Several Typical Indexes Assessment for City Area Substation Power Quality

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Abstract. With the development of frequency converter, lots of electrical equipments are using the technology to save energy, but by using this technology, the harmonic voltage and harmonic current is increasing much more quickly than before. In this article, a deep research about the characteristics in power supply of city area substation is implemented. At last, a new power quality evaluation method for city area substation is put forward, which is based on the typical power quality parameters in city. This method is established by four elements, which are: harmonic voltage, harmonic current, voltage change and power. All these elements constitute a new method to evaluate the power quality of city area substation.

1. Introduction
For now, the frequency converter technology is widely used in city, saving energy is one of the advantage. But when the user are using this kind of electrical equipment, the harmonic component is much more than the power frequency equipment.

To make a good monitoring for the harmonic voltage and voltage current, the power supply company has built a harmonics monitoring platform[6]. But the platform can not tell the users which point is qualified directly and promptly, because the number of index is so many. So we need an easy way to find a few typical indexes of the city area[1].

This article introduces the typical indexes for the city area, and then summarizes the differences between different power quality ways[5]. According to the features of city area substation grid, there are many demands for all types of consumers. At last, a new method “Several Typical Indexes Assessment” is put forward, which is based on the harmonics monitoring platform.

2. Concerns of Power Quality for Urban consumer

2.1. Kinds of Urban consumers
In the cities, there are various kinds of users for power supply, such as domestic users, Big Data centers, government sector, hospitals, banks, shopping malls, precise instruments manufactures and so on. For different consumers, the focuses are unlike too[9].

2.2. Focus of diverse consumers
For domestic users, the most important demand for domestic users is the stability of power supply.

For the Big Data centers, the most vital focus is harmonics, voltage dips, voltage swells and short interruptions.
For precise instruments manufactures, the crucial thing is the harmonics voltage and current, voltage dip, voltage interruptions, voltage unbalances.

3. The Method and Significance of the Assessment of Power Quality System

3.1. Construction of Harmonics Monitoring Platform
Recent years, more and more power quality issues occurred, these issues caused lots of damage to the users [9], so the power supply company realize that power quality had already became a serious problem for both consumers and the companies themselves. In this case, the harmonics monitoring platform was established, from 2006, more than 6000 monitoring devices are installed in all voltage levels of transformer substations. And the data scale became very huge for now, this gave us a firm foundation of data to analyze and estimate the status of power grid.

3.2. Methods of Power Quality Assessment
Power quality assessment, which is based on the parameters of the power grid, there are 10 standards of power quality, and there are always several indicators in one standard, so that there are more than 50 indicators for all the power quality. Obviously we can not make an evaluation with all index, we need to select some more important index to make the assessment in purpose.

Due to the power quality index is numerous, therefore there are many ways for assessment [3,7], according to different application environment and the external conditions, ways and methods have very big distinction, rough classification of evaluation way as shown in figure 1.

![Figure 1. Classification of Power Quality Estimation Methods](image)

As we can see from figure 1, a variety of power quality evaluation methods are put forward, according to different needs assessment object, methods also have very big difference. Therefore, we need to distinguish these methods into different areas, and adjust measures to local conditions to develop a suitable for this type of power quality system evaluation method [2,11].

In this paper, we make a use of aforesaid methods, which are based on the results of evaluation index of content, form and the three methods are geared to the needs of users of the evaluation process, focus on urban region accounts for the larger area of power quality system evaluation method has carried on the induction and summary [12].

4. Multi Element Evaluation Method
We present a multi element evaluation method, which is based on the harmonics monitoring platform.
4.1. Significant Index of Urban region
According to the users, we consider the process of power quality assessment for city area should be mainly focused on the following aspects.

1. Harmonic voltage, in the city area, because of the diverse of power application, various electric equipments make influence to the others, especially the great use of inverter air-conditioner[10];
2. Harmonic current, there is much harmonic current when the equipment make influence to the others, sometimes the voltage is more apparent and sometimes the current is apparent[4];
3. Power, for the Big Data center, banks and hospitals, these consumer are very sensitive to the power factor and power fluctuation[2];
4. Stability of voltage, this element is very significance for precise manufactures, elevators in shopping malls and Big Data center[2].

4.2. Multi Element Evaluation Method Composition
According to the characteristics of urban area users, and the four items needed to be paid attention to, we put forward a multi element evaluation method. This method is established by the foundation in plenty of power quality data. We choose 12 evaluation indexes for this method, and detailed indicators are shown in table 1:

| Serial number | Index                          | Serial number | Index                          |
|---------------|--------------------------------|---------------|--------------------------------|
| 1             | Typical harmonic voltage       | 7             | Power factor                    |
| 2             | Total harmonic voltage distortion | 8             | Fluctuation of power            |
| 3             | Long time flickers             | 9             | Voltage deviation               |
| 4             | Typical harmonic current       | 10            | Voltage dip and short interruptions |
| 5             | Total harmonic current distortion | 11            | Voltage swells                  |
| 6             | Negative sequence current      | 12            | Negative sequence voltage       |

4.3. Scores of the Method
After obtaining the value of the above 12 indexes, here we set it as “v”, then we compare these numbers with the standard values, here we set the standard values as “s”, the calculation formula is $\frac{v}{s}$, then we can get a preliminary outcome. And the method to calculate scores for those “v” are shown in table 2.

| Values       | Meaning   | Point | Values       | Meaning   | Point |
|--------------|-----------|-------|--------------|-----------|-------|
| $v < 0.6$    | excellent | 3     | $0.9 \leq \frac{v}{s} < 1$ | qualified | 1     |
| $0.6 \leq \frac{v}{s} < 0.9$ | fine      | 2     | $\frac{v}{s} \geq 1$ | unqualified | 0     |

For example, there is a 66kV substation harmonic voltage 5 as 1.0%, according to the national standard in the limit of 5 harmonic voltage is 1.6%, $v/s = 1.0/1.6 = 0.625$, according to the methods in table 2, then the assessment score is 2 points for substation harmonic voltage 5 times.
5. Multi Element Evaluation Method Application
For a urban power station, we make the estimation of power quality. According to the different indexes values, the final assessment results of the typical harmonic component is shown in table 3.

| Harmonic times | Harmonic voltage Values | Harmonic current values | Harmonic times | Harmonic voltage Values | Harmonic current values |
|----------------|-------------------------|-------------------------|----------------|-------------------------|-------------------------|
| 3              | 0.27%                   | 1.1(A)                  | 11             | 0.1%                    | 0.32(A)                 |
| 5              | 0.71%                   | 0.52(A)                 | 13             | 0.09%                   | 0.23(A)                 |
| 7              | 0.96%                   | 0.46(A)                 |                |                         |                         |

As can be seen from table 3, the mainly typical frequency harmonic voltage of the urban power station are 3, 5, 7, 11 and 13 times, but the harmonic content is small, failed to meet 1% of the fundamental wave voltage. Also the typical harmonic current frequency are also 3, 5, 7, 11 and 13 times, and the same as harmonic voltage the content is small, only 3 times harmonic current get to 1.1A, the others are all less than 1A.

According to the operating characteristics of the urban power station, the weight parameters of the final results are all set as 0.2, resulting in A final score of 2.6, so that the final result is A, as we can see in figure 2.

![Figure 2. Finally Evaluates the Results](image)

6. CONCLUSION
This article put forward a “Multi element method” evaluation method to assess power quality of new energy roundly and quickly. The method classifies 12 indicators into four elements. Then it assigns weight factor for every elements based on the grid structure and the composition of power source in this area. So that we can make a quickly and entirely assessment on power quality of new energy power industry. And we can also show the final result to the manager or technician in a simple way, which is much more easily understood. At last, an urban region station is evaluated by “Multi element method” method, as shown in figure 6, which can easily tell the advantage and disadvantage of power quality about the urban power station, this shows that the “Multi element method” method is simple and feasible.

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