# Multi-Functional Shoe Cabinet

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## 1 Introduction

### 1.1 objective

Traditional household shoe cabinets have only single function for the placement and storage of shoes, and most of the time they are closed and unventilated, so that the bacteria in the shoes can easily breed in the dark and damp environment, which cannot meet people's basic needs for foot health care.

Our objective is to build a multi-functional shoe cabinet. The cabinet system consists of control module, temperature and humidity detection module, combination key module, dynamic display module, alarm module and sterilization module. The control module takes STC89C52 microcontroller as the core unit to realize the control of temperature and humidity sensor, liquid crystal display LCD, dryer and ozonator. It can monitor the temperature and humidity of the cabinet in real time, start the dryer when the humidity exceeds the limit, and sterilize the cabinet regularly. There is also a Wifi module allow us to remote the settings in the cabinet
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### 1.2 background

A study which investigated germs collected on footwear, by Dr. Charles Gerba[1], microbiologist and professor at the University of Arizona, and The Rockport® Company, found large numbers of bacteria both on the bottom and inside of shoes; averaging 421,000 units of bacteria on the outside of the shoe and 2,887 on the inside. Some of the bacteria found on the shoes included: Escherichia coli, known to cause intestinal and urinary tract infections, meningitis and diarrheal disease; Klebsiella pneumoniae, a common source for wound and bloodstream infections as well as pneumonia; and Serratia ficaria, a rare cause of infections in the respiratory tract and wounds.

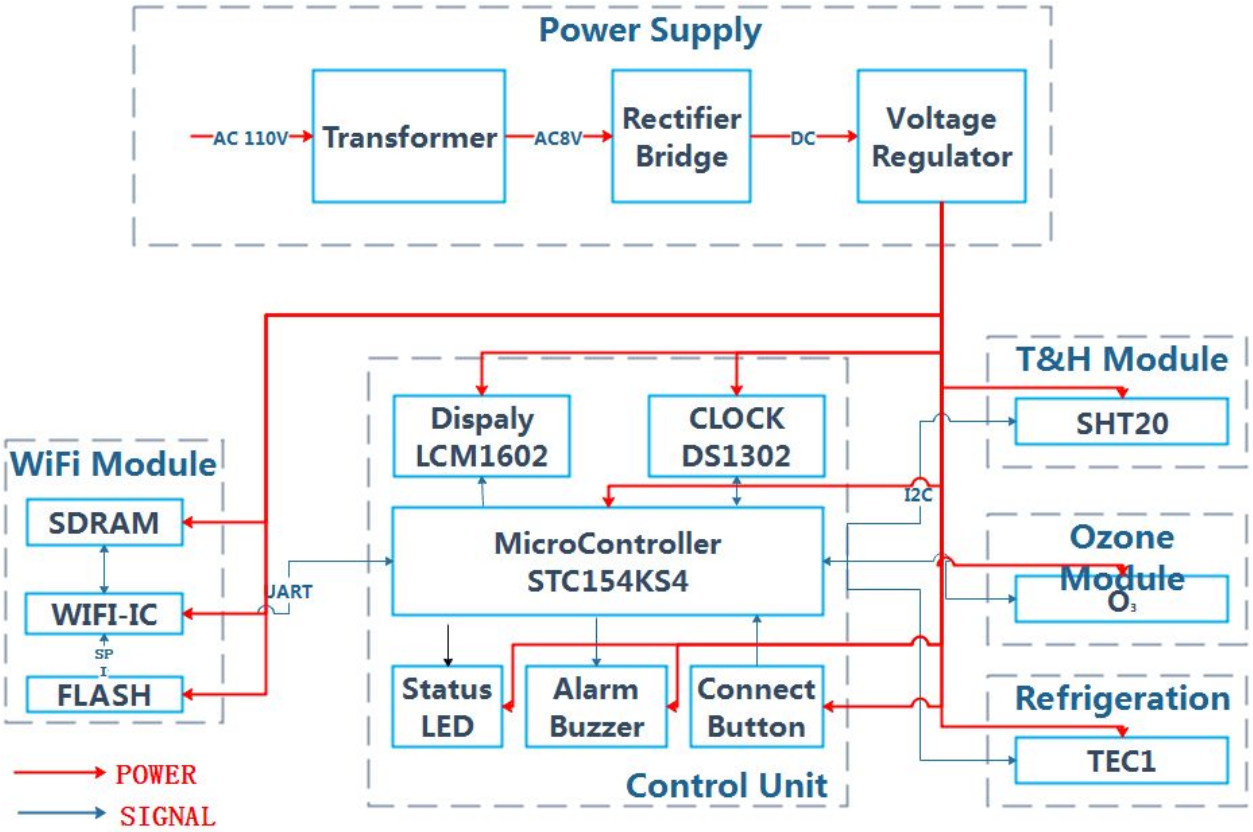
By the time of writing, shoe cabinet with these multi-function has not been found yet.We think there may be a chance to develop a more functional cabinet for the customers. [2]In 2017, there were about 126.22 million households in the United States. According to the U.S. Census Bureau, a household consists of all the people who occupy a housing unit.If only 10 percent of them update cabinet, there is a huge potential market.

### 1.3 High level requirement

- Cabinet must display and adjust humidity and temperature accord to 4 key combination.
- Alarm module must work if the cabinet is open within 30 mins after ozone generated.
- A remote display must be completed through WIFI.

## 2 Design

The multi-functional shoe cabinet system consists of control module, temperature and humidity detection module, connect button module, dynamic display module, alarm module, in-home HVAC module, WIFI module and sterilization module. A power supply will also included to ensure the system could continuously work for all day with 5V.




### 2.1 Power Supply

The power supply part we used should convert 110V AC to 5V DC continuously, which will fulfill the requirement of voltage for all parts in the design.

#### 2.1.1 Voltage Transformer

Our voltage transformer will used to transfer voltage from 110V AC to around 8V AC, using 7805 voltage regulator.

### 2.1.2 Rectifier Bridge

By using rectifier bridge to filter the voltage change from AC to DC.

### 2.1.3 Voltage Regulator

As there exist ripples in DC supply, we need to use LM705 as three terminal regulator to smoothing the supply voltage to 5V DC.

## 2.2 Control Unit

Control unit manages the signal send from temperature/humidity sensors, control the in-home HVAC, the alarm, the Sterilizing device and prepares data that is later sent to WIFI module.

### 2.2.1 Microcontroller

STC89C52 is a microcontroller belonging to the series of STC89. It is a system based on 8-bit MCU processing chip STC89C52RC. The single clock / machine cycle (1T) single-chip microcomputer that is compatible with 8051 core, has a new pipeline / reduced instruction set structure and an internal integrated MAX810 special reset circuit.

*Requirement 1*: Working voltage should around 5V.
*Requirement 2*: Should have enough pins.

### 2.2.2 Dynamic Display Module

A dynamic display module located on the shoe cabinet, serves to display the current temperature/humidity in the shoe sabinet, the threshold and trigger value of our in-home HVAC system. It will also display the date and time on the screen.

### 2.2.3 Clock Chip

A clock chip will be also contained in the design and is able to collect time and date.

### 2.2.4 Connect Button Module

The connect button module will have two parts; one part is used to select shoes options, the other is used to set up the system.

#### 2.2.4.1 Shoes Type Button

Four buttons on the outside of the cabinet, each represents one kind of shoes. The system should be managed by pressing buttons or mobile phone application. For different kinds of shoes, system will provide a temperature range and humidity range, in order to provide best environment to the shoes.

*Requirement 1*: The buttons should be pressed easily.
*Requirement 2*: Should have a long working period.

#### 2.2.4.2 System Setting Button

For the second part of the button, four buttons located outside the shoe cabinet could be used to adjust system running time, calendar, temperature range and also humidity range for the system. This could make the system to achieve the specific request from the user.

### 2.3 Temperature and Humidity Detection Module

As for the sensors, our group plans to use SHT20 humidity/temperature sensors to detect the humidity and the temperature, and to send all the information to the microcontroller.

*Requirement*: The sensor should keep the precision within decimal digit.

### 2.4 Function output module

Considering the health protection and maintenance benefits to the foot, the functional output module consists of two sub-functional modules: in-home HVAC module and sterilization module. Each executable sub-module can be single, multi-use and full use according to the user's needs.

### 2.4.1 In-home HVAC Module

Heating, ventilation, and air conditioning (HVAC) is the technology of indoor and vehicular environmental comfort.

#### 2.4.1.1 Heating/Cooling

In our design, we plan to use two Peltier coolers, put them on both side of the cabinet, and provide them with different DC current flow direction, so they will act as heater and cooler individually. By the temperature and humidity sensors provide on-time information to microcontroller, it could used to change the temperature into the set range and could also be changed by system setting button locate outside of the shoe cabinet.

#### 2.4.1.2 Dehumidification

By inserting a condenser between two Peltier coolers and next to "cool" side, after providing voltage, the vapor in the cabinet will start liquidation on the condenser next to "cool" side, and water will flow out into the water tank thus to dehumidify the cabinet while at the same time the other side Peltier cooler will act as a heater in order to temperature complementation. This function is controlled by microcontroller and work with humidity sensor to keep best environment for shoes. It could also allow user to adjust humidity in the cabinet by setting buttons.

#### 2.4.1.3 Ventilation

A ventilator will be used to accomplish the ventilation function, and will work every 10 mins following the signal from the clock.

*Requirement*: Ventilator should be small and suitable within the cabinet.

### 2.4.2 Sterilization module

Ozonator is used as sterilizing module, it is a device that can be used to generate ozone which are widely used to kill the bacteria, and Ozonators are widely used in drinking water, industrial oxidation, sewage, pharmaceutical synthesis, food processing and preservation, and space sterilization. The sterilization module will work only one time during the first 30 mins[6] and should close when alarm system start.

*Requirement*: We should prevent direct contact between human and ozone and make certain no harmful substances will be leaked into environment.

## 2.5 WIFI module

Wifi module will used to connect the shoe cabinet to the phone APP, it's function include real-time information of the cabinet environment, adjust button for temperature/humidity and also include alarm module to warn the user.

### 2.5.1 WIFI microchip

We chose ESP8266 32-bit microchip for our UART-WiFi module. ESP8266 supports standard IEEE 802.11 b/g/n specification. It has a relatively low price and has standby power of as low as 1.0mW.

ESP8266 supports Smart Config function for Android and iOS products, which we will use for mobile control.

Since ESP8266 has a working voltage of 3.3V, we will implement a voltage divider to prevent short circuit of the chip.

#### 2.5.2 Flash

We will choose 2M flash to program WiFi module. We estimate our program will use around 1Mb space.

### 2.6 Alarm Module

An alarm module will be included in the design as O3 is harmful to human body during the first 30 minutes as it is expelled to the air, after which it fully decomposes. We will build a alarm system in order to protect shoe cabinet and user.

#### 2.6.1 Status LED

A status LED will show the current status of the system, and will collaborate with alarm buzzer to warn user.

#### 2.6.2 Alarm Buzzer

An alarm buzzer will also be used and connected in series to the status LED, and will work with Status LED to function as sound-light alarm system.

*Requirement*: The volume of the buzzer should be loud enough.

#### 2.6.3 APP alarm

When the alarm module is triggered, it will also send signal to the phone APP, warning user.

### 2.7 Risk Analysis

In order to make Peltier coolers to work properly, the time difference between providing different direction of current should be longer than five minutes. We need to provide a clock signal to the heating/cooling system as well as dehumidification part.

For the sterilization module, as O3 is harmful to the human body and it will decomposed in the air after 30 minutes, for safety proposes, we will install the Ozone generator instead of building one, and will make certain it works under control by the microcollter, clock and alarm system all the time.

## 3 Ethics and Safety

It is of paramount importance to address ethical and safety issues as we are obligated to devote ourselves to good conducts which positively affect our communities.

We are accountable for stating correct data of relevant variables in our project, such as temperature and humidity. In rare cases, unexpected feedback from temperature sensor may be monitored. Regardless, we will be truthful in disclosing it, as honesty is more valued than desirable results. This is in accordance to the IEEE Code of Ethics, #3: “To be honest and realistic in stating claims or estimates based on available data”[3].

While it feels satisfactory to be recognized for contributing thoughts and hard work towards our project, we should invariably remain humble to accept constructive feedback and to admit and rectify errors. Proper compliments should be awarded towards insightful contributions, as we adhere to #7 of IEEE Code of Ethics: “to seek, accept, and offer honest criticism of technical work…”[3]. For instance, when one group member finds out that one dehydrant poses better control over moisture, he should not hesitate to ask for testing and renewal, even though it means replacement of other members’ work.

It is inevitable to find out there exist enormous amount of gendered products on the market. Some are optionally made for men or one race only, while others are labelled with higher prices against women[4]. This kind of merchandise goes against gender and racial equality and places women and minorities at inferior level. As the IEEE Code of Ethics indicates: “to treat fairly all persons and to not engage in acts of discrimination…”[3], we promote equality by fully designing shoe cabinets. In addition to loafers, options of heel shoes and sandals will be added with more adjustments. Dryer module will be turned on for longer period if moisture sensor detects more sweat residues on these shoes.

There are safety considerations. Making voltage adaptor is both a challenge and a potential safety hazard. Inadequate design will not only short circuit entire circuit board but also poses threats to human safety. To avoid this issue, we use a 7805 voltage regulator and 10 micro farad capacitor in addition to a DC adaptor. We closely monitor the output voltage every time we turn it on to ensure it is 5V. A fuse will be added in series for double protection. As indicated by ACM Code of Ethics and Professional Conduct 1.2: “Avoid harm”[5], after all, ensuring physical safety is top one consideration we will always have in mind.

Temperature regulator can burn shoes and circuits, leading to irrevocable consequences. After detecting a drop in temperature, the controller can order an amplified power to the heater. To prevent this, we will set upper and lower temperature thresholds to be 28.5°C and 18.5°C respectively. Also, heater device will be isolated from the rest of circuit to meet higher safety standard.

## References

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