Instructions for Continuous-Wave Fiber Laser of Welding

Applicable to：

RFL-2000/2000-ABP-R	**RFL-4000/2000-ABP-R**
RFL-4000/4000-ABP-R	**RFL-5000/3000-ABP-R**
RFL-6000/4000-ABP-R	**RFL-6000/6000-ABP-R**

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CONTENTS

1 Safety Information

Thank you for choosing Raycus Fiber Laser. This user manual provides you with important safety, operation, maintenance and other relevant information. Please read the manual carefully before using this product. To ensure safe operation and optimum product operation, please observe the following cautions and warnings as well as other information within this manual.

1.1 Security Label

Security label are shown in Figure 1.

Figure 1 Schematic diagram of the distribution location of laser safety signs.

The detailed description of safety signs are as follows:

	◆**WARNING:**Describes a hazard that leads to severe injury or death to people.

	◆**CAUTION:** Describes a hazard that leads to general injury to people or damages to product.

 Label in English  Label in Chinese	 Label in English（6000W）  Label in Chinese（6000W）	 Label in English  Label in Chinese
1:Laser Emit Head	2: Type 4 Laser Product	3: Class 2 Laser Product Label-1mW Red Laser
		
4: DO NOT OPEN THE DOOR	5: ID Label (6000W)	6: Laser Radiation Hazard
		
7:Electrical Hazard		

1.2 Laser Safety Grade

According to European Standard EN 60825-1, Clause 9 and Chinese Standard GB 7247.1-2012 Safety of Laser Products Part 1:Equipment Classification Requirements, this series of lasers are Class 4 laser instruments. The product emits laser radiation at a wavelength of 1080 nm or around 1080 nm, and the average laser power radiated from the output head is 4 kW~12kW. Direct or Indirect exposure to high power laser radiation causes damage to the eye or skin. Although the radiant laser is not visible, the beam will cause irreparable damage to the retina or cornea, so appropriate and certified laser safety glasses must be worn throughout the laser emitting.

	◆**WARNING:**Users must use appropriate laser goggles when operating this device. The laser goggles should be selected according to the range of wavelength emitted from this product. Users must ensure that the pretect range of laser goggles over the entire range of laser wavelengths. Please do not directly view the laser output head when laser emitting.

1.3 Optical Safety

Any dust on the end of the collimator assembly can damage the crystal of output head or the entire laser device.

	◆ **CAUTION:**DO NOT emit when the protective cap is not removed, otherwise the lens or crystal will be damaged.

1.4 Electrical Safety

a) Ensure that the PE line is effectively grounded, and the installation environment is safe and reliable.

	◆ **WARNING:** The disconnection of the product grounding will electrify the enclosure, which may result in personal injury to the operator.

b) Ensure that the AC voltage is supplied normally.

	◆ **CAUTION:** Wrong wiring mode or power supply voltage will cause an un recoverable damage to the laser device.

1.5 Product Maintenance Instructions

a) General safety instructions

1) Do not view the laser output head directly when laser is emitting.
2) Do not use fiber lasers in dim or dark environments.
3) Please strictly follow this User Guide to operate the laser. Otherwise, any damage to the laser will not be covered by warranty.
4) Operation under high temperature will accelerate the aging of the laser, or increase the current threshold value, or reduce the sensitivity of the laser and wall-plug efficiency. If the laser overheats, please stop using it and ask Raycus for help.

b) Optical part instructions

1) See that the laser's end cap is removed before starting the laser. Otherwise, the output head of the laser's fiber cable will be damaged irreversibly.
2) The door of the space for placing the laser shall be equipped with interlock control, and warning signs shall be affixed around to mark and limit the safe area for operating the laser.

3) See that the laser is turned off and the power supply is disconnected when installing and dismantling the cutting head or collimator.

Attention:

When the laser is used in conjunction with external collimating and focusing output device, please make sure that all optical components of the collimating and focusing components are clean and free from contamination. The dust and contamination in the whole output optical system will not only damage the external collimating and focusing system, but also damage the laser itself, posing risks to the safe use of the laser. For the sake of safety, regular and timely inspection to the optical components of the collimating and focusing system, through which the high-power laser beam will pass, is recommended. Timely inspection, timely cleaning and timely replacement are required.

c) Electrical part instructions

1) In the process of maintenance, the circuit fuse employed to replace the old one must be of the same type and grade with the old one, if necessary. Other fuse or substitute material are not allowed to use.

2) There is no operator serviceable parts or components inside the product. All inspection and maintenance shall be performed by professionals from Raycus.

3) Please do not dismantle the housing of the laser. Dismantling and installing the laser and damaging related labels without authorization will bring about the risk of electric shock or burn. Any laser dismantled without authorization will no longer enjoy guarantee.

Attention:

If the laser is placed in an environment no more than 0℃，please see that a corresponding proportion of antifreeze is added to the water channel of the water chiller. If the laser is expected to be left idle for a long time, please see that the water in the inlet channel and outlet channel is drained completely (a high-pressure water gun is recommended), so as to prevent water delivery devices from being damaged by the freezed residual water.

2 Product Description

2.1 Features

Fiber lasers are more compact and ready to use than conventional laser structures, with higher electrical and optical conversion efficiencies, lower power consumption and better beam quality. Thanks to its flexible laser output, it can be easily integrated with system equipment.

Main Features:

a)High beam quality;

b) High reliable;

c)Adjustable output beam;

d) Center/ring power adjusted independently;

e)Free-maintenance operation;

f) High electro-optical conversion efficiency;

g) Convenient control interface;

h)Fast modulation.

Applications:

a)Industrial cutting and welding;

b) Scientific research.

2.2 Package Parts

Please refer to package accessoriesare in the packing box.

2.3 Unpacking and Inspection

Through the specially designed packaging materials and cabinets, Raycus ensures that the lasers are fully protected during transportation. Nevertheless, in order to prevent unpredictable situations during transportation, the users still need to carefully check whether the package is correctly placed before unpacking, and there is no damage from phenomenon such as collision, cracking and flooding on the outside of the box. Once you find that there is an abnormality in the external cabinet, please inform Raycus Company in time to deal with it as soon as possible.

Please double check if each listed content is inside the package; and contact Raycus as soon as possible if there are any issues.

Take extra care when removing the unit from the package and make sure that the fiber optic cable stays away from any possible collision and vibration. Please do NOT distort, bend or pull the output cable when unpacking the device; and avoid any collision to the head of laser output.

	**CAUTION:** The fiber optic cable and output head are precise optic instrument, ANY vibration or impact to the output head, and twist or excessive bend to the cable will damage the instrument.

2.4 Operation Environment

The operation conditions are listed as the following table:

Table 1 The Operation Environment Conditions for the Laser

Model	2000/2000	4000/2000	5000/3000	6000/6000
Supply voltage (V)	Three-phase four-wire systemAC380V、50/60 Hz			
Power supply capacity (kVA)	＞18	＞25	＞35	＞50

Water cooling flow (L/min)	＞35	＞52	＞64	＞94
Normal temperature Water's flow (L/min)	QBH：＞1.5; QD：＞2			
Installation Environment	Flat, no vibration nor impact			
Ambient Temperature	10℃～40℃			
Relative Humidity	30%~70%			

a)Make sure the product is properly grounded before use.

b) The laser output head is connected with fiber optic cable. Please inspect the output head carefully for dust or other contaminations. Use appropriate lens paper to clean it if necessary.

c)Failure to follow the instructions when operating the laser may cause malfunction and damage.

d) It is not allowed to install the output head when the laser is in operation.

e)Do not look into the output head directly. Wear appropriate protective eye glasses all the time when operating the laser.

Tips: Install the laser in an air-conditioned environment for longer life and better performance.

2.5 Attentions

a)Make sure that the correct voltage of 380VAC is used. Connecting failure of power supply will damage the device.

b) The output laser is collimated by the collimating lens, it is important to keep the collimating lens clean, otherwise it will damage the device.

c)Please cap the output head when it is not in use. Do not touch the output lens at any time. Use appropriate lens paper to clean it if necessary.

d) Safety keep the cap when using the laser. To avoid dust, make sure the opening direction of the cap is put down.

e)Failure to follow the instructions may cause laser power loss, such loss is not covered by warranty.

2.6 Specifications

Table 1 Product Specifications

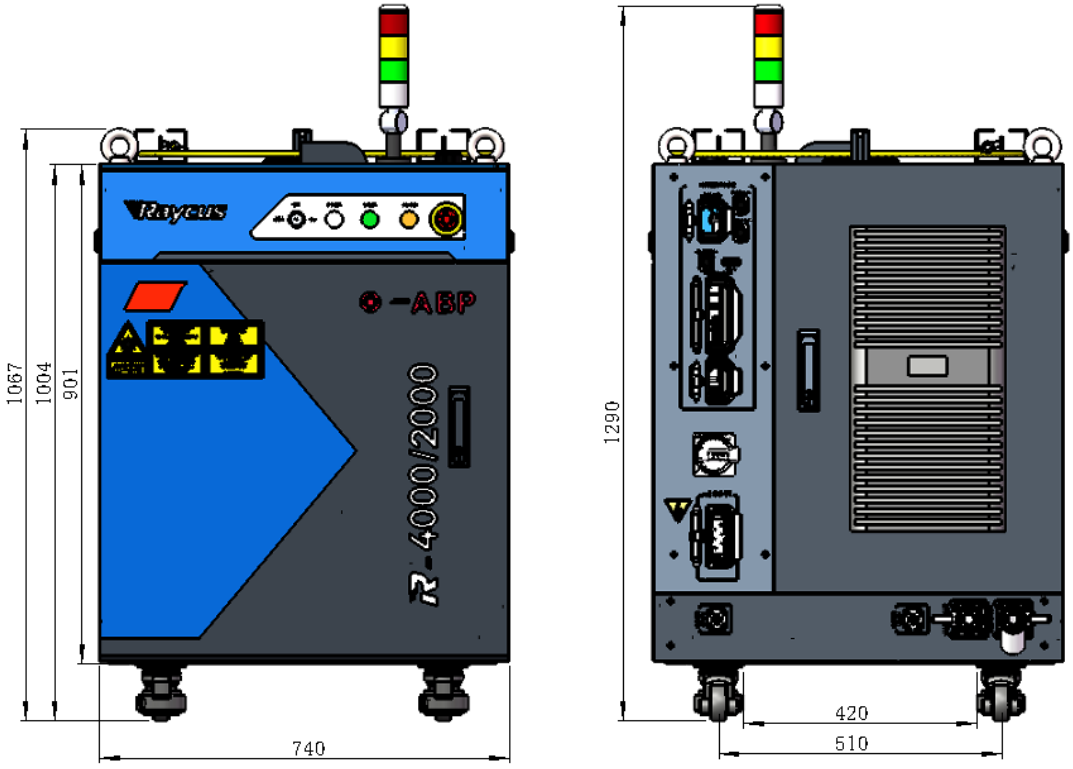
Optical properties				
Model	2000/2000	4000/2000	5000/3000	6000/6000
Output Power(kW)	4	6	8	12
Operation Mode	CW/Modulated			
Polarization State	Random			
Output Power Tunability (%)	10～100			

Emission Wavelength(nm)	1080±5（Nominal Output Power）			
Output Power Unstability	±1.5%（Nominal Output Power; Duration: 1hrs）			
Modulation Frequency (Hz)	1～5000			
Red Guide Laser Power(mW)	0.5～1			
Fiber output Types	QBH（customizable）			QD
Beam Quality (BPP, mm•mrad)	＜2.2（@50um）(center) ＜7.0(@150um)(ring) （Nominal Output Power）			
Delivery Cable Length(m)	20（customizable）			
Electrical characteristics				
Operating Voltage	Three-phase four-wire system AC380V、50/60 Hz			
Maximum Power Consumption (kW)	11.5	17.5	23	34.5
Way to control	Serial communication / AD/ TD/FieldBus (EtherCAT/PROFINET/DeviceNet)			
Other characteristics				
Dimension (W×H×D)	738mm×1067mm×12770mm （Includes casters and rings, without Warning lights）			
Weight (kg)	＜280	＜400	＜400	＜500
Operating Ambient Temperature（℃）	10～40			
Storage Temperature (℃)	-10～60			
Cooling method	Water cooling			

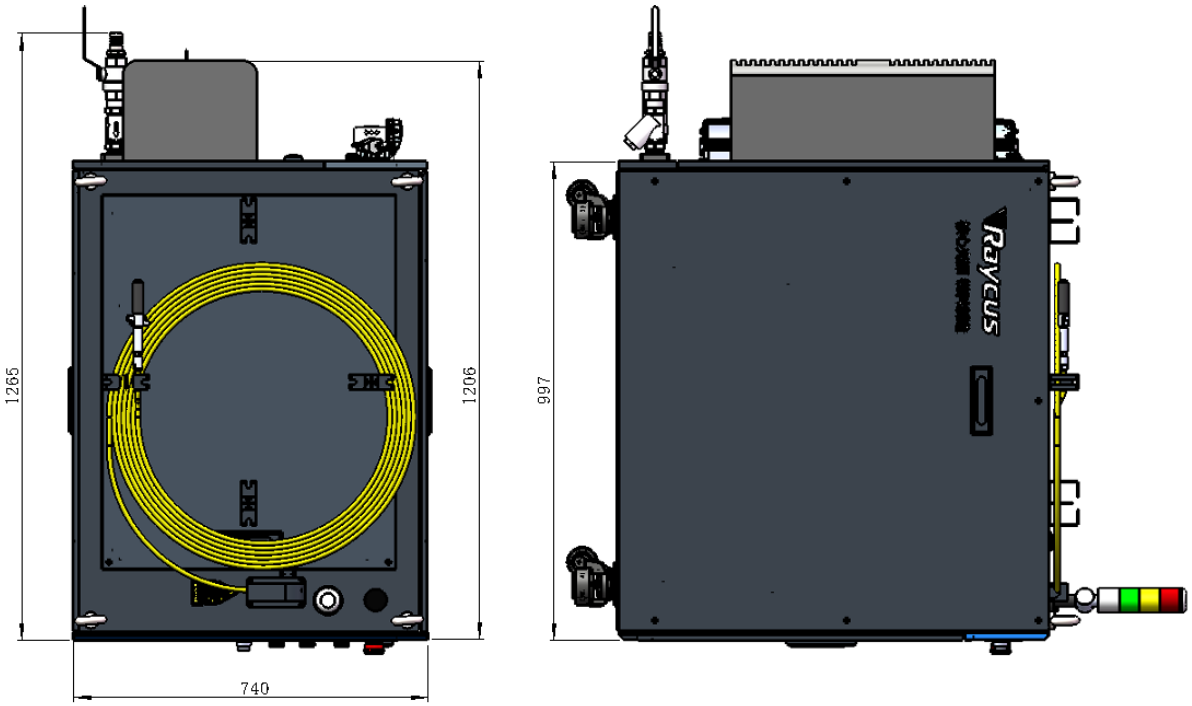
3 Installation

3.1 Dimensions

The main body dimensions of RFL-4000/2000-ABP-R continuous fiber laser are shown in Figure 2.



a) Front and rear view of the laser.



b) Top and left view of the laser.

Figure 2 The dimensions of RFL-4000/200-ABP dual-optical channel continuous wave fiber laser for welding

The standard output cables of Continuous-Wave Fiber Laser of Welding fiber laser for welding uses

QBH or QD output fiber cable. The dimension of the output fiber cable head are shown in Figure 3 :

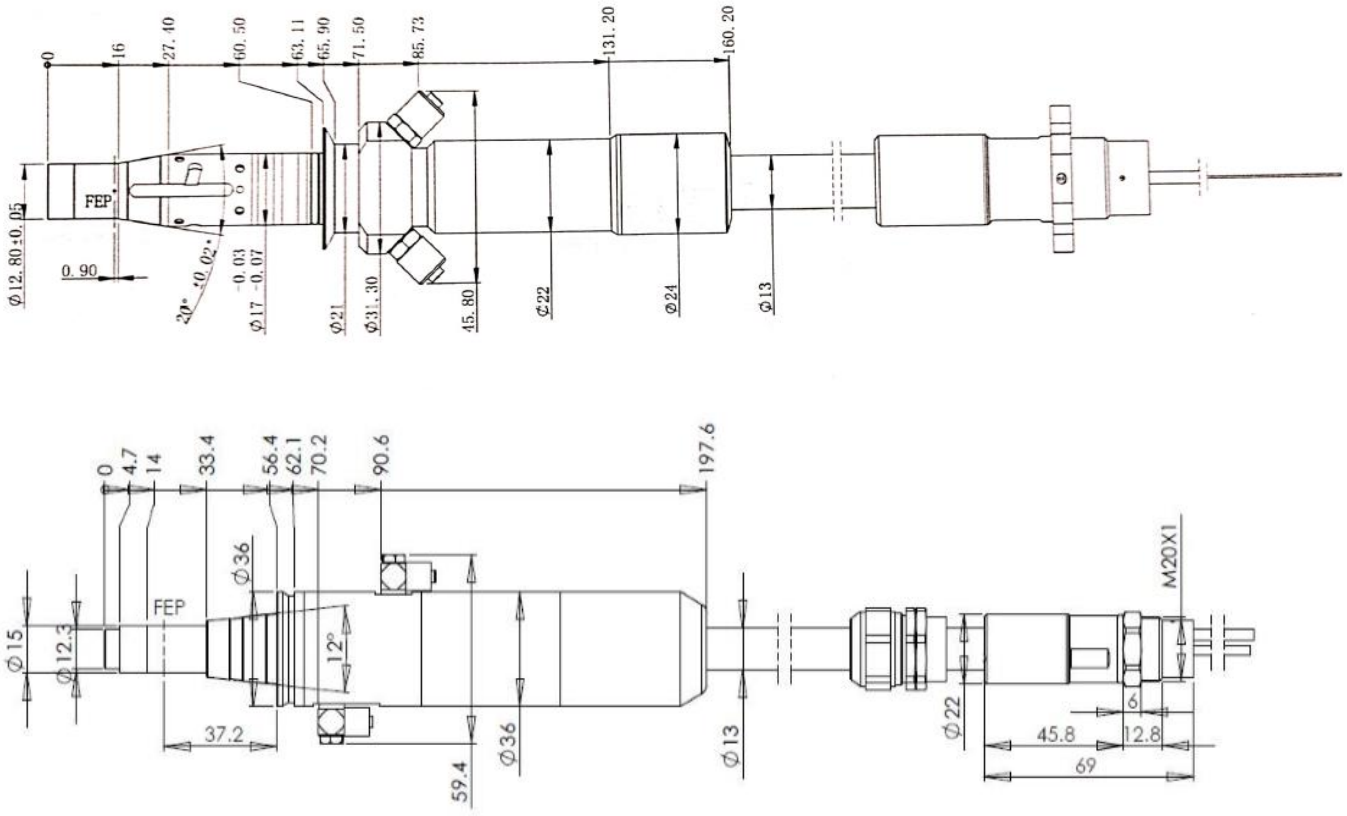


Figure 3 Dimension of the QBH and QD output fiber cable head

Attention: The dimensions in the above diagram are in the unit of mm.

Before the laser works, make sure that the two copper contacts (Interlock pins) on the output head are shorted, otherwise the laser will not work properly. Before installing the output cable into the processing head, the lens of the output cable must be inspected. If the output cable lens is dirty, the lens must be cleaned. It is forbidden to disassemble the output lens by anyone other than staff in Raycus, otherwise the warranty will be invalidated.

3.2 Installation rules

a)Place the laser horizontally in a suitable position and fix it as necessary;

b) Before the laser is powered on, Please check if the power supply has the correct voltage (380VAC±10%, 50/60Hz, See Table 2 Product Technical Data Sheet for details.), whether the grounding line is well grounded;

c)Connect the power cable and control cable to the product when power supply is OFF;

d) Connect the cooling system to the laser and output optical cable head according to the water inlet and outlet signs;

e)Please check the laser output head and make sure to clean it before installing it in the equipment;

f) Do not step on, squeeze or excessively bend the protective tube during the installation of the output optical cable to avoid damage to the optical fiber;

g) In the process of installing the optical cable output head, ensure the cleanliness of the surrounding environment (do not use electric fans to dissipate heat when it is hot in summer to avoid large dust in the air);

h) The minimum bending diameter of the laser transmission cable in non-working conditions such as transportation and storage shall not be less than 20cm. When the laser is emitting light, the minimum bending diameter shall not be less than 30cm;

i) By using the four hoisting rings on the top of the laser or the four castors at the bottom of the laser, customers can lift or push the laser. Before lifting the laser, please see that the four hoisting rings are firmly and reliably installed. When lifting the laser, please see that all the four hoisting rings are used. Before pushing the laser, please see that the supporting shoes of the castors have left the ground. After the laser is positioned, the supporting shoes need to be adjusted to touch the ground, so as to avoid movement of the laser.As shown in Figure 4.

Figure 4 Laser top lifting ring and bottom level adjustment caster.

	**CAUTION:** All the cables can only be connected when power supply is off. Hot plug may damage the device.

	CAUTION: (a) The placement of the laser output cable should be as natural as possible, and the output cable should not be twisted; (b) If the coil diameter of the output optical cable is too small, it will damage the laser.

	CAUTION: (a) In the process of installation and disassembly, please handle the laser output head gently, and avoid vibration; (b) Before assembling the laser output head, ensure that the optical lens and cutting head cavity are clean and free of pollution.

3.3 Cooling Requirements

3.3.1 Water cooling requirements for laser

Table 3 Cooling Requirements

Model	2000/2000	4000/2000	5000/3000	6000/6000
Cooling Capacity (kW)	≥12	≥18	≥24	≥36
Minimum Flow （L/min）	≥35	≥52	≥64	≥94
Input Pressure (Bar)	4-6			
Hose Inner Diameter (mm)	Φ32			
Cooling Water Temperature (℃)	22±1			

※Note：

a)The laser source cooling water connection is shown in Figure 11, and the arrow direction indicates the water flow direction;

b) Cooling water needs to use pure water;

c)In order to prevent the water in the water cooler from growing mold and causing pipeline blockage, it is recommended to add alcohol when filling pure water, and the amount of alcohol added is 10% of pure water;

d) If ambient temperature is between -10℃ and 0℃, must be used to use 30% alcohol (volume ratio), and replace it every 2 months;

e) If ambient temperature is below -10℃, the chiller with both heating and cooling functions must be used, and keep it in full-time operation;

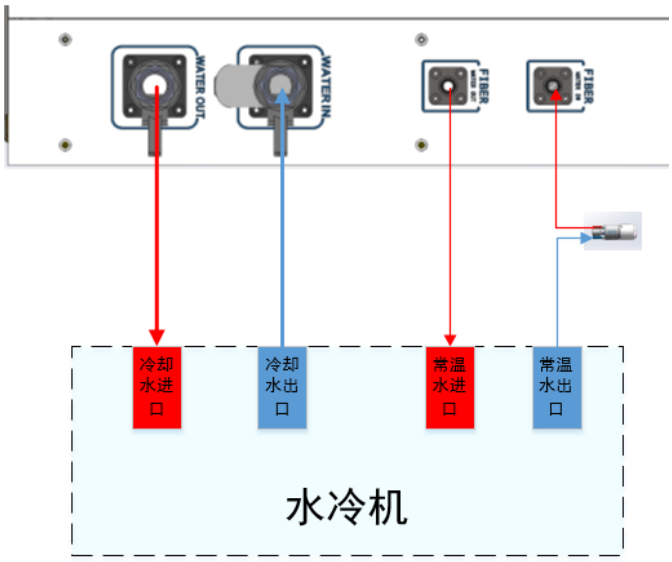


Figure 5 diagram of laser cooling system connection

3.3.2 Water cooling requirements for output optical cables

Table 4 Water cooling parameters for output fiber cable

Type of output fiber cable	Water flow rate（L/min））	Input pressure (Bar)	Inner diameter of the hose (mm)	Temperature range (℃)
QBH	≥1.5	4-6	φ13	15-35
QD	≥2	4-6	φ13	15-35

Attention:

a) The laser output optical cables cooling water connection is shown in Figure 5, and the arrow direction indicates the water flow direction;

b) Cooling water quality: deionized water, distilled water, purified water. it is recommend to replace once a month, and the replacement period should not exceed two months;

c) PH value of cooling water: 5.5～9;

d) The water cooler needs to be equipped with a filter element whose filter particle size is less than 100um, the filter element needs to be cleaned once a month;

e) Additives in cooling water: meet the above PH value and solid particle size requirements;

f) Armored pipe bending radius: in non-working conditions such as transportation and storage, the minimum bending diameter shall not be less than 20cm. When the laser is emitting, the minimum bending diameter shall not be less than 30cm;

g) Long-term vibration, less than 2G; impact, less than 10G.

3.3.3 Other requirements:

a)When starting the cooling system for the first time, check the entire water system and joint for water leakage.The external water pipes must be installed and connected according to the water inlet (IN) and water outlet (OUT) marked on the Laser. Otherwise, the laser may not work properly;

b) If the laser is not used for a long time, the cooling water inside the cooling system and the laser inside should be drained, otherwise the laser equipment will be damaged;

c)Please use compressed gas below 0.5MPa when emptying water from the device. Failure to do so may cause permanent equipment damage to cooling system.

	**CAUTION:** (1) Set the water temperature of the cooling system correctly according to the ambient temperature. Setting the water temperature too high will result in the laser not working properly. Setting the water temperature too low will cause condensation inside the laser or the laser output head, which will cause damage to the laser; a)(2) Before turning on the laser, the cooling system must be working properly and the water temperature should be suitable for the temperature.

4 Using the Product

4.1 Front Panel

The buttons on the front panel of the laser as shown in Figure 6:

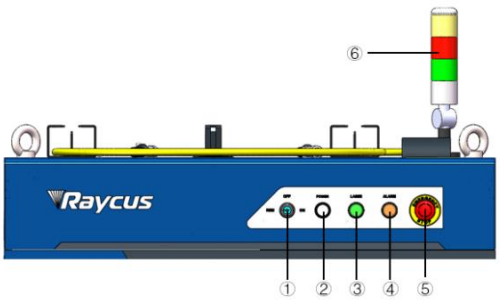


Figure 6 Front view of the panel

Note: ①-REM/OFF/ON ②-POWER ③-LASER

④-ALARM ⑤-STOP ⑥-INDICATOR LIGHT

REM/OFF/ON：The key switch, the main control switch of the laser. Insert the key and turn it to the "ON" position, the main control part of the laser is powered on, and the POWER light is on；Rotate to the "REM" position, you need to close the 8 and 9 pins of the XP1 interface on the rear panel to realize remote power-on, and rotate to REM to activate the hard-wired control mode of the laser.

POWER：Control power indicator, when the white indicator light is on, it means the main control system is on.

LASER：The power button of the laser main power supply has a green light indicator function. After the laser main control system is powered on and all INTERLOCKs are detected as normal, press this button, the laser main power supply is powered on, and the button lights up after the main power supply is powered on.

ALARM：INTERLCOK alarm indication, the ALARM indicator lights up during the power-on self-check on the control panel. After the self-inspection is completed, all INTERLOCK interfaces are normally closed, and the ALARM indicator is off. During the operation of the laser, if any INTERLOCK is disconnected and the laser preparation is not completed, the indicator light will be on.

STOP：Emergency stop button, press to turn off the main power of the laser immediately; turn the button clockwise to release the button.

INDICATOR LIGHT：After the main power supply of the laser is powered on, the green indicator light is on when the laser is Ready; when the laser is emitting light, the red indicator light is on; when the laser has a fault, the yellow indicator light is on, accompanied by an alarm sound.

4.2 Rear Panel

The buttons on the rear panel of the laser as shown in Figure 7:

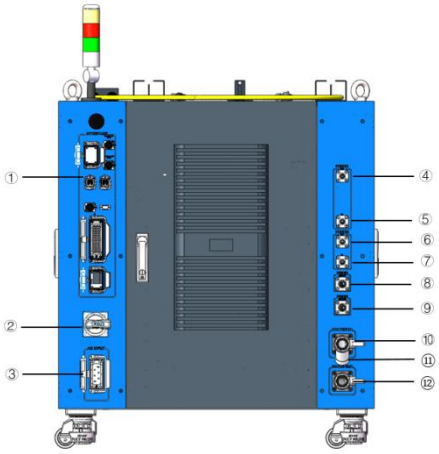


Figure 7 Rear view of product panel.

注：①—INTERFACE，②—Breaker，③—AC INPUT

④—FIBER1 IN，⑤—FIBER1 OUT，⑥—FIBER2 IN

⑦—FIBER2 OUT，⑧—FIBER SUPPLY ⑨—FIBER RETURN

⑩—WATER IN，⑪—FILTER，⑫—WATER OUT

INTERFACE: This interface provides all control signals, including: RS232 communication, laser on/off control, laser remote control mode selection, analog control, modulation signal, Interlock interface, etc. Refer to 4.4 for the definition of control lines. This socket comes with a protective cover and a lock. When you are not using the product, you can cover the power input socket with the protective cover and lock it with the lock.

BREAKER: The circuit breaker (air switch) on the rear panel of the laser is the main power switch of the laser.

AC INPUT: The power input socket must be matched with the plug provided by us. This socket comes with a protective cover and a lock. When you are not using the product, you can cover the power input socket with the protective cover and lock it with the lock.

FIBER1 IN：Room temperature water inlet of the output fiber cable 1, which is connected to the water outlet of the output fiber cable head by φ13 hose and quick connector.

FIBER1 OUT：Room temperature water outlet of the output fiber cable 1, which is connected to the water inlet of the output fiber cable head by φ13 hose and quick connector.

FIBER2 IN：Room temperature water inlet of the output fiber cable 2, which is connected to the water outlet of the output fiber cable head by φ13 hose and quick connector.

FIBER2 OUT：Room temperature water outlet of the output fiber cable 2, which is connected to the water inlet of the output fiber cable head by φ13 hose and quick connector.

FIBER SUPPLY：Room temperature water supply inlet, which is connected to the room temperature water outlet of the water chiller by φ19 hose.

FIBER RETURN：Room temperature water supply outlet, which is connected to the room temperature water inlet of the water chiller by φ19 hose.

WATER IN: The water inlet of the laser, this interface is connected to the water outlet of the cooling water of the water chiller, and connected to the φ25 inner diameter water pipe.

Filter: Filter for removing the impurity in the water. It requires regular cleaning (Cleaning per three months is recommended). When the water flow rate warning appears, check the filter to see if it is blocked.

WATER OUT: The water outlet of the laser, this interface is connected to the cooling water return port of the water chiller, and connected to the φ25 inner diameter water pipe.

4.3 Power connection

CAUTION:

(1) Before connecting to the AC power supply, please check whether the supplied AC power supply meets the requirements in Table 1;

(2) Incorrect wiring will cause damage to the laser, so please check whether the power cord is connected correctly before powering on the laser.

The AC power line of continuous-wave fiber laser of welding adopts a eight-core cable. The definition and parameter requirements of the AC input line interface are shown in Table 5.

Table 5 The interface definition and parameter requirements of AC input line.

Interface definition and parameter requirements of AC power line for continuous-wave fiber laser of welding.					
Connector Tag	Interface definition	Logo	4kW/6kW Wire diameter	12kW Wire diameter	Wire color
1、2	AC380V-L1	L1	$4mm^2/4mm^2$	$6mm^2/6mm^2$	Brown
3、4	AC380V-L2	L2	$4mm^2/4mm^2$	$6mm^2/6mm^2$	Black
5、6	AC380V-L3	L3	$4mm^2/4mm^2$	$6mm^2/6mm^2$	Gray
7、8	Protective	PE	$4mm^2/4mm^2$	$6mm^2/6mm^2$	Yellow-green

The standard length of AC power line is 30 meters.

4.4 Control interface definition

4.4.1 SAFETY XP2 24 PIN Interface

24-pin safety interface, with remote control system power-on, remote main power power-on and active and passive output of some lasers. The detailed interface definition is shown in Table 6.

Table 6 XP2 security interface definition

Pin number	type	description
1	Reserved	/
2	Reserved	/
3	OUT(FET S pole)	Laser output indication,MOS pipe D, S output; current<1A, V_{DS}<30V, passive signal.
4	OUT(FET D pole)	
5	OUT	Connect the negative pole of the external laser-emitting indicator, current＜100mA
6	OUT	Connect the negative pole of the external power-on indicator, current＜100mA
7	OUT（24V）	Connect the positive pole of the external laser-emitting indicator and power-on indicator, current＜400mA
8	IN	On REM mode, the main control board is powered on when pin-8 and pin-9 are closed;24V active contact Output,no external voltage or grounding.
9	IN	
10	24V OUT	Connect the positive pole of the external laser-emitting indicator and power-on

		indicator; current＜400mA
11	OUT	Emergency output 1 on the front panel, relay output contact, passive contact, current <100mA, voltage<30V; If the current panel stop pressed, B3 and B6 are open, or else close.
14	OUT	
12	OUT	Emergency output 2 on the front panel, relay output contact, passive contact, current <100mA, voltage<30V; If the current panel stop pressed, B4 and B5 are open, or else close.
13	OUT	
15	OUT(FET S pole)	Main power supply power on output indication, MOS pipe D, S output current＜0.5A,VDS＜60V
16	OUT(FET D pole)	
17	IN	Interlock1 input, the C1 and C4 should be closed normally; active contacts, no external voltage or grounding.
20	IN	
18	IN	Interlock2 input, the C2 and C3 should be closed normally; active contacts, no external voltage or grounding.
19	IN	
21	IN	Close the C5 and C6 to start the main power supply remotely. (The function is the same as the LASER button on the front panel.) active contacts, no external voltage or grounding.
22	IN	
23	OUT	C7 and C8 indicate the laser key switch status: Opened - the laser key switch is in the OFF position and the laser control system isn't powered; Closed - The laser key switch is in the ON or REM position and the laser control system is powered. Passive contact, external voltage signal, the voltage is less than 30V, and the current is less than 1A.
24	OUT	

a) MOD Signal(in Table 9)

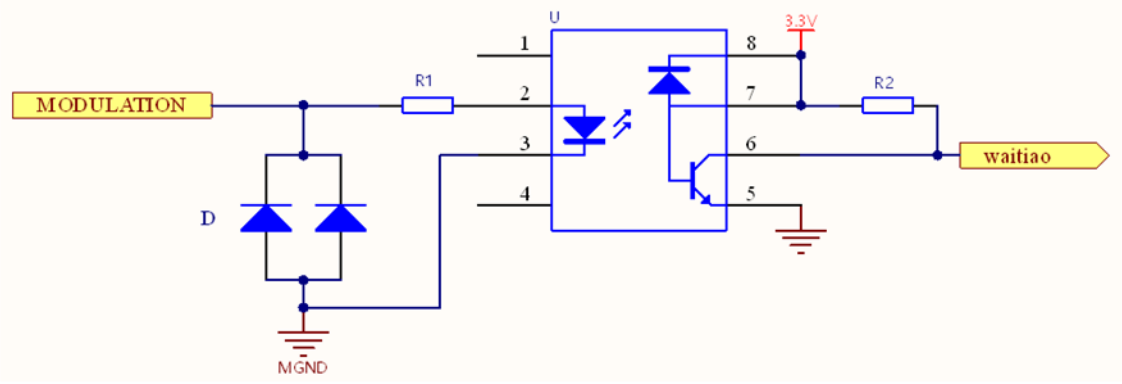


Figure 8 MOD Signal Schematic Diagram

The MOD signal can be 18V~30V, and reverse connection is not allower.

When turn the key switch to "ON" and the laser emission power is externally controlled, MOD singal can control laser output or turn off.

When turn the key switch to “REM” and the laser emission power is externally controlled, MOD Singal and XP1-A2(A2 is the laser enable signal) jointly control the laser output or turn off(on REM mode, emission externally controlled is only controlled by A2, and can be custom-ized).

a)The laser output indicator and main power indicator(in passive signal)

XP2’s A3/A4 is the laser output indicator and B7/B8 is main power indicator. They are passive signal. The internal circuit diagram is as follows.

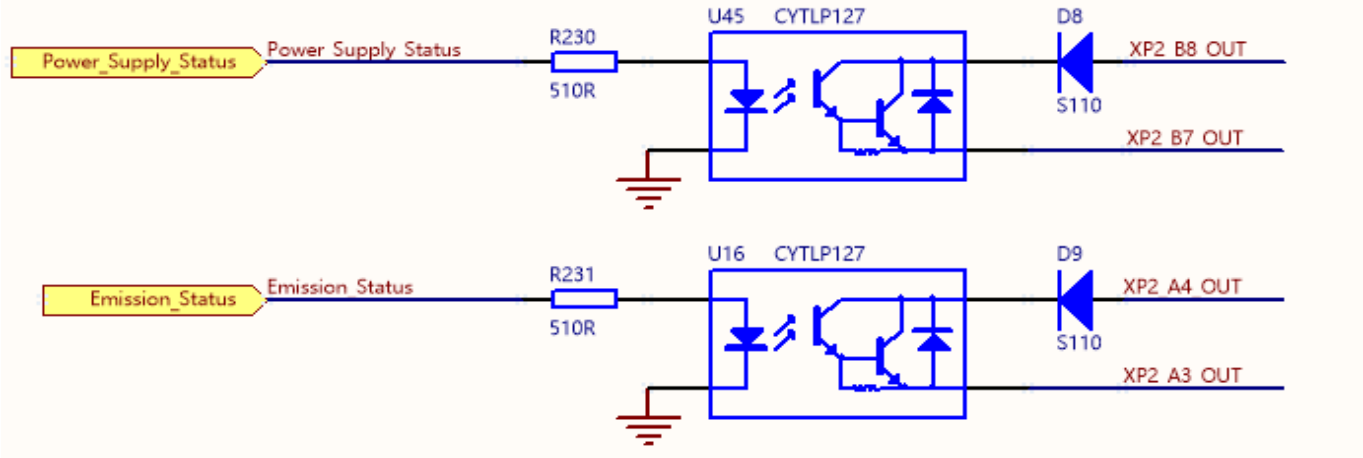


Figure 9 The internal circuit diagram of the laser output indicator and main power supply power on output indicator (in passive signal)

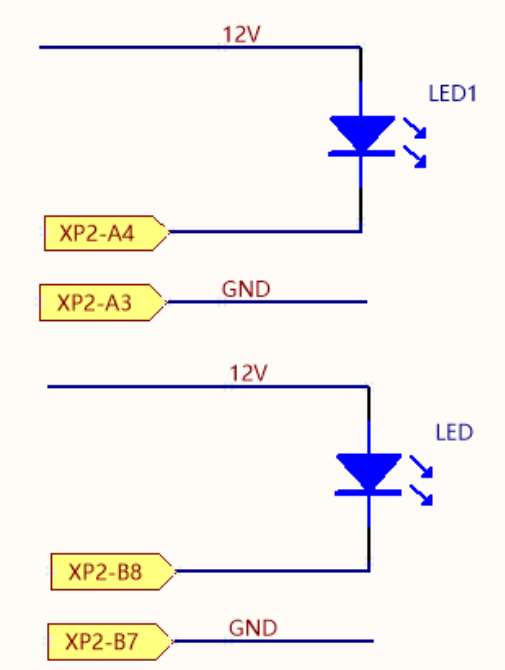


Figure 10 The proposed circuit diagram of the laser output indicator and the main power indicator

b) Indication of active beam emission and indication of power-on of the main power supply

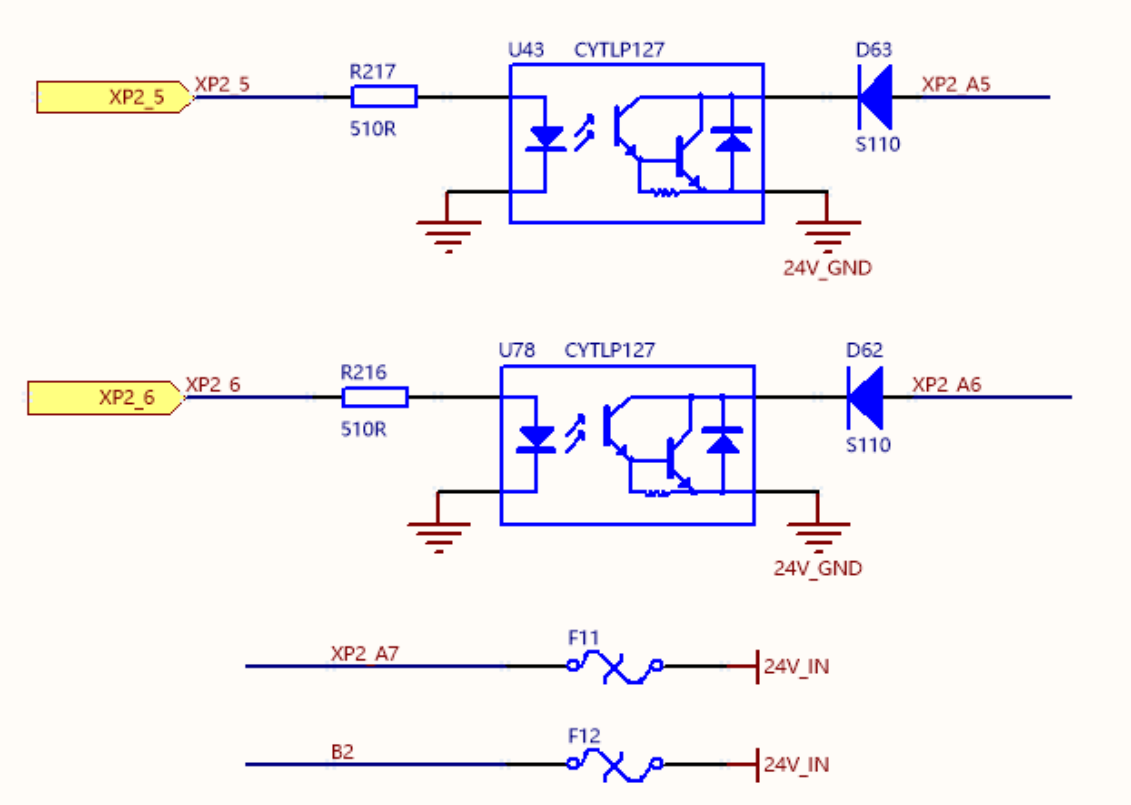


Figure 11 The internal circuit diagram of the laser output indicator and main power supply power on output indicator (in active signal)

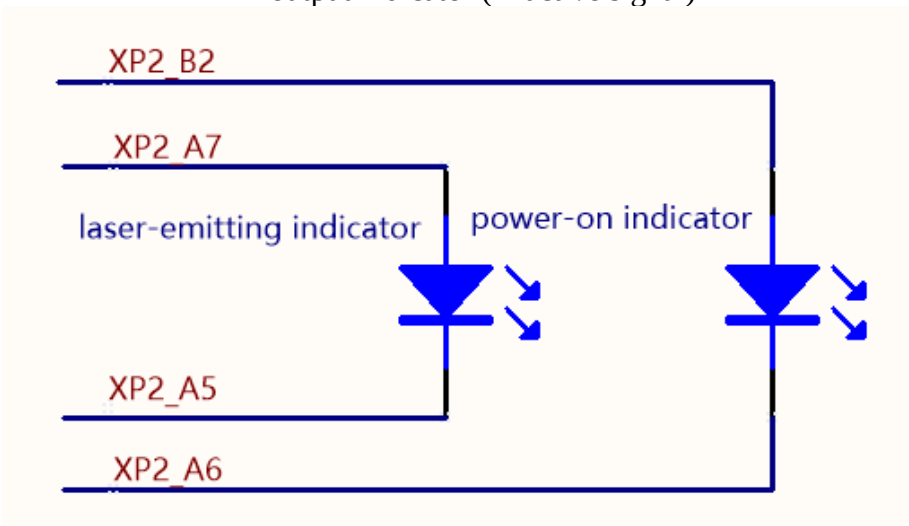


Figure 12 The proposed circuit diagram of the laser output indicator and the main power indicator

d) The control system is powered remotely

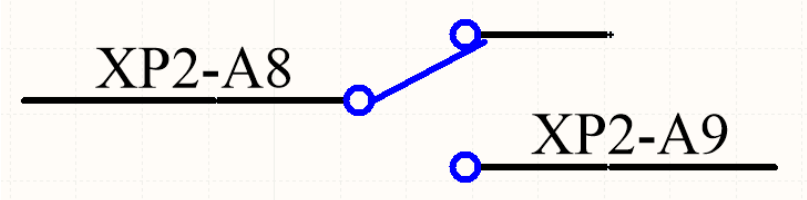


Figure 13 The proposed circuit diagram of the control system is powered on remotely

When the laser key switch is turned to REM mode, pin A8/A9 must be short circuited, or the main control board cannot be powered on.

e) Remote power-on of the main power supply

This signal is used for power-on of the main power supply via XP2 interface.

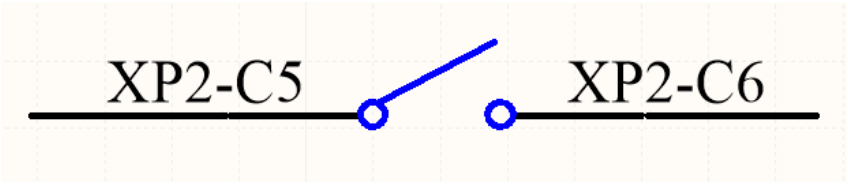


Figure 14 The proposed circuit diagram of the main power supply is powered on remotely

f) The control board has been powered on and started output

This signal is outputted by relay. The relay will operate after the control board is powered on.

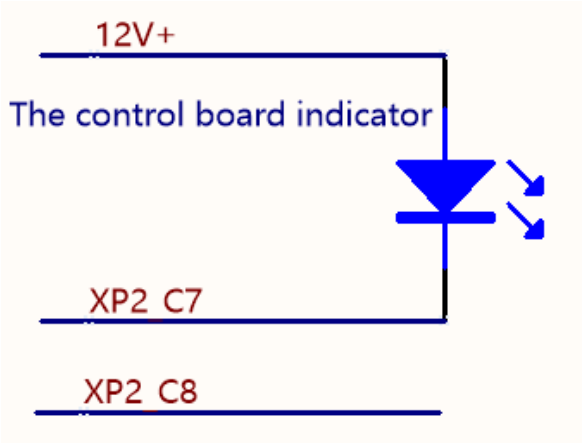


Figure 15 The indicator light of the control system is powered

4.4.2 HARDWIRING XP1

64 pin hard wire interface, control signal input and output interface of laser in remote mode. Input high level is greater than 18V valid, input low level is less than 3V valid. Specific interface definitions are shown in Table 7 below.

Table 7 XP1 Hardwire interface definitions

Interface Definition		Type	Description
Pin No.	Pin Definition		
A1	Laser request signal	Input signal	Laser request signal, only after this bit is valid will the laser receive other XP1 hard-wired interface input commands.

A2	Programming mode start-up execution	Input signal	When A8~A14 are all low, A2 is the laser enable signal; if there is a high level in A8~A14, it enters the programming mode, the program command is executed from the rising edge of A2, and the program number is determined by A8~A14. Users need to ensure that A2 is always high during program execution (B9 is high), and then set A2 low after the program is executed (B9 is low). The laser output power is set by the program if the program number is not 0000000; the laser output power is set by AD analog if the program number is 0000000 and the A6 is high.
A3	Enabling Internal patter	Input signal	High level enables PC software control function.
A4	Reset signal	Input signal	Active on rising edge; to clear laser alarm bit; effective high-level time at least 1 ms.
A5	Red light indicator	Input signal	The guide led light indicator is on when A5 is high.
A6	Simulation control enabling energy	Input signal	When A6 is high, the analog input signal is enabled. The program number Program Number is required to be set to 0, or A8~A14 are all low (non-programming mode).
A7	Stop programming Mode	Input signal	In programming mode, program execution is terminated immediately when A7 is high.
A8~A14	Set program Number	Input signal	Hardwired address for selecting a stored program number. A8 is the lowest bit and A14 is the highest bit.
A15	synchronous input	Input signal	Synchronous input signal, used with the program command WAIT in programming mode.
A16	COM	Reference ground	Reference ground for all input signals of XP1.
C1	Laser-driven power supply	Input signal	The rising edge turns on the main power, and the falling edge turns off the main power.
C2	Not connect		

C3~C6	Select the optical gate channel	Input signal	C3 is the lowest bit, C6 is the highest bit: 0000-close all optical gate channels; 0001-open channel 1; 0010-open channel 2; 0011-open channel 3. (For lasers with optical gate channels only, these pins are spare in other lasers)
C7	Enable QCW mode	Input signal	Enable QCW mode (For lasers with QCW modes only)
C8~C16	Not connect		
B1	The laser is ready	Output signal	The laser is ready to emit laser light when B1 is high.
B2	Laser output	Output signal	The laser is emitting light when B2 is high.
B3	The laser operates in internal mode	Output signal	The laser works in the internal control mode when B3 is high. In this mode, the laser can be controlled by communication.
B4	Laser anomalies	Output signal	The laser is abnormal when B4 is high.
B5	Laser red light indication	Output signal	The laser is emitting guide light when B5 is high.
B6	AD mode	Output signal	The laser works in the AD mode when B6 is high.
B7	Feedback signal of A1	Output signal	The laser has received the A1 signal when B7 is high.
B8	Main power supply of laser	Output signal	The main power of laser is on when B8 is high.
B9	Program running	Output signal	Laser program is running when B9 is high.
B10	Program ending	Output signal	Laser program is ended when B10 is high. B10 clears when the A2 is invalid.
B11	Abnormal Wave Mode Termination	Output signal	Laser program is ended abnormally when B11 is high. B11 can be cleared when the A4 is high.
B12	Synchronous output	Output signal	Sync signal output in programming mode.
B13	Warning output	Output signal	Laser is warning when B13 is high.
B14	Not connect		
B15	External power supply (Positive pole)	Input signal	The 24 V input voltage, power supply of all XP1 output signal. Only when B15 and B16 access 24 V power, output signal is effective.
B16	External power (Negative pole)	Input signal	

D1~D4	Current optical gate channel	Output signal	Indicates the current optical gate channel: 0000-all optical gate channels closed; 0001-channel1 opened; 0010-channel 2 opened; 0011-channel 3 opened. D1 is the lowest bit, D4 is the highest bit.
D5	Water cooler warning	Output signal	Indicates the current water temperature warning, indicating a risk of emitting laser. (Used with Water Cooler)
D6	Water cooler alarm	Output signal	Indicates the current water temperature alarm, prohibits laser emission. (Used with Water Cooler)
D7	QCW mode	Output signal	Output signal indicating that the current laser operates in QCW mode (For lasers with QCW mode only)
D8~D11	Laser hardwire address	Output signal	Set the laser hardwire address (Coding-Cable function): 0000- laser 0; 0001- laser1.
D12~D16	Not connect		

4.4.3 RS232 XP3 Interface

The 9-pin serial interface is used for the communication between the laser and the upper computer. It can be used to communicate with the upper computer of Raycus Company or the software of the upper computer which integrates the communication protocol of Raycus. The definitions are shown in Table 8.

Table 8 XP3 Serial Interface Definitions

Pin No.	type	Description
2	IN	RXD，Serial port receiving pin of
3	OUT	TXD，Serial Sending Foot of Laser
5	COM	GND，Serial port public end

4.4.4 Analog Interface XP4

The analog interface, is used to control the output center or ring power of the laser by analog in AD mode, control laser output or turn off by MOD singal in external control , and can also monitor the output light and power feedback signals of the laser. The interface definition is shown in Table 9 below.

Table 9 XP4 Analog interface definitions

Pin	type	description
1	Pout_C	Center power amplifier voltage output. 0 V: 0% laser power output; 8 V: 100% laser power output.
2	Pout _GND	Reference Ground for Power amplifier Voltage
3	Pout_R	Ring power amplifier voltage output. 0 V: 0% laser power output; 8 V: 100% laser.
5	HBR+	High back-amplification voltage (reserve, no)
6	HBR-	Reference Ground for High Backup Voltage
7	AD_C	0～10 V analog signal, center laser power control signal in AD mode , 0～10 V corresponding to 0～100% output
8	AD_GND	Reference Ground for Analog signal Voltage
12	AD_R	0～10 V analog signal, ring laser power control signal in AD mode , 0～10 V corresponding to 0～100% output
9	MOD_C	The central laser emission enables the signal, and the maximum modulation frequency is 5KHZ， Laser ON：18～30V；Laser OFF：-3～4V
10	MOD_GND	Reference Ground for modulation signal Voltage
11	MOD_R	The ring laser emission enables the signal, and the maximum modulation frequency is 5KHZ， Laser ON：18～30V；Laser OFF：-3～4V
/	/	Reserve

4.4.5 INTERNET Interface XP5

Table 10 XP5 Communication interface definitions.

Pin	Function	Description
1	TX+	Data
2	TX-	Data
3	RX+	Data
4	N/C	connectionless
5	N/C	connectionless
6	RX-	data acceptance-
7	N/C	connectionless
8	N/C	connectionless

4.4.6 BEAM SWITCH SAFETY INTERFACE XP8/XP9

The BEAM SWITCH SAFETY interface（XP8/XP9）is 8-pin interface, which can be

used for controlling the on and off of the BEAM SWITCH safety door and monitoring the open/close status of the channel 1 and channel 2 of the beam switch. The interface definition of the interface is shown in table 11.

Table 11 XP8/XP9 Interface Definition

Pin	Function	Description
1	Output signal for opening/closing the safety door of the channel 1/2 of the beam switch	They are active contact points: 1 and 2 are one group, and 3 and 4 are another. These two groups of contact points have interlock function. Normally, these two groups of contact points needs to be short connected.
2		
3		
4		
5	Mirror1/2 OFF	Feed back output signal (passive contact point) when the channel 1/2 of the beam switch is closed
6		
7	Mirror1/2 ON	Feed back output signal (passive contact point) when the channel 1/2 of the beam switch is open
8		

4.4.7 FIELDBUS INTERFACE FIELDBUS IN/ FIELDBUS OUT

The FieldBus IN interface is the input interface that communicates with the PLC device. FieldBus OUT can be used as the FieldBus IN series interface of the next laser. The definition of its interface are shown in Table 12.

Table 12 FieldBus IN/FieldBus OUT interface definition

Pin	Function	Description
1	TX+	Data transmission+
2	TX-	Data transmission-
3	RX+	Data acceptance+
6	RX-	Data acceptance-
4,5,7,8	termination	

4.5 Introduction to Safety Interlock

Raycus' product is designed with a safe interlocking loop, which is a two-channel system with output monitoring and manual reset. When the safety interlocking circuit is open, the safety circuit will disconnect the working power of the optical module, that is, the main power supply of the optical module. To start the main power supply, you must close the two interlocking channels (24 pin interface : 17 and 20 feet short ,18 and 19 feet short). Otherwise, the main power will be turned off and the laser can not be

turned on at this time. When one of the channels is open, the laser main power supply is impossible to start until the other channel is open, and then the two channels are closed before the laser main power supply can be started. If the interlock is closed (the stop button is also released) and there is no error alarm, press the start (LASER) button to start the main power supply, and the 'main power has been started' pin of the external interface will have a high-level output.

When the security interlocking circuit is open or the error is detected, the main power supply of the optical module will be turned off, and the 'main power supply has been started' signal of the interface will become low level. The detected 'error state' is latched and the on-board relay opens the manual reset loop with monitoring until the error is cleared, thus preventing the laser from being restarted. If errors such as short circuit between interlocking channels or short circuit of start (LASER) button are detected, the safety loop can not be reset before the error is cleared.

4.6 Schematic diagram of the internal electrical circuit of the laser

The internal electrical circuit of the laser is shown in figure 16:

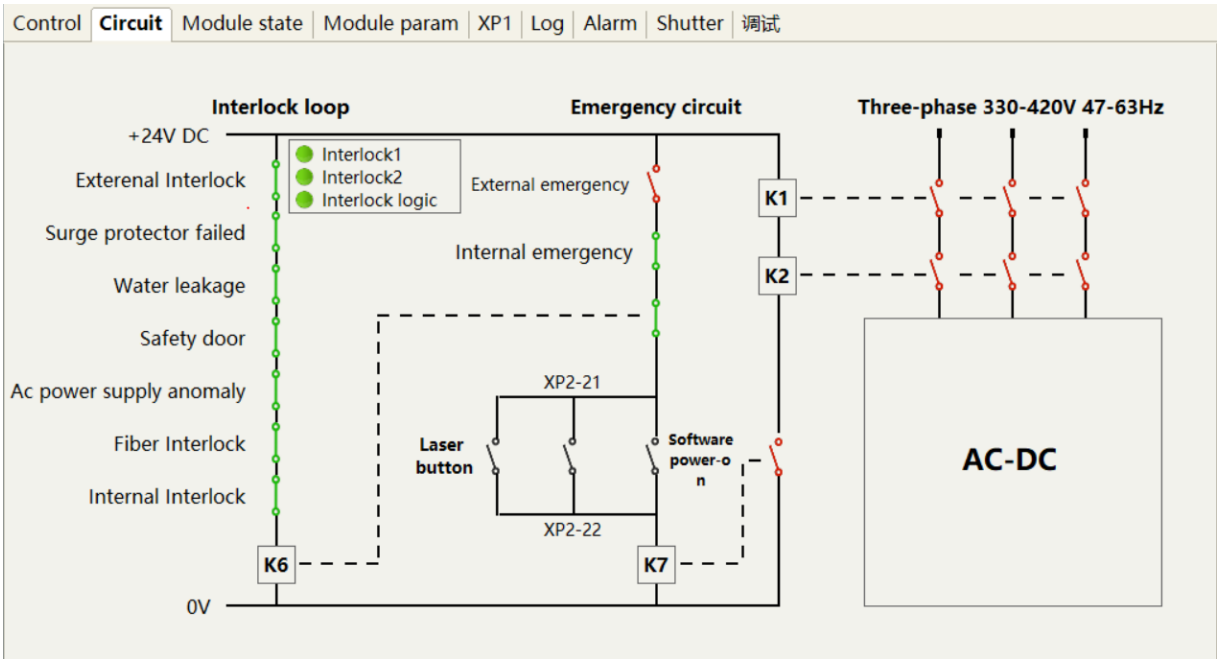


Figure 16 Schematic diagram of the internal electrical circuit of the laser

4.7 Beam Control Page

The beam switch control page is shown in Figure 17: When the status indicator lamp of the beam switch channel turns green, it means this channel is open; when switching channels from one to another, from channel 1 to channel 2, for example, it is required to switch from channel 1 to channel 0 of the beam switch (i.e. close all beam channels), and then switch to channel 2. When switching channels of the beam switch via C3-C6 of the safety circuit XP2, it is also required to switch to channel 0 of the beam switch (close all channels of the beam switch) before switching to other channels.

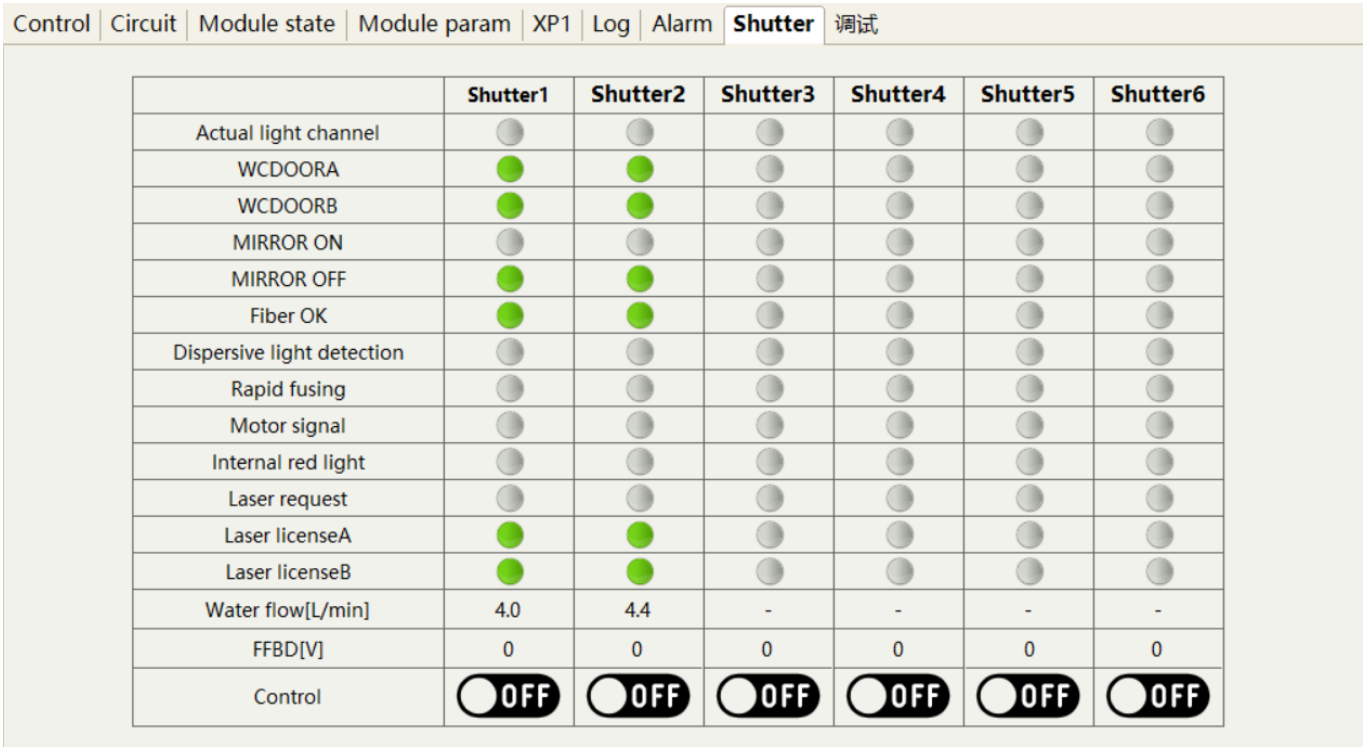


Figure 17 Laser beam switch control page

4.8 Start operation sequence

a)Turn on the water cooler, check whether the water pipe is leaking, turn off the water cooler and connect electrically.

b) Make sure the circuit breaker is in a OFF state and the stop button on the front panel of the laser EMERGENCE STOP pressed; all electrical connections must be completed before the laser is powered on.

c)Confirm that the three-phase electrical connection is correct and the power supply meets the specifications of the power supply, turn on the water cooler.

d) Close the rear panel circuit breaker, release the laser front panel emergency stop switch; ensure that all laser doors are closed, optical cable output head has been inserted into the cutting head (or corresponding equipment), all interlock interfaces have been closed;

e) Select the required control mode according to 5 control mode, turn on the key switch, start the main power supply waiting for the laser to Ready, the laser Ready, the tricolor green light above the machine, representing that the laser can light.

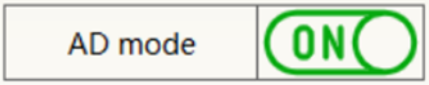
5 Control Mode Selection

The Raycus high-power CW laser has two control modes: namely ON mode and REM mode. Users can select the mode to be entered through the key on the front panel. The specific operation are shown in Table 15.

Table 15 Working Mode Selection of Raycus High-power Continuous Wave Fiber Laser and Operation Method

	AD Mode	External control	programming mode	Power	Laser ON and off	Red laser
ON Mode	close①	close②	-	communication⑬	communication ⑪	communication ⑫
	Enable③	close②	-	XP4-7/8、12/8pin pressure	communication ⑪	communication ⑫
	close①	Enable④	-	communication ⑬	XP4-9/10、11/10 pin level	communication ⑫
	Enable③	Enable④	-	XP4-7/8、12/8pin pressure	XP4-9/10、11/10 pin level	communication ⑫
REM Mode	close⑤	close⑥	close⑦	communication ⑬	communication ⑪	communication ⑫
	Enable⑧	close⑥	close⑦	XP4-7/8、12/8pin pressure	communication ⑪	XP1-A1/A5 is high level
	close⑤	Enable⑨	close⑦	communication ⑬	XP1-A1 laser request is high XP1-A2 laser emission enable is high XP2-A1、A2input MOD singal	XP1-A1/A5 is high level
	Enable⑧	Enable⑨	close⑦	XP4-7/8、12/8pin pressure	XP1-A1 laser request is high XP1-A2 laser emission enable is high XP4-9/10、11/10 input MOD singal	XP1-A1/A5 is high level
	close⑤	Enable⑨	Enable⑩	determined by programming command	XP1-A1 laser request is high XP1-A2 high level indicates operating program	XP1-A1/A5 is high level

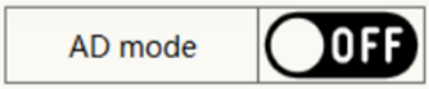
Note: Operation method of ①～⑬: ①Send “DEC” by communication;②Send “DLE” by communication; ③ Send “EEC” by communication; ④ Send “ELE” by communication; ⑤ XP1-A1 is high level, and XP1-A6 is low level or suspended; ⑥ XP1-A1 is high level, and XP1-A3 is high level; ⑦XP1-A1 is high level, and XP1-A8~A14 are all low level or suspended; ⑧XP1-A1 is high level, and XP1-A6 is high level; ⑨XP1-A1 is high level, and XP1-A3 is low level or suspended; ⑩XP1-A1 is high level, and not all of XP1-A8~A14 are low level；⑪Send “EMON” by communication to emit beam, and send “EMOFF” to turn off the emission; ⑫Send “ABN” by communication to emit guide beam, and send “ABF” to turn off the guide beam; ⑬Send “SDC XX” 、“SRDC XX”by communication to set the center and ring power by percentage point; XX means the power by percentage point.

①Send "DEC" by communication, or click 

button on the host computer software；

②Send "DLE" by communication，or click 

button on the host computer software；

③Send "EEC" by communication，or click 

button on the host computer software；

④Send "ELE" by communication， or click 

button on the host computer software；

⑤XP1-A1 is high level， XP1-A6 is low level or suspending;

⑥XP1-A1 is high level， XP1-A3 is high level;

⑦XP1-A1 is high level， XP1-A8~A14 is low level or suspending;

⑧XP1-A1is high level， XP1-A6is high level;

⑨XP1-A1is high level， XP1-A3 is low level or suspending;

⑩XP1-A1 is high level， XP1-A8~A14 is not all low level;

⑪Send "EMON" by communication，or click 

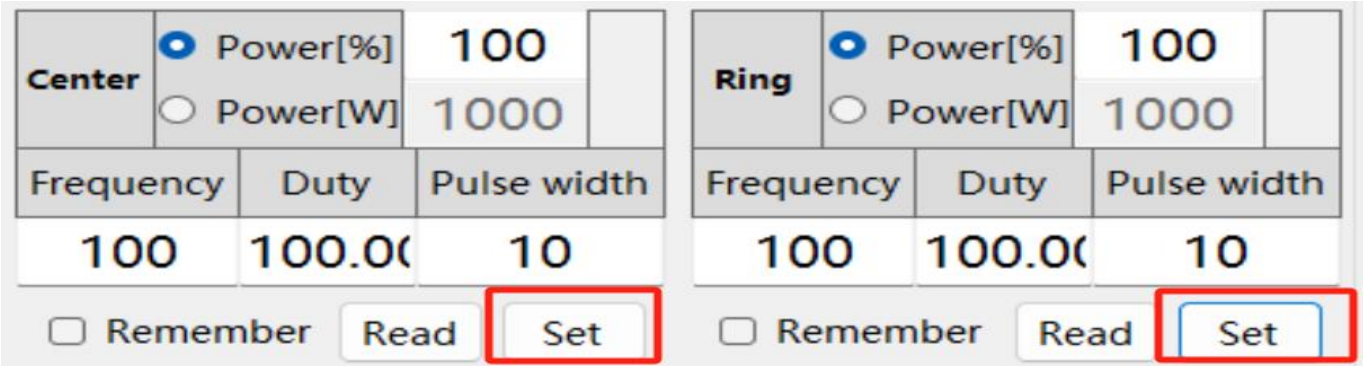
button on the host computer software to emit laser;Send "EMOFF" by communication， or click

button on the host computer software to turn off the laser;

⑫Send "ABN" by communication， or click 

button on the host computer software to emit red light;Send "ABF" by communication， or click Guide laser ON button on the host computer software to turn off red light;

⑬The communication sends "SDC XX"、“SRDC XX” to set the power percentage, XX represents the power percentage, or click



button on the host computer software.

5.1 ON Mode

During ON mode, the user can set different working modes through the host computer software or direct communication command, and the laser will remember the mode before the power is cut off after re-powering.

5.1.1 Emission External Control Enable

When the emission external control is enabled, the laser emission is determined by the level difference between the pins of 7/8, 12/8 in the XP4 port; if the emission external control is not enabled, the laser emission or shut down are determined by the emit button in the Raycus Laser Control System. Also, you can send “EMON” command to turn laser emission on, and send “EMOFF” command to turn laser emission off.

5.1.2 Guide Laser (Red Guide Beam) Control

In “ON” mode guide laser can only be turned on/off by using Raycus Laser Control System, or by sending command of “ABN” (on) / “ABF” (off).

The red light module inside the laser works through communication, so there is a time delay of at least 10ms for the opening and closing of red light；

When the red light is on, the laser cannot be set to “Ready”. Only after the red light is turned off the laser can be set to “Ready”. (This limit can be changed, please contact Raycus Engineer).

5.1.3 Programming Mode

In “ON” mode, when the current program number of the laser is not 0, the laser runs in the “Programming” mode.

Please use the Raycus Host Computer Software to edit the waveform and select the pre-run program number.

When the laser is in the internal control mode: Press the 

“ON” button or send the “EMON” command, the laser will start to run the program,

Send the “EMOFF” command or press the 

“OFF” button can terminate the laser emission at any time

When the laser is in the external control mode, the rising edge of MOD starts to operate the program, and the falling edge of MOD can terminate the program at any time.

5.2 REM Mode

5.2.1 AD enable mode Emission external control

When both A1 and A6 of XP1 are set high, the laser operates in AD mode, and the current laser center and ring power is determined by the analog voltage of pin 7/8 and pin 12/8 of XP4; When A6 of XP1 is set low or suspended, the current laser power is set by sending "SDC 80" and “SRDC 80” command through PC software or communication.

5.2.2 Emission external control

When both A1 and A3 of XP1 are set high, the laser is in the internal control mode, and the laser emission is controlled by the computer software's light on button or through communication sending"EMON" to control the light output, and "EMOFF" to control the light off; When A1 of XP1 is set high, A3 is suspended or set low, the laser is in the external control mode, the output light is determined by the high and low TTL of the MOD signals at A2 (XP1) and pin 9、10 (XP4) and pin 11、10 (XP4).

5.2.3 Red light control

When both A1 and A3 of XP1 are set high, the laser is in the red light internal control mode, and the red light is controlled by the computer software red light button or through communication by sending "ABN"or "ABF" command to control the ON/OFF of the red light; When A1 of XP1 is set high, and A3 is suspended or set low, the laser is in external control mode, and the red light is controlled by A5 of XP1.

The red-light module in the laser works by means of communication, so there is a time delay of at least 10ms when the red light is turned on and off.

When the red light is on, the laser cannot be set to Ready. Only after the red light is turned off the laser can be set to “Ready”. (This limit can be changed, please contact Raycus Engineer).

5.2.4 Programming Mode

When A1 of XP1 is set high and A8-A14 is not 0, the laser is in “Programming Mode”. At this time, the laser emission is controlled by A2 of XP1, and the laser emission waveform is determined by the edited waveform.

6 Laser Wiring Diagram and Operation Steps

6.1 Internal control in ON Mode

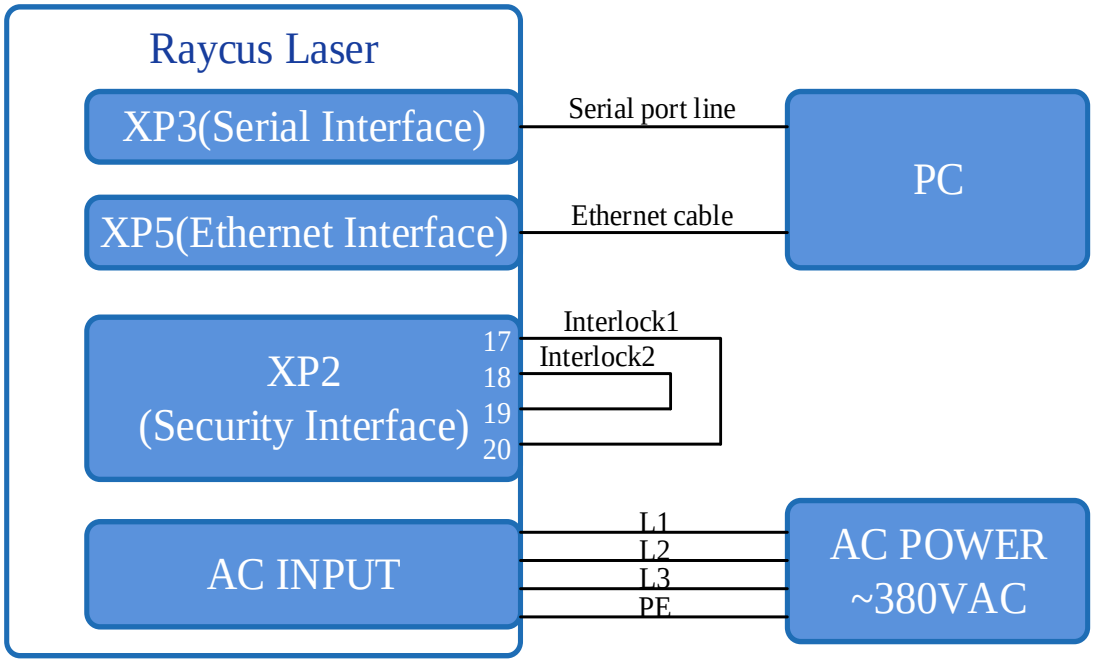


Figure 18 software mode wiring diagram when key switch at “ON” position

Operations Steps

a) Turn the knob switch on the rear panel to“ON”

b) Turn the key switch to“ON”

c) Open the Raycus Laser Control System

d) Click the guide laser “ON” button to view the guide laser

e) Turn off “AD” mode and turn off external control mode (this mode can be memorized when power off)

f) Click the main power “ON”

g) Waiting for “Ready”

h) Set laser emission parameters

i) Click the laser “ON”.

6.2 In ON Mode, Laser Operating in External Control Mode

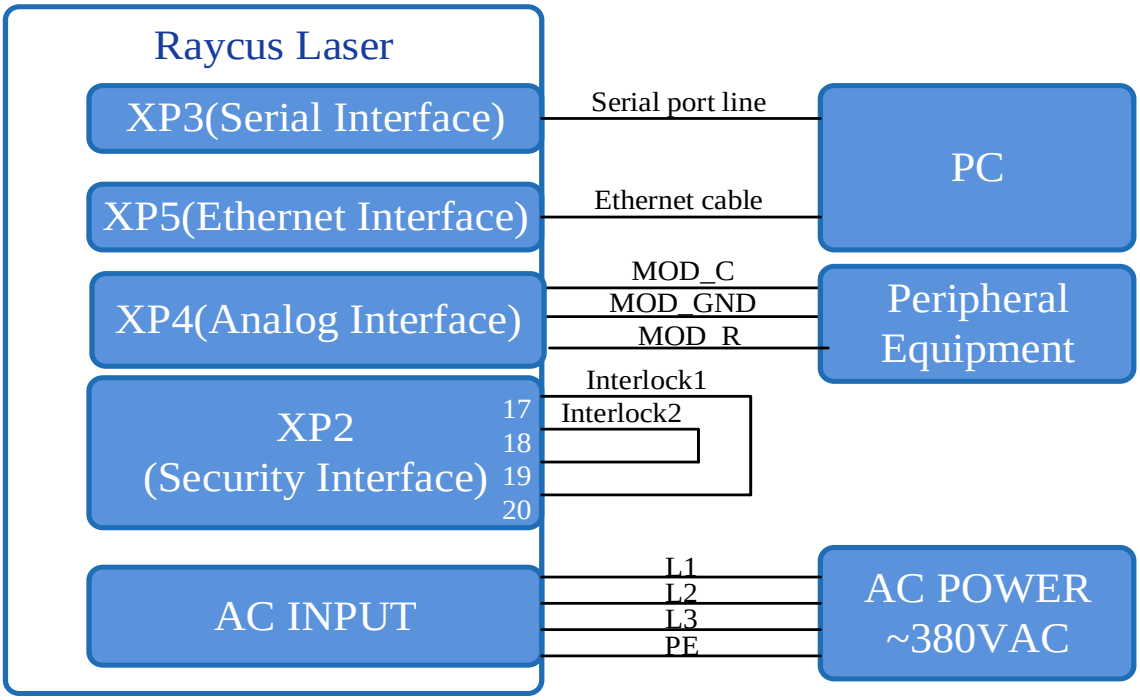


Figure 19 The wiring diagram of laser operating in external control mode

Operations Steps

a) Turn the knob switch on the rear panel to“ON”

b) Turn the key switch to“ON”

c) Open the Raycus Laser Control System

d) Click the guide laser “ON” button to view the guide laser

e) Turn off “AD” mode and turn on “External Control” mode (this mode can be memorized after power off)

f) Click the main power “ON”

g) Waiting for “Ready”

h) Set the percentage of laser emission power

i) Turn on the center and ring laser through the high level output by MOD signal

6.3 In ON Mode, the Laser Emission Power is Externally Controlled by Analog Signal

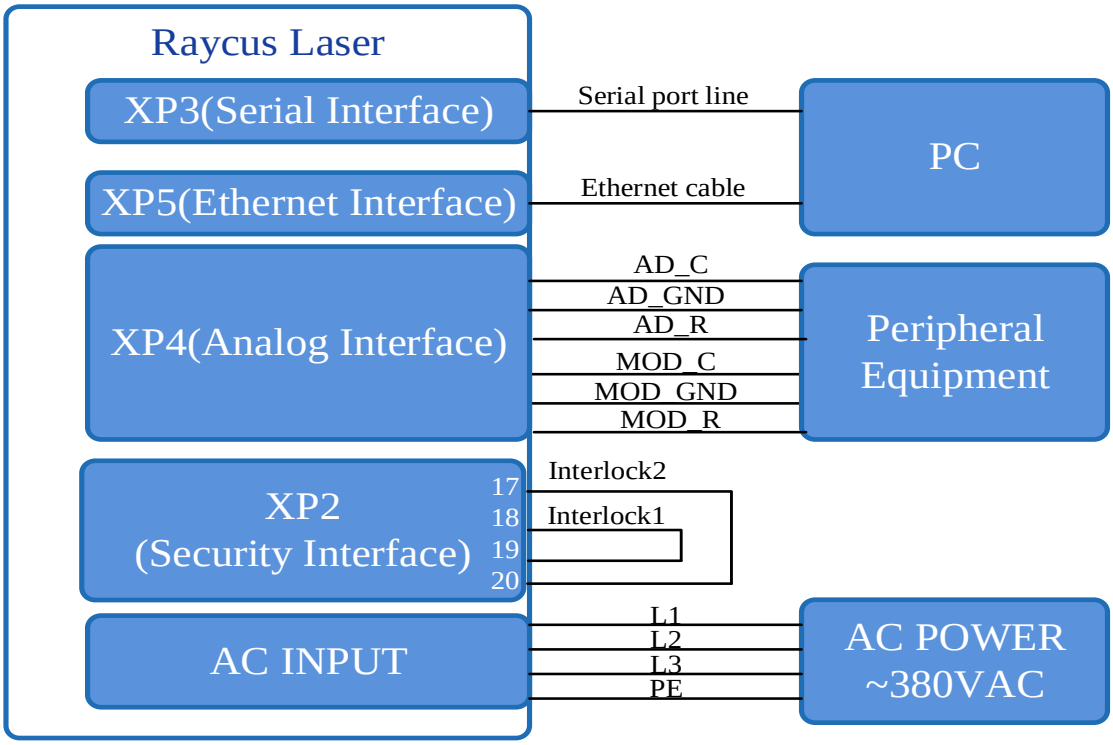


Figure 20 In ON mode, the wiring diagram of the power and laser emission controlled by analog signal

Operations Steps

a) Turn the knob switch on the rear panel to“ON”

b) Turn the key switch to“ON”

c) Open the Raycus Laser Control System

d) Click the guide laser “ON” button to view the guide laser

e) Turn on the “AD” mode and turn on “External Control” mode (this mode can be memorized after power off)

f) Click the main power “ON”

g) Waiting for “Ready”

h) The control board card outputs center and ring power analog and emit control signal.

6.4 Under ON mode, external control of emission under programming mode

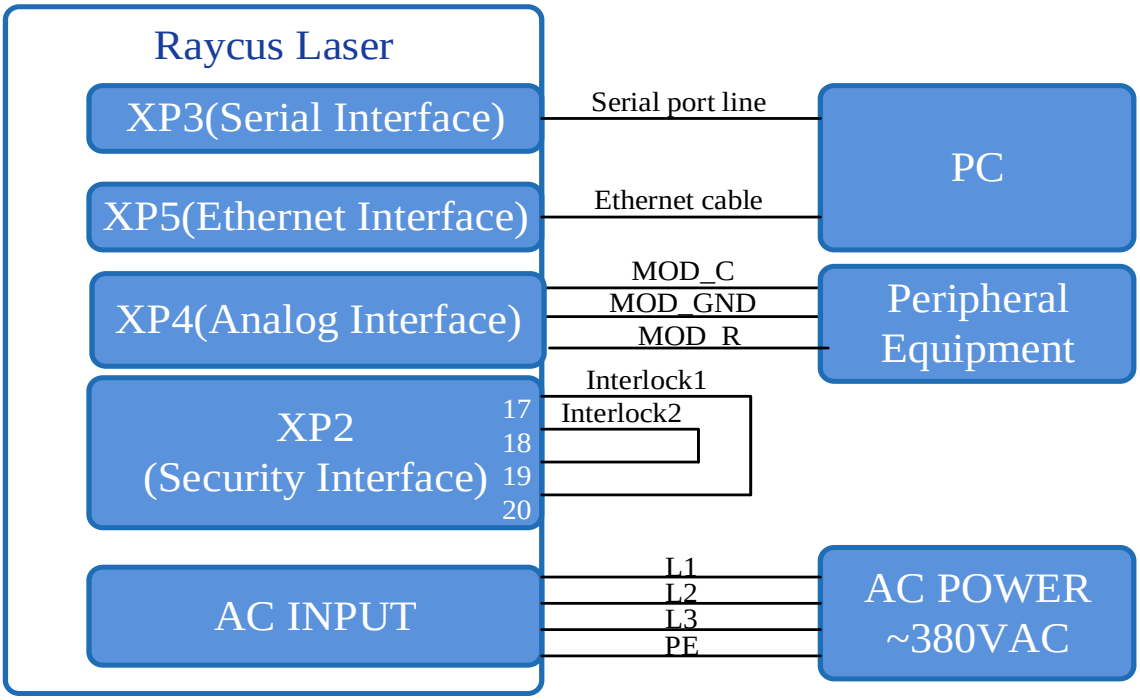


Figure 21 Wiring diagram of external control laser emission in programming mode, in ON mode

Operations Steps

a) Turn the knob switch on the rear panel to“ON”

b) Turn the key switch to“ON”

c) Open the Raycus Laser Control System

d) Click the guide laser “ON” button to view the guide laser

e) Click the main power “ON”

f) Waiting for “Ready”

g) Set the pre-executed waveform number (the program number is greater than 0);

h) Start waveform at the rising edge of MOD signal.

NOTE:

In programming mode, only the MOD_C signal is used to start the waveform, and the MOD signal high level time must be greater than the program running time. If the MOD gives the falling edge in advance, the upper computer software will display the abnormal suspension of the laser program

6.5 Set the Power Analog Quantity to Control the Laser Emission in REM Mode

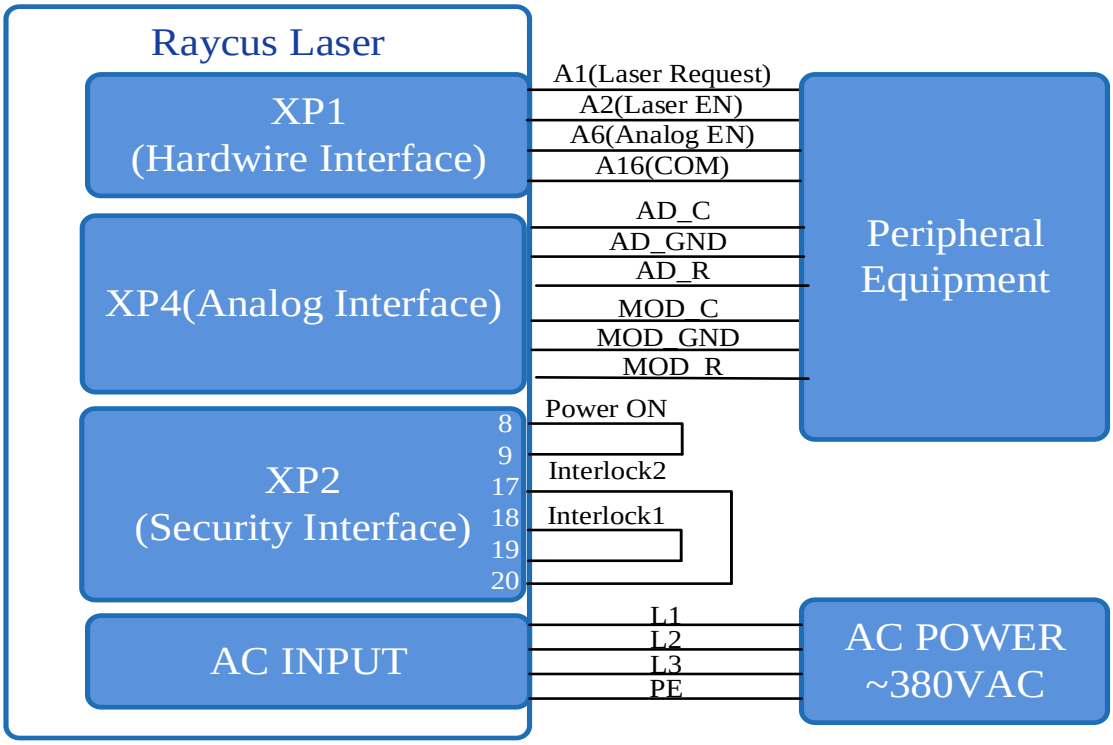


Figure 22 REM mode power and laser emission are externally controlled wiring diagram

Operations Steps

a) Turn the knob switch on the rear panel to“ON”

b) Turn the key switch to“REM”

c) Short-circuit pin 8/9 on XP2

d) XP1-A1 connects to 24V, XP1-A6 connects to 24V

e) Connect XP1-A5 to 24V and turn on the guide laser; after checking the optics, connect XP1-A5 to 0V and turn off the guide laser

f) XP1-C1 is connected to 24V, and the main power is turned on (operator can also directly press the LASER button, or the host computer software clicks the main power “ON”);

g) Waiting for “Ready”;

h) XP1-A2 connects to 24V, and the control board outputs center or ring analog and MOD signals

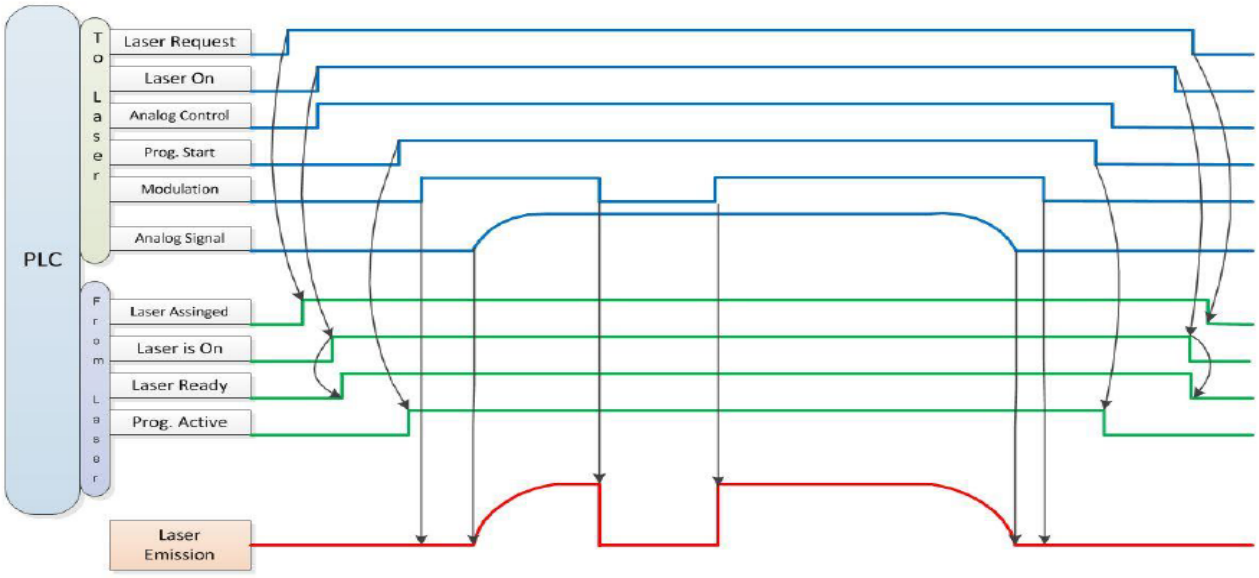


Figure 23 Timing diagram

6.6 Wiring diagram of power internal control and laser emission external in REM mode

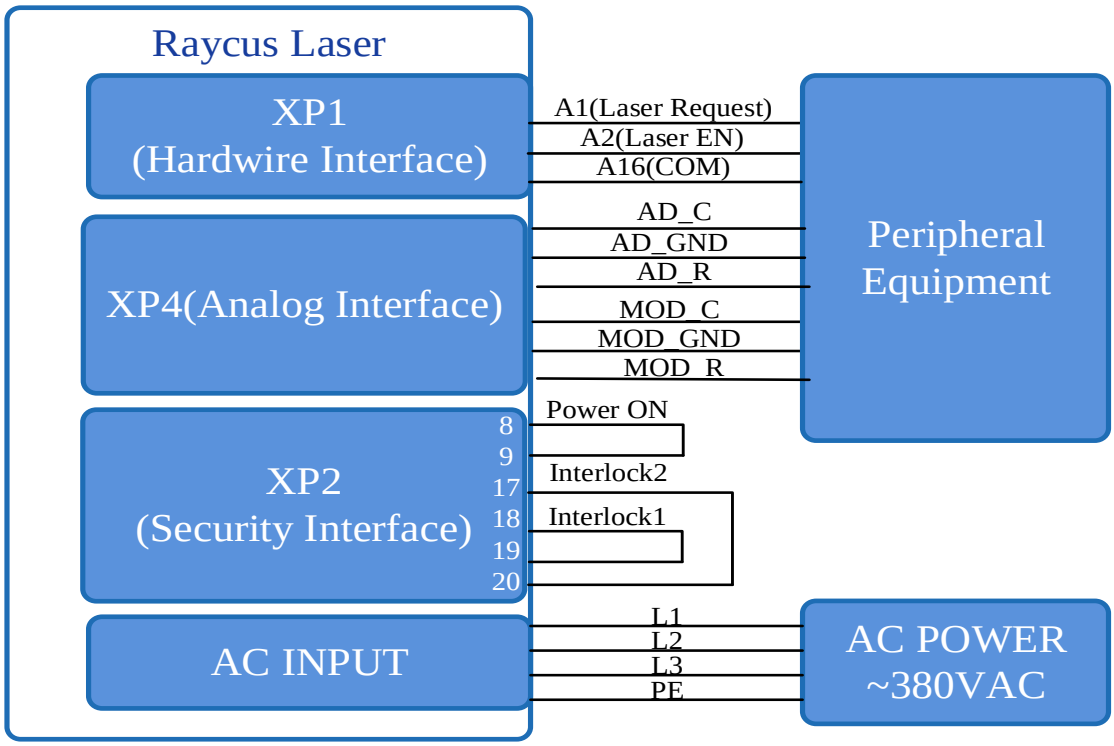


Figure 24 Wiring diagram of power internal control and laser emission external in REM mode

Operations Steps:

a) Turn the knob switch on the rear panel to“ON”

b) Turn the key switch to“REM”

c) Short-circuit pin 8/9 on XP2

d) XP1-A1 connects to 24V

e) Connect XP1-A5 to 24V and turn on the guide laser; after checking the optics, connect XP1-A5 to 0V and turn off the guide laser

f) XP1-C1 is connected to 24V, and the main power is turned on (users can also directly press the "LASER" button, or the host computer software clicks the main power "ON")

g) Waiting for "Ready"

h) The Raycus Laser Control System sets the power, XP1-A2 is connected to 24V, and the control board card outputs center and ring MOD signal

6.7 Programming Mode in REM Mode

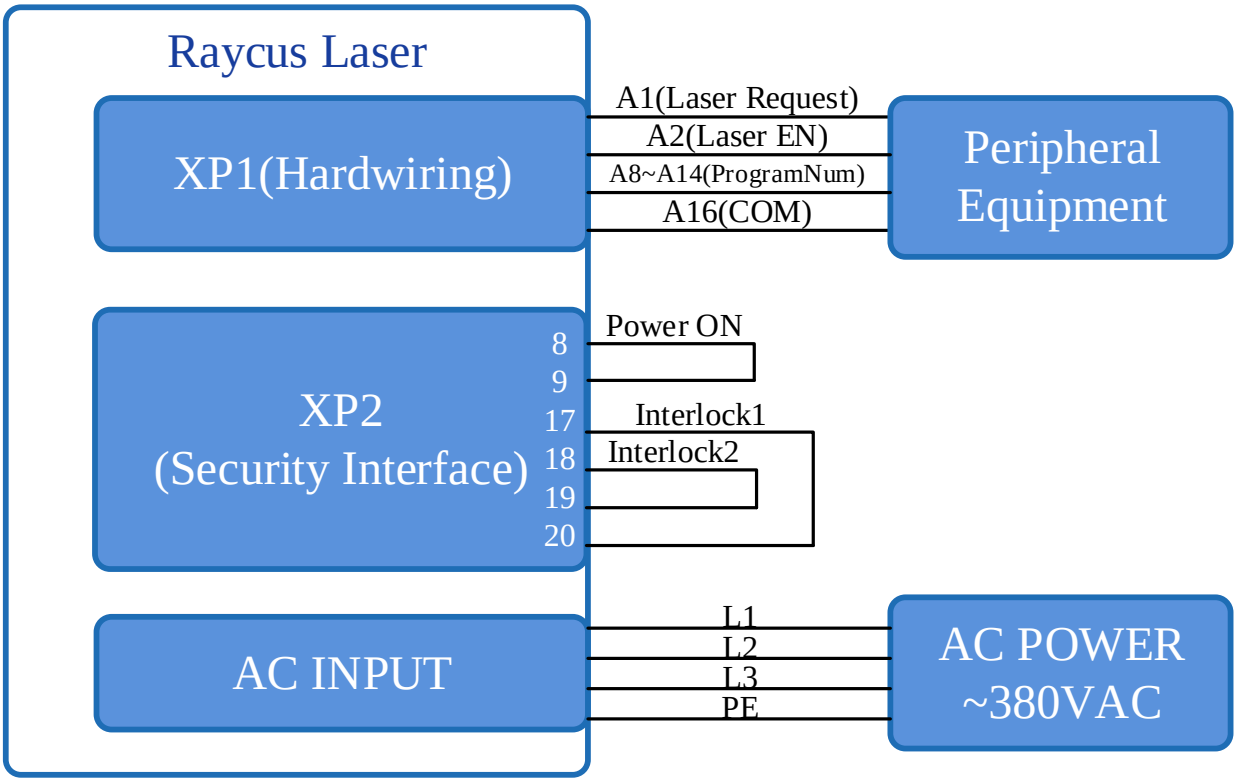


Figure 25 Wiring diagram of programming mode in REM Mode

Operations Steps:

a) Turn the knob switch on the rear panel to"ON"

b) Turn the key switch to"REM"

c) Short-circuit pin 8/9 on XP2

d) XP1-A1 connects to 24V

e) Connect XP1-A5 to 24V and turn on the guide laser; after checking the optics, connect XP1-A5 to 0V and turn off the guide laser

f) XP1-C1 is connected to 24V, and the main power is turned on (users can also directly press the "LASER" button, or the host computer software clicks the main power "ON")

g) Waiting for "Ready"

h) XP1-(A8-A14) select the number of the pre-executed program, set XP1-A2 high to start executing the program.

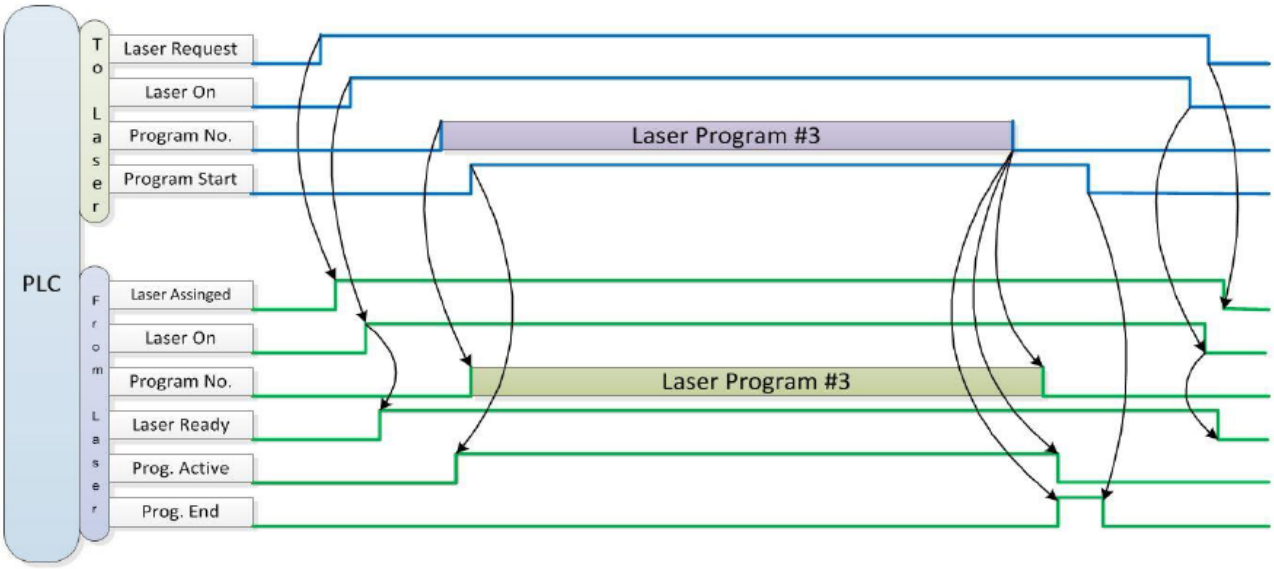


Figure 26 Timing diagram

7 RS232 and INTERNET communication command

7.1 Port Configuration

RS-232 configuration is as follows:

baud rate :9600, data bit :8, stop bit :1, no parity bit and no control flow.

Ethernet port is configured as follows:

Default laser IP address :192.168.0.10

Laser port :10001

7.2 Laser Communication Protocol (Network Port & Serial Port)

All commands and return values in this Agreement are composed of ASCII characters. Note the following points when entering：

a) Commands generally consist of three or four letters, sometimes with additional values.

b) All commands and return values end with the enter character (CR,0x0D, \r.) If this product receives a string with a ‘enter’ character but the command is invalid, the “Command Err! \r” is returned.

c) For easy identification, all commands are capital letters, but in fact this product is not case-sensitive. To facilitate identification, add a space between the command and the parameter.

d) This product sends a return value for each command received. The return value generally contains the command content itself. If the returned content contains a numeric value or contains an error type, the returned command content is separated from the numeric value or from the error type by “:”.

The specific agreement content and command examples of this product are shown in Table 16.

Table 16 Specific Protocol Contents and Command Examples of Laser

Command	Description	Command example
ABF	Aiming Beam OFF –Turn off red	Send: ‘ABF\r’ Return: ‘ABF\r’
ABN	Aiming Beam ON – Turn on red	Send: ‘ABN\r’ Return: ‘ABN\r’
DEABC	Disable External Aiming Beam Control	Send: ‘DEABC\r’ Return: ‘DEABC\r’
EEABC	Enable External Aiming Beam Control	Send: ‘EEABC\r’ Return: ‘EEABC\r’
DEC	Disable External Control	Send: ‘DEC\r’ Return: ‘DEC\r’
EEC	Enable External Control	Send: ‘EEC\r’ Return: ‘EEC\r’
DLE	Disable Hardware Emission Control	Send: ‘DLE\r’ Return: ‘DLE\r’
ELE	Enable Hardware Emission Control	Send: ‘ELE\r’ Return: ‘ELE\r’
EM OFF	Stop Emission	Send: ‘EMOFF\r’ Return: ‘EMOFF\r’
EMON	Start Emission	Send: ‘EMON\r’ Return: ‘EMON\r’
MPWR OFF	Main Power OFF	Send: ‘MPWROFF\r’ Return: ‘MPWROFF\r’
MPWR ON	Main Power ON	Send: ‘MPWRON\r’ Return: ‘MPWRON\r’
SPW	Set Pulse Width	Send: ‘SPW 100\r’ Return: ‘SPW:100\r’ （Set pulse widthas 100ms） Other return values: ‘ERR: input Err\r’ （Input pulse width ＜0.0001） ‘ERR: Out of Range\r’ （Over maximum pulse width） “ERR：Duty Cycle too High\r” “ERR：Duty Cycle too Low\r” “SPW：100,Duty=100%\r”

SPRR	Set Pulse Repetition Rate	Send: 'SPRR 1000\r' Return: 'SPRR： 1000\r' Other return values: 'ERR: input Err\r' (The input repetition rate is less than 0） 'ERR: Out of Range\r' （Exceed the maximal pulse duration range） 'ERR: Duty Cycle too High\r' （The duty cycle set is too high） "ERR： Duty Cycle too Low\r"（The pulse width is set less than 0.02） "SPW： 100,Duty=100%\r" （Working in CW mode）
SDC	Set Diode Current （%） The set value must be less than 100% and above the minimum current setting value, which can be set to 0. If the set value is greater than 100, the default is input 100.	Send: 'SDC 100\r' Return: 'SDC： 100\r' Other return values: 'ERR: Input Err\r' （The input value is less than 0） 'Laser is working in AD Mode\r' （Working in external AD mode; instructions are ineffective）
SRPW	SetRing Pulse Width	Send: 'SRPW 100\r' Return: 'SRPW:100\r' （Set pulse widthas 100ms） Other return values: 'ERR: input Err\r' （Input pulse width ＜0.0001） 'ERR: Out of Range\r' （Over maximum pulse width） "ERR： Duty Cycle too High\r" "ERR： Duty Cycle too Low\r" "SRPW： 100,Duty=100%\r"
SRPRR	SetRing Pulse Repetition Rate	Send: 'SRPRR 1000\r' Return: 'SRPRR： 1000\r' Other return values: 'ERR: input Err\r' (The input repetition rate is less than 0） 'ERR: Out of Range\r' （Exceed the maximal pulse duration range） 'ERR: Duty Cycle too High\r'

SRDC	SetRing Diode Current （%） The set value must be less than 100% and above the minimum current setting value, which can be set to 0. If the set value is greater than 100, the default is input 100.	Send: 'SRDC 100\r' Return: 'SRDC：100\r' Other return values: 'ERR: Input Err\r' （The input value is less than 0） 'Laser is working in AD Mode\r' （Working in external AD mode; instructions are ineffective）
RCS	Read Current Setpoint	Send: 'RCS\r' Return: 'RCS: 56.7\r' (The current set value is 56.7 %)
RPRR	Read Pulse Repetition Rate (Hz)	Send: 'RPRR\r' Return: 'RPRR:10\r' (Repeat frequency is10Hz)
RRCS	Read Ring Current Setpoint	Send: 'RRCS\r' Return: 'RRCS: 56.7\r' (The current set value is 56.7 %)
RRPRR	Read Ring Pulse Repetition Rate (Hz)	Send: 'RRPRR\r' Return: 'RRPRR:10\r' (Repeat frequency is10Hz)
RBT	Read Board Temperature	Send: 'RBT\r' Return: 'RBT:36.6\r'
RPW	Read Pulse Width (ms)	Send: 'RPW\r' Return: 'RPW:5.5\r' (pulse width is 5.5ms)
RRPW	Read Ring Pulse Width (ms)	Send: 'RRPW\r' Return: 'RRPW:5.5\r' (pulse width is 5.5ms)
ROP	ReadOutPower	Send：“ROP\r” Return：“ROP：12000\r” (Current OutPower12000W)
RROP	ReadRingOutPower	Send：“ROP\r” Return：“ROP：12000\r” (Current OutPower12000W)
RCT	Read Laser Temperature	Send: 'RCT\r' Return: 'RCT:34.5\r'
PERR	Reset Errors	Send: 'PERR\r' Return: 'PERR\r'
RIP	Read IP – Read the current IP address	Send：“RIP\r” Return：“RIP：192.168.0.10\r“

RMASK	Read Subnet Mask – Read the current subnet mask address		Send：“RMASK\r” Return：“RMASK：255.255.255.0\r”
SIP	Set IP – Set the laser’s IP address		Send：“SIP 192.168.0.10\r” Return：“SIP：192.168.0.10\r”
SMASK	Set Subnet Mask – Set the subnet mask with a string of decimal digit containing “.”		Send：“SMASK 255.255.255.0\r” Return：“SMASK：255.255.255.0\r”
SIP	Set IP –Set the IP address with a string of decimal digit containing “.”		Send：“SIP 10.0.0.231\r” Return：“SIP：10.0.0.231\r”
SUT	Set Up Time (ms)		Send: ‘SUT 50\r’ Return: ‘SUT:50\r’
SDT	Set Down Time (ms)		Send: ‘SDT 50\r’ Return: ‘SDT:50\r’
RUT	Read Up Time (ms)		Send: ‘RUT \r’ Return: ‘RUT:50\r’
RDT	Read Down Time(ms)		Send: ‘RDT \r’ Return: ‘RDT:50\r’
PSRT	Program Start		Send: ‘PSRT 1\r’ Return: ‘PSRT:1\r’
PSTP	Program Stop		Send: ‘PSTP\r’ Return: ‘PSTP\r’
ECM	Enable Calibration Mode –Power linear correction mode (in this mode, the external analog is corrected and output after filtering, so the response time of AD analog is larger than that of through mode)		Send: ‘ECM \r’ Return: ‘ECM\r’
DCM	Disable Calibration Mode （AD analog response time is less than 100 us in this mode）		Send: ‘DCM\r’ Return: ‘DCM\r’
Others	Command error		Send: ‘BGM\r’ Return: ‘Command Err!\r’
	Read device status – Read the product status. A return value of 32-Bit digital information. The meaning of each Bit is as follows (undefined or ‘reserved’ Bit negligible):		
STA	Bit 0	normal operation	Send: ‘STA’ Return: ‘STA:4100’ returned value 4100(Decimal) can be converted to 0 x1004 (hexadecimal), and then converted to binary to see that Bits2
		Authorization time	
	Bit 1	normal	
		Temperature too high	

	Bit 2	Emission Off	and 12 have been set. The laser enable is on and the modulation mode is enabled
		Emission On or in preparation	
	Bit 3	No high reflection	
		High reflection Abnormal	
	Bit 4	External AD mode=off	
		External AD mode=on	
	Bit 5	Power Correction Mode=off	
		Power Correction Mode=on	
	Bit 6	normal	
		Sub-controling communication	
	Bit 7	Normal	
		Sub-modual abnormal	
	Bit 8	Guide red light=off	
		Guide red light=on	
	Bit 9	The laser is not ready	
		The laser is ready	
	Bit 10	QCW mode=off	
		QCW mode=on	
	Bit 11	Module Main Power=off	
		Module Main Power=on	
	Bit 12	Modulation mode=off	
		Modulation mode=on	
	Bit 13	normal	
		Leakage sensors 1 leaking	
	Bit 14	normal	
		Leakage sensors 2 leaking	
	Bit 15	No laser	
		Laser is power on	
	Bit 16	Gate mode=off	
		Gate mode=on	
	Bit 17	AC input normal	
		AC input abnormal	
	Bit 18	external Emission control=off	
		external Emission control=on	
	Bit 19	normal	
		Laser fault	
	Bit 20	Slow up slow down mode off	
		Slow up slow down mode on	
	Bit 21	A laser operates in ON" mode	
		A laser operates in REM" mode	
	Bit 22	Wave mode off	

		Wave mode on	
	Bit 23	Surge protector normal	
		Serge protector failure	
	Bit 24	normal	
		Low temperature fault	
	Bit 25	normal	
		Humidity alarm	
	Bit 26	normal	
		Water flowmeter 1 Flow Alarm	
	Bit 27	Red light internal control	
		Red Light External Control	
	Bit 28	normal	
		Water flowmeter 2 Flow Alarm	
	Bit 29	normal	
		Module locked	
	Bit 30	Optical circuit safety interlock	
		Optical circuit safety interlock	
	Bit 31	normal	
		High average power	

8 PC software instructions

8.1 Main interface of PC software

The PC software's main interface is shown in Figure 27.

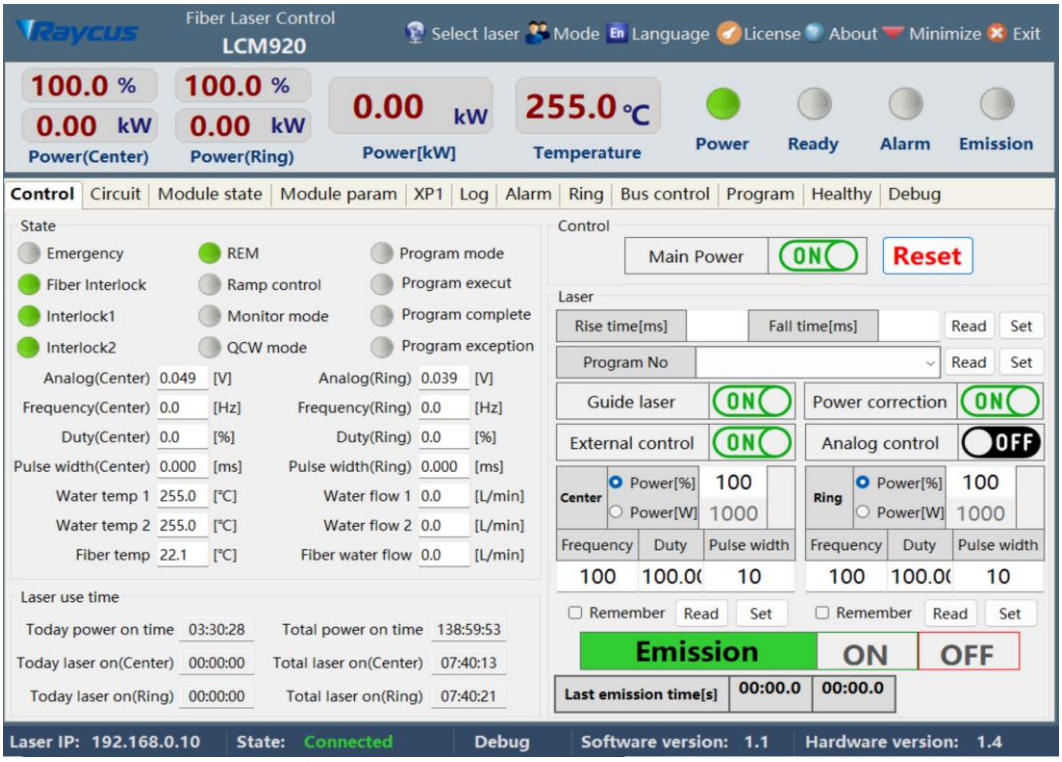


Figure 27 PC software display main interface

8.2 Main working status display area

On top of the laser's main interface is the main status display area, which mainly shows the power of the laser by percentage point set currently, the real power of the laser beam, the temperature of the laser and so on. Please refer to 17 for the detailed description.

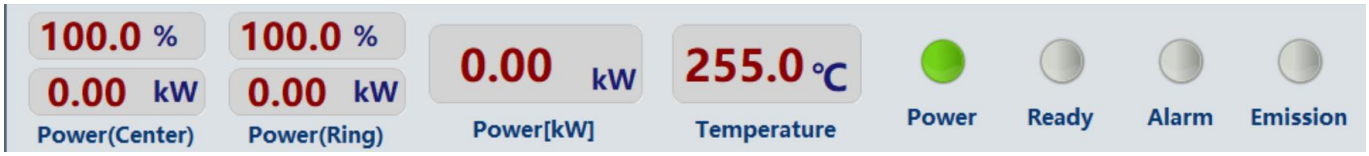


Figure 28 A diagram of the laser's main display area

Table 17 The laser main display content and meaning

Display	Meaning
Output center power[%]	current setting percentage of center power in real time
Output center power[KW]	Average laser output center power in real time（KW）
Output ring power[%]	current setting percentage of ring power in real time
Output ring power[KW]	Average laser output ring power in real time（KW）
Output total power[KW]	Average laser output total power in real time（KW）
Laser temperature	Water cooling temperature in real time（℃）
Power light	Status of main power supply:green-main power supply is on, gray-main power supply is off
Ready light	Indicates readiness of current laser:green-laser is ready,gray-laser is not ready
Alarm light	indicates alarm status of current laser:yellow- laser is abnormal,gray-laser is normal
Emission light	indicates the working model of the current laser： red-laser is in working model gray-laser is not in output model

8.2.1 Laser's cumulative operating time display area

The laser's cumulative operating time display is shown in Figure 29. The cumulative start-up time, cumulative laser output time, today's power-on time and today's lighting time can be displayed in hours, minutes and seconds respectively.

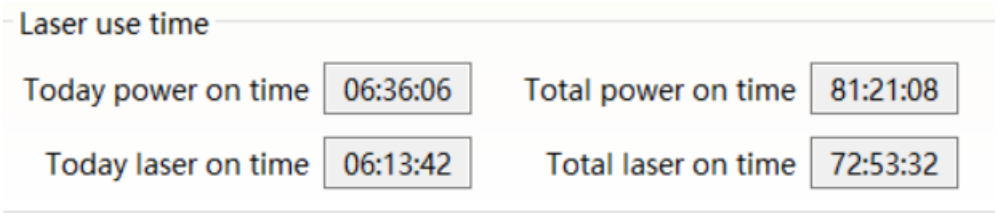


Figure 29 Laser cumulative operating time display interface

8.2.2 Laser working status display area

The laser working status display area is as Figure 30, the display content is as in Table 18.

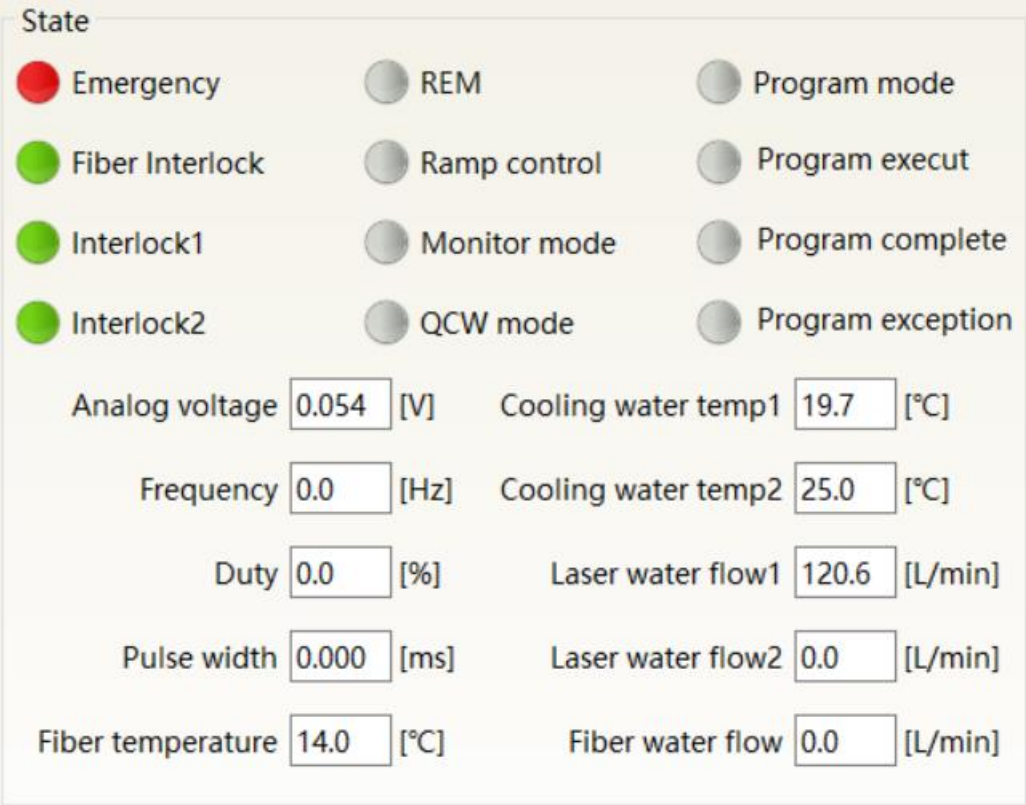


Figure 30 A diagram of the laser's working status display area

Table 18 The laser main display area clarification

Display	Content explanation
Emergency stop	Red: emergency stop button on front panel is pressed Gray: engergency stop button on front panel is reset
REM	Green: laser works in REM mode Gray: laser works in ON mode
Program model	Green: Laser is in program mode Gray: Laser is not in program mode
fiber Interlock	Green: Interlock spot at output fiber end is closed; Gray: Interlock spot at output fiber end is opened.
Ramp control	Green: laser works in power slow rise & fall mode Gray: laser does not work in power slow rise & fall mode
InterLock1 make	Green: XP2 leg 17,20 on safety interface make Gray: XP2 leg 17,20on safety interface break
InterLock2 make	Green: XP2 leg 18,19on safety interface make Gray: XP2 leg 18,19 on safety interface break

Monitoring model	Green: PC software is in monitoring mode. User can monitor laser status only, but not able to take control of laser. Monitoring model is activated when interface 10001 of laser occupied. Gray: PC software operate in normal mode
Monitoring model	Green: PC software is in monitoring mode. User can monitor laser status only, but not able to take control of laser. Monitoring model is activated when interface 10001 of laser occupied. Gray: PC software operate in normal mode
QCW mode	Green: Laser is in QCW mode Gray: Laser is not in QCW mode

8.2.3 Laser power-up, mode selection, light-out control area

Laser power-up, mode selection, light out control display area is as in Figure 31, the display content is as in Table 19.

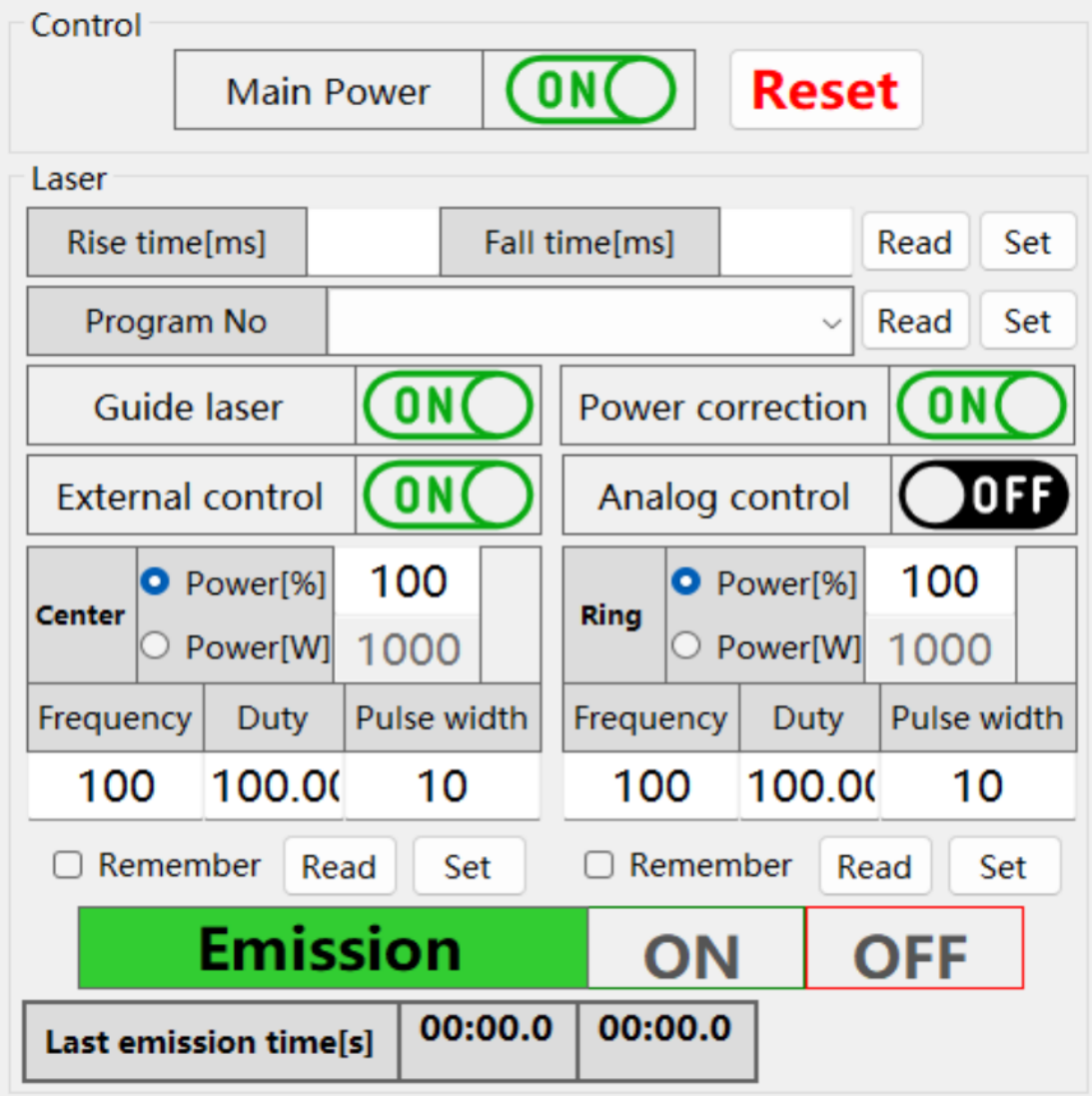


Figure 31 Laser control display area.

Table 19 Laser control display area explanation.

Display	Explanation
Main power button	Click ON, main power on click OFF, main power off
External control mode	Click ON, activate laser external control Click OFF, shut laser external control mode power-off memory automatically
AD mode	Click ON, AD analog mode on click OFF, AD analog mode off mode power-off memory automatically
Red guide beam	Click ON, red guide beam on click OFF, red guide beam off
Power correction	Click ON, activate laser power correction mode click OFF, shut laser power correction mode; This function works only when AD mode is on. mode power-off memory automatically
Eliminate alarm	Eliminate current laser alarm
Laser ON	Laser is in output
Laser OFF	Laser is off

8.3 Laser parameter display area

The display interface for laser parameter display area is as Figure 32. The module status is used to shield the faulty module, the green light indicates the number of modules installed inside the current laser, and the check box indicates the module that is actually running in the current laser.

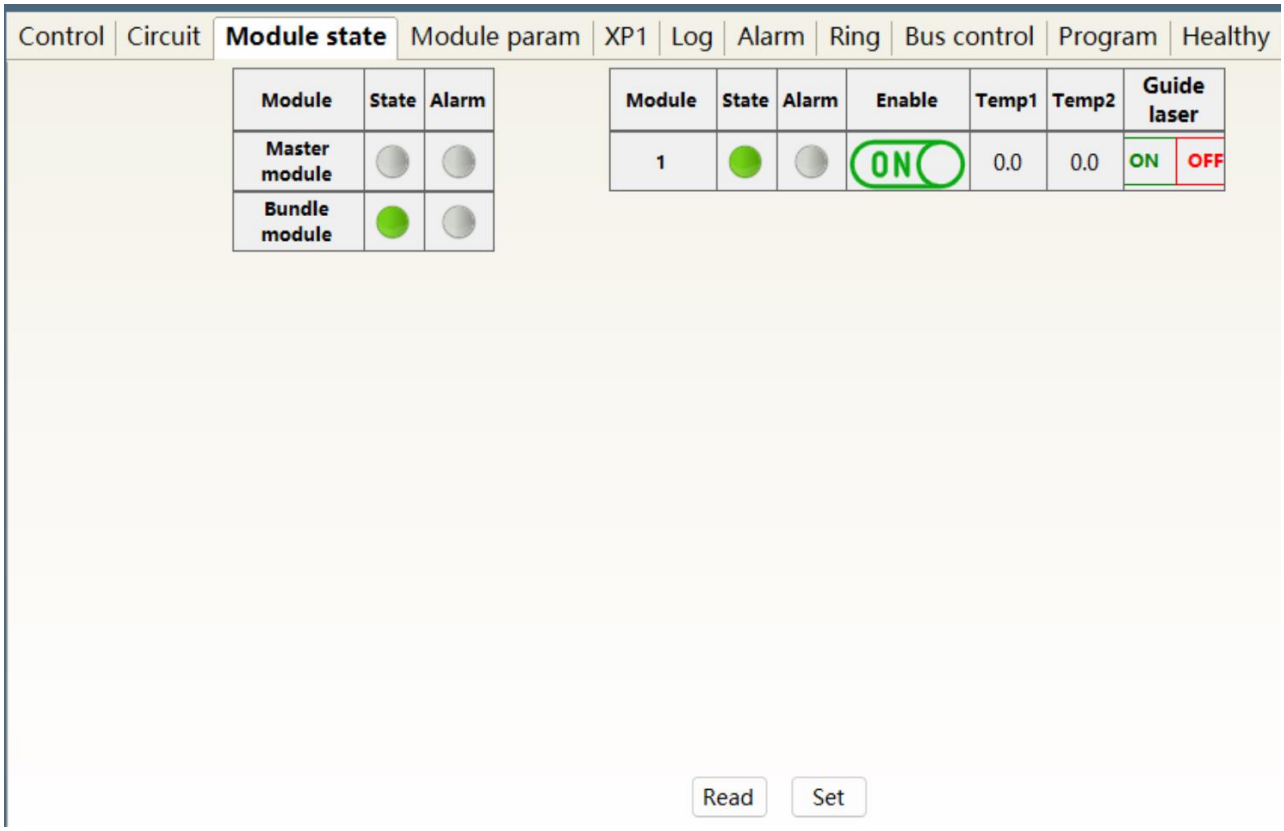


Figure 32 Laser parameter display area display interface

8.4 Alarm type display area

The laser alarm type display area interface is as Figure 33. This interface shows the cause of the alarm for the current laser.

Figure 33 Laser alarm type display area interface

8.5 PC software operating mode selection

The laser operating mode is set by the PC software. Its operating interface is as Figure 34. The interpretation of the various patterns can be found in Table 20. The programming editing interface is displayed on the software only when programming mode is selected.

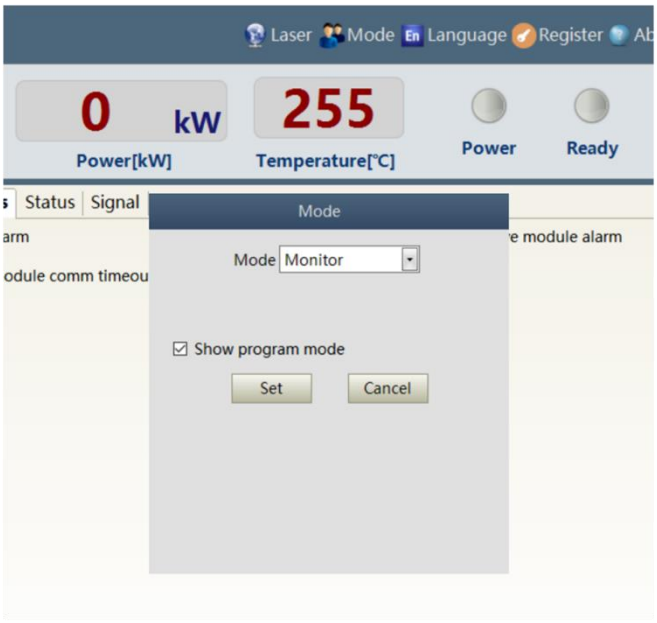


Figure 34 Laser operating mode selects the display area interface

Table 20 Laser operating mode and explanation

Mode selection	Mode explanation
Monitor	A concise software interface, which can monitor basic status information
Control	Supports the selection of control modes, such as AD mode, external control mode, and programming mode
Diagnostics	Displays laser's all status and parameters for diagnosis purposes
Debug	You can modify laser parameters(subject to valid password)

8.6 Language

User can choose between Chinese simplified and English by click ‘setting language’. Setting effective after PC software restarted.

Figure 35 Language selection interface

8.7 Authorization (time-limited locking)

8.7.1 Authorization in user mode

The authorization settings in user mode are as Figure 36. Laser can be locked and unlocked by valid authorization code.

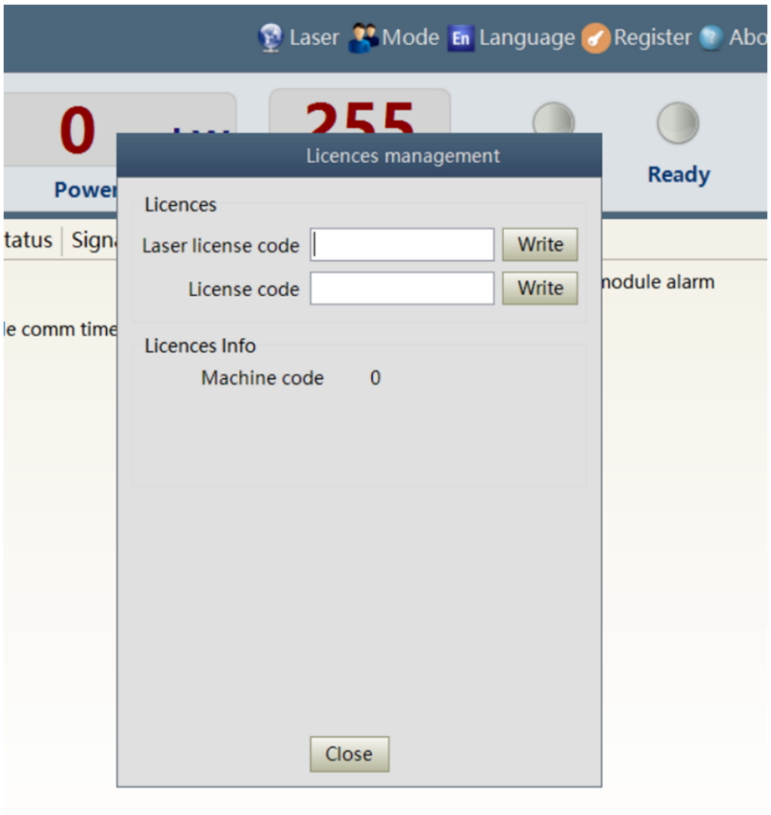


Figure 36 The authorization settings operating interface in user mode

8.7.2 Authorization in authorization mode

The authorization settings in laser authorization mode are as Figure 37. This interface allows the customer to lock and unlock the machine and can also be used as an authorization code generator.

a)The locking time setting can set the effective using time of laser. For example, the locking time: May 21, 2020, indicating that the laser is locked until 0:00 on May 21, 2020. 0/0/2000 means the laser is permanently unlocked.

b) The terminal password is set for the laser locking party. The terminal code can only be set once, and no modification is allowed after its set. The terminal password is 8-byte long, e.g. 0123456789ABCDEF, no other characters are allowed.

c)The software automatically calculates the authorization code when user click to generate an authorization code. Laser's limited time lock is achieved when user click again to set the authorization time.

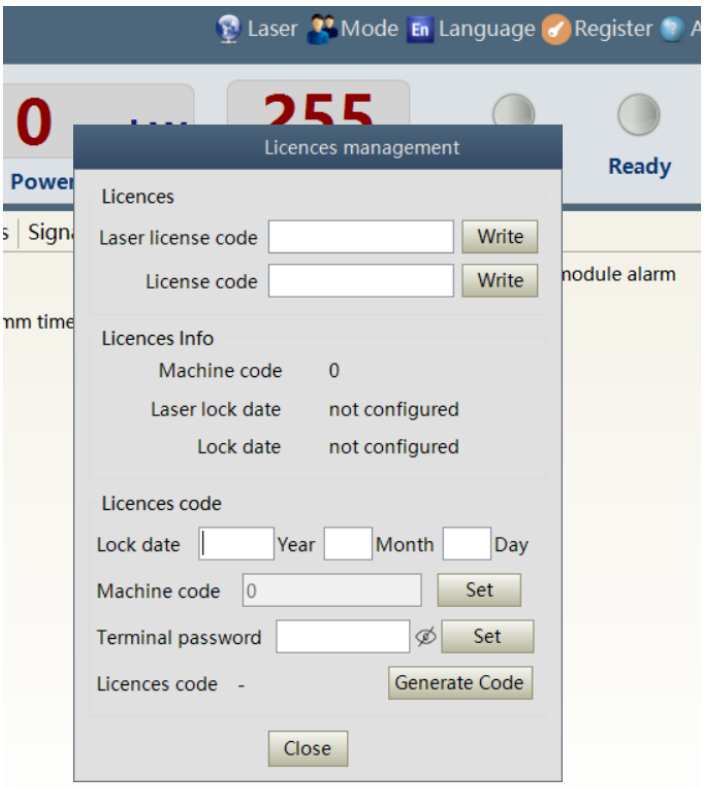


Figure 37 Authorization settings operating interface in authorization mode

8.8 About

Laser relevant information such as date of manufacture, model, serial number, controling serial number, token version number, system information and other information can be queried in the PC software ‘about’ item. Specific interface is as Figure 38.

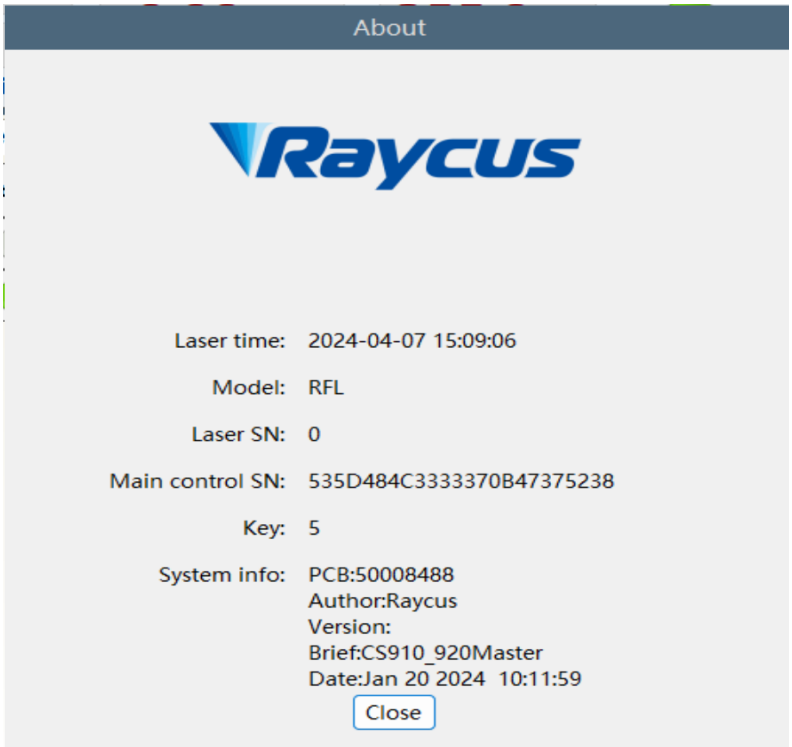


Figure38 Laser relevant information query interface

8.9 XP1 interface status indication (in diagnostic mode)

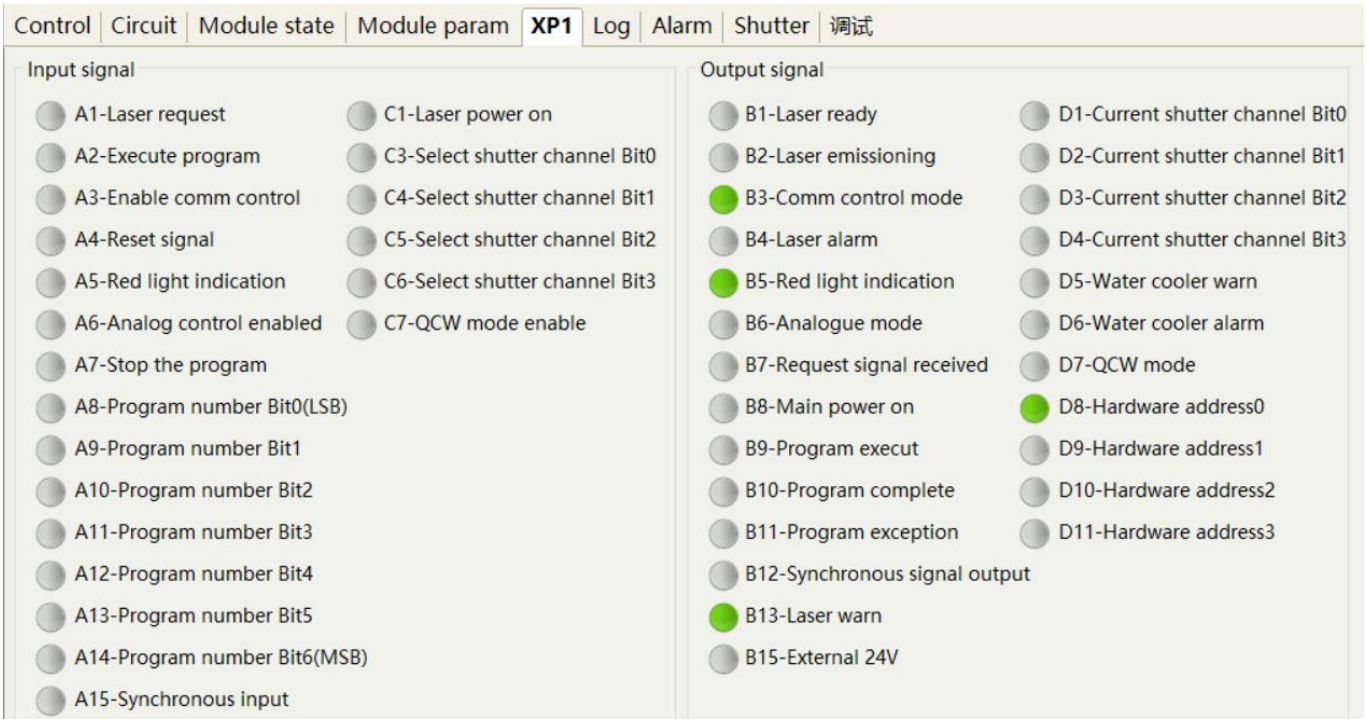


Figure 39 XP1 Interface check

The laser interface status indicator interface is as Figure 50. It is convenient to view the interface status information which represents the input and output status of the XP1 interface on the back panel.

8.10 Log (in diagnostic mode)

Laser's working log interface is as Figure 40. User can query work log by entering the time to query and click on the 'search' button.

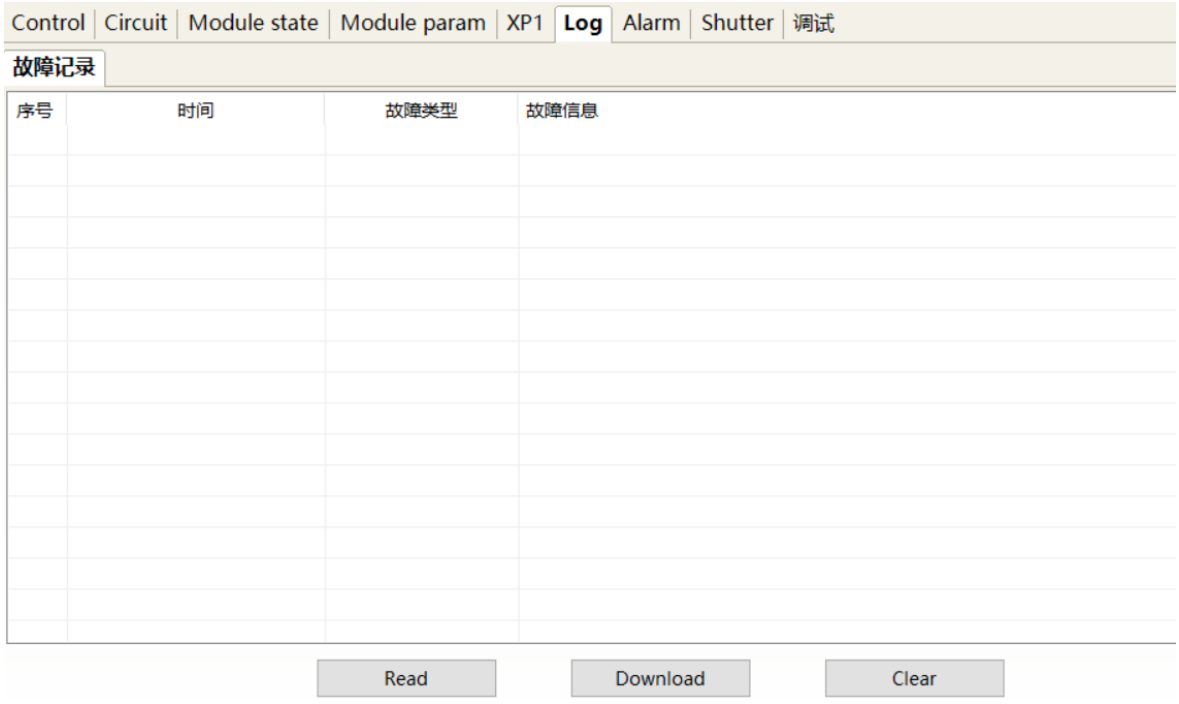


Figure 40 Laser's working log interface

The file address query interface for all download information is as Figure 41.

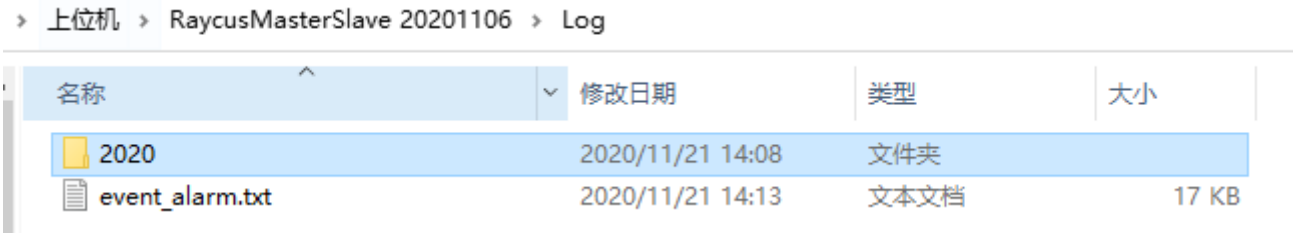


Figure 41 The file address query interface for all downloaded information

8.11 Module parameters (in diagnostic mode)

Laser module parameter query interface is as Figure 42. The interface is for the parameter query in diagnostic mode from which Raycus technicians can analyze the cause of laser anomalies.

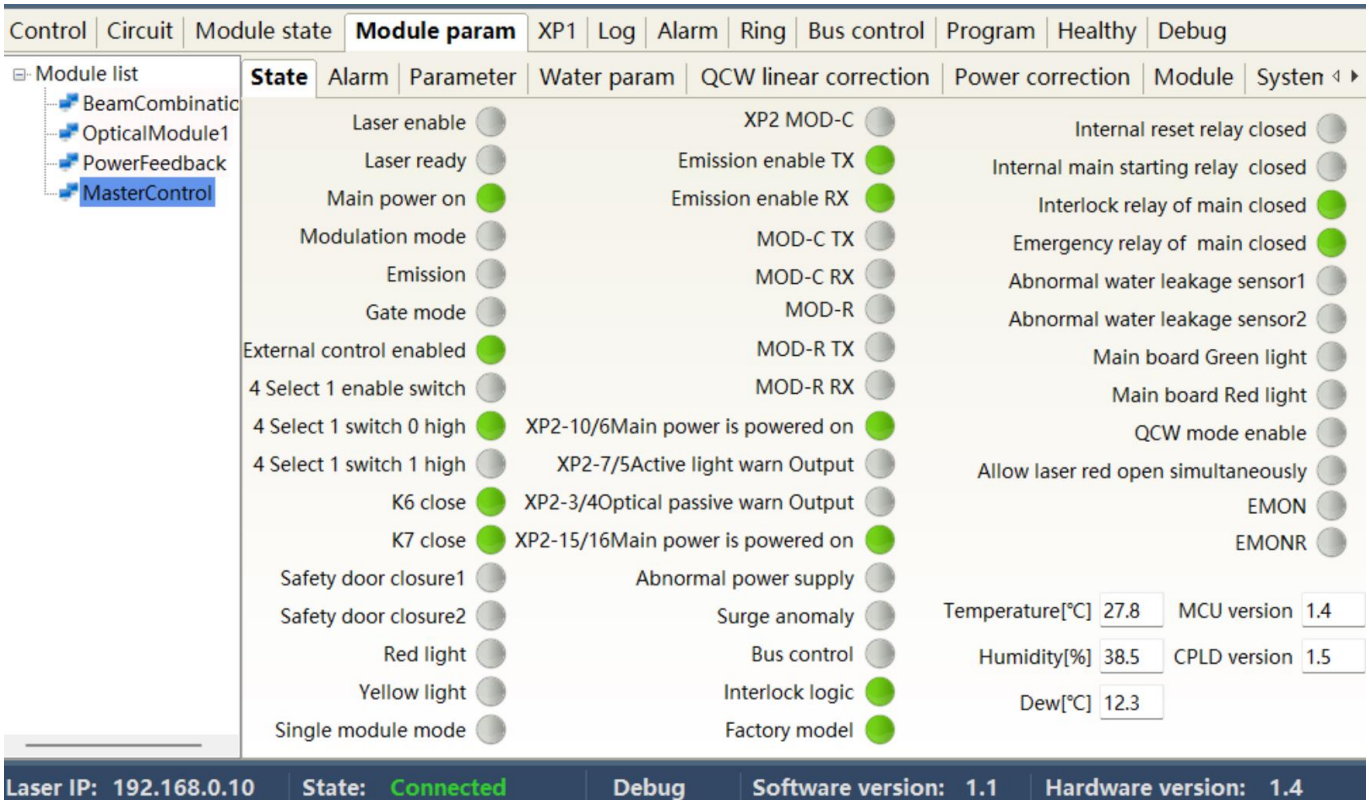


Figure 42 Module parameters query interface in diagnostic mode

8.12 Programming settings (programming editing)

Operating interfaces of view the number of wave bar stored inside the current laser is as Figure 43. The software automatically lists the number of wavelength bars that have been saved by click on the ‘Refresher List’ button. Green indicates the bar already has a program and white indicates that the bar is empty.

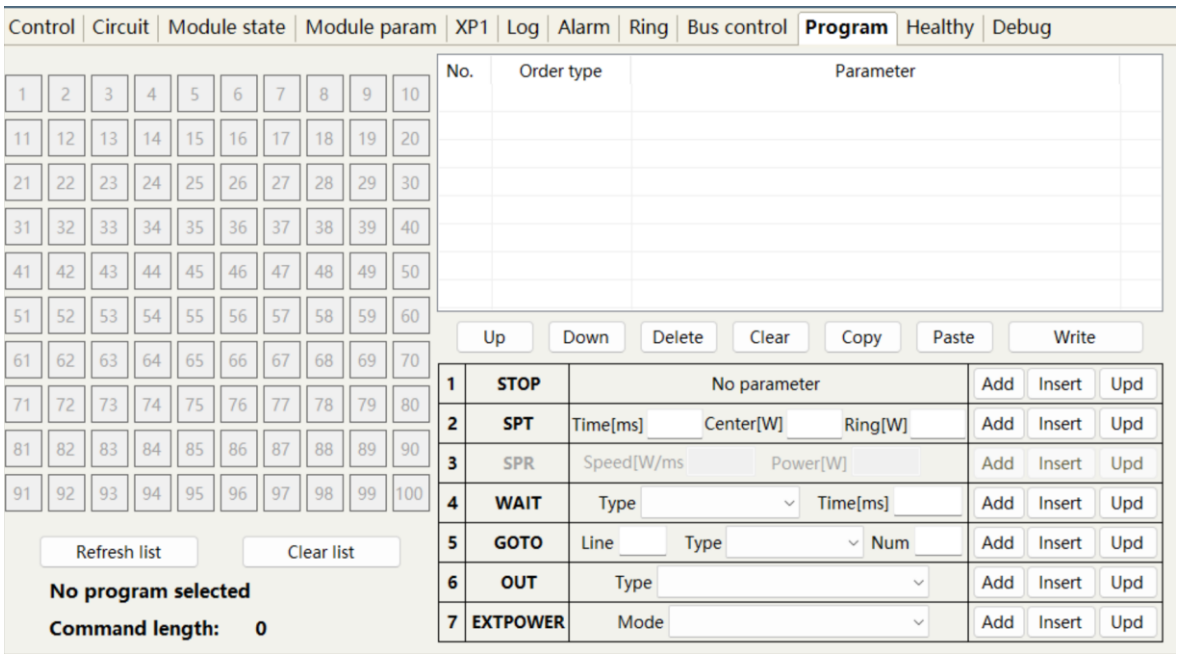


Figure 43 The programming interface in programming editing mode

Edit Wave form:

Step 1:left click the pre-edited programming number.

Step 2:select the command under the command type, click ‘Add’.

Step3:enter the parameters and click ‘Save’. The instruction appears in the left program list immediately.

Step 4:after editing all commands, click ‘Write Laser’.

Step 5:the new programming number will turn green when user re-click the ‘refresher list’ button. Write successfully.

Command meaning in laser working status is as Table 21.

Table 21 command meaning in laser working status

Code		Parameter1	Parameter 2	Note
1	Stop	none	none	The program end command. the last command must be this command.
2	SPT	0～65000（ms）	Center Power 0～65000(W) Ring Power 0～65000(W)	Change power to 2 in time 1
3	/	/	/	/
4	WAIT	Wait for sync signal low level	Null	Keep waiting, and then execute the next command when the synchronous input signal becomes low level
		Wait for sync signal high level	Null	Keep waiting, and then execute the next command when the synchronous input signal becomes high level

		Wait for sync signal rising	Null	Keep waiting, and then execute the next command when the synchronous input signal is rising edge
		Wait for sync signal droping	Null	Keep waiting, and then execute the next command when the synchronous input signal is falling edge
		Wait	0～65000ms	
5	GOTO	Line 0-99	Switch at low sync signal	When the synchronous input signal is low, jump to the line number of the parameter 1; when the synchronous input signal is high, execute next command
		Line 0-99	Switch at high sync signal	When the synchronous input signal is high, skip to the line number of the parameter 1; when the synchronous input signal is low, execute next command
		Line 0-99	0-32767	When condition is met, skip to the number of other lines
6	OUT	SO	sync signal low level output	
			sync signal high level output	
7	EXT Power	Analog		
		FieldBus		

9 Warranty, Repair and Return

9.1 General Warranty

After all the lasers manufactured according to the standard or non-standard model production documents are shipped, Raycus guarantees the products with material and technical problems and guarantees that they meet the specifications under normal use.

Raycus has the right to selectively repair or replace any product that has a material or technical problem during the warranty period. All products repaired or replaced during the warranty period only provide free warranty services for products with special problems. Raycus reserves the right to collect payment for products that have problems under normal use.

9.2 Limitations of Warranty

The warranty does not cover the maintenance or reimbursement of our product of which the problem results from tampering, disassembling, misuse, accident, modification, unsuitable physical or operating environment, improper maintenance, damages due to excessive use or not following the instructions caused by those who are not from Raycus. Thecustomer has the responsibility to understand and follow

this instruction to use the device. Any damage caused by fault operating is not warranted. Accessories and fiber connectors are excluded from this warranty.

According to the warranty, client should inform us within 31days after the defect is discovered. This warranty does not involve any other party, including specified buyer, end-user or customer and any parts, equipment or other products produced by other companies.

	**WARNING:**It is the customer's responsibility to understand and follow operating instructions in this User Guide and specifications prior to operation-failure to do so may void this warranty. Accessories and fiber connectors are not covered by this warranty.

9.3 Service and Repair

This product has no user serviceable parts. All service and maintenance shall be performed by qualified Raycus personnel.

If any problem is found in the process of using the product, please inform Raycus' technician of the problem as earlier as possible. Raycus' technician will handle the problem and perform troubleshooting.

All products to be repaired or replaced must be placed inside the original packaging box provided by Raycus. Otherwise, in the event of any damage to the product caused by failure to do so, Raycus is entitled not to repair the product for free.

When you receive Raycus' product, please check in time if the product is intact. In case of anything abnormal, please contact your carrier or Raycus.

9.4 Scrap requirements

The fiber laser equipment can be scrapped and recycled if it has reached its useful life or has serious faults and has no value for modification or repair, or meets other scrapping conditions stipulated in the safety technical specifications.The recycling and disposal shall meet《*Regulations on the Administration of the Recycling and Disposal of Waste Electrical Appliances and Electronic Products*》.

Raycus will continuously develop new products. The product information listed in this User Guide is subject to possible change without notice. All technical parameters are subject to the terms of the contract.

All the items within warranty and service above provided by Raycus are for uses' reference; formal contents about warranty and service are subject to the contract.

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