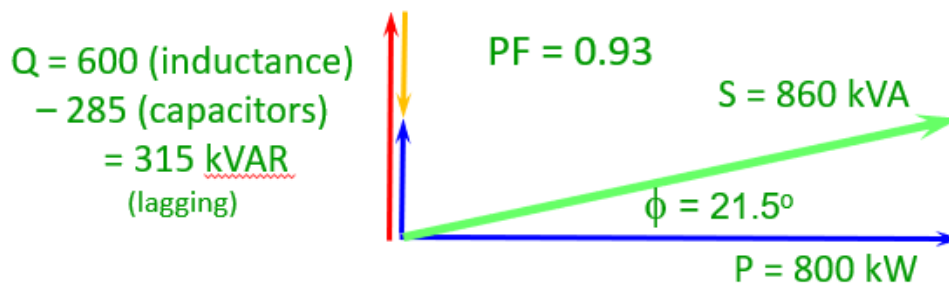
system to compensate for the inductive reactive power and improve the power factor of the system closer to unity.

When a power system has more inductive loads than capacitive, we say the power factor for the system is lagging. When the power system has more capacitive loads than inductive, we say the power factor for the system is leading.

The below example outlines how capacitors can be used to improve power factor on an inductive power system. The graph shows an inductive power system with 800kW of inductive load with 0.8 power factor, meaning that the total active power draw is 1000kVA with reactive power of 600kVAR. Therefore, the power factor of the system is 0.8 lagging (inductive).

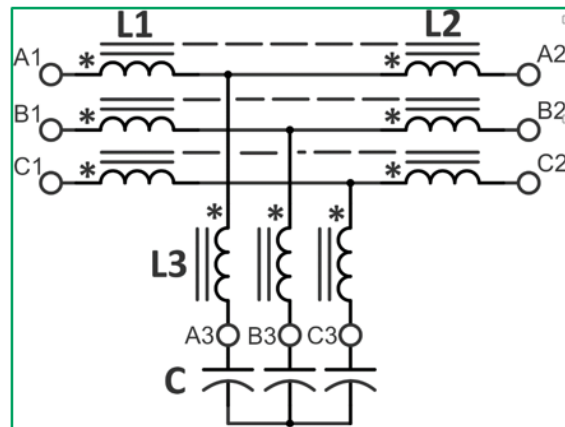


When 285kVAR of capacitive reactive power is added to the power system, it acts to offset the inductive reactive power and results in a combined inductive kVAR draw of 315kVAR. With this reduction in reactive power, the power factor of the system improves to 0.93 lagging (inductive).



**Lineator AUHF Circuit Components and How They Impact Power Factor and Utility Billing**

Below is a simplified circuit diagram of the Mirus Lineator AUHF harmonic filter:



When the load connected to the harmonic filter output is not running (ie. there is 0 amps drawn at the A2, B2, and C2 terminals), the inductors L1, L2, and L3 in the filter have no effect on the circuit. Therefore the filter can be effectively reduced to just a capacitor bank C.

As mentioned earlier, most facilities have a lagging power factor at high load levels since these are the points at which induction motors, inductors, transformers, or other electrical equipment are running. These loads will all make the power system go lagging and this effect will be offset by the Lineator AUHF’s capacitor bank if the filter’s load is not running at this time.

**What if my power system does not have inductive loads or my power factor is already corrected?**

Even if there are no inductive loads in the facility to offset the capacitive kVAR or if the power factor is corrected by power factor correction capacitors already, customers still will not pay for having a small amount of reactive power (kVAR) being drawn by the Lineator AUHF filter. In the case of the Lineator AUHF filter, the only time it is drawing this kVAR is when the load is off or lightly running. Therefore, it is by definition a low load level for this load, with peak kW load occurring only when the load is running. Since it is a low load level when this kVAR is drawn, there is no reason why a customer would ever see a power factor penalty applied in this situation.

**Conclusion**

The effect of capacitors on a power system can be complicated in the details, but the overall trend is simple: small capacitive kVAR draw will not have a detrimental effect on a facility’s power system, and the facility owner will not be charged for the current draw that is seen on any metering connected to the filters.