Design of Electric Power Data Acquisition System Based on Internet of Things

Haodong Du1*, Fu Huang1, Libin Liu1

1Digital Grid Research Institute, China Southern Power Grid, Guangzhou Guangdong, 510663

*Corresponding author e-mail: duhaodong@dgri.org

Abstract. In today's era of rapid economic development, China’s Internet is also developing rapidly, and intelligence is becoming more and more common in people's daily life, which also promotes the intelligence of my country's electricity data collection. This paper designs a power data acquisition system based on the power Internet of Things. Through the analysis of the power Internet of Things and its relationship with the smart grid, a data acquisition system is constructed with three parts: smart meters, concentrators and data management systems. And use GPRS and VPN to analyze, explain how to analyze the collected data.

Keywords: power Internet of Things, data acquisition system; data analysis

1. Introduction
With the development and popularization of the Internet, intelligence has been fully integrated into the daily life and work of the general public in our country. Therefore, our country’s electric power data collection also needs to gradually move closer to intelligence, so as to improve the power system’s data processing speed and use the operation of the power system is more stable and reliable. The standard for judging whether the performance of a power data acquisition system is excellent is whether it can automatically process the data collected from the power line under the control of the relevant program, whether it can distribute and count the power consumption without unmanned operation circumstances and whether it can be combined with the operation and maintenance system of the power supply department. Therefore, the power system has improved the real-time and accuracy standards of its collected data, ensuring that the collected data will not be lost in the event of an emergency. Therefore, this article studies and analyzes the power data acquisition system based on the power Internet of Things, and it has a complementary relationship with the smart grid, and provides technical support for the development of the smart grid. After it is optimized and upgraded, it will give birth to more novel, simple and convenient technology [1-3].

2. Power Internet of Things

2.1. The concept of power Internet of Things
The power Internet of Things is an advanced technology that is applied to today's society and
generated by various behaviors of the power system, such as the most common artificial intelligence technology and mobile Internet technology. In addition, communication technology, comprehensive state perception systems, and human-computer interaction should be used to meet the needs of the people. After these technologies in the power Internet of Things, a flexible intelligent service system can be formed, that is, the power Internet.

The use of advanced technology devices in the power Internet can achieve better results than before, and at the same time promote the development of the power Internet of things in the society. There are three more common technical devices. One is the most common global positioning system; the second is RFID device, or radio frequency identification, which is a relatively common automatic identification technology. If the device is used in large quantities, it can be used to power Internet of Things and show the best effect; the third is the use of laser scanning devices in the actual operation of the Internet of Things. From the above description, it is not difficult to see that the types of related technologies or devices used in the power Internet of Things are complex, so that a power Internet of Things with a huge intelligent network can be formed, so as to achieve the goal of achieving its own intelligent development.

2.2. The relationship between power Internet of Things and smart grid
Under the trend of rapid social development, people's social life and daily life are slowly developing towards intelligence, and so is the development of power grids. The essence of the power Internet of Things is to connect various power equipment with a sensor network system into one place. While reducing the related work burden, it can make the work of the power Internet of things more convenient, more efficient, and can promote social development. Because the data acquisition system of the power Internet of Things can enable high-speed and two-way data transmission, while improving the reliability and intelligence of the entire power grid, it also makes people's social life and daily life more convenient and efficient [4-6].

3. Power data acquisition system structure based on power Internet of Things
The data acquisition system in the power system consists of three parts, namely smart meters, concentrators, and information management systems. Smart meters are used to monitor power consumption. The main function of the concentrator is centralized management. The information management system integrates and stores information. And the basic network architecture is shown in Figure 1.

![Figure 1. Data acquisition system in power system](image-url)
energy metering and billing system, EIS5000 electric energy information integrated management system, DTSD566/DSSD566 electronic remote transmission multi-function meter, SJT-500/b. The characteristics of the collection terminal, the OPEN-3500 dispatching integrated data platform system of Guodian NARI Company, the DTST566 three-phase electronic carrier energy meter and the low-voltage power line centralized meter reading system of Xu Ji Group are analyzed and summarized.

3.1. Smart meter
The realization of a smart meter requires three steps, namely data collection, data transmission and feedback, and status self-checking.

Data collection. It is an important part of the data acquisition system of the power Internet of Things, and the role that the smart meter can achieve in this part is to carry out basic data acquisition, and due to its own particularity, it can only perform basic data acquisition. The work content includes active power, reactive power, voltage, and current. The functions of traditional electric meters are almost the same as their basic functions.

Data transmission and feedback. The realization process of its function does not only depend on a single way. After analyzing and researching the references, it is found that there are 3 ways of data transmission and feedback, which are the common power carrier, RS485 and GPRS communication methods [7-9].

State self-check. Although the smart meter only performs basic data collection, the collected data is very important. Once the basic data collected deviates, big problems will occur in the overall working process of the power Internet of Things. Therefore, the smart meter itself should have a status self-check function to ensure that it can report its own status to the concentrator in real time, and solve the problem as soon as possible when the smart meter has problems.

3.2. Concentrator
During the working process of the system, the concentrator and the smart meter will conduct two-way communication. The role of the concentrator in this process is mainly to collect and transmit data. The implementation process is similar to that of a smart meter, including data transmission and feedback, data statistics, and status self-checking. The following three steps are explained.

Data transmission and feedback. The concentrator is a very important part of the data collection process of the power Internet of Things, because it is the transit part of the data transmission, and it carries out two-way data transmission with smart meters and two-way data transmission and feedback with the information management system. Special attention is that the data transmission method with the smart meter is different from the transmission method with the information management system. The transmission method with smart meters is mostly GPRS and RS485, and the transmission method with information management system is mainly Ethernet.

Statistics. One of the main contents in the daily work of the concentrator is the timely summary and storage of meter reading data. At the same time, the living standards of our people have improved, and the frequency of using communication and power resources in daily life has also increased. Under these conditions, it is necessary to establish a small database to improve the efficiency of the concentrator.

State self-check. The purpose of its setting is similar to that of a smart meter, and it plays a role in quickly processing the data collected by the smart meter. At the same time, because of the setting of the self-check function, the parameter changes and operating status of the concentrator can be effectively monitored. If the concentrator fails, the relevant staff will receive the message as soon as possible and solve the problem in time. Avoid economic losses and make the operation of the entire data acquisition system more stable [10].

3.3. Information management system
After all the data information collected by the smart meter is processed by the concentrator, the final place for aggregation is the information management system. Therefore, one of the daily tasks in the
information management system is to count and store a large amount of data information. After the end, the statistical results need to be fed back to the concentrator. In addition, due to the large amount of data designed in the information management system, a large database can be established to save the data in real time, making the required data real-time data, and enhancing the accuracy of results and feedback information. In addition, it is necessary to pay special attention to the differences in the information transmission methods of each part.

Based on the above analysis, the design scheme of the power data acquisition system based on the power Internet of Things in this paper is:

The communication mode between the smart meter and the concentrator is set to GPRS VPN mode or radio frequency communication mode, and the design alternative is RS485.

Assuming that the power center of the community is a concentrator, the VPN method based on GPRS can choose the VPN method that meets the 3G standard. From the city to the city, the VPN method with limited broadband can be selected from the city to the regional national grid. The regional national grid can also choose the optical fiber private network. And the overall structure is shown in the figure below:

![Overall structure diagram of power data acquisition system](image)

**Figure 2.** Overall structure diagram of power data acquisition system

4. **Realization of data acquisition system of electric power Internet of Things**

4.1. **Realization of GPRS**

The realization of GPRS, which is the abbreviation of Packet Radio Service Technology, is a new data transmission technology in the second generation of mobile communications, and is a mobile data service available to GSM mobile phone users. GPRS is a continuation of DSM, but it is different from the previous channel transmission method. The channel transmission method used nowadays is packet transmission, so the user's cost is no longer based on the entire channel, but based on the transmission of data. Billing for the unit, so from a theoretical level, the price is more affordable and cost-effective, while being able to complete complex and tedious tasks, introducing sufficient human resources, is an effective way to implement a data collection system.

4.2. **Implementation of VPN**

VPN, that is, a private network built on a public network and with encrypted communication function that is widely used on corporate networks. If you need to encrypt data packets for the gateway through VPN and use the conversion of the destination address of the data packets to achieve remote access. Because VPN needs to be implemented through software, hardware, and servers. VPN is a very important link in the actual implementation of the power Internet of Things data collection system, and it is also the main guarantee for ensuring network security. In the specific implementation of the data collection network, relevant departments and work units have correctly recognized the importance of VPN, which greatly increases the security of the data collection network.
5. Data analysis

After sorting out the actual collected data, it is found that there are data missing in the original data, and it directly affects the accuracy of load forecasting and increases the noise of the data sequence. To solve this problem, it is necessary to find suitable data to fill the data gaps caused by missing data and improve the overall quality of data. Repair the missing data while retaining the original data characteristics so that it can be used in algorithms. There are many ways to deal with missing values. The most common method is to directly delete the missing values. This method is very simple, but it will reduce the amount of data recorded, destroy the original coherence of the data, and cause the potential characteristics of the electrical load to be changed. There is also a very common method, which is to find the most suitable value to replace according to the actual background of the problem, such as the average value, global variable, mode and extreme value. Under the influence of the periodic characteristics of the load data, the situation will become more complicated. Therefore, when a large amount of data is missing, the normal data of adjacent days can be weighted and filled appropriately to reduce errors. The calculation formula is as follows shown.

\[ x(d, t) = \omega_1 x(d_1, t) + \omega_2 x(d_2, t) \]  

(1)

The above formula \( x(d, t) \) represents the load value corresponding to the \( t \)-th hour on the \( d \)-th day; \( \omega_1 x(d_1, t) \) represents the load value corresponding to the \( t \)-th hour on the \( d-1 \)-th day; \( \omega_2 x(d_2, t) \) represents the load corresponding to the \( t \)-th hour on the \( d+1 \)-th day value, and separately \( \omega_1 = \omega_2 = 0.5 \) represents the weight of the load value of the previous day and the next day.

This method comprehensively considers the load value of the missing value in the past two days, reduces the influence of other factors on it, and reasonably fills the vacant load value to ensure the continuity of the load data.

Because the collected data is the bus current, when processing the load data, it is not difficult to find that the field values. Some fields are different from most of the recorded values, which have no specific meaning. These data are abnormal data. This type of data is processed, then after they are mixed with normal data, the amount of noise will increase, which will affect the detection results, so this type of data must be processed. There are two processing schemes. The first is to directly delete data records containing outliers, but the corresponding will also affect the continuity of the data; the second is to smooth the outliers. This article analyzes the box line, after obtaining the abnormal value, choose the second method, and this method only considers the data corresponding to the two days before and after the abnormal value, and weights it to replace the abnormal data. It can be seen from the above that the processing methods for missing values and outliers are very similar, both of which are to create a more reasonable data to replace them.

Because the value range in the original data has different characteristics, and there are big differences. If the analysis is performed directly without analyzing such data, the data features with a small value range will be directly covered by the data features with a large value range, which cannot be used reasonably. In response to this problem, the characteristics of the original data are standardized. There are two common standardization methods, as shown below.

(1) Standardization

According to the characteristics, the values are unified and normalized, and the range is not fixed. The calculation formula is as follows:

\[ x_i' = \frac{x_i - \bar{X}}{s} \]  

(2)

In the above formula, \( s \) and \( \bar{X} \) respectively represent the standard deviation and average value of the characteristic \( X \), \( X_i' \) represent the value after the standardization, and \( x_i \) represent a certain value of the characteristic \( X \).

(2) Interval standardization

According to the boundary value of the characteristic value interval (that is, the maximum value
and the minimum value), the data is unified into the interval of. The calculation formula is as follows:

\[
x'_i = \frac{x_i - X_{\text{min}}}{X_{\text{max}} - X_{\text{min}}}\quad (3)
\]

In the above formula, \(X_{\text{max}}\) and \(X_{\text{min}}\) respectively represent the maximum and minimum of the feature \(X\), \(X'_i\) represent the value after normalization, and \(X_i\) represent a certain value of the feature \(X\).

6. Conclusion
In this paper, through the research and analysis of the power Internet of Things, and based on the power Internet of Things, the power data acquisition system is designed. In the design process, the system structure and how to realize the system were considered comprehensively. It is found that the structure of the power data acquisition system based on the power Internet of Things is mainly composed of three parts: smart meters, concentrators, and information management systems. Both smart meters and concentrators need to be self-checked. Only in this way can the value of the data be guaranteed deviations will occur, and the effective implementation of the data acquisition system is guaranteed. The main function of the information management system is to process the data collected by the smart meter through the concentrator, and then perform a unified total processing. After the whole design is completed, it is realized by GPRS and VPN, and finally it analyzes how to process the collected data.

References
[1] Zhang Lei. Research on Trusted Computing Technology of Acquisition Terminal under the Power Internet of Things. Electronic Components and Information Technology, 2019, 3(12): 113-116.
[2] Zhao Guolong, Sun Yan, Xiang Mingming, Zhang Tianyi, Liu Qian. Design and Implementation of a Substation Battery Monitoring System based on the Internet of Things. Electric Power Big Data, 2019, 22(03): 77-80.
[3] Zhang Hailong, Liu Xuan, Ren Yi, Liu Yan. Feasibility Study on Narrowband Internet of Things for Electricity Information Collection System. Electrical Measurement and Instrumentation, 2019, 56(06): 82-86.
[4] Gao Yuan. Design and Optimization of Electric Energy Acquisition and Control Terminal and Electric Power Marketing Information System based on Internet of Things Technology. Automation Technology and Application, 2019, 38(09): 88-91+101.
[5] Wan Lisheng, Li Yuchen, Cao Yang. Research on Line State Perception Monitoring and Data Sharing based on Control Cloud under Ubiquitous Power Internet of Things. Electric Power Information and Communication Technology, 2019, 17(11): 32-37.
[6] Dang Qian, Qiu Yu, Wei Li. Application of Key Technologies for Smart Grid Data Processing. Information Technology and Informatization, 2020(10): 217-219.
[7] Yao Lei, Lu Xiaopeng, Zhang Ke, Huang Darong. Design of Wireless Power Meter Data Acquisition System based on Zigbee. Automation Instrumentation, 2020, 41(01): 77-80.
[8] Lu Qiang, Cheng Xin, Wang Ping, Xu Weigang, Luo Xun. Park Electric Power Data Visual Analysis System. Journal of Hefei University of Technology (Natural Science Edition), 2019, 42(05): 638-645.
[9] Sun Hongfei, Gong Lidong, Zhang Haitao, Wu Huijuan. Research on Smart Grid Big Data Analysis Framework and Its Application Evolution. Modern Electric Power, 2016, 33(06): 64-73.
[10] Wu Kaifeng, Liu Wantao, Li Yanhu, Su Yipeng, Xiao Zheng, Pei Xubin, Hu Songlin. Cloud Computing-Based Power Big Data Analysis Technology and Application. China Electric Power, 2015, 48(02): 111-116+127.