Design of Air Quality Monitoring Platform Based on Internet of Things

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Abstract

The air quality monitoring platform based on the Internet of Things (IoT) uses the STM32f407 main control module. Data such as temperature, humidity, PM2.5 and carbon monoxide concentration in the atmospheric environment are collected for a long time by each sensor module. Not only the system has the LCD display function, users can also log on to the ESLINK IoT cloud platform to remotely observe the data collection status. The upper limit of each parameter can be set in a specific environment. If the data monitored by the system exceeds the upper limit, the system will alarm. The system has a good application prospect in the environment of office, automobile, factory and so on.

Keywords: Internet of Things, STM32f407, PM2.5, sensor

1. Introduction

With the development of industry, environmental problems have become more and more serious, especially air pollution has seriously affected people's lives. Traditional meteorological monitoring stations are bulky, susceptible to environmental and time constraints, and their communication networking costs are high and deployment is difficult. At present, it is hoped that a low-cost portable atmospheric monitoring device can obtain air quality information in real time. The monitoring equipment can be accurately monitored in the home, in the car, in the workplace[1], etc.

The air quality monitoring platform developed by this design can be applied to various occasions, and can monitor the temperature, humidity, PM2.5, CO and other concentration changes in the air in real time, and can monitor the current data information on the LCD screen and terminal equipment. The system has an alarm function, and when a certain parameter exceeds the set range, it can immediately alert the user. The system has low cost, high precision, convenient use and certain market application prospects.

2. Hardware structure design

The hardware data acquisition part mainly uses each sensor node to monitor the atmospheric environment quality in real time, and transmits the detected environmental data information to the network layer in real time, and displays it on the LCD display in real time. The environmental monitoring hardware system uses STM32F407 as the main control chip for signal processing, and each sensor module performs sensing signal extraction. The signal conditioning circuit shapes, amplifies, and filters the circuit waveform to condition the data into a signal that the microprocessor can process.

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The A/D signal acquisition module performs signal acquisition, and the MCU part performs signal processing analysis. The overall hardware design of the system is shown in the Fig.1.

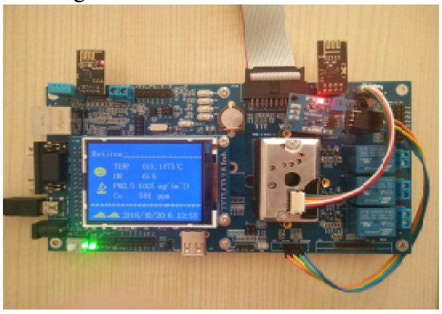

Fig.1. Hardware design of the system

2.1. STM32F407 master chip

The main control chip adopts high-performance 32-bit ARM M4 architecture series chip STM32F407. The chip's clock speed is up to 168MHz, integrating single-cycle DSP instructions and floating point units. The processing capacity is up to 210DMIPS, which is about 200 times that of a normal 8-bit microcontroller.

2.2. Wireless Communication Technology

The wireless communication technologies currently used in the market include Bluetooth technology, Zigbee technology, and WIFI technology. WIFI (Wireless Fidelity) is a certification standard for wireless LAN products consisting of Access Point and wireless network cards[2]. WIFI technology is easy to integrate with existing wired Ethernet networks[3].

The ESP8266 is an ultra-low power UART-WIFI pass-through module designed for mobile devices and IoT applications. The user's physical device can be connected to a WIFI wireless network for Internet or LAN communication for networking. The hardware schematic is shown in the Fig.2.

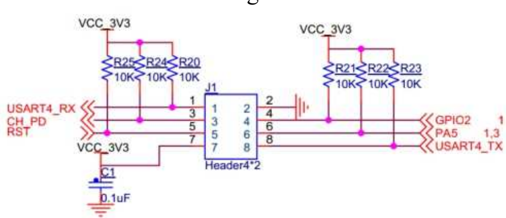

Fig.2. WIFI hardware schematic

2.3. Humidity sensor module

This design uses the DHT11 temperature/humidity sensor, which is a temperature and humidity composite sensor with a calibrated digital signal output. It uses dedicated digital module acquisition technology and temperature and humidity sensing technology to ensure high reliability and stability[4]. The sensor consists of a resistive wet sensor and an NTC temperature sensor connected to a high performance 8-bit microcontroller. The calibration coefficients are stored in the OTP memory as a program, and these calibration coefficients are called internally during the processing of the detection signal. The single-wire serial interface makes system integration easy and fast. The product is a 4-pin single-row pin package for easy connection. The circuit principle of DHT11 interface is shown in the Fig.3.

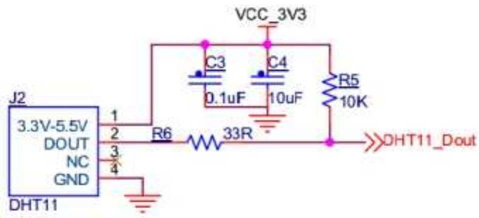

Fig.3. DHT11 hardware schematic

2.4. Carbon monoxide collection module

This design uses the MQ-7 carbon monoxide concentration monitoring sensor, which is a dual signal output (analog output and TTL level output). The TTL output valid signal is low level (when the output is low, the signal light is on, it can be directly connected to the single chip); the analog output is 0~5V, the higher the concentration, the higher the voltage[5]. The sensor has high sensitivity and good selectivity to carbon monoxide, and has a long service life and reliable stability. The MQ-7 sensor hardware schematic is shown in the Fig.4.

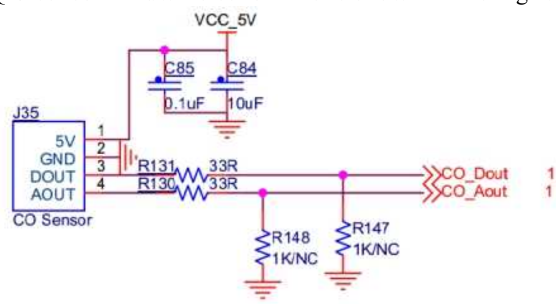

Fig.4. MQ-7 sensor hardware schematic

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2.5. Temperature acquisition module

With the DS18B20 temperature sensor, only one port line is required to connect the microprocessor to the two-way communication between the microprocessor and the DS18B20. The working power supply is 3.0~5.5V/DC, no external components are needed in use; the measurement results are serially transmitted in 9~12 digits; multi-point networking function is supported[6]. To achieve multi-point temperature measurement, if the number is too much, the power supply voltage will be too low, resulting in unstable signal transmission. The hardware schematic of the DS18B20 temperature sensor is shown in the Fig.5.

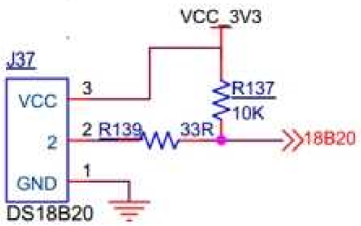

Fig.5. DS18B20 temperature sensor

2.6. PM2.5 acquisition module

The GP2Y1010AU0F optical dust concentration detection sensor is designed to sense dust particles in the air. An infrared light-emitting diode and a phototransistor are placed diagonally inside, so that it can detect the reflected light in the air. Even very small particles such as tobacco smoke can be detected, and tiny particles of 0.8 micron or more can be measured to perceive phlegm and pollen produced by tobacco, house dust and the like. The sensor has a very low current consumption and can be used up to 7VDC. The sensor output is an analog voltage whose value is proportional to the dust concentration. The hardware schematic is shown in the Fig.6.

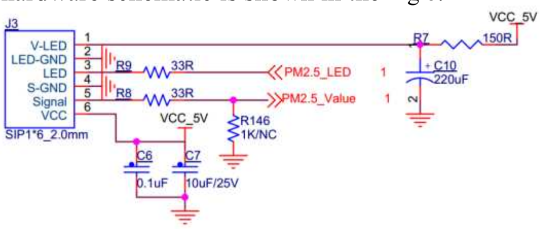

Fig.6. GP2Y1010AU0F hardware schematic

2.7. LCD display module

The LCD9341 with 320*240 pixels displays the data collected by each sensor. Generally, there are three ways to connect the liquid crystal display to the main chip: serial port connection, SPI bus connection and SRAM memory interface. The LCD panel of the project development board uses the SRAM interface, which is equivalent to the LCD connected to the memory interface of the main chip. Therefore, accessing the LCD is equivalent to accessing the memory of the main chip by accessing the three buses (data bus, address bus and control Bus) implementation. The hardware schematic of LCD9341 is shown in the Fig.7.

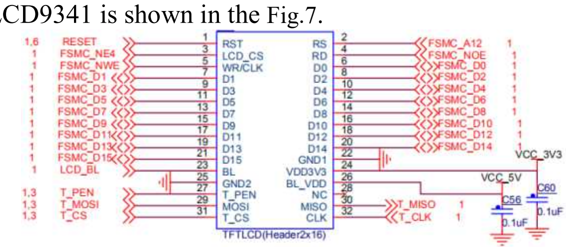

Fig.7. The hardware schematic of LCD9341

3. Software design

3.1. Temperature acquisition humidity realization

The temperature sensor DS18B20 is a digital temperature sensor that does not require AD conversion. The sensor converts temperature to digital up to 93.75ms at 9-bit resolution and temperature to up to 750ms at 12-bit resolution for even more accurate results. This design selects 12-bit data representation. The upper 5 bits are sign bits, the lower 4 bits are fractional parts, and the others are integer bits. After parsing this data, the temperature is obtained. According to the read and write timing of the DS18B20, the program realizes the reset, initialization, read and write data of the sensor and the conversion function of the read data.

3.2. Program implementation of humidity acquisition

The humidity sensor DHT11 is also a digital temperature/humidity sensor that does not require AD conversion. DHT11 should use the GPIO port of the MCU for initial configuration, set the required GPIO port pin (PA4) to general push-pull output, no pull-up pull-down, 50MHz output mode, so that the DHT11-DATA pin of the MCU is set to none. Pull-up pull-down input mode. The single-bus data format communication between the microprocessor and the DHT11 takes about 4ms. The data is divided into fractional part and integer part. The complete data transmission is 40bit, and the high position is first out. After the user MCU sends a start signal, the DHT11 switches from the low power mode to the high speed mode. After waiting for the host start signal to end, the DHT11 sends a response signal, sends 40 bits of data, and triggers a signal acquisition, and the user can select to read part of the data.

3.3. Program implementation of carbon monoxide and PM2.5 acquisition

The mq-7 and GP2Y1010AU0F for collecting carbon monoxide and PM2.5 are analog sensors, and the output is analog, so the acquired analog signal needs to be converted into a digital signal. There are 3 ADCs in the STM32F407zgtx, a total of 24 channels, each ADC is 12 bits, corresponding to the converted digital range from 0 to 4095. In this project, for MP2.5, channel 10 of ADC1 is selected; Co selects channel 4 of ADC3. When programming the ADC converter, it includes several functions such as initialization, turning on AD conversion, waiting for the end of AD conversion, and obtaining the conversion result.

3.4. Program implementation of wireless communication module

Software programs include WIFI initialization functions, connect WIFI, establish connections, disconnect, and send data functions. A macro API_KEY defined in the program is the connection key obtained after the cloud platform is successfully registered. After the module initialization is completed, the WIFI connection is implemented by the customized esp8266_link_wifi() function, where the first parameter of the function is the network name to be connected, and the second parameter is the connection password. The status of the corresponding device in the ESLINK IoT cloud platform is obtained by the download_sensor_status() function. The parameters of the function include the IP address of the connection route, one or more device numbers, and API_KEY. Upload the data collected by each sensor to the cloud platform through the upload_device_datas() function. The function has six parameters: the IP address of the connection route, the device number, the API_KEY, the array of sensor numbers, and the data collected by each sensor. The array and size are composed.

4. Conclusion

After the system is running, the actual changes of each parameter can be monitored on the IoT cloud platform. Take the data waveform monitored by the temperature sensor as an example, as shown in the Fig.8. It can be seen that the system can monitor temperature changes and generate waveforms in real time over a certain period of time.

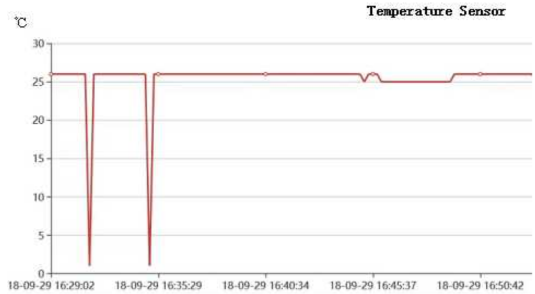

Fig.8. Temperature data waveform

Acknowledgement

The research is partly supported by the “13th Five-Year” comprehensive investment and basic research business fee items of China (000040192).

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