

Improved Method for Detection and Classification of Transients and Waveform Distortions Using Sine Fitting Algorithms

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Abstract. In this paper, a method for detection and classification of some power quality disturbances (namely transients and waveform distortions) is presented. The proposed method uses sine fitting algorithms for extraction of the event from the voltage signal and for its classification. The performance of the proposed method is demonstrated by examples of measured events.

Key words

Power quality detection and classification, transients, waveform distortions, sine fitting algorithms.

1. Introduction

One of the most common power quality disturbances encountered in power systems are transients and distortions of the voltage waveform (such as harmonic or interharmonic distortions or notching). Monitoring of these disturbances is an important task as these disturbances may have harmful impact on the equipment connected to the power system (e.g., increased levels of harmonic distortion can cause overheating of motors [1]).

The presented method is an improvement of the method presented by the authors [2] and improves the classification stage.

2. Detection and Classification Method

The proposed method consists of two stages. In the first stage the presence of potential events is detected. When an event is detected, the method proceeds to the second stage in which the type and the parameters (such as magnitude and duration) of the event are determined.

Individual parts of the detection and classification process are described in the following sub-sections.

A. Event detection

In the detection stage of the proposed method, the power system voltage signal u is processed using the 4-parameter sine fitting algorithm [3]. The algorithm separates the fundamental u_F and the component u_e that contains potential events

$$u = u_F + u_e \quad (1)$$

The absolute value of the signal u_e is further processed using mathematical morphology operation closing [4]. The closing operation produces an envelope of the input signal $|u_e|$ simplifying detection of potential events

$$u_{\text{MORPH}} = |u_e| \bullet s_{50} \quad (2)$$

where s_{50} is a so-called structuring element. In this case, the structuring element is a vector of ones, whose length corresponds to 50 ms (2.5 periods of the fundamental).

The events are detected by thresholding the closing's output signal u_{MORPH} using a threshold level Morph_THR ; i.e., an event is detected when the signal u_{MORPH} exceeds this threshold level.

B. Classification

In the classification stage the type and the parameters of the detected event are determined. First, the input voltage u (the part that contains the event) is processed using the non-iterative multiharmonic sine fitting algorithm [5]. The multiharmonic sine fitting algorithm estimates the parameters of H harmonics of the signal u (in-phase component A_h and quadrature component B_h , DC

component u_{DC}), which allows separating the harmonic u_H and interharmonic u_{IH} part of the detected event

$$u_e = u_H + u_{IH} , \quad (3)$$

$$u_H = \sum_{h=2}^H A_h \cos(h\omega t) + B_h \sin(h\omega t) , \quad (4)$$

$$u_{IH} = u - u_{DC} - \sum_{h=1}^H A_h \cos(h\omega t) + B_h \sin(h\omega t) . \quad (5)$$

The results of the multiharmonic sine fitting are then used to calculate the total harmonic distortion (THD) and total interharmonic distortion (TIHD)

$$THD = \frac{\sqrt{\sum_{h=2}^H (A_h^2 + B_h^2)}}{\sqrt{A_1^2 + B_1^2}} \quad (6)$$

$$TIHD = \sqrt{\frac{1}{N} \sum_{n=1}^N u_{IH}^2 [n]} . \quad (7)$$

An event is classified as a waveform distortion when either of the following conditions is true:

- a) its duration exceeds 50 ms OR
- b) its duration is longer than 20 ms and the THD during the event exceeded the THD_THR threshold.

This means that the proposed method considers an event to be a waveform distortion when the event has a clearly steady-state character (duration longer than 2.5 periods in a 50 Hz power system) or it is at least one period (20 ms) long and its harmonic content exceeds a preset threshold level.

Other events are classified as transients; i.e. transients are events that are

- a) shorter than one period OR
- b) longer than one period, shorter than 2.5 periods and having mostly of interharmonic content.

The events classified as waveform distortions are further marked as either harmonic or interharmonic depending which of the maximum values of THD and TIHD is greater. The events magnitude A_{WD} is calculated as the maximum value of u_{MORPH} during the event. The duration of a waveform distortion t_{WD} is calculated as the time difference between the times when the signal u_{MORPH} crosses the $Morph_THR$ level and the time it returns below this level.

In case of transients, further processing is required since the long structuring element s_{50} used to obtain the u_{MORPH} signal can make several neighbouring transients appear as a single event. In order to separate the potential multiple transients, the signal $|u_e|$ is processed using a closing operation once again, this time using a structuring element s_4 which is only 4 ms long. The resulting signal is thresholded using the $Morph_THR$ level in order to determine the location in time and duration (t_T) of individual transients. The transient's magnitude A_T is

calculated as the maximum value of the signal after closing during the event.

3. Conclusion

The proposed method detects and classifies the following three categories of events: i) transients; ii) waveform distortions caused by harmonic frequencies and iii) waveform distortions caused by interharmonic frequencies.

In the event detection stage, the method uses the 4-parameter sine fitting algorithm to extract the potential event. When an event is detected, the method uses the non-iterative multiharmonic sine fitting algorithm to separate the harmonic and interharmonic content of the voltage during the event. The classification is based on this information and also on the typical parameters of the considered events [6].

References

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