

# Semiconductor-Based 650nm Class I Laser Eye Protector

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**Abstract.** Eye health is essential to national health and involves all age groups throughout the lifespan. Visual impairment seriously affects people's physical and mental health and quality of life, increases the burden on families and society, and is a public health and social problem involving people's well-being. Our method of combining acupuncture and physiotherapy to stimulate acupoints was found to relieve eye muscle fatigue and reduce eye tendon contracture and blood stasis. It also causes bio-stimulation within the tissues and improves local blood circulation. On this basis, using a laser instead of a silver needle was improved to stimulate the acupoints. The laser is low-intensity laser irradiation through the laser beam deep inside the tissue, which can play the proper bio-thermal effect and does not damage the body's normal biological tissues.

**Keywords.** laser; eye health; semiconductor industry; shortsighted; acupuncture point

## 1. Introduction

Red laser acupuncture was found to be a novel therapeutic tool by Wang<sup>[1]</sup> et al. study showed that infrared laser moxibustion is safe and effective in relieving fatigue in tumor patients and that the 657 nm, 35 mW red laser can metrologically activate mast cells in a measure-dependent manner. Zhao<sup>[2]</sup> et al. compared the differences in natal temperatures between patients with cancerous fatigue and normal subjects, as well as the differences in natal temperatures between those in the true laser moxibustion therapy group and those in the sham laser moxibustion therapy group. The study showed that 10.6  $\mu$ m laser moxibustion of the foot-sanli, Qihai, and Guanyuan could increase the temperature of the natal gate, help patients cultivate vital energy, and improve the fatigue status of cancer patients. He analyzed the mechanism of laser moxibustion in the treatment of bronchial asthma and found that laser moxibustion may increase plasma levels, ratio and plasma cortical intoxication levels in patients as well as acupuncture. Zhou<sup>[3]</sup> applied 654-2 plus iproniazid and light moxibustion combination of diarrhoea treatment methods. The

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efficacy results significantly improved, the number of days to stop diarrhea is also significantly shorter, and the method is simple. Infants and young children are happy to accept.

This design uses an STM8S103F3P6 microcontroller (SMD type), which has a lower system cost, internal integration of true EEPROM data memory, can be up to 300,000 erase and write cycles, highly integrated internal clock oscillator, watchdog and power-down reset function with 16MHz CPU clock frequency, high performance and high reliability, powerful I/O functions, and discrete clock source independent watchdog. Its powerful functions, compact size, and very low power consumption align with this design's requirements; the product's basic idea and the microcontroller schematic diagram are shown in Figure 1.

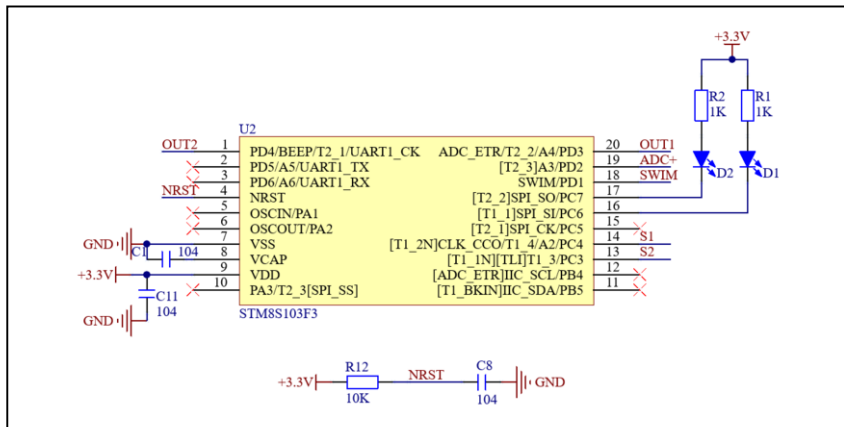


Figure 1. Microcontroller Schematic.

## 2. PCB Design

In terms of different acupoints around the eyes, in the design, 9  $\Phi 6\text{mm}$  semiconductor lasers are installed around each eye, with a total of 18 lasers<sup>[4,10]</sup>. The control circuit adopts an STC microcontroller as the main chip, and the peripheral circuit is composed of a PWM constant current drive module, LED display module, button module and power supply module, as shown in Figure 2.

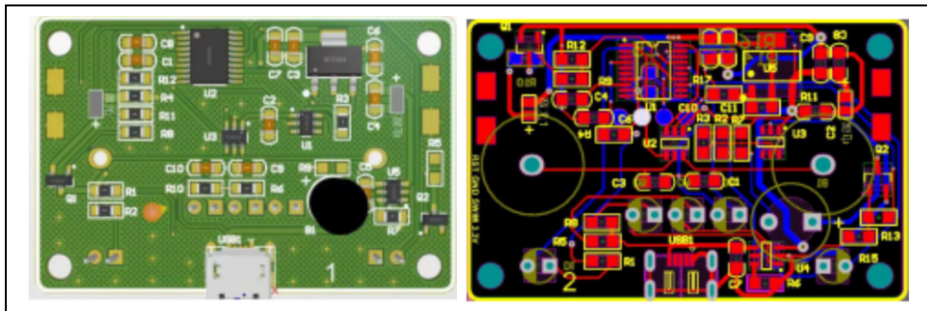


Figure 2. PCB 3D mockup with wiring diagrams.

### 3. Modular Design

#### 3.1 Laser Module Design

The laser module consists of 18 semiconductor laser tubes connected in parallel, each of which emits red light at 650nm wavelength and corresponds to acupoints around the eyes<sup>[4,5]</sup>. When working, the nationally recognized 650nm Class I laser light emitted by the laser tubes reaches the acupoints and empowers the acupoints with light moxibustion to achieve the effect of myopia treatment<sup>[13]</sup>. The laser tubes used in this project have an operating power of 2mW each. The laser module circuit is shown in Figure 3.

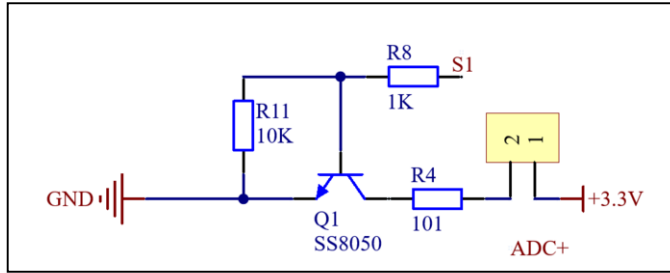


Figure 3. Laser Module Circuit.

#### 3.2 Constant current driver module

Texas Instruments' TPS54200 constant-current chip is used to drive 18 semiconductor laser tubes, which is characterized by a high degree of integration, reducing the complexity and instability of the drive circuit of independent components. The chip integrates field effect transistors, output current up to 1.5A, latch, shutdown function, overheating and overcurrent and other perfect functions.

Pulse width modulation has the advantages of high precision, can be combined with digital control technology, and can be realized through software. Since the PWM duty cycle is proportional to the internal reference voltage, the reference voltage can be changed by changing the PWM duty cycle, thus realizing the change of the output voltage of the FB pin. The current through resistor  $R_6$  can be calculated from the laser drive current. The calculation formula is shown below.

$$I_L = \frac{V_{FB} * D}{R_6} \quad (1)$$

Where  $I_L$  is the laser drive current,  $V_{FB}$  is the reference voltage,  $D$  is the PWM duty cycle, and  $R_6$  is the sampling resistor. When the PWM frequency is too low, it may generate large ripples at the voltage reference.

So, the microcontroller PWM<sup>[6]</sup> output frequency is designed to be 50 kHz. The constant current driver circuit is shown in Figure 4.  $I_L$  is the laser drive current,  $V_{FB}$  is the reference voltage,  $D$  is the PWM duty cycle, and  $R_6$  is the sampling resistor. When the PWM frequency is too low, it may generate large ripples at the voltage reference.

So, the microcontroller PWM<sup>[6]</sup> output frequency is designed to be 50kHz. The constant current driver circuit is shown in Figure 4.

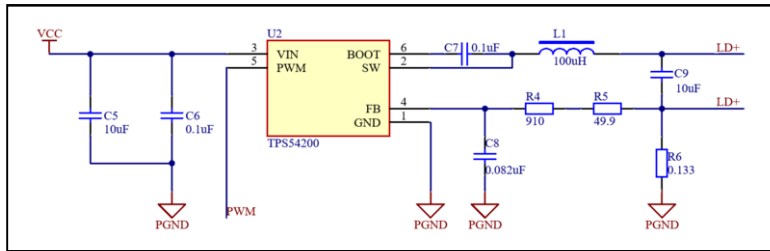


Figure 4. Constant Current Driver Circuit.

### 3.3 Battery and Charging Modules

The HX70A series is a three-port low voltage detector<sup>[7]</sup> realized by applying CMOS technology, which can detect fixed voltages ranging from 2.2V to 7V. The detector comprises four parts: a high-precision and low-power standard voltage source, a comparator, a hysteresis circuit, and an output driver. CMOS technology ensures low power consumption, and even though the detector is mainly designed to detect fixed voltages, it can also detect user-specified threshold voltages using peripheral components. Capable of detecting user-specified threshold voltages.

The TP4057 is a single-cell lithium-ion battery constant-current/constant-voltage linear charger<sup>[8]</sup>. The simple external application circuitry is ideal for portable device applications and is suitable for USB and adapter power operation. It features an internal anti-inverting charging circuit that eliminates the need for external isolation diodes. The HX70A and TP4057 modules are shown in Figures 5 and 6.

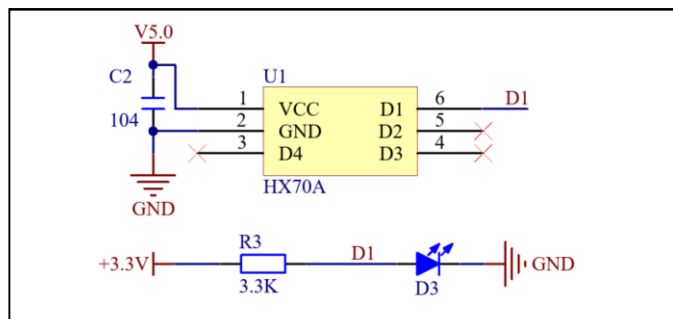


Figure 5. HX70A modules.

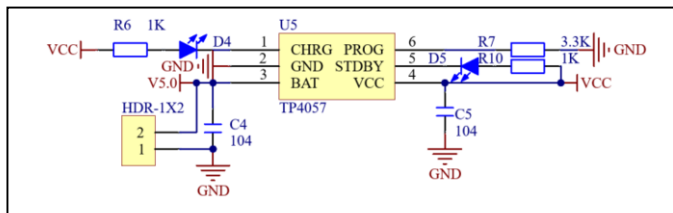


Figure 6. TP4057 modules.

### 3.4 Buck Modules

Buck modules, the principle is to change the duty cycle to realize the buck and regulator. Buck circuit is commonly known as BUCK circuit<sup>[9]</sup>. Buck circuit structure, mainly through an IC chip, the output of a square wave signal to control the opening and closing of a switching tube, thereby controlling the input voltage to the output of the length of time. The greater the duty cycle of the square wave signal, the higher the output voltage, the smaller the duty cycle, the smaller the output voltage. Buck Modules are shown in Figure 7.

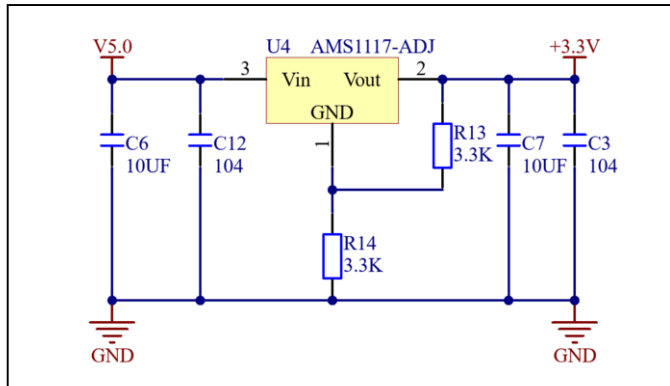


Figure 7. Constant Current Driver Circuit.

### 3.5 Product

According to the national strategic needs and directions, this paper innovatively proposes a multifunctional integrated device for correcting myopia, treating glaucoma and dry eye, which will be the development direction of this field in the future. The eye light moxibustion device developed by the project is a product based on the concept of "low cost, high efficiency and fast effect". The device's ergonomic structure, moxibustion acupuncture point design, laser power control and other design concepts are original, in the industry's leading level. The physical product and test charts are shown in Figure 8:



Figure 8. Constant Current Driver Circuit.

## 4. Experimental Analysis

A typical adolescent myopia patient was tested with the semiconductor laser myopia

control instrument designed in the paper, and the refractive error data of the right and left eyes before the test and after the treatment were recorded<sup>[10,12]</sup>.

The test results are shown in the Table 1. The experimental results show that the instrument can effectively improve the refractive error of the adolescent's eyes and effectively control the adolescent's myopia.

**Table 1.** Semiconductor laser myopia prevention and control test data comparison.

Name	Age	Prevision (left/right eye)	Pre- refraction (left/right eye)	Post-treatment visual acuity (left/right eye)	Post-treatment refraction (left/right eye)
Wang	8	0.12/0.15	-4.50/0.8 -4.50/0.8	0.15/0.15	-4.50/0.8+4 -4.50/0.8+3
Zhang	11	0.4/0.4	-1.50/1.0 -1.75/1.0	0.4+3/0.5	-1.25/1.0 -1.25/1.0
Li	9	0.5/0.1	-1.00/-0.50*160 -2.75	0.6/0.12	-1.00/-0.50*160 -2.25
Sun	12	0.25/0.25	-1.50 -1.50	0.3/0.3	-1.50 -1.50
Liu	13	0.5/0.5	-1.75 -1.50	0.6/0.6	-1.50 -1.25
Zhang	15	0.8/0.6	-0.50	-0.75 0.8+4/0.8	-0.25 -0.75
Wang	14	0.12/0.15	-4.50/0.8 -4.50/0.8	0.14/0.14	-4.50/0.8+4 -4.50/0.8+3

## 5. Conclusion

In this paper, a semiconductor laser<sup>[11]</sup> is designed to prevent myopia in adolescents, which avoids the defects of He-Ne laser and is realized by using semiconductor, pulse width modulated constant current driver and information technology. Experiments show that the semiconductor laser can effectively improve the refractive error of adolescent eyes and prevent myopia of adolescents, which is of certain reference significance for the clinical application of adolescent eye diseases. However, the wavelength of the laser is fixed, and further research and development is needed.

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