Research on the Method of Improving the Quality of Electric Energy Measurement Data

Bing Sui¹, *, Xiaodong Chen¹, Zeng Shou¹, Hongzhe Wang¹, Zhitong Guo¹

Liaoning Electric Power Dispatching and Control Center, State Grid Corporation of China, Shenyang 110000, China

*E-mail: sw8w123456@126.com

Abstract: In the process of collecting data in the power grid harmonic monitoring and analysis system, changes in load, operating modes, and equipment failures will cause data changes. For the strong correlation index, this paper establishes a mathematical model of the monitoring value for the measurement index, while for the weak correlation index, considering that the monitoring data is a type of time series data, a time series model of the monitoring value for the measurement index can be established, and then the abnormal value monitoring is performed by statistical methods. Moreover, experiments prove that the research method used in the paper to detect whether abnormal data exists in the data can effectively improve the efficiency and provide a guarantee for the quality of data monitoring.

1. Introduction

The two important characteristics of power quality monitoring data are the large number of measurement indicators and strong timing. Complex power quality monitoring data places high demands on data processing. What is more, the evaluation of power quality monitoring indicators is particularly important, and the data changes caused by load changes and operating mode changes are called normal data changes which will last for a short period of time in most cases. On the contrary, abnormal data changes are caused by equipment failures and the influence of the external environment, which are usually short-term changes. In addition, some outliers can be identified by their own data, while some need to be identified by monitoring data of other indicators.

Whether there is an abnormality in one or more sets of sample data is determined in the paper with the help of the control chart to implement an abnormal data detection method based on the control chart. Moreover, the index-related strength calculation uses normalized mutual information to measure the correlation, and an experimental comparison method is adopted to verify the effectiveness of the research content in the paper.

2. Anomaly Detection Method Based on Control Chart

The quality monitoring data is fluctuation data. Through the obtained fluctuation range, it is judged whether the data is stable, and the unstable data will be regarded as the existence of abnormal values. What is more, to determine whether there is an anomaly in a set of data, the commonly used control charts are adopted in the quality control process for anomaly detection. Generally, for data with a sample size greater than \( \delta \), the mean-standard deviation control chart is used.
The mean-standard deviation control chart is mainly established to judge whether there is abnormality in a group of data. The steps of the anomaly detection method based on the control chart are as follows.

Step 1: Prepare historical monitoring data samples to be group. The samples are divided into m groups, and each group has \( n \) data. There is a total of \( m \times n \) data. Taking harmonic current as an example, the historical data granularity is 1 minute, and the analysis window is 30 minutes, then the data within 30 minutes is a group. In addition, the monitoring data obtained every hour is divided into 2 groups of calculations. Besides, the number of data points in each group is \( n=30 \). If a minimum of 40 sets of data are taken, the time span of the training sample will be \( 40 \times 0.5/24 = 0.83 \) days.

Step 2: Calculate the statistical characteristic value of each group of data, namely mean and standard deviation.

Step 3: Calculate \( \delta \) statistical control parameters and draw statistical control charts.

The formulas for the upper control limit (UGL), center line (GL), and lower control limit (LGL) of the statistical control parameters of the S control chart are as follows.

\[
\bar{\delta} = \frac{1}{m} \sum_{i=1}^{m} \delta_i \\
UGL_\delta = \alpha \bar{\delta} \\
GL_\delta = \overline{\delta} \\
LGL_\delta = \beta \overline{\delta}
\]

(1) \( \alpha \), \( \beta \) is related to the value of \( n \). When \( n \leq 25 \), the value of \( n \) will be obtained from the control limit coefficient table.

When \( n > 25 \),

\[
\beta = 1 - \frac{3}{c} \quad 2 \leq (n-1), \quad \alpha = 1 + \frac{3}{c} \quad 2 \leq (n-1), \quad c = \frac{4(n-1)}{4n-3}
\]

(5)

Step 4: Dot on the control chart to determine whether the data is stable. If it is stable, proceed to the step. If it is unstable, the unstable group will be removed to add a new number of groups, so that the total number of groups can reach \( m \) groups. Then the mean and standard deviation of the newly added data group will be recalculated to proceed to step 3. Dot on the control chart to determine whether the data is stable. If it is stable, proceed to the step.

Step 5: Calculate the \( X \) statistical control parameters and draw the average control chart.

\[
\bar{X} = \frac{1}{m} \sum_{i=1}^{m} X_i \\
UGL_x = \bar{X} + A\overline{\delta} \\
GL_x = \overline{X} \\
LGL_x = \bar{X} - A\overline{\delta}
\]

(6) \( \alpha \), \( \beta \) is related to the value of \( n \). When \( n \leq 25 \), the value of \( n \) will be obtained from the control limit coefficient table.

When \( n > 25 \),

\[
A = \frac{3}{c\sqrt{n}}
\]

(10)

Step 6: Dot on the \( \bar{X} \) control chart to determine whether the data in this group is stable. If it is stable, proceed to step 7. If it is unstable, the unstable group will be removed to add a new group number, so that the total number of groups can reach \( m \) groups. Then the mean and standard deviation of the newly added data group will be recalculated to proceed to step 3.
Step 7: Form steady state $\bar{X}$ and $\delta$ control charts.

The algorithm flowchart is shown in Figure 1:

**Figure 1. Control chart algorithm flow chart**

3. Experiment Analysis

There are a total of 2555 measurement indexes in the power quality monitoring data, and experiments verify whether all the indexes can form a steady state control chart. Therefore, in the experiment, two measurement indexes the phase angle of the 42nd harmonic voltage and the phase angle of the 25th harmonic voltage are selected. The 42nd harmonic voltage phase angle selects a whole day of data for a certain day, and 1440 data points are divided into a total of 30 groups, each of which has 40 data. The results of the two control charts are shown in Figure 2.

**Figure 2. Steady state control results**

In the process of forming a steady-state control chart, part of the data is eliminated during the non-steady-state process of the control chart. The final remaining data of 1440 data is 240. Moreover,
the 240 data divided into 8 groups and then dotted on the two control charts are used for experimental verification in the experiment. The results of RBI are shown in Figure 3.

![Control Chart](image)

Figure 3. Results of unsteady state control

Dotted on the steady state control chart, it can be seen that there are abnormal values in the sixth and seventh groups of data, but it needs to be judged which specific abnormal value is.

Another measurement index is the 25th harmonic voltage phase angle with a total of 4320 data points, and the steady-state S control chart and X control chart are separately sought to eliminate unstable data. During the experiment, 4320 data points are used up and no steady-state control chart is formed, for which the monitoring value of the 25th harmonic voltage phase angle fluctuates greatly. Therefore, based on the two experiments, it is difficult to judge the data with large fluctuations through the control chart. However, for the measurement index data with small data fluctuations in the power quality monitoring data, it is possible to find a steady-state control chart for historical data to judge whether there is an abnormal value in the data collected every hour, which has a good effect.

For the power quality monitoring data, there are a total of 2555 measurement indexes, and the monitoring values of all the measurement indexes are calculated to form a steady state control chart. The experimental results are shown in Table 1.

| Project                                      | Quantity |
|----------------------------------------------|----------|
| Total number of indicators                   | 2555     |
| Number of indicators that can form a steady state control chart | 1336     |

It can be seen that more than half of the measurement indicators can form a steady-state control chart, which proves the feasibility of the method proposed in the paper. Additionally, the speed using control charts to detect a whole set of data is fast. Moreover, after many experiments, a steady-state control chart is formed. The average time using the control chart to detect the monitoring value of a measurement index is about 50ms, and the detection time of these 1336 measurement indexes is about 67s.

4. Conclusion

Based on the study of power quality monitoring data, an abnormal data monitoring method is established in the paper. In order to detect whether there is abnormal data in the data, an abnormal data detection method based on control chart is first implemented. Experiments prove that the method proposed in the paper is effective in detecting whether there is abnormal data.
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