Understanding Power Factor and Efficiency in power converting supplies

Vern Fleming
Applied Energy Solutions,
One Technology Place Caledonia, New York 14423

Abstract:
A key element in understanding energy savings utilizing different power converting technologies is to first understand the basics regarding power factor and how it relates to the overall conversion process of taking AC power and converting it to DC power in a unit such as an industrial charger.

This brief is designed to educate and give readers the fundamental basic information required to become familiar with Power Factor its effect on efficiency and the cost of power, along with a more comprehensive understanding of efficiency.

Background:

The phrase Power Factor for sinusoidal waveforms is a term used to describe the alignment or miss alignment of the sinusoidal wave of the Voltage and Current entering an electrical device. There is a natural state of alignment and or miss alignment of the curves at any given time which depends on the nature of the load. These alignments can change at any time in any given situations causing them to miss align further as well. For more complex waveforms Power Factor is considered to be the ratio of the power consumed by the circuit divided by product of rms input current and voltage.

The more miss aligned wave forms are the greater the rms value of the current has to be in order to provide a given power level. This means that the input wiring has to be a larger cross section and the generator has to provide more current than would be needed for a circuit with unity (perfect) Power Factor.

Solution:

There are several means, passive or active that can be used to improve Power Factor. All of these require circuitry built into the unit at the incoming stage of the AC supply. The goal of these devices is to correct the power factor and re-align the Current and Voltage waves in an effort to provide the best power factor. Steps should also be taken to remove high frequency noise from the waveforms. The circuitry should be chosen to minimize additional losses to maintain good overall efficiency.

A passive Power Factor Correction circuit would correct power factor to an acceptable level without utilizing components that introduce switching noise and potentially additional loss. The slight down side is a passive PFC device is that it does not correct as well at low power levels, so it becomes a balancing act of getting the best PFC correction at the lowest operating cost of the over all power supply.

Another method is to provide an active PFC circuit that would use powered components to again align the wave forms. This device would have the ability to more fully align the wave forms but at a cost. This device would require the use of additional potentially resulting in an overall reduced efficiency of the total unit.

Efficiency:

Many people confuse the aforementioned Power Factor and Efficiency as one in the same but they are different. The efficiency of a power supply device speaks to the overall ability of the unit to efficiently utilize energy/power. This simply means the ratio of output power divided by input power. In the case of Industrial charging how much power goes into the battery divided by input power to the charger. Many factors come into determining the efficiency of any of these devices. Certainly as described above the Power Factor Correction circuit plays a large part in the potential efficiency, along with the internal design and devices chosen. Additionally the topology used in the design has a very large part in determining the charger efficiency. It is widely accepted that the following topologies will have an effect on efficiency in order from worst case to best case.

However please note that at any point one topology could out rank another due to the internal design and the designer's ability to utilize proper components and design theory. Additionally to the right of these topologies is a complexity rating speaking to how complex the design may be which typically indicates a higher part count potentially resulting in a shorter mean time to failure as well, with 10 being the most complex.

Silicon Controlled Rectifier	5
Ferro resonant	3
Controlled Ferro resonant	4
High Frequency	8

Let's look through the end users eyes for a moment and understand what it is they want. This is simple they want the most affordable and efficient device they can get that will be reliable over the long term. Again the answer to this can be different depending on budget, operating environment, the need for flexibility, and other factors.

Please see the white paper titled "Applying the right charging topology", for further information regarding this.

For more information contact:

Applied Energy Solutions
One Technology Place
Caledonia, NY 14423
Phone: 585.538.4421 800.836.2132
Fax: 585.538.6345
E-mail (thru website): www.appliedenergysol.com