

PAPER • OPEN ACCESS

## Design of Intelligent Air Purifier and Indoor Environment Improvement System

To cite this article: Fengfeng Chen and Xueqiong Hong 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **300** 032102

View the [article online](#) for updates and enhancements.

# Design of Intelligent Air Purifier and Indoor Environment Improvement System

Fengfeng Chen<sup>a</sup>, Xueqiong Hong<sup>b</sup>

Gongqing College of Nanchang University, Gongqing City, China

<sup>a</sup>190823802@qq.com, <sup>b</sup>75952992@qq.com,

**Abstract.** Smart homes have developed rapidly in the wave of informationization, and Internet of Things water purifiers and air purifiers have gradually entered the families of ordinary people. In order to improve indoor environment, realize the remote control and state monitoring of the water purifier, the intelligent water purifier system is constructed by using the related technologies of the Internet of Things, and the communication and interaction between the hardware device and the APP are completed through the combination of software and hardware programming. An air purification system that integrates infrared remote control and Android mobile phone control, uses STM32 single-chip microcomputer as the control core, and uses various sensors to intelligently detect the indoor environment by using information fusion algorithm. The air purifier adopts an ion decomposition purification method, and the design of the finless device can reduce the loss of the consumables, reduce the growth of bacteria, and have low noise during operation. Experiments show that the purifier can effectively purify indoor air and improve purification efficiency.

## 1. Introduction

With the rapid development of the global economy and the improvement of industrial level, the problem of air pollution faced by mankind is becoming more and more serious, and the quality of air quality is receiving more and more attention. When people's living standards improve and their living conditions improve, having a healthy and pollution-free indoor environment has become the common aspiration of many people. Industrial emissions of absorbable particulate matter, formaldehyde emitted from renovated rooms, VOC pollutants emitted from indoor carpets, and soot emitted from kitchens are the main sources of indoor environmental pollution. There are many ways to solve the pollution problem in the indoor environment. Many air purifiers sold on the market have relatively simple functions and the purification effect is not ideal [1].

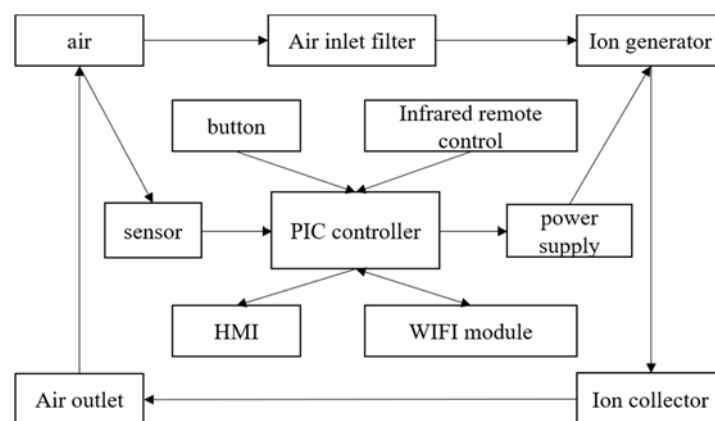
There are many researches on dust removal by electrostatic technology at home and abroad, but most of them are industrial. This paper designs an efficient home electrostatic intelligent air purification device based on Android wireless control. With STM32F103RCT6 as the control core, the indoor air data is automatically detected by the sensor module, and the air is purified by the filter, ultraviolet lamp and electrostatic technology in the automatic mode according to the monitoring data. In manual mode, each module can be set up, combined with infrared remote control and Android device to realize intelligent control of air purifier. It is also pre-set with sleep mode to work under low noise and low



power consumption, and high-speed mode for poor air quality. Quickly purify the air, greatly improving the user experience.

## 2. System settings

The overall architecture of the air purifier system is shown in Figure 1. The system allows air to first pass through the filter of the air inlet to reach the generator pole, and ionizes some molecules through the generating pole; then the charged ions accelerate under the action of the electric field to collide with other particles, causing them to carry electric charges through a series of snowball-like avalanches. The effect causes all dust and bacteria particles to carry a positive charge, which is eventually collected on a collector with opposite potentials to form an ion wind [2]. And for some harmful substances, such as bacteria, through the plasma field, it can also be killed by some free radicals with high energy, while some organic molecules are also oxidized and decomposed into carbon dioxide and water; when the air returns to space, all the charged particles are completely neutralized to ensure safe work. And through the wireless network and Android mobile phone client network communication [3].



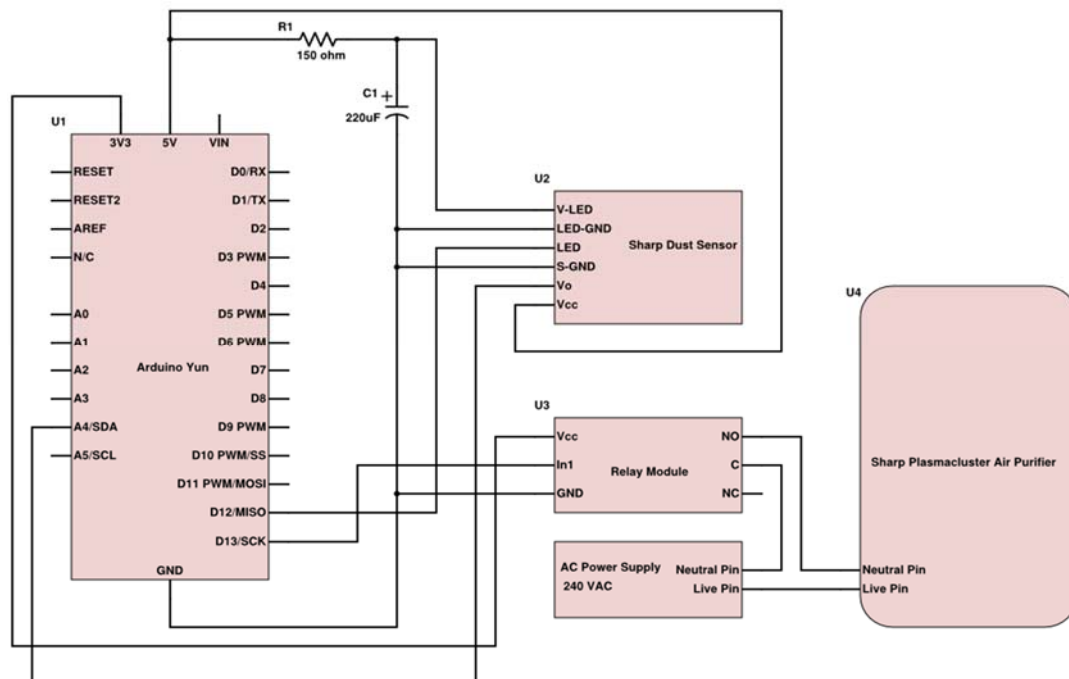
**Figure 1.** Air purification system based on Android system

### 2.1. Processor

STM32F103VET6, which is a microcontroller with ARM 32-bit Cortex-M3 core, clocked at 72MHz, with 512kB Flash, 64kB SRAM, 80 fast I/O ports, 2 16-bit general-purpose and advanced timers, 2 I2C interface, 2 SPI interfaces, 3 USARTs, 1 full-speed USB2.0 interface, SDIO interface, etc., fully meet the design requirements. The chip is low in price and rich in peripherals. At the same time, it is the earliest time to market as a chip using the Cortex-M3 core. Therefore, it has many materials and is one of the preferred chips for small embedded systems. The processor also has the advantage of power savings: The STM32F103VET6 supports three low-power modes to achieve the best balance between low power consumption, short startup time and available wake-up sources. Sleep mode: Only the CPU stops working, all peripherals continue to run, wake up the CPU when an interrupt/event occurs; Stop mode: Allows the contents of the SRAM and registers to be held with minimal power consumption. The processor obtains environmental information through the detection module, and can also control the air purifier by processing data sent by the wireless module. Figure 2 shows the detection module.

### 2.2. PIC16F1947 peripheral circuit design

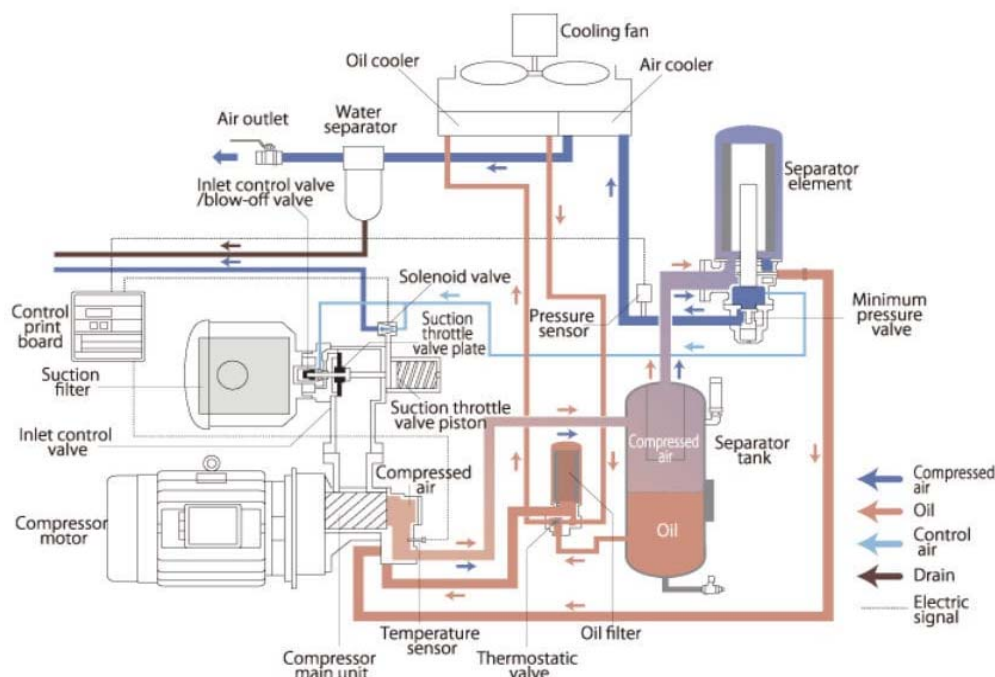
The air purifier controller uses the PIC16F1947, a high-performance RISC CPU [4] with an integrated LCD controller that can drive up to 184-segment LCDs to meet system requirements. Because when the air ionization is decomposed, it will generate strong electromagnetic interference. Therefore, for the idle pins, external pull-up resistors are used to improve the anti-interference ability [5]. Its peripheral circuit design is shown in Figure 2.



**Figure 2.** PIC16F1947 peripheral circuit design

### 2.3. Sensor module circuit

The module is mainly responsible for the detection of indoor environment, including three sub-modules: temperature and humidity sensor module, dust sensor module and air quality sensor module. The digital temperature and humidity sensor DHT11 use a single-bus temperature sensing probe, including a resistive sensing element and an NTC temperature measuring element, and is connected to the PA0 pin of the STM32 as shown in Figure 3.



**Figure 3.** System overall structure

The dust sensor SM-PWM-01A can sense cigarettes, dust, spores, etc. The sensor adopts the principle of particle counting. The heater is installed in the module to heat up the airflow. The outside air enters the module. If particles such as dust pass through, the LED light source is blocked. If the photodetector does not detect the light source, the low potential output; when no particles pass, the high potential is output, and the PMW signal is amplified and output. The low pulse rate of the sensor is linear with the number of dust particles. As long as the low pulse rate is calculated, the number of detected particles can be obtained by referring to the characteristic curve, and the parameters of PM2.5 can be calculated. The MQ135 sensor is mainly used to monitor ammonia, sulfide, benzene vapor and smoke and other harmful gases. The conductivity is low in clean air. When there is polluted gas in the environment, the conductivity increases with the concentration of the polluted gas. A simple circuit can be used to convert the change in conductivity into an output signal corresponding to the gas concentration [3]. Its circuit connection is shown in Figure 4. The system collects the signals of temperature and humidity, dust and gas sensors, and uses the information fusion algorithm to make full use of multi-sensor data resources of different time and space, analyze, dominate, use and synthesize under certain algorithms, and evaluate the air quality. According to the evaluation results, the corresponding control strategies (such as adjusting wind speed, purification device control, etc.) are formulated. Through information fusion technology, the air quality is judged more accurately and the performance of the control system is improved [1].

#### *2.4. Temperature sensor*

The temperature sensor measures the temperature of the indoor environment on the one hand and the temperature inside the purifier on the other hand. When the purifier starts to work, the UV lamp diode generates heat continuously. The temperature sensor detects the temperature inside the purifier and sends the data to the CC2530 MCU, which determines whether it is necessary to turn off the purification device to reduce damage to the components. The DS18B20 is a digital temperature sensor that meets the design requirements.

#### *2.5. Purification module design*

The interior design of the purification module uses a two-way ventilation design. Two convection fans are arranged in the front and rear of the box to blow the inside of the box, forming a circulation inside the box, as shown in Figure 7. Tiles with TiO<sub>2</sub> are placed on the left and right sides and the bottom surface of the box, and ultraviolet tubes are installed on the left and right sides of the box, so that the circulation can be purified, and the harmful substances in the air can be fully purified, and the purification efficiency can be improved. With the air outlet at the top of the box, the purified air can be removed. We can control the air volume by controlling the fan to save energy.

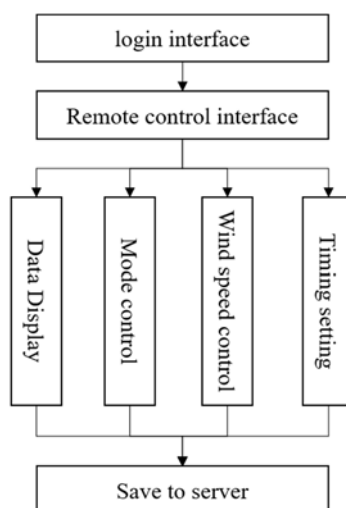
### **3. Software design**

#### *3.1. MCU control program design*

After the purifier is powered on, the program begins to execute. The parameters are initialized first, then enter the main loop, read the sensor information, display the information on the LCD, and update the status. The main program then scans the buttons. The system is designed with 6 independent function keys for power switch, wind speed adjustment, mode selection, UV light switch, timing and filter timing reset function. In the manual mode, if there is a button press, the program will process the corresponding button subroutine to change the working state of the purifier. Among them, the infrared remote-control information is cut into the main program in the form of an interrupt, and different actions are also performed through different keys. The Android client control signal is transmitted through the serial port and acts according to the received signal. In the automatic mode, the wind speed and the working status of other modules are automatically controlled by the sensor acquisition data.

### 3.2. Android client design

How to use the client to achieve indoor air data monitoring and control is one of the key technologies in this paper. That is, when the client sends a data request, the control module responds quickly to the client's request, provides a response query and control service, and the software work flow diagram is as shown in Fig.4.



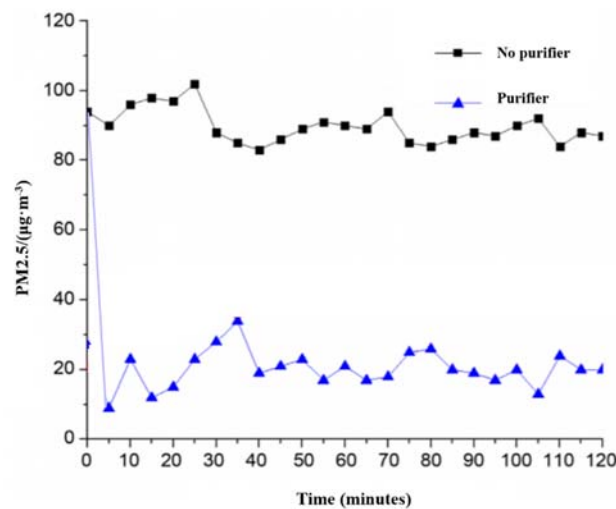
**Figure 4.** Client functional structure

The client consists of a login module and a remote-control module. It uses the SQLite integrated by the Android system itself, and provides some new APIs to use the SQLite database to implement database operations. The login module first adjusts the WIFI Manager Service, checks the phone, determines to open the WIFI, and then enters the remote interface through the Web-Service incoming account and password, and needs to set the WIFI permission and networking permission in the Android Manifest.xml file [6]. As the code shows: `< uses-permission android: name "android. Permission. INTERNET" / >`.

In reality, the existence of a large number of local area networks adds some difficulty to the web server to connect to the external network. If we are in a LAN and use the IP of the intranet, the web server or VPN server in the intranet cannot be opened to the outside world. Some services must be opened to the public through the wide port mapping function of the router. The method is to first enter the router address, select the forwarding rule - virtual server, add a new entry, and fill in the window: server port: 80, IP address: IP address protocol on the computer: TCP, save. For example, if the IP address of the router server is 192.168.44.203 and the IP address of the computer server is 192.168.1.2, follow the above method. After the setting is completed, just fill in the 192.168.44.203 on the address bar of the other computer. Ability to automatically identify the link to our computer server.

## 4. System test

System testing is divided into testing of the control system and testing of the purification function. The test of the control system is to operate the purification system by means of buttons or remote control (infrared and WIFI) to observe the change of state. The purification function test verifies the purification effect of the purifier by detecting the air quality in the test chamber at different time periods. The purification function was tested in two student dormitories. The room size was about 30m<sup>3</sup> and the room structure was exactly the same. One room is equipped with a purifier, and the other room is not equipped with a purifier as a control environment [6]. Using mosquito-repellent smog as a source of particulate matter, paint is used as a source of volatile organic matter. To ensure consistency, PM2.5 detectors were used to record changes in PM2.5 and TVOC concentrations in both rooms. The data is shown in Figure 5.



**Figure 5.** Mass concentration change of PM2.5

## 5. Summary

This paper designs and implements the Android multi-function ion wind air purification system. Based on the overall design, the corresponding software, hardware and Android client design is designed to realize the monitoring of indoor air quality parameters, and can be automatically adjusted according to the above data changes. Or manually adjust the working status of the system. Experiments show that the system is stable and can effectively purify indoor air.

## Acknowledgements

This work is funded by Jiangxi Provincial Department of Education, by the Science and Technology Project. (Project number: GJJ181480)

## References

- [1] Yang Qian, Dong Yude, Chen Guangchao. Design of Multi-function Air Purifier Control System Based on ATmega128. *Journal of Xi'an Engineering University*, Vol. 3 (2015) No.28, p. 103-105.
- [2] Xu Bang, Wang Jun. Design of Air Purifier Control System Based on ARM Processor. *Mechatronics*, Vol. 7 (2015) No.21, p. 45-49.
- [3] Zhao Rongxin, Dai Shuguang. Design of Air Purifier Control System Based on Android and PIC. *Electronic Science & Technology*, Vol. 6 (2017) No.15, p. 35-39.
- [4] Ma Baijiang, Yang Fan, Lu Rundong. Design of Intelligent Air Purifier Control System Based on 51. *Computer Knowledge and Technology*, Vol. 13(2018) No.14, p. 238-239.
- [5] Yu Ailing, Chen Xianbin. Design of Air Purifier Control System Based on ATmega16 Single Chip Microcomputer. *Journal of Electric & Electronic Education*, Vol. 1 (2016) No.38, p. 71-74.
- [6] Sa Shizhong, Zhou Yuqiang, Bao Liang, et al. Design, Installation and Operation Management of Air Purifiers for Air Conditioning Systems. *Refrigeration, Air Conditioning and Electric Machinery*, Vol. 3 (2009) No.30, p. 66-68.