

Analysis of Current Research Status of Power Quality Analysis at Home and Abroad

Xiao Sun^{1, a}

¹Guangdong university of Science & Technology, Guangdong 523083, China.

^a476805916@qq.com

Abstract

The grid structure and load composition of modern power systems have shown new trends, the resulting power quality issues have gradually attracted the attention of power departments and users. Power quality analysis and control strategies are the prerequisites for analyzing and improving power quality. It has important practical significance to ensure the safe and economic operation of the power system and the safety of users' electricity.

Keywords

Power quality, analysis, development trend.

1. Introduction

With the development of metallurgical industry, chemical industry and electrified railway, and the wide application of DC transmission and high-power rectification technology in industrial sectors and electrical equipment, the pollution of the power system is becoming more and more serious and has become an important factor affecting the quality of power. After the impact power load (such as arc furnace, DC transmission converter station) is put into operation in the power grid, the voltage of the power grid will fluctuate, which will seriously interfere with the normal operation of the power grid's fluctuation-sensitive loads such as lighting, computers, precision electronic instruments and so on. As computers and precision electronic instruments are becoming more and more sensitive to the quality of power supply, once power quality problems occur, it will cause equipment failures, or damage to the entire system, and the resulting losses are incalculable. In addition, a large number of modern equipment based on power electronics technology used to improve production efficiency, save energy and reduce environmental pollution are becoming the main source of power quality problems. The power grid is facing more and more power quality problems, which makes the research on power quality very urgent.

On the other hand, the power sector and power users are increasingly concerned about power quality. High-quality electric energy is of great significance for ensuring the safety and economic operation of power grids and electrical equipment, improving product quality and ensuring the normal life of residents. With the development of modern industrial technology and the gradual formation of the power market, power quality has become an important index concerned by the departments of power system generation, supply and consumption. Moreover, as the sensitivity of various electrical equipment to power quality changes, the scope of power quality is further expanded, the classification is finer, and the requirements are higher. Therefore, some new technologies are urgently needed to promote the research of power quality. Through the application of these new technologies, power quality can be improved from the aspects of detection, analysis and monitoring, so as to find problems and rules, improve power supply quality and service.

2. Development and Research Status at Home and Abroad

The denoising, compression, detection and classification of power quality disturbance signals are the core issues of power quality research and current research hotspots. Scholars at home and abroad have carried out a lot of research and summarized the published literature, which can be divided into the following four aspects :

(1) De-noising method of power quality disturbance signal: The purpose of de-noising power quality disturbance signal is to retain important signal characteristics as much as possible while eliminating noise. At present, there are many methods for power quality signal denoising. For example, wavelet (packet) threshold denoising has been widely used because of its simplicity and effectiveness. The selection of the closed value is the main factor affecting the effect of wavelet denoising. This literature has made some improvements in the selection of idle values, and the performance of wavelet denoising has been improved. Some literature proposes to use the correlation between wavelet coefficients of different scales for denoising. The disadvantage is that the calculation is complicated. There are also some papers that divide wavelet coefficients into several blocks for threshold processing by using their distribution property of "clustering", which has been improved in terms of global and spatial adaptability, but it still involves how to select the correct size of "blocks" and threshold problem. Or the method of denoising by rationally selecting multiwavelet bases, the key is to find a suitable preprocessing method. It also has the advantages of combining fuzzy median filtering and fuzzy mean filtering. The signal is denoised by weighted filtering, but the improper selection of filter factors will affect the denoising effect. In addition, mathematical morphological filtering methods can also be used to denoise. The difficulty is how to select structural elements suitable for power quality signals. Some literature proposes the use of Gaussian filters for denoising, which is very effective in filtering out the noise that obeys the normal distribution. The denoising performance of other types of noise needs to be further studied.

(2) Power quality disturbance signal compression method: Wavelet transform is a new time-frequency analysis method, especially suitable for non-stationary signal analysis, it has been widely used in the field of power quality analysis. Since the energy of the signal in the wavelet transform domain is concentrated on a few coefficients, a large number of coefficients can be changed to 0 through closed value processing, thus greatly reducing the amount of storage, thereby achieving the purpose of data compression. Therefore, the data compression method of power quality disturbance based on wavelet transform has been widely studied.

(3) Power quality disturbance detection method: The basic method for power quality disturbance detection is the root mean square method, but it can only detect special disturbance events. As a classical signal analysis method, discrete Fourier transform (DFT) has many advantages such as orthogonality and completeness, and it has fast algorithms such as FAST Fourier Transform. Therefore, it has been widely used in the field of power quality analysis. But when using Fourier transform, the following conditions must be met: First, the sampling frequency must be more than twice of the highest signal frequency to satisfy the requirement of sampling theorem. Second, the waveform to be analyzed must be stable and change with time period. Therefore, when the sampling frequency or signal cannot meet the above conditions, the use of FFT analysis will cause errors. In addition, since the FFT is an integral over the entire time period, the time information is not fully utilized; any sudden changes in the signal, its frequency spectrum will be scattered throughout the frequency band. In order to solve the above problems, Gabo proposed STFT method by adding Windows, which regarded unsteady process as a collection of a series of short-time stationary processes, and applied Fourier transform to the analysis of unsteady signals. Since the analysis of the actual multi-scale process requires the time window to be adaptive, that is the high-frequency time-frequency window is large and the time window is small; the low-frequency time-frequency

window is small and the time window is large, the time-frequency window of STFT is fixed. Therefore, it is only suitable for analyzing processes with roughly the same characteristic scale, and not suitable for analyzing multi-scale processes and mutation processes.

(4) Identification method of power quality disturbance: In recent years, new pattern recognition technologies represented by expert systems and neural networks have begun to be used in power quality research more comprehensively, because it is a relatively complex system with a large workload and data processing volume. As a more mature pattern recognition technology, artificial neural network has been widely used in power quality. ANN has the following advantages: first, it can handle multi-input and multi-output systems, and it has the characteristics of self-learning and self-adaptation. Second, it is not necessary to establish an accurate mathematical model, only the input-output relationship can be considered. The neural network method has the disadvantages of complex structure and time-consuming training, and when new disturbances increase, the network needs to be retrained, which brings inconvenience to the application. Although the expert system takes too long in the development process, many applications still appear. Compared with the ANN, the expert system has the advantage of variable scale, and only needs to add corresponding rules for the newly added disturbance types. As the power quality disturbance changes greatly with the change of working conditions within a certain range, it is uncertain. This kind of uncertainty is suitable to be dealt with by fuzzy logic. Support vector machine improves its generalization ability by means of the principle of structural risk minimization, which solves the problems of small sample, nonlinear, high dimension and local minimum well, and has been applied to the identification of power quality disturbance events. Based on the Hidden Markov Model of Discrete Orthogonal Wavelet Transform, the Markov chain is established through wavelet transform coefficients, and the maximum likelihood classification method is adopted to automatically identify power quality disturbances.

3. The Development Trend of Power Quality Research

Power quality monitoring is the most direct way to obtain power-related data, and it is also the front end of other follow-up advanced application research on power quality. However, with the rapid development of the power system, many new power systems and user electrical equipment have been incorporated into the power system, and power quality monitoring methods have become more extensive, making power quality problems more prominent. Background conditions such as noise, harmonics have become more complex, and the development trend of power quality research is: (1) In practical engineering applications, due to the location of equipment installation, external electromagnetic interference and other factors, the detected signal usually contains noise interference. The presence of noise will affect the effect of some analysis methods, or even make them invalid. Therefore, the denoising research of power quality disturbance signals has changed from a single consideration of denoising effects to filtering out as much noise as possible while retaining the most important characteristics of the signal.

(2) With the expansion of power grid scale, both power supply departments and users are in urgent need of monitoring a large number of monitoring points. Remoteness can adapt to different levels of monitoring requirements. However, the inevitable problem of remoteness is the transmission of a large number of power quality data. Therefore, the compression of power quality disturbance signals is not only studied to greatly improve the compression ratio while preserving the important characteristics of the signal, but also to study the real-time implementation technology of the compression method.

(3) Because many instantaneous disturbances (ms-level or even ns-level) are difficult to describe completely with individual parameters (such as effective values), and the randomness

is strong, it is necessary to study methods that can capture instantaneous disturbance waveforms. At the same time, the detection algorithm of power quality disturbance has been developed from classic algorithms such as effective value method and DFT to modern algorithms such as wavelet transform, Hilbert yellow transform and S transform.

(4) In terms of power quality monitoring, the classification, identification and statistics of power quality indicators show a large amount of data, and the main trend is artificial intelligence, which aims to reduce human labor and can automatically identify and deal with power quality problems, so as to achieve a comprehensive unmanned monitoring function. In recent years, new pattern recognition technologies represented by neural networks, expert systems, fuzzy logic and evolutionary computing have begun to be applied to power quality research more comprehensively, because it is a relatively complex system with a large workload and data processing volume jobs. Moreover, one of the outstanding features of these new technologies is that they are widely used in cross-applications. Sometimes it is difficult to determine which technology is the one, but one is the main one and the other is the supplement.

4. Conclusion

This article starts with the research status and concept of power quality, by studying various power quality phenomena, summarize various methods of power quality analysis and control at home and abroad, summarizes the current research status of power quality control methods and strategies at home and abroad, as well as research status and development trends at home and abroad.

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