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Research on the control system of laser power supply based on microcomputer

Ziqiang Hao [a], Hongzuo Li [b]

Changchun University of Science & Technology, Changchun, Jilin, China

[a]shuil47@163.com, [b]lihongzuo@sohu.com

Abstract. This paper introduces the laser power control system based on 80C51. The system software uses the modular structure, which has the functions of self check, display, keyboard control, protection circuit, light power feedback and other functions. Also the system has a simple design: it integrates all data processing and all the functions into two chips: the C51 chip and the 7128 chip, greatly improving the precise control and the protective control of laser film and improving anti-interference against the disturbance of high frequency such as arc discharge.

Introduction

In recent years, many kinds of lasers have not only been widely used in industrial processing field, such as laser cutting, laser marking, laser heat treatment, but also been used in medical field as a new type of medical equipment. Despite the great application, the laser's power supply still adopts the ordinary thyristor phase rectifier mode on the machine, and use potentiometer manually to adjust the output current, and thus the system dynamic response time is tens of milliseconds. Therefore, for high frequency arc discharge disturbance, the system can not make rapid response, whose random fluctuations in the laser power is generally greater than 5%, reducing the beam quality of death and limiting the applications of laser. In addition, when we need to adjust the pulse width and period of laser output in the processing process, it can only be realized by manual adjustment, instead of by computer synchronous control, which reduces the techniques of machining processing, the machining accuracy and the automatic degree.

With the development of power electronic devices, the emergence of the new insulated gate bipolar transistor (IGBT) in the 80's, coupled with continuous improvement and promotion of microcomputer technology, promoted the rapid development and wide application of measurement and control technology of the microcomputer. The PWM switching power supply technology and single chip control is introduced in the laser power supply, which can effectively improve the performance price ratio, simplify the hardware structure of the laser power, greatly enhance the degree of automation and the function of the expansion of capacity and facilitate computer control and management of the laser power supply.

In order to meet the requirements of the laser in the medical field, we combine the single chip computer control system with 80C51 as the core with the insulated gate bipolar transistor (IGBT) to produce the new laser power supply. This paper focuses on laser power supply of MCU control.

The overall design of the system

The circuit uses a high precision D/A conversion circuit based on pulse width modulation

principle of photoelectric isolation to realize digital control of laser power supply, to realize closed-loop control of the laser power by utilization of receiving the laser output pulse, to realize automatic detection of power failure in the interrupt mode. The display uses LCD dot matrix liquid crystal display, which can automatically show the important information about laser power supply, such as lamp discharge time, equipment total power on working time, working voltage, and power failure, and this information can be stored in a power-off protection in RAM.

Circuit design

The circuit of switch laser power supply can be divided into two parts: the main circuit and control circuit. The main circuit rectifies and filters the electricity supply directly into a DC voltage by pulse modulator to generate a switching devices V1 to V4 of a pulse voltage control DC converter with the phase difference of 180°, which converts DC into high Fang Bo, followed by high frequency rectification to the energy storage capacitor C0 charging, then reaches a predetermined value, the control circuit sends out the external trigger signal lamp, discharge thyristor to trigger conduction. And C0 discharges by xenon lamp, to provide energy to the laser target. The main circuit diagram is shown in fig. 1.
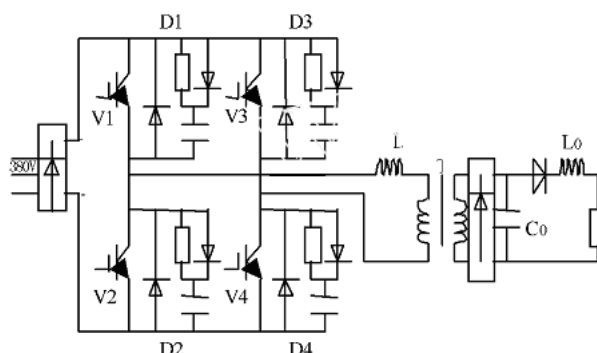

Fig. 1 Main circuit diagram

Pulse modulator is controlled by the voltage comparator and the microcontroller I/O port, and the voltage comparator's working state is decides by the voltage sampling values of energy storage capacitor and reference voltage of D/A output. When the main power sampling voltage is lower than the reference voltage of D/A converter output, pulse modulator provides a signal to the DC converter to charge the energy storage capacitor. When the main power sampling voltage is higher than the reference voltage of D/A converter output, it will close pulse modulator signal. When we change the output D/A conversion value, we change the main electrical energy storage in the voltage of the capacitor. In addition, the microcontroller can make the pulse modulator at work or stop working. When the system starts or detects the fault and other severe interference, we can cut the pulse modulator off to terminate the main electrical charging process. The MCU realizes the charge and discharge on the laser power control by controlling the xenon lamp, pulse modulation signal, and the D/A conversion circuit.

(1) Pulse width modulation D/ A converter

MCU controls laser power supply, whose core is the D/ A conversion circuit, that is, to convert set digital voltage to the main analog charging voltage of laser power supply. This circuit uses the D/A converter based on pulse width modulation principle, which is controlled by single chip microcomputer 8253 counter / timer to produce different duty cycle square wave pulse output, by photoelectric isolation and the active filter's amplifying, it is shifted into the different reference

voltage sources in order to control the laser power size of charging voltage. Its working principle diagram is shown in fig. 2.

The use of programmable timer 8253 as the pulse width modulation circuit can easily generate different pulse width square wave signals. 8253 has 6 kinds of different programmable working modes, which can be directly fit to MCU interface. The selection of operating mode is decided by different control words registered in the write control machines, and the output pulse width can be programmed.
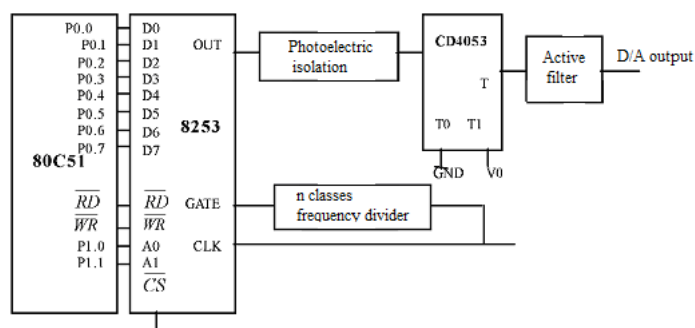

Fig. 2 PWM D/A convert circuit

(2) Closed-loop control

SCM through a number of received laser output pulse, can realize the closed-loop control charging voltage of laser power supply. The receiving circuit through the photoelectric receives the laser pulse, the counter reads the pulse number, and then compared with the pulse number of preset, when they are equal, the D/ A output unchanged. When the pulse number is less than a preset number of measured, which indicates the laser power injected energy shortage and the need to improve the charging voltage of the main circuit, i.e. to improve the D/ A conversion value, otherwise, to reduce the D/ A conversion value. The control process of automatic compensation for laser output is realized.

In order to improve the reliability of control, when we program the control software, we take the measure of the digital filtering, instruction redundancy and other measures, to process the numerical photoelectric sampling, for example, when numerical photoelectric samplings are double pulse for 3 times, and pulse number preset is 1, we should reduce the D/A conversion value. D/ A conversion value of the charging voltage, the laser output pulse number and the main power, can be determined by experimental measurements. In the software programming, the measurement values can be tabulated for query for D/ A conversion value.

(3) Laser power supply fault detection

Laser power supply fault detection uses interrupt mode, which is to input the power detection signal such as short circuit, over-current, over-voltage through the 80C51 interrupt to realize all kinds of protection to the laser power control, namely when any detection signal becomes low, 80C51 interrupt. For example, when it detected main charging voltage of laser power supply is over-voltage, 80C51 interrupt, and then perform the interrupt handler, shut off the modulation signal switch power supply, turn off the main power supply switch and display power fault information in the LCD liquid crystal display.

(4) Keyboard

The keyboard is composed of start/stop buttons, waveform selection, power preset button, the buttons of increment and decrement, which can preset the value of power, frequency, pulse width, and pulse number. The five key priorities from high to low are the start/stop, waveform selection,

power preset, increment, and decrement. When the power is on, the keys of waveform selection, power preset, increment, and decrement are effective. When the key of increasing and decreasing is pressed continuously, the increasing and decreasing speed will automatically speed up as soon as possible, so as to achieve the desired value. After power has been on for 5S, start/stop button starts to work. When the system is in operation, only a start/stop key is effective.

(5) Display

We can use LCD to display the output frequency, output pulse width, and output pulse number. In the standby mode, the frequency, pulse width, and output current pulse numerical are on display; when in the preset state, LCD display block flash, if the increase and decrease key is pressed, it will increase or decrease the corresponding value; when in a state of alarm, LCD displays "error" and flashes.

(6) Circuit's anti-interference measures

Switch type laser power supply has large disturbance, especially when the xenon lamp uses the external trigger mode, as it will produce strong electromagnetic interference. Interference will impose detrimental influence on the control system, and it will make the information error of the system increase or make the whole system break down. Therefore, in the design of the control system, we need to adopt various anti-interference measures to ensure the reliable operation of the system. As in between single-chip microcomputer and input and output of peripheral control unit, we can adopt photoelectric isolation technology. On the one hand, we can effectively eliminate the external disturbance along signal transmission line; on the other hand, we can also limit the internal interference effects on other circuits. In order to prevent the interference from power lines, in the input power, we use the noise filter, while in the circuit board, we set the decoupling capacitors and high frequency filter capacitance to eliminate high frequency interference filter in power supply. By using the digital filter, instruction redundancy, software trap, sleep disturbance and other measures, we reduce the effect of interference on the system as far as possible.

Software design

The system software consists of several program modules, including initialization module, keyboard management module, display module and a table look-up module. The main program's flow chart is shown in Fig. 3
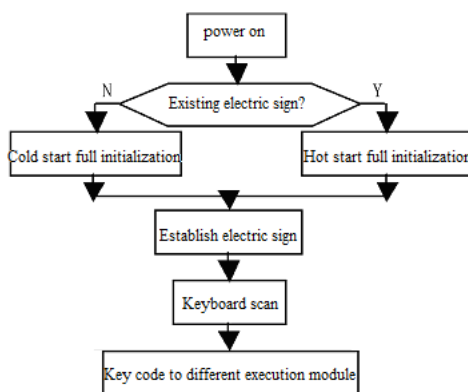

Fig. 3 System main program chart

After the power is switched on, the system first checks whether the electric flag, if there is electric sign, the system is in the reset operation due to the interference, and thus the system should be hot start. And the system will automatically repair and initialize for the current state, and then

perform keyboard scanning procedures. If there is no electric mark, system needs a cold start, and it will fully initialize, and then executes keyboard scanning procedures. But if a key is pressed, it executes the corresponding function module.

Conclusion

The system can output continuous, single pulse, and repetitive pulse, and the output power is adjustable ranging from 0W~50W continuously. The pulse width is small. We can preset parameters, take precise control of operation range, depth, and make intelligent medical equipment. Laser output power is accurate, stable to make the doctor operation much safer. The laser output power and irradiation time on the panel can be reflected by a digital display, intuitive and convenient, which provides accurate data for the medical staff to summarize the clinical data. When the laser outputs, the function buttons on the control panel has the lamp displays which can correspondingly indicate the state of the system and improve the operation safety.

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