

The design of the meteorological data monitoring system based on mobile network

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Abstract: To deal with the global climate and environmental issues, low carbon development is becoming the trend of the world in smart grid. Accordingly, it is important to obtain the completed grid carbon emission evaluation system and build the online evaluation model. The mathematical model of carbon emission established in smart power grids for low carbon city assessment and verification system, should refer to the actual environmental monitoring data. So a meteorological data acquisition and monitoring experimental platform has been built in this paper, which makes use of ARM's high-performance low-cost and low-power STM32 as the core processor to acquire data. The GPRS module, which has several advantages including wide coverage, forever online mobile network, high data transmission speed and high communication quality, is thereby used to transmit data. The whole system can guarantee the accuracy of the meteorological data acquisition and transmission reliability.

Keywords: low-carbon ; smart grid ; mathematical model ; mobile network; GPRS

I. INTRODUCTION

In response to the global climate and environment issues, low carbon development is becoming a world trend in smart grid. China's social and economic development has been faced with severe problems such as the traditional energy supply unsustainable, low capacity of environment and climate warming. Grid as an important part of energy industry chain plays an important and irreplaceable role on promoting low-carbon development. Electric power industry as the mainstay of CO₂ emissions accounts for as high as the percent of 38.73 compared with all domestic fossil energy carbon emissions. Research shows that: thermal power plants would produce about 1 kg CO₂ per KWh, thereby the decrease of reducing CO₂ emissions and

establishment of smart power grids for low carbon city is particularly important and urgent. All kinds of new technologies are applied in the following sides of smart power grids for low carbon city: in source side , distributed power grid side and demand side ,so that the coordinating operation ability in each link of the power system should be promoted. As a result, smart grids would achieve carbon emission optimization .To determine whether the grid carbon emissions achieved is optimized or not, there are two important procedures. Firstly, the completed Grid carbon emission evaluation criterion system should be built. Secondly, the online evaluation model should be defined. Then it can evaluate and optimize low carbon smart city power grid. The mathematical model of carbon emission should refer to the actual environmental monitoring data. Due to carbon emissions monitored indirectly, it is necessary to monitor some of the variables in environment, such as Temperature, humidity, PH value and so on. At last, weight of each environment data will be converted into final actual carbon emissions by monitoring and integrating these environment variables^[1].

This article makes use of ARM's STM32 as the core processor which has high-performance, low-cost and low-power to collect data .In addition, the GPRS module, which has several advantages including wide coverage, forever online mobile network, high data transmission speed and high communication quality, is used to transmit data. Through experiments, the whole system can guarantee the accuracy of the meteorological data acquisition and transmission reliability. Furthermore, it has advantages on keeping safe as well as stable operation, and satisfactory results finally are achieved.

II. ARCHITECTURE DESCRIPTION

Meteorological data monitoring system based on mobile network includes data collection system, remote wireless communication system and terminal server system^[2, 3]:

1) *Data acquisition system.* The main role of the data collection system is local meteorological environment real-time data collection and data storage. The system are mainly composed of sensor module、CPU module and serial interface circuit. The central processing unit takes responsibility for real-time control of the sensor opening and stop. Data collected by sensor is sent to CPU to deal with. The CPU also plays the role in communicating with computer through the wireless serial port.

2) *Remote communication system.* A remote communication system is mainly composed of serial ports (232/485) and wireless transmission module (GPRS). This system has the role of Protocol conversion and information communication.

3) *The terminal server system.* The terminal server system mainly is responsible for management and control the whole system. It is also in charge of human-computer interaction, network data link building and environmental data online showing. The server terminal either is a computer fixed IP address or a local area network, which is composed of more than one computer. For the convenience of GPRS communication terminal connection, the internet IP address of the router is fixed. GPRS communication terminal is connected with the server of monitoring master station with the style: "IP: port", and then realize the two-way transparent data transmission. The block diagram of the whole system is shown in Fig. 1:

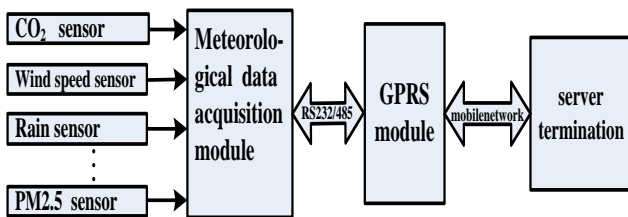


Figure1. The block diagram of the whole system

III. DESIGN OF HARDWARE

In our paper, the hardware of the system mainly contains three parts: meteorological environment information sensor, main control unit (MCU) and GPRS module. The analog signals produced by the meteorological environment information sensor are sent to the MCU after corresponding conversion and conditioning. Then, the signals are sent to the Internet through GPRS modules and GPRS nets. The server in the data center surfs the Internet to get data^[4, 5]. The overall structure of hardware is shown as Fig. 2.

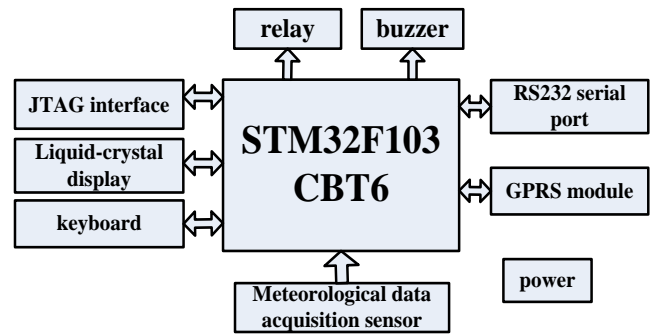


Figure2. Diagram of Overall hardware block

A. The SCM data acquisition terminal

STM32F103CBT6 whose core is Cortex™-M3 CPU is used for data acquisition. Memory is from 32K bytes to 128K bytes and SRAM is from 6K bytes to 20K bytes. It is supplied by 3.3V DC power, and has processing speed and function of 32-bit chip. What's more, its highest processing speed can reach 72 MHz. Rich peripheral interfaces are integrated in the SCM, including two 12-bit ADC, two I2C and 16-bit timer and so on. The system makes use of modules of the chip, which greatly reduces the complication of the peripheral circuits and the cost^[6].

B. Bsensor module

Eight sensors are used for data acquisition, they are as follows:

1) *Carbon dioxide sensor (PHCO):* PHCO is a hybrid element which contains thermistors, and has sensitive to CO₂. Its two electrodes are filled with cationic solid electrolyte. Its cathode is made of Lithium carbonate and gilt while its anode is made of gilt. The base lining of the sensitive element is reinforced by benzene diester polyethylene and glass fiber and packaged cylindrically with stainless steel net. Technical parameters: 0--2000ppm, accuracy: 40ppm+2%, resolution: 1ppm.

2) *PM2.5 monitoring sensor:* PM2.5 sensor adopts advanced new built-in membrane online laser dust sampler. It can collect particulate matter in continuous monitoring of dust concentration in order to analyze its ingredients and calculate the mass concentration coefficient K. Technical parameters: 0---500ug/m³, resolution: 1ug/m³.

3) *Wind speed sensor:* PHWS adopts the traditional structure of three wind cup. Wind cup USES carbon fiber materials, high strength, good start. In each cup, signal processing units are built so that it can input corresponding wind speed signal according to the need of users. Technical parameters: 0---70m/s, accuracy: 0.3+0.03V, resolution: 0.1m/s.

4) *Wind direction sensor:* PHWDC uses magnetic sensitive chip which has high precision and good dynamic performance. It also uses low inertia light metals as wind vane to respond to wind direction. The sensor has the advantages of high sensitivity, high accuracy, wide range,

no dead zone, good linear, and so on. Technical parameters: 0--360°, accuracy: $\pm 3^\circ$, resolution: 1°.

5) *Atmospheric temperature sensor*: PHQW uses high precision thermistor as inductive components which have the characteristics of high accuracy and good stability. Technical parameters: -50--100, accuracy: $\pm 0.5^\circ\text{C}$, resolution: 0.1°C.

6) *Atmospheric humidity sensor*: PHQS uses polymer thin film humidity sensitive capacitance as inductive components which have the characteristics of high accuracy and good stability. Signal transmitter which can convert humidity into current or voltage signals according to the need of the user, adopts advanced integrated circuit module. Technical parameters: 0--100%RH, accuracy: $\pm 5\%$ RH, resolution: 0.1%RH.

7) *Illuminance sensor*: PHZD uses silicon blue photovoltaic detector as sensor. Users can set different ranges according to different fields measured. It has the characteristics of wide measurement range and good linearity. Technical parameters: 0--200000LUX, accuracy: $\pm 7\%$, resolution: 10LUX.

8) *Digital pressure sensor*: PHSZQY uses pressure sensor and has the advantages of high accuracy and good stability. Technical parameters: 10~1100hpa, accuracy: $\pm 0.3\text{hpa}$, resolution: 0.1hpa.

C. GPRS communication system

1) Introduction of modules

Communication modules adopt GPRS DTU device produced by cooperation HongDian which has the characteristics of high speed, forever online and transparent data transmission. Data transparent transmission is realized through GPRS network platform, and various departments' needs for networking are taken into full consideration. What's more, virtual data private networks are applied to the network structure. It has RS232/485 interface and high performance and it is industrial grade and external. It is suitable for use in various industrial monitoring, traffic management and meteorology^[7].

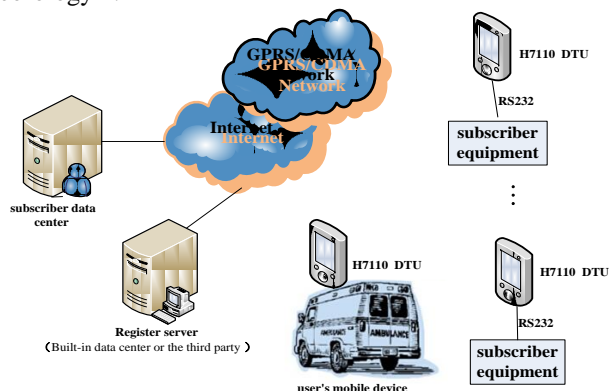


Figure3. The topological diagram of the application of GPRS module

2) Implement of communication

GPRS stands for General Packet Radio Service, which adopts the same wireless standard modulation, frequency

band, emergent structure, frequency hopping rules and frame structure as GSM (Global System for Mobile Communications). Base station subsystem (BSS) provides a comprehensive GPRS coverage. GPRS allows users to send and receive data in the mode of terminal-to-terminal packet transfer rather than in the mode of circuit switching which needs cyber source. In this monitoring system, H7710 GPRS DTU module produced by cooperation HongDian are adopted to provide users with virtual private data communication network which has the characteristics of high speed, forever online and transparent data transmission. GPRS/CDMA1x network platform is used to realize the transparent transmission of data informatio. At the same time, virtual private networks (VPNS) data should be built on the network structure considering the need of each network application department. Through the establishment of GPRS management station and the use of GPRS mobile communication network, weather stations meteorological environment datas collected by GPRS remote monitoring terminal are transmitted to the station, realizing management unit remote transmission and comprehensive intelligent management. Now, GPRS has the following characteristics, in order to realize the remote control:

a) *strong real-time capability*. Because of GPRS uninterrupted online properties, it can meet the demand for data acquisition and transmission of real-time.

b) *Can be set up for monitoring terminal for remote command*. People can adjust command parameter of monitoring terminal through GPRS two-way system.

c) *Wide range of application*. It is convenient to communicate in the GSM/GPRS wireless network coverage area due to the wide GPRS range.

IV. DESIGN OF SOFTWARE

A. Software design of data acquisition system

The environment data collection and transmission system based on mobile network consists of a data collection system and a wireless network communication system. The part of system software is mainly responsible for the management of system parameters, data analysis and processing, sending data to the remote server and receiving instructions from such the remote server, like transmitting data on time and parameter setting, etc. The main design ideas of software are as follows: The first is to initialize system electrification, which is the initialization of all kinds of registers and interrupts initialization. The second is to initialize counters, STM32F103 and GPRS network, etc. Finally, interruption is opened by main program after initialization completed, then the interrupt information is read by CPU. Program of the software enters the interrupt subroutine to do execution-interruption and makes the corresponding processing^[8, 9]. Most system program was written by C language or assembly language. The whole chart of software flow is shown in Fig. 4:

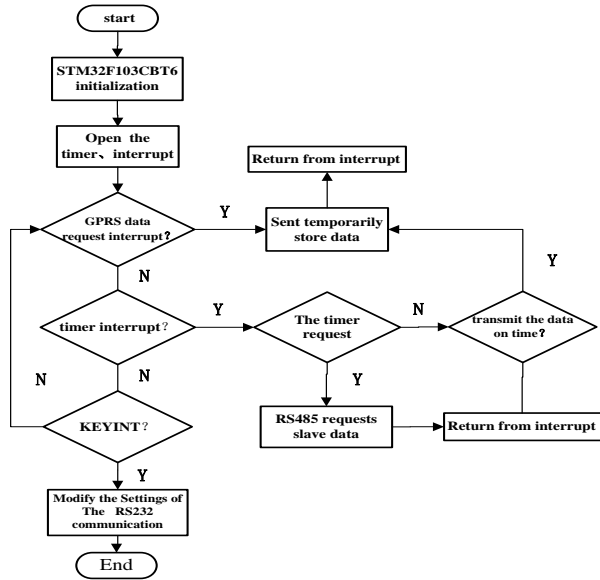


Figure4. The chart of program flow

B. Data transport protocol of GPRS

The wireless communication module H7710 GPRS DTU developed by Hongdian Technology Corporation was used in this design. The communication protocol is MODBUS following the DTU format, and the frames of Modbus are simple, compact and easy to understand. Processing center gets meteorological data such as temperature, carbon, wind and other meteorological data by bus. Then GPRS module realizes the transparent data transmission. What's more, the monitoring terminal can be connected to multiple devices and inquire slave address to communication by MODBUS protocol^[10, 11]. Table 1: The format of request data for monitoring terminal; Table 2: the format of the slave data returned after the host requested data.

TABLE I. TABLE 1. MODBUS PROTOCOL QUERY COMMAND TABLE OF THE HOST

Serial number	Name	Length	Content
0	Slave address	1	Addr
1	Function code (Command)	1	#03
2-3	Reading starting address of data	2	High Byte first
4-5	Reading data length	2	High Byte first
6-7	Error-checking CRC16	2	Low Byte first

TABLE II. THE RETURN DATA TABLE OF SLAVE REQUERY

Serial number	Name	Length	Content
0	Slave address	1	Addr
1	Function code (command)	1	#03
2	Data length	1	(2×L)
3	Data	1	Data field
...
2L+2	Data2L	1	Data field
2L+3	Verify CRC_L	1	Low Byte first
2L+4	Verify CRC_H	1	Low Byte first

V. METOMONITORING RESULTS OF METEOROLOGICAL DATA ON THE SERVER

The meteorological data receiving software in data center was written by C# in the sever. Meteorological software installed on the PC, can monitor in real-time, download and storage real-time or historical data, which also can inquire and analysis the meteorological data by computer. What's more, many configuration of communication styles are included in weather station software, which are Client-TCP, RS232/RS485/USB/Zigbee and Server-TCP, etc. Figure 5: The data display of online real-time at some time; Figure 6: The historical data shows in a certain period of time.

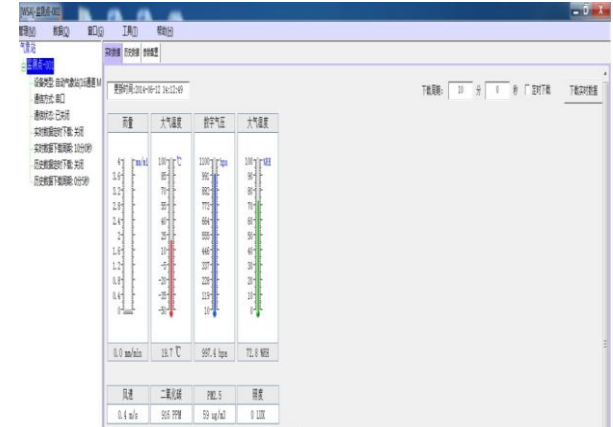


Figure5. Online real time data display

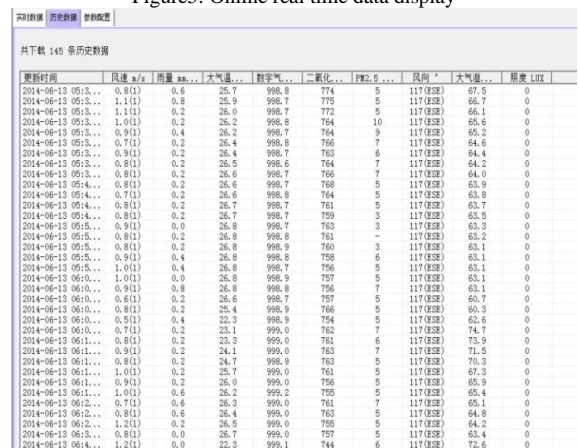


Figure6. Historical data display

VI. CONCLUSION

In this paper, we designed a meteorological data acquisition system, which can provide the reference for

low-carbon smart grid evaluation and validation system. This design adopts STM32 as the main control unit, and it forms a compact, low cost and friendly man-machine interaction system structure. The GPRS network was used to transmit data, which has features of high speed data transmission, wide range of, high quality of communication and forever online. This system is being used in Komsomolsk of Jiangxi province, which can accurately fast send meteorological data of the area to center server, and real-time display. Also it has been kept in the safe and stable operation for a long time, and satisfactory results have been achieved.

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