Friday, February 8, 2008

What is PFC and why do I need it?

Switchmode power supplies without Power Factor Correction (PFC) tend to draw the AC input current in short bursts or spikes relative to the line voltage, as shown in Fig. 1. The Power Factor of a power supply is technically the ratio of the real power consumed to the apparent power (Voltsrms x Ampsrms) and is a decimal between 0 and 1.0. If left uncorrected the Power Factor (PF) of switchmode supplies will generally be around 0.65 or less.

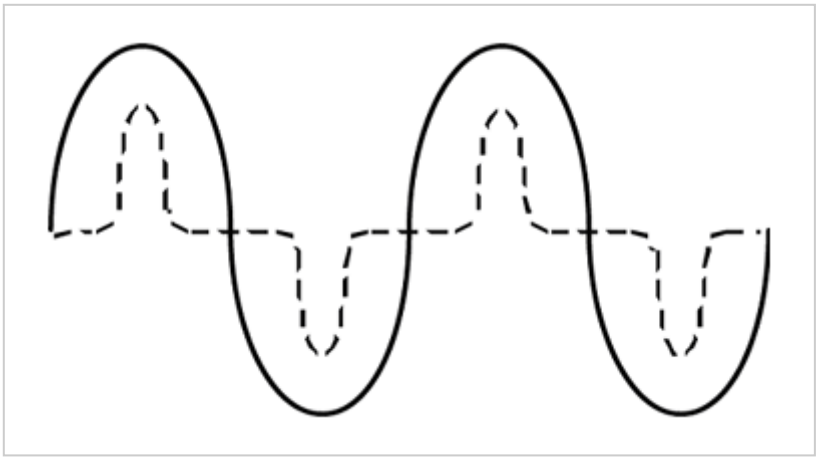

Figure 1. Input of switchmode power supplies without PFC. The voltage waveform is a sinewave and the current waveform is a pulse or spike. PF<1

The Power Factor can be improved by using PFC circuits. These circuits "smooth out" the pulsating AC current, improving the PF, and reducing the chances of a circuit breaker tripping prematurely. There are two basic types of PFC, passive and active. Passive PFC circuits are less expensive and typically can correct the PF to about 0.85. Active PFC circuits are the most popular, are built into the switchmode power supply and can increase the PF to 0.98 or higher. The closer the PF comes to being 1.0, the better the performance of the power supply. Ideally, we want to end up with the input voltage and current waveforms being sinusoidal and in phase with each other as shown in Fig. 2.

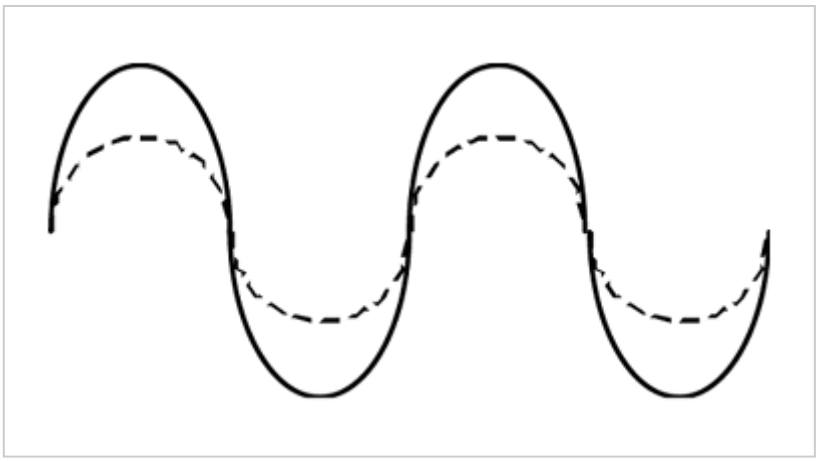

Figure 2. Voltage and Current waveforms are sinusoidal and in-phase. PF=1.

PFC is Required by International Regulations

An important reason to have PFC in your power supply is to comply with international regulations, especially if you intend to sell your equipment in Europe. Since 2001, the European Union (EU) established limits on harmonic currents that can appear on the mains (AC line) of switchmode power supplies. Today, the most important regulation is the "European Norm" EN61000-3-2. This regulation applies to power

supplies with input power of 75 watts or greater, and that pull up to 16 amps off the mains. It sets severe limits on the harmonic currents up to the 39th, when measured at the input of switchmode power supplies.

For example, the first harmonic is the primary input frequency, typically 50 Hz for the EU countries. The third harmonic is 150 Hz, and the 39th harmonic is 1,950 Hz. These unwanted harmonic currents have a direct relationship to the Power Factor of switchmode power supplies. Therefore, power supplies that meet EN61000-3-2 inherently have high power factors that are typically 0.97 or higher.

PFC Increases the Supply's Output Power Capability
The PF, much like the supply's efficiency rating, determines the amount of useful power a switchmode power supply can draw from the AC line and then deliver to its output load. Specifically, the formula that determines this is:

$$VLrms \times ILrms \times PF \times Eff = Pout$$

As an example, if a power supply is operating off of 120VAC line, which is protected by 15A circuit breaker, UL guidelines say you should not draw more than 12A. So, using the formula above, we can compare two power supply examples with different Power Factors, as follows:

Example A: No PFC, PF = 0.65, 85% Efficiency, 120VAC input, 12A max. current:
Therefore: 120VAC x 12A x 0.65 x 0.85 = 796 Watts Output Power

Example B: PFC used, PF=0.98, 85% Efficiency, 120VAC input, 12A max. current:
Therefore: 120VAC x 12A x 0.98 x 0.85 = 1200 Watts Output Power

As can be seen above, the power supply in Example B (with PFC) can deliver 404 Watts or 51% more power to its output load than the non-PFC supply, a significant increase.

Why do I need PFC?
A power supply with PFC can supply higher output load currents than those without PFC. PFC significantly reduces the AC current harmonics, leaving mainly the "fundamental" current frequency that is in-phase with the voltage waveform (Fig. 2). International regulations dictate the substantial reduction of harmonic currents. The vast majority of AC-DC power supplies manufactured by Lambda Americas has active PFC, is in accordance with EN61000-3-2 and provides typical power factors in the range of 0.97 to 0.99.

Posted by Power Guy