Design of a Lift-able Multi-functional Intelligent Wardrobe

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Abstract: The paper proposes a design scheme for a lift-able wardrobe, which is comprised of four major mechanisms: Cable Lifting Mechanism, Pinion and Rack Mechanism, Scissor type Lifting Mechanism, Support rail Mechanism. The paper also designs so many circuits to achieve lighting, ventilation, dehumidification and drying, sterilization and other functions through various electronic components, such as microcontroller, UV sterilization device, LED light, PTC ceramic semiconductor air electric heater, temperature, humidity sensor and so on, so as to let people enjoy the convenience and comfort of science and technology to life.

1. Introduction

Today, many residences have adopted smart furniture, integrated into modern high-tech elements to give intelligent vitality, which let people enjoy the convenience and comfort of science and technology to life. Wardrobe is a family essential storage furniture, but traditional wardrobe can't meet people's fast-paced, high-quality lifestyle, such as the increase in the number and variety of clothing makes finishing clothes difficult, wasting time. In addition, the traditional high wardrobe for the elderly and children there is an inconvenience to take goods because of safety risks, which may be appear in the case of the need to climb high or bend over to take things.

In view of the above background, this paper puts forward a new intelligent wardrobe, to achieve classification storage, automatic lifting, lighting, ventilation, dehumidification and drying, sterilization and other functions.

2. Design Ideas

The depth of the wardrobe should meet the width of the hanger, the wardrobe height should meet the length of the coat naturally hung in it, and the width of the wardrobe is generally depending on the number of pieces hanging clothes and the spatial position of hanging 1 piece of clothing.

2.1.Concept Development

The whole cabinet body is consist of the left and right cabinet body, where the buffer devices and limit devices are used to prevent the cabinet in the lifting process of collision interferences and damages. The left-hand wardrobe has a lift-able hanging rod for hanging items that are not suitable for folding, and includes lighting devices, dehumidification, ventilation and sterilization. The right-hand wardrobe is a lift-able combination wardrobe section, consisting of several small wardrobes, which driven independently by the motor. The front panel of the right-hand wardrobe contains two retrieval windows and a control display.

The right-hand wardrobe is divided into the upper, middle and lower three layers, the upper wardrobe uses the cable lift to achieve its body vertical up-or-down movement, the middle layer wardrobe uses the pinion and rack mechanism to achieve left -or-right translation, the lower wardrobe uses the scissor type lifting mechanism to achieve up-or-down movement.

The middle part of the right-hand wardrobe is set to pick up the port, surrounded by a LED light belt, to provide a good line of sight for picking clothing. The left-hand wardrobe is controlled by the cable lift, just as the upper wardrobe in the right-hand wardrobe. The layout diagram of the whole machine is shown in Figure 1, and the parameters are shown in Table 1.

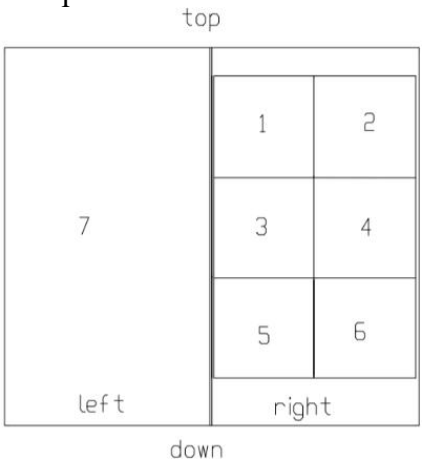


Figure 1: The layout diagram of wardrobe.

Table 1: The parameters of wardrobe design.

Project.	Design parameters.
Wardrobe width.	2300mm
Wardrobe height.	2200mm
Wardrobe depth.	800 mm
The dressing windows.	3#、4#、7#
Time for taking clothes and exercising.	6s

2.2.Mechanism Design

2.2.1. Cable Lifting Mechanism

The left-hand wardrobe (No.7) lifting and hanging rod and the right-hand upper wardrobe (No.1, No.2) are connected to the wire rope, the wire rope is wound in the drum radially, who is drove by the forward and reverse motor, so as to achieve the cabinet or the hanging rod moving up and down, while the motor is mounted on the top floor of the cabinet.

Now, setting the right upper wardrobe (No.1) maximum carrying capacity is 20Kg, including self-weight, the vertical travel is 600mm. Setting the drum initial winding diameter is 12mm, choosing rust-free wire rope diameter is 1mm, it needs to wind 11 turns and the drum diameter will increase to 35mm by winding in the drum radially when the vertical travel reaches 700mm， just as shown in Figure 2. Supposing the vertical travel is 600mm, while the time required to reach the pick-off position is 4s, so the average power of the required motor is 30w, the minimum output torque of the required motor is 3.5N.m.

2.2.2. Pinion and Rack Mechanism

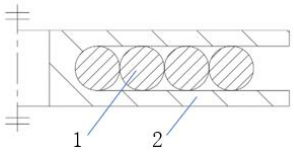
The right-hand wardrobe Middle layer cabinet (No.3 or No.4), uses motor driving gear in the horizontal rack direction to achieve left or right movement, where the drive motor is installed on the back of the cabinet body.[1][2] The middle cabinet needs to be moved horizontally, when we tries to get clothes from the upper or lower cabinets, otherwise no need. Sensors set in horizontal direction to ensure moving safety.

2.2.3. Scissor Type Lifting Mechanism

The right-hand wardrobe Lower layer cabinets (No.5, No.6) using scissor type lifting mechanism, can achieve the cabinet up or down movement by motor driven screw on the lifting mechanism. [1]

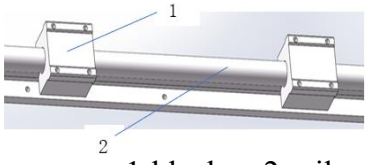
2.2.4. Support Rail Mechanism

One support rail mechanism is used on the right-hand wardrobes (No.1 to 4), to achieve the vertical guide or horizontal hanging support of the wardrobe.[2] The support rail mechanism is shown in Figure 3. One side of the rail is connected to the wardrobe fixing panel, and the other side is connected to the middle of the active wardrobe body, all with bolted connections.



1-wire rope 2-drum

Figure 2: Drum.



1-block 2-rail

Figure 3: Support rail mechanism.

2.3.Accessibility Design

In this design, UV sterilization device is used to reduce the production of bacteria in the wardrobe. For easy access clothes, the flexible LED light strip surround is design to increase the light, who is controlled by touch-sensing switch. In order to increase the air circulation in the cabinet, to achieve the purpose of ventilation and drying, the fan is mounted on the top or down floor of the cabinet side wall.

PTC ceramic semiconductor air electric heater is chose because of dehumidification and anti-mold, so as to keep the wardrobe dry, which has an automatic thermostat control system with protective isolation layer, that will not cause harm to clothing. The interior of the cabinet is equipped with temperature, humidity sensor, for monitoring cabinet temperature and humidity, who sent data feedback to the microcontroller to decide whether to heat dehumidification and ventilation. The ultraviolet sterilization device is periodic work.

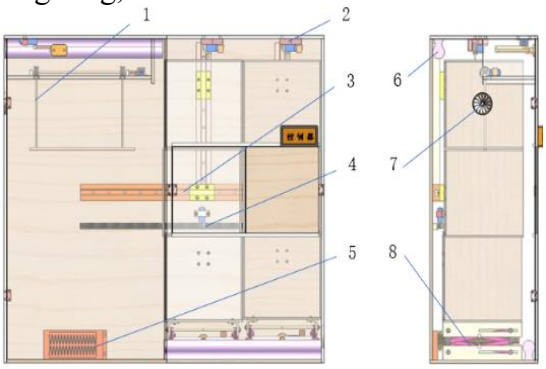
3. Control System Design

The multi-functional intelligent wardrobe, whose whole machine 3D model is shown in Figure 4 and the overall structure of the control system is shown in Figure 5, uses STM32 microcontroller to achieve functions as follows:

(1) people can enjoy convenience at a suitable height to quickly access clothes by through the external multi-motor drive cabinets lifting or horizontal moving.

(2) wardrobe's inside environmental information can be collected and transmitted to microcontroller in real-time through the temperature and humidity sensor, including temperature, humidity and light intensity and so on.

(3) heating tube can be heated for dehumidification, ultraviolet lamp can be sterilized, touch switch can achieve intelligent lighting, and fan can work.



1-wire rope 2-motor 3-support rail 4-rack 5-heater tube
6-UV light 7-Fan 8-Scissor type Lifting Mechanism

Figure 4: 3D model.

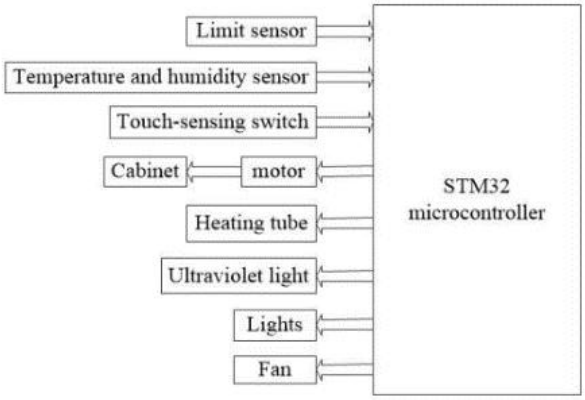


Figure 5: The overall structure diagram of system.

3.1. Microcontroller Power Supply Circuit Design

According to the electrical demand of each chip of the hardware circuit, DC 12V voltage needs to be converted to DC 5V, then to DC 3.3V, so the LM2576-5 buck switch type integrated regulator chip and NCP1117ST33 chip are selected, the design circuit is shown in Figure 6.

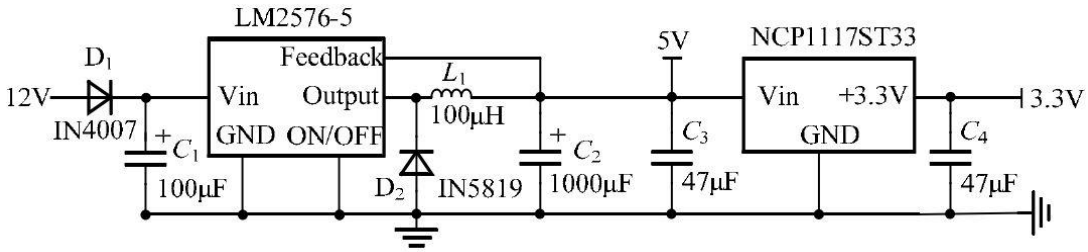


Figure 6: Power supply circuit diagram.

3.2.Motor Circuit Design

The 220V voltage is converted to 24V by using the LM2596-ADJ buck chip, and the conversion circuit is shown in Figure 7. The motor drive circuit, as shown in Figure 8, uses the L298N drive chip, whose optimum voltage range is 2.5V between 46V and the best current is 2.5A, so the driving capacity is very strong in line with the system requirements.

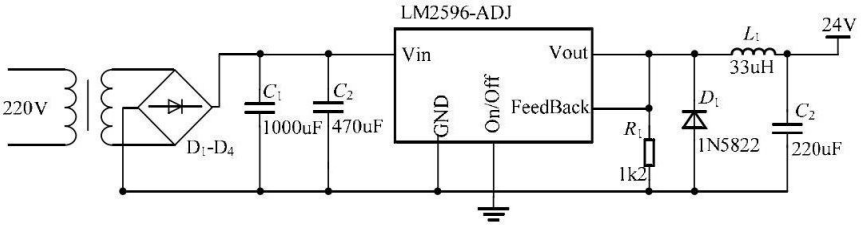


Figure 7: Voltage conversion circuit diagram.

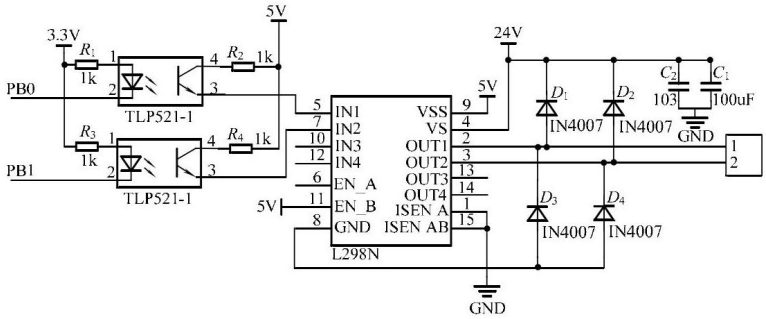


Figure 8: Motor drive circuit diagram.

3.3.UV Light Circuit Design

The UV lamp is controlled by the Omron G5V-1 relay, where NO.2 and NO.9 feet are coils, NO.5 and NO.6 feet are common ends, NO.1 foot is normally closed contacts, NO.10 foot is normally open contacts, and the coil operating voltage is 12V. When a pulse signal is received is high, the relay is on and the UV lamp works. The connection circuit is shown in Figure 9.

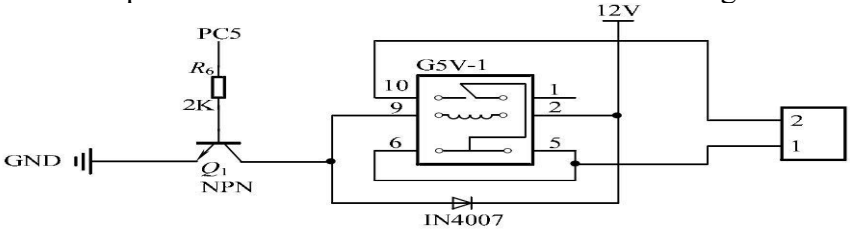


Figure 9: Germicidal lamp connection circuit diagram.

3.4.Heating Tube Circuit Design

In Figure 10, when the microcontroller PA10 output is low, the internal diode on the TLP521-1 optocoupler generates a current, and its 3,4 ends are equivalent to switch closing, making the three-pole TR409 work, so is the load circuit, and the heater starting to work.

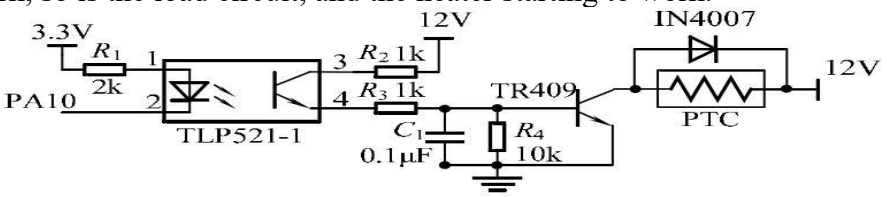


Figure 10: Heater connection circuit diagram.

3.5.Temperature and Humidity Sensor Circuit Design

The AM2305 sensor is selected and its connection circuit is shown in Figure 11.

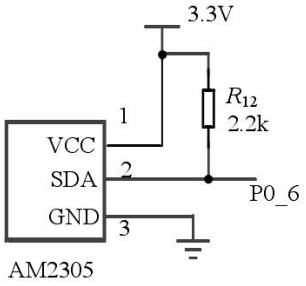


Figure 11: AM2305 connection circuit diagram.

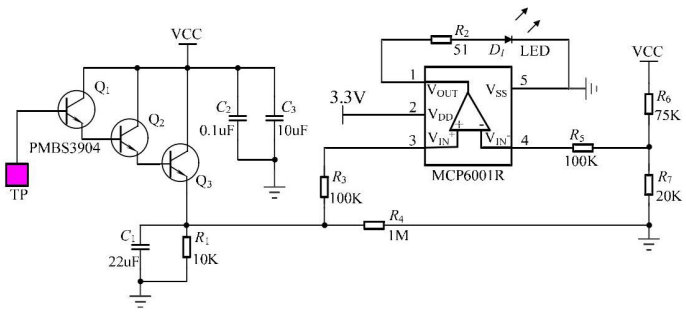


Figure 12: Touch lighting circuit diagram.

3.6.Intelligent Lighting Circuit Design

This design uses touch lighting for lamp control, when a person touches the metal sheet TP, there are three triodes to amplify the signal, through the transport output to drive the LED lights. When Touch Leaves, the LED light decreases until it goes out. The touch lighting circuit is shown in Figure 12.

3.7.Multi-Cabinet Motion Control Design

There is a total of eight independent moving motors in this multi-functional intelligent wardrobe. In this device, there are three windows for picking clothes, which are located in NO.3, NO.4 and NO.7 cabinet body. It is important to reasonably control the order of each motor operation in picking clothes. By setting the motor number and cabinet sequence number to maintain same, the picking

clothes movement process is shown in the Table 2 below, and the recovery process is the opposite control. All functions in this device can be met by the program control, including lighting, sterilization and so on.

Table 2: Order of motor working.

Motor No. / Cabinet No.	1	2	3	4	5	6	7	8	Picking window
1	③↓	×	②←	×	×	×	×	①	3
2	×	④↓	②←	③←	×	×	×	①	4
3	×	×	×	×	×	×	×	×	3
4	×	×	×	×	×	×	×	×	4
5	×	×	②←	×	③↑	×	×	①	3
6	×	×	②←	③←	×	④↑	×	①	4
7	×	×	×	×	×	×	②↓	①	7

Notes:

(1)1-6 stand for the right side of the small cabinet number and the corresponding motor number, 7 for the left hanging wardrobe lift motor, 8 for the left door motor.

(2) ①~④represent the start order, arrows represent the direction of motion, x for static.

4. Summary

Compared with the traditional wardrobe, the project designs a lift-able multi-functional wardrobe, by using microcontroller control, has so many advantages, just as classification access, convenient and fast, and effectively solving the difficult situation of bending or climb high taking, additional ventilation drying and sterilization, lighting function.

In other words, the whole machine design is simple, low cost, cost-effective, practical, can effectively save the time required to find clothing, adapt to the current fast-paced life characteristics, can effectively help people release from the heavy domestic work, suitable for the current needs of the vast number of families. There is a great marketing market.

References

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