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Methods of Reactive Energy Management

Although today electronic digital signal processing (DSP) enables reactive energy measurements to be closer to the theoretical value, there is no consensus in the field of energy metering on the methods of measurement. This change in the end-consumer profile is a disadvantage for energy distributors which bill energy based only on active power. With the application of non-linear loads to power lines the active energy no longer represents the total energy delivered. As a response to improve billing, the measurement of reactive energy is gaining interest.

This article aims to explain and compare the three main methods in use, namely the Power Triangle, the Time Delay and Low-pass Filter.

Method 1: The Power triangle method is based on the assumption that the three energies, apparent, active and reactive. The reactive power can

$$\text{Reactive } Power = \sqrt{Apparent\ Power^2 - Active\ Power^2}$$

then be processed by estimating the active and apparent energies and applying: Although this method gives excellent results with pure sinusoidal waveforms.

Method 2: Time delay A is introduced to shift one of the waveforms by 90° at the fundamental frequency and multiply the two waveforms:

$$\text{Reactive energy} = \frac{1}{T}\int_0^T v(t) \cdot i\left(t + \frac{T}{4}\right) dt$$

where T is the period of the fundamental. This method presents drawbacks if the line frequency changes and the number of samples no longer represents a quarter-cycle of the fundamental frequency.

Method 3: Low-pass filter A constant 90° phase shift over frequency with an attenuation of 20 dB/decade is introduced. This solution, which has been implemented by Analog Devices, can be realized with a single pole low-pass filter on one channel input

If the cut-off frequency of the low pass filter is much lower than the fundamental frequency, this solution provides a 90° phase shift at any frequency higher than the fundamental frequency. With more and more non-linear loads in household appliances, measuring reactive energy accurately becomes a key issue for energy distributors. Traditional measurement methods like the Power triangle and the Time delay comply with international standards but show limitations in the presence of harmonics or line frequency variation. With the latest advancements in integrated circuit development, as proposed by Analog Devices, energy meter designers can now easily implement more accurate reactive energy measurements and thereby, satisfy emerging requirements from energy providers.