Oxygen Zero-Cross Detector

DEWETRON

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1 Introduction

The Zero-Cross Detector is a part of the Oxygen Software (OPT-POWER) to correctly detect the fundamental frequency and each single Zero-Cross. To comply with the today's challenges (distorted signals, pulse-width modulated signals), a robust method was implemented, to fulfil the following properties:

- Gapless Detection (no "blind" spots)
- Adjustable working area (maximum fundamental frequency)
- Highest Dynamic in time and magnitude (correct behaviour, even with fast frequency changes e.g. motor start-up)
- Correction of eventually filter delays (no time lag)

The method is called „Smart Frequency Filter with Delay Compensation" and working as follows

2 Method

2.1 Block wise Computation

The Input Signal is computed block wise (typically block size is 0.1s)

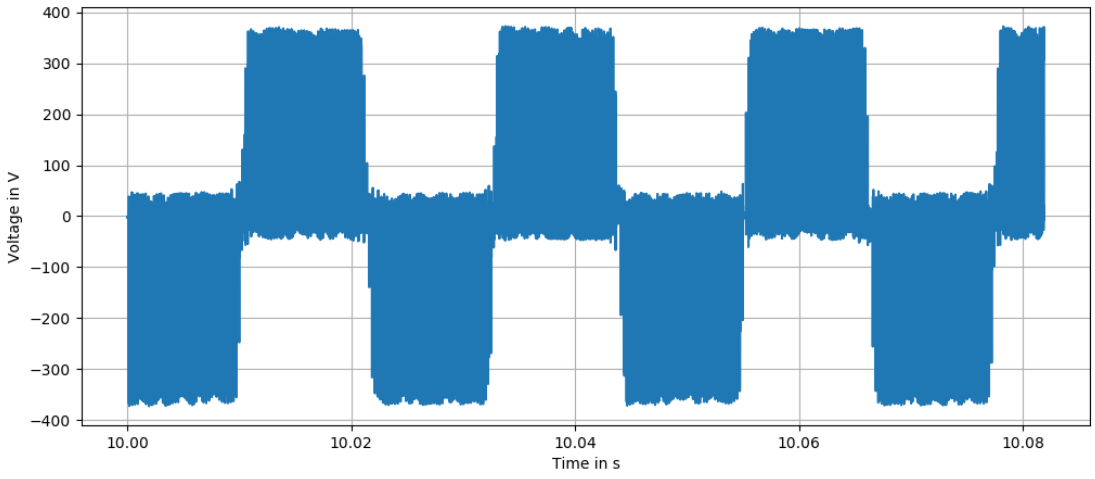

Figure 1: Example signal of line-line voltage (motor converter)

2.2 FFT-Analysis

Each block is processed with an FFT-Algorithm for a rough frequency estimation (max-peak method)

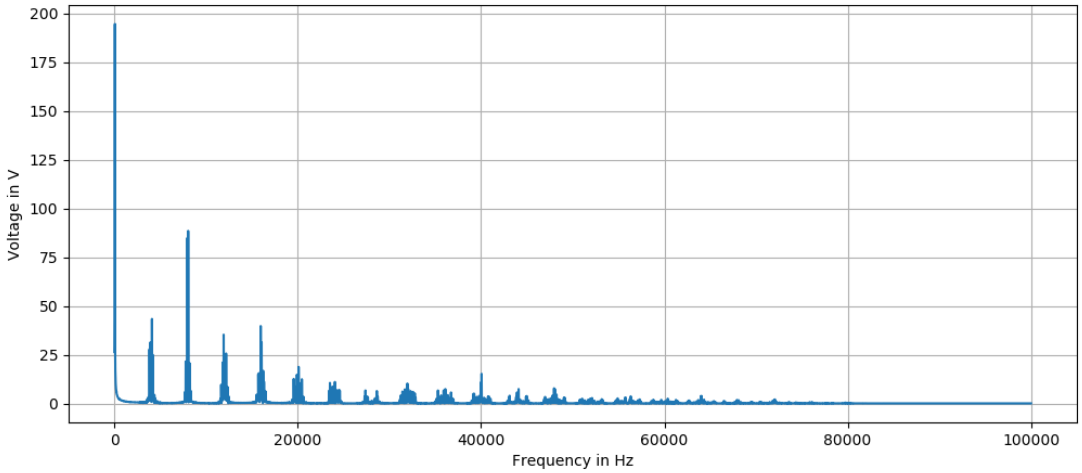

Figure 2: Spectrum (Magnitude) of the original signal

From this amplitude spectrum, the approximate frequency of the fundamental oscillation is determined from the range up to the maximum specified fundamental frequency (typically 1500 Hz).

2.3 Filtering of Input Signal

This roughly determined fundamental oscillation serves as a decision criterion for the filtering of the input signal. There are several filters stages with a very narrow transition bandwidth.

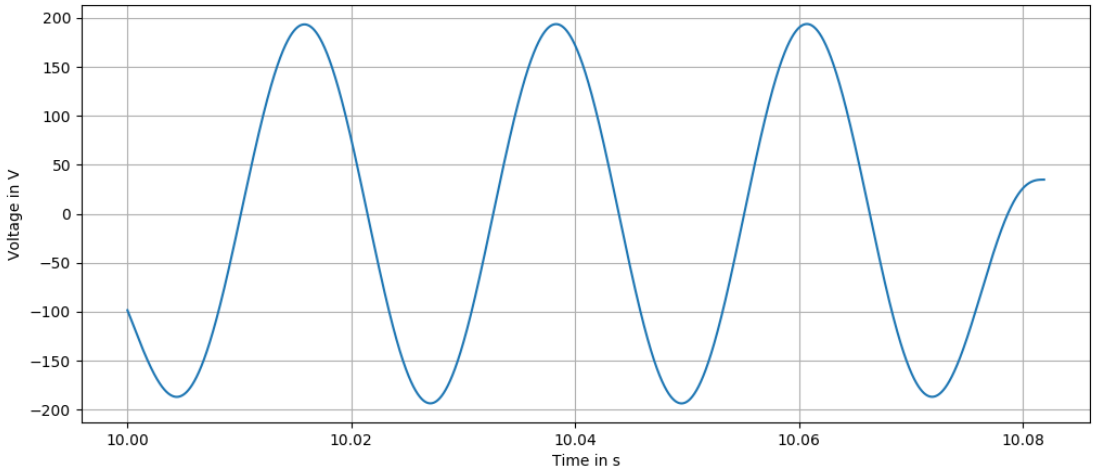

Figure 3: Filtered Input Signal with a Cut-off Frequency of 400 Hz

The filtered input signal is corrected by its specific filter delay.

2.4 Detection of Zero-Crossings

The time-corrected, filtered signal is fed to the definite zero-crossing detector. The positive zero crossing is searched and found with an automatically determined hysteresis (0.1% - 1% of the measuring range). The hysteresis serves to avoid unwanted false detections.

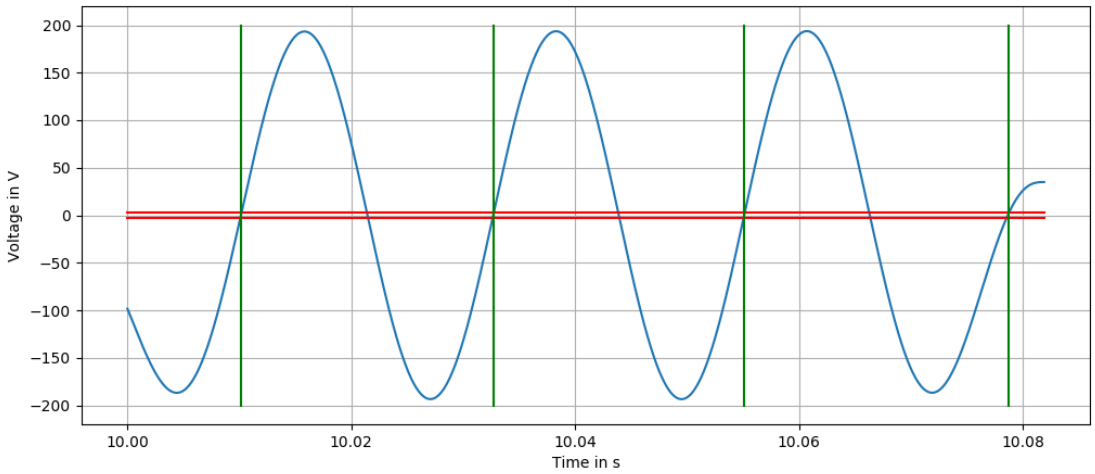

Figure 4: Filtered signal with zero crossings and hysteresis

For the exact time of zero crossing, an interpolation method is used to increase the time resolution beyond the sampling rate.

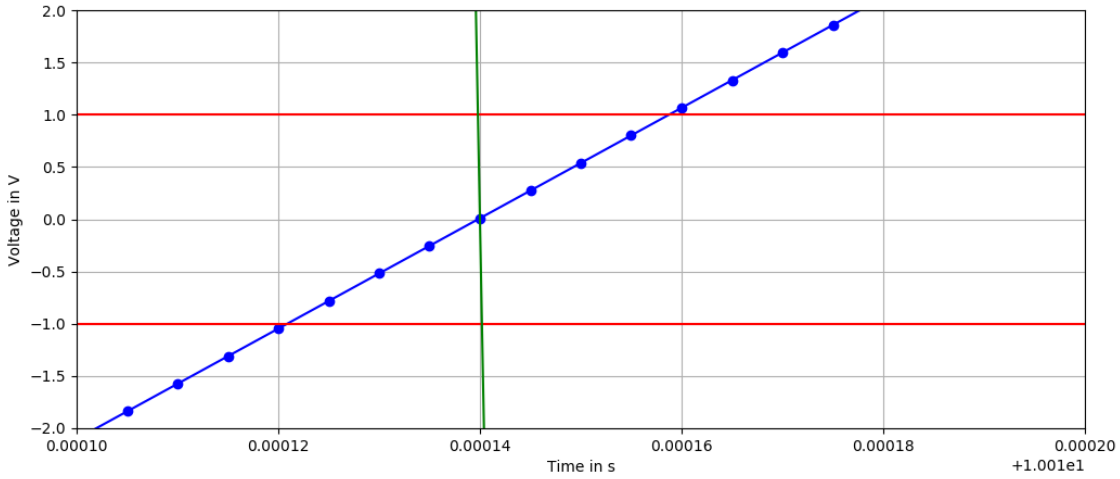

Figure 5: Detail view of Figure 4

2.5 Frequency Measurement

The fundamental frequency is now determined from the reciprocal of the time difference of the zero crossings.