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Design of Air Environmental Monitoring System in Mount Taishan Scenic Spot

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Abstract: *In view of the increasingly concerned air environment quality problem, combined with the actual needs of Mount Tai scenic spot, the remote monitoring system of air environment quality in scenic area is designed by using Internet of things technology and embedded technology. The system consists of monitoring master station, monitoring substation and remote communication module. The monitoring substation collects PM2.5, temperature and humidity, atmospheric pressure, carbon monoxide concentration and other air quality parameters, saves them and sends them to the monitoring master station through the communication module. The monitoring master station analyzes the data and makes prompt for the monitoring engineer to process. In order to ensure the communication quality, the communication module adopts can bus with strong anti-interference ability to transmit data. After a long time of testing, the system runs stably and the data acquisition, transmission and processing are timely and accurate.*

Keywords: *air environment; remote monitoring; Internet of things; embedded; real-time acquisition; anti-interference*

1. Introduction

As a world natural heritage and cultural heritage, Mount Taishan Scenic Spot[1] attracts a large number of tourists every year. Only in 2018, the number of tourists in Mount Taishan Scenic Area reached 5.621 million[2]. In recent years, the air environment quality has attracted more and more attention. The quality of air in Mount Taishan Scenic Area affects the experience of tourists. Therefore, Mount Taishan Scenic Area needs to monitor the air quality. Traditional monitoring adopts manual methods[3], with workers holding air quality monitors for fixed point inspections and monitoring. This method is inefficient and lacks monitoring data, which cannot meet the current monitoring requirements for air quality in scenic areas. With the rise of Internet of Things technology and the maturity of embedded technology, modern remote monitoring has become a reality. Therefore, a system for monitoring the air quality of Mount Taishan scenic spot is designed by using CAN bus for communication. The system sets up monitoring sub stations in each scenic spot and sightseeing artery of Mount Taishan Scenic Spot to monitor air quality, and collect data including PM2.5, temperature and humidity, atmospheric pressure, carbon monoxide concentration, etc; The collected data is transmitted and collected to the monitoring master station through a strong anti-interference CAN bus [4-5]. The system has achieved real-time and remote monitoring of air quality in scenic areas.

2. Composition of monitoring system

The air environment monitoring system in the scenic area is divided into three parts. One is the monitoring sub station, which serves as the front-end data collection part to collect air environmental parameters at specific locations in the scenic area. The second is to monitor the main station, which serves as the central control unit to complete data storage and analysis. The third is the CAN bus, which serves as a data transmission channel to achieve data transmission between the monitoring substation and the monitoring master station. The monitoring master station is implemented using a server, which is equipped with an RS232 interface but does not have a CAN bus interface. Therefore, the monitoring master station needs to achieve the conversion between RS232 bus and CAN bus through a bus conversion module. The system structure diagram is shown in Figure 1.

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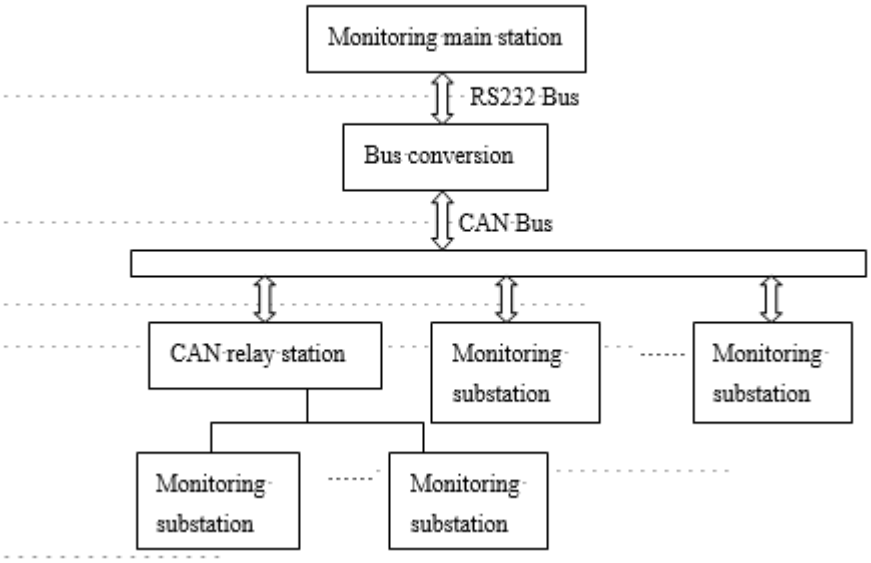

Figure 1: Structure diagram of system

3. Design of each module of the monitoring system

3.1 Monitoring substation main control module

The monitoring substation uses PM2.5 sensors, temperature and humidity sensors, atmospheric pressure sensors, and carbon monoxide concentration sensors according to the needs of collecting parameters. Collecting sensor data and transmitting it is implemented by the main control module of the monitoring substation. The main control module adopts a mini STM32 circuit board with punctual atoms, and uses STM32F103RCT6 as a microcontroller. While collecting air parameters, it is equipped with communication, display, storage, alarm, and power circuits to achieve real-time display, storage, and transmission of air quality in scenic areas. The structural diagram of the monitoring substation is shown in Figure 2.

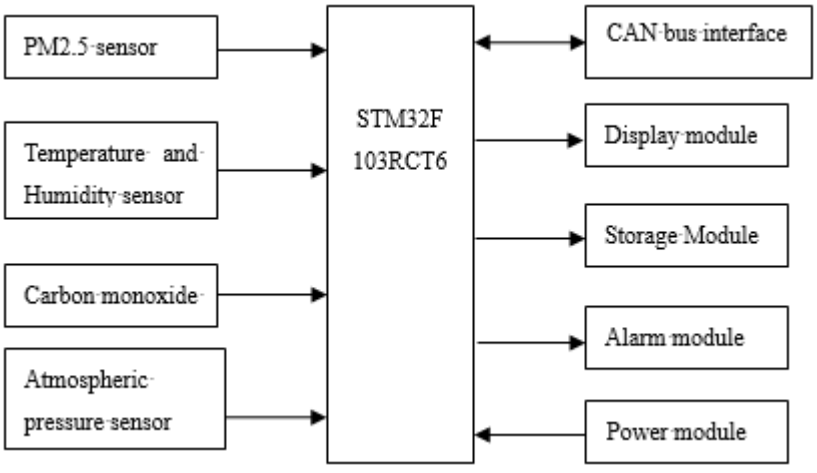

Figure 2: Structure diagram of monitoring substation

STM32F103RCT6 is an advanced low-cost microcontroller based on the Cortex-M3 core launched by Italian semiconductor company[6]. The operating frequency can reach up to 72MHz, and it has 256KB of Flash (flash memory) internally to store program code, and 48KB of RAM (random access memory) to store data information during program operation. The operating voltage is 2.0-3.6V, and the performance indicators fully meet the task requirements of monitoring substations. The display module adopts a 2.8 inch TFT LCD touch screen with a resolution of 320 * 240, which comes with the punctual atomic miniSTM32 circuit board. It is small in size and low in cost. The storage module uses

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Winbond's 8MB W25Q64 Flash memory, which comes with the circuit board, to store monitoring parameters and ensure that power failure data is not lost. The alarm module adopts a buzzer, which sounds an alarm when the detected air parameters reach the set value, indicating that the air parameters exceed the standard and the air quality is poor.

3.2 PM2.5 module

The PM2.5 module adopts the SDS011 digital sensor produced by Qianyong Company. The sensor adopts the principle of laser scattering[7] to detect suspended particles ranging from 0.3 to 10 microns in the air, and digitally outputs PM2.5 and PM10 particle concentrations. The output data unit of the sensor is micrograms per cubic meter, which is consistent with the official unit and can be directly applied without conversion. The data transmission adopts a serial interface with a communication rate of 9600 bps; Data frame format: 8-bit data, 1-bit stop bit, no checksum. The serial transmission voltage standard is TTL, which can be directly connected to the USART1 interface (PA9, PA10) of the microcontroller STM32F103RCT6. The connection circuit is shown in Figure 3.

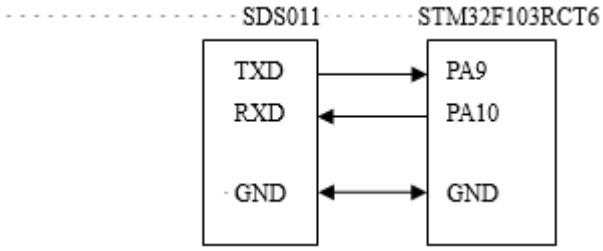

Figure 3: Connection diagram of PM2.5 sensor and MCU

3.3 Temperature and humidity module

The DHT11 integrated temperature and humidity sensor was used for temperature and humidity measurement[8]. The sensor integrates NTC temperature measurement elements and resistive humidity measurement elements internally, which can simultaneously measure temperature and humidity, and the output signal is a digital signal that can be directly collected by the microcontroller STM32F103RCT6. The sensor measures a temperature range of 0~50 ℃, with a measurement accuracy of ± 2 ℃; The humidity measurement range is 20~90% RH, and the measurement accuracy is ± 5% RH. The sensor signal transmission can reach 20m and is connected to PA11 of STM32F103RCT6 using a single bus. The connection circuit is shown in Figure 4.

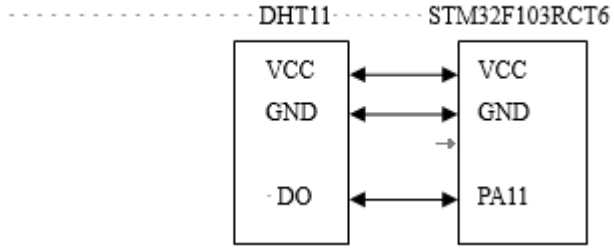

Figure 4: Connection diagram of temperature and humidity sensor and MCU

3.4 Atmospheric pressure module

The atmospheric pressure measurement module adopts the BMP180 sensor launched by BOSCH (Bosch) company. The sensor uses a piezoresistive sensor, an A/D converter (analog-to-digital converter), and non volatile memory internally[9]. The piezoresistive sensor detects atmospheric pressure and converts it into an analog voltage value, which is then converted into a digital output through an A/D converter. Non volatile memory is used to store calibration information. The sensor communication interface uses the I2C bus to connect with the I2C1 interfaces (PB6, PB7) of STM32F103RCT6, and the connection circuit is shown in Figure 5.

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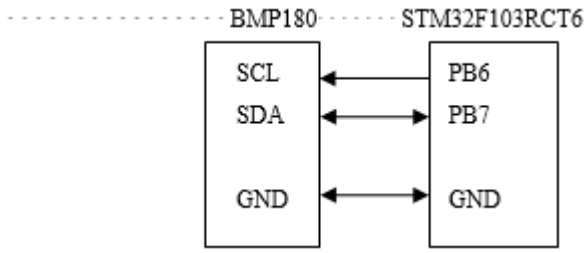

Figure 5: Connection diagram of atmospheric pressure sensor and MCU

3.5 Carbon monoxide module

The MQ-7 sensor module is used for carbon monoxide detection. The module internally converts carbon monoxide concentration information into conductivity, and then converts conductivity into voltage value output[10]. When the concentration of carbon monoxide increases, the output voltage increases in a linear relationship. The sensor has high sensitivity and strong stability. Due to the analog voltage value output by the sensor, it needs to be converted into a digital quantity through AD conversion before being processed by MCU. Therefore, the sensor is connected to the ADC1 interface (PA1) of STM32F103RCT6, and the connection circuit is shown in Figure 6.

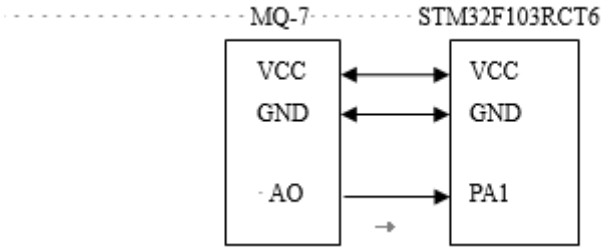

Figure 6: Connection diagram of carbon monoxide sensor and MCU

3.6 Communication interface module

The monitoring master station and monitoring sub station communicate data through CAN bus. The communication interface module includes the CAN bus controller MCP2515 and the CAN bus transceiver TJA1050T. MCP2515 is a CAN bus controller launched by Microchip Corporation (Microchip Technology) in the United States. It supports the CAN V2.0B specification, has a communication speed of 1Mb/s, and is connected to the MCU through the SPI (Serial Peripheral Interface) bus. TJA1050T is a CAN bus transceiver produced by PHILIPS, which meets the ISO 11898 standard and can drive 110 nodes. MCP2515 is connected to the SPI2 interface (PB12, PB13, PB14, PB15) of STM32F103RCT6, and then transmitted to the CAN bus through TJA1050T. The specific connection circuit is shown in Figure 7.

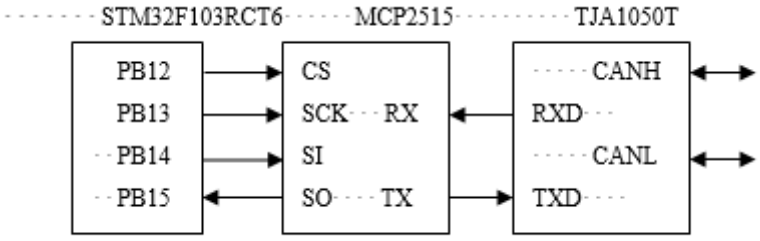

Figure 7: Connection diagram of communication module and MCU

4. Conclusion

Aiming at the monitoring demand of Mount Taishan scenic spot for the air environment, this paper designs a monitoring system that takes STM32F103RCT6 as the control core, uses SDS011, DHT11,

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BMP180 and MQ-7 sensors to monitor the air environment parameters, and uses CAN bus for transmission. After testing, the system can measure air environmental parameters in real-time, display, store, and transmit them, and operate stably, with good application value.

Acknowledgements

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