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Design and Implementation of A Monitoring System for Geological Archives

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Abstract

A monitoring system for geological archives with TCP/IP network communication is designed in this research to address wide distribution range, long distance, slow data updating, and difficult maintenance of city and county geological archives. The designed system uses the single chip STC11F32XE and the Ethernet control chip RTL8019AS as a hardware platform. The hardware design scheme, software design method, and the main programming flowchart of the geological archive monitoring unit were presented, and a specific data test was carried out. This monitoring system not only monitors and controls temperature, humidity, ponding, power supply, and other environmental data in geological archives, but also realizes geological data transmission between city (county) and provincial geological archives. In addition, this system is designed with a GSM warning mechanism, which could accelerate the quick response mechanism of the system. The entire monitoring system is accessed through the provincial environmental resources website with a fixed IP address. To ensure standardization of the monitoring system, the data transmission standard of the application layer used the associated standards of the Ministry of National Land and Resources. The entire system design improves the storage environment of the geological data effectively. It provides important data support to solve inconsistencies between provincial and city (county) geological data, as well as ensures scientific management of geological issues.

Keywords: *Geological data, Safety monitoring, Ethernet*

1. Introduction

The promotion of digital management has improved the efficiency of the management of paper documents significantly in recent years. Paper documents that are almost one hundred years old are rare and valuable. High temperature, high humidity, drastic changes in temperature and humidity, power failure, and ponding damage these paper documents; such damage presents certain threats to the storage of digital documents [1]. The design and implementation of a monitoring system for geological archives have a significant application value.

Traditionally, special personnel are hired for environmental supervision of geological archives. Such a task is labor consuming, and discovering hidden dangers in a timely manner is difficult. Security management mainly focuses on software (e.g., network fault and data backup), and neglects management of temperature, humidity, and ponding, thereby resulting in major economic losses [2]. Moreover, data updating is slow, which may easily cause inconsistencies between provincial and city (county) geological data [3]. Existing research on monitoring systems mainly concentrates on internal environmental protection, such as the installation of dehumidifiers. Although dehumidifiers decrease internal humidity, they lack data statistics and early warning mechanisms [4]. Geological management lacks uniformity and comparability of geological management approaches among different regions, thereby having a negative effect on working enthusiasm. Therefore, a monitoring system for geological archives was designed for real-time monitoring and management of environmental data, as well as for receiving and sending related commands. The test run of the system obtained positive results; the system improved the 24 h duty mode and provided timely warnings, thus reducing risks and avoiding losses.

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2. Description of Geological Archive Monitoring System

A geological archive safety monitoring system is a distributed measurement and control system that covers an entire province. Such a system is composed of a city (county) geological archive safety monitoring system, a provincial geological resources website, and a provincial monitoring center host. It involves concentrated monitoring of geological archives through computer technology, sensor technology, electronic technique, and communication technologies, all of which monitor and control the operation safety of the conditions of geological archives. The system also monitors operation parameters of equipment and record data, copes with failures, and ensures that early warning and alarms correspond to certain requirements. The monitoring center host of provincial geological archives could assess the operations of the city (county) geological archives.

The city (county) geological archive monitoring system consists of an environmental detector, a monitor, and a monitoring center host. The detector acquisition modulus transfers collected data to the monitor through 485 bus [5], and PCF8563 is used as the system clock. The monitor accesses the provincial National Land Environmental Resources' IP network through a fixed IP address and then transfers data. The structure of the monitoring system for geological archives is shown in Figure 1.

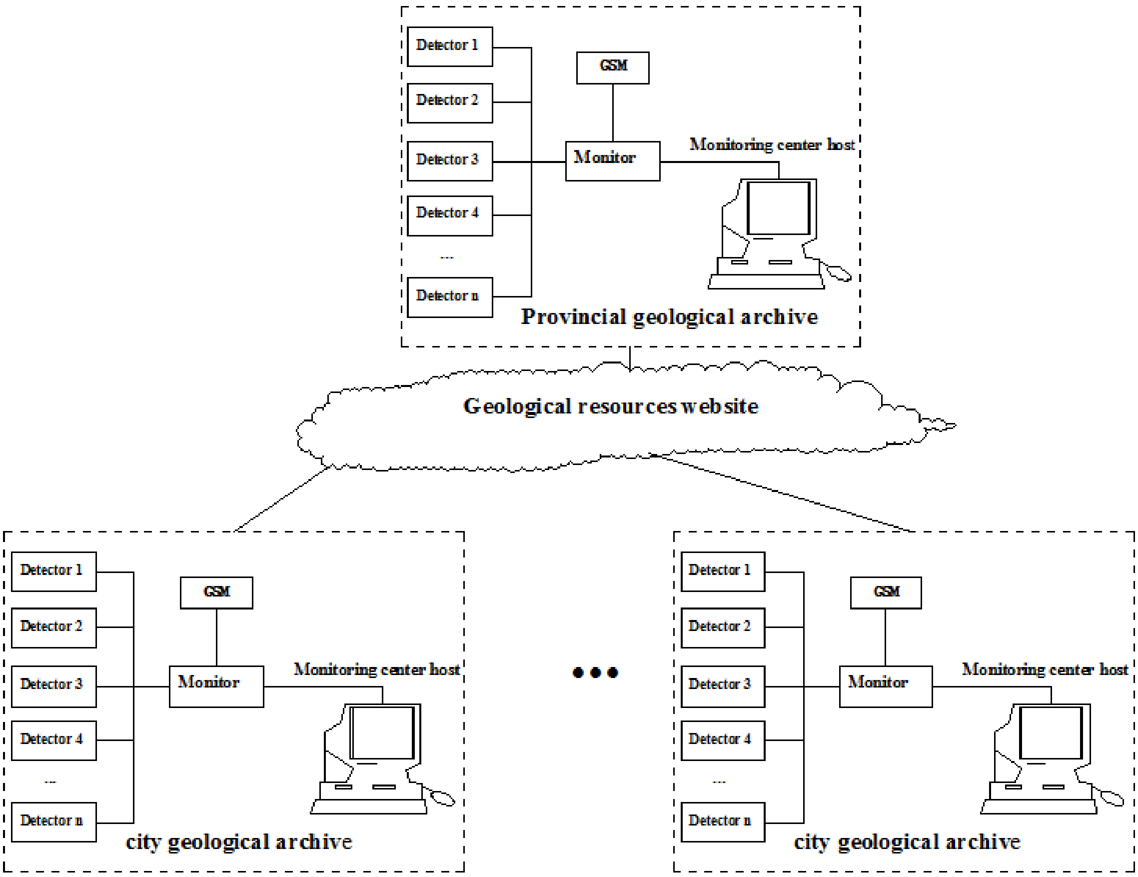

Figure 1. Structure of the monitoring system for geological archives

3. System Hardware Design

The hardware design and implementation procedure of the monitor are introduced in the following text. An 8-bit embedded microprocessor STC11F32XE was chosen to ensure simple system design and installation, as well as minimum cost for communication module and transmission reliability. EEPROM of STC11F32XE is 29 K, and the address range is 0000H-73FFH, with a total of 58 sectors and 512 bytes per sector. A sector is the basic unit of readwrite operation of EEPROM [6]. Based on the geological resources website, the network chip RTL8019AS was used for Ethernet data transmission. RTL8019AS performances conform to Ethernet II and IEEE 802.3 standards, full duplex, and 10 mb/s transmit-receive rate [7]. The remote PC sends data to the Ethernet interface, which stores the data in the RAM. A field serial port device and a single chip were used for communication. The data from the RAM were collected as control command of the field equipment, thus changing the working state of the field equipment. STC11F32XE uses 8-bit data bus. Therefore, an 8-bit bus network card. IORB and IORB are connected with WR and RD of STC11F32XE, respectively. With respect to the connections of 20-bit bus of the RTL8019AS chip, SA0–SA4 are connected to P0.0–P0.4 of STC11F32XE. Five data buses are needed to address the 32 registers in the RTL8019AS chip. SA8 and SA9 are connected to VCC, and the other 13 address buses are connected to GND. The hardware structure is shown in Figure 2.

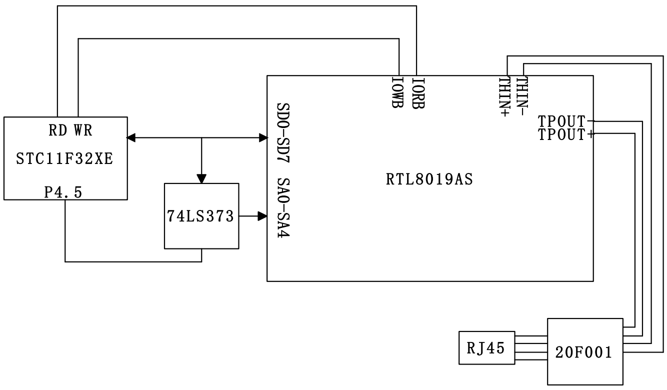

Figure 2. Hardware structure of the monitor

4. Upper Computer Software Design

A dedicated control lenlib.ocx under VB was set to ensure convenient data communication of the monitor through the Ethernet (provincial resources website) and one upper PC node of the Ethernet (provincial resources website). Users could invoke it on WINXP by installing the 10/100 Base-T Ethernet card on the PC. In this way, a distributed monitoring system based on the Ethernet could be achieved by embedding lenlib.ocx to design the network control system application software.

Lenlib.ocx is an ACTIVEX that uses lenuser object. It provides application developers with one attribute (remoteip), three methods [GetData(), SendData(), and Link()], and one event [dataarrival()]. The invoking steps are as follows:

(1) The PC is connected to the monitor. Remoteip attributes the IP address to the monitor. The PC and the monitor are connected through Link(). The connection is successful when the “ACK” string is received. Then, the next communication can be performed.

(2) Communication. After successful connection, GetData() is used to receive network data and SendData() is used to send data to the network. The PC will trigger DataArrival() after receiving the data from the monitor. GetData() in the DataArrival() is used to acquire the sent information and store it in variables of the variant type.

(3) SendData, GetData, link gramm

Returned value Void

a. object.SendData data

b. object.GetData data, [type,] [maxLen]

5. Communication Protocol Design

According to related regulations of the Ministry of National Land and Resources, data transmission and communication protocol correspond to the application layer of the seven-layer protocol defined by ISO/OSI, thereby providing mutual communication between field devices based on different transmission networks and monitoring centers [9].

The application layer depends on the chosen transmission network and performs data communication on the chosen transmission network. If the basic transmission layer is established, then the protocol of the entire application layer is unrelated with the specific transmission network. In this system, the communication between the monitor and the monitoring center is based on TCP/IP, and the transmission layer uses the UDP protocol [10]. The communication between the monitor and the monitoring center host is shown in Figure 3.

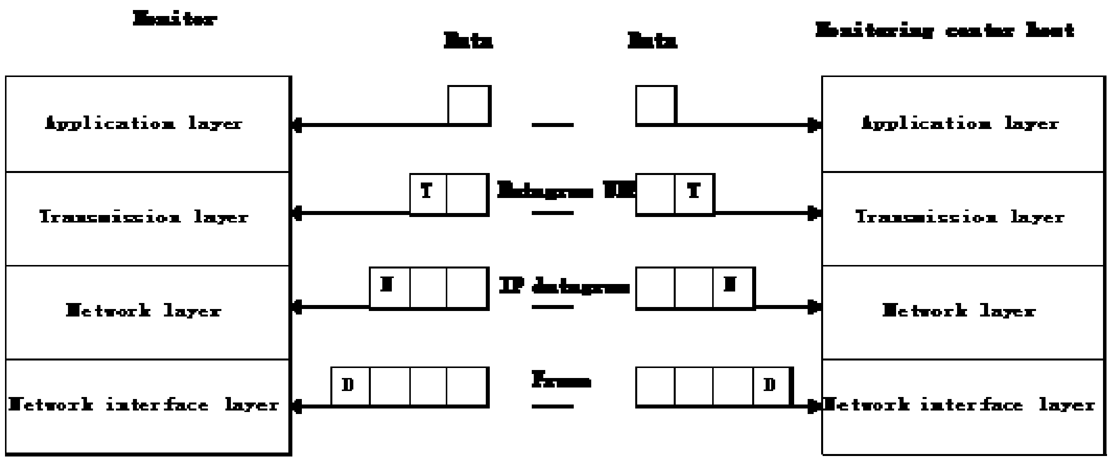

Figure 3. Communication process of Ethernet

When the monitor wants to send data through UDP, it will transmit the data, a pair of socket addresses, and the data length, to the UDP. The UDP will then add UDP data prelude to the received data and then send it to the IP, marking it from the UDP protocol. Then, this IP datagram is sent to the data link layer (DLL). The DLL will add its prelude to the received datagram and then send it to the physical layer. The physical layer will convert these bit codes into an electrical signal and then transmit them [11]. When the monitoring center receives these data, it will unpack them layer by layer to obtain the real effective data and then make corresponding treatments.

Communications between the monitor and the upper computer use an incompressible ASCII pattern. The command format from the host to the terminal is

HEAD	CLA	LC	DATA	CRC	END

Specific command definitions

The communication protocol mainly includes 11 commands.

Command of collector time setting

(1) Definition and range: The upper computer sets the collector time. The direction is from the PC to the terminal.

(2) Command message

STAR	WCLK	012	YYMMDDHHMMSS, 12 bits in total	XX	END

(3) Response message

STAR	WCLK	002	SW1 SW1	XX	END

(4) Returning data meaning: SW1 SW2=“00”/“FF” (command is executed successfully/setting failed).

Command of collector time reading

(1) Definition and range: The upper computer reads the current time of the collector. The direction is from the PC to the terminal.

(2) Command message

STAR	RCLK	000	Nothing	XX	END

(3) Response message

STAR	RCLK	012	YYMMDDHHMMSS, 12 bits in total	XX	END

(4) Returning data meaning: Nothing.

Command of collector upload interval setting

(1) Definition and range: The upper computer sets the upload interval of the collector. The direction is from the PC to the terminal.

(2) Command message

STAR	WUPT	001	Interval mark of 1 byte can only be 0, 1, 2, and 3.	XX	END

Note: DATA supports 0, 1, 2, and 3 only. Hence, other values are viewed as errors. 0 represents an untimed upload; 1 indicates an upload every 10 min; 2 indicates an upload every 30 min; and 3 indicates an upload every 60 min.

(3) Response message

STAR	WUPT	002	SW1 SW1	XX	END

(4) Returned data meaning: SW1 SW2="00"/"FF" (command is executed successfully/setting failed).

Command of collector beginning to upload real-time data

(1) Definition and range: After the upper computer sends this command, the collector will return the current real-time data every 30 s until the upper computer stops sending the command to the collector. The direction is from the PC to the terminal.

(2) Command message

STAR	SRDA	000	Nothing	XX	END

(3) Response message

STAR	SRDA	002	SW1 SW1	XX	END

(4) Returning data meaning: SW1 SW2="00"/"FF" (command is executed successfully/setting failed).

Command of collector stopping to upload real-time data

(1) Definition and range: After the upper computer sends this command to the collector, the collector will stop returning the current real-time data state every 30 s. The direction is from the PC to the terminal.

(2) Command message

STAR	ERDA	000	Nothing	XX	END

(3) Response message

STAR	ERDA	002	SW1 SW1	XX	END

(4) Returning data meaning: SW1 SW2="00"/"FF" (command is executed successfully/setting failed).

Command of collector uploading real-time data

(1) Definition and range: After the upper computer sends a command to start collecting real-time data to the collector, the collector will send the current real-time data to the upper computer every 30 s. The direction is from the terminal to the PC.

(2) Command message

STAR	UPRD	XXX	Refer to reference for more details.	XX	END

(3) Response message

STAR	UPRD	012	DATA	XX	END

where DATA regulates

Time	Voltage	Current	Temperature	Humidity	UPS/air conditioning switch
12 bytes	3 bytes	2 bytes	2 bytes	2 bytes	1 byte (1111XXXX)

Command of collector uploading data regularly

(1) Definition and range: The collector will send the mean within the user setting time to the upper computer. The direction is from the terminal to the PC.

(2) Command message

STAR	UPTD	XXX	The format is the same as the collector's uploading real-time data.	XX	END

(3) Response message
Returning data meaning: SW1 SW2="00"/"FF" (successful/failed data sending)
Command of setting alarm threshold
(1) Definition and range: The upper computer sends an alarm threshold to the collector. The direction is from the PC to the terminal.
(2) Command message

STAR	WBJY	009	Environmental parameter threshold	XX	END

where environmental parameter thresholds are

Voltage	Current	Temperature	Humidity
3 bytes	2 bytes	2 bytes	2 bytes

(3) Response message

STAR	WBJV	002	SW1 SW1	XX	END

(4) Returning data meaning: SW1 SW2="00"/"FF" (successful/failed data sending).
Alarm
(1) Definition and range: The collector sends an alarm signal to the upper computer. The direction is from the terminal to the PC.
(2) Command message

STAR	UPBJ	XXX	Alarm sensor address and data	XX	END

(3) Response message

STAR	UPBJ	002	SW1 SW1	XX	END

(4) Returning data meaning: SW1 SW2="00"/"FF" (successful/failed data sending).
Setting discharge starting time and time span
(1) Definition and range: The upper computer sets the discharge start time and time span of city (county) geological archives UPS. The direction is from the PC to the terminal.
(2) Command message

STAR	WFDT	014	YYMMDDHHMMSS HH, 14 bytes	XX	END

(3) Response message

STAR	WFDT	002	SW1 SW1	XX	END

(4) Returning data meaning: SW1 SW2="00"/"FF" (successful/failed data sending).
Setting archives switching control
(1) Definition and range: The upper computer sets the switching control signal for city (county) geological archives.
(2) Command message

STAR	WCDN	001	8 channels corresponding to 8 bits	XX	END

(3) Response message

STAR	WCDN	002	SW1 SW1	XX	END

(4) Returning data meaning: SW1 SW2="00"/"FF" (successful/failed data sending).

6. Main Program Flowchart of the Monitor

The monitor is the core of the entire monitoring system. It accomplishes time adjustment through system initialization and sets the data upload interval, the alarm threshold, the UPS discharge parameters, and the cellphone number for message alerts. The program flowchart is shown in Figure 4.

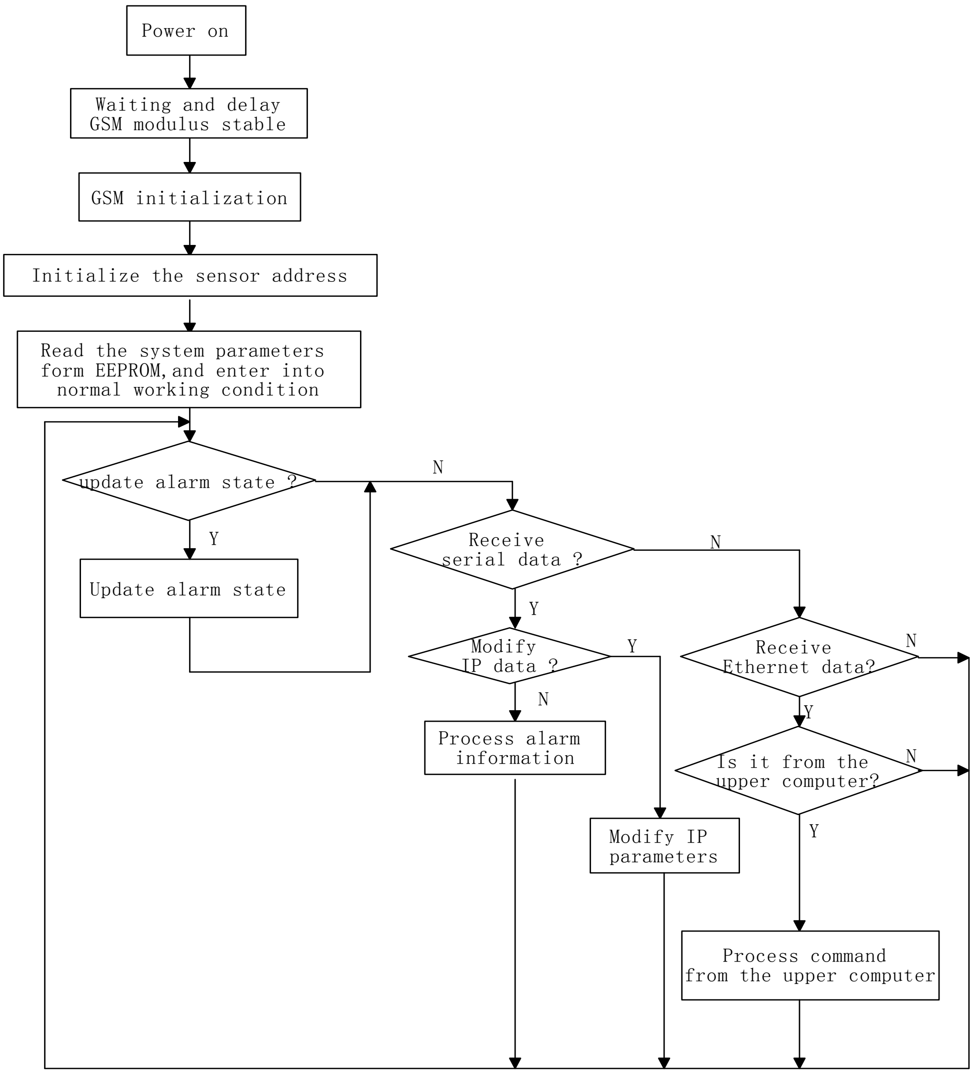

Figure 4. Main program flowchart of the monitor

7. System Test

The Ethernet linkage and the connection between the monitor and the detector were tested. Results are shown in Figures 5 and 6. The on/off test of the main supply and the test results of related processing are presented in Figure 7.

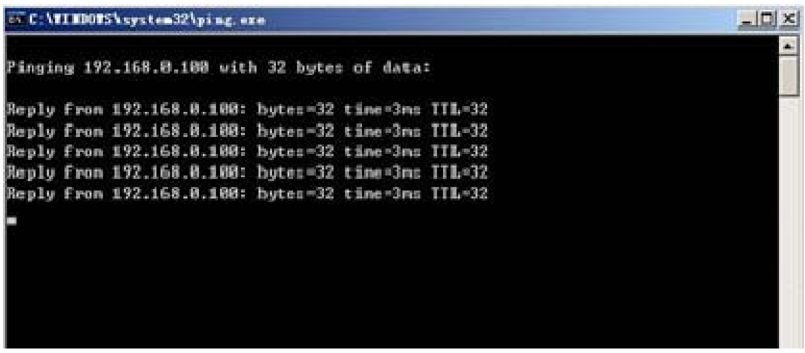

Figure 5. Ethernet linkage test

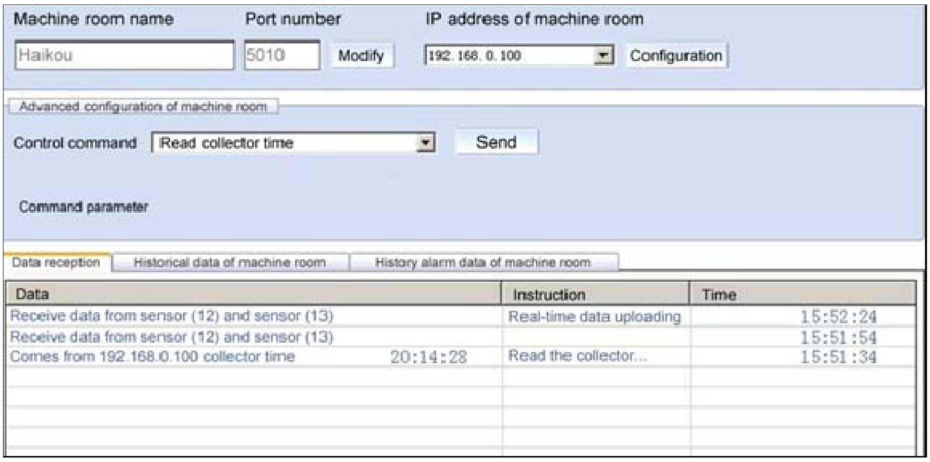

Figure 6. Received data and responses of monitor to control command

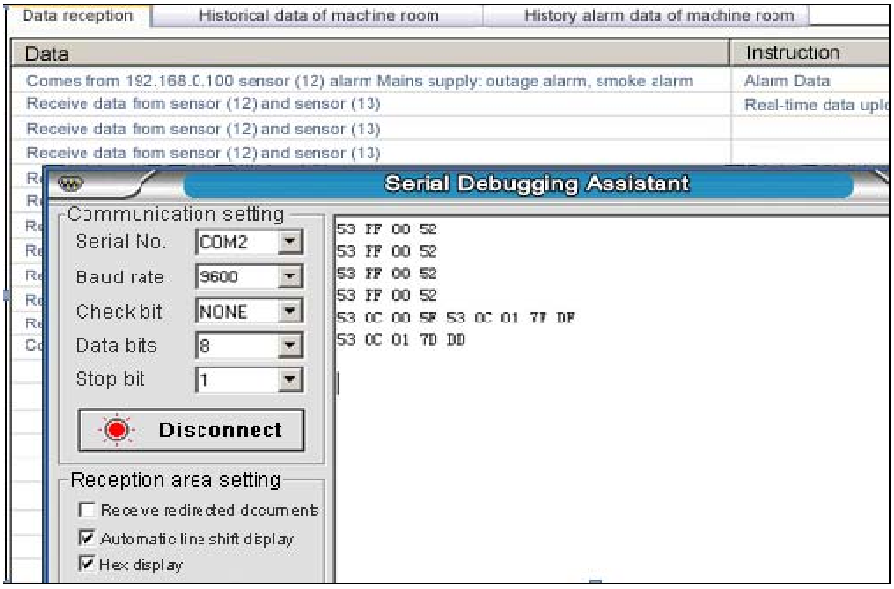

Figure 7. Outage alarm test

8. Conclusions

The monitoring system has achieved good overall operation in the Hainan Geological Archives since it became operational. The system met the design requirements of the Bureau of National Territory Resource of Hainan and provided data support for further data management. Given the emphasis on the “people-oriented” principle, the combination of new management and a continuously refined management mechanism ensured that geological data management is humanized. This approach also enhanced the enthusiasm and consciousness of geological staff and relieved their management burden, as well as improved management efficiency.

(1) The application of the geological archive safety monitoring system has fundamentally changed the original 24 h duty modes of managers.

(2) Air humidity in the archives was high because of continuous rainfall during the middle to the end of July 2014. The monitoring system sent alerts immediately, and the managers activated the dehumidifier as soon as they received the SMS alert. The designed monitoring system could discover potential safety hazards, thereby reducing risks to geological data storage caused by high air humidity.

The data support provided by the monitoring system guarantees the safety of the city (county) geological archives. It also provides accurate and intuitive digital information for geological safety management in Hainan, thereby accelerating the informatization of Hainan.e.

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