Power Factor Enhancer from Full to Light Load Conditions

Summary of the Idea

Power Factor Enhancer (PFE) may be used in a power factor correction (PFC) controller to increase the power factor (PF) of a power converter. The PFE may provide controlled distortion of the sensed current of the power converter to improve PF. At high line input voltages, where power factor correction may be more difficult to achieve by other methods, the PFE may be enabled from light-load to full-load conditions. The PFE provides controlled distortion of the sensed current of the power converter to improve PF.

Description

The power factor (PF) may be compromised due to the phase lag in the electro-magnetic interference (EMI) filter, diode bridge, and the hold-up capacitor that follows the diode bridge. Achieving the wanted PF for certain load conditions at high line input voltages may be difficult due to this phase lag.

Figure 2 illustrates example waveforms of the line input voltage and line input current without power factor enhancement. For ideal PF, the input current is expected to follow the input voltage. Figure 2 shows that during the rising slope of the first half line cycle, the input current is distorted by being pulled up while during the falling slope of the first half line cycle, the input current is distorted by being pushed down.

The Power Factor Enhancer (PFE) improves the PF by pre-distorting the sensed current to compensate for the phase lag and the line input current shape. The sensed current may be an inductor current or the power switch current for the power converter.

PFE may be implemented with, or as an add-on to, the input voltage peak-detector of a PFC controller.

The sensed current is pre-distorted in response to the detected peak of the line input voltage. In particular, pre-distortion is responsive to the square of the peak line input voltage. In an example, pre-distortion manipulates the detected peak of the line input voltage by multiplying it by a variable multiplication factor that is non-constant throughout the line cycle and is a ramped down function of the line half cycle phase angle. This pre-distorts the sensed current to compensate for the current waveform distortion.

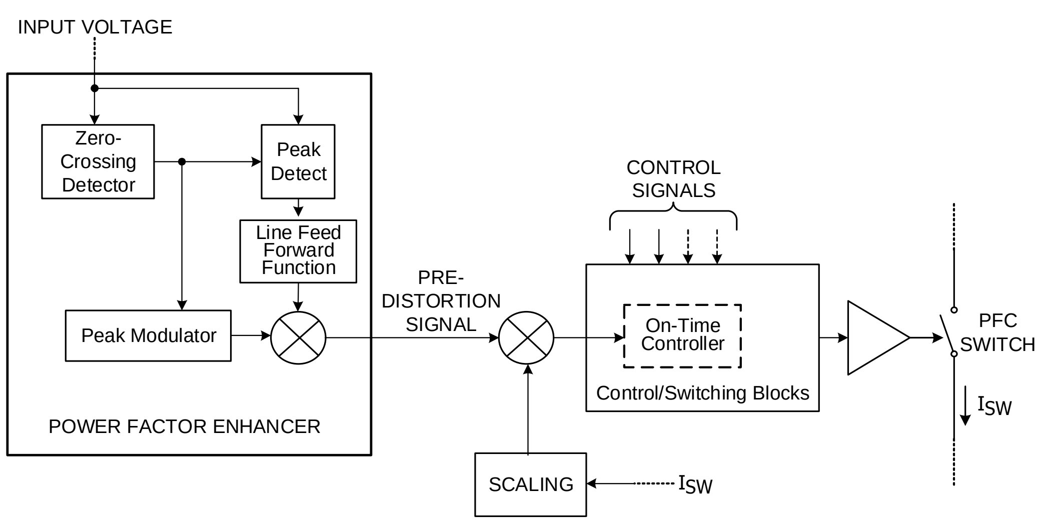

Figure 1. Example block diagram of a PFE circuit

Figure 1 illustrates one example block diagram of the PFE receiving the input voltage at a zero-crossing detector as well as peak detector. The zero-crossing detector detects zero-crossing of the input voltage, which are then used by the peak detector to generate the peak value of the input voltage. To keep the loop gain constant, a line feed forward function may be applied on the peak value. In one example, the line feed forward function may be a square function or a piecewise linear function that simulates a second order parabolic function.

Zero-crossings would also be used by the peak modulator block to generate a peak modulator function for each half line cycle. In one example, the peak modulator function for each half line cycle may be a sloped down linear or non-linear function that is tailored to compensate the required reshaping of the line input current waveform to achieve an improved sinusoidal current waveform with reduced total harmonic distortion and high power factor. The peak modulator function would modulate the line feed forward output through the multiplier. The output of multiplier forms the pre-distortion signal that is generated at each half line cycle. As shown, the pre-distortion signal modulates the scaled sensed switch current.

Figure 2 illustrates example waveforms of the line input voltage and line input current without PFE while Figure 3 illustrates example waveforms of the line input voltage and line input current with PFE enabled.

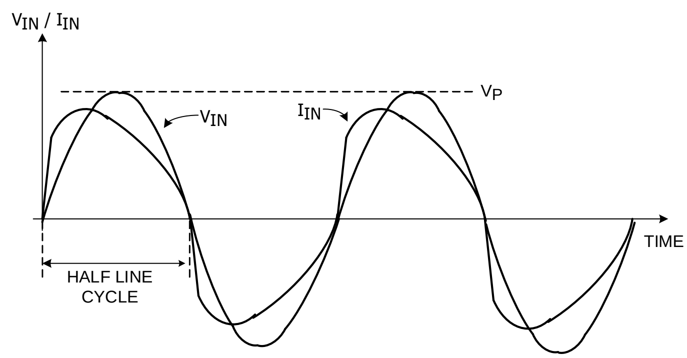

Figure 2. Line input voltage (V_{IN}) and line input current (I_{IN}) without Power Factor Enhancement

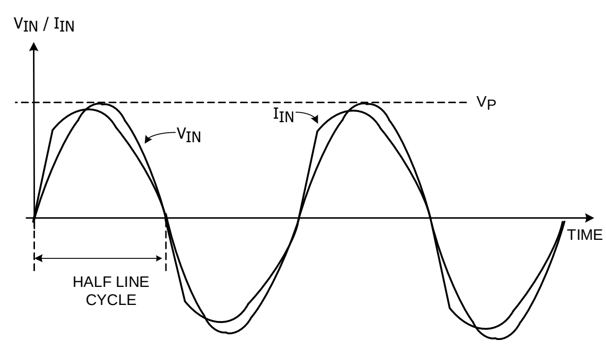

Figure 3. Line input voltage (V_{IN}) and line input current (I_{IN}) with Power Factor Enhancement enabled