Research on Remote Monitoring System for Leakage Protection of Electric Grid in Underground Mine

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Abstract. Aimed at realizing remote monitoring system for leakage protection of low-voltage power grid in underground mine in Shanxi Province, intelligent leakage protection device with ZigBee are used underground, and the monitoring software based on LabVIEW is designed on PC, the data of power grid is sent to the mine monitoring center over ground through industrial ring network and published on Web, so as to build a remote monitoring system for leakage protection of low-voltage power grid in coal mine. Industrial experiments results show that the designed system is reliable and stable, which has improved the automation level and information management in coal mine.

Introduction

At present, there is a coal mine in Shaanxi Province of China with 660V and 1140V low voltage power grid underground, neutral point ungrounded, the leakage is the main kind fault of low-voltage power grid underground. Leakage can not only lead to personal electric shock and electrical equipment damage, but also cause gas and coal dust explosion accidents [1].Therefore, leakage protection system is a key point of the coal mine power grid protection. The leakage protection device has the function of intelligent leakage detection and communication is the development trend of current leakage protection technology [2-3]. In the case of leakage fault, the leakage fault lines and equipment can be automatic removed to ensure the non-fault section can continue to work at the same time, thus to reduce the leakage fault range, minimize the leakage fault outage time, as well as, the leakage fault information containing the fault location can be sent to the control room underground and the coal mine remote monitoring center over ground as soon as possible.

Wired communication is used in the original leakage protection system of this coal mine underground, it's difficult to maintain and upgrade, and the monitoring information of all device needs to be transmitted to the control room underground for centralized processing to realize leakage protection, with a long protection control process, it is easy to cause incorrect detection. With the rapid development of wireless communication technology, many wireless communication technologies have been mature, and the traditional wired communication is gradually replaced. ZigBee is one kind of emerging wireless communication technology, which has the features such as low cost, low power consumption, low complexity and self-organization network, et al. and it's very suitable for the special environment in coal mine underground [4].In this paper, the intelligent leakage protection device with ZigBee are used, and the monitoring software is designed based on LabVIEW, the data of power grid is sent to the mine monitoring center over ground through industrial ring network and published on Web, so as to build a remote monitoring system for leakage protection of low-voltage power grid in coal mine.

Systems structure

According to the situation of this coal mine, the overall structure of the remote monitoring system is shown in figure1. Underground leakage protection devices (including monitoring master station and

monitoring substation) are used to make power grid monitoring and protection, which are networked by ZigBee for communication. The power grid and protection data is sent from the monitoring master station to the explosion-proof computer in the control room underground by serial communication of RS485, which is displayed by software designed on LabVIEW and transferred again to the sever in the coal mine monitoring center over ground through industrial ring network. After the data is published on WEB, the underground power grid monitoring status can be checked the specified webpage by the coal mine workers and leaders with login names and passwords.

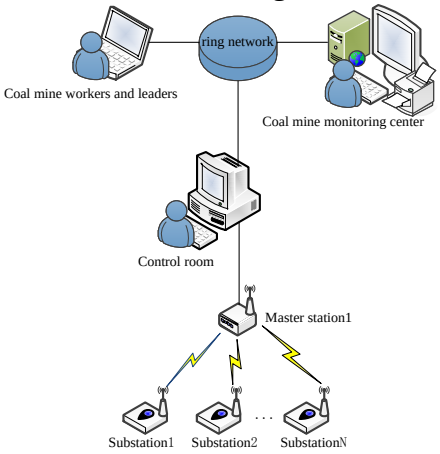

Fig.1 system overall structure

The monitoring master station and monitoring substation are networked according to the star configuration. The monitoring master station is installed on the prime feeder switch in the underground power grid, which is connected with the monitoring substation installed on minor feeder switch of each bus bar and each branch by ZigBee to receive and dispatch data.

Monitoring master/substation design

The data of each substation is gathered on monitoring master station and transferred to upper computer. The monitoring master station is the core of the ZigBee communication network, which plays a great important role in keeping reliability of the whole network. According to the star configuration, there is only one is only one master station and multiple substations in a ZigBee network. The entire network is established and managed by master station, the monitoring substations are distributed within the coverage area of the master station, communicating with master station directly, the data is transmitted rapidly so as to make protection control and keep synchronization of the system.

The monitoring master station is a FFD(full Function Device), which is the main manager of the ZigBee network and responsible for establishing the network and managing each substations in network, with the routing function, the routing discovery and routing selection can be realized, and the function of receiving and forwarding data is also indispensable. The monitoring substation is a RFD (Reduced Function Device), which is only responsible for sending the processing results of monitoring data, to the monitoring master station. The storage capacity of monitoring substation is small, and it can turn into standby mode without sending data. A FFD is able to communicate with another FFD or RFD, whereas RFD is only able to communicate with FFD, and there is no communication between each RFD.

The zero sequence voltage and zero sequence current of the underground power grid are monitored by monitoring substation so as to realize leakage detection and locking control. When there is no leakage detected, the substation will send the monitoring and controlling information to the master station regularly by ZigBee. Once there is a leakage fault detected, the monitoring substation will make locking control to remove the corresponding fault branch and immediately send the information of leakage protection equipment, fault alarm and fault location to the monitoring master station, which will be transmitted by serial communication of RS485 to the explosion-proof computer in the control room underground to warn the coal mine workers. The problem of the

original power grid leakage protection system such as low anti-interference capacity and centralized data processing of multipath detection are solved by the method of each monitoring substation making leakage detection and locking control independently, therefore, the fault detection is faster and more accurate, which can be more effective to reduce misjudgment of leakage protection.

In addition, the Data of power grid status is sent from the monitoring master station to upper computer in the control room underground for displaying, storing, and warning, which is convenient for the technical personnel timely to troubleshoot.

Monitoring software design

The producer/consumer pattern based on LabVIEW is designed as the core of the monitoring software on the upper computer in the control room underground, so as to realize data acquisition, display, storage, sending, alarm and historical data query, et al. The overall software structure is shown in figure 2.

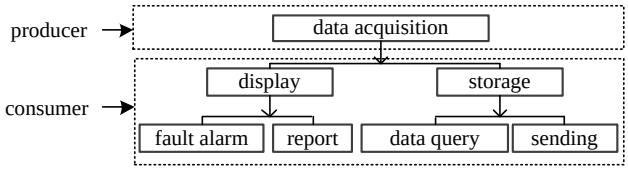

Fig.2 overall software structure

In LabVIEW, the basic program structure of producer/consumer pattern is shown in figure 3, which includes multiple parallel while loop. Each while loop can run at different rates, in the form of an event-driven, to generate queue items (data). The module generating data is called producer; in contrast, the module processing data is called consumer. All cycle of consumer are controlled by producer, with data transmission. In order to keep the data transmission synchronization, the queue is adopted in producer/consumer pattern. A buffer zone is created by the queue of data transmission to perform data input and output according to the principle of FIFO (first in first out), The new data element is added to the end of queue, meanwhile, the first element of queue is always the first to leave, thus the data loss is avoided in the process of data transmission.

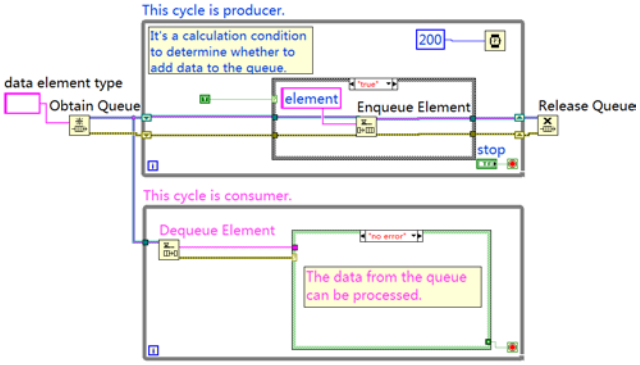

Fig.3 producer/consumer model

In this paper, the data of power grid status and protection control configuration obtained by leakage protection device is used as producer, while the consumer mainly includes the following two parts:

Data display. The data transmitted through the queue from the producer will be operated as data type conversion and numerical calculation, et al. The waveform of power grid voltage and current are real time displayed, as well as, the relative RMS, peak, harmonic content and power factor are displayed after calculation. The fault alarm with sound and light is realized by setting alarm thresholds to the working condition parameters. In addition, the fault report can be generated automatically.

Data storage. The data transmitted through the queue from the producer and the calculation results are saved into the TDMS (Technical Data Management Streaming) database on upper computer. TDMS is a kind of binary log database in LabVIEW, which is put forward by NI(National Instruments) Corporation, with the advantages such as high speed, easy to access and use, et al. A

series of API function can be created for calling by other program or software. TDMS logical structure can be divided into three layers: file, channel group and channel, and each layer can be attached specific attributes. The data can be defined effectively through these three logic layer, which makes the data query easy to access in particular order.

In the control room underground, the monitoring software program periodically retrieves the local TDMS database to discover the new data storage files, which will be sent intelligently by using FTP (File Transfer Protocol) to the sever in coal mine monitoring center over ground through the industrial ring network. After sending of each data file, a notification will be sent from the sender to the receiver by using TCP, further processed by the receiver. In the coal mine monitoring center over ground, the receiver program keeps listening to the fixed TCP port. When the notification is received, the program will check the received data file, and analyze the data file only if the file is integrated to insert the data into the database for Web publishing.

Web publishing

On the sever in the coal mine monitoring center over ground, the receiver program keeps receiving and storing the underground power grid status and protection control configuration data, which is published on Web in order to realize remote networked monitoring. The Web publishing program based on B/S structure is designed by using JAVA language, and the SQL-SERVER-2008-R2 database is also used, besides, the SPRING is developed as the core, integrating the STRUTS and IBATIS framework, which not only simplify the development process, but also improve the scalability and maintainability of the program with low code maintenance cost.

Through the WEB platform, the underground power grid status and protection control configuration can be checked on specified webpage on any computer connected with the internal industry ring network by the coal mine workers with login names and passwords, including real-time working condition data, working condition comparison, historical data query, fault and maintenance information, teal.

Summary

In this paper, the remote monitoring system for leakage protection of low-voltage power grid in underground mine is studied, and the remote real-time monitoring and automatic protection control are realized. The intelligent and wireless Leakage protection devices are easy to net, with the following advantages: high anti-jamming capability, rapid fault detection and accurate control, which can be more effective to reduce the misjudgment of leakage protection, and it has a very good application prospect.

In addition, the information management and automation level are improved through the Web publishing, which effectively guarantee safety and reliability of the underground low-voltage power grid, providing scientific basis for the coal mine management and maintenance. With the rapid development of mobile intelligent terminal, the designed software program is able to be transplanted to the mobile intelligent terminal.

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