Distributed communication power monitoring system based on big data technology

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Abstract—Communication system has high quality requirements for power supply. Realizing the effective monitoring of power supply system is an important measure to improve power quality. In order to better and effectively manage massive power information in complex environment and avoid communication power failure, a design method of distributed communication power monitoring system based on big data technology is proposed. The system operation performance is proposed, and the software function and operation process of the communication power monitoring system are simplified by using big data technology to improve the system monitoring accuracy. Finally, the experiment shows that the distributed communication power monitoring system based on big data technology has significantly higher response speed and relatively lower monitoring error in the actual application process.

1. Introduction

Traditional communication systems mostly use the principle of neural network for information acquisition and real-time monitoring. In the process of practical application, this method is prone to the problem of uneven information acquisition and distribution of communication power supply equipment, which makes it difficult to realize effective monitoring. On this basis, many experts put forward optimization suggestions combined with manual monitoring. They use manual duty and neural network to track and monitor massive data information. However, this manual monitoring method has low detection efficiency, large error and will occupy a lot of human resources[1]. These deficiencies make it difficult to popularize this model on a large scale. With the development of technology, people use distributed monitoring system to monitor the communication power supply. Although this mode liberates manpower and improves the detection accuracy, it has large acquisition error and is difficult to realize automatic control. With the large-scale development of communication equipment, this mode is difficult to provide satisfactory service[2]. The emergence of distributed monitoring system based on big data provides a new scheme for the monitoring system of communication power supply[3]. Big data technology can not only process a large number of simple data, but also process some complex data. Big data technology includes data collection, data access, infrastructure, data processing, statistical analysis, data mining, model prediction and result presentation. In the process of communication, the design of communication power monitoring system using big data technology can stabilize power transmission and ensure the normal operation of communication equipment.
2. Distributed communication power monitoring system

2.1. Hardware structure configuration of distributed communication power monitoring system

The core idea of the distributed monitoring system is the hierarchical control and management of the control system. In order to realize the hierarchical control and management of the system, the first thing to be completed is to optimize the hardware structure configuration of the distributed communication power monitoring system to ensure that the underlying equipment is endowed with programming ability and communication ability\(^4\). This way takes LAN or WAN as the basic network platform and network operating system as the management basis of data exchange, monitoring and management. The third way is to combine the first two methods. The core processor of each unit adopts TMS320F2812 DSP chip of TI company\(^5\). The control unit and monitoring unit transmit data through CAN bus, and each unit forms a CAN node. The structure takes the main monitor as the monitoring center, and each acquisition module as the bottom layer of field information acquisition\(^6\).

The power monitoring master station of distributed communication equipment shall be built on the standard and general software and hardware basic platform, with the characteristics of availability, reliability, safety and scalability, and shall select and configure software and hardware according to the actual power scale, distribution and actual demand of automatic communication equipment at the station end\(^7\). It should also have a certain power supply guarantee. By standardizing and optimizing the structural configuration of the above main modules, we can better realize the comprehensive processing of massive information and receive and analyze monitoring information in real time. Based on this, first standardize the hardware configuration parameters of the equipment monitoring system, as shown in the table 1 below:

| Hardware equipment       | Performance configuration | Availability | Power consumption |
|--------------------------|---------------------------|--------------|-------------------|
| processor                | 100base-FX                | 78.6%        | 61.5%             |
| chip                     | X86-64 (AMD64 / EM64T)    | 78.2%        | 65.2%             |
| data processor           | Single core Pentium 4ee   | 93.2%        | 53.2%             |
| The central controller   | RS232C control port       | 90.5%        | 41.6%             |

Based on the analysis of the system performance parameters in the table, further optimize the system hardware structure and other equipment configuration, so as to better build the equipment monitoring system structure and ensure the operation efficiency of the system and the rationality of the system configuration. In the design process, TMS320F2812, a 32-bit fixed-point digital signal processor newly launched by TI company, is selected, and the processing speed can reach 150mips. The processor also integrates 128KB flash memory and 128 bit password protection mechanism, which greatly improves the flexibility of application. At the same time, a 16 channel high-performance 12 bit ADC unit is integrated on the chip, and two sample and hold circuits are provided, which can realize the synchronous sampling of dual channel signals, which can fully meet the requirements of the monitoring system. Each control unit adopts the form of CAN bus. At the same time, the CAN controller of TMS320F2812 provides DSP with a complete can protocol and reduces the processing overhead during communication. Therefore, it is an ideal centralized monitoring method to build a distributed power monitoring system based on DSP chip and CAN communication.

2.2. Optimization of system software function and operation process

In the process of tapping the potential of data, it can drive the innovation of ideas, models, technologies and application practices. The highlight of data value and the improvement of data acquisition means and data processing technology are the root causes of the outbreak of "big data". With the development of data production factors, the continuous development of data science and data
technology and the in-depth mining and application of data value, a big data revolution is under way, which will drive the innovation and change in various fields such as national strategy and regional economic development, smart city construction, enterprise transformation and upgrading, social management and personal work and life. How to really apply big data and give full play to the power of big data is a problem that everyone is studying and exploring together. From the development of cloud computing, distributed processing technology, storage technology and perception technology, this paper explains the results of big data from collection, processing and storage. In this design, the specific idea of software design is: first, carry out the overall planning and design the overall framework of the software, then divide the software into several modules according to different functions on the basis of hardware modules, each module realizes a specific function, and finally hand it over to μC/OS-II real-time operating system unified scheduling and processing. When developing applications on the distributed operating system platform, it is necessary to know the system startup process. μ The startup process of C/OS-II is: after the distributed device system is powered on and reset, first initialize the CPU to provide a basic running environment for subsequent C language programs. stay μ After C/OS-II is started, initialize each hardware module and call osinit() function to initialize the operating system[8]. The longer the sampling time is, the more accurate the read data is. The sampling time is set to several ADCs by modifying the corresponding registers_CLK cycle. The total conversion time is

\[ T_{\text{CONV}} = T_{\text{SAMP}} + 12.5 T_{\text{ADC-CLK}} \]  

This part of the function is cycled in the main program. For AC energy, the electrical parameters to be calculated mainly include the effective value of voltage and current, apparent power, active power, and power factor. In the analysis of AC signal, considering the influence of harmonics, the instantaneous values of AC voltage \( U(T) \) and current signal \( I(T) \) in the power supply can be expressed as:

\[ u(t) = T_{\text{CONT}} \sum_{n=1}^{\infty} \sqrt{2} U_n \sin( n\omega_0 t + \phi_n ) \]

\[ i(t) = T_{\text{CONT}} \sum_{n=1}^{\infty} \sqrt{2} I_n \sin( n\omega_0 t + \phi_n ) \]

Where, \( \phi_n \) and \( \phi_n \) are effective values of voltage and current of each harmonic component, \( n \) is the fundamental angular frequency, \( t \) and \( \omega_0 \) are the initial phase of voltage and current of each harmonic component[9]. According to the definitions of AC energy RMS and instantaneous power, the expressions of voltage RMS \( u \), current RMS \( T \) and instantaneous power are as follows:

\[ U_{\text{rms}} = \sqrt{ \frac{1}{T} \int_0^T u^2(t) \, dt } \]

\[ I_{\text{rms}} = \sqrt{ \frac{1}{T} \int_0^T i^2(t) \, dt } \]

\[ P(t) = u(t)i(t) \]

According to the sampling theorem, \( n \) points are sampled in each fundamental period \( T \) of the signal, \( T_s \) represents the sampling period, then \( T = NT_s \). In this design, we collect by converting the AC signal into the positive signal. Therefore, the actual instantaneous value \( u(n) \) is the measured value \( u(n) \), and the DC bias voltage \( V \) needs to be subtracted, that is:

\[ u(n) = u'(n) - V_{\text{offset}} \]

In the implementation of the algorithm, according to the setting of the sampling frequency of the signal acquisition part, 64 points are sampled in each cycle. When the input data buffer reaches half,
that is, when the AC signal is collected for 2 cycles, half transmission interrupt occurs, and when the buffer is full, transmission completion interrupt occurs. In the interrupt service subroutine, the semi transmission and transmission completion are indicated by setting a flag.

2.3. Implementation of information monitoring of distributed communication power supply

Big data is usually used to describe a large number of unstructured data and semi-structured data. These data will spend too much time and money when downloaded to relational database for analysis. Big data analysis is often associated with cloud computing. Technologies suitable for big data, including large-scale parallel processing database, data mining grid, distributed file system, distributed database, cloud computing platform, Internet and scalable storage system[10]. Firstly, the monitoring system obtains the real-time operation data of the equipment by using modern sensor technology, and realizes the problem of data acquisition and conversion; Then, because the equipment is scattered in different machine rooms of each bureau and station, it is necessary to use bus technology, high-speed and large-capacity memory, superior operating system, powerful database system and customized monitoring software to realize data processing, management and maintenance; Finally, through the man-machine interface, the content processed by the computer is translated into the visual and intuitive expression that people are used to, and the simple operation of the mouse and keyboard is transformed into the commands that the computer can recognize.

From the perspective of application, the functions of the monitoring system can be simply divided into five aspects: monitoring function, interactive function, management function, intelligent analysis function and auxiliary function. The management function includes data management function, alarm management function, configuration management function, security management function, self-management function and file management function. The whole monitoring system can be divided into four management levels: provincial monitoring and management system, regional monitoring and management system, county monitoring and management system and bureau and station monitoring and management system. Among them, the Bureau and station monitoring and management system can also be divided into a monitoring module SM that directly deals with equipment. These different levels of systems are endowed with different functions. They coordinate work, exchange information and jointly complete the monitoring and management tasks of the whole monitoring system. Monitoring items can be divided according to telemetry, remote signaling and remote control: telemetry refers to data acquisition of continuously changing analog signals; Remote signaling refers to data acquisition of discrete switching signals; Remote control refers to discrete control commands issued by the monitoring system. See Table 2 for information management contents of monitoring system.

| Equipment category | Equipment subclass | Type   | Content                              |
|--------------------|--------------------|--------|--------------------------------------|
| High voltage       | Go in the cabinet  | Shake  | Overcurrent challenge warning, grounding |
| configuration      | Get out of the cabinet | letter | trip warning, voltage loss trip warning |
|                    | transformer        | Shake  | Overcurrent challenge warning, grounding |
|                    |                    | letter | trip warning, voltage loss trip warning |
|                    |                    |        | High temperature warning             |
| Low voltage        | Go in the cabinet  | Shake  | Switch condition                     |
| configuration      | Capacitor cabinet | letter | Working state of compensation capacitor |

The software of these two parts is written in delphi50, and the database engine is BDE of Borland company. Because each monitoring module uses MCS-51 single chip microcomputer as the main control chip, the monitoring programs are written in assembly language. The management program
flow of the monitoring management center is relatively simple. The following mainly introduces the monitoring program flow running on the communication power monitoring host and the main program flow of the monitoring module monitoring program.

3. Analysis of experimental results

In order to verify the practical application effect of distributed communication power monitoring system based on big data technology, it is adjusted through the peripheral signal acquisition circuit, and then sent to the on-chip ADC of STM32 for sampling and conversion. The signal acquisition part is the signal input of the monitoring terminal, and its measurement accuracy is directly related to the performance of the whole system. The following summarizes the causes of the error in the signal acquisition part, and gives the corresponding solutions. The power grid signal monitoring video processing chip of DSP model and MPEG-4 video compression standard are adopted. In order to ensure the accuracy of the experimental results, the specific experimental parameters are set uniformly. The specific conditions are shown in the table 3.

| Parameter               | Numerical value |
|-------------------------|-----------------|
| Signal input port       | 3, 6, 9         |
| Input interface level   | 2.5Vp-p         |
| Supported formats       | PAL             |
| sampling rate           | 10KHz           |

Further, the interference experimental environment is established in Matlab / Simulink environment for real-time tracking and monitoring. The simulation results are recorded, as shown in the figure 1.

![Comparison and detection results of measurement error of system monitoring data](image)

Fig. 1 Comparison and detection results of measurement error of system monitoring data

It can be seen from the figure that the traditional system is used for disturbance monitoring, its response speed is slow and oscillates at the maximum power output point. The system in this paper overcomes the disturbance in a short time, has fast response speed, and has good dynamic performance and accuracy. Take the absolute value of the measurement error value of the two tests, and then draw the waveform of the absolute value of the error according to the monitoring sequence of the real power supply. The results are shown in the figure 2:
Fig. 2 Comparison test results of system monitoring error

It can be seen from the measurement results that in the practical application of the traditional system, there is signal frequency fluctuation, resulting in periodic error in signal sampling. Under this method, the system detection error value is obviously lower, the measurement error fluctuation is small, and the measurement accuracy of the data has been greatly improved, which can meet the requirements of the design index.

4. Conclusion
In-depth research and analysis are made. The monitoring and management of communication power supply can be effectively realized by using big data distributed monitoring system, And it can realize the problems of high deviation and slow response speed of communication power monitoring system.

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