The University of Hong Kong

Department of Electrical & Electronic Engineer

M.Sc.(Eng.) in Electrical & Electronic Engineer

Final report

Optoelectronic Device Stability Testing Setup

ZHANG, Kecheng (3035895569)
Pan, Yen Fu (3035667209)

Supervisor:

Prof. Wallace C.H. Choy

Date of submission:

July 2022

Abstract

LED has shown many unique advantages as a new type of light source and has been widely used. Thus, our demand for testing problems of LED performance is gradually increasing. In this paper, we improved the current LED test device and developed the LED brightness test device. The main work is as follows: 1. Improvement of the LED control system based on stm32. 2. Improvement of the LED power supply system. 3. Integrate the separate modules to make a PCB. 4. Implement a 3D printed shell. This paper emphatically expounds on the electrical hardware design and software design principle and realization of the test device in detail.

TABLE OF CONTENTS

List of Figures iv

Chapter 1 Introduction....................1

1. Background 1

2. LED lighting principle 1

Chapter 2 Analysis of problem....................3

1. Existing systems....................3

2. Analysis of problem 7

2.1. Power supply system 8

2.2. Software system....................8

2.3. Package 8

Chapter 3 PeLED Aging Test System 2.0 10

1. An increase in the number of channels....................10

2. 0-10mA current range circuit 10

3. 10-50mA current range circuit 11

4. Development of software....................13

4.1. Function of current input....................13

4.2. Development of testing interface 17

4.3. The detail of code 18

5. Analysis of problem 29

Chapter 4 PeLED Aging Test System 3.0 31

1. 10-50mA current range circuit 31

2. Development of interface....................32

3. Design of the shell 32

3.1. Introduction to Modeling Software 34

3.2. Part1 34

3.3. Part2 35

3.4. Part3 37

4. Analysis of problem 39

Chapter 5 PeLED Aging Test System 4.0 40

1. Development of 10-50mA power supply circuit 40

2. PCB making 40

2.1. PCB1 (Control system and sampling module)..41

2.2. PCB2(10-50mA power supply system) 47

3. 3D printing 53

Chapter 6 Conclusions...59

Appendix 61

List of Figures

FIGURE2.1 Motherboard of STM32..4

FIGURE2.2 Resistive touchscreen..4

FIGURE2.3 S13948-01SB..5

FIGURE2.4 Photocurrent VS. Illuminance..5

FIGURE2.5 AD7606 module..6

FIGURE2.6 Power supply module..6

FIGURE2.7 Function intro & logic of PeLED Aging Test System 1.0......................7

FIGURE3.1 Parts of schematic..12

FIGURE3.2 Interface of current range selection..14

FIGURE3.3 Interface of the current setting value (before settle)............................15

FIGURE3.4 Interface of the current setting value input..16

FIGURE3.5 Interface of the current setting value (after settle)..............................16

FIGURE3.6 Interface of the current setting value checking...................................17

FIGURE3.7 Interface of the current setting value checking...................................17

FIGURE3.8 Part of the code for function CH8set...18

FIGURE3.9 Part of the code for function CH8set...19

FIGURE3.10 Part of the code for function CH8set...20

FIGURE3.11 Part of the code for function currentset..20

FIGURE3.12 Part of the code for function currentset..21

FIGURE3.13 Part of the code for function currentset..21

FIGURE3.14 Part of the code for function currentset..22

FIGURE3.15 Part of the code for function currentset..23

FIGURE3.16 Part of the code for function anjian..24

FIGURE3.17 Part of the code for function anjian..24

FIGURE3.18 Part of the code for function anjian..25

FIGURE3.19 Part of the code for function currentset..26

FIGURE3.20 Part of the code for function CH8set 26

FIGURE3.21 Part of the code for function CH8set 27

FIGURE3.22 The code for function my_strcat 27

FIGURE3.23 Part of the code for function sendvol..28

FIGURE3.24 Part of the code for function sendvol..29

FIGURE3.25 Part of the code for function sendvol..29

FIGURE4.1 Interface of the 10-50mA current setting reminder.............................32

FIGURE4.2 Module1 35

FIGURE4.3 Module2..35

FIGURE4.4 Module2 (actual)..35

FIGURE4.5 Module3 (open)..36

FIGURE4.6 Module3 (close) 36

FIGURE4.7 Module3 (actual)..37

FIGURE4.8 Module4..37

FIGURE4.9 Module5..37

FIGURE4.10 Module4 and module5 (actual) 38

FIGURE4.11 Module6 38

FIGURE5.1 Partial schematic of PCB1 43
FIGURE5.2 Partial schematic of PCB1 44
FIGURE5.3 Partial schematic of PCB1 45
FIGURE5.4 Partial schematic of PCB1 46
FIGURE5.5 Partial schematic of PCB1 46
FIGURE5.6 Circuit diagram of PCB1..47
FIGURE5.7 PCB1...47
FIGURE5.8 Partial schematic of PCB2 49
FIGURE5.9 Partial schematic of PCB2 50
FIGURE5.10 Partial schematic of PCB2 50
FIGURE5.11 Partial schematic of PCB2...51
FIGURE5.12 Partial schematic of PCB2 52
FIGURE5.13 Partial schematic of PCB2 52
FIGURE5.14 Circuit diagram of PCB2...53
FIGURE5.15 PCB2...53
FIGURE5.16 Module1..54
FIGURE5.17 Module1 with layer 55
FIGURE5.18 Closed module1..55
FIGURE5.19 Module1 (actual) 56
FIGURE5.20 Module1 with one layer 56
FIGURE5.21 Module1 with two layers..57
FIGURE5.22 Module1 with three layers..57

FIGURE5.23 Module1 with four layers 58

FIGURE5.24 The completed module 58

1. Chapter 1 Introduction

1.1.Background

A light emitting diode (LED) is a small PN junction light emitting device. Due to its high luminous efficiency, long service life, small footprint, and many other advantages, it is bound to have many applications in general and particular lighting. [1]

The traditional LED stability test system consists of an integrating sphere, a spectrometer, and a current source. The integrating sphere collects all the photons emitted by the LED, obtains the optical power spectrum through the spectrometer, and then uses the Lambertian distribution approximation of the light emitted by the LED to calculate the brightness value of the LED. By periodically and continuously measuring the brightness value of the LED's brightness-time curve is obtained, which is used as the criterion for the stability of the LED. The traditional LED stability test system has high test accuracy. Still, the cost of the system is expensive (the cost of the spectrometer and high-precision current source is more than tens of thousands of HKDs), and a system can only test one LED at a time, and the test efficiency is lower. It is large and inconvenient to operate. Therefore, developing a low-cost, high-precision LED stability test system that can simultaneously test multiple LEDs is essential.

1.2.LED lighting principle

LED is a solid-state semiconductor device that can convert electrical energy into light energy. The LED chip is the most crucial part of the light-emitting diode camp. The LED chip is attached to the bracket, and the two ends of the bracket are connected with the power supply's positive and negative poles and are covered by epoxy resin. The LED chip consists of two semiconductors parts: a P-type semiconductor, where holes are dominant; the other is an N-type semiconductor, where electrons are dominant. A transition layer between these two parts of the semiconductor is called a PN junction. The PN junction

has the volt-ampere characteristics of forwarding turn-on, reverse turn-off, and reverse breakdown. When an LED is operated at a forward voltage, the action of an electric field drives electrons across the region of the N-type semiconductor to recombine with the holes of the P-type semiconductor. Since the electrons are in the conduction band energy level and the holes are in the valence band energy level, the energy level of the holes is smaller than that of the electrons. During the recombination process of electrons and holes, part of the energy is consumed, and the excess energy is dissipated in light and heat.
[1]

2. Chapter 2 Analysis of problem

2.1.Existing systems

Before I start the project, we already have a system which can finish a simple test. Its name is PeLED Aging Test System. Since we still need to develop it, we name the original system as PeLED Aging Test System 1.0 in the following narrative. The components of this system and my research and understanding of it are as follows

(1) Control center

Since the purpose of this equipment is to design a portable LED test device, the PeLED Aging Test System 1.0 uses a small single-chip microcomputer as the control center. Compared with the commonly used single-chip microcomputer, we chose Stm32 because of the following characteristics.

1. Super low price.
2. Lots of peripherals. STM32 has many peripherals and functions with a high degree of integration.
3. Excellent real-time performance. 84 interrupts, 16 programmable priority levels, and all pins can be used as interrupt input.
4. Excellent power consumption control. Each peripheral of STM32 has its own independent clock switch, which can reduce power consumption by turning off the clock of the corresponding peripheral.
5. Very low development cost. The development of STM32 does not require an expensive emulator, only a serial port is needed to download the code. W We only need a USB cable to download the program. [2]

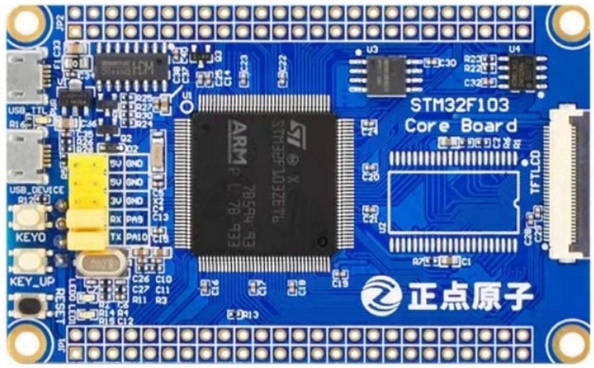


FIGURE2.1 Motherboard of STM32

(2) Interactive device

In order to facilitate operation and portability, the PeLED Aging Test System 1.0 uses a resistive screen as a human-computer interaction device to avoid the inconvenience caused by traditional connection to a computer. We chose the 3.5-inch resistive screen matched with stm32, and use this screen to input parameters and feedback test data and information, which is convenient for operation and observation in the experiment.

FIGURE2.2 Resistive touchscreen

(3) Photo detector

In order to measure the signal more conveniently, the PeLED Aging Test System 1.0 uses a photodiode as the detection device of the light signal, so that we can convert the light signal into an electrical signal for monitoring. Based on the following characteristics it possesses, we chose it as a detector.

1. Spectral response close to human eye sensitivity is attained without using visual-compensated filter.

2. Easy Operation.

3. Lower output-current fluctuations.

4. Excellent linearity

5. Low output fluctuations for light sources producing the same luminance at different color temperatures.[3]

FIGURE2.3 S13948-01SB

The figure below shows the relationship between current and illuminance. From the figure, we can clearly see that its linearity is very good.

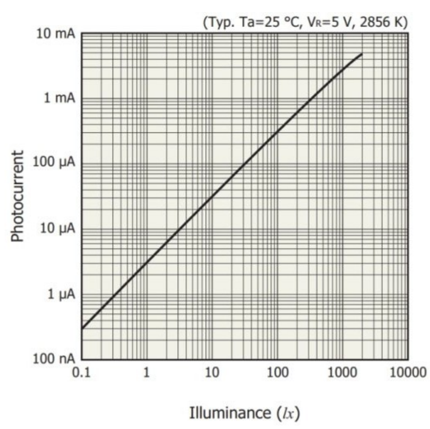


FIGURE2.4 Photocurrent VS. Illuminance

(4) Sampler

AD7606 is an analog-to-digital data acquisition chip with 16-bit, 8-channel simultaneous sampling and sampling rate of 200ksPS per channel. AD7606 can use a single 5V power supply with on-chip filtering and high input impedance. It can be used in power line monitoring and protection of multi-phase motor control, instrumentation and control, multi-axis positioning, data acquisition and other systems. We use this to detect the electrical signal from the photo detector to reflect the current brightness of LED.[4]

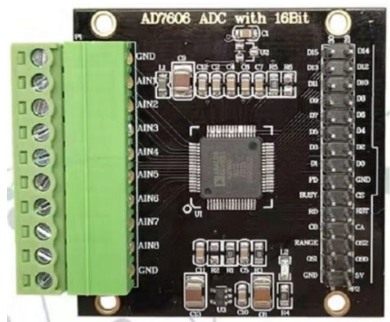


FIGURE2.5 AD7606 module

(5) Power supply

The PeLED Aging Test System 1.0 choose DAC8830 module as the power supply system, DAC8830 is a single, 16-bit, serial input, output voltage digital-to-analog converters (DAC) operating from a 3V to 5V power supply. And it has some features. Its linearity is really good, the failure rate is really low, and the noise is really low as well. In the range of -40 degrees Celsius to 85 degrees Celsius, its settling rate is very fast. At the same time, its output is not buffered, which helps to reduce the power consumption of his runtime, and can also reduce the errors introduced by the buffer.[5]

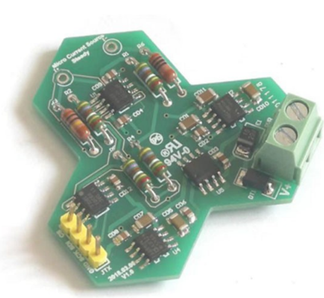


FIGURE2.6 Power supply module

(6) Software

To control the test and power supply, the software of the PeLED Aging Test System 1.0 has function shown as below. It mainly contains two modes.

The first is Test Mode. It can control the current and the test by read the parameters the user input in the txt file before the test. After enter test mode, PeLED Aging Test System 1.0 will automatically read input parameters from /INPUT/INPUT.txt. The user may edit following parameters: Device area (cm2), Current density (mA/cm2), Test interval (s), User name, Directory name, File name (.txt) and endpoint. If parameters are correct user can use the LED screen to click “Continue” button on the right hand to enter the test. Test will be automatically performed and save data to /[User name]/[Directory name]/[File name] instantly. And the data will be saved automatically after end of the test.

The second is USB Mode. PeLED Aging Test System 1.0 apply a 128GB SD card as storage medium. STM32 board can be used to emulate a SD card reader.

The user can edit input parameters or save test data through this mode.

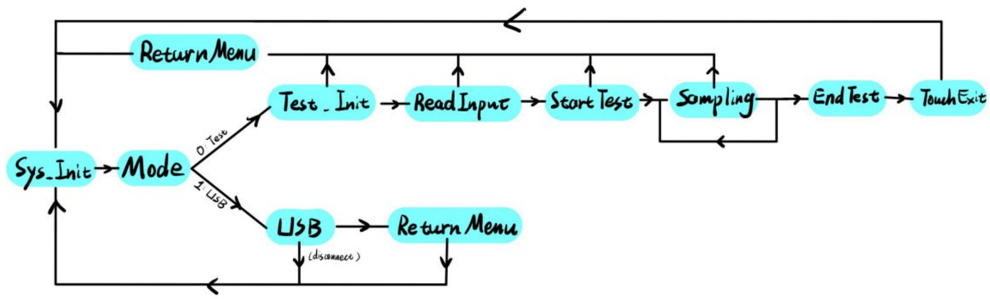


FIGURE2.7 Function intro & logic of PeLED Aging Test System 1.0

2.2.Analysis of problem

2.2.1.Power supply system

Current devices can only provide a maximum current of 5mA, while the LEDs under test in our lab are rated at around 6mA or 7mA. There are even LEDs on the market with voltage ratings above 10 mA. Therefore, our current power supply cannot meet the most basic requirements. So we plan to increase the range of supply current. Strive to able to reach 50 mA.

2.2.2.Software system

In the current control, we must manually input the current by reading and writing the SD card before the experiment, making every investigation very troublesome. We must read the SD card in advance and input the current every time the experiment is performed, and once the device is in the experimental stage, we cannot change the input, and the card must be re-write and re-read. Therefore, we decided to improve this problem and change the setting of the current value to input on the resistance screen. In this case, we only need to go back to the setting interface to re-input the present, and if the set current needs to be changed, there is no need to reconnect the computer. It can realize independent operation from the computer during use. In this way, the dependence on the computer is effectively reduced, which is equivalent to increasing the flexibility of the device and providing users with more convenient use conditions.

2.2.3.Package

In the process of using, we often have the situation that the device cannot run, the system reports errors, and so on. After continuous investigation and research, we found that wiring stability is a significant factor in ensuring the correct operation of the equipment. So we decided to make the whole system a PCB. PCB (Printed Circuit Board) is indispensable in production and life as well as in industrial manufacturing. As a support for electronic components and a carrier for electrical connection with electronic components, PCB avoids manual wiring errors due to the consistency of printing. The production process can ensure the quality of electronic equipment, improve labor productivity, reduce costs and facilitate maintenance through automatic insertion or installation, automatic welding and automatic detection of electronic components. Therefore, making the circuit into a PCB can effectively mitigate problems such as unstable line connection and manual wiring errors, significantly improving the device's convenience and optimizing the user experience.[6]

3.Chapter 3 PeLED Aging Test System 2.0

3.1.An increase in the number of channels

In PeLED Aging Test System 1.0, we only have one power supply channel and one detection channel, which does not allow us to use the maximum capability of our equipment. The measurement of each LED takes several hours. In this case, the measure of multiple LEDs takes several days. In addition, the numerical connection circuit needs to be manually modified. This time brings much time to our batch experiments—a burden and waste of time. Therefore, according to the upper limit of the monitoring capability of the AD7606, we changed the test channel to eight so that we could measure 8 LEDs simultaneously. At the same time, to meet the measurement conditions of 8 LEDs, we need eight power supply channels, so we also expand the power supply channels to 8. In this way, our measurement capability has been increased by eight times, and our efficiency has been dramatically improved.

3.2.0-10mA current range circuit

Since the current rated current of the LED in the laboratory is less than 10mA and requires high precision, we choose 10mA as the maximum value of the current provided by the power supply circuit. The circuit we have chosen contains the following main chips and primary functions.

The chip AMS1117 its primary function is voltage conversion. The circuit voltage input value we chose is 12V, but the power supply voltage of the data chip on the board is 5V or 3.3V, so we will need a voltage conversion function to convert the 12V voltage to 5V or 3.3V. The entire board can then be powered using only one external power connector.[7]

The chip AD8227 is a low-cost, wide-supply-voltage range instrumentation amplifier that requires only one external resistor to set the gain, ranging from 5 to 1000. The device is suitable for many different voltages. Because the chip has a wide input range and its output is rail-to-rail, the signal can take full advantage of the supply rail. Since the input range can also be below the negative supply voltage, we can put the size signal close to the ground without the need for dual power supplies. The device operates in the voltage range of ±1.5 V to ±18 V supplies (2.2 V to 36 V single supply). The robust inputs of the AD8227 are designed to interface with actual sensors. In addition to having a wide operating voltage range, it can handle voltages beyond the supply rails. For example, when powered from a ±5 V supply, voltages up to ±35 V at the input are guaranteed not to damage the device. The minimum and maximum input bias current characteristics facilitate open circuit detection.[8]

The chip AD8554 is a quad amplifier with rail-to-rail input and output swing capability, all guaranteed to operate from a single 2.7 V to 5 V supply. The AD8554 offers feature advantages previously only available with expensive auto-zero or chopper-stabilized amplifiers. With the Analog Devices' circuit topology, these zero-drift amplifiers combine low cost with high precision without needing external capacitors. The AD8554 has an offset voltage of only 1 μV, and an offset voltage drifts about 0.005 μV/°C, which making it ideal for applications where error sources are not tolerated. These devices have near-zero drift over the operating temperature range, making them highly beneficial to temperature, position, pressure sensors, medical devices, and strain gage amplifier applications. Rail-to-rail input and output swing capability makes both high- and low-side detection easy.[9]

3.3.10-50mA current range circuit

For larger rated current LEDs, we choose a power supply circuit with a maximum supply current of 50ma. In this circuit, we choose the chip DAC8830 to cooperate with the 50mA constant current source that the chip LT1466L carries. Some of the schematic diagrams are as follows.

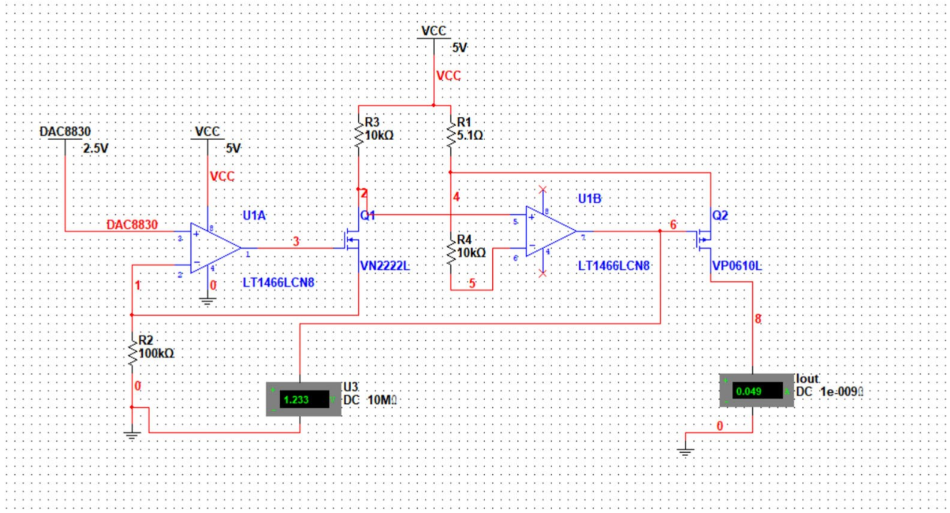


FIGURE3.1 Parts of schematic

The LT1466L are dual bipolar operational amplifiers that combine rail-to-rail input and output operation with precision specifications. With a patented technique, both input stages of the LT1466L/LT1467L are trimmed: one on the negative supply and the other on the positive supply. The resulting 83dB minimum common-mode rejection is much better than other rail-to-rail input op-amps. The minimum open-loop gain for a 10k load is 400V/mV, virtually eliminating all gain errors. Operation is specified for 3V, 5V, and ±5V supplies, which is same with other element in the circuit. [10]

The chip DAC8830 can carry out numerical control voltage output, LT1446 cooperates with the transistor VN2222L to form a constant current source, and the signal output by DAC8830 enters the LT1466L chip, as the input voltage, according to the calculation formula below.

$$I_{out} = \frac{V_{DAC8830}}{51\Omega} \tag{3.1}$$

The output current range can be calculated as 10-50mA according to the voltage range of 0-2.5V provided by the DAC8830. This feature can meet our needs for the power supply range. At the same time, the DAC8830 is a 16-bit DAC (digital-to-analog conversion) chip, which means that 16-bit binary data can be transmitted at a time. That is, the minimum value is 0, and the maximum value is 2 to the 16th power, which is 65536, which means that our minimum current accuracy is 0.7uA. Thus, it can meet our need for precision.

3.4.Development of software

3.4.1.Function of current input

Regarding the problem of the current input we mentioned before, we have upgraded this function in PeLED Aging Test System 2.0. The current input method we used before is to use the USB to connect to the computer and use the SD card to write and read, write the set current value into the SD card through the computer, and then extract it during the test. This method is very troublesome because every input change has to be performed by the computer. It means that if we find any problems with the setting current during the experiment, we must immediately terminate the experiment and find a computer to modify the assignment. This is a great hindrance to us being able to use the device conveniently. Therefore, we changed the way of current input to input through a resistive screen.

In order to be able to set the current value through the resistance screen, we have added new digital input functions such as CH8set(), current value setting functions such as Currentset(), and serial communication functions such as USART2_Send_Data(). We use the digital input function to complete the human-computer interaction of the current value input. We use the current setting function's output to complete the numerical value and string conversion function. At the same time, according to the set communication protocol, use stm32 to send the set value string through the serial communication function and use the power supply system to receive the corresponding set value string to achieve the control effect of stm32 on the power supply system.

For better human-computer interaction, we have added the current range selection interface, the current setting value interface, the current setting value input interface, and the current setting value checking interface to the system. Each interface is shown below.

Since 0-10mA is no different from how 10-50mA is set, we only use 0-10mA as an example in the description below.

First, we will enter a current range selection interface after entering the test mode. In this interface, we must select the current range we need. There are two options: “0-10mA” and “10-50mA”. Assuming that we currently select 0-10mA as our current range, we will click “0-10mA” on the left to set the current value.

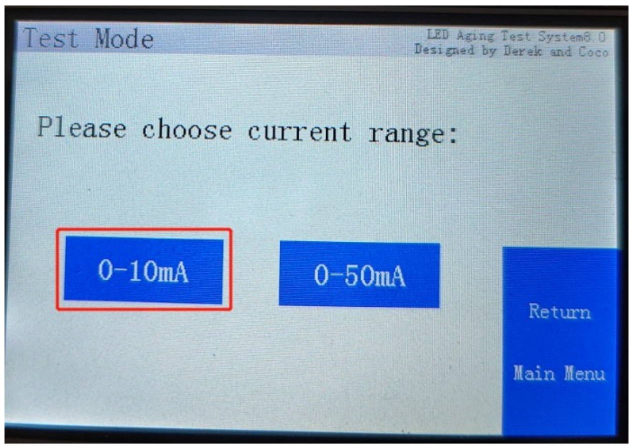


FIGURE3.2 Interface of current range selection

After entering the setting interface, we will see the current range we selected, “0.008-10.000mA” at the top of the interface, which can help us check whether it is in the correct setting interface. After checking, we can select the channel we need to set. A total of 8 channels can be selected, and from “CH1” to “CH8” each channel is a separate current that can be set separately. Suppose we need to set the current of the sixth channel. We need to click on the area where “CH6” is located to enter.

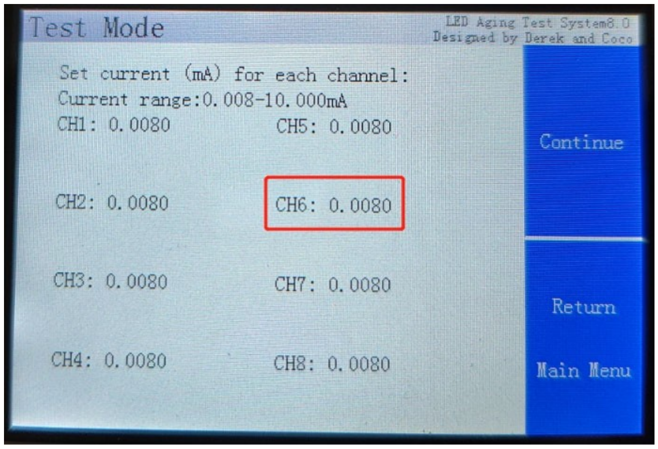


FIGURE3.3 Interface of the current setting value (before settle)

After entering, we will first see four values above, namely “CH”, “V”, “Length”, and “I”. Among them, “CH” represents the current channel, which helps us determine the accuracy of the set channel. “V” represents the voltage signal to be transmitted. It should be noted here that this voltage value only represents the voltage signal corresponding to the current value, that is, the signal that needs to be transmitted to the power supply circuit, not the voltage value output by the actual power supply circuit. This voltage value is only used as a check. The specific value does not affect our setting as long as the voltage value here is positive. “I” represents the current value that we have currently set.

Regarding the current value setting, we only need to use the keyboard below to click the corresponding number. Since this value is converted from a string, the distinction between decimal points cannot be completely accurate. Therefore, we need to use “Length” in the setting. “Length” indicates that the setting of the current number of digits has been completed, as shown in the figure. As shown in the figure, the currently displayed value of 3 means that the setting of the first three digits of the “I” value has been completed. Taking the figure below as an example, the first three digits are “3.2”. With the help of “Length”, we can determine which digit we are entering. If there is a misplaced input, we need to click “DEL” to delete it. After completing the setting, click “OK” to return to the previous, current value setting interface.

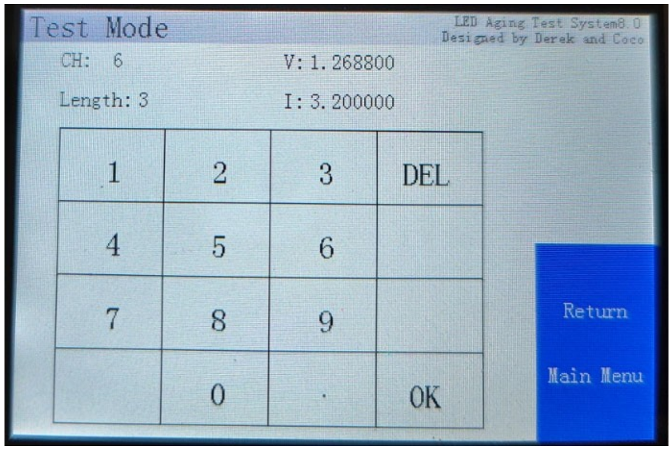


FIGURE3.4 Interface of the current setting value input

Repeat the above steps and we can complete the settings of all channels. If there are unneeded channels, there is no need to make any changes. After setting, we can see the current values corresponding to the completed 8 channels in the setting interface. After checking, click "Continue" to enter the following voltage confirmation interface.

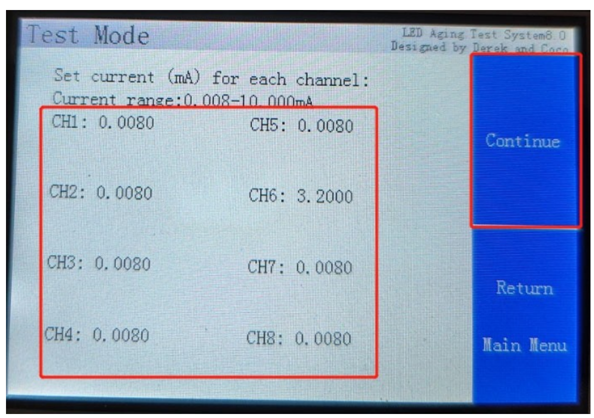


FIGURE3.5 Interface of the current setting value (after settle)

The existence of the voltage confirmation interface is to check whether all voltages are positive and send data to the corresponding power supply module through the serial port. After completing all checks, click "Continue" to enter the testing phase.

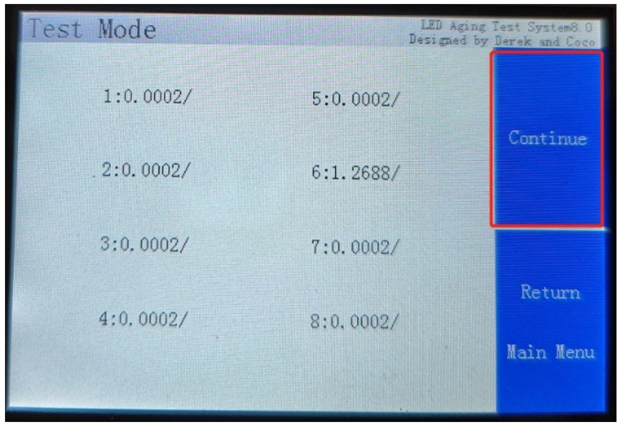


FIGURE3.6 Interface of the current setting value checking

3.4.2.Development of testing interface

Since we have set up a total of 8 power supply channels, we need to display all eight channels in the test session. However, due to the limitation of the interface size, we only draw a graph for channel 1, and the other seven channels only display account for the current brightness of the initial brightness percentage. At the same time, we added the data storage path reading at the top, through which we can find the location of the tested data storage more quickly.

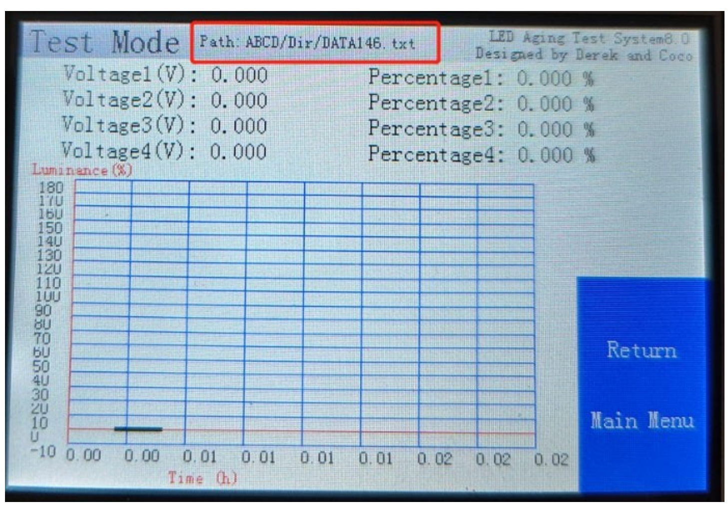


FIGURE3.7 Interface of the current setting value checking

3.4.3.The detail of code

The changes in our code in this part of the programming mainly add new functions. The following is a detailed description of the relevant function code. The first is the CH8set function.

First, we draw the primary border of the screen and continue the button, use the LED_Clear function to set the interface background to white, the DrawReturnMenuButton function to draw the lower right corner of the interface to return to the main menu button, and the DrawBar function to draw the upper border. The POINT_COLOR and BACK_COLOR parameters set the font color and background color of the following “Continue” button. LCD_Fill sets the background fill color and fill area. The LCD_ShowString function sets the font size, length, and text content of the “Continue” button. PONIT_COLOR and BACK_COLOR set the font color and background color of the other text that follows.

```
void CH8set(void)
{
  u8 key;

  LCD_Clear(WHITE);
  DrawReturnMenuButton();
  DrawBar(0); //0: test

  POINT_COLOR=WHITE;
  BACK_COLOR=BLUE;
  LCD_Fill(390,24,480,170,BLUE);
  LCD_ShowString(435-8*4,90,8*8,16,16,"Continue");
  POINT_COLOR=BLACK;
  BACK_COLOR=WHITE;
```

FIGURE3.8 Part of the code for function CH8set

Next, we set the interface display content, including some tips and the current value of each channel. We use the LCD_ShowString function to set the font size, position, length, and content of the text that needs to be displayed on the page.

```
LCD_ShowString  (30 ,40,280,16,16, "Set current (mA) for each channel:" );
LCD_ShowString  (30 ,60,240,16,16, "Current range:0.008-10.000mA" );

LCD_ShowString  (30 ,80, 240,16,16, "CH1:" );
LCD_ShowString  (30 ,140,240,16,16, "CH2:" );
LCD_ShowString  (30 ,200,240,16,16, "CH3:" );
LCD_ShowString  (30 ,260,240,16,16, "CH4:" );
LCD_ShowString  (200,80, 240,16,16, "CH5:" );
LCD_ShowString  (200,140,240,16,16, "CH6:" );
LCD_ShowString  (200,200,240,16,16, "CH7:" );
LCD_ShowString  (200,260,240,16,16, "CH8:" );
```

FIGURE3.9 Part of the code for function CH8set

Next is screen reading. We use the while loop to continuously trigger the screen sampling operation, read the click position delay_ms function to set the delay, and the key is used for screen calibration. tp_dev.scan is a screen scan function. If the condition function is reached, if the x-axis coordinate tp_dev.x[0] and y-axis coordinate tp_dev.y[0] of the tapped screen position are smaller than the screen width lcddev.width and the screen length lcddev.height respectively, enter the next cycle. The next-level cycle is divided into two cases according to the position of the x-axis coordinates, one is CH1, CH2, CH3, CH4 on the left side of the screen, and the other is CH5, CH6, CH7, CH8 on the right side of the screen. After the second-level condition selection, enter the third-level selection. At this time, the screen selected at the second level is divided into four areas from top to bottom according to the y-axis, corresponding to different channels. The entire condition selection function allows us to enter the channel that is being shocked, continue to complete the current setting below, and enter the Currentset function.

```
while(1)
{
    delay_ms(10);

    key=KEY_Scan(0);//触屏校准键
    tp_dev.scan(0); //扫描触摸屏.0,屏幕扫描;1,物理坐标;
      if(tp_dev.sta&TP_PRES_DOWN)         //触摸屏被按下
    {
        if(tp_dev.x[0]<lcddev.width&&tp_dev.y[0]<lcddev.height)
        {
            if((tp_dev.x[0]>390)&&(tp_dev.x[0]<480)&&(tp_dev.y[0]<170)&&(tp_dev.y[0]>24)) break;
            else if(tp_dev.x[0]>20&&tp_dev.x[0]<150){
                if(tp_dev.y[0]>40&&tp_dev.y[0]<100){      chc=1; inputlen=0;
                }else if(tp_dev.y[0]>100&&tp_dev.y[0]<160){chc=2;inputlen=0;
                }else if(tp_dev.y[0]>160&&tp_dev.y[0]<220){chc=3;inputlen=0;
                }else if(tp_dev.y[0]>220&&tp_dev.y[0]<280){chc=4;inputlen=0;
                }
            }else if(tp_dev.x[0]>150&&tp_dev.x[0]<280){
                if(tp_dev.y[0]>40&&tp_dev.y[0]<100){      chc=5;inputlen=0;
                }else if(tp_dev.y[0]>100&&tp_dev.y[0]<160){chc=6;inputlen=0;
                }else if(tp_dev.y[0]>160&&tp_dev.y[0]<220){chc=7;inputlen=0;
                }else if(tp_dev.y[0]>220&&tp_dev.y[0]<280){chc=8;inputlen=0;
                }
            }
            currentset();
        }
    }
```

FIGURE3.10 Part of the code for function CH8set

The Currentset function allows us to enter the required current value. We first set the two additional local variables, “vol” and “k”, and set the top border and return key as in CH8set.

```
void currentset(void)
{
  float vol;
  int k=0;
  u8 key;
  LCD_Clear(WHITE);
  DrawBar(0);
  DrawReturnMenuButton();
    POINT_COLOR=BLACK;//设置字体为黑色
```

FIGURE3.11 Part of the code for function currentset

Next, we use the LCD_ShowString function to set the content to be displayed, including the set channel number “CH”, the current-voltage transmission value “V”, the current set value I, and the current set current length “Length”. We use the LCD_ShowxNum function to display the currently selected channel “chc” to ensure correct settings. At the same time, use the LCD_ShowxNum function to list the numbers 1-9 on the keyboard, the delete key “DEL” and the confirmation key “OK”. Finally, use the LCD_DrawLine function to draw lines to draw the borders and grid lines of the numeric keyboard.

```
LCD_ShowString(200,30,50,16,16,"V:");
LCD_ShowString(30,60,50,16,16,"Length:");
LCD_ShowxNum(70-3,115-5,1,1,24,0);
LCD_ShowxNum(150-3,115-5,2,1,24,0);
LCD_ShowxNum(230-3,115-5,3,1,24,0);
LCD_ShowString(280+10,115-5,35,24,24,"DEL");//删除
LCD_ShowxNum(70-3,170-5,4,1,24,0);
LCD_ShowxNum(150-3,170-5,5,1,24,0);
LCD_ShowxNum(230-3,170-5,6,1,24,0);
LCD_ShowxNum(70-3,225-5,7,1,24,0);
LCD_ShowxNum(150-3,225-5,8,1,24,0);
LCD_ShowxNum(230-3,225-5,9,1,24,0);
LCD_ShowxNum(150-3,280-5,0,1,24,0);
LCD_ShowString(230,280-5,3,1,16,".");
LCD_ShowString(280+15,280-5,15,24,24,"OK");//确认
LCD_ShowString  (30 ,30,240,16,16, "CH:" );
LCD_ShowxNum(70,30,chc,1,16,0);
LCD_ShowString  (200  ,60,240,16,16, "I:" );
```

FIGURE3.12 Part of the code for function currentset

```
LCD_DrawLine(30,90,350,90);
LCD_DrawLine(30,145,350,145);
LCD_DrawLine(30,200,350,200);
LCD_DrawLine(30,255,350,255);
LCD_DrawLine(30,310,350,310);
LCD_DrawLine(30,90,30,310);
LCD_DrawLine(110,90,110,310);
LCD_DrawLine(190,90,190,310);
LCD_DrawLine(270,90,270,310);
LCD_DrawLine(350,90,350,310);
```

FIGURE3.13 Part of the code for function currentset

Next, we initialize the global variable “inputcur”, set all 0s, and set the second digit to the decimal point “.”, so that the initial value of the “inputcur” variable becomes “0.00000000”. Next comes the screen sampling, and we continue to enter the loop using the while function. The x-coordinate and y-coordinate in the drawing keyboard correspond to the set number or function button one by one, and the variable “digital” representing the number and the variable “mod” representing the function will be assigned values when the corresponding position is pressed down. Then assign a value to the “vol” variable and enter the anjian function.

```
for(k=0;k<10;k++)
{
  inputcur[k]='0';
}
inputcur[1]='.';
  while(1)
  {
      //LCD_ShowxNum(190,120,flag,1,24,0);
      delay_ms(10);

      key=KEY_Scan(0);//触屏校准键
      tp_dev.scan(0); //扫描触摸屏.0,屏幕扫描;1,物理坐标;
      if(tp_dev.sta&TP_PRES_DOWN)          //触摸屏被按下
      {
          if(tp_dev.x[0]<lcddev.width&&tp_dev.y[0]<lcddev.height)
          {
              if(tp_dev.x[0]>30&&tp_dev.x[0]<110){
                  if(tp_dev.y[0]>90&&tp_dev.y[0]<145){      digital=2;
                  }else if(tp_dev.y[0]>145&&tp_dev.y[0]<200){digital=5;
                  }else if(tp_dev.y[0]>200&&tp_dev.y[0]<255){digital=8;
                  }

                  //else if(tp_dev.y[0]>280&&tp_dev.y[0]<320){}
              }else if(tp_dev.x[0]>110&&tp_dev.x[0]<190){
                  if(tp_dev.y[0]>90&&tp_dev.y[0]<145){      digital=3;
                  }else if(tp_dev.y[0]>45&&tp_dev.y[0]<200){digital=6;
                  }else if(tp_dev.y[0]>200&&tp_dev.y[0]<255){digital=9;
                  }else if(tp_dev.y[0]>255&&tp_dev.y[0]<310){digital=1;
```

FIGURE3.14　Part of the code for function currentset

```
                }
            }else if(tp_dev.x[0]>190&&tp_dev.x[0]<270){
                if(tp_dev.y[0]>90&&tp_dev.y[0]<145){       digital=4;
                }else if(tp_dev.y[0]>145&&tp_dev.y[0]<200){digital=7;
                }else if(tp_dev.y[0]>200&&tp_dev.y[0]<255){digital=10;
                }
                else if(tp_dev.y[0]>255&&tp_dev.y[0]<310){digital=11; //.
                }
            }else if(tp_dev.x[0]>270&&tp_dev.x[0]<350){
                if(tp_dev.y[0]>90&&tp_dev.y[0]<145){       mod=2; //DEL
                }else if(tp_dev.y[0]>255&&tp_dev.y[0]<310){mod=4; //OK
                }
            }

        }
        vol=anjian();
        cur=(vol+0.00300287)*9.058/3.6; //V=(3.6/9.058)*(A+c)-0.00300287
        LCD_ShowFloat   (220  ,30,   vol,5,16);
    }
    delay_ms(50);
  }
  f_close(&fil);
delay_ms(5);
  }
```

FIGURE3.15   Part of the code for function currentset

The anjian function mainly implements the corresponding function according to the clicked number or function button. First, set the variables “n”, “i”, “digitalch” and “inputvol” as auxiliary. When the length variable “inputlen” representing our input is less than or equal to 6, we choose the switch function to enter different situations based on the “digital” variable. For example, before we input 1, the value of the “digital” variable is 1, and it enters the case1. At this time, the position of the current length of the “inputcur” variable is set to the number “0” and the “inputlen++” statement is used to increase the length by 1. to enter the following setting. The cycle goes back and forth to complete the set of all values.

```c
float anjian(void)
{
  int n=0;
  int i=0;
  int digitalch;
  float inputvol;
  if(inputlen<=6){
  switch(digital){
    case 1:
      {inputcur[inputlen]='0';
        inputlen++;
        digital=0;
      break;}
    case 2:
      {inputcur[inputlen]='1';
        inputlen++;
        digital=0;
      break;}
    case 3:
      {inputcur[inputlen]='2';
        inputlen++;
        digital=0;
      break;}
```

FIGURE3.16 Part of the code for function anjian

```c
    case 4:
      {inputcur[inputlen]='3';
        inputlen++;
        digital=0;
      break;}
    case 5:
      {inputcur[inputlen]='4';
        inputlen++;
        digital=0;
      break;}
    case 6:
      {inputcur[inputlen]='5';
        inputlen++;
        digital=0;
      break;}
    case 7:
      {inputcur[inputlen]='6';
        inputlen++;
        digital=0;
      break;}
    case 8:
      {inputcur[inputlen]='7';
        inputlen++;
        digital=0;
      break;}
```

FIGURE3.17 Part of the code for function anjian

There are several cases for the functional variable “mod”. The first is that if the value of “mod” is 4, it means that the setting is completed, and “inputcur” will be re-initialized to wait for the following setting and return to the CH8set function. If the value of “mod” is 2, it means to delete the function, use to clear the current position of “inputcur” and use the “inputlen--” statement to reduce the current set length by one. Moreover, initialize the value of “mod” back to 0. Finally, use the atof function to convert the string “inputcur” into a variable of type float and store it in the “inputcurnum” variable. Furthermore, display the variable “inputcur” representing the current and the variable “inputlen” representing the current set length on the screen. After that, the corresponding voltage value “inputvol” is calculated and output as the function return value.

```
if (mod==4)
      {
      for(n=0;n<10;n++)
         {
           inputcur[i]='0';
         }
         mod=0;
         CH8set();
      }
      if(mod==2)
      {if(inputlen){
      inputcur[inputlen]='\0';
         inputlen--;
      inputcur[inputlen]='0';

         mod=0;}
      }
           inputcurnum=atof(inputcur);
           LCD_ShowFloat    (220   ,60,   inputcurnum,5,16);
           LCD_ShowFloat    (90  ,60,   inputlen,0,16);
      inputvol=(3.6/9.058)*(inputcurnum)-0.00300287;
      return inputvol;
}
```

FIGURE3.18 Part of the code for function anjian

After the function anjian is executed, we return to the function currentset. After the obtained voltage value, the current set current is calculated in reverse, and the currently set voltage value “vol” is displayed in the corresponding position on the screen. Thus, the function currentset function is completed. Execute and return to the CH8set function.

```
            vol=anjian();
            cur=(vol+0.00300287)*9.058/3.6; //V=(3.6/9.058)*(A+c)-0.00300287
            LCD_ShowFloat   (220  ,30,  vol,5,16);
        }
        delay_ms(50);
    }
    f_close(&fil);
  delay_ms(5);
    }
```

FIGURE3.19 Part of the code for function currentset

At this point, the switch function will be entered, and the current value of the corresponding channel will be set according to the previously selected channel. For example, the previously selected channel is 1, then enter case 1, and assign the current to the current variable “cur1” of channel 1 to set the value of the variable “cur”.

```
switch(chc){
  case 0:
  {
    break;
  }

  case 2:
  {
    cur2=cur;
    chc=0;
    break;
  }
  case 3:
  {
    cur3=cur;
    chc=0;
    break;
  }
  case 1:
  {
    cur1=cur;
    chc=0;
    break;
  }
  case 4:
  {
    cur4=cur;
    chc=0;
    break;
  }
  case 5:
  {
    cur5=cur;
    chc=0;
    break;
  }
  case 6:
  {
    cur6=cur;
    chc=0;
    break;
  }
  case 7:
  {
    cur7=cur;
    chc=0;
    break;
  }
  case 8:
  {
    cur8=cur;
    chc=0;
    break;
  }
```

FIGURE3.20 Part of the code for function CH8set

At this point, the switch function will be entered, and the current value of the corresponding channel will be set according to the previously selected channel. For example, the previously selected channel is 1, then enter case 1, and assign the current to the current variable “cur1” of channel 1 to set the value of the variable “cur”. Use the LCD_ShowFloat function to display the current value of each channel on the screen, and then click the continue button to end the loop and enter the “sendvol” function.

```
        LCD_ShowFloat   (70 ,80, cur1, 4 , 16);
        LCD_ShowFloat   (70 ,140, cur2,4,16);
        LCD_ShowFloat   (70 ,200, cur3,4,16);
        LCD_ShowFloat   (70 ,260, cur4, 4 , 16);
        LCD_ShowFloat   (240,80, cur5, 4 , 16);
        LCD_ShowFloat   (240,140, cur6,4,16);
        LCD_ShowFloat   (240,200, cur7,4,16);
        LCD_ShowFloat   (240,260, cur8, 4 , 16);
        delay_ms(10);
    }
    LCD_Clear(WHITE);
    sendvol();
    StartTest();
    f_close(&fil);

  delay_ms(5);
}
```

FIGURE3.21 Part of the code for function CH8set

Before executing the sendvol function, we need an auxiliary function my_strcat, which can piece together three strings into one, which is convenient for our later functions to send. Use the while loop function to assign a new value to the pointer when the string is not empty, thus completing the string concatenation. Finally the function returns the new string value.

```
char *my_strcat(char *str1, char *str2, char *str3)
{
    char *pt = str1;
    while(*str1!='\0') str1++;
    while(*str2!='\0') *str1++ = *str2++;
    while(*str3!='\0') *str1++ = *str3++;
    *str1 = '\0';
    return pt;
}
```

FIGURE3.22 The code for function my_strcat

In the sendvol function, we still set the basic screen settings first, then calculate the corresponding voltage value and use the sprintf function to convert the float format into a string format.

```
void sendvol(void)
{

  LCD_Clear(WHITE);
  DrawBar(0); //0: test
  DrawReturnMenuButton();

  POINT_COLOR=WHITE;
  BACK_COLOR=BLUE;
  LCD_Fill(390,24,480,170,BLUE);
  LCD_ShowString(435-8*4,90,8*8,16,16,"Continue");
  POINT_COLOR=BLACK;
  BACK_COLOR=WHITE;

      vol1=(3.6/9.058)*(cur1)-0.00300287;
      vol2=(3.6/9.058)*(cur2)-0.00300287;
      vol3=(3.6/9.058)*(cur3)-0.00300287;
      vol4=(3.6/9.058)*(cur4)-0.00300287;
      vol5=(3.6/9.058)*(cur5)-0.00300287;
      vol6=(3.6/9.058)*(cur6)-0.00300287;
      vol7=(3.6/9.058)*(cur7)-0.00300287;
      vol8=(3.6/9.058)*(cur8)-0.00300287;
      sprintf(b1,"%.4f",vol1);
      sprintf(b2,"%.4f",vol2);
      sprintf(b3,"%.4f",vol3);
      sprintf(b4,"%.4f",vol4);
      sprintf(b5,"%.4f",vol5);
      sprintf(b6,"%.4f",vol6);
      sprintf(b7,"%.4f",vol7);
      sprintf(b8,"%.4f",vol8);
```

FIGURE3.23 Part of the code for function sendvol

Use the auxiliary function my_strcat to concatenate the strings together, and use the USART2_Send_Data function to send the concatenated string through the serial port. So that the current source module can accept the data and process it.

```
d1=my_strcat(a1,b1,c1);
LCD_ShowString  (70 ,60,240,16,16, d1 );
USART2_Send_Data(d1,9);//通过串口1将接收到的固定长度字符发送出去

d2=my_strcat(a2,b2,c2);
LCD_ShowString  (70 ,120,240,16,16, d2 );
USART2_Send_Data(d2,9);

d3=my_strcat(a3,b3,c3);
LCD_ShowString  (70 ,180,240,16,16, d3 );
USART2_Send_Data(d3,9);

d4=my_strcat(a4,b4,c4);
LCD_ShowString  (70 ,240,240,16,16, d4 );
USART2_Send_Data(d4,9);

d5=my_strcat(a5,b5,c5);
LCD_ShowString  (240,60,240,16,16, d5 );
USART2_Send_Data(d5,9);

d6=my_strcat(a6,b6,c6);
LCD_ShowString  (240,120,240,16,16, d6);
USART2_Send_Data(d6,9);

d7=my_strcat(a7,b7,c7);
LCD_ShowString  (240,180,240,16,16, d7 );
USART2_Send_Data(d7,9);
```

FIGURE3.24 Part of the code for function sendvol

Finally complete the data transfer and click the continue button to end the while loop and enter the next link.

```
  while(1){
    tp_dev.scan(0);
    if(tp_dev.sta&TP_PRES_DOWN)
    {
      if(tp_dev.x[0]<lcddev.width&&tp_dev.y[0]<lcddev.height)
      {
        if((tp_dev.x[0]>390)&&(tp_dev.x[0]<480)&&(tp_dev.y[0]<170)&&(tp_dev.y[0]>24)) break;
      }
    }
    delay_ms(10);
  }

  f_close(&fil);

  delay_ms(5);
}
```

FIGURE3.25 Part of the code for function sendvol

3.5.Analysis of problem

However, in the actual construction, we found that due to the loss of the circuit formed by the LM chip and the power limitation, the maximum circuit load that cannot reach 50mA and can meet the set current condition is 100 ohms. Once it is more significant than 100 ohms, it will be limited by power. The rated current cannot be reached. Therefore we abandoned the use of this circuit.

4.Chapter 4 PeLED Aging Test System 3.0

4.1.10-50mA current range circuit

Based on the problems with PeLED Aging Test System 2.0, we started looking for a new 50mA power supply. At this point, we found that in order to achieve a higher load capacity, we need a more powerful circuit. Therefore, we found a constant voltage and constant current source composed of a buck circuit.

The constant voltage function is not involved in the current source we designed before because the maximum voltage we provide does not exceed 10V, and for laboratory LEDs, the voltage of 10V will not cause damage to the LED. Therefore, when the LED is just powered on, the resistance is considerable, and the current is small. At this time, in order to reach the rated current, the control terminal will increase the voltage to the maximum to supply power. The voltage value at this time is generally the maximum voltage that the power supply circuit can provide. However, if the maximum voltage is too large, the LED will be damaged, so when we choose a high-power circuit, we must consider the maximum withstand voltage of the LED. We must set a voltage upper limit for the LED as a guarantee on the basis of the original constant current power supply so as to ensure that the maximum voltage will not damage the LED reached the beginning.

The maximum supply voltage of the Buck circuit we selected is 36V, which is far greater than the maximum voltage of the LED known in our laboratory, so it is very necessary to set the upper limit of the voltage.

The power supply module can set the upper limit and rating of the voltage by pressing the button. The way it works is:

1. After the module is powered on, set the maximum voltage and rated current through the buttons.
2. Connect the LEDs correctly and press the button to start powering.

3. When the LED does not reach the rated current, it works in constant voltage mode. That is, the voltage is kept as the upper limit of the set voltage, and the operation is maintained at this voltage.

4. After the LED reaches the rated current, it works in the constant current mode. That is, the voltage is no longer the upper limit of the set voltage but maintains the state of the rated current.

4.2.Development of interface

Due to the change of the 50mA circuit, we no longer need to input the current value from the LED screen. We changed the corresponding interface to the text prompt of the current setting so that the user can click the “Continue” to proceed to the next step after the setting is completed.

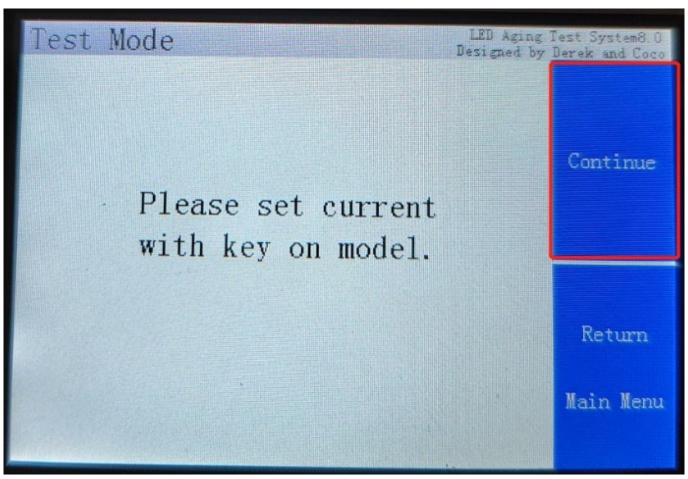


FIGURE4.1 Interface of the 10-50mA current setting reminder

4.3.Design of the shell

In order to better fix the various parts of the whole system, we are going to use containers to fix it, but due to the connection problems of various wires, we need to have enough connection space and a place to fix the circuit board. Considering the sturdiness and integrity of the casing, we chose 3D printing. 3D printing technology, also known as a rapid prototyping technology, of course, some scholars or experts also call it additive manufacturing technology. These technical means are mainly based on the digital model file, with the help of metal powder, plastic, and other materials, under the action of bonding, the technical means of constructing the structure of the object through layer-by-layer printing [11]. 3D printing technology does not need to use various mechanical equipment for processing like traditional mold making. However, a process in which virtual data is directly transformed into parts of various shapes. The advantage of 3D printing technology is that there are various forms of printed products, and in time to create more complex products, the cost of materials used will not increase significantly. The 3D printed solid model also does not need to be assembled, glued, and so on. Therefore, it can be seen that 3D printing technology has the characteristics of low cost, unlimited design space, no by-products, and an accurate physical model [12]. At present, in the field of scientific research or the production of models and parts, the use of this technology has been very mature, which has dramatically improved production efficiency and use efficiency. At present, there are many methods of 3D printing. The primary technology types are Fused Deposition Rapid Prototyping (FDM) [1], Light Solidification (SLA), 3D Printing (3DP, 3D Powder Bonding), Selective Laser Sintering (SLS), Layered entity manufacturing (LOM) [13], moldless mold manufacturing technology (PCM) and so on. Among them, photo-curing forming is the most studied method at present, and it is also a method with relatively mature technology. The printing material is the fundamental factor that restricts the development of 3D printing technology. There are many different technologies in 3D printing, but they are different in that the parts are created in different layers in the way of available materials. Different printing processes use different printing materials. There are more than 100 kinds of 3D printing materials, which can be divided into four categories: metal materials, ceramic materials, polymer materials, and composite materials. Commonly used materials are nylon glass fiber and polylactic acid. ABS resin, durable nylon materials, gypsum materials, aluminum materials, titanium alloys, stainless steel, silver-plated, gold-plated, rubber materials, etc. Compared with traditional materials, 3D printing materials are more environmentally friendly. In general, materials can be recycled and reused after use. [14] Due to the different functions of each module, we plan to assemble the modules in several parts.

4.3.1.Introduction to Modeling Software

Solidworks is a widespread 3D drawing software on the market. Solidworks is a top product in the CAD field of Dassault AG. Because of its powerful functions, Solidworks has become the world's most widely used design software. Solidworks software is a 3D design software developed based on the Windows operating system. It is widely used in production and teaching in various industries because of its excellent performance, such as high eases of learning, operability, and innovation. [11] Solidworks has three main features, easy to be learned, powerful function, and innovative technology, which can provide different design solutions, reduce errors in the design process and improve product quality. Solidworks provides an unparalleled feature-based solid modeling function, realizes the design of products through operations such as extruded cutting, and can realize 3D modeling functions. At the same time, the proposed model can also be exported to .stl .xt and other formats, and the model diagram can be converted into a binary code that can be recognized by the computer and then transmitted to the machine to realize the 3D printing function.

4.3.2.Part1

The first is part1 which contains 8 of 10-50mA modules. Since each module can be used independently, we put each module into a small box and put the small 8 small boxes (Module1) into a large storage compartment (Module2) so that as long as we leave a long enough connection line, we can pull out each module for use, so that we can operate without being limited to a small place for power supply. In order to be able to read more clearly, we changed all the lids of the box to be transparent so that the reading can be taken with the box closed.

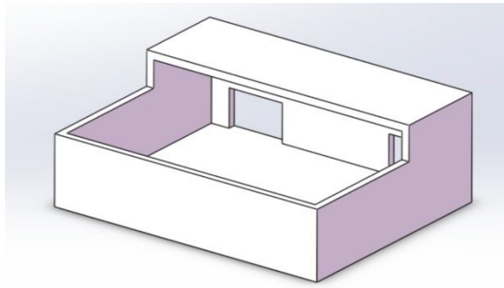


FIGURE4.2 Module1

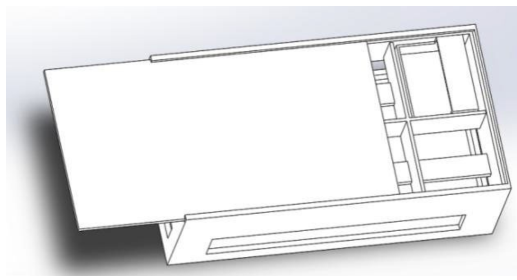


FIGURE4.3 Module2

The actual fixed effect is shown in the following figure.

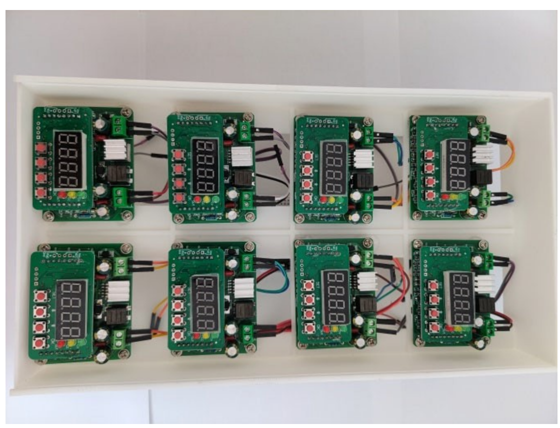


FIGURE4.4 Module2 (actual)

4.3.3.Part2

Due to the connection between stm32 and resistive screen, AD7606, 0-10mA module, we put stm32, resistive screen, AD7606, 0-10mA module in one box. In order to facilitate installation and subsequent replacement, we divide it into five layers of removable partitions, each module is placed on each layer, and cables are routed through the holes between the partitions. When it is fixed, the cover can be closed, and all modules can be fixed. Just leave the wires that need to be connected outside for use. Same as part 1, in order to be able to read more clearly, the lids of the box have also been changed to be transparent for the user to read the parameter when the box closed.

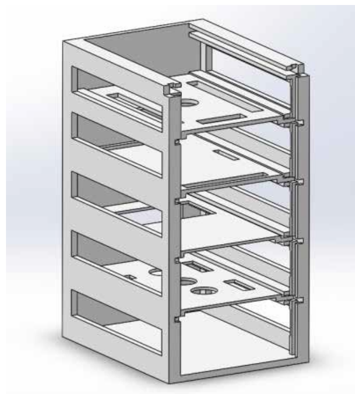


FIGURE4.5 Module3 (open)

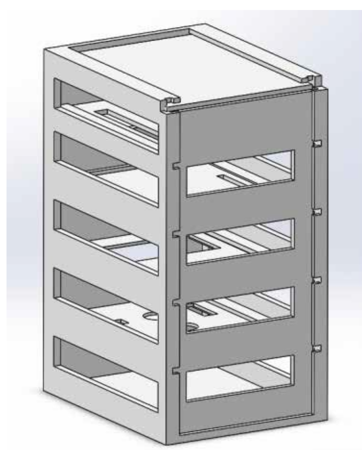


FIGURE4.6 Module3 (close)

The actual fixed effect is shown in the following figure.

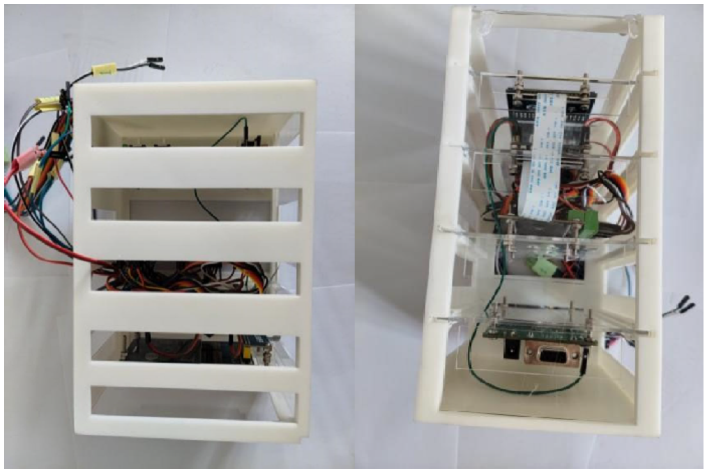


FIGURE4.7 Module3 (actual)

4.3.4.Part3

In our preliminary tests, we found that the photo detector was difficult to fix, so we made a fixing device to use with the LED fixing module. This consists of two small modules, a base that attaches to the LED fixing module (Module4) and a slot that holds the photo detector (Module5).

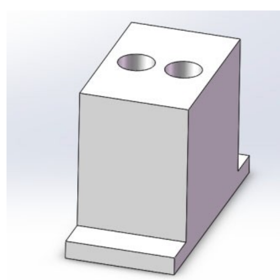


FIGURE4.8 Module4

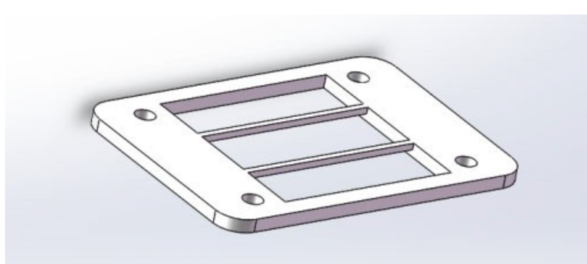


FIGURE4.9 Module5

The actual fixed effect is shown in the following figure.

FIGURE4.10 Module4 and module5 (actual)

In addition, because the tested parameters are LED light-emitting characteristics, the experiment has high requirements for ambient light. Therefore, in order to use the device under normal light-on conditions and not be affected by the light-emitting of the resistive screen, we actually built a holding box (Module6) to hold it.

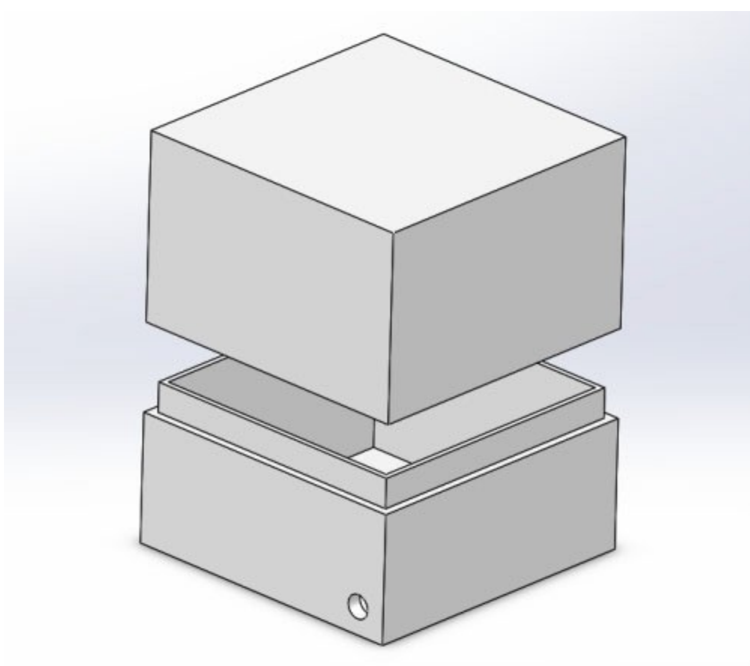


FIGURE4.11 Module6

4.4.Analysis of problem

The current system has no problems in use and can meet the requirements of use, but out of the need for simplicity, convenience and stability, we need to make the system into a PCB to reduce the volume and the probability of errors. During this process, we found that if the eight buck circuits are integrated on a PCB, the key operation will be very inconvenient. This seriously affects the experience of use. At the same time, due to the mismatch of the size of the power supply, in order to play the best operation effect of the buck circuit, we need an additional 36V power supply, which means that we need to increase the size of the entire system, which cannot be the same as before, unified use of 12V power supply. This will cause unnecessary trouble.

5.Chapter 5 PeLED Aging Test System 4.0

5.1.Development of 10-50mA power supply circuit

Combining the various power supply circuits we have done before, if we want to increase the load capacity, we need to increase the voltage of the power supply to the module, and if we want to use the 12V power supply to reduce the size and increase the convenience, we cannot drive a large load. We decided to use the buck circuit as a separate power supply module in this case. This decision is based on the following considerations. The first is that the buck circuit does not need resistive screen control and can be operated by buttons alone. In this case, we can power on the buck circuit alone without considering the operation of other circuits. This satisfies our condition for using the buck circuit alone.

Moreover, taking out the buck circuit separately means sharing a power supply with other circuits is not necessary. We can provide a power supply for the buck circuit alone. At the same time, due to the convenience of its independent operation, the buck circuit can be used when testing one or two LEDs, which can help us save the operation of the current setting. The big feature that the buck circuit can change the voltage and current setting values during operation also help us better studies a certain LED's influence on the supply voltage and current during the test process. Combining the above points, we decided to place the buck circuit separately as an auxiliary device.

For the power supply of 10-50mA, we decided to continue to use DAC8830 to complete, but considering the problem of insufficient load capacity before, we replaced the chip with OPA2277 and LM358 so that the circuit could provide more power.

5.2.PCB making

After completing the design of the circuit, we need to draw the circuit into a PCB. Due to the limitation of the inner diameter of the entrance of the operation box in the laboratory, we need to consider the volume of the PCB produced. After trying, we found that integrating the control center (stm32), sampler (AD7606), eight 0-10mA power supply circuits, and eight 10-50mA power supply circuits on one PCB will bring several problems. The first is the size issue. When all functions are integrated on one board, the resulting PCB will be very large, so if the outer shell is added, the operation box cannot be entered. The second is the new problem of accuracy. We all know that the production of PCB is not 100% correct. Even the correct schematic diagram and correct wiring will cause the PCB to fail to function correctly due to some unforeseen problems. Therefore, concentrating all functions on one PCB will have a greater possibility of failure, and it will be more challenging to troubleshoot the location of the failure point. Considering these two points, we decided to divide the PCB into three parts. The first is the first PCB, which will contain the control center (stm32) and sampler (AD7606). Because the wiring between the control center (stm32) and the sampler (AD7606) is very cumbersome, placing them on different PCBs will increase the possibility of wiring errors and increase the difficulty of operation. Concentrating on one PCB can not only meet the needs of functions but also simplify the complexity. At the same time, since the control center (stm32) and the sampler (AD7606) both use a 5V power supply, we can make them two modules share a power supply. Followed by the second PCB, we integrated 8 10-50mA circuits on this PCB because they have the same structure and the same power supply. This will make our layout tidier, and at the same time, only one signal transmission connection line is required between this PCB and the first PCB, which can effectively reduce the volume and simplify the connection of the entire circuit. Finally, there is the third PCB. Since the 0-10mA module is already a 0-10mA current source for eight channels, we don't need to make any additional changes to it. Just use it directly. And there is only one connection between it and the first PCB so that we can complete the entire device with only two connections between the three PCBs.

5.2.1.PCB1 (Control system and sampling module)

The function of our designed PCB1 is control and sampling. The reason for integrating these two functions on one PCB is that we want to reduce the connection between each

PCB as much as possible to achieve the effect of simple and easy operation. There are nine wires between the control center, stm32, and the sampling module AD7606, so if we separate them, we need to connect nine wires between the two PCBs. It is very complicated and unsightly. So after concentrating these two parts on one PCB, we can minimize board-to-board wiring. The schematic diagram is shown below.

First of all, it is the schematic diagram of the control part. Since the module we use is the stm32f103zet6 minimum system board of the ALIENTEK, the schematic diagram of this part is adapted from the schematic diagram of the stm32f103zet6 minimum system board of the punctual atom. [2] We removed some unused modules. For example, we removed SWD (Serial Wire Debug) because we have already completed the corresponding program and do not need to debug, so we removed this interface. In this way, we can reduce the volume and cost of the PCB produced

The first is the chip part of stm32f103zet6, which mainly includes the chip itself and the clock crystal oscillator. The Stm32 chip uses 3.3V voltage, the crystal oscillator is 8M, and the clock frequency is 32.768kHZ. At the same time, a coupling capacitor is configured to make the system more stable.

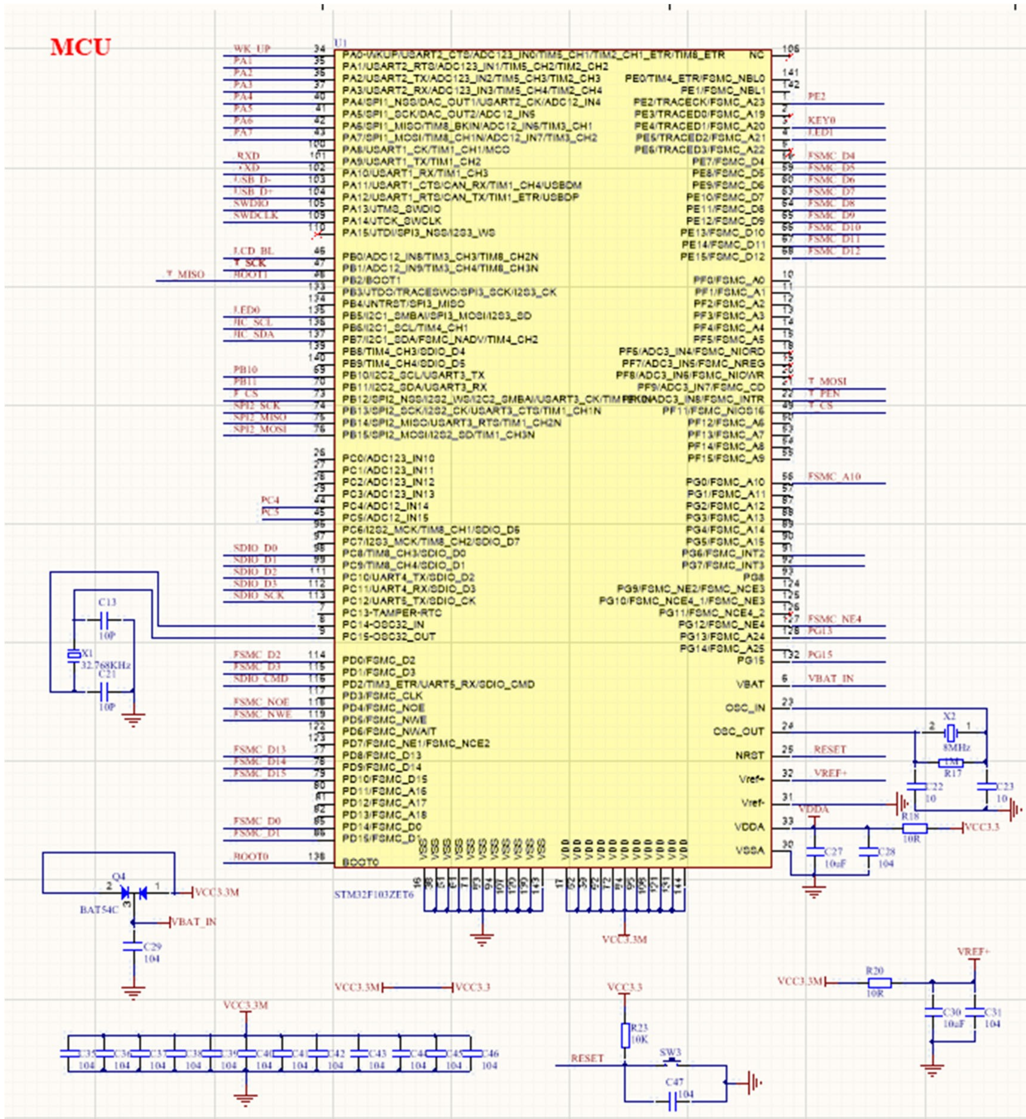


FIGURE5.1　Partial schematic of PCB1

Second, this figure includes the following parts. In the SD card part, we connect the card slot to the IO port of the stm32 to transmit data. For the M3 hole part, we reserve the M3 hole for later use of bolts. In the USB USART part, we use the CH340 chip to convert the signal from the USB TTL interface into a serial port signal transmission and transmit it to the stm32 through the two IO ports of the stm32 serial port 1, which can complete the program burning function.

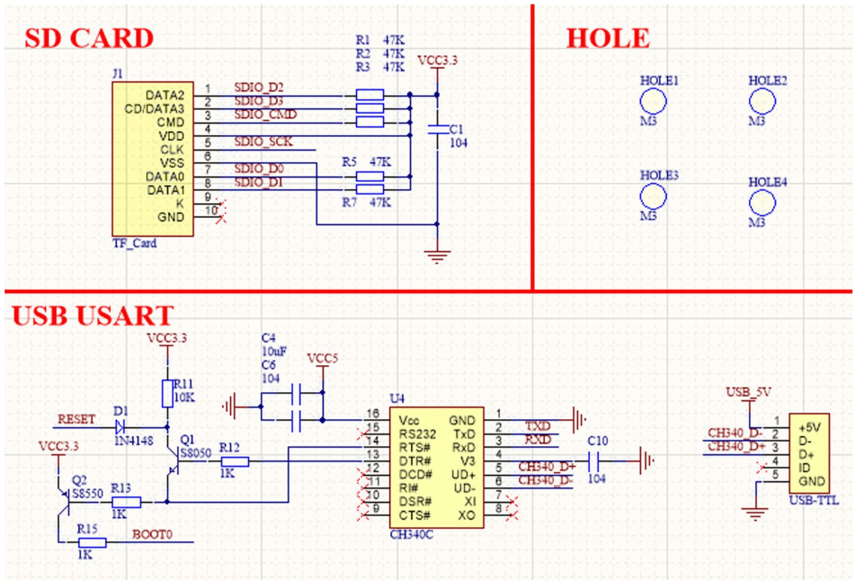


FIGURE5.2 Partial schematic of PCB1

The following picture includes the following parts. The key part, where the two keys are connected to the stm32 as a key input, this part is not used in the current design but is reserved for future system upgrades. The Boot part is used to change the program burning mode. The LED includes two functional LEDs and a power supply display LED. Through LED3, we can confirm that the circuit is in a regular power supply, and the other two LEDs are currently reserved for the same key functions. The LCD part is the 32P cable connection port with the LCD resistive screen. The FLASH part is used to store the code. The EEPROM (Electrically Erasable Programmable Read-Only Memory) part helps us erase and reprogram the program. The last USB SLAVE part is the interface between the board and the computer, which can be connected to the computer to read the content on the SD card directly.

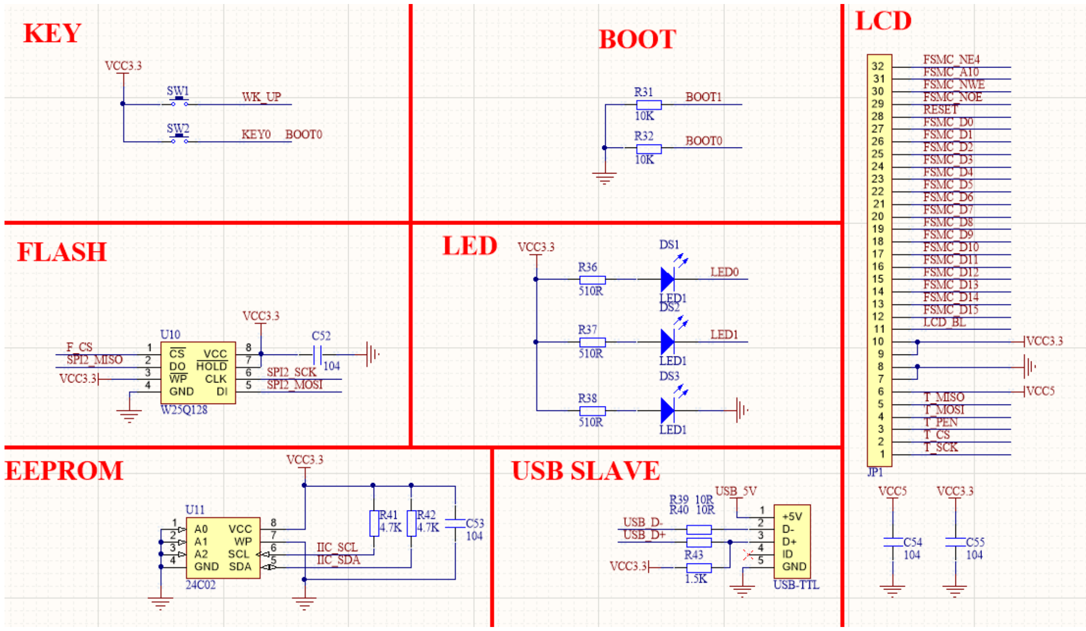


FIGURE5.3 Partial schematic of PCB1

Then there is the sampling part. Since we are using the AD7606 module of Kangwei Technology, our schematic diagram uses the schematic diagram of Kangwei Technology. [4] We mainly made changes to the wiring between the AD7606 chip and the stm32.

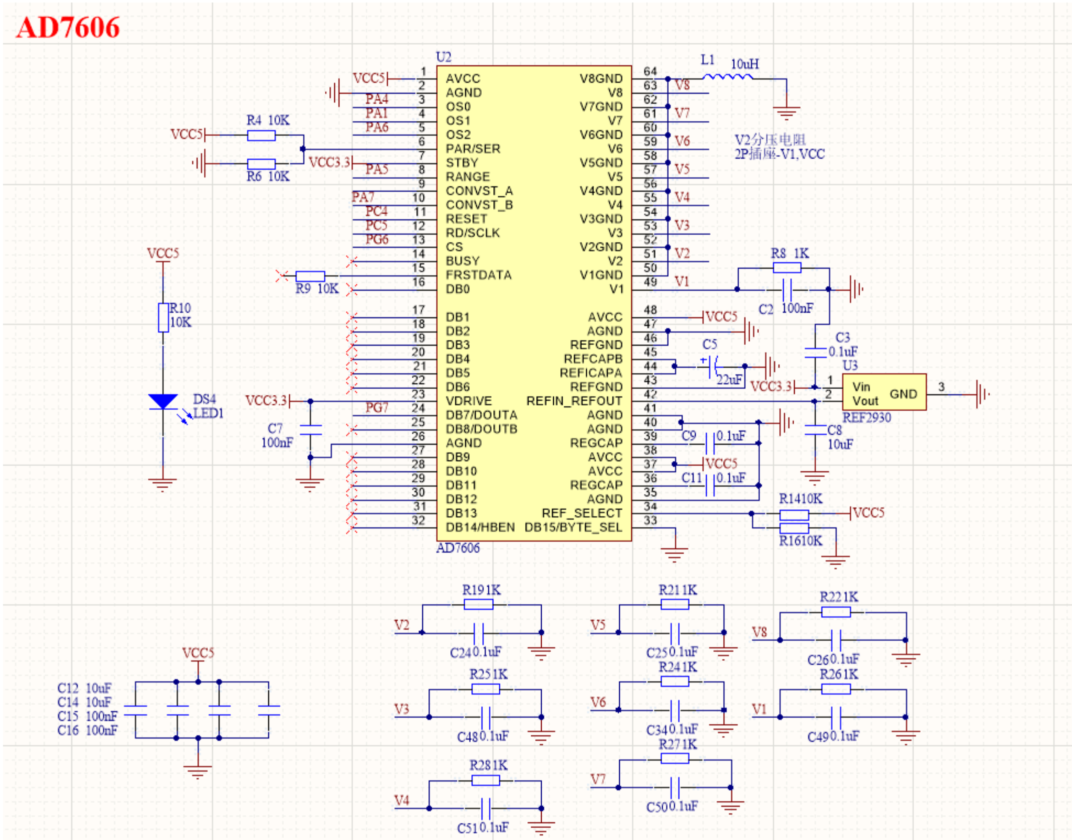


FIGURE5.4 Partial schematic of PCB1

The last part is the power supply. In order to be able to supply power with other PCB boards, we changed the input of the power supply from 5V to 12V. At the same time, in order to provide a 3.3V power supply to the stm32, we also have a 3.3V output.

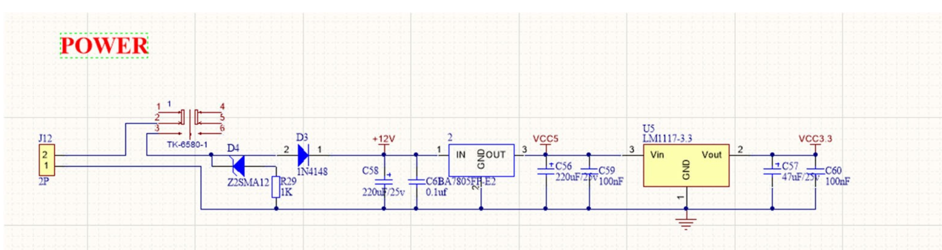


FIGURE5.5 Partial schematic of PCB1

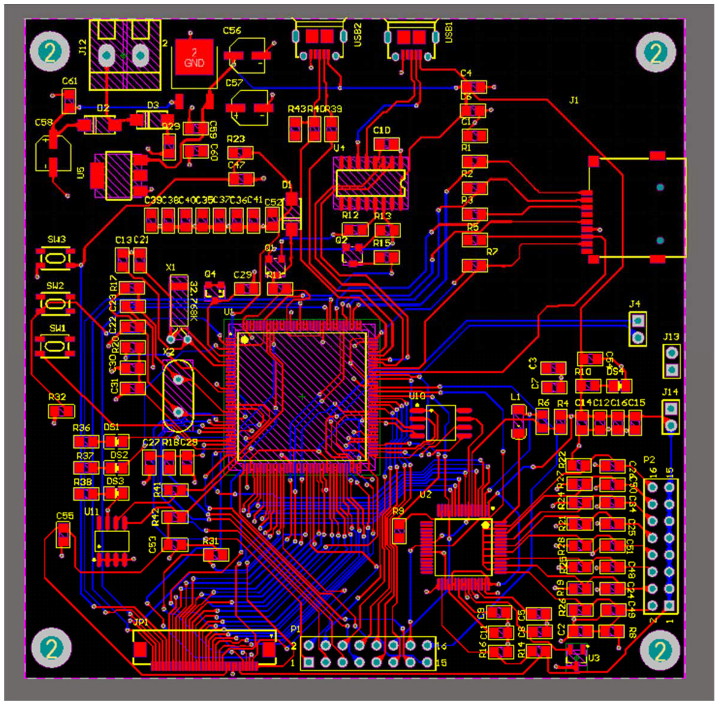


FIGURE5.6 Circuit diagram of PCB1

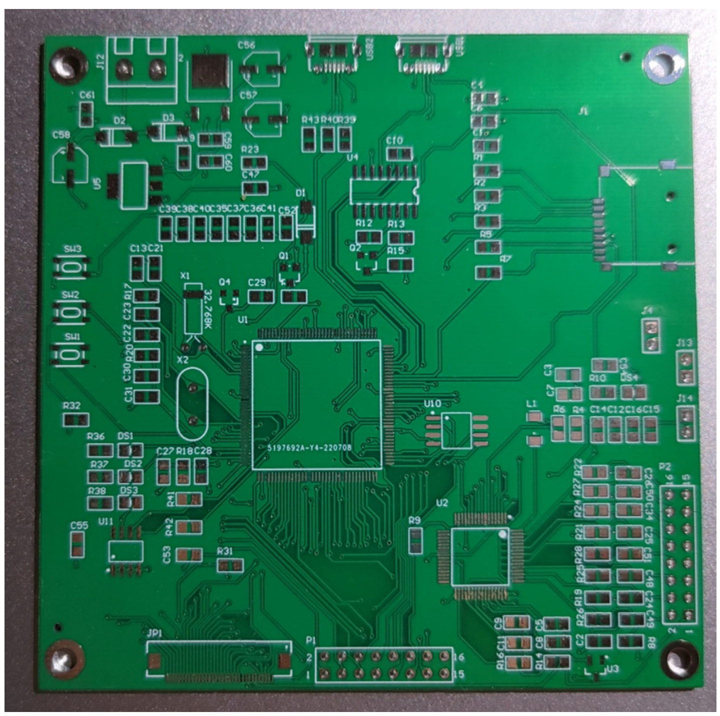


FIGURE5.7 PCB1

5.2.2.PCB2(10-50mA power supply system)

The function of the PCB2 we designed is a power supply module, which can provide an adjustable current of 10-50mA. Moreover, since we are an 8-channel constant current source and need to set a different current for each channel, we need to have eight independent power supply systems. We chose the DAC8830. We need at least ten wires between the stm32 and the 8 DAC8830s to transmit data in the limit state. This way, there will be at least ten connecting lines between PCB2 and PCB1. Therefore, in order to reduce the connection with other PCBs, we add an stm32 chip to this module so that we can let the stm32 chip of the power supply system and the stm32 chip of the control system realize serial communication so that, in the simplest case, only need The output transmission function can be realized by connecting the serial port sending end of the control center and the serial port receiving end of the power supply module. The detailed schematic is shown below.

The first is the stm32f103zet6 chip that is controlled. Like PCB1, we only configure the relevant essential functions, the voltage is 3.3V, the crystal oscillator is 8M, and the clock frequency is 32.768kHZ.

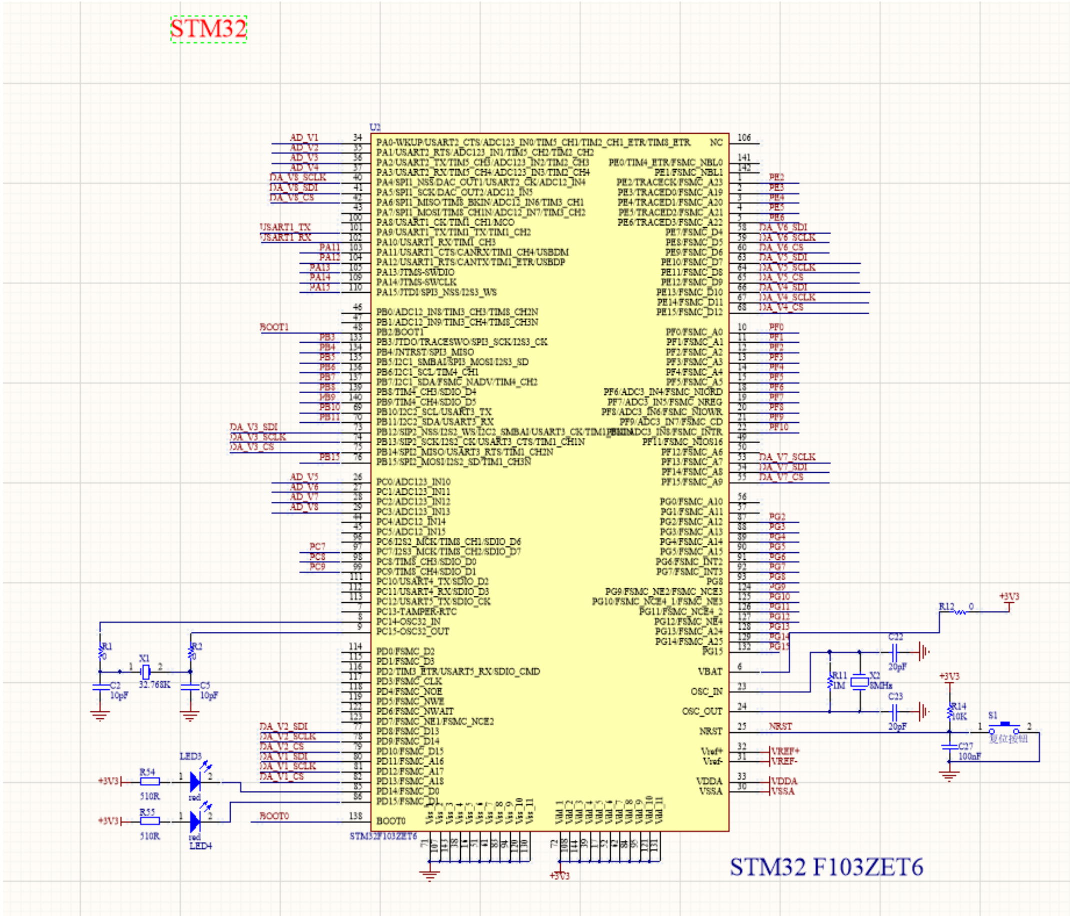


FIGURE5.8 Partial schematic of PCB2

Like PCB1, we use the serial port to burn the program, so we continue to use the CH340 chip to connect the USB and serial ports.

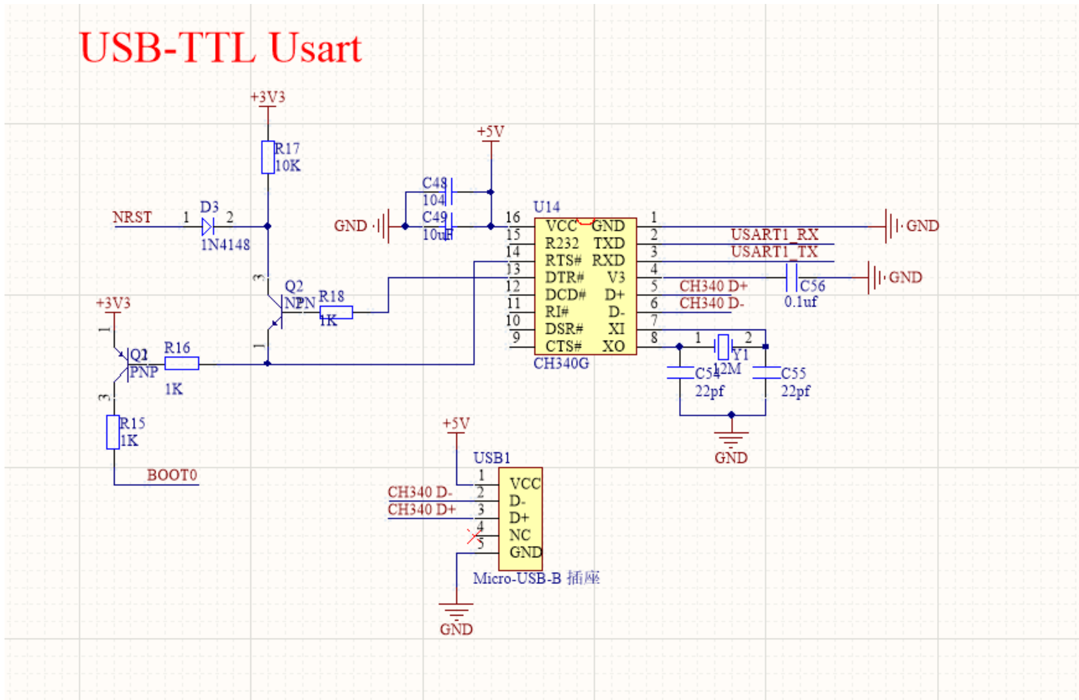


FIGURE5.9 Partial schematic of PCB2

Because we used the stm32f103zet6 of the control center as the controller of the DAC8830 in the process of building the module before, and the PCB2 we made is Using a separate stm32f103zet6, our program has been slightly changed, so we added the header of Boot0 and Boot1 to prevent accidents. In order to prevent the phenomenon that the program cannot be burned when there is a problem.

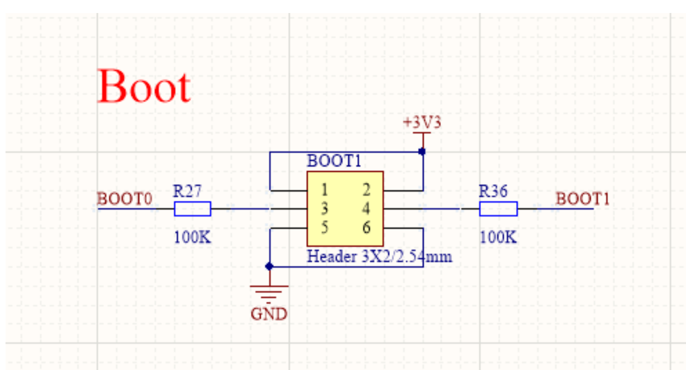


FIGURE5.10 Partial schematic of PCB2

Our adjustable constant current circuit mainly includes regulating and constant current parts. The adjustment part is to change the constant current source current size by adjusting the voltage output by the DAC8830. When the voltage of the sampling resistor changes, it is directly fed back to the inverting input terminal of the operational amplifier OPA2277. The operational amplifier amplifies the difference between it and the non-inverting input voltage, and the output controls the base current of the MOS tube and changes the internal resistance of the MOS tube. Therefore, the voltage drop between the S pole and the D pole is changed so that the sampling resistor's voltage remains unchanged to achieve the purpose of constant load current. The load current is fed back in real-time by the sampling resistor. When the load current becomes more extensive, the voltage at the inverting input terminal of the operational amplifier is higher than the voltage at the non-inverting input terminal, and the operational amplifier outputs a low level, which turns off the MOS tube and reduces the load current. When the load current becomes small, the voltage of the inverting input terminal of the operational amplifier is lower than the voltage of the non-inverting input terminal, and the operational amplifier outputs a high level, which makes the MOS transistor conduct, and the load current is large. Therefore, the load current finally achieves a constant stable current through the real-time feedback of the sampling resistor.

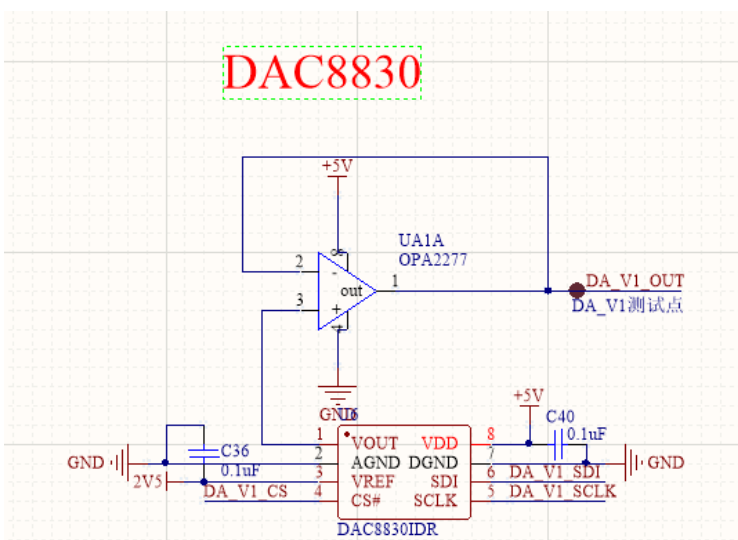


FIGURE5.11 Partial schematic of PCB2

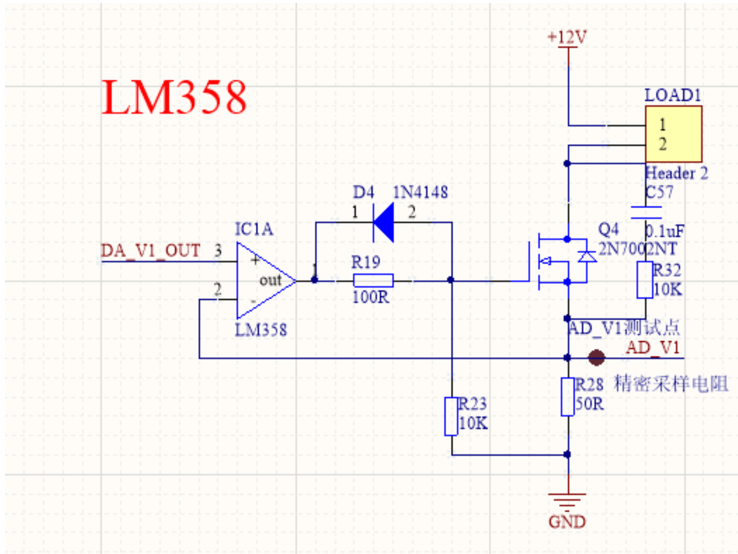


FIGURE5.12 Partial schematic of PCB2

The final current of 12V, 5V, and 3.3V is the same as PCB1 because the constant current part needs 12V voltage and other modules need 5V or 3.3V voltage so that 12V is converted into 5V and 3.3V, but due to the DAC8830's voltage The reference voltage is 2.5V, and we use the ADR421 to convert the 5V voltage to 2.5V.

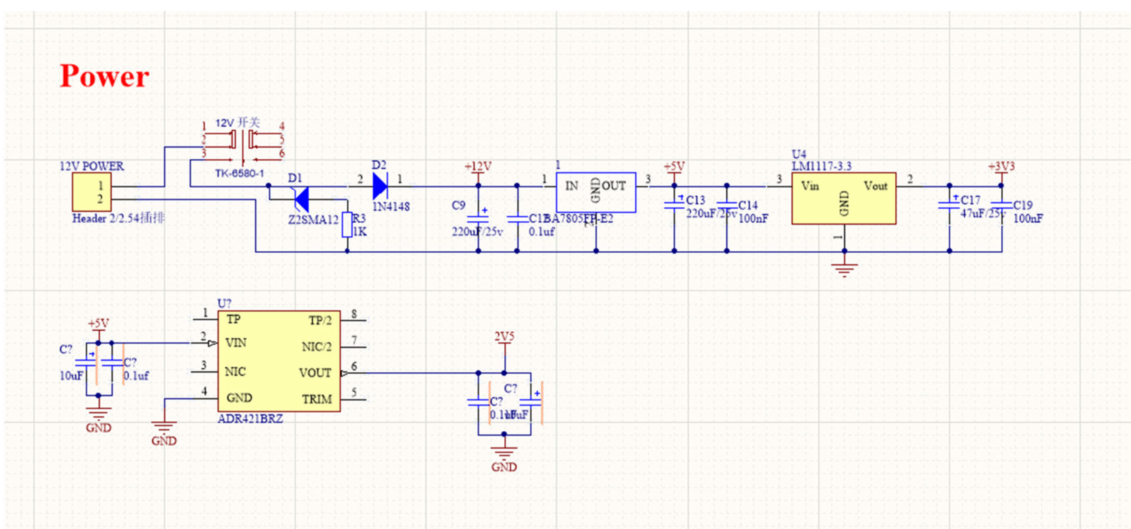


FIGURE5.13 Partial schematic of PCB2

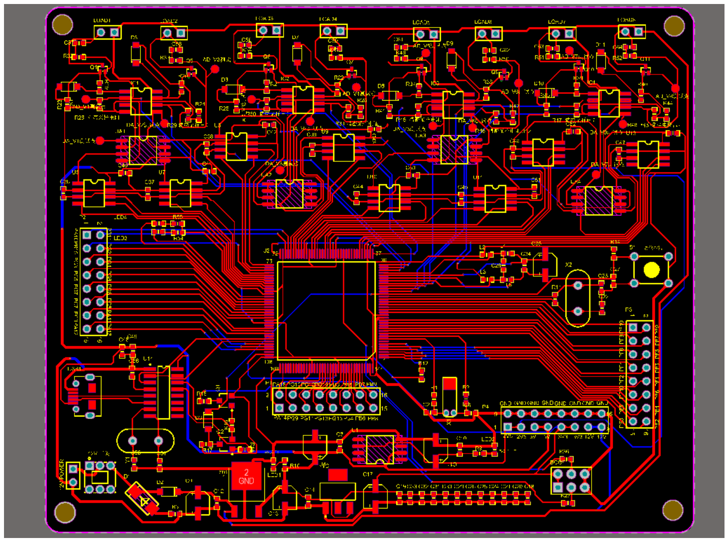


FIGURE5.14 Circuit diagram of PCB2

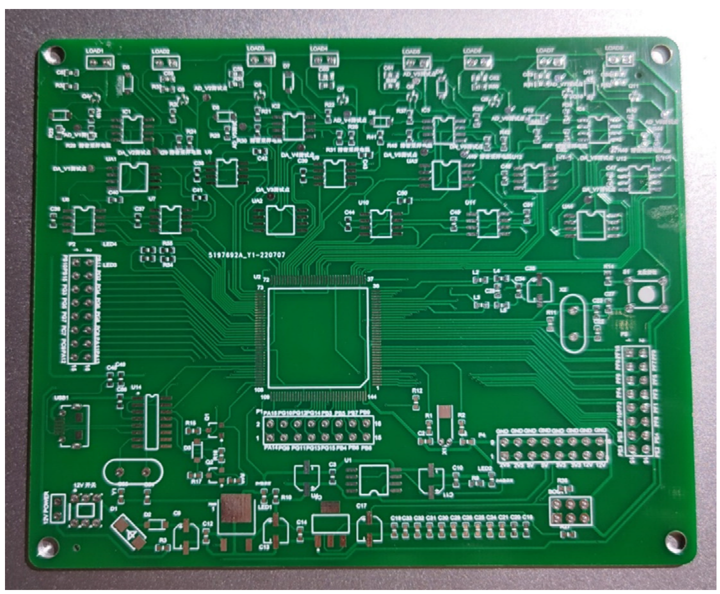


FIGURE5.15 PCB2

5.3.3D printing

For the PCB that has been made, we need a container to install and fix several PCBs so that we can directly take out the box for testing each time without wiring between the PCBs.

Since we only have three PCBs this time, we choose to combine all of the PCBs and modules in one shell. We still divide the whole box into several layers according to the style of the previous design and then fix different PCBs on different layers so that we can quickly put them in, and if we need to replace them later, it is also convenient to remove them and replace. The problem with the previous model was that the base set for the photodiode was minimal, so it was not easy to find every time. Therefore, this time we have added a storage compartment, which can put the unused base in it so that it can be stored more conveniently and can reduce the occurrence of the loss of the base.

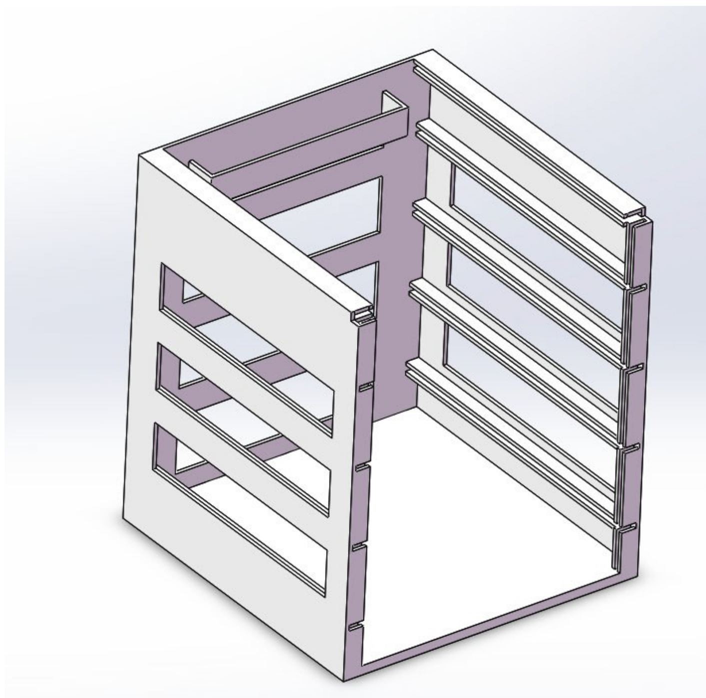


FIGURE5.16   Module1

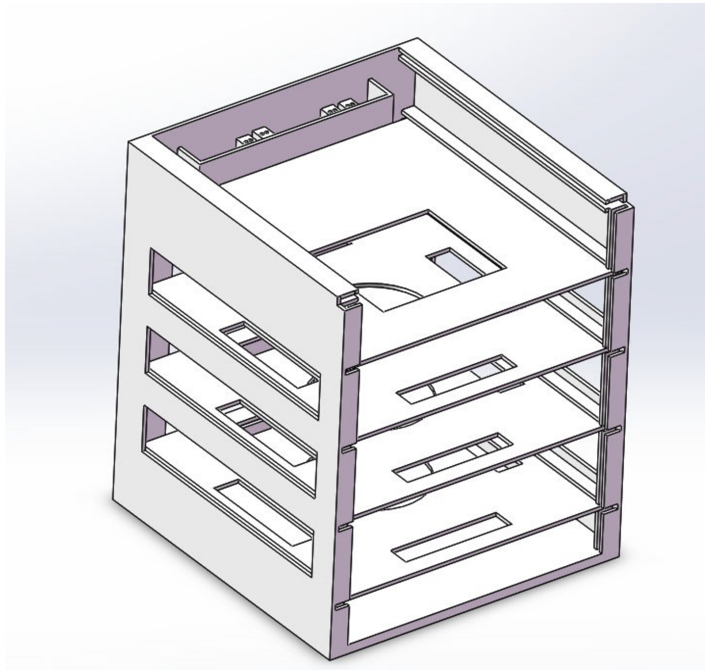


FIGURE5.17   Module1 with layer

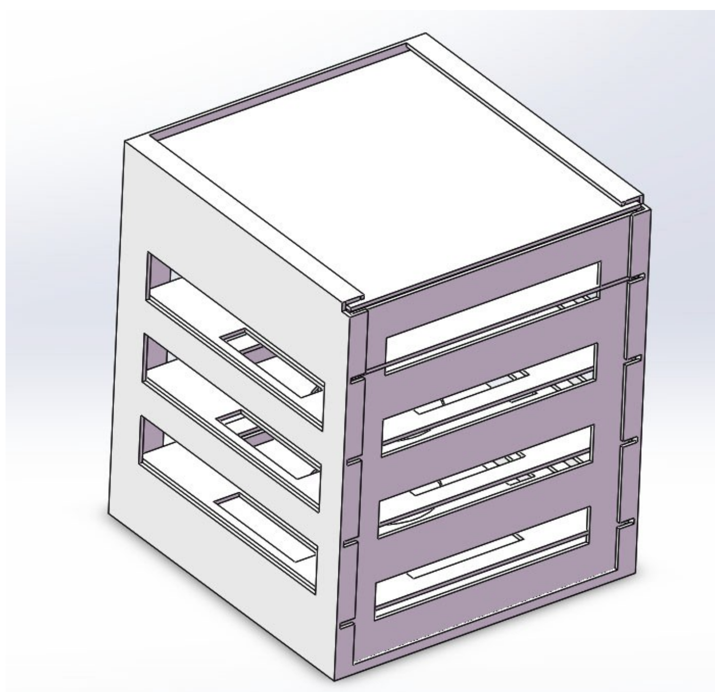


FIGURE5.18   Closed module1

The actual assembly completed renderings are as follows.

FIGURE5.19　Module1 (actual)

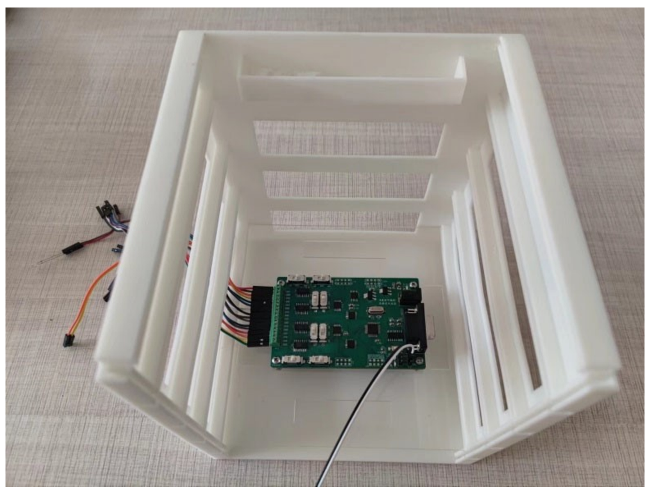


FIGURE5.20　Module1 with one layer

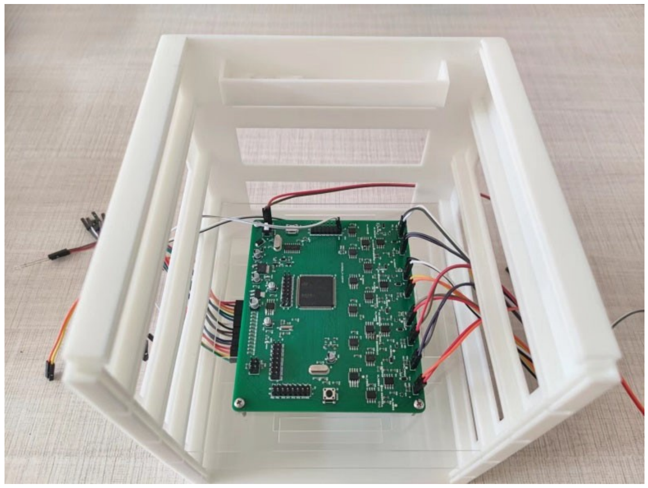


FIGURE5.21　Module1 with two layers

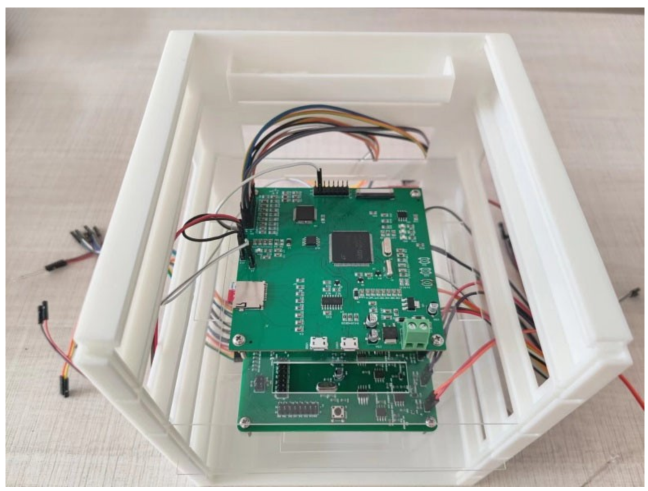


FIGURE5.22　Module1 with three layers

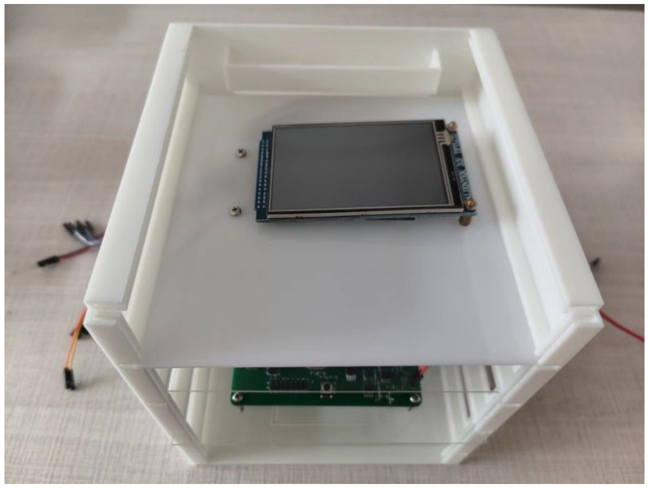


FIGURE5.23　Module1 with four layers

FIGURE5.24　The completed module

6. Chapter 6 Conclusions

The general content of this project is as described above, and the specific operation manual, wiring method, part of the source code, and others are all in the appendix. In this project, we started with a simple test device, namely PeLED Aging Test System 1.0, and studied the problems in each stage, improved the modules in the current stage, continuously improved the system functions, and upgraded the software system and hardware system at the same time. Finally, achieve what we want to accomplish.

References

1. W. Yan, “Investigation on surface-Luminance Measurement of Light-Emitting Diodes and Development of Luminance Analysis System,” Xiamen University, 2017
2. STMicroelectronics, “High-density performance line ARM-based 32-bit MCU with 256 to512KB Flash, USB, CAN, 11 timers, 3 ADCs, 13 communication interfaces”, stm32f103zet6 datasheet, Sep. 2009
3. Hamamatsu, “Photo IC diode”, S12948-01SB datasheet, May. 2019.
4. Analog Devices, “8-/6-/4-Channel DAS with 16-Bit, Bipolar Input, Simultaneous Sampling ADC”, AD7606 datasheet.
5. Texas Instruments, “16-Bit, Ultra-Low Power, Voltage-Output Digital-to-Analog Converters”, DAC8830 datasheet, Feb. 2019.
6. “Printed Circuit Board”, [Online], Available: https://baike.baidu.com/item/PCB/146397
7. Advanced Monolithic Systems, “800mA Low Dropout Voltage Regulator”, AMS1117 datasheet.
8. Analog Devices, “Wide Supply Range, Rail-to-Rail Output Instrumentation Amplifier”, AD8227 datasheet.
9. Analog Devices, “Zero-Drift, Single-Supply, Rail-to-Rail Input/Output Operational Amplifiers,” AD8554 datasheet.
10. Linear Technology, “Micro power Dual/Quad Precision Rail-to-Rail Input and Output Op Amps,” LT1466 datasheet.
11. X. Chang and G. Shen, “Application of 3D printing technology in college innovation and entrepreneurship education,” Science & Technology Vision, 2021(13):123-125.

[12]X. Wang, “Research on security risk prevention and control using 3D printing technology,” People's Public Security University of China, 2020.

13. H. Lu, Analysis of teaching reform of mechanical drawing based on Solidworks. China Southern Agricultural Machinery, 2020, 51(22):157-158.
14. J. Yang, M. Zheng and J. Yang, “Introduction to 3D Printing Technology,” Nan Jing Normal University Press, 2016.

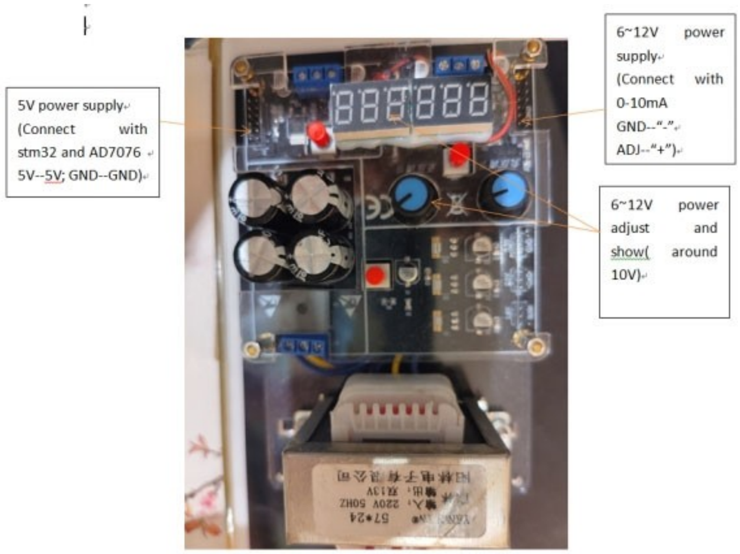
Appendix

PeLED Aging Test System 3.0 Operation Manual

1. Preparatory work:

1.1.Line connection

1.1.1. Power:

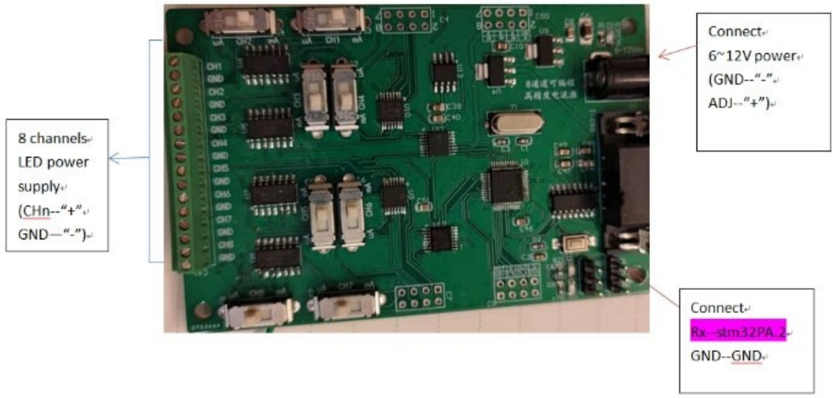


Connection:

GND----GND/negative pole

5v/ ADJ ----positive pole

1.1.2. 0-10mA 8 channels power supply:



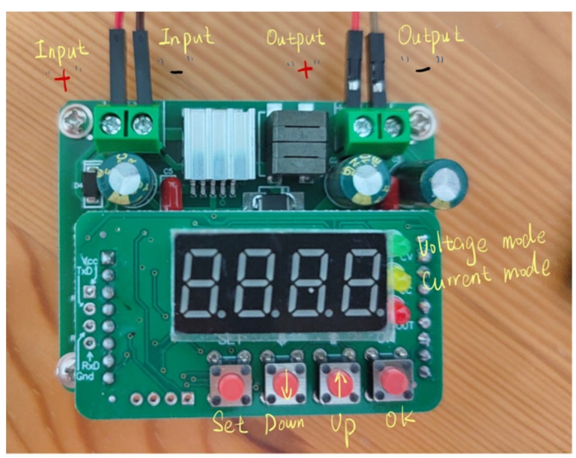
Connection:

CHn of 8 channels ----test LED positive

GND of 8 channels ----test LED negative

Rx----stm32.PA2

1.1.3. 0-50mA module:



Connection:

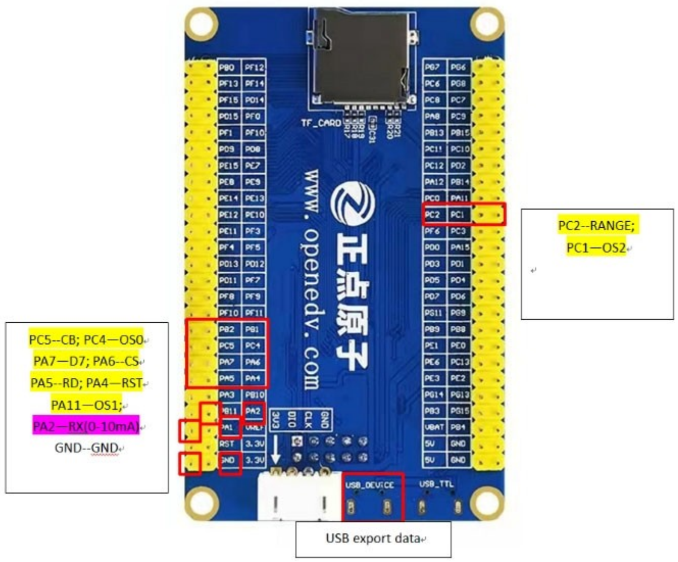
output "+"----voltage transformation model 6~12V"ADJ"

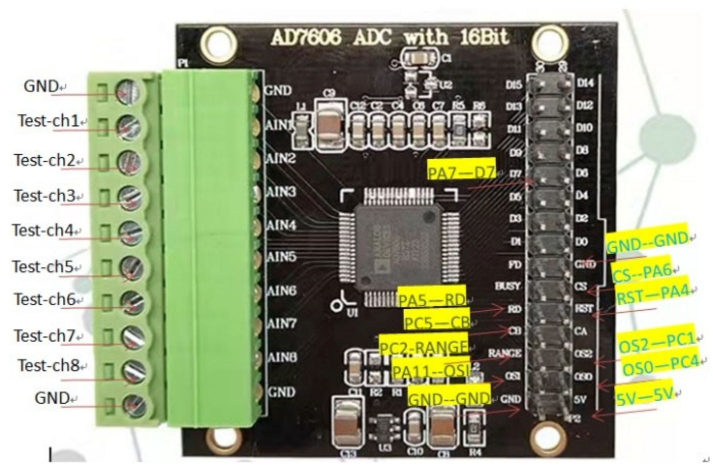
output "-"----voltage transformation model 6~12V "GND"

Input"+"----test LED positive

Input”-”----test LED negative

1.1.4. Monitor:





Connection:

Stm32.PA5 ----AD7606.RD

Stm32.PC5-----AD7606.CB

Stm32.PC2-----AD7606.RANGE

Stm32.PA1---- AD7606.OS1

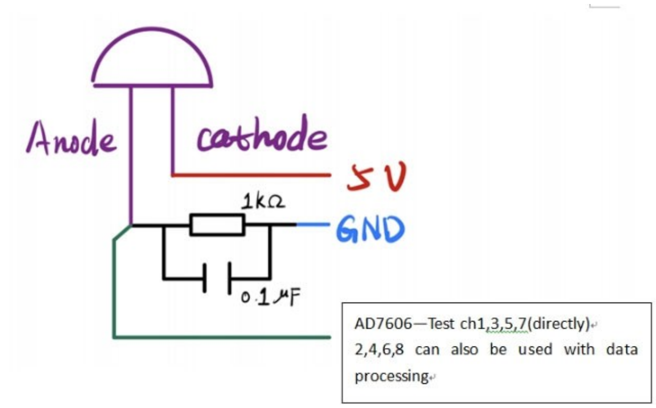
Stm32.PA6-----AD7606.CS

Stm32.PA4-----AD7606.RST
Stm32.PC1-----AD7606.OS2

Stm32.PC4---- AD7606.OS1

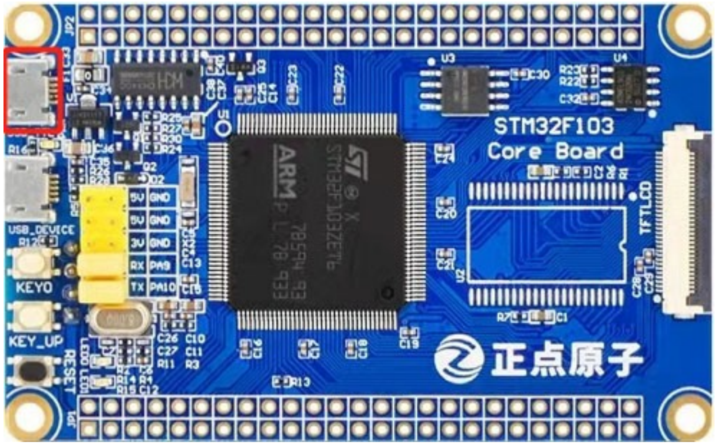
Stm32.PA7---- AD7606.D7

1.1.5. Photo detector:

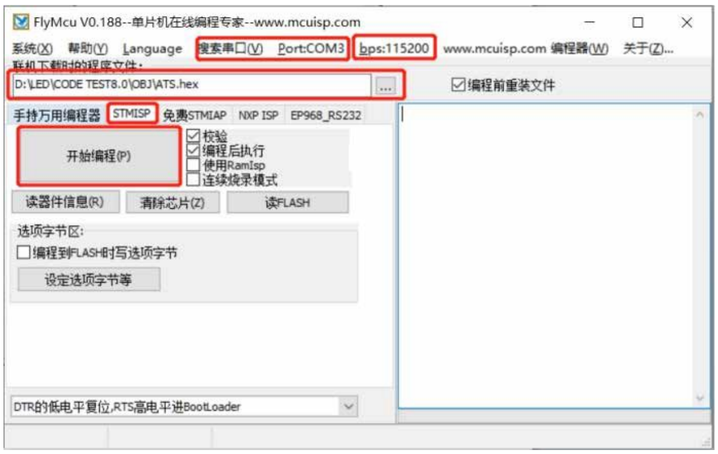


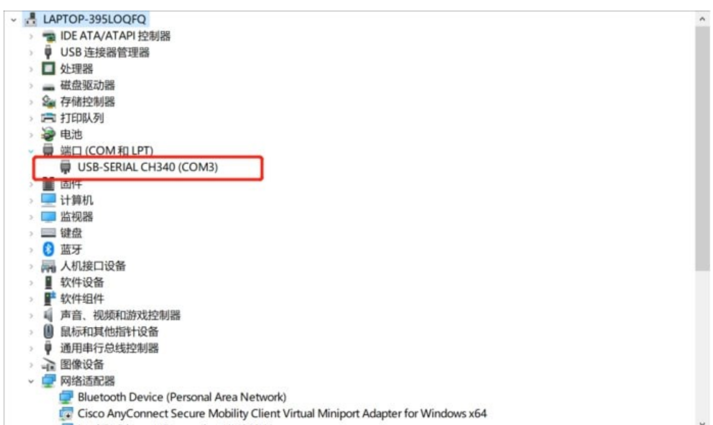
1.2.Program download

(1) Use the type-B data cable to connect the computer USB port and the TTL port on the stm32 motherboard.

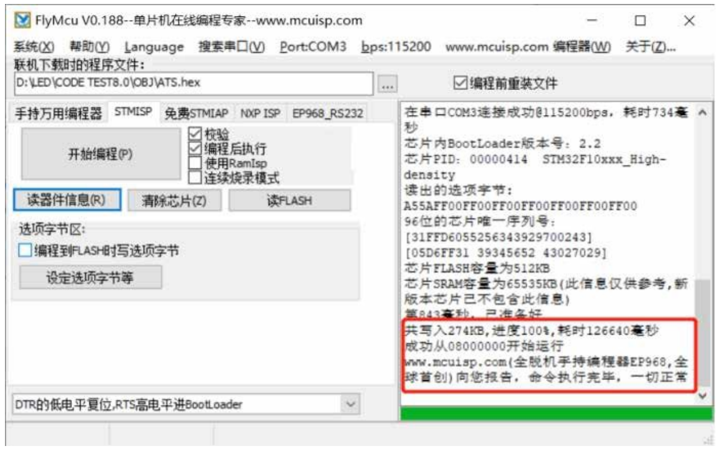


(2) Open the flyMcu program to download. Confirm that the download mode is selected as “STMISP”, and click “Search port” to search for the serial port corresponding to the connected motherboard. If there are multiple serial ports and you do not know which one is, you can use the device manager. Confirm that the “bsp” is 115200. Select the .hex file to be downloaded and click “Start programming” to start.



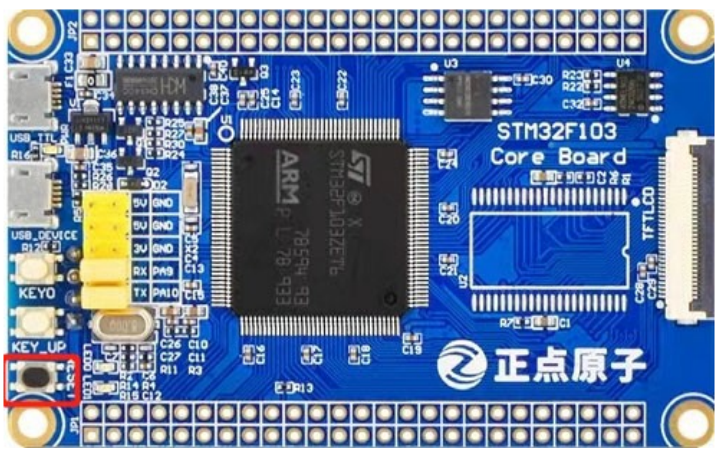


(3) Wait for about two minutes until the display progress is 100%, and complete the program download. At this time, the screen lights up as the main interface.



2. Operation steps in the experiment

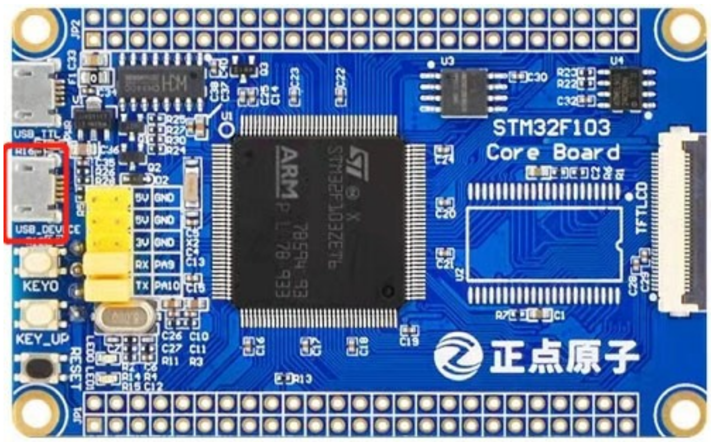
Turn on the power to start using the program. If there is any problem such as a black screen and a stuck screen during the process, please press the “Reset” button on the stm32 motherboard, that is, the black button.



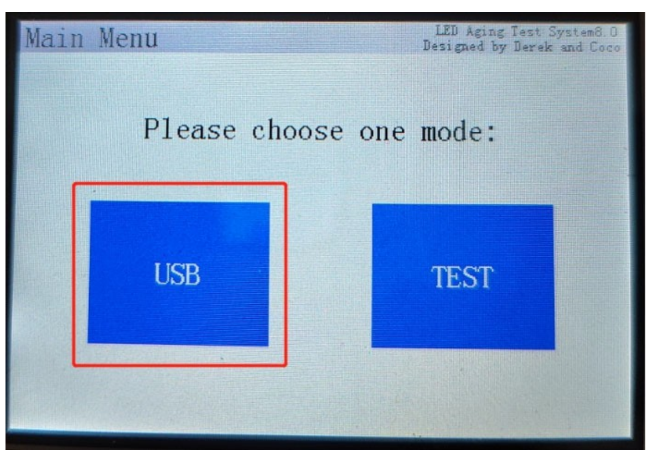
2.1.USB Mode

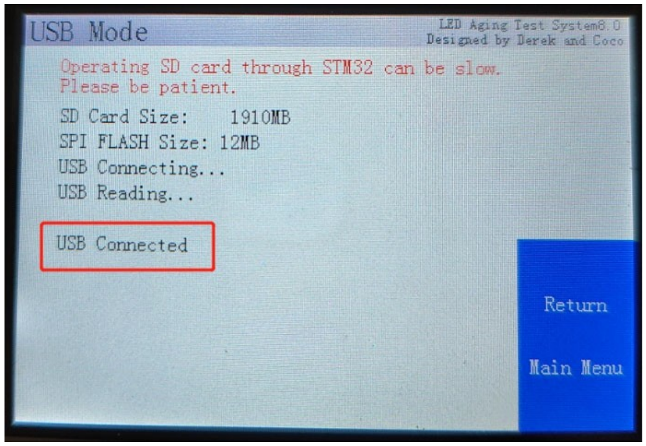
On the left of the main interface is the “USB” button. The USB function includes the setting of the sampling condition to end the test and the reading of the sampling data. How to use the USB function:

(1) Use the type-B data cable to connect the computer port to the device port on the stm32 motherboard.

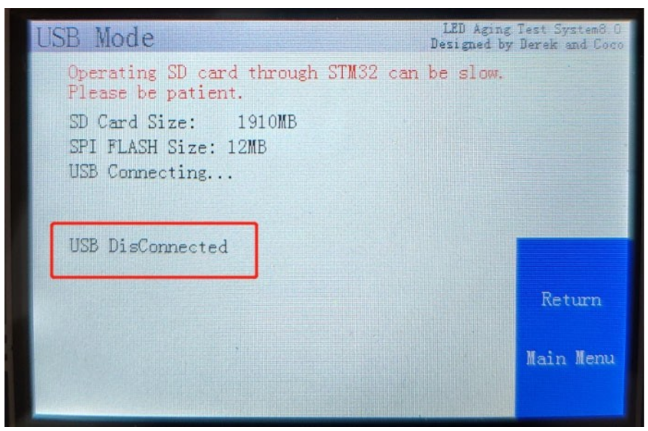


(2) Click the "USB" button to enter the waiting interface until "USB connected" is displayed.

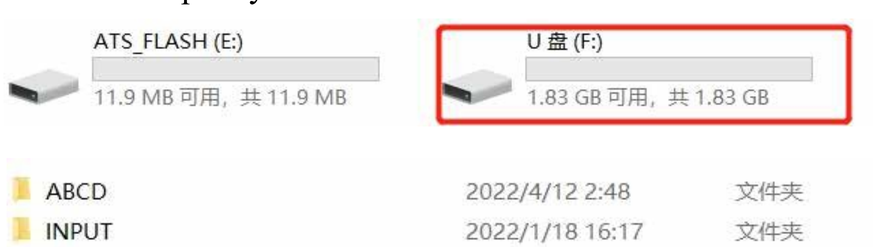




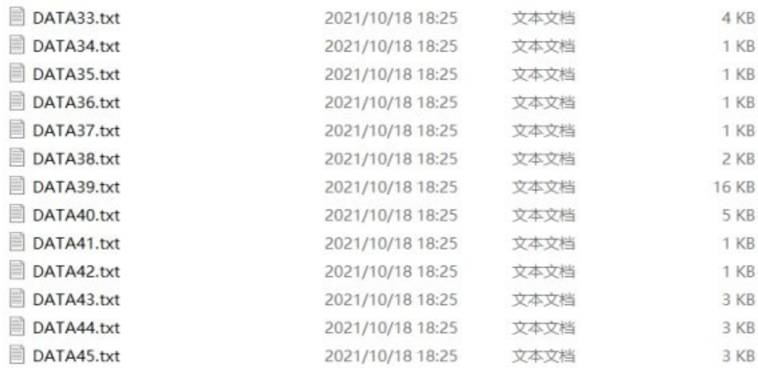
If "USB disconnected" is displayed, you need to recheck whether the connection is correct.



(3) Find the corresponding newly added storage device on the computer and enter. Since the difference of each SD card, there may be differences in the device name and capacity of the SD card.

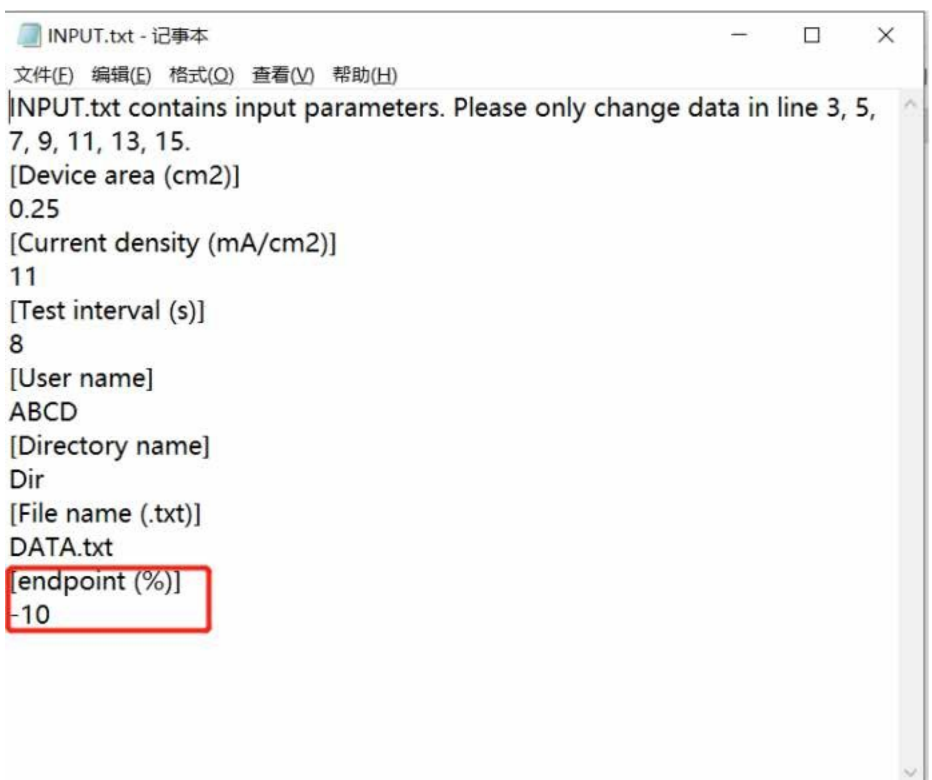


(4) The experimental data are in the ABCD file. Generally, it is the latest folder, and the saved file name will be displayed during the test.



DATA33.txt	2021/10/18 18:25	文本文档	4 KB
DATA34.txt	2021/10/18 18:25	文本文档	1 KB
DATA35.txt	2021/10/18 18:25	文本文档	1 KB
DATA36.txt	2021/10/18 18:25	文本文档	1 KB
DATA37.txt	2021/10/18 18:25	文本文档	1 KB
DATA38.txt	2021/10/18 18:25	文本文档	2 KB
DATA39.txt	2021/10/18 18:25	文本文档	16 KB
DATA40.txt	2021/10/18 18:25	文本文档	5 KB
DATA41.txt	2021/10/18 18:25	文本文档	1 KB
DATA42.txt	2021/10/18 18:25	文本文档	1 KB
DATA43.txt	2021/10/18 18:25	文本文档	3 KB
DATA44.txt	2021/10/18 18:25	文本文档	3 KB
DATA45.txt	2021/10/18 18:25	文本文档	3 KB

(5) The data in INPUT is modifiable. Currently, the useful one is the endpoint, which can end the test by modifying the corresponding condition to end the test, that is, it is lower than X% of the initial brightness.



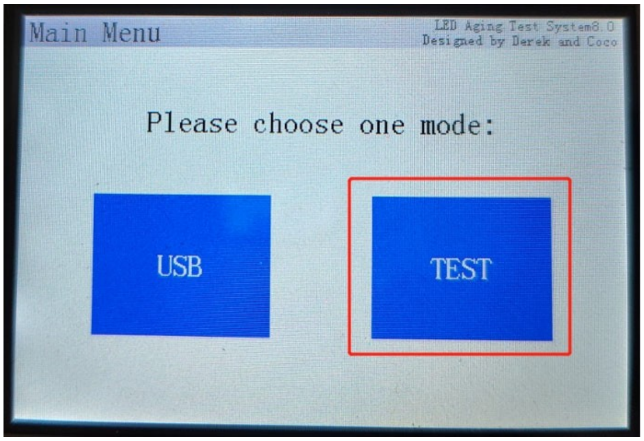
INPUT.txt - 记事本

文件(F) 编辑(E) 格式(O) 查看(V) 帮助(H)

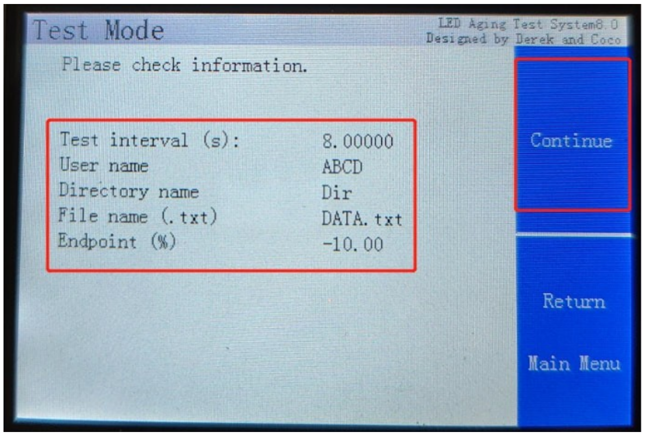
INPUT.txt contains input parameters. Please only change data in line 3, 5, 7, 9, 11, 13, 15.
[Device area (cm2)]
0.25
[Current density (mA/cm2)]
11
[Test interval (s)]
8
[User name]
ABCD
[Directory name]
Dir
[File name (.txt)]
DATA.txt
[endpoint (%)]
-10

2.2.TEST function

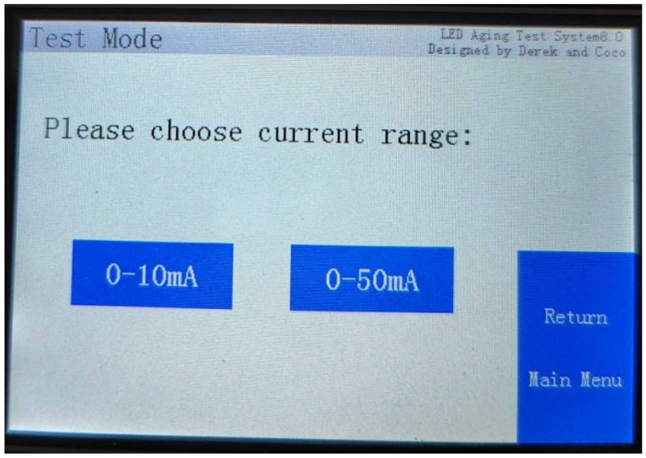
(1) Select the "TEST" button on the right to enter the test.



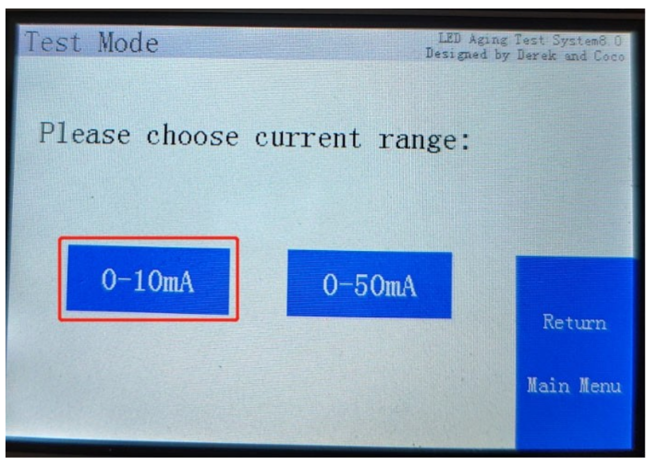
(2) Confirm the information and click the "Continue" button to continue.

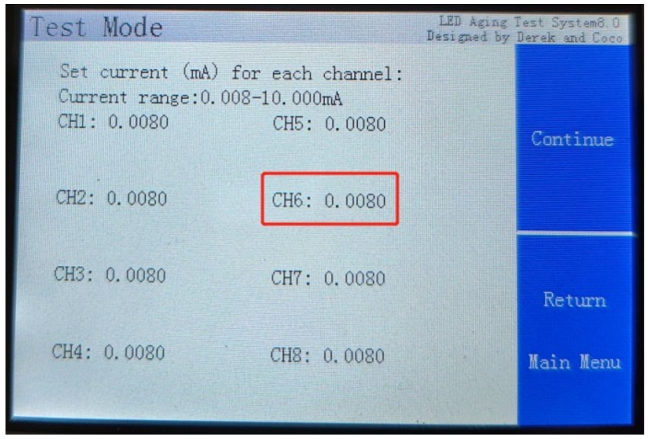


(3) Enter the current range selection interface.

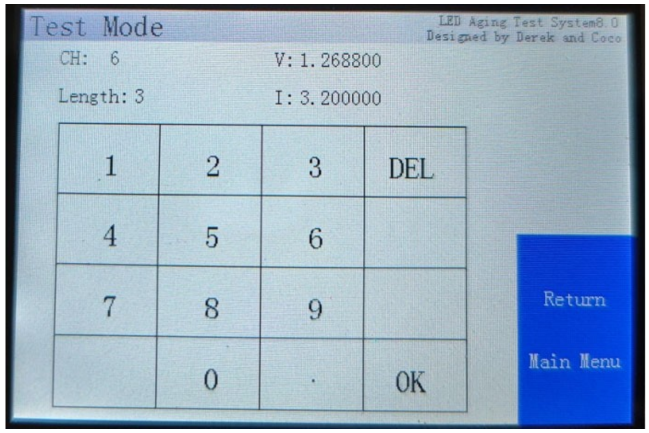


(4) Select “0-10mA” mode to enter the current design interface, click the corresponding channel. If you need to modify the current of channel 6, click the “CH6” to enter the keyboard interface.

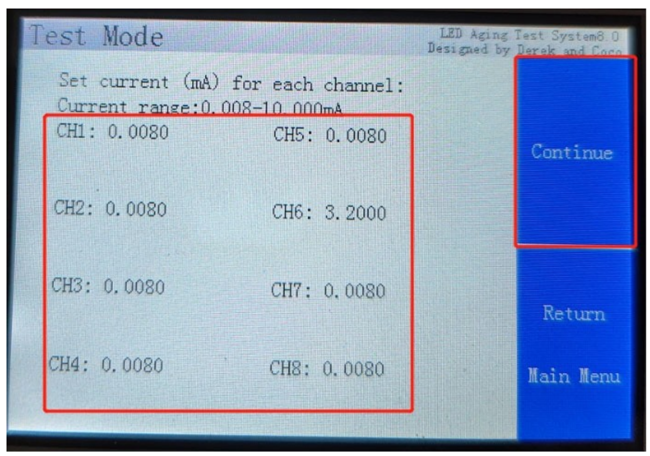




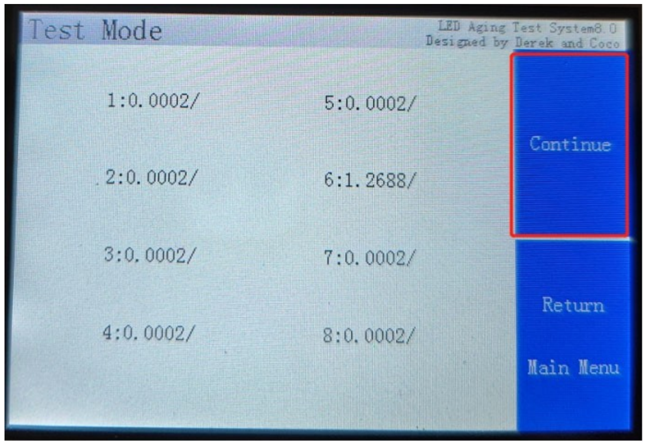
(3) Input current with keyboard. "CH" is the currently selected channel, please confirm and continue. "V" is the voltage value input to the current output board and has nothing to do with the actual supply voltage. Its relationship with the set current is V=(3.6/9.058)*A -0.00300287. I is the current setting current, be sure to pay attention to each quick click here! Otherwise, the numbers will have strange lengths (this bug is currently unknown how to fix)! But it does not affect subsequent operations. "Length" indicates the number of digits you have input already (including the decimal point). If it is found that the current "I" above the input number does not change, it is recommended to use "DEL" to clear it all and then re-enter it. Be sure to make the length display 2 after the decimal point, and then continue to enter the content after the decimal point. After the input is complete, click "OK" to return.



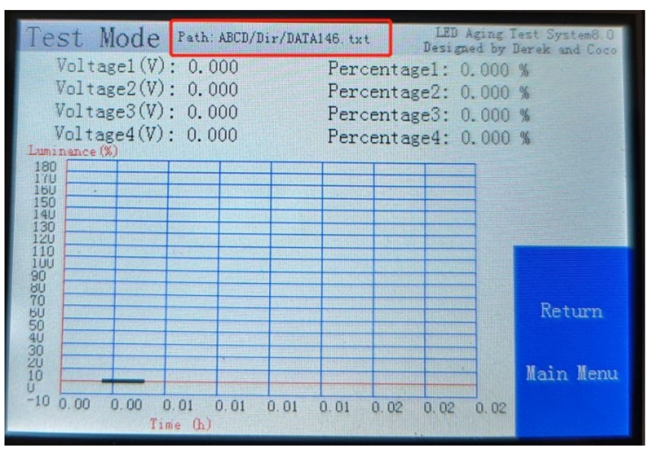
(4) Repeat step (3) until all settings are completed. After checking, click the "Continue" button to enter the output value checking interface.



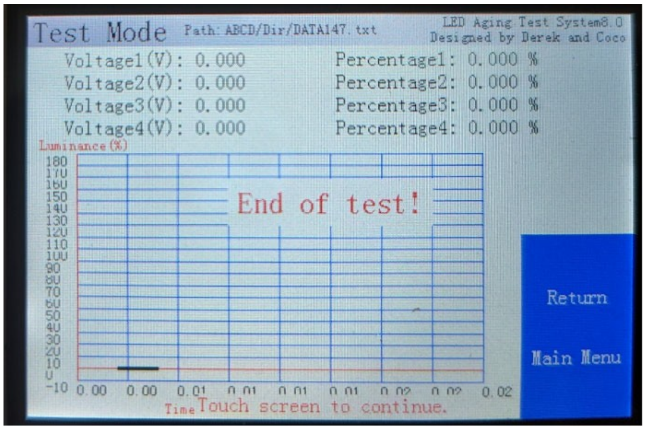
(5) The voltage value input to the current output board is shown here has nothing to do with the actual supply voltage. Its relationship with the set current is V=(3.6/9.058)*A -0.00300287. At this point, confirm that there are no negative numbers and click the "Continue" button to continue.



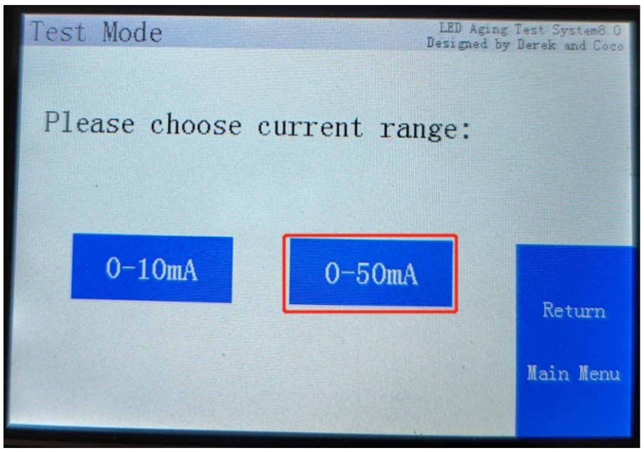
(6) Enter the experiment interface, and the data saving path is displayed at the top. After waiting for the experiment to complete, click "Return Main Menu" to end the experiment. See the USB function above for the data reading method.



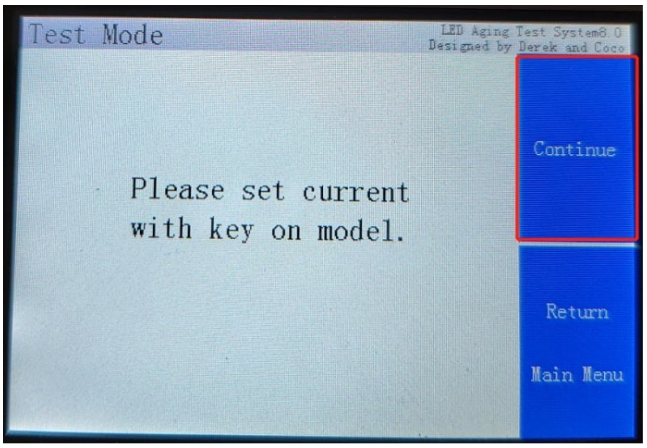
(7) If the condition corresponds with the condition to end the test, the test will be terminated, and shows "End of test!" on the screen. Click anywhere to finish the test and return main menu.



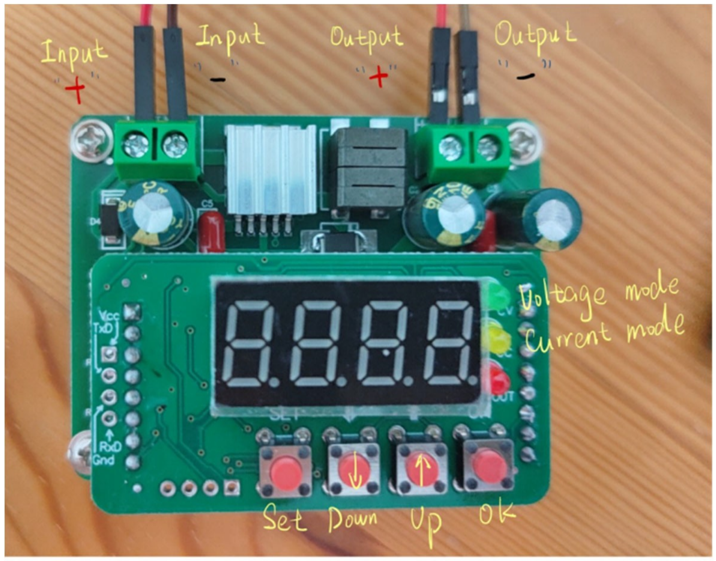
(8) If choose the “0-50mA” mode



(9) Enter the setting waiting interface. For the setting method, please refer to the 0-50mA module in the subsequent introduction section.



0-50mA module wiring and setting:

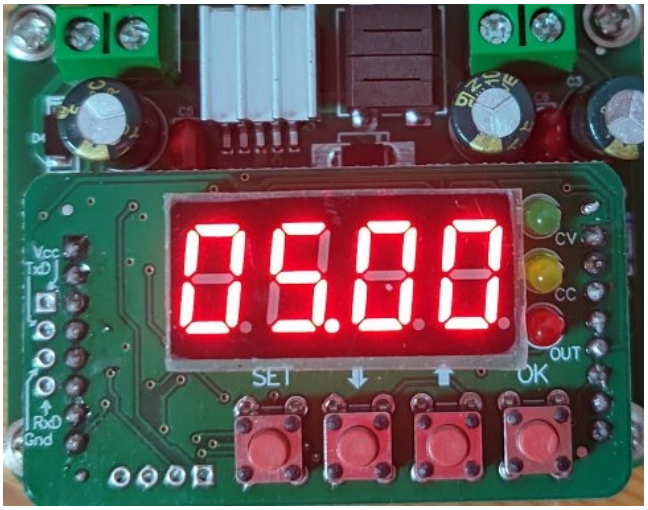


Output setting:

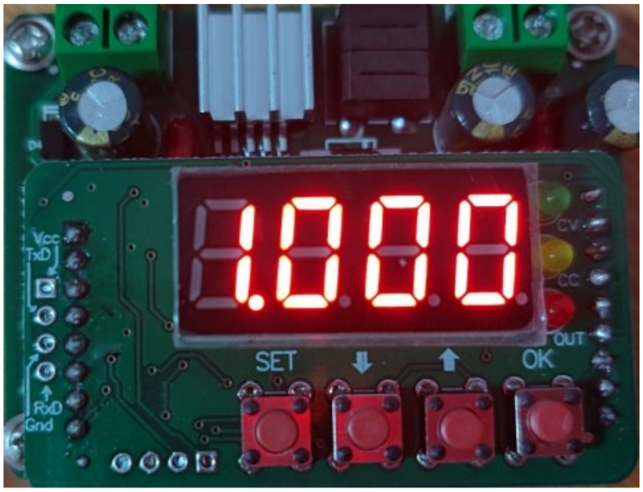
1. Set the desired voltage and current value. If it is displayed with two decimal places, it is the voltage value (such as 00.00) at this time, and if it is displayed with three decimal places, then it is the current value (such as 0.000). The method of setting the voltage and current value is: after power-on, the voltage setting value is displayed by default, and the format of the voltage value display is “00.00”. Press the “SET” button to switch to the current setting value, and the format of the current value display is “0.000”, press the button to increase the set value, press the button to decrease the set value, short press for precise setting, and long press for quick setting. After

the voltage or current value changes, press the “SET” key and it will display “----”, indicating that the current set voltage or current value is saved. If the voltage or current value is not changed, pressing the “SET” key will switch to the current or voltage value.

As shown in the figure below is the voltage value



The following figure shows the current value



2. After the setting is completed, press the “OK” button to output.

3. In the output state, when the voltage value is displayed, press the button to increase the output voltage, and press the button to decrease the output voltage. When the current value is displayed, press the button to increase the current setting value, and press the button to decrease the output voltage. Small current setting value, short press for precise setting, long press for quick setting. In the output state, short press the “OK” button to switch the display of parameters such as voltage, current, power, and capacity. Press and hold for 3 seconds to automatically display in turn, and long press again to cancel the display in turn. If the CV light is on, it is the voltage output at this time, if the CC light is on, it is the current output at this time.

4. In the output state, press the “SET” button to turn off the output.