Time Frequency Aggregation Performance Optimization of Power Quality Disturbances Based on Generalized S Transform

Mengda Li

Shanghai Dianji University, Shanghai 201306, China

limd @ sdju.edu.cn

Abstract

In order to study the problem of power quality disturbance signal detection and localization more accurately, this paper studies a method for analyzing the time-frequency aggregation performance of disturbance signal based on generalized S transform. According to the theory of standard S transform based derivation of the generalized discrete S transform formula, to extract features of various disturbance signals from different angles, and determine the starting and ending time of the disturbance signal, the results were analyzed and compared with the standard S transform. The results show that the generalized S transform is more flexible than the standard S transform. It can not only effectively detect the instantaneous change of signal amplitude, but also accurately determine the frequency variation of higher order components.

Keywords

Power Quality Disturbances, Generalized S Transform, Time - frequency aggregation.

1. Introduction

The solution and improvement of the power quality problem is the hot spot of the current power system research, and correctly identify the power quality disturbance such as harmonics, voltage spike, voltage interruption, voltage sags, Problem, there must be accurate and rapid detection and analysis methods. Experts at home and abroad have put forward different methods, such as short time Fourier transform, short time Fourier transform, wavelet transform WT (Wavelet Transform) and so on.

The S-transform proposed by Stockwell et al is an extension of the idea of continuous wavelet transform. The fundamental wavelet consists of the product of the simple harmonic and the Gaussian window function. The simple harmonic wave is scaled only in the time domain, and the Gaussian window function is scaled and translated compared with short-time Fourier transform, wavelet transform has its unique advantages, such as the signal S-transform resolution and frequency-related, while maintaining a direct relationship with its Fourier spectrum, the basic wavelet does not have to meet the permissibility conditions[1]. However, due to the fact that the fundamental wavelet is fixed in the S transform, it is restricted in the application of the actual signal processing and analysis. For this reason, many scholars have developed and generalized the S transform, and proposed the generalized S transform[1-2]. They have their own advantages and disadvantages when dealing with different actual signals.

In this paper, the time-frequency clustering measure proposed by Jones and Parks is introduced into the generalized S-transform, and the simulation results are proved by the synthesized power quality disturbance signal. The effectiveness of the method is proved and the detection effect is good.

2. S- transform and Generalized S–transform

In 1996, R.G. Stockwell et al proposed S-transform[3-5]. The S-transform is a generalization of the idea of continuous wavelet transform. It has some properties lacking continuous wavelet transform. It is based on a Gaussian window which is localized by translation and extension. When it is used to detect non-stationary signals, it can not only maintain the frequency relevant resolution, but also with the Fourier spectrum also has a direct link, which is any other transformation does not have the nature. The transformation formula is:

$$S(\tau, f) = \int_{-\infty}^{\infty} h(t) \frac{|f|}{\sqrt{2\pi}} \exp\left\{-(t-\tau)^2 f^2/2 - j2\pi ft\right\} dt \tag{1}$$

Where: f is the frequency; τ is the center point of the window function, and controls the position of the Gaussian window function on the time axis.

And for generalized S transform, let $\sigma(f) = \frac{1}{|f|^p}$, where $p = p(f)$ is the optimal adjustment factor corresponding to the frequency f, then the generalized S transform has the following expression:

$$S^p(\tau, f) = \int_{-\infty}^{+\infty} h(t) \frac{|f|^p}{\sqrt{2\pi}} \exp[-\frac{(\tau - t)^2 f^{2p}}{2}] \exp(-j2\pi ft) dt \tag{2}$$

The parameter p controls the width of the window function. For a given signal, the generalized S transform can be realized as long as the optimal value of the parameter p can be determined.

3. An Algorithm for Improving Time - Frequency Aggregation by Generalized S-Transform

In this paper, Jones and Parks proposed the time-frequency aggregation measure into the calculation, used to determine the optimal value of P, the entire calculation process is as follows [6].

1) Calculate each p value in $p \in (0,1]$ according to the discrete form of generalized S transform and calculate the generalized S time-frequency distribution of time domain signal respectively.

2) For each p and f according to Jones and Parks time-frequency aggregation metrics:

$$M_{JP}(f, p) = \int_{-\infty}^{+\infty} |S^p(\tau, f)|^4 d\tau / [\int_{-\infty}^{+\infty} |S^p(\tau, f)|^2 d\tau]^2 \tag{3[“-¥]}$$

3) Take $M_{JP}(f, p)$ to the maximum p value as the optimal adjustment factor corresponding to frequency f:

$$P_{opt}(f) = \arg\max_p [M_{JP}(f, p)]$$

4) to improve the time-frequency aggregation of the generalized S-transform:

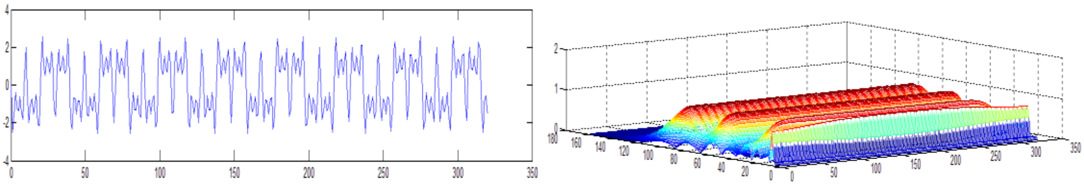
$$S^p(\tau, f) = S^{P_{opt}(f)}(\tau, f)$$

4. Algorithm Simulation and Result Comparison

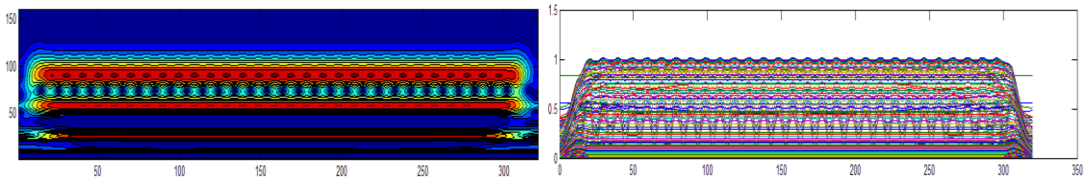
In this paper, the use of MATLAB programming to achieve harmonics, voltage spikes, voltage interrupt, voltage sag typical signal, sampling frequency 1.6KHz.

4.1 Signal Analysis and Comparison of Harmonics

Figure1 (a) is to synthesize the third harmonic, 7th harmonic, 11th harmonic time domain signal, resulting in strong perturbation; Figure1 (b) for the generalized S transform after the energy aggregation measure after the calculation of the three-dimensional network Figure1 (c) is the equivalent curve; Figure1 (d) is the amplitude envelope. Figure2 is the equivalent curve after S transformation. Compared with Fig 1 (c), although the harmonic frequency can be proposed, it can be seen that the resolution after calculating the energy aggregation measure is obviously improved.



(a) Time-domain waveform (b) D mesh



(c) Equivalent curve (d) Amplitude envelope diagram

Fig.1 Generalized S transform of harmonic signal

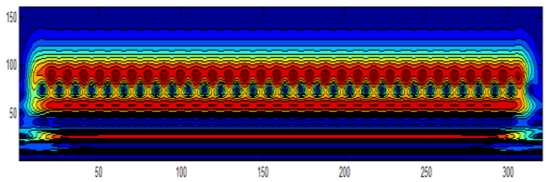
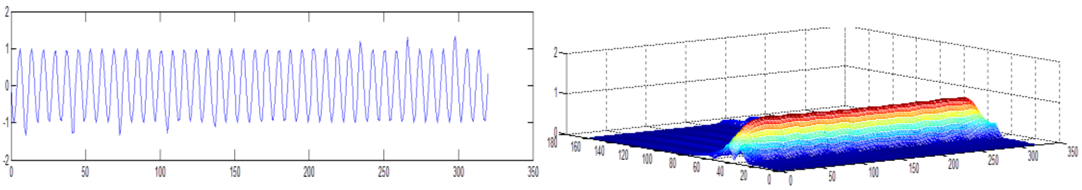


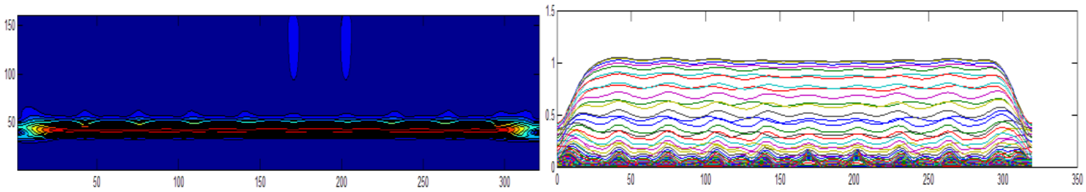
Fig.2 S transform of harmonic signal

4.2 Signal Analysis and Comparison of Voltage Spikes

Fig.3 and Fig.4 show the simulation results of the voltage spike signals in the generalized S-transform and the S-transform. Comparing Fig.3 (c) and Fig.4, it can be seen that the former has a high resolution, and the singularity is detected and the energy aggregation performance is revealed.



(a) Time-domain waveform (b) D mesh



(c) Equivalent curve (d) Amplitude envelope diagram

Fig.3 Generalized S transform of voltage spike signal

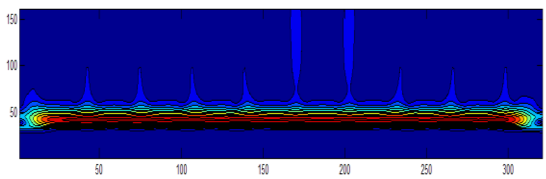
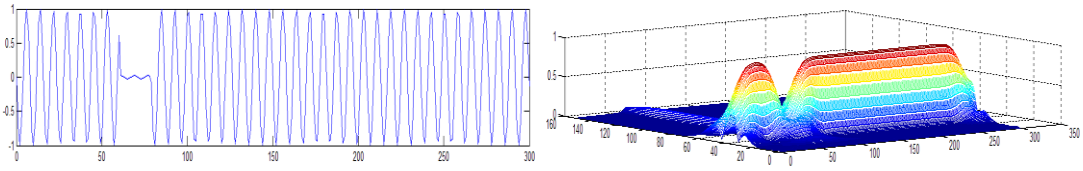


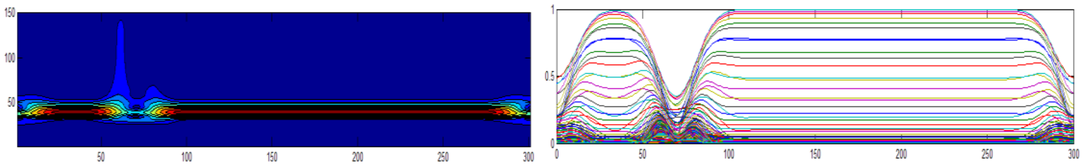
Fig.4 S transform of voltage spike signal

4.3 Signal Analysis and Comparison of Voltage Interruption

Figure5 (a) is a set of voltage interrupt the time domain signal, resulting in a strong disturbance; Figure5 (b) for the generalized S-transform after the energy aggregation measure after the calculation of the three-dimensional grid; Figure5 (c) Figure5 (d) is an amplitude envelope graph. Figure6 is the equivalent curve of S transformation. Compared with Fig.5 (c), although the position of the singular point of the signal can be detected, it can be seen that the resolution after calculating the energy aggregation measure is obviously improved.



(a) Time-domain waveform (b) D mesh



(c) Equivalent curve (d) Amplitude envelope diagram

Fig.5 Generalized S transform of voltage interruption signal

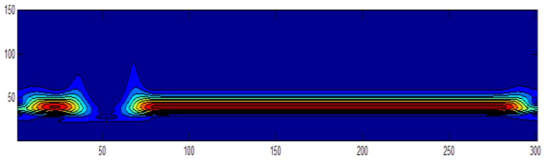
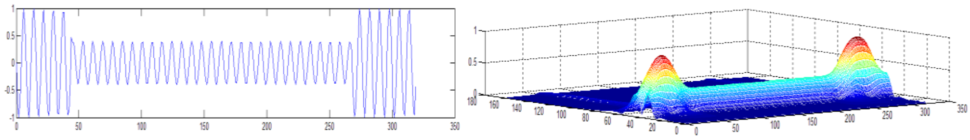


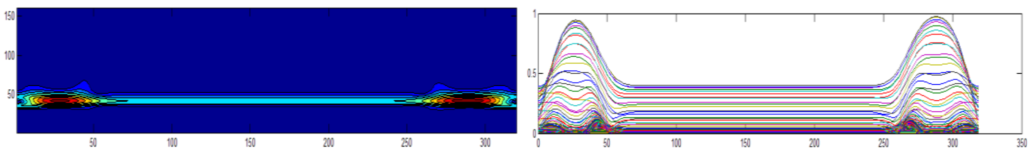
Fig.6 S transform of voltage interruption signal

4.4 Signal Analysis and Comparison of Voltage Sag

Figure7 (a) shows the time domain signal of the set voltage drop; Figure7 (b) is a three-dimensional grid diagram of the generalized S-transform after the energy aggregation measure; Figure7 (c) is the equivalent graph; Figure7 (d) is the amplitude envelope. Figure8 is the equivalent curve of S transformation. Compared with Fig.7 (c), it can be seen that the resolution after energy accumulation measure is obviously improved.



(a) Time-domain waveform (b) D mesh



(c) Equivalent curve (d) Amplitude envelope diagram

Fig.7 Generalized S transform of voltage sag signal

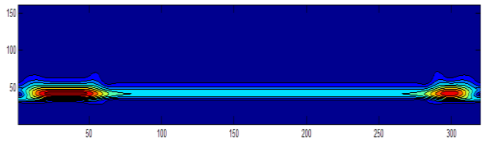


Fig.8 S transform of voltage sag signal

Acknowledgements

Heilongjiang Province Natural Science Fund Project, E201410.

References

[1] Zhan Yong, Cheng Haozhong, Ding Yifeng, et al. S-transform- based classification of power quality disturbance signals by support vector machines[J]. Proceedings of the CSEE, 2005, 25(4):51-56.
[2] Gao Jinghuai, ChenWenchao, Li Youming , et al. Generalized S transform and seismic response analysis of thin interbeds[J]. Chinese Journal of Geophysics, 2003, 46(4): 526-532.
[3] Mallat Stephane. Wavelet guidance for signal processing (English version 2)[M]. Beijing: Mechanical Industry Press, 2002.
[4] Liu Sho uliang, Xiao Xianyong , Yang Honggeng. Classification of short duration power quality disturbance based on module time-frequency matrixes similarity by S transform[J]. Power System Technology, 2006, 30(5): 67-71.
[5] Stockwell, R.G.Mansinha L, Lowe R P. Localization of the complex spectrum: the S-transform[J].IEEE Transaction on Signal Processing, 1996, 44(4):998-1001.
[6] Pinnegar C R, Eeton D W. Application of the Stransform to prestack noise attenuation filtering[J].Journal of Geophysical Research, 2003, 108(B9):2422-2431.