

## Power Factor Correction With Ultrafast Diodes

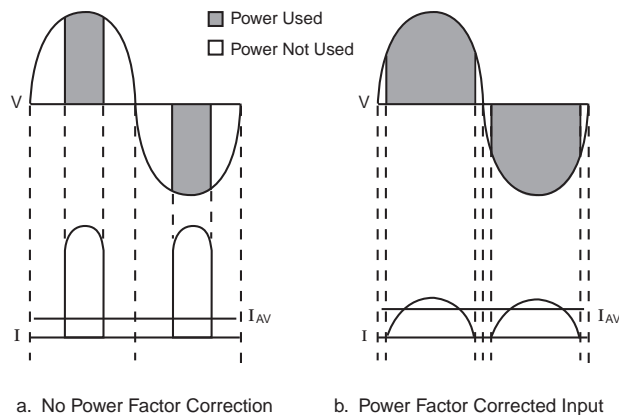
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More and more switched mode power supplies (SMPS) are being designed with an active power factor correction (PFC) input stage. This is mainly due to the introduction of regulations aimed at restricting the harmonic content of the load current drawn 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  $V_{RMS} \cdot I_{RMS} \cdot \cos\phi$ , where  $\phi$  is the phase difference between the voltage and current waveforms. Therefore, as  $\phi$  approaches zero,  $\cos\phi$  approaches unity, which maximizes the real power (now just  $V_{RMS} \cdot I_{RMS}$ ).

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

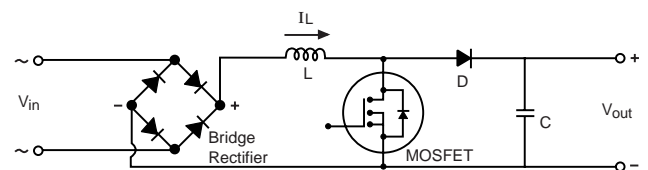
The basic concept behind PFC is to make the input look as much like a resistor as possible. Resistors have a power factor of 1 (unity). This is ideal, because it allows the power distribution system to operate at its maximum efficiency.

Lets consider a continuous current mode 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.

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)

**Figure 2**

Continuous Mode Boost Converter Circuit



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 current 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 UG-series for PFC applications. Please refer to Table 1, on the next page, which lists all applicable UG part numbers, along with their electrical specifications.



**Table 1**

*UG-Series Mini Selector Guide*

GS Series	Case	Description	$I_{(AV)}$ (A)	$V_{RRM}$ (V)	$T_{rr}$ (ns)
UG06(A-D)	MPG06	Axial	0.6	50-200	15
UG1(A-D)	DO-204AL	Axial	1	50-200	15
UG2(A-D)	DO-204AC	Axial	2	50-200	15
UG4(A-D)	DO-201AD	Axial	4	50-200	20
UG8(A-J)T	TO-220AC	Single	8	50-600	20-35
UGB8(A-J)T	TO-263AB	Single	8	50-600	20-35
UGF8(A-J)T	ITO-220AC	Single	8	50-600	20-35
UG10(A-G)CT	TO-220AB	Common Cathode	10	50-400	25-35
UGB10(A-G)CT	TO-263AB	Common Cathode	10	50-400	25-35
UGF10(A-G)CT	ITO-220AB	Common Cathode	10	50-400	25-35
UG18(A-D)CT	TO-220AB	Common Cathode	18	50-200	20
UGB18(A-D)CT	TO-263AB	Common Cathode	18	50-200	20
UGF18(A-D)CT	ITO-220AB	Common Cathode	18	50-200	20
UG30(A-D)PT	TO-247AD	Common Cathode	30	50-200	20

Since PFC is typically a 600V application on a universal power supply, one might question the inclusion of <600V parts in the mini-selector guide. Using a combination of (3) 200V parts in series is equivalent to 600V total, while at the same time reducing switching losses, due to the lower individual voltages.