Renewable Energy and Power Quality Journal (RE&PQJ), ISSN 2172-038 X, No.9, 12th May 2011, Reference Paper: 354

Visualization of the power waveforms frequency fluctuations with the use of the constant length time window

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Abstract. This paper presents a new method of visualization of the power waveforms frequency fluctuations in terms of analysis of harmonics and interharmonics in an electric power signal. The presented method is based on image analysis and can be competitive, in some specific cases, to both Fourier transformation and wavelet method. The presented method constitutes a specific image preparation which consists of a split waveform signal. The article shows examples of simulations results for real life and simulated signals.

Key words

Power quality, harmonics, Fourier transform, signal processing, image analysis

1. Introduction

Recently, due to the considerable increase in the number of power receivers as well as gradual liberalization of the power market, more attention has been paid to the quality of power. Knowledge of the performance of the power system and the quality of the power signal sent enables modernization and installation of additional protection for usually expensive electric and electronic devices. Although there are plenty of different devices for online analysis and monitoring of power quality nowadays, post event processing is still important. It enables advanced feature extraction for detection, localization and characterization of PQ events.

Several methods using Fourier transform, wavelet, Gabor, Prony's method or Wigner-Ville distribution have been developed for analysis of power quality, in e.g.: [1]-[5]. In this paper, the authors develop two-dimensional (2D) representation of the power quality signal introduced in [6]. Presented method enables both variability of power waveform frequency analysis and detection of impulse and transient events, because prepared 2D representation of the signal has more operation flexibility than the regular 1D representation. In Section 2, presented method of power waveform analysis is developed. A combination of image analysis, Fourier transformation and least squares method is proposed as a tool to apply on the 2D data. To test the method's performances, the authors used voltage waveforms of simulated and also real life power quality events. In Section 3 the analysis results are obtained using the method described in Section 2. It is observed that the presented method easily detects such power quality event types as frequency fluctuations, but also sags, swells, impulses and oscillatory transients.

2. Method description

Figure 1 illustrates the method of a 1D signal transformation to a 2D image. The new representation of power waveform signal consists of two-dimensional matrix whose rows correspond to prepared segments of 1D signal. The columns of that matrix represent the numbers of the time windows. Prepared 2D image can be analyzed in the next step with the known image processing methods, Least Squares estimation method and Fourier transformation.

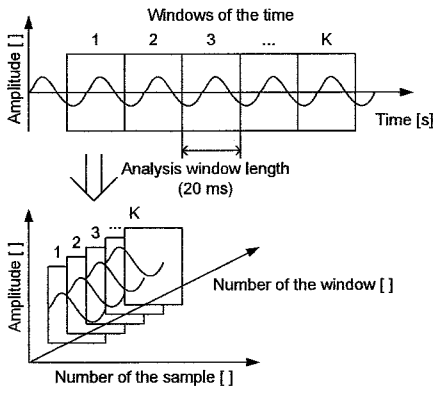

Fig. 1. An image (2D) preparation from regular 1D signal representation.

Figure 2 illustrates the process of finding fundamental harmonic, constructing vector of data - edge in an image that is then used for fundamental frequency estimation and computation of its fluctuations in time. The first step in this block scheme is binarization of the image, next edge detection with image processing method and then, again, another binarization. After these steps, the longest of the edges found is transformed to frequency vector