Power Quality

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As we make advances on green technology, we get a better understanding of the efficiencies and deficiencies on how we consume electricity. Most modern electrical loads, like those imposed by motors, are part active (Watts) and reactive (VAR).The sum of the two loads is known as total or apparent power.

The ventilation industry recognized a need for a better way of rating energy consumption and in 2008, the Air-conditioning Heating and Refrigeration Institute (AHRI) released a new edition of the standard for performance rating of terminals (AHRI 880), which has an optional system for testing and rating power consumption based on performance. This system will use measurements of power quality like active power and power factor to describe energy consumption. The standard also specifies the meter to be used for acquisition of these measurements.

POWER QUALITY

Power quality is an expression often misinterpreted and commonly mistaken for power distribution reliability. Power quality (PQ) describes the load's effectiveness in the use of the total power and it uses several different measurements to do so. These measurements are voltage, electrical current, apparent power, active power, and power factor among other measurements like harmonics, reactive power, and displacement power factor and phase balance.

UNDERSTANDING THE DIFFERENT PQ MEASUREMENTS

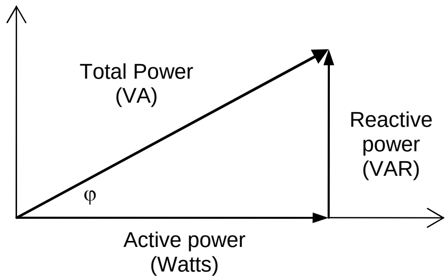
Total power refers to the power drawn by a load. It is measured in true RMS volts times true RMS amperes (VArms). Power companies must supply customers the total power required to meet the load.

Active power is the power used by the load to produce the desired energy which for electric motors is shaft speed and torque. It is measured in watts or kilowatts. We are all billed for electricity based on kW and some other multipliers that electric companies use to calculate the rate per kW.

Reactive power is generated by the power transformation itself and it can be inductive or capacitive. If the load is inductive the electric current leads the voltage by 90deg and vice versa if the load is pure capacitive. This means that the reactive power can be positive or negative and it either leads or lags the current. Pure resistive loads like incandescent bulbs and electric heat do not cause the current to lead or lag the voltage therefore do not have the reactive component of the load.

Power factor is mathematically calculated and it is the algebraic division of the active power and apparent power and is typically expressed as leading or lagging depending on the reactive power load.

If we think of active power and reactive power as power vectors, we can add the two and calculate total power. Power factor can also be calculated as the ratio of active power to total power or cosine of φ. A pure resistive load with no reactive component has a power factor of one and total power and active power have the same magnitude.



Power quality depiction

POWER QUALITY AND MOTOR EFFICIENCY

A common misconception is that power quality is synonymous with motor efficiency. PQ simply describes how the electricity is used by the motors and different loads while motor efficiency rates the power used (active power) to produce a task. PQ does relate to motor efficiency, but it does not directly translate into the motor's efficiency to produce a task. Motor efficiency, unfortunately, is a difficult value to quantify.

THE CITY OF SEATTLE AND CALIFORNIA'S TITLE 24

The City of Seattle and California's Title 24 call for either an Electrically Commutated Motor (ECM), or a motor that is 70% efficient, when used in a series fan terminal. Both reference a NEMA standard that does not cover fractional horse power motors like those used by our industry. At this time there are no industry standards regulating testing and reporting of these types of motors. In effect, these codes require the use of ECM motors.

AHRI 880-2008 STANDARD AND THE NEW REQUIREMENTS

The Air-conditioning Heating and Refrigeration Institute (AHRI), in an effort to make meaningful comparisons between the different fan box manufacturers and their products, has opted for an optional system to rate efficiency based on Watts per CFM and to rate power factor. As, an industry, we chose this method of rating energy consumption because even if there were a standard for rating motor efficiency, the information would be meaningless without the fan box cabinet and blower attached to it. Furthermore a single point rating would be meaningless as well, as fan terminals are used over a range of air flows.

Section 8.1 of AHRI 880-2008 specifies that all fan boxes are to be rated at 4 different operating points. Energy consumption will be rated at each operating point in Watts per CFM (Watts/ m^3/min), fan power in Watts, airflow in CFM (m^3/min), voltage (V), and frequency in Hz, motor designation, power factor in Watts/VA(True RMS), and motor nameplate power in HP (KW).

The performance rating points will be based on percentage of the manufacturer's stated airflow capacity. Series fan boxes will be rated at 100%, 75%, 50%, and 25%. Parallel fan boxes will be rated at 80%, 60%, 40%, and 20%. Data is to be reported at 0.25inWg downstream static pressure.

The airflow range of any two fan boxes will most likely be different and one can not directly compare manufacturer A versus manufacturer B at any given percentage of capacity. Units can not be rated at specified airflows because there are an infinite number of applications and fan box capacities between manufacturers. A four point rating system is beneficial because we can plot the given data and interpolate (estimate) the desired airflow.

WHY DO WE CARE ABOUT RATING ACTIVE POWER AND POWER FACTOR?

As the world catches up with green building design and energy conscious designing, electric companies realized that buildings with low power factor meant that they must produce and provide more electricity to their customers than they are charged for. To them, a poor building power factor means larger power plants with greater carbon foot prints, oversize transformers and conductors, with no return.

Most of us pay for electricity based on the total watts consumed over a time period and multipliers based on location, type of building (industrial, commercial, or residential), among others. Penalties are being implemented by many electric utility companies to buildings with low or poor power factor to compensate for the added demand in KVA.

The building's power factor can be corrected at a centralized location using banks of capacitors and inductors. These instruments are simply called power factor correctors or PFC. Power factor can also be treated at the source. Improving the power factor at the source directly impact the performance and life of the equipment.

POWER FACTOR CORRECTION AT THE SOURCE

Krueger offers an inductor (often referred to as a choke) to treat the power factor (PF) on an ECM motor. We made the inductor optional to give design engineers the option of treating PF at a centralized location or at the source.

Studies are yet to be made on fully functioning buildings to see the real effect of the low PF on electrically commuted motors which typically have a power factor of between 0.40W/VA and 0.80W/VA. Some electrical engineers claim that with the variety of electric loads the reactive power (which can be positive or negative) cancels out yielding a net PF close to 1.00W/VA. Permanent split capacitor motors generally have a PF of 0.70 or better.

ECM VERSUS PSC POWER QUALITY

ECM motors were introduced to the market promising great power savings and they do. An ECM will always use fewer watts than a PSC for the same unit. We are coming to realize, however, that the low active power consumption of an ECM comes with a penalty, the penalty being a much lower power factor compared to a PSC motor.

At Krueger we are currently doing extensive studies on electrical performance and have found that almost always an ECM fan box above 76% of max airflow (not percentage of range) can be less efficient than a PSC motor due to the low power factor of the ECM motor. The following example shows the difference:

	Fan box A	**Fan box B**
Motor Designation:	ECM	PSC
Motor Nameplate:	½ HP	½ HP
Energy Consumption:	0.32 Watts per CFM	0.43 Watts per CFM
Fan Power:	570 Watts	780 Watts
Power factor:	0.52 Watts / Volt-Ampere	0.92 Watts / Volt-Ampere
Voltage:	277 Volts	277 Volts
Frequency:	60 Hz	60 Hz
Airflow	1800 CFM	1800 CFM

Given the previous data, one can quickly observe how comparable the two fan boxes are. Both fan boxes use a 277V, 60Hz ½ HP motor, they both operate at the same airflow. Fan box A has a PF of 0.52W/VA and Fan Box B 0.92W/VA.

Looking at power quality we now know that PF is the result of the mathematical division of active power and apparent power. By doing this calculation we get the total power (apparent power) used by either fan box. Fan Box A yields 1096VA and Fan Box B 848VA.

The data shows that Fan Box B used 35% more active power (Watts) than Fan Box A. Fan Box A uses 30% more Total Power (VA) however.

WHY SHOULD YOU CARE ABOUT POWER QUALITY?

Power quality affects electrical equipment differently, and those with delicate electronics like an ECM are more susceptible to damage or shortening of life due to poor power quality are, and thus Krueger suggests treating the ECM power factor at the source with the recommended inductor.

Every day more electrical companies chose to measure PQ and calculate the building's power factor in order to determine the cost per KW. They do this not to penalize building owners but because of all the extra energy that they have to produce and distribute because of buildings with low power factor.

We have to understand that although we might be consuming less active power (Watts), the electric companies have to supply more actual power to meet demand based on total power (KVA). They also have to invest in more expensive equipment, installation and maintenance to meet the actual total power demand. In addition, Total power dictates the size of transformers, wire gauge, fuses and more.

When power quality is a priority on equipment selection, one must seek equipment which consumes the least amount of active power (Watts) with a power factor (Watt/Volt-Amps) that nears one in the normal mode of operation. Most electric companies are happy with a building power factor of 0.9Watts/Volt-Ampere. Such is the case of the El Paso Electric Company which in 2006 published a Newsletter for El Paso Electric's Business Customers titled "Improving Power Factor". This document is available for public view at www.epelectric.com.

RECAP

Power factor and power quality is not a new topic for those responsible to produce and distribute electricity but it is a topic of interest in the modern world. We have to look back in time to understand why PQ was a dormant topic. In the past, most electric loads were pure resistive loads and only a few appliances had complex loads involving active and reactive power. In these buildings total power (Volt-Ampere) and active power (Watts) were almost equal in magnitude therefore buildings had a power factor that near the unit making power factor a non issue unless severe problems were occurring at the building.

Today's electric loads are more complex than ever. Computers, variable frequency drives, power supplies and electrical power commutation all require voltage transformation of some kind and this causes distortion in the electrical current and the voltage sinusoidal waves decreasing power factor.

Expect an increase in research from the industries fabricating electrical and electronic equipment, those of us who use the components and the power companies in charge of power distribution. The HVAC industry has taken a huge step forward by establishing methods of testing and rating terminal units. The AHRI 880-2008 standard includes the new power rating system which will be optional in the beginning but we do foresee it will become mandatory in time. We will present all the data we have, including both VA and Watts/CFM, so that the design engineer can make a reasoned decision when selecting equipment for a project.