Power Factor Correction with Ultrafast Diodes

By Neven A. Soric, Applications Engineer

More and more switched mode power supplies (SMPS) are being designed with an active power factor correction (PFC) input stage. This is mainly due to the introduction of regulations aimed at restricting the harmonic content of the load current drawn from power lines. However, both the user and the power company benefit from PFC, so it just makes good sense.

Non-PFC power supplies use a capacitive input filter, when powered from the AC power line. This results in rectification of the AC line, which in turn causes high peak currents at the crests of the AC voltage, as in Figure 1.a. These peak currents lead to excessive voltage drops in the wiring and imbalance problems in the three-phase power delivery system. This means that the full energy potential of the AC line is not utilized.

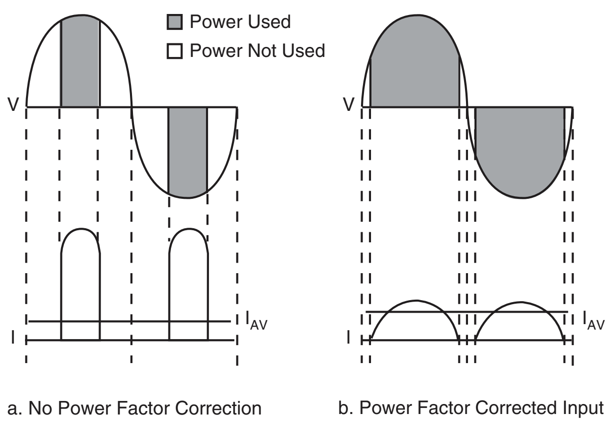

Figure 1. Non-PFC vs. PFC Waveforms (Current, Voltage)

Power Factor Correction (PFC) can be defined as the reduction of the harmonic content, and/or the aligning of the phase angle of incoming current so that it is in phase with the line voltage. By making the current waveform look as sinusoidal and in phase with the voltage waveform as possible, as in Figure 1.b., the power drawn by the power supply from the line is maximized for real power.

Real power is equal to $V_{RMS} \times I_{RMS} \times \cos \varphi$, where φ is the phase difference between the voltage and current waveforms. Therefore, as φ approaches zero, $\cos \varphi$ approaches unity, which maximizes the real power (now just $V_{RMS} \times I_{RMS}$).

Mathematically, Power Factor (PF) is equal to Real Power/ Apparent Power.

The basic concept behind PFC is to make the input look as much like a resistor as possible. Resistors have a power factor of 1 (unity). This is ideal, because it allows the power distribution system to operate at its maximum efficiency.

Lets consider a continuous conduction mode (CCM) boost converter being used for active PFC. The boost topology was chosen because it is the least expensive (cheapest) solution, and cost is always a major consideration. Please refer to Figure 2.

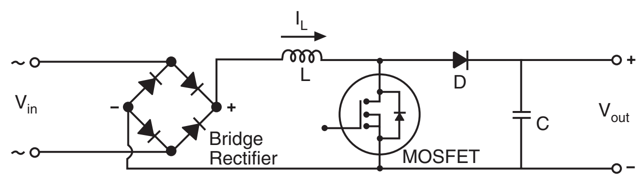

Figure 2. Continuous Mode Boost Converter Circuit

The input full-wave bridge rectifier converts the alternating current (AC) to direct current (DC). The MOSFET is used as an electronic switch, and is cycled “on” and “off” by an external source. While the MOSFET is “on”, the inductor (L) current increases. While the MOSFET is “off”, the inductor delivers current to the capacitor (C) through the forward biased output diode (D). The inductor current does not fall to zero during each switching cycle, which is why this is known as a “continuous conduction mode.” The MOSFET is pulse-width-modulated so that the input impedance of the circuit appears purely resistive, and the ratio of peak to average current is kept low.

The most cost-effective way of reducing losses in the circuit is by choosing a suitable diode for the application. Diodes for use in PFC circuits typically have higher forward voltages than conventional ultrafast epitaxial diodes, but much shorter (faster) reverse recovery times.

Vishay recommends the use of the UH-series for PFC applications.

TABLE 1 - PFC ULTRAFAST RECTIFIERS - MINI SELECTOR GUIDE					
VISHAY PART NUMBERS	**CASE OUTLINE**	**DESCRIPTION**	**I_{AV} (A)**	**V_{RRM} (V)**	**t_{rr} (ns)**
USB260	DO-214AA(SMB)	Plastic SMD	2	600	30
MURS260	DO-214AA(SMB)	Plastic SMD	2	600	50
31GF6	DO-201AD	Plastic Axial	3	600	30
SUF30J	P600	Plastic Axial	3	600	35
MURS360	DO-214AB(SMC)	Plastic SMD	3	600	50
MUR460	DO-201AD	Plastic Axial	4	600	50
UHF5JT	ITO-220AC	Isolated Power Pack	5	600	25
UH5JT	TO-220AC	Plastic Power Pack	5	600	25
UG5JT	TO-220AC	Plastic Power Pack	5	600	25
UGB5JT	TO-263AB	Power Pack SMD	5	600	25
UGF5JT	ITO-220AC	Isolated Power Pack	5	600	25
UH8JT	TO-220AC	Plastic Power Pack	8	600	25
UHF8JT	ITO-220AC	Isolated Power Pack	8	600	25
UG8JT	TO-220AC	Plastic Power Pack	8	600	25
UGB8JT	TO-263AB	Power Pack SMD	8	600	25
UGF8JT	ITO-220AC	Isolated Power Pack	8	600	25
UHF10JT	ITO-220AC	Isolated Power Pack	10	600	25
UG12JT	TO-220AC	Plastic Power Pack	12	600	30
UGB12JT	TO-263AB	Power Pack SMD	12	600	30
UGF12JT	ITO-220AC	Isolated Power Pack	12	600	30
UG15JT	TO-220AC	Plastic Power Pack	15	600	35
UGB15JT	TO-263AB	Power Pack SMD	15	600	35
UGF15JT	ITO-220AC	Isolated Power Pack	15	600	35