

Wireless Sensor Network for Indoor Air Quality Monitoring

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Abstract: Indoor air quality monitoring system consists of wireless sensor device, nRF24L01 wireless transceiver modules, C8051MCU, STM32103 remote monitoring platform, alarm device and data server. Distributed in the interior space of wireless sensors measure parameters of the local air quality, wireless transceiver module of the MCU to transmit data to the remote monitoring platform for analysis which displayed and stored field environment data or charts. The data collecting from wireless sensors to be send by wireless Access Point to the remote data server based on B/S architecture, intelligent terminals such as mobile phone, laptop, tablet PC on the Internet monitor indoor air quality in real-time. When site environment air quality index data exceeds the threshold in the monitoring device, the remote monitoring platform sends out the alarm SMS signal to inform user by GSM module. Indoor air quality monitoring system uses modular design method, has the portability and scalability has the low manufacture cost, real-time monitoring data and man-machine interaction. *Copyright © 2014 IFSA Publishing, S. L.*

Keywords: Wireless sensor network, Remote monitor, Air quality, Data server.

1. Introduction

The life of people more than 3/4 of the time is spent indoors, whether at home, office, entertainment or all kinds of transportation, carrying 24 hours a day of indoor space. Indoor air are pollutants, respirable particles or pollutants such as formaldehyde, in a crowded room, air quality has direct influence on human health, the real-time monitoring of indoor air quality is very necessary [1].

Air Quality Index (Air Quality Index, referred to as AQI) [2] is a quantitative description of the air quality status of the dimensionless index. AQI ranges from 0 to 500, more than 100 of pollutants exceeding pollutants. Control AQI grading standards, determine

the air quality level, type and color of said measures, health effects and recommended action [3].

Indoor air quality monitoring system based on wireless sensor networks uses the STM32 chip as the core, to build a distributed wireless sensor networks.

Monitoring system collects temperature and humidity, harmful gases, smoke and other environmental information from the wireless dust sensors [4-6].

The collected data is transmitted to the wireless transceiver nRF24L01, different from the wireless transceiver indoors position sensor to the different environmental parameters, and wirelessly transmit the data stored in the server.

We process data in the data server and build visualization website, anyone browser the website remote monitoring via the Internet by terminals, such as mobile phones, laptop, Tablet computers.

Monitor the air quality status of the sensor to sensor networks, when site environment air quality index data exceeds the threshold, the remote monitoring platform sends out the alarm or through the intelligent Home Furnishing timely cut off power supply and open window.

2. Overall Design

Indoor air quality monitoring system consists of two major components of hardware and software, wireless sensor device to detect the field environment, wireless transceiver modules, C8051MCU, remote monitoring systems and alarm devices.

The wireless transceiver module comprises a connecting indoor wireless sensor network signal, to receive the detection information and the detected information into the wireless transmitter signal. C8051MCU in connection with the signal of wireless transmitter, wireless receiver receives signals; for receiving a wireless transmitter emits a wireless receiver signal. Remote monitoring device is connected with the signal. Single chip microcomputer control and alarm device is connected, value exceeds the threshold in the monitoring device monitoring site environment detection, control and alarm device sends out the alarm signal.

Indoor air quality monitoring system consists of five modules. The first module of the system, sensor to measure environmental parameters, such as temperature and humidity, dust concentration; the second module, wireless sensor measurement data is transmitted to the wireless transceiver nRF24L01, a wireless transceiver transmits the data to the single chip microcomputer. Processor Cortex-M3 to process data such as temperature and the amount of dust monitoring and experimental, then the data transmission and storage to the data server, distributed monitoring network consists of by a number of wireless sensors [7-9]. The third module, The power supply module, monitoring system of wireless sensors distributed in different locations, some nodes without power interface, some nodes location inconvenient frequent battery replacement, require battery can be used for a long time. The fourth module, the alarm module, using the touch threshold automatically send alarm message. The fifth module, Established the observation website, remote monitoring can be achieved through the Internet, in order to keep abreast of air quality of monitoring environment to make appropriate and timely preventive measures. The framework for the overall design of the air quality monitoring system is shown in Fig. 1.

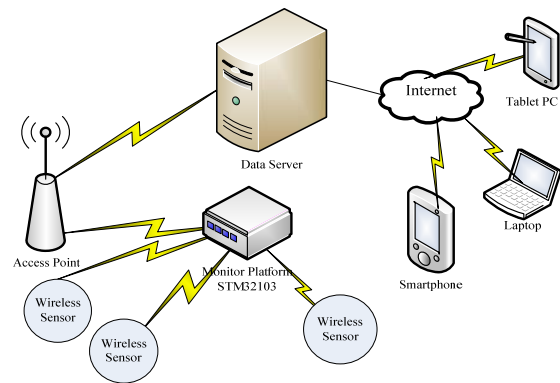


Fig. 1. The framework for the overall design of the air quality monitoring system.

3. The Hardware Design of Air Quality Monitoring System

The hardware part of air quality monitoring system is composed of STM32103 control board monitoring platform, the wireless sensor module and C8051 MCU and nRF24L01 wireless module. The sensor data acquisition and wireless transmission to the monitoring platform is shown in Fig. 2.

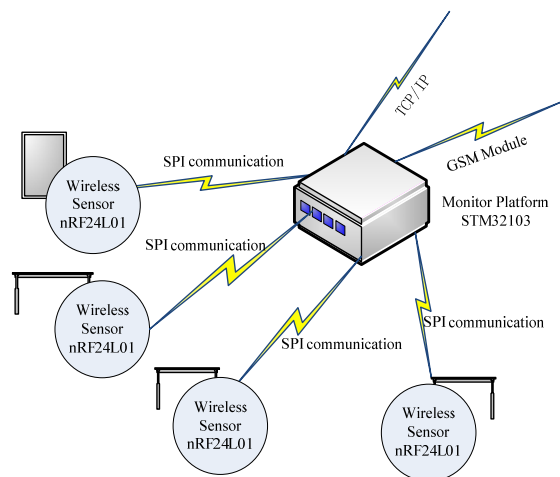


Fig. 2. The hardware part of air quality monitoring system.

STM32103 board is composed of ARM 32-bit nuclear Cortex-M3, in the field of industrial control, interrupt faster, processing based on hardware. Cortex-M3 processor ARM7-M architecture, which includes all 16-bit Thumb instruction set and the basic 32-bit Thumb-2 instruction set. STM32103 monitoring platform with GSM module [9], GSM RF chip, baseband processing chip, memory, power amplifier devices integrated in the monitoring platform of circuit board, with independent of the operating system, GSM radio frequency processing, baseband processing and functional modules to provide a standard interface. ARM-Cortex-M3 via RS232 serial communication with GSM modules,

using standard AT commands to control the various GSM modules wireless communication capabilities, for example: send SMS, call, GPRS dial-up Internet access. We use the GSM module enable to send messages to a user. When the air pollution index in the space above a certain concentration, GSM module send a text message notifies the user, allows users timely protection measures of air pollution.

In wireless sensor module, Sensor communication interface circuit design is a SPI (Serial Peripheral Interface) bus system [10], which is a high-speed synchronous serial peripheral interface, can make the MCU communicates serially with a variety of peripheral devices to exchange information. The periphery is provided with a FLASHRAM, network controller, LCD display driver, A/D converter and MCU etc. The communication of SPI working in master-slave mode, there is one master and one or more slave devices, usually 4 lines, 3 lines are used for one-way transmission of the half duplex. Based on SPI equipment common line is the master output/slave input data from the machine MOSI, master input/slave output data from the host machine of line MISO, the serial clock line (SCLK), active low level from the slave data line SS (optional). SPI bus system works directly with many standard peripheral devices of various manufacturers to produce a direct interface, the external interface as shown in Fig. 3.

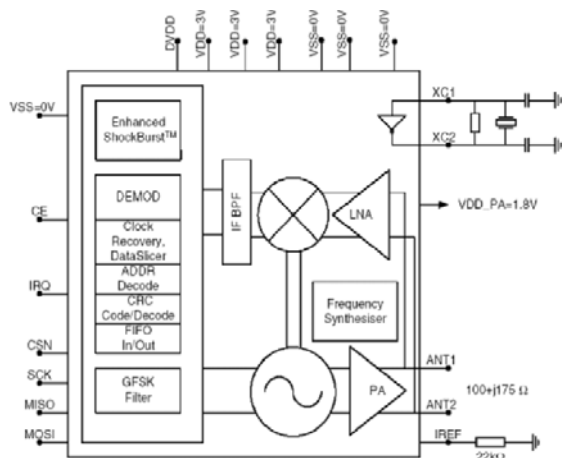


Fig. 3. The external interface.

Wireless transceiver nRF24L01 in wireless sensor module is working in the 2.4 GHz to 2.5 GHz ISM band, including frequency generator, enhanced-mode controllers, power amplifiers, oscillators, modulators and demodulators. When working in launch mode transmit power is 0 dBm current consumption 11.3 mA, receive mode is 12.3 mA, the power-down mode and standby current consumption lower. Output channel selection and protocol settings can be set through the SPI communication interface, connect C8051 single chip computer complete the wireless data transmission, realization of monitoring platform for communication with monitoring sites.

Wireless sensor to measure dust concentrations in the indoor air quality using the dust sensor GP2Y1010au0fx1 Sharp Co, the measured data is transmitted to the wireless transceiver nRF24L01.

Wireless transceiver transmits the data to the MCU, achieve the storage temperature and the amount of dust monitoring, the data through the wireless network will store data transmitted to the monitoring site.

The power supply module, because of the wireless device, the signal in each sensor node needs to be connected continuously and the signal is strong enough, and the requirements in the power of monitoring system that is relatively high, we consider the low power consumption and anti-jamming technology in hardware and software design.

We use two 18650 lithium-ion batteries are connected in parallel to obtain higher capacity through charge management IC booster module rose 3.7 Volts to 5 Volts, and the linear-regulator output voltage of 5 Volts or 3.3 Volts. We designed external circuit simplicity for USB interface power supply input, and stability in performance.

4. Design for Monitoring Software

Indoor air quality monitoring software system consists of data storage module, alarm module, data server and monitoring website. The flow of system data transfer is composed of sensor data collecting, data stream transmission channel and the data server.

Sensor by measuring the concentration of dust in the air for real time monitoring and analysis, and data transmission channel analysis of data to the server, and then by the server sending a warning message to the user. The system can collect and store sensor data information, monitor air quality measuring point distribution in the indoor situation, remote monitor via the Internet, the data flow shown in Fig. 4.

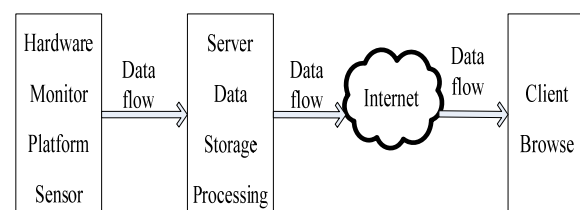


Fig. 4. The data flow chart.

The data storage module, we choose MySQL database as the storage of the collected data, that is a powerful and free database system, effectively reducing the cost. Wireless sensor data is transmitted through the nRF2410 wireless transceiver in chip C8051 board to the STM32103 control platform. Monitoring platform processor Cortex-M3 collected from different position sensor temperature and the

amount of dust monitoring data, it will be transferred to the server for data collection, storage and processing. Database storage of data structure is designed as shown in Table 1.

Table 1. The description of the member of the data structure.

Member name	Description
CUR_TIME	Current Time
AQI	Air quality index
PM2.5	Respirable dust 2.5
PM10	Respirable dust 10
PIC	Live chart
TEMPERATURE	Temperature
STAT_TIME	Statistics time

The alarm module, each sensor node monitoring data exceeds the set value, the alert begins, while abnormal signal incoming monitoring platform, GSM modules users can receive SMS alerts, through terminals, such as mobile phones, notebook computers, Tablet browser through the Internet can directly receive the alarm signal from the indoor air quality sensor location exception. The trigger threshold automatically send text message alerts, we design different voice alerts, such as email alerts, mobile phone App alerts and other forms.

The indoor air monitoring website, the user interface is a browser platform based web sites, to display on the website and early warning, to show the user data trends. The web server architecture is comprised by IIS and MySQL database, the client program design using HTML + CSS + JavaScript scripting language, data is updated by the Ajax implementation, web interface landscaping done by Photoshop. Remote monitoring through Internet to know the air quality of the indoor environments, measurement data curves can be observed on the site, as shown in Fig. 5.

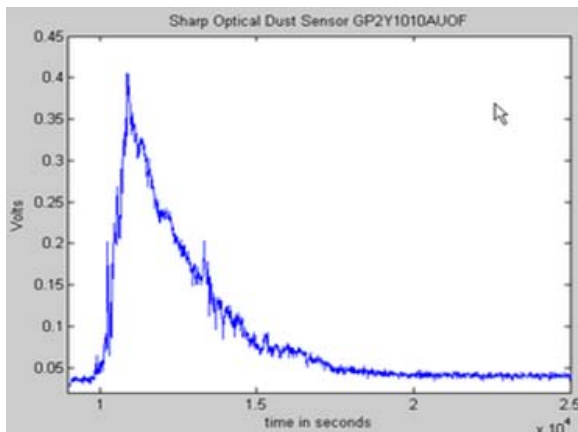


Fig. 5. The measurement data curves.

5. Conclusions

With the development of information technology, the future demand for automation in the family more and more diversified. The air quality monitoring device of the intelligent home has a monitoring function, can be monitored at any time in the home environment. If you have a gas leak, the carbon monoxide sensor will detect the first time gas immediately sends alarm signals to the owner of the mobile phone to send the alarm signal, and automatically shut off the gas valve and turn on the ventilation system.

The indoor air quality monitoring system prototype, is authorized the national utility model patent (China patent number ZL201320166629.4) "an indoor air quality monitoring device" in 2013 [11], shown in Fig. 6.

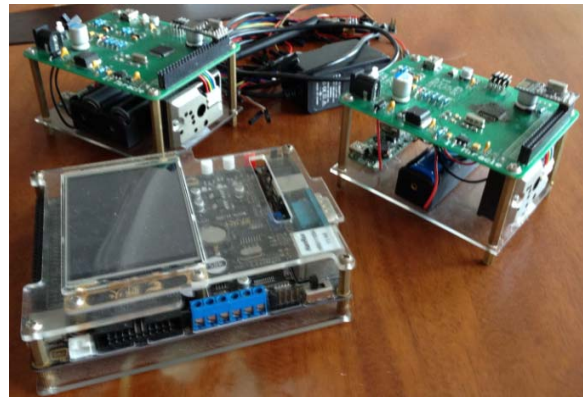


Fig. 6. The prototype system.

By setting the dust sensor, temperature sensor, humidity sensor, measurement unit, has the features of multi parameter measurement, testing faster and higher sensitivity characteristics; Light weight, small size, suitable for public places, families, health monitoring, air quality monitoring environmental.

Acknowledgements

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