# Design of a Control System for a Fresh Air conditioner

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**Abstract:** With the improvement of living quality, people demand higher and higher air quality in buildings. That leads to performance improving for air-conditioner control systems. This paper presented a control system for a fresh air conditioner. Firstly, it designed a controller for one type of fresh air conditioners. It was developed with sensor module, display module and unit control module by using very cheap microcontroller STC89C51. The fresh air valve will be controlled via judging the concentration of carbon dioxide. Except for the concentration of carbon dioxide, the sensor module will collect temperature and humidity data. Whole hardware design procedure is elaborated in this paper. Secondly, a client software developed to control a fresh air conditioner with mobile terminators, such as smart phone, tablet computer, is discussed. Through the control system developed in this paper, a fresh air conditioner can monitor and control indoor air quality better.

**Key Words:** Fresh air unit; Indoor air quality control; Intelligent building

## 1. INTRODUCTION

In the process of social development, an air conditioner is one kind of inevitable products which is used to improve people living level, and it is a necessity of life for a long time in the future. However, faced with practical problems of resource shortage and lack of energy, we have to improve energy efficiency with consideration of not reducing comfortable level of air conditioner [1-3]. The development trend of air conditioners has made them toward lower power consumption, more comfortable and more intelligent [4, 5].

The important part of fresh air conditioning system which determines the performances of a fresh air unit is its controller. Fresh air not only affects the index of environment comfort level, but also has an impact on temperature, humidity and cleanliness of indoor air [6-8]. A fresh air unit controller senses fresh air's temperature and relative humidity, return air's temperature and relative humidity, the concentration of carbon dioxide and indoor air's temperature and relative humidity. The fresh air unit controller opens or closes the fresh air valve by using concentration of carbon dioxide control, which directly determines the quality of indoor air and affects people's health in a building.

With the accelerated pace of advanced technologies, people require their living more simple, more intelligent and more humanized. That makes a fresh air unit be conform people's expectations, meet their expectations and comply with the current social requirements of high energy usage efficiency and lower power consumption [9-13]. The fresh air control unit uses microcontroller STC89C51 as its core controller. In the fresh air control unit, there are a sensor module, a display module and unit control module. The microcontroller processes data of the concentration of carbon dioxide, air temperature and relative humidity. Then it uses PID algorithm to control fan speed with sensing data of indoor air's temperature and relative humidity. The fresh air control unit contains smoke alarm, temperature monitoring, remote communications to improve the air quality of people's working, living and learning environment.

## 2. FRAME DESIGN OF A CONTROL SYSTEM FOR FRESH AIR CONDITIONER

To control a fresh air conditioner, this paper proposed a control architecture shown in Figure 1. With consideration of operation principles of a fresh air conditioner, it consists of a computer and a fresh air conditioner controller. To provide people with a comfortable, convenient and healthy living environment, the control system shown in Figure 1 has functions of data acquisition, information processing, algorithm computing, data displaying and relay controlling.

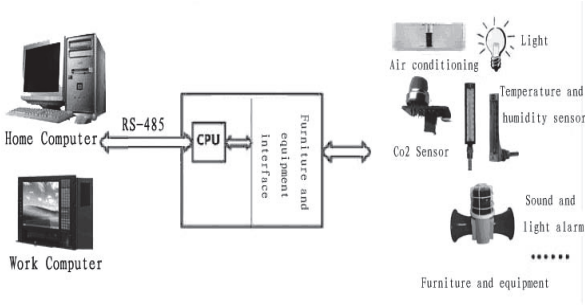


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Figure 1. The diagram of a fresh air conditioner control system

The fresh air unit controller uses microcontroller STC89C51 as the control core, collects environmental information by temperature sensors, humidity sensors, smoke density and light intensity sensor and photoelectric switch, using relay as control terminal to control the opening size of the valve, air conditioner start/stop, and failure alarm In addition, the appropriate keyboards are used to realize the on-site control.

## 3. FINE DESIGN OF A FRESH AIR UNIT CONTROLLER

### 3.1. Hardware topology

The fresh air unit controller uses STC89C51 chip as its control core with taking into account control requirements and fresh air conditioner operation characteristics. To achieve comfortable environment, it deployed temperature sensors and humidity sensors in three different spots: fresh air pipe, return air pipe and indoor space. Except for temperature sensors and humidity sensors, it also designed with carbon dioxide concentration sensor with which it can monitor the concentration of carbon dioxide in a building and turn on/off the fresh air valve.

Fresh air unit controller focused on real-time measurement and automatic control. It has a remote control function through a RS-485 serial port to communicate with host computer. The aim of a fresh air unit controller is to monitor indoor air quality with parameters of temperature, humidity and carbon dioxide concentration, and control the fan and valves. Smoke sensor signal acquisition is non-real-time required to detect its concentration of a certain cycle, emitting alarm signal when exceeds the warning value.

The hardware system mainly includes MG811 carbon dioxide concentration sensing module, ADC0804 digital-to-analog conversion module, 18B20 temperature sensor circuit, MAX485 communication circuit, optical isolation and relay control circuit, LCD display module, MQ2 smoke concentration sensing circuit and alarm circuit, which is shown in Figure 2.

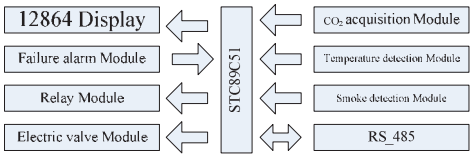


Figure 2. Diagram of the fresh air conditioner hardware

### 3.2. Hardware Platform

#### 3.2.1 Design of the control core

Fresh air unit controller uses a single chip STC89C51 as its control core to build simple, stable and feasible peripheral circuits. This chip is low power, high performance, powerful function, fully meted the design requirements for embedded systems. The smallest embedded system with STC89C51 is shown in Figure 3.

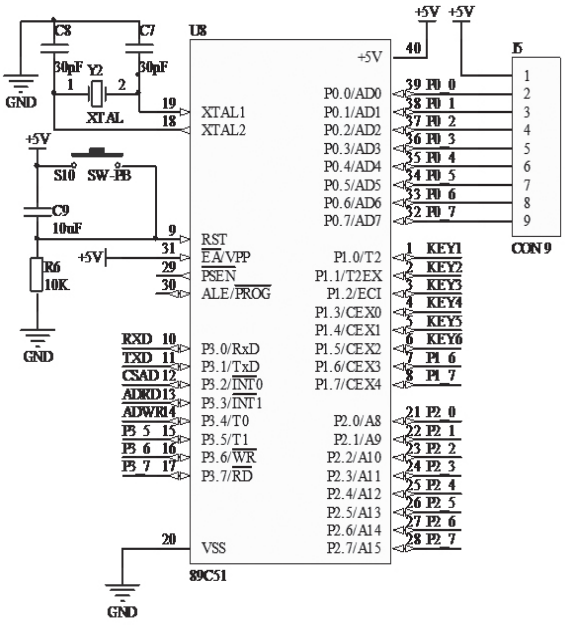


Figure 3. Diagram of the microcontroller STC89C51

#### 3.2.2 Serial communication interface

A RS-485 serial communication interface has been designed in the system. So that a fresh air conditioner controller can transfer data with a host computer. The diagram is shown in Figure 4, where a chip MAX485 has been adopted. The standard RS-485 serial port is powered by a 5v DC source.

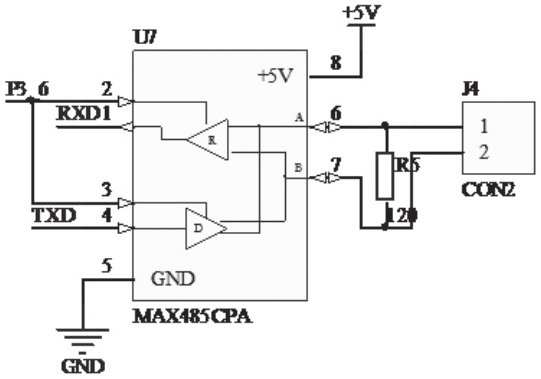


Figure 4. Diagram of the RS-485 serial communication module

The microcontroller STC89C51 has a full-duplex serial port, RXD and TXD. Hence, it is very easy to realize communication between a computer and a fresh air conditioner. Since a computer's serial port complies with RS-232 electrical protocol, it deployed a chip MAX485 as a conversion circuit to transfer signals to RS-485 electrical protocol.

#### 3.2.3 Display circuit

A LCD module is used to display sensor data and other information, such as fresh air temperature and relative humidity, indoor air temperature and relative humidity, return air temperature and relative humidity, smoke

concentration, light intensity, carbon dioxide concentration, and so on. Its interfaces are designed friendly for human usage.

To make the microcontroller STC89C51 work efficiently and economy, the microcontroller STC89C51 is designed to communicate with LCD module by using a serial mode. The fourth pin is used as the chip select signal. The fifth pin of the microcontroller STC89C51 is used as a serial data pin. The sixth pin is set as a serial synchronous clock output pin. The fifteenth pin is used to select communication modes. One is high level, which stands for parallel more. If it is set to low electrical level, the microcontroller will choose serial communication mode. The seventeenth pin of it is reset pin, which will be active when input signal is low.

### 3.2.4 Temperature sensing module

Intelligent temperature sensor 18B20 module is a new generation of smart temperature sensor which is widely used in industrial, civil, military and other fields. It has many characteristics such as miniaturization, low power consumption, high performance, strong anti interference ability, easy to match with a microprocessor and longer transmission distance. Especially, temperature data of a DS18B20 module can be converted directly into serial digital signals for a processor via only one pin. In a fresh air conditioner controller, it uses pin P2.7 to communicate with a DS18B20 module.

### 3.2.5 Particulate matter concentration sensing module

$SnO_2$ is usually used as gas-sensitive material for a solid particulate matter sensor. A particulate matter concentration sensor's conductivity will increase with the increasing concentration of combustible gases when an environment embraces a flammable gas. The changes of the conductivity can be transformed by a simple circuit into an output signal corresponding to the gas concentration. The particulate matter concentration sensor has a higher sensitivity of liquefied petroleum gas, propane and hydrogen, also with natural gas and other flammable vapor. This kind of sensors can sensing a variety of combustible gas, which is a low-cost sensor and suitable for a variety of applications. The diagram of a particulate matter concentration sensor module is shown in Figure 5.

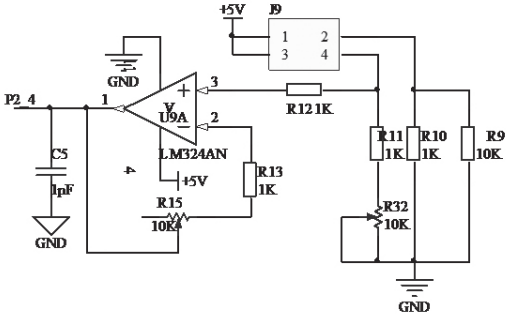


Figure 5. Diagram of a particulate matter concentration sensor module

### 3.2.6 Carbon dioxide concentration module

Carbon dioxide concentration detection uses carbon dioxide gas sensor MG811, which is characterized with high sensitivity to carbon dioxide, less impact with changes of temperature and humidity, and good stability and reproducibility. The sensor MG811 is widely used in air quality control systems. The circuit diagram of a carbon dioxide concentration measurement module is shown in Figure 6

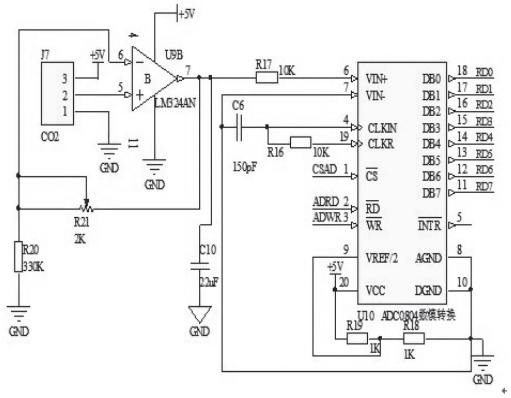


Figure 6. Diagram of a carbon dioxide concentration module

### 3.2.7 Optoelectric isolation module

The role of the optical isolation circuit is to isolate electrically an input circuit from its output circuit. When isolated, it uses light as a medium to transmit signals. It can effectively suppress interference and eliminate system noise. So it is widely used in embedded system, especially in transfer channels of control systems. The optoelectric isolation circuit is shown in Figure 7.

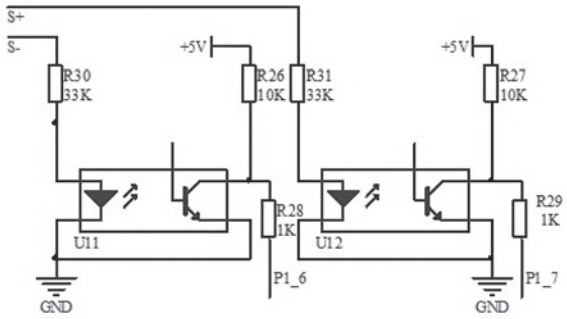


Figure 7. Optical isolated module

The advantages of an optoelectric coupler are one-way signal transmission, fully realization of electrical isolation between input parts and output parts, long service lifetime and high transmission efficiency.

## 4. SOFTWARE DESIGN

### 4.1. Software design of fresh air unit controller

The fresh air unit controller software was written with C language mainly based on the operating system μVision II. software for programming, In order to achieve various functions of the control system, it includes diversity tasks, such as initialization task, serial communication task, carbon dioxide concentration data acquisition task, LCD display task, delay task, temperature data acquisition task, matrix keyboard scanning task, and so on. The LCD display

task used a cyclic query mode to display corresponding measured values. The flow chart of the software of a fresh air unit controller is shown in the Figure 8.

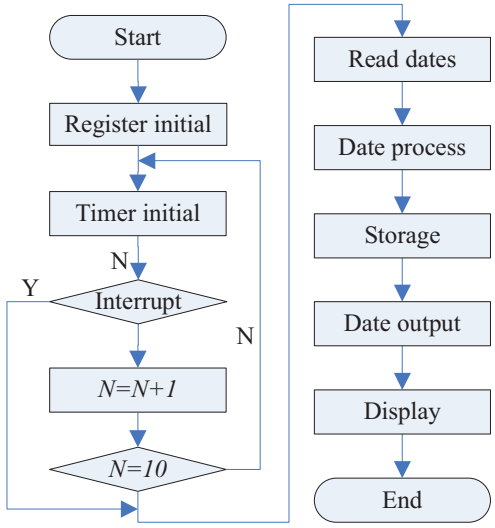


Figure 8. The flow chart of the controller software

The first step of the controller software is controller initialization. The initialization work includes the setting of various microcontroller registers, interrupt flag setting, and peripheral devices setting. Then it will go into a interrupt task to collect sensing data. The next step is PID computing. After that, it outputs its command signals to relays. Meanwhile, it uses a LCD to display the corresponding interfaces, including valve states, indoor temperature, carbon dioxide concentration, etc.

### 4.2. Client software based on Android operating system

To control a fresh air conditioner with a mobile terminator, a client software has been developed based on Android operating system. If a mobile phone is to control a fresh air conditioner, it uses client software to connect with a host computer in a building via a internet router firstly. Then the host computer transfer data with the fresh air unit controller through a RS-232 to RS485 converter. The client software consists of functions of user management, scene control, energy consumption monitoring, security guard and equipment control. After a user logs in, an interface will come out, which is shown in Figure 9. There are six control logos in the interface. They are room selecting, scene controlling, energy consumption monitoring, security guarding, express service and setting. Each logo is a control button. Once it is pressed, the client software will enter into a new interface. For example, if the logo of room select is touched down, a room selecting interface will appear which is shown in Figure 10.


Figure 9. Main interface of the client software

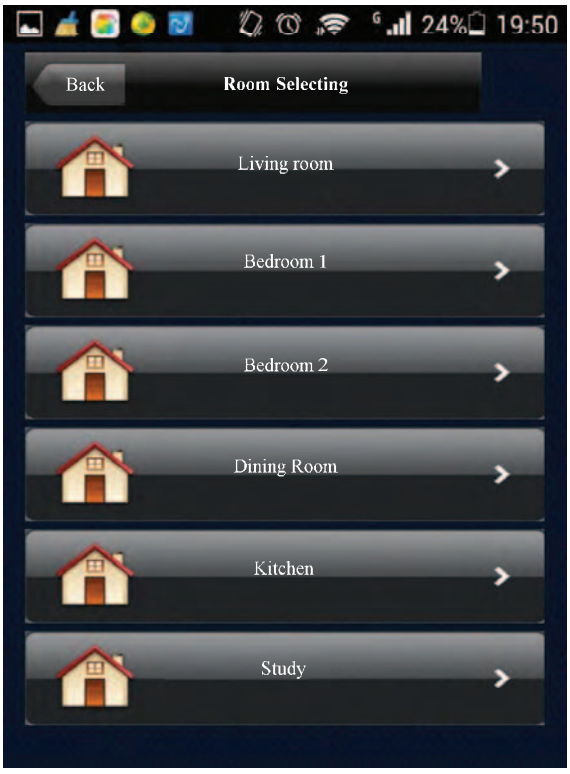


Figure 10. Interface of room selecting

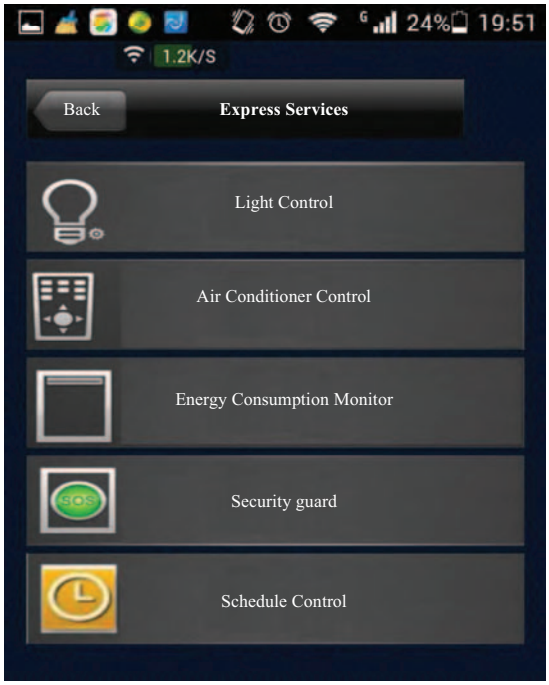


Figure 11. Interface of home appliance controlling

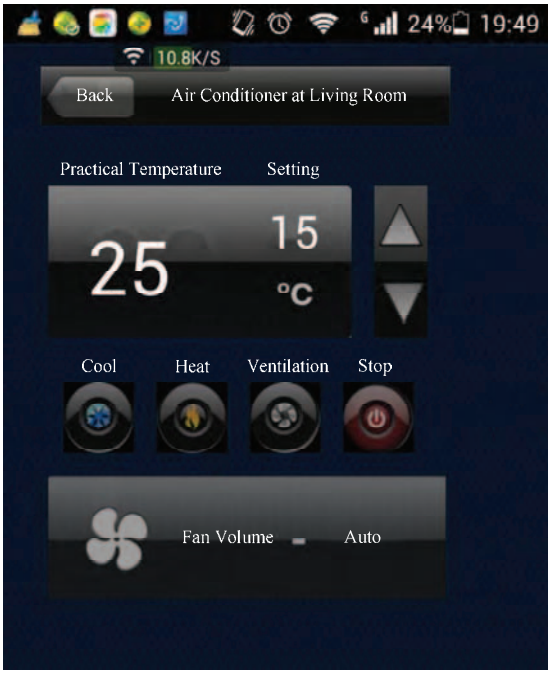


Figure 12. Interface of air conditioner controlling

Once a user enters the room selecting interface, one of these rooms can be chosen from living room, kitchen, bedroom, dining room, etc. Then the user will go into the interface of home appliance controlling shown in Figure 11. All controllable home appliances have been listed in the interface. To control an air conditioner, the client software provides a interface of appliance control shown in Figure 12. Through the interface, it can set temperature, select cool/heat mode, ventilation control for an air conditioner.

## 5. CONCLUSION

This paper presented a control system for fresh air conditioners. The design of a fresh air unit controller in it had been discussed, which is with a carbon dioxide sensor, temperature sensors and humidity sensors. With real-time acquisition of carbon dioxide concentrations, it achieves fresh air automatic control. The fresh air unit controller developed with microcontroller STC89C51 is simple, economical and practical. Moreover, client software for mobile terminators had been developed based on Android operating system. Hence the fresh air conditioner control system developed in this paper has a broad application potential in building control systems.

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