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Design of Coal Mine Comprehensive Parameters Monitoring System Based on DSP

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Abstract. Coal mine comprehensive parameters monitoring system based on DSP TMS320LF2407A and wireless module G20 is proposed,which takes DSP as controller of monitoring terminal and GPRS network as communication channel.The structure model, communication interface and functional module of this system have been analyzed emphatically.This system can realize coal mine security production via monitoring the real-time parameters such as environment and operational equipment,at the same time the information resource can be shared via remote data transmission based on GPRS and Internet.

Keywords: coal mine, monitoring system, dps, gprs

1. Introduction

In recent years, the security production of coal mine industry in china is unoptimistic and the mine accident occurs frequently because of the unperfected safety monitoring system and the dated management styles. Aimed at the serious situation, coal mine comprehensive parameters monitoring system, which primarily consists of monitoring terminal based on TMS320LF2407A and wireless data telecommunication base on GPRS network is proposed. Many parameters such as the mine environment parameters, ventilator operational state parameters, substation power parameters, electrical equipment operational state parameters and so on, should be collected, processed, displayed and transmitted to the [*]ground monitoring center. This monitoring system can realize the real-time monitoring of coal mine parameters and the prompt processing of equipment fault, as a result the early warning and controlling ability is extremely enhanced and the security production of coal mine is achieved.

2. Composition of system

2.1. Method of System Structure

Coal mine comprehensive parameters monitoring system is composed of some monitoring terminals, data collection substations, GPRS wireless module, monitoring center and many clients, of which the block diagram is shown in Figure 1.

In monitoring terminal, many parameters including the concentration and content of underground various gas, equipment operational status and other data are collected through the sensor (such as CO sensor, airflow sensor and equipment start/stop sensor),then these data will be transmitted to the data collection substation through the CAN bus. Multiple coal mines have multiple stations, but a substation is only shown in figure 1.

The distance between the data collection substations located in underground and ground is 500 meters at least, and the GPRS wireless communication module G20 adopted in this system is RS232 serial communication interface, of which communication distance is between 10m and 25m, so the RS232/485 transform circuit is utilized in controller of data collection substation in order to transmit the data to GPRS wireless communication module. Then the data are transferred to Internet through GPRS

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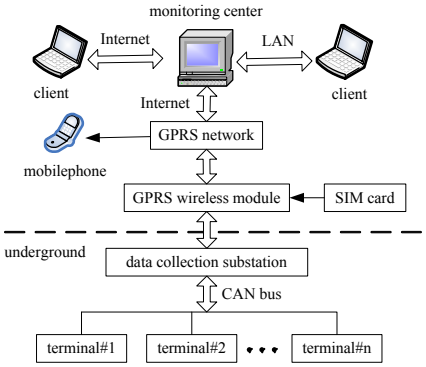

Fig.l. system structure

network and the monitoring center server is ind by packets through IP addressing, as a result, the data telecommunication is realized. The monitoring center server implements the real-time analysis of collected data and judgment of production conditions in coal mine, thus providing favorable technical support of security production. The monitoring center connect the server of security department through the network, in addition the dangerous data can be directly sent to the mobile phones of relevant superintendent, so the accidents should be reduced extremely.

2.2. Hardware Design of Monitoring Terminal

The monitoring parameters of coal mine mainly have two types. One is environmental parameters: such as gas concentration, CO concentrations, tunnel wind speed, negative pressure, temperature, etc. The other kind is mechanical equipment operational status parameters: such as vibratory magnitude, bearing temperature, motor current and start/stop state, the power switch state, etc. The signal procession of environmental parameters is composed of the processing by 3 σ eliminate algorithm and mean statistics algorithm, judgment and threshold alarm, uploading the results to network. The signal processing of equipment operational parameters is composed of noise reduction of vibration signals and current signal, time-domain analysis, FFT transform, frequency-domain fault diagnosis, uploading the results to network, and furthermore, the vibration and current original data is uploaded to the monitoring center for accurate diagnosis apart for a certain cycle [1].

Digital signal processor is applied broadly in signal processing and control field for cost-effective, quick speed, plentiful signal processing instructions, so it is becoming the system core of the new intelligent instrumentation. Monitoring terminal based on TMS320LF2407A is primarily responsible for the coal mine parameters collection, site equipment control and alarm signal display. The chip can sample the parameters of coal mine laneway, such as gas, temperature, wind speed, CO, etc, then the data are uploaded through the CAN bus. TMS320LF2407A chip has a high-performance, 10-bit analog-to-digital converter (ADC) which has a minimum conversion time of 375 ns and offers up to 16 channels of analog input, so the analogue signal is collected. The collected on/off signal is input by IOPA , and the on/off output signal is controlled by IOPB which can realize the equipment remote control such as start/stop, alarm and locked.

The sensors convert the environmental parameter signals into the standard current 4-20mA/0-5mA. Aimed at the signal types, the analog signal preprocessing circuit set three kinds of input mode for each channel and choose corresponding input path through program-controlled switch. In this way, the preprocessing circuit converts the output signal of sensor into the 0-5V voltage signal which entered into signal-followed circuits, optocoupler isolation circuit and low-pass filter circuit. The input circuit of on-off signal (such as equipment start/stop parameter) is composed of optocoupler isolation circuit and shaping circuit. The output control circuit of on-off signal is composed of optocoupler isolation circuit, amplifier and solid-state relays. Because the electromechanical equipment operational monitoring parameters are more and the amplitude of collected signal is variable, the analog signal processing circuit is more complex. For

example, the vibration signal processing channel includes signal-followed circuit, program-controlled filter and program-controlled amplifier.

The MAX262 device which integrated with 2-lines programmable filter is adopted by filter circuit. The filter is programmable due to its type and frequency are controlled by DSP. The program-controlled amplifier circuit is composed of the DS1844 device (digital potentiometer) with 4-line, 64-tap and the AD526 device integrated operational amplifier, of which gain is controlled by DSP. A/D conversion is implemented by TMS320LF2407A. The sampled data are stored in buffer, the signal analysis and processing procedure are started after sampling finished, which carries on the analysis of time domain statistics. Finished the analysis of sampled data, the communication subprogram is started, which upload the analyzed results to the network. The hardware diagram of data acquisition and equipment control circuit is shown in figure 2.

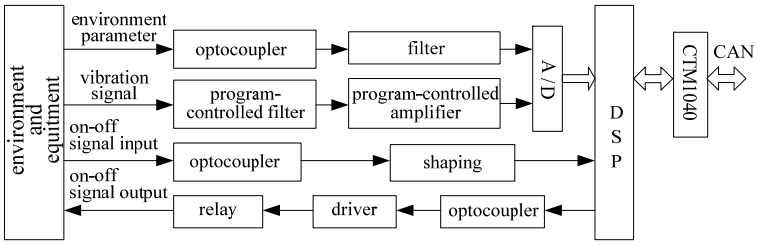

Fig.2. hardware diagram of monitor terminal

2.3. Data Communication

The environment of coal mine is complex and wicked, meanwhile the monitoring points are more and scattered. But the CAN bus which working in multi-host way has its unique advantages in the distributed control system. At the same time, the CAN bus is suitable for coal mine safety monitoring system because of the perfect real-time performance and reliability. The system implements the underground data transmission through CAN bus. The basic topology structure (protocol structure) of network is bus-style, and the physical structure (link structure) can be extended ， which is composed of many sensors, CAN controller, special anti-jamming communication cable and PC card. The theoretical transmission distance is 15km, transmission speed is up to 1Mb/s. Considering of the actual situation, the 2-4 repeaters should be added in transmission path to enhance signals power and prevent speed decreases due to attenuation [2]. Each monitoring terminal in this system is a node of CAN bus network, which will transfers the real-time parameters to the well-head collection substation through the CAN bus and realize the storage of monitoring data.

The CAN bus communication is achieved by CAN bus controller module in TMS320LF2407A, which is a 16-bits peripheral module and supports CAN specification 2.0B. The CAN transceiver CTM1040 with high-speed photoelectric isolation and bus driver serves as the external extended circuit, the system has simple structure and high reliability.

The telecommunication of data is accomplished by GPRS network. GPRS is the world's most ubiquitous wireless data service, now available with almost each GSM network. GPRS wireless module and CPU module of data collection substations are connected with serial port, and through which the data is transmitted to GPRS network. Then GPRS network transmit the data to the mobile company intranet, and each GPRS terminal is assigned to a IP address of GPRS internal networks when it is connected GPRS network. Then the port is mapped into Internet through GPRS gateway nodes, thus the data is transmitted to the Internet and find a designated center server in the Internet which can receives the data through data receiving software. After received, the data can be forwarded to specified data processing server of the enterprise internal network. The whole data transmission process is based on the TCP/IP protocol, which can form the "center server - multiple terminal" network mode [3].

The wireless network control (such as wireless transceiver of data, packing and reverse of network data packets) is implemented by GPRS wireless communication module which directly related to the stability and reliability of the whole system. The system adopts the G20 module produced by MOTOROLA, through which to login in China mobile GPRS network by dialling. G20 module integrates the complete RF circuit

and GPRS base band processor, embed TCP/IP protocol, and supports the voice, data, fax and short message function. G20 with superior performance and small in size (24.4 mm x 48.2 mm x 6.0 mm), can offer advanced service quality of data transmission. It has four communication interfaces: RS232, USB, SIM and SPI, and its input voltage range is 3.0 V-4.2 V. When external input voltage is lower than 2.85 V or higher than 4.25 V, G20 will become disconnected and stop working because it contains a voltage detection unit. The system can connect to the Internet through GPRS network after linking the SIM card with open GPRS function. G20 module support most AT instructions, and also provides proprietary AT instructions to support GPRS service. In this system, the communication between G20 and the controller of data collection substations is realized by use of RS232/485 bus and related AT instructions.

2.4. Monitoring Center

The monitoring center is composed of monitoring software and databases software. The server of monitoring center has its fixed IP address, through which it can connect the Internet. The server can receive data from each GPRS communication module through binding IP address, and send these data to monitor software for analysis and processing, so the data storage, fault diagnosis and chain control are realized. The monitoring center establish priority level according to the importance of monitoring objects, so the important parameters are selected firstly and transmitted to the server for comprehensive analysis and concerted control when alerting beforehand or network congestion. At the same time the associated control information will be sent to monitoring terminal. Monitoring data is shared through the network, so the management organization and remote diagnosis expert can browse, examine and analyze the coal mine condition on the network.

3. Design of system software

3.1. Function Module of System

1) Comprehensive parameters monitoring function: By using monitoring system, the parameters such as gas concentration, equipment operational status, wind speed, airflow, etc, can be monitored dynamically, and the monitoring facilities can be located in the electronic map. The on-site operator can directly know coal mine state according to various data displayed in electronic map. When the threshold is exceeded, the corresponding parameters will be displayed with red and sound-light alarm.

2) Authority management functions: According to the user permissions set by the administrator, the ordinary user can only check the equipment operational status and the field parameter variations, but the responsible users have the right to control the equipment with login user name and password.

3) Data storage function: Date such as the monitoring data, alarm records ,the various operating information of the operators and so on can be stored in the database. Through inquiring and analyzing the historical data of each monitoring point in coal mine, the coal mine safety condition is understand and mastered effectively.

4) Report exporting function: All sorts of the real-time monitoring data and historical monitoring data are exported in the form of table, so the operators will report or file these data.

5) Report printing function: The real-time monitoring data and alarm records is printed, also the historical monitoring data and fault information of some day can be printed [4].

3.2. Software Design of Monitoring Center

Because of the monitoring system is faced to the users finally, so the system operating conveniently and efficiently is determined by the development of the user monitoring software. Due to the Windows operating system pandemic and convenient operation, the Windows operating system and Visual c++ development platform are adopted to implement the data display and processing of this system. The monitoring center software consist of user management, data read and display, alarm parameter setting, remote network communication, data processing, database management and so on. Remote network communication and database management are the key technique, thus in this system the remote network communication based on calling API function and database management based on SQL2000 are proposed. Due to the large amount of data, the system can achieve a efficient operation by adopting data mining and data warehouse technology. The communication between PC and data collection terminal is realized in addition to interface protocols [5].

4. Conclusion

The coal mine comprehensive parameter monitoring system based on DSP can simultaneously monitor multiple scattered mine, and extremely guarantee the timeliness, accuracy of data collection, as well as reliability of data transmission. GPRS has the advantages of the easy networks, low construction and maintenance cost, broad covering, strong ant jamming, etc, which is adopted to realize information resources sharing. This system with mobile ability can understand the production site information not only in the monitoring center, but also in any authorised computer that is hooked up to the Internet, furthermore the important information can directly be sent to relevant personnel mobile with messages. Thus this system will be popular in coal mine safety remote monitoring field.

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