The Design of Double YAG Laser Implement Controlled by Industrial Computer

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Abstract

Discuss the principle of laser implement and the debug of laser route,the modulate of laser pulse.Then analyse the work principle of power supply, and demonstrate project of main tache of power. contain preignition circuit, control circuit, charge circuit, discharge circuit, connect circuit and so on。

Keywords

YAG laser implement, Adjust Q, Convertor, Industry computer.

1. Introduction

With the continuous progress of science and technology, laser advantage constantly reflected, laser application fields is increasing, how can convenient control of the laser into the urgent need to solve the problem. But laser system of high voltage, high current, strong interference makes control part does not work properly, this thesis focuses on the analysis of the laser power and the laser, interference sources, characteristics, and how to solve the problems of anti interference, weak control strong and control signal isolation and linear coupling problem in order to make the system a technical indicators, control interface is beautiful, convenient, can well reflect the laser system parameters and state, the system is stable and reliable.

2. Theoretical analysis and practical debugging of two way solid pulse laser

2.1 The basic structure of two way solid pulse laser

Dual solid pulse laser by the oscillator and amplifier, the amplifier stage is mainly composed of xenon lamp, yttrium aluminum garnet crystal through mirror, mirror and other optoelectronic devices.

(1) Pump speed must be greater than the active medium to the metastable spontaneous transition rate A21, otherwise, the activation of the medium can not accumulate a large number of inversion particles;

(2) Q mutation must be fast, otherwise by stimulated emission of radiation growth slow, does not meet the mechanism in front of lost large amounts of activated particles decreased peak power, pulse width is increased;

(3) The metastable life of the gain medium is as long as possible, and the width of the fluorescence line is wide.

The Q technique[1] is to compress the laser energy into a very narrow pulse, so that the peak power of the light source can be improved by several techniques.

Q hardware circuit design is a relatively complex process, the laser Q circuit is composed of three main circuit: crystal power circuit, crystal Q switch circuit, delay control circuit.

2.2 Circuit design of two way solid pulse laser

The following parts of the overall structure of the power circuit are discussed respectively.

The power network provided by the frequency of 50Hz for the rectification of the AC voltage regulator, the circuit as shown in figure 1.

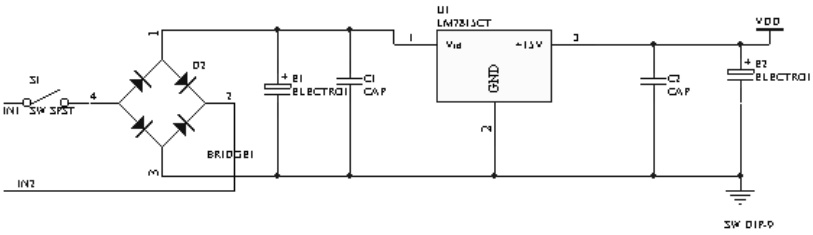

Figure 1 Rectifier voltage regulator circuit

The pulse transformer coupling back pressure switch Q circuit as shown in figure 2.

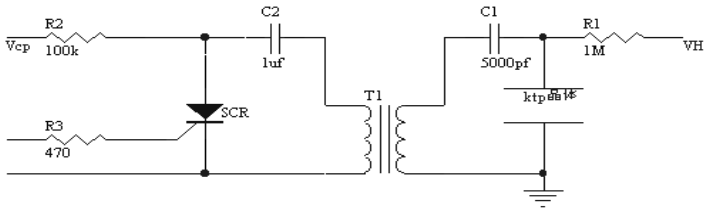

Figure 2 The crystal part of the circuit

In this design the circuit connection method is shown in figure 3.

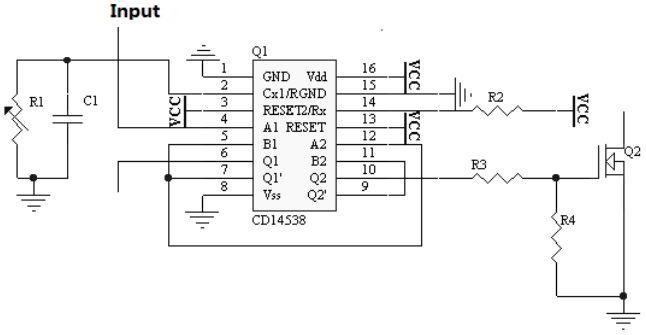

Figure 3 Delay part of the circuit

In this design we use the double precision single stable multi harmonic oscillator CD14538 to achieve CMOS is.CD14538 device with high stability temperature drift small circuit loss small circuit function and so on. The 4538 chip is a double precision single steady state trigger trigger which can be used to produce a precise pulse delay and timing, and can also be used to generate pulse. In this design we use it to produce a precise time delay, control the time of the back voltage circuit, that is, the use of its rising edge triggered, resulting in a 20 s - 300 s adjustable delay time.

Working process: the computer sends out a certain frequency of PPS pulse, after the optical coupler by the emitter electrode output, the way to take its rise along the 4 pin to send to the double precision single stable multi harmonic oscillator CD14538 to trigger CD14538, another way to send CD14538 2 pin through the external voltage and capacitance control delay time. CD14538 9 pin output signal after a three transistor amplifier through a radio with the output of a pulse to control the conduction of the BT1690. In addition, the former panel input 100V AC voltage through the push delay switch to two capacitors, one added to the BT1690 of the anode and cathode for the BT1690 to provide a voltage, and the other for the pulse transformer primary supply voltage.

3. Design of dual channel YAG laser power supply

3.1 Power infrastructure and various performance indicators

The power load is pulse xenon lamp, xenon gas discharge lamp with negative resistance characteristics, it puts forward the following requirements for power supply:

1. High voltage trigger pulse, which is about 20 thousand volts;

2.The xenon lamp required to maintain the current pre 80-200mA in general;

3.Charging to the storage capacitor can be from 0 to 1000V and can be preset;

4.The storage capacitor to discharge pulse xenon lamp discharge, 1 to 20 times per second can be adjusted.

The first part and the second part of the combination of a circuit, called SIMMER (pre) circuit. With the third part of the inverter to complete, regardless of the switching element for SCR, VMOS or IGBT, the inverter principle are the same, namely the rectified DC inverse into high frequency AC pulse.

3.2 Principle analysis of series resonant charging circuit and selection of parameters L and C

The principle diagram of series resonant DC-DC inverter circuit is shown in Figure 4.

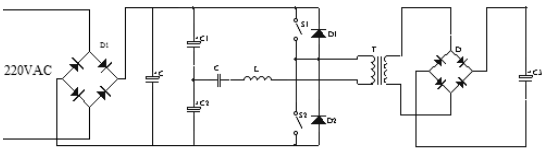

Figure 4 Half bridge series resonant charging circuit

The circuit is composed of a voltage dividing capacitor C1 and C2, a resonant capacitor C, a resonant inductance L, a power switching element S1 and S2, a fast reverse recovery diode D1and D2, a high frequency isolation boost transformer T and a high frequency full bridge rectifier circuit D, which is charged for capacitor C3. Assuming capacitance C1=C2, and much more than the resonant capacitor C.

According to the transition process of the RLC circuit, when the meeting $R < 2\sqrt{\frac{L}{C}}$ is met, the waveform of the damping oscillation characteristic is generated.Assuming that all kinds of elements are ideal components, R=0,

Then

$$\omega_0 = \frac{1}{\sqrt{LC}} \quad f_0 = \frac{1}{2\pi\sqrt{LC}} \tag{1}$$

The natural angular frequency of the LC series resonant circuit isω0,the natural frequency of the LC series resonant circuit is f0.The selection of parameters C and L is the key of the series resonant charging circuit. In the actual design, the high frequency power switching element s1 and s2 is selected according to the function and performance index of the whole design, such as the charging repetition rate required. Optional power field effect transistor VMOS, thyristor SCR or insulated gate bipolar transistor IGBT, so as to determine the operating frequency range of the switching tube. And in the half bridge inverter, two times that of the switching frequency f_s of the resonant frequency f_o of the switch tube. By charging circuit required power index, formula:

$$\mathrm{P}_0 = \frac{1}{2}\mathrm{C}V^2 f_s \tag{2}$$

This can determine the value of the resonant capacitor C, according to the formula (3.2) to determine the parameter L0 in the actual design should take into account the current characteristics of the selected switching element and charging voltage, according to the formula:

$$I_L = \frac{V/2}{2\sqrt{L/C}} \tag{3}$$

The reasonable choice of C, L and fs, so that the whole circuit work in the best state, to achieve the required charging performance indicators, taking into account the stability of the system here we choose the SCR SCR as the inverter, the inverter frequency in 10kHz.

3.3 Simmer circuit design

The effect of pre ignition circuit

(1) Provide trigger pulse amplitude 20 thousand volts;

(2) Provide the xenon lamp current is about 100mA.

Simmer circuit is shown in Figure 5.

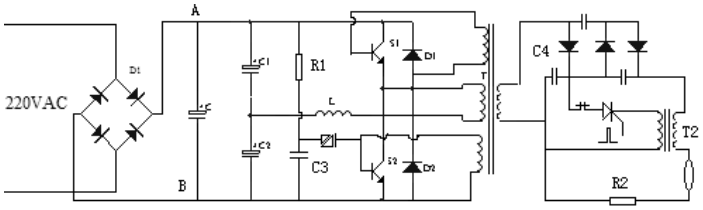

Figure5 The preignition circuit diagram

As shown in Figure 6, the circuit consists of three parts: rectifier filter, dual self-excited oscillation, voltage pre.

First part, when the power is on, the city electric power rectifier bridge rectifier, and then by the C filter, in the A, B between the two points of the DC potential of 300V. $U_{C_1} = U_{C_2} = U_{AB/2}$.

Second part: from the knowledge, R1 charging through C3 to UAB, when the trigger voltage to trigger the two tube, the trigger diode, transistor S2 open, C2 discharge, C1 charging, and inductance L to form LC resonance, when the resonant current reverse through the coupling transformer will S1 open, C1 discharge, C2 charge, and L to form LC resonance, when the resonant current reverse closed by a coupling transformer to S1, S2 will open at the same time. So repeatedly, S1, S2 conduction and globe in turn, oscillation can be built up.

The third part: the secondary pressure by three times, and the xenon lamp poles for xenon lamp to provide pre voltage stability and maintaining current.R2 current limiting resistor, because xenon lamp to simmer, it must be given a 10000 volt ignition voltage, so the voltage on the C4 and the relay normally closed nodes. This is to give the SCR a trigger signal, SCR conduction, C4 power through the early release of T2, this is a nearly 20 thousand volt ignition voltage in the secondary induction of T2. After entering the glow discharge lamp simmer, state. At the same time, long closed node relay off, after three times of pressure on the xenon lamp at both ends, so that it can be lit. This is equivalent to a transformer inductance, formed to maintain the current network and R2, maintain the current in 80-100mA.

4. Design of control and interface part

The control part should be completed by the computer, which can give full play to the advantages of the computer, the convenience of computer operation and visibility to the control has brought great convenience. This increase the corresponding large number of software production, at the same time the computer anti-interference ability to put forward higher requirements.

4.1 The source of interference in the control laser of industrial control computer and its solving measures

Main interference sources are:

(1)After the formation of light precombustion is almost continuous spectrum of electromagnetic radiation interference;

(2) The high voltage generated by the high voltage of the Q circuit is very strong;

(3) When the switch device is switched on or off, the spike interference caused by the inductance element in the power supply is generated.

These interference signals can enter the system through the space control circuit, which is mainly through the introduction of power grid, the task of anti interference circuit to suppress the interference of the power grid system.

Interference of the power grid to the system:

(1) High frequency interference in power supply line;

(2) Transient noise generated by inductive load;

(3) Interference caused by thyristor switching.

In order to improve the system resistance from the power of the various interference, take the following measures:

(1)Noise filter in power supply input end;

(2) The use of transient voltage suppressor;

(3) Shielding of power transformer;

(4) Using separate power supply mode;

(5) High frequency filter of rectifier circuit;

(6) DC side filter;

(7) Power supply decoupling of circuit board.

From the point of view of anti power interference, some anti-interference measures are taken, in fact, these measures have a good effect on the interference caused by other factors such as space electromagnetic interference.

4.2 Interface design and Implementation

Because the system need computer to manage the work of laser power supply, which relates to the problem of high voltage part and weak parts of the isolation, optocoupler isolation, coupling relay, transformer coupled.

To realize the control of laser power supply, the corresponding interface circuit is essential, the front has been discussed, the power in the work will produce a strong interference signal, in order to make the industrial control system in such a harsh conditions of the normal work, the interface circuit anti-interference and isolation technology requirements, the control system and power signal:

(1)Control system: discharge signal, charging voltage preset signal;

(2) The signal from the power supply: the voltage sampling signal.

For general switch control signal, the common photoelectric coupler can be used to achieve a certain speed and isolation purposes. The control unit and the rear stage circuit should be separated from the photoelectric isolation, which is the digital and analog circuit. The transmission signal can be obtained through the photoelectric coupling.

The pulse signal sent by industrial control computer can be sent to the rear stage circuit. High speed optical coupler has a very small delay time, rise time and fall time, through reasonable selection of devices and design circuit, can achieve time accuracy requirements. The sampling voltage signal is not only required to achieve the purpose of signal isolation, but also relatively convenient, only through simple data processing can be the digital signal transmission, can be used to simulate the transmission, its linearity and accuracy are very poor.

But when the VI is less than 0.7 V, 4N25 internal light emitting diode is not entirely mediated by Tong state, then V0 no output so it will not be possible from the input from zero volts began coupling. At the same time by diode voltage - current curve can also know the linearity is not good, so to to achieve a linear coupling to the synthesis of the "bottleneck" problem. And the high precision linear optocoupler SLC800 solves this problem.

SLC800 is by an infrared LED irradiation bifurcation configurations of an isolated feedback light emitting diode and an output is composed of a light emitting diode. The device of special technology can be compensated led time and temperature characteristics of the nonlinear, the output signal and led a servo flux into linear proportion.

Characteristics of SLC800:

(1)AC or DC signal coupling;

(2) Bandwidth >200kHz;

(3) To gain high transmission stability: + 0.05% / ℃;

(4) 3500V peak isolated voltage.

According to the above characteristics, can fully meet the design requirements, so I choose the chip.

Its working principle diagram is shown in Figure 6

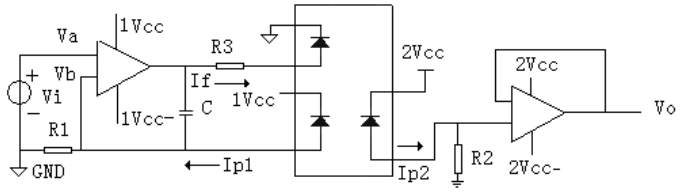

Figure 6 The employment principium drawing of SLC800

Input voltage to drive the LED infrared light and irradiation isolation feedback photoelectric PN junction, the current through R1, R1 and the input voltages VI constitute a differential amplifier circuit, so as to control the If to control Ip1, $V_b = I_{p_1} \times R_1$,eventually make $V_a = V_b$, and SLC800 structure has two identical p-n junction, so that the basic equal Ip2 and Ip1, $V_0 = \frac{V_i \times R_2}{R_1}$, if selected R1 = R2, the Vo = Vi, achieve linear coupling.

5. Conclusion

In summary, IPC control design of YAG laser system based on dual with simplified control, solve the interference, the weak control of high voltage and control signal isolation and linear coupling and made a systematic exposition. For industrial control, dual YAG laser systems from laboratory to market provides a convenient.

Industrial control, dual YAG laser system design is completed, complicated operation process to beautiful, convenient control interface reflection under the WINDOWS system, realized the sitting in front of a computer with a mouse commands a sophisticated laser systems work by the theory into practice.

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