

Design and Implementation of an Electronic Medical LED Phototherapy System

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Abstract: According to the working mechanism and characteristics of LED phototherapy system, medical LED therapy system of the light source module, constant current driver module, display control module and interactive modules were designed, finally the system achieves a stable output of light irradiance and light irradiance can be linearly adjusted. The composition, design and implementation of phototherapy system were introduced in this paper.

Keywords: LED; Phototherapy system; circuit control; Light irradiance.

1. INTRODUCTION

With the rapid development of semiconductor technology, the application of LED products extends to all walks of life. LED application in biomedical field is currently one of the hottest research topics, especially phototherapy device with LED as light source, is the hotspot in the field of medical research^[1]. LED has the characteristics of high efficiency, low power consumption, less heat production, long life, and green environmental protection, and LED is widely used in the field of phototherapy as a safe and efficient light source^[2]. But phototherapy systems have low efficiency, side effects, complex circuit etcetera defects, and its difficult to maintain and interact with the system at the present stage^[3]. According to the domestic and foreign phototherapy equipment, a high-power LED medical phototherapy system was put forward in this paper. Using electronic system development software Altium Designer Summer to design display and driving circuit, optical simulation software Tracepro simulate system light ray tracing, reflow package power LED Cree xp-e blue-green chip array, and AMC7150 chip constructs constant current driving module, AT89C52 MCU and LCD12864 display construct control module, then Labview design the human-computer interaction. Compared with the traditional phototherapy system, the system designed in this paper has better therapeutic effect, higher biological safety, more convenient man-machine interaction, and more economical and convenient features. It is particularly suitable for treatment of neonatal jaundice^[4].

2. THE GENERAL SITUATION AND DESIGN OF THE SYSTEM

LED phototherapy system mainly consists of the following four modules: uniform lighting module, the constant current driving module, display control module and a man-machine interactive module.

2.1 LED LIGHTING MODULE:

The effect of phototherapy photometric are radiation and light uniformity^[5], being aimed at different photoelectric properties of 459nm blue LED and 500nm green LED, The blue and green LED special array are adopted to meet the strength and uniformity of light phototherapy. According to the national medical electrical equipment light treatment equipment safety requirements^[6], we designed a more favorable configuration with spot area is 250mm×500mm, blue light irradiance reaches 2mW/cm², green light irradiance reaches 1.5mW/cm², the uniformity of light is over 90%. The design of phototherapy indications can be effective treatment in children with severe jaundice, and it overcomes so many side

effects of traditional phototherapy and instability. There is no longer need to give children with blood transfusion and other painful surgery therapy. Preliminary experiments to determine LED array as shown in Figure 1.



Fig.1 LED array

Using optical simulation software Tracepro to simulate the light source tracking, in the working distance of the working plane to get an spot area of 250mm x 500mm^[7], and uniform degree up to 80%, as shown in Figure 2.

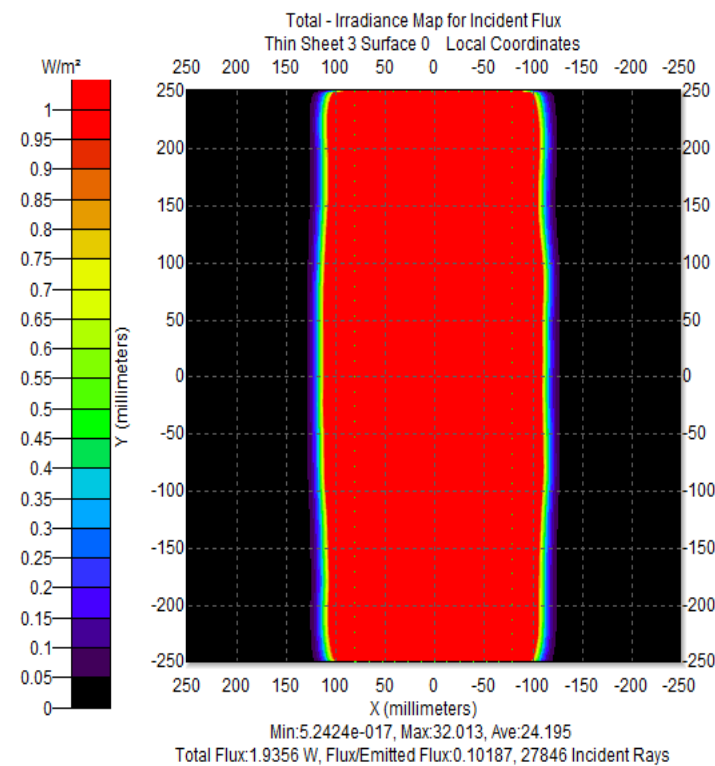


Fig.2 The spot

2.2 CONSTANT CURRENT DRIVE MODULE:

Based on the requirements of design parameters, phototherapy system need 10 blue LED which wavelength is 459nm and 15 green LED which wavelength is 500nm, the photoelectric parameters test were shown in Table 1.

Tab.1 Photoelectric parameters of LED

Chip tape	Number	Connection mode	Current(A)	Voltage(V)
Blue LED	10	Series connection	0.715	31.2
Green LED	10	Series connection	0.715	31.2
Green LED	5	Series connection	0.720	15.7

AMC7150 is a kind of PWM power LED driver chip with only 5 external components. It has the features of high efficiency and low cost, and it is suitable for driving power phototherapy system^[8]. A single constant current driving module as shown in Figure 3. The input voltage is 4-40V, drive current is 0-1.5A. Three circuits are connected to the AMC7150, while receiving the enable signal PWM for dimming control from microcomputer.

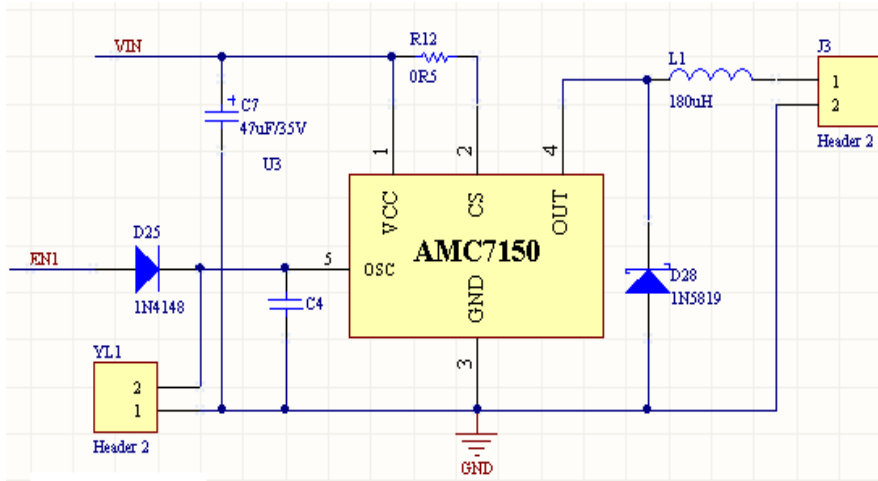


Fig.3 constant current driving module

2.3 DISPLAY CONTROL MODULE:

Specific I/O ports of AT89C52 microcontroller produce PWM enable signal, and PWM enable signal added to the pin OSC of AMC7150 through the small signal high speed switching diode IN4148^[9]. By adjusting the PWM to achieve the adjustment of three LED brightness. LCD12864 communicates with MCU about data transmission and display. AT89C52 microcontroller is connected to the clock circuit, temperature control circuit, level conversion circuit at the same time, 24V DC power is used for energy supply for the entire system operation as shown in Figure 4 below.

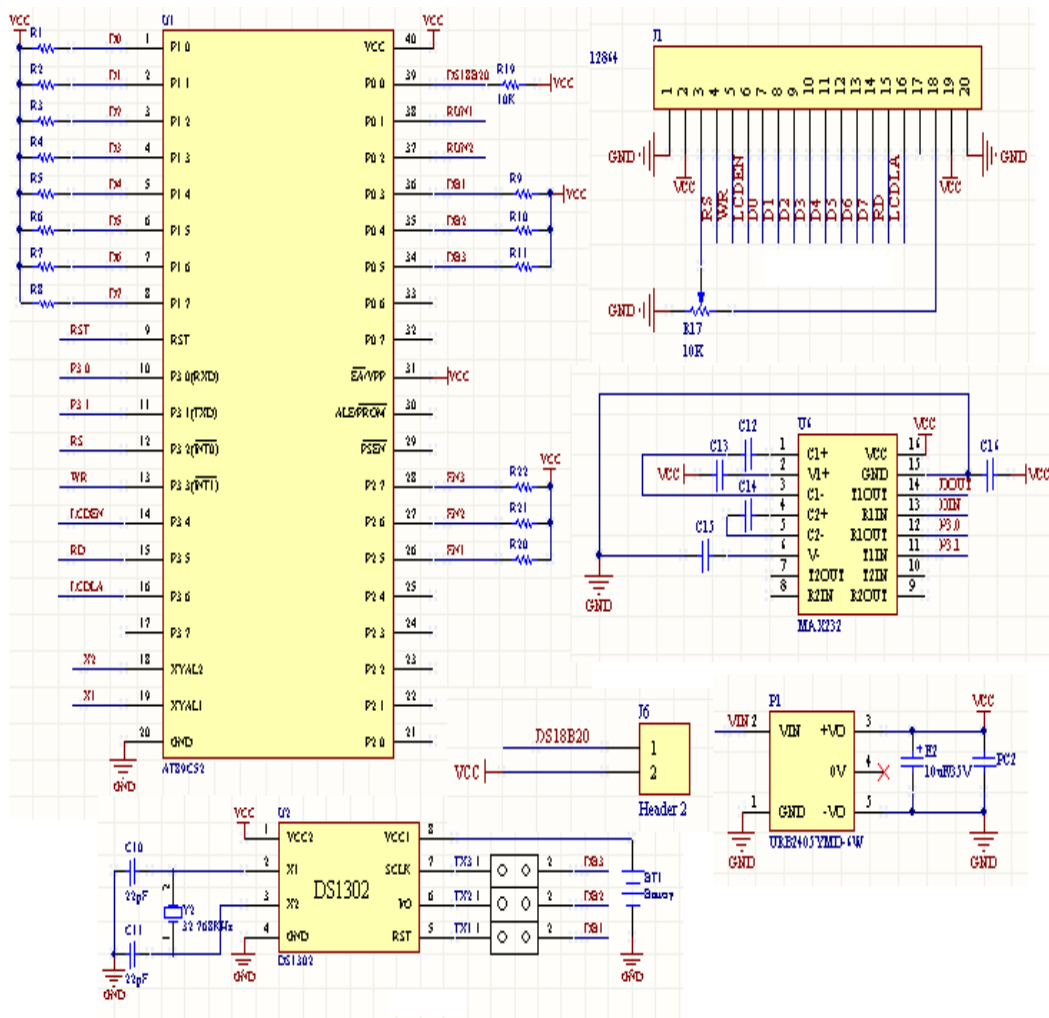


Fig.4 AT89C52 display control module

2.4 HUMAN-COMPUTER INTERACTION MODULE:

Using Labview designs human-machine interface of phototherapy system. Figure 5 is the interface of front panel for display of information input and processing the data. The serial port of configuration module in the figure are the serial number, baud rate, data bits, stop bits, parity bit and other parameters. Serial number is used to set the communication interface between PC machine and equipment, The baud rate for the communication rate between PC machine and equipment, the system default is 9600bit/s. Patient information module is used to input the patient's specific information, such as name, gender, birth days, jaundice type and so on. The treatment plan module is used to set the brightness and the illumination time of the three circuits of LED lamp. When the brightness of the lamp and light time and other related information is set, click on the "start therapy" button, PC machine will be sent to the parameters of the instrument, the patient's information and treatment parameters will be saved to the excel file. Instrument outputs PWM according to the received command to control LED lamp brightness, when the time reaches the set value, the operation of LED is off. In the course of treatment, you can click on the "stop therapy" button to compulsory end the treatment.

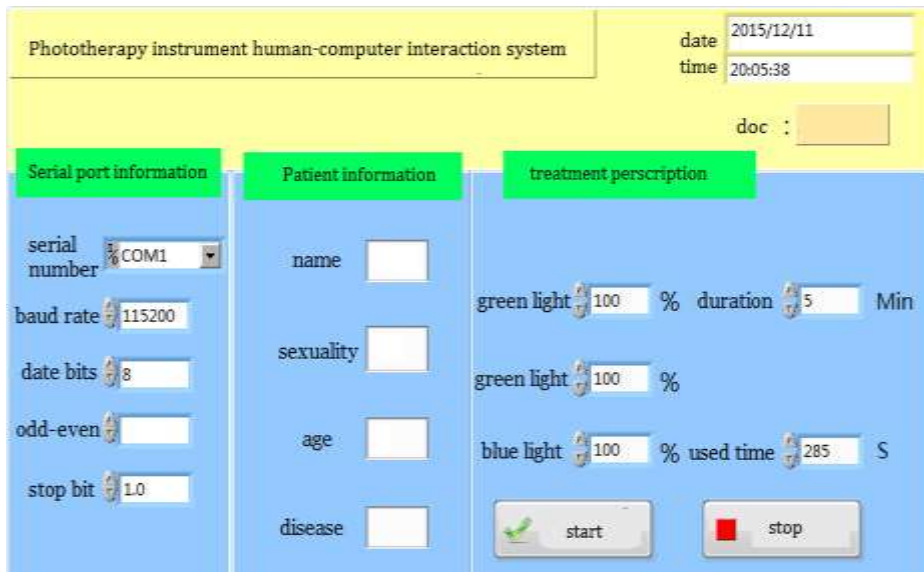


Fig.5 Human-computer interaction interface

3. EXPERIMENTS

The use of SMT reflow technology in the high-power LED lamp is installed in the position corresponding to cooling type PCB lamp board^[10], then lamp panel and display driver circuit is connected as is shown in Figure 6.



Fig.6 Display driver circuit

Clicking on the "start treatment, phototherapy system starts and begins to work normally. When setting different percentage parameters, light irradiance is different correspondingl. When the parameters are all set to 100%, phototherapy irradiation intensity reaches the maximum, as shown in Figure7(a); when the parameters are all set to 50%, phototherapy irradiation intensity is only half of the maximum value, as shown in Figure 7(b).

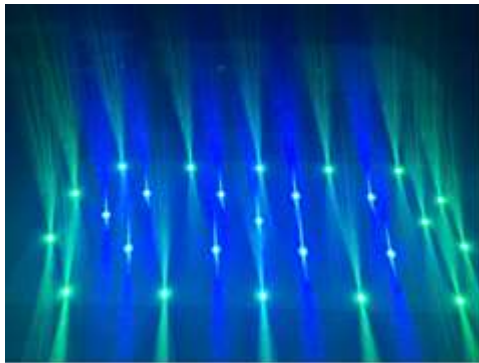


Fig. 7 (a) phototherapy of 100%intensity



Fig. 7 (b) phototherapy of 50% intensity

The I400 irradiance detection of Beijing bofeilai Technology Company is used for the optical parameters of detection. When phototherapy irradiation intensity reaches the maximum in the distance to the light 400mm work plane, measurement of blue and green light irradiance results such as shown in Figure 8. The overall tendency of the spectral irradiance in the effective illumination plane is stable. According to the light uniformity definition, calculated blue and green irradiance meet the design requirements, phototherapy system standards.

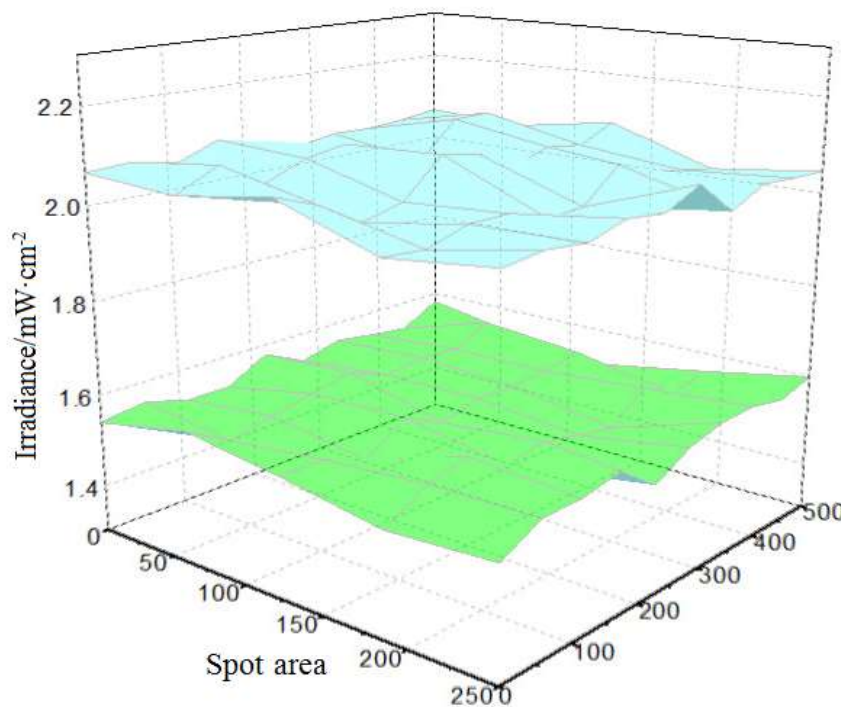


Fig.8 blue and green light irradiance

4. CONCLUSIONS

Aiming at the defects of phototherapy instrument at home and abroad, and according to the ideal standard of phototherapy, a LED electronic medical phototherapy system is put forward in this paper. Through the design and experiments of electrical system phototherapy, phototherapy system can work normally, blue and green light irradiance and light uniformity are up to the standard. Which makes phototherapy system being much safer, more efficient, more stable, more humane, more convenient etc advantages. The system also can be used in the treatment of facial acne vulgaris, Study on rat liver regeneration and so on.

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