

Study on Laser Micro-Cladding Integrated Circuit Manufacturing Equipment Control System

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Abstract—Among the micro-cladding integrated circuit-based manufacturing equipment, we use closed-loop control of the laser output control unit to precisely control the laser power and change the power of the laser beam. Equipment adopt galvanometer control card and AT89S52. Method of communication using RS232 serial communication, using Time To Live (TTL) level to control the Q-switching through Computer numerical control (CNC) adjustable external control mode. Real-time acquisition of power of the laser beam and timely feedback, and then adjusting the laser power output current size, repeat feedback regulation, until the laser output power reaches the target accurately.

Keywords—micro-cladding; AT89S52; galvanometer; Q-switching; closed-loop control

I. INTRODUCTION

In microprocessor-based cladding circuit manufacturing equipment used to make a variety of different components with different metal powder composition, its melting point is also different, so to strictly control the optical power of the laser beam, it is possible to make different kinds of metal powder to achieve the best cladding effect, precise control of the laser power to change the power of the laser beam is critical. Laser output control unit of the control system using closed-loop control, real-time acquisition of power of the laser beam and timely feedback, and then adjusting the laser power output current size, repeat feedback regulation, until the laser output power reaches the target accurately.

II. AT89S52 AND MAX232 PRACTICAL SYSTEM DEVELOPMENT

In this paper, a control circuit with a galvanometer control card, also using AT89S52, communication using RS232 serial communications.

A. MCU Development

We selected ATMEL company's AT89S52 microprocessor, which has the following advantages: low power, high performance, and support In-system programmable (ISP) advantages, AT89S52 is compatible with the MCS-51 microcontroller series [1].

B. Microcontroller Circuit Interface

According to the principle of overall control hardware circuit design, we can design a basic circuit AT89S52 microcontroller, shown in Figure 1, the design chosen communication interface standard interface, and consider matching the transmission medium, the level of conversion, a standard interface to easily put the microcontroller and peripherals, measuring instruments and other organically connected to form a control system.

In the communication section, there are three ways to choose: RS232, TTL serial and custom two-wire mode[2]; this article using RS232 serial communication, it is by using a serial interface chip MAX232 standard DB9 and PC directly connected to a network system while readers use it to debug the system, eliminating the need for multiple single-chip design stage production card reader hardware system, so the PC can not only manage the online readers, but also for the general management of machine, card reader and PC relatively independent of each machine, PC function better handle other administrative matters. Maxim's MAX232 is dedicated serial interface chip, which includes two-way receiver and drive, take this article transceiver chip which has a power supply voltage converter to +5V power input voltage is converted to RS232 output levels $\pm 10V$ required voltage (negative logic), therefore, the system uses this chip serial communication interface is just a single +5V supply.

(1) RS232 communication interface chip features

Single 5V power supply and other readers in the same chip operating voltage;

Meet all EIA / TIA-232E standard;

Multiple input and output.

(2) RS232 Standard Message Format

RS232 using serial format, shown in Figure 1, this standard specifies: start information is the start bit, stop bit of information is ended; information itself can be 5,6,7,8 bits, plus one parity bit [3]. If there is no information between the two information, write "1" to indicate empty.

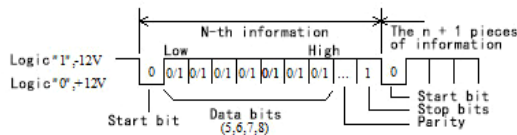


FIGURE I. RS232 INFORMATION FORMAT.

(3) RS232 level converter

RS232 provides its own electrical standards, as it is developed before the TTL circuits, so it is not the level of +5V and ground, instead of using negative logic: the logic "0": +3V ~ +15V; logic "1" : -3V ~ -15V.

Therefore, RS232 and TTL level can not be directly connected. Must be level conversion when used, or will burn TTL circuits, we must note that in the practical application, common level converter IC is a transmission line driver MC1488 and the transmission line receiver MC1489, used in this design is another common level conversion circuit is MAX232.

III. THE ELECTRICAL CONNECTION OF LASER MICRO-CLADDING SCANNING GALVANOMETER SYSTEM

Laser micro-cladding scanning galvanometer system wiring connection diagram shown in Figure 2.

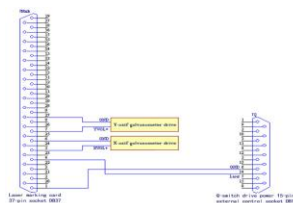


FIGURE II. GALVANOMETER SCANNING SYSTEM CIRCUIT CONNECTION GRAPH.

Laser marking card's 4th pin and first pin output light control signal[4], 4th pin output high level and low level, first pin is GND, the output is TTL level. Q-switch drive power's 14th pin and 6th pin receive light control signal, and then complete the truncated laser and laser appeared, 14th pin high and low input, 6-pin connector and GND, TTL level input, Q switch drive power can be set high or low for effective optical signal. 14th pin input high level and low level, 6th pin is connected to GND, TTL level input, Q switch driver power supply can be set high or low for effective optical signal.

Laser marking card's 5th pin and 6th pin output galvanometer X axis servo motor drive signal, 7th pin and 27th pin output galvanometer Y axis servo motor drive signals. Galvanometer servo motor using a 28V DC power supply.

IV. LASER POWER SUPPLY CURRENT REGULATING CIRCUIT

Laser power operating mode is divided into two kinds: internal control mode and external control mode. Under the internal model, only by manual adjustment of the laser power supply current. Laser power supply with external control interface for 25-pin female socket, the model is DB25 / F, we can connect the external control circuit via a standard 25-pin pin connector, shown in Figure 3, the external control interface as defined in Table 1 show.



FIGURE III. BACK OF LASER POWER.

The *Ie of Table 1 represents the rated current, external control mode machine control signal input requirements for standard TTL level, when input some other level of the enter signal, the current flowing through the op to coupler diode to be met:

- (1) When the circuit is turned on, the current is greater than 5mA and less than 10mA;
- (2) When the circuit is turned off, the current is less than 0.1mA.

Under external control mode, there are two ways to adjust the operating current, analog voltage regulator and TTL level adjustment. We use current analog voltage regulator work in two ways:

- (1) potentiometer adjustment. Select the external control of the work. Adjust the

potentiometer, the operating current of the machine will be between sleep

current and maximum allowable operating current continuous change

(potentiometer resistance take 1KΩ).

- (2) Analog voltage signal provided directly to the set voltage. Between the 13th

feet (positive terminal) and 25th feet (negative side) with a forward voltage

signal, you can set the operating current of the machine:

Setting the operating current (A) = Rated current (A) / 9.0 (V) × external

setting voltage signal (V)

For 30A Laser Power:

Setting the operating current (A) = (30.0 / 9.0) × external setting voltage

signal (V)

For 20A Laser Power:

Setting the operating current (A) = (20.0 / 9.0) × external setting voltage

signal (V)

Analog voltage regulator operating current data flow shown in Figure 4.



FIGURE IV. SIGNAL AND DATA STREAM IN DIGITAL COMMUNICATIONS.

TABLE I. DEFINITION OF 25 PINS.

Pin	Code	Name	Definitions
13 25	VIN+ VIN-	Analog input voltage+ Analog input voltage-	External control current is set analog input signal. When the external control state, 13th, 25th feet enter 0-9.0V, corresponding 0-1e current.
12 24	VC+ VC-	High reference voltage Low reference voltage	High and low reference voltage analog output signal.
11 23	VOUT+ VOUT-	Analog output voltage+ Analog output voltage-	SELECT button on the operation panel can select the output current, voltage or power signal. When an external high-impedance load, the output voltage of 6.0V corresponding to the current of 40A (display current) or voltage of 400V (display voltage).
10 22	VCC-O GND	Internal voltage Internal ground	10th and 22th pin provide a set of VCC (+5V) DC power supply for external analog input and output signals, the output current requirement is <200mA.
9 18	+5V-O COM-O	External voltage+5V external voltage0V	9th and 18th pin provide a set of +5V DC power supply for external digital input and output signals, the output current requirement is <200mA.
21	DHCG	Light trigger success	TTL level signal output high level after the success of light trigger.
8	ALARM	Alert	TTL level signal output low when the machine fails.
20	POWER	Power Good	TTL level signal output low level when the control power supply is normal.
7	READY	Ready	TTL level signal output low level when the power is normal.
19	STOP	Stop state	TTL level signal output low level when at a standstill.
6	RUN	Operating status	TTL level signal output low level when in operation.
5	XM	Sleep request	TTL level input signal sleep at a low level and work in a high level.
17	QD	Start	TTL level input signal is effective at a low level.
4	TZ	Stop	TTL level input signal is effective at a high level.
16 3	WK COM	External control stops External shared	Shorting between 16th and 3th pin, meaning start allowed. otherwise, the meaning is to start the ban.
15	QR	Confirm	Effective at a low level.
2	DATA+	Data+	Effective at a low level.
14	DATA-	Data-	Effective at a low level.
1	RESET	Reset	Reservations, undefined

The control system uses TTL level digital adjustment of external control mode[4], Numerical Control (NC) directly send the current data to the laser power, laser power settings to internal digital circuitry for processing. We can capture the current feedback signal after the laser power setting internal circuit current, this approach can accurately set the output current size, although there is a delay in the time, but its delay length within the allowable range, so the use of numerical methods TTL level is the best choice. Test found, PC parallel port output level to meet TTL level requirements, so this control system uses a PC parallel port to control the laser power [5], PC parallel port and the 25th pin of laser power circuit connection diagram shown in Figure 5.

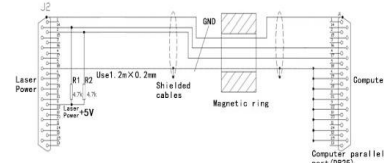


FIGURE V. PARALLEL PORT OF PC AND 25 PINS OF LASER POWER CONNECTION GRAPH.

As can be seen from Figure 5, PC parallel port is not a simple connection the 25th pin of laser power to complete the data transfer, laser power clock signal line and the laser power data signal lines are connected to the pull-up resistor 4.7KΩ, laser power supply + 5V output pin is connected to the other end of the pull-up resistor. Prior to the pull-up resistor is not connected with the oscilloscope measured waveform display, PC parallel port drive capability is not enough for the laser power supply external control interface, therefore, the two cables were added pull up resistor. Outside the "cable" setting up a magnetic ring and a shield, In order to prevent high-frequency data transmission or external electromagnetic interference fleeing, effectively ensuring the reliability of data transmission.

The control system uses external control mode TTL-level digital adjustment, the circuit is simple, and there is a great advantage on cost, the focus of this control method in the programming software.

V. CONCLUSION

In this paper, we have successfully achieved the closed-loop control of the laser output control unit and real-time acquisition of the laser beam power and timely feedback. By adjusting the laser power output current size, coupled with feedback regulation, we can achieve a laser output power accuracy within ± 10mW and different types of cladding metal powder to achieve the best results.

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