

PFC-Fundamentals

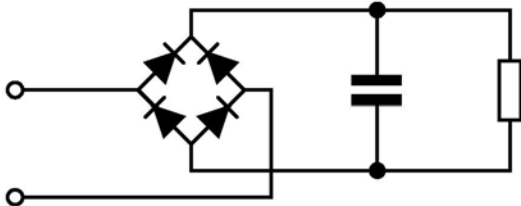
1. Sinusoidal Current Sourcing from the Public Power Grid

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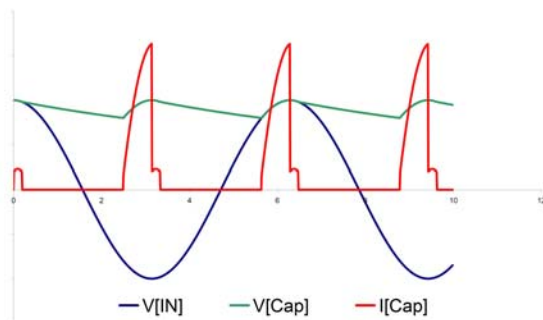
Associated with power electronics connected to the public power grid obtrudes more and more the required power factor correction. The power factor reflects to what extent effective power is sourced from the power grid. With a power factor less than 1 additional non-reactive power cause additional power dissipation in the mains supply and the power cable. A maximal power factor is aimed for. The term power factor associated with power electronics isn't wrong but misleading. The traditional electro-mechanic power factor is displacement of the sinusoidal current to the also sinusoidal voltage ($\cos(\varphi)$). For most power electronics applications is the non-sinusoidal shape of the current the problem to solve. It is more precise to call this challenge as the target of a sinusoidal current sourcing.

The Problem:

In power electronics applications usually the AC voltage is converted into DC voltage via Rectifier Bridge and capacitor. The capacitor is charged only in the time interval were the input voltage exceeds the DC-voltage at the capacitor.



This leads to short heavy current pulses causing interferences and increased power dissipation in the supply line.



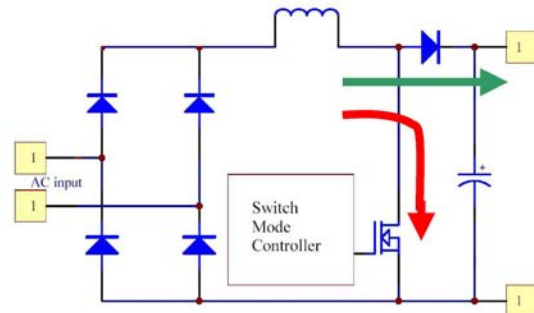
The trigger level of the mains fuse is linear dependent with the average losses in the supply line. Applications exceeding 4kW are not running at the usual for 16A designed and fused installations.

These current pulses cause not only interferences and losses in the individual home installation also in the power grid interferences with other consumer loads and power losses in the electrical supply line. Therefore the electricity suppliers push for a sinusoidal

current sourcing as regulated e.g. in Europe by standards as EN61000-3-2.

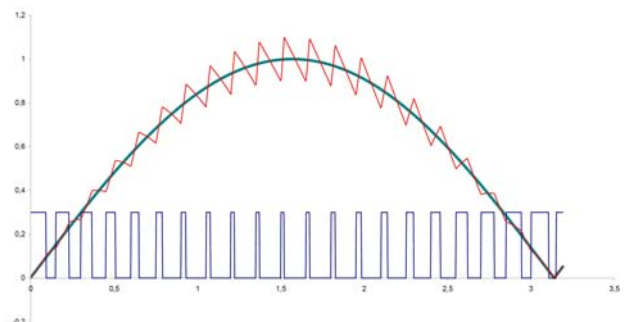
The PFC-Boost Circuit as a Solution:

The sinusoidal current sourcing might be achieved with a PFC boost. This circuit contains additionally to the input rectifier and the capacitor a choke, a transistor and a diode.



Function:

Is the transistor switched on energy is stored in the choke. After switching OFF the energy will flow via diode into the capacitor. With an appropriate sequence of pulses at the transistor control current is pumped during the complete half wave into the capacitor. With this boost topology an almost sinusoidal current sourcing is achievable.



Example:

A power application requires 3.7kW effective power from the power grid. The half wave duration in a 50Hz grid is 10ms. With sinusoidal current sourcing the current in a 230V power line is 16A_{RMS}. The power losses in the 50mΩ home installation results to:

$$P_{V(\sin)} = I^2 * R = 12,8W$$

With a pulsed current sourcing without correction the capacitor is charged during 2ms per half wave only. In 1/5 of the time 5 times higher current have to charge the capacitor to keep the 3,7kW power level. But the current influences the losses by square, the time shortage is only linear. The losses are increased by factor 5!

In this example:

$$P_{V(\text{noPFC})} = (1/5 * (5*16A))^2 * 0,05\Omega = 64W.$$

Result:

The application without PFC cannot be used at a usual 16A installation. The not reactive power causes in the home installation additional losses of 61,8W and additional losses in the electrical supply line. Supply line losses were one factor for the US electricity blackout in 2002.