User Manual of Metal Laser Cutting Machine

Introduction to Characteristic Parameters and Primary Structure

Jinan Bodor Laser Corporation Limited

CONTENTS

Foreword

Thanks for your choice of our products. Complete after-sales and solutions will be provided for you. Please keep the Manual and other annexes properly for your better operation.

The Manual describes safety matters, operating principle, transportation and storage, installation method, operation and application, troubleshooting, maintenance and service, etc of the product. The Manual is applicable to standard configuration of our company's products; please read over detail files attached for some component items.

Please read this Manual carefully before installation and utilization if you use this product for the first time.

For quickly effective use of the product, the operating personnel should:

Firstly, be familiar with some professional computer knowledge and be able to use relevant authoring and mapping software, including SolidWorks, Autocad, etc.

Secondly, have some knowledge in optics and maintenance and repair related to electromechanical equipment.

Thirdly, recognize whether you are familiar with operational process of equipment and could be able to operate according to the process before starting.

Due to unceasing update of product functions, your product received may be slightly different from the description in the Manual. Therefore, we hereby apologize for this.

Chapter I Safety Instructions and Prevention Measures

1.1 General

Prior to machine tool operation and routine maintenance, the operating personnel are required to read over the section for learning about safety measures and requirements of the machine tool to some extent, and abide by relevant safety precautions.

1.2 Safety standards related to the machine

Laser processing equipment and operation should be performed in accordance with two national standards of Radiation Safety of Laser Products, Equipment Classification, Requirements, and User's Guide (GB7247.1-2001) and Electrical Safety of Laser Equipment and Installations (GB/T10320-2011).

1.3 Safety warning labels and instructions

See the second volume of the Manual, "Safety before Use and in Use, Safety Protection, Safety Signs and Instructions".

1.4 Safety management warning

a) Safety management personnel should be assigned and allocated with relevant duties; operating personnel should be trained in safety operation and safety protection.
b) The laser safety management area should be designated, and warning board(s) should be provided at the entrances and exits in this area, contents of the board including: power and type of laser of laser machine, outsiders' entry limitation, eye protection, name of safety manager, etc.
c) The operating personnel of laser machine must have specialized trainings to master a certain level of knowledge, and could take the relevant posts after being approved by the security manager.

1.5 Laser safety notice

The laser will injure human body, especially the eyes and skin. Any part of human body will be burnt in case of laser radiation. ***In particular, the retina will be impaired severely in case of long-time watching fiber laser! Therefore, all operating personnel shall wear strictly 1064nm lasering protective eyeglass! No one could operate and watch without wearing the eyeglass!*** No part of human body shall be put on the range of laser cutting to avoid from injury due to misoperation.

1.5.1 Eye and skin protection

During laser processing, directly radiated light beam or scattered beam will cause injury to

eyes and skin, or even fire. ***The laser device provided on the machine tool is a fiber laser, so the operating personnel shall strictly wear the protective eyeglass.*** The laser of device shall be adjusted by trained professionals; it's worth noting that no skin or eye could be directly radiated during operation and adjustment.

1.5.2 Flameproof protection

Oxygen applied in carbon steel cutting and processing by laser, together with splashing spark, is easy to cause a fire. Therefore, no flammable or combustible could be put in the workspace; simultaneously relevant containment facilities shall be provided.

1.6 Electrical safety

a) No wet hand could touch any switch so as to avoid electric shock. Locations labeled with lightning signs on the machine tool indicate HV electric appliance or electrical element herein, so care must be exercised by the operating personnel to avoid electric shock when approaching or maintaining these locations. For example: Shield of servo motor, transformer cubicle of machine tool, electrical cabinet door, etc.

b) Please read over the machine tool manual and electrical schematic diagram for knowing functions and operational approaches of corresponding keys well.

c) Do not open the electrical cabinet door at will, and put a ban on changes in given parameters of machine tool without permission. For any changes if required, it shall be performed by an accepted professional who has been trained by the device manufacturer. Parameters, before changes, shall be recorded for future original state restoration if necessary.

d) The supply voltage of laser for processing generally is HV, so it shall avoid the HV injury inside the laser device and X-ray injury generated from HV herein.

e) Do not touch active components and elements in the electrical cabinet under a power-up state, including numerical control system, servo device, transformer, fan, etc.

Warning

Do not touch the terminal until more than 5 minutes waited after power disconnection. For fear of electric shock, do not touch power line terminals on which HV may stay within a period of time after power disconnection.

1.7 Protective measures of machine

- Safety management personnel should be assigned and allocated with relevant duties; operating personnel should be trained in safety operation and safety protection.
- The safety management area of laser cutting machine should be designated, and warning

board(s) should be provided at the entrances and exits in this area, contents of the board including: power and type of laser of laser cutting machine, outsiders' entry limitation, eye protection, name of safety manager, etc.

- When in idle state, cut off the main power of laser cutting machine for fear of injury caused by miscellaneous personnel's misoperation.
- Discharge the fume gas generated during processing and laser working gas outside via off-gas line, and place all gas cylinders steadily and in order.

1.8 Notes for users

- The operating personnel of laser cutting machine must have specialized trainings to master a certain level of knowledge, and could take the relevant posts after being approved by the security manager.
- The operating personnel of laser cutting machines or the personnel close to the laser shall wear suitable lasering protective eyeglasses during application. Meanwhile, the areas in which the operating personnel need to wear protective eyeglasses must have good indoor illumination so as to ensure the smooth operations of the operators.
- To protect the operating personnel, processing room, protective screen, etc. shall be provided. Moreover, the processing room shall be equipped with devices that protect operating personnel and prevent laser against diffusion; If the processing room is to be opened, the laser optical gate shall be closed.

Chapter II Product Overview

2.1 Product representation

Metal laser cutting machine is a standardized mature product developed individually by our company, which is applied in cutting process by fusing metal material under the support of energy released by fiber laser beam that focuses and reflects on the pipe surface, and by blowing slag generated by metal fusing away with the help of HP gas. It is chiefly applicable to the cutting of stainless steel, carbon steel, manganese steel, spring steel, copper plate, aluminium plate, metal titanium and other sheet metals.

The laser cutting is an advanced processing method featuring high efficiency and precision and high cutting surface smoothness during sheet metal processing, which are not provided concurrently by other processing methods.

Optional imported or domestic laser devices, as required by customers, are applied in the laser cutting machine manufactured by our company; simultaneously, servo motor, decelerator, gear rack, ball-screw & linear guide and other components are famous international brands selected, thus guaranteeing the high quality and precision of cutting products.

2.2 Product classification

Laser cutting machine produced by our company is chiefly classified into the following items:

1. Small size sheet metal fiber laser cutting machine: i series laser cutting machine
2. Large size sheet metal fiber laser cutting machine
   a. Benchmark sheet metal laser cutting machine: F series laser cutting machine
   b. Exchange platform sheet metal laser cutting machine: E series laser cutting machine
   c. All cover exchange platform sheet metal laser cutting machine: P series laser cutting machine
3. Plate and tube laser cutting machine
   a. Benchmark metal plate and pipe laser cutting machine: F-T series laser cutting machine
   b. Exchange platform metal plate and pipe laser cutting machine: E-T series laser cutting machine
   c. All cover exchange platform metal plate and pipe laser cutting machine: P-T series laser cutting machine
4. Tube laser cutting machine
   a. Benchmark metal tube laser cutting machine: T series laser cutting machine
   b. Auxiliary load metal tube laser cutting machine: T-E series laser cutting machine
   c. Automatic load metal tube laser cutting machine: T-A series laser cutting machine
5. Laser cutting robot: RC series laser cutting machine

2.3 Introduction to structure of i series laser cutting machine

2.3.1 External view

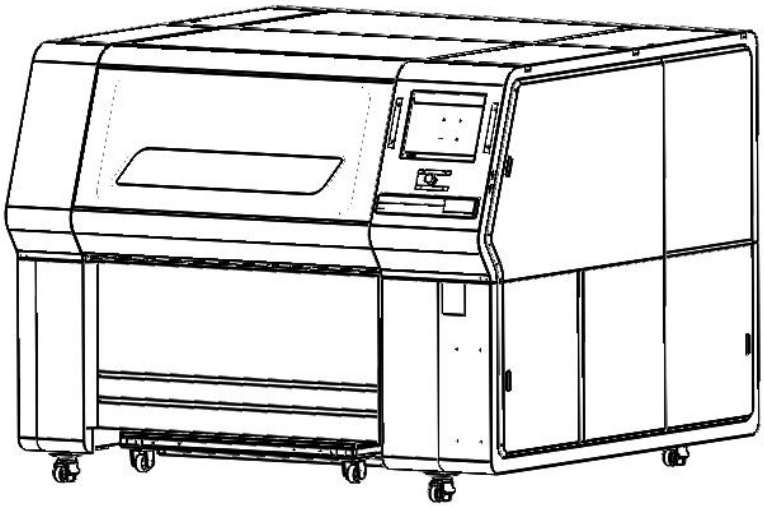


Figure 2.3.1.1: External view of i series cutting machine

(subject to material object)

2.3.2 Main features:

1. High-performance laser device associated with stable operation system enables optimal cutting effects.
2. Perfect cooling, lubrication and dedusting systems ensure stable, efficient and durable performance of the whole machine.
3. Inblock cast cross beam makes the device highly rigid, stable and antiknock.
4. Automatic height-adjustment performance keeps constant focal length and stable cutting quality.
5. Airtight working space could improve dedusting effects and avoid light pollution.
6. It could cut mental in various materials and realize excellent and stable cutting effects.
7. It takes precise linear guideway and ball screw as driving elements which could realize high precision and rapid speed.
8. It is equipped with special CAD/CAM automatic programming and jacking software to save raw materials to the maximum extent.
9. Remote communication and monitoring in laser cutting process could be realized through the direct communication between network interface and numerical control system.

2.3.3 Environmental condition

a) Quality of power supply: Tri-phase unbalance factor <2.5%, line voltage fluctuation <5%.

b) Grounding protection: independent grounding of machine tool; independent grounding of tube cutting section; independent grounding of power distribution cabinet; independent grounding of laser device; ground resistance required ＜4Ω. Ground pile: shall be smashed into the ground through an angle iron or wide-diameter rebar no less than 2-3m long; simultaneously proper salt water shall be poured for better grounding effect.

c) Draughty, dust-free, non-corrosive and pollution-free site environment is required.

d) No large vibration is permitted around the installation foundation.

e) The water chilling unit is applied in dedicated devices such as cooling laser device and cutting head; for circulating cooling water, high-quality and mineral-free purified water, distilled water or deionized water is required;

f) For fear of fire hazard, appropriate fire extinguishers and reserved fire fighting access shall be provided in the processing site.

g) Over 1.2M shall be kept between workshop wall and left and rear sides of machine tool; Over 1.0M shall be reserved around the laser device.

The control unit, servo unit, displayer and control panel are core components of machine tool, which are demanding on the environment to some extent, and shall be kept away from electromagnetic wave interference, such as arc welding and electric discharge machine, for fear that the normal operation of machine tool is affected.

2.3.4 Impact on environment and energy

Since the laser device of laser cutting machine is a fiber generator, harmful flue gas and dust will be generated in the process of cutting; therefore, it is necessary to purify the flue gas exhausted from the dust exhaust apparatus before emission; simultaneously, it shall avoid fire hazard.

The laser device of laser cutting machine is a Class 4 laser product, whose beam ejected, whichever reflected through a lens or reflected diffusely, will impair human body (especially eyes); therefore, it is worth noting that operating personnel and on-site personnel shall wear protective eyeglasses, which the optional SD-4, 1064nm ones are a choice.

Remark: No system and component above shall be changed without permission for the purpose of normal operation of laser head and laser device, as well as guaranteeing steady power of laser device and good mode of laser. It is beyond the warranty coverage including low laser power, poor laser mode and other parts injured due to a user's using undesirable water, electricity and gas without permission.

2.3.5 Technical parameters:

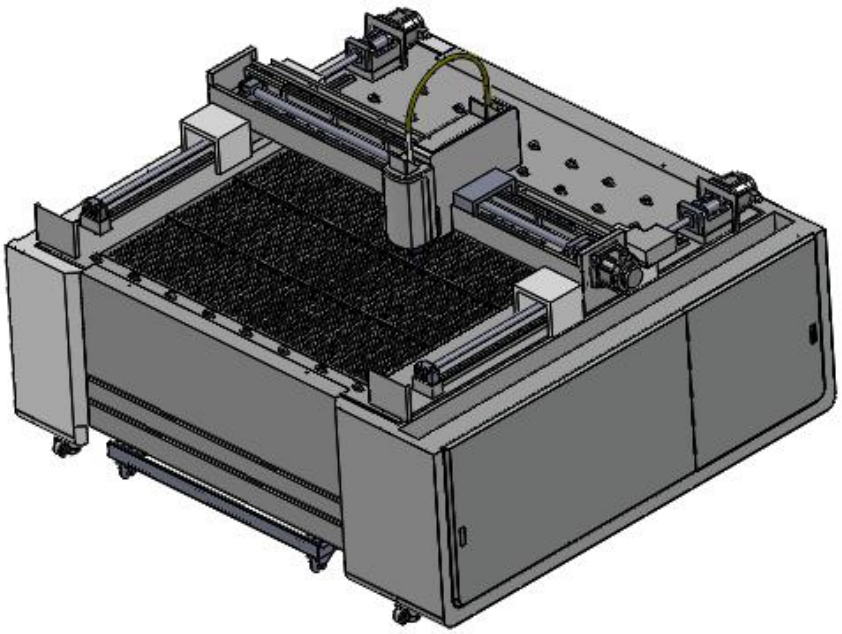
Parameters of i series laser cutting machine

Model	i3	i5	i7

Maximum processing range		500X500mm	1300X900mm	1500X1000mm
Stroke of X axis		520mm	1320mm	1520mm
Stroke of Y axis		520mm	920mm	1020mm
Stroke of Z axis		60mm		
Positioning precision of X/Y axis		±0.03mm		
Repeated positioning precision of X/Y axis		±0.02mm		
X/Y axis maximum moving speed		40m/min		
X/Y axis maximum cutting speed		35m/min		
Maximum acceleration		0.6G		
Power of optional laser device		500W,800W,1000W,1500W,2000W		
Maximum load		100Kg	250Kg	300Kg
Gross power	500W laser device	9KW		
	800W laser device	11KW		
	1000W laser device	11KW		
	1500W laser device	13KW		
	2000W laser device	15KW		
Overall size (L * W * H)		2000×1500×1800	2200×2300×1700	2500*2200*1700
Weight of whole machine		1000kg	1500kg	1800kg

2.3.6 Introduction to mechanical structure

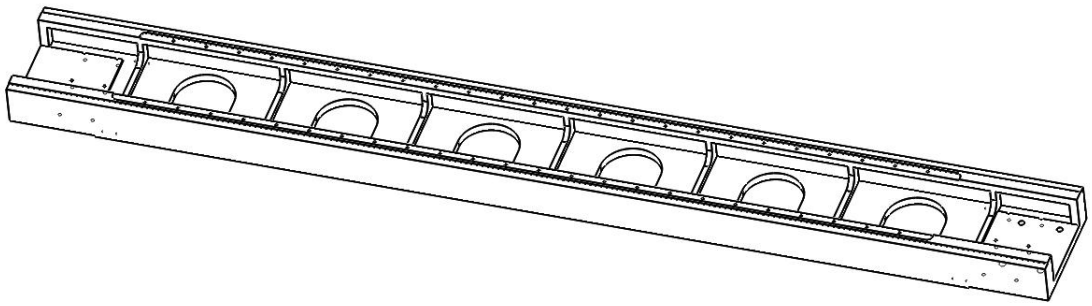
2.3.6.1 Lathe bed part



100mm×100mm×6mm sectional material is integrally welded and formed into the lathe bed, and then heat treatment is adopted to relieve the internal stress on the completion of welding, thus greatly reducing the deformation of lathe bed installed and improving the synthesized mechanical properties.

The installation surface sizes of lathe bedway, rack, cross beam, etc. are clamped and processed one time, thus improving the processing precision of lathe bed and ensuring a high cutting precision in the meanwhile.

2.3.6.2 Cross beam part



As for cross beam, the aluminum casting is adopted and machined after moulding by casting, thus not only reducing the weight of cross beam and improving the operating performance of product, but also endowing cross beam with high strength, processing precision and excellent

synthesized mechanical properties.

2.3.6.3 Drive part

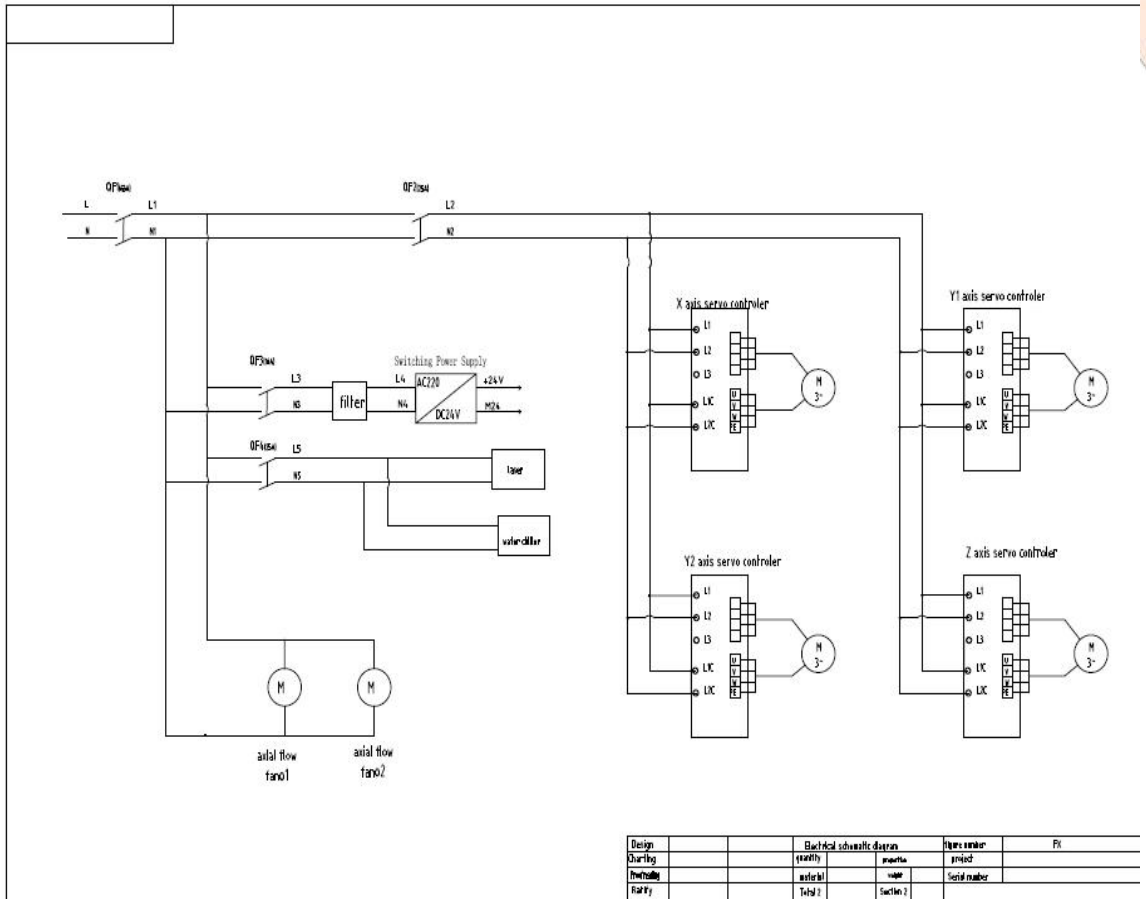
With regard to X, Y and Z axes, the kind of drive combining ball screw and linear guideway, and strict match commissioning applied in drive mechanism and servo control system ensure high-speed, precise and steady movement of various axes.

The drive part is provided with servo motor, ball screw, linear guide, decelerator and other domestic and overseas well-known brand products, improving the control and operation precision and service life of products.

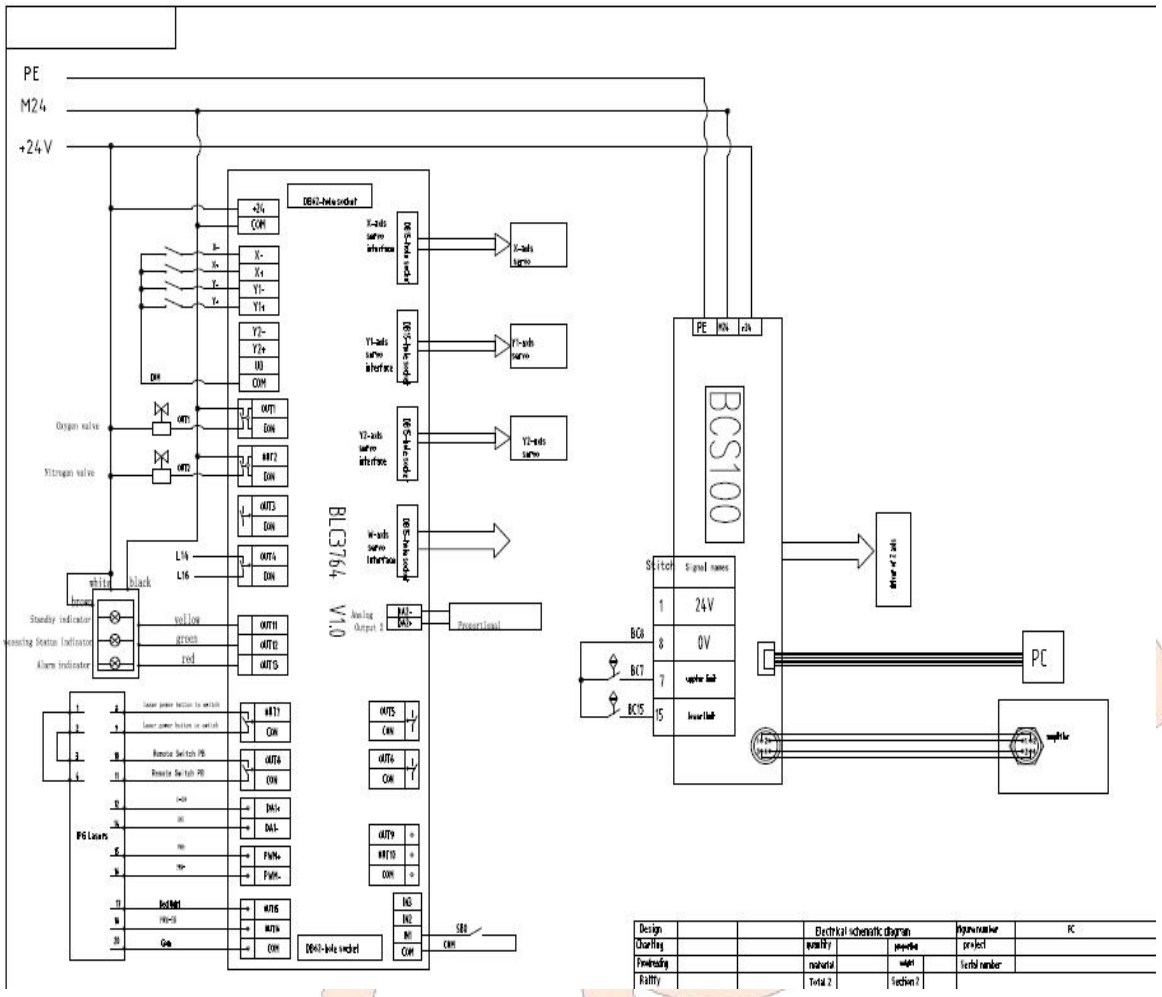
2.3.7 Electrical part

I. Schematic diagram

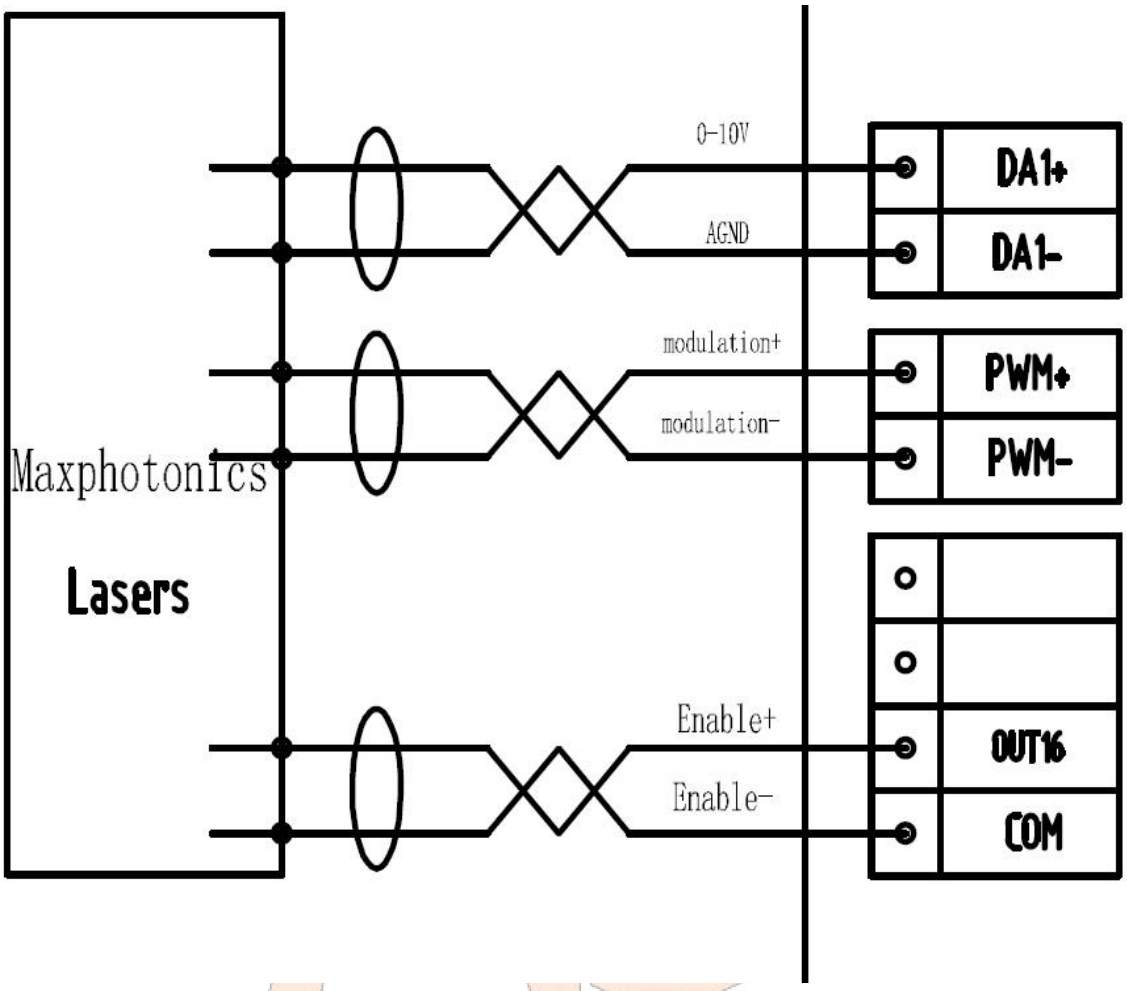
1) Major Loop

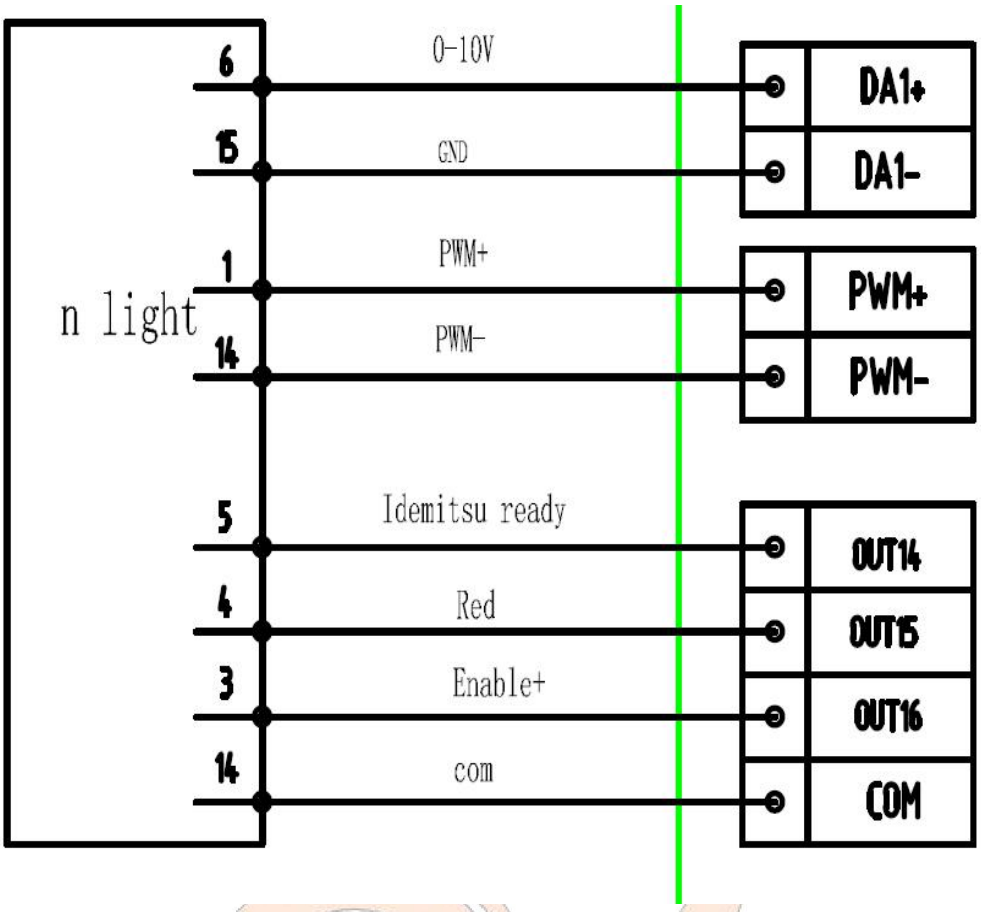


2) Control Loop



3) Connection Diagram of Laser Device


0-10V
AGND
modulation+
modulation-
Maxphotonics
Lasers
Enable+
Enable-
DA1+
DA1-
PWM+
PWM-
OUT16
COM


n light
6
15
1
14
5
4
3
14
0-10V
GND
PWM+
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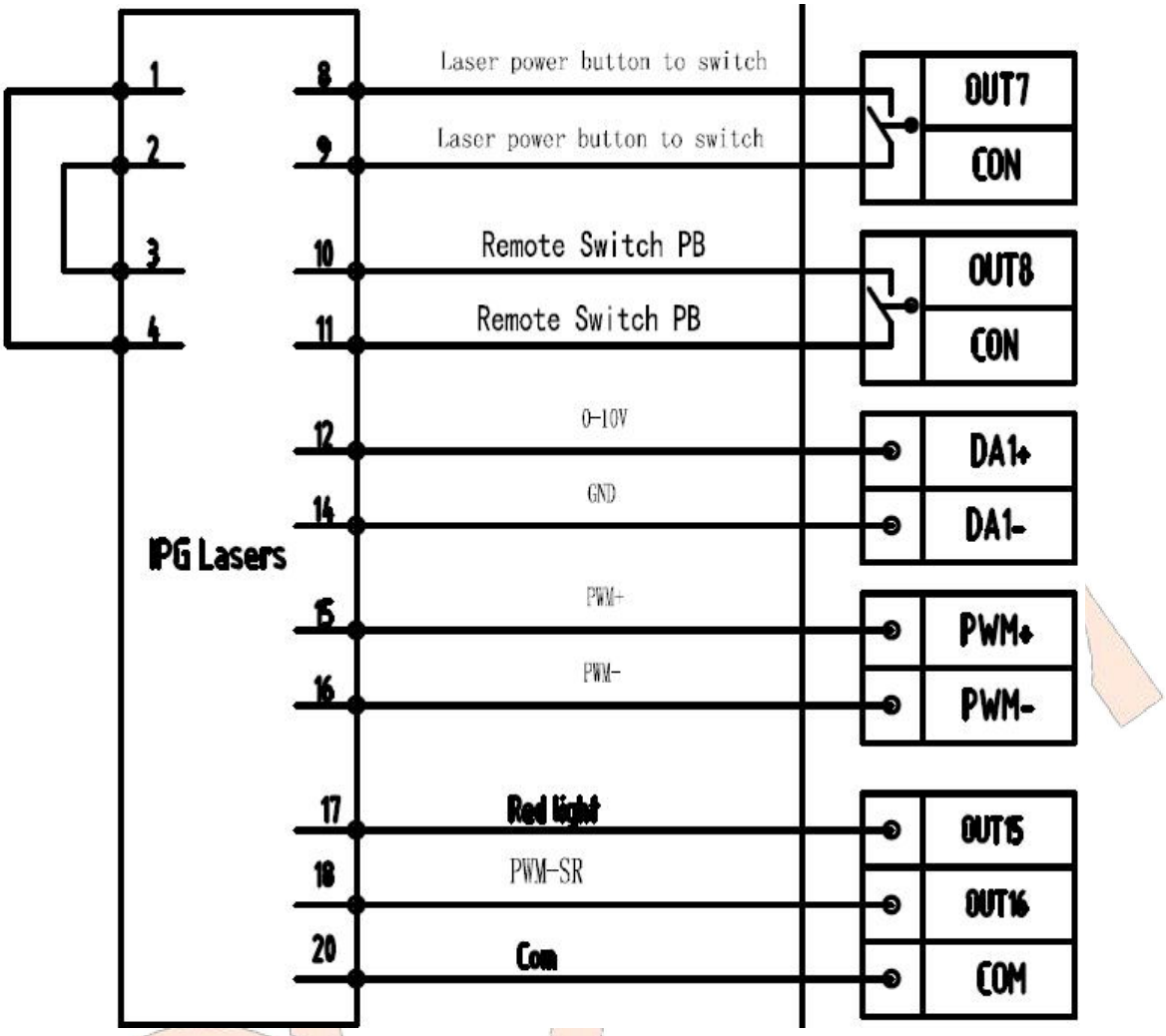
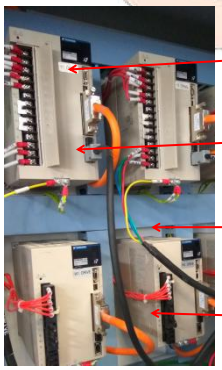


II. Basic electrical parts and their functions

The majority of electrical components is mounted inside and used to supply electricity for the machine.

1) Drives



Power line, used to supply

Supply electricity for

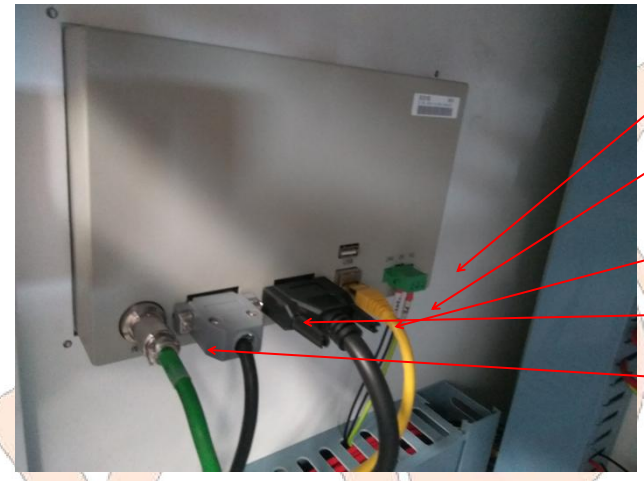
A line of encoder that provides a feedback

Signal line, employed to control the

Servo drives, also called "servo controller" or "servo amplifier", just like a variable-frequency drive acting on general AC motor, is a controller to control a servo motor; as a part of the servo system, it is mainly applied in a high-precision positioning system. It currently is a cutting-edge product of drive technology, which is generally used to control a servo motor

through three modes of location, speed and moment of force to achieve high-precision positioning of drive system.

2) Height-adjustment device



Supply 24V electricity

Network cable,

Connect drives

Limit signal

Signal line of

During cutting, it is the laser head to maintain a constant distance between laser head and sheet metal, not only getting laser head protected effectively, but also achieving sophisticated techniques, including multi-stage perforation.

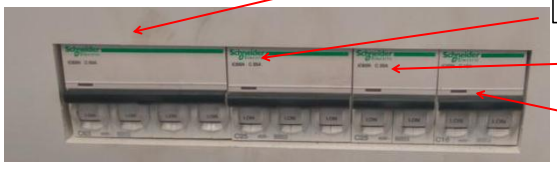
3) Circuit breaker

Main power

Main power switch of

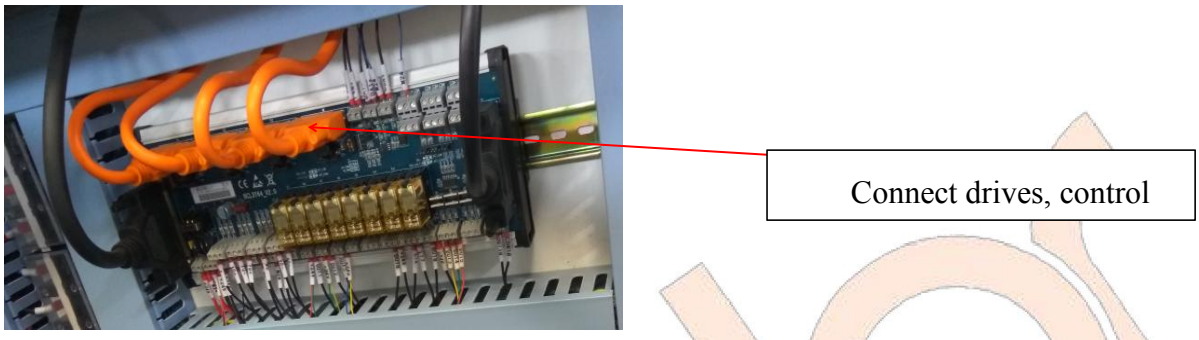
Power switch of laser water

System power



The circuit breaker could be used to distribute electric energy, start occasionally an asynchronous motor and protect power line and motor and so on; in case these devices are in overload, short circuit, undervoltage and other trouble states, it could shut down the circuit automatically, which functions as the combination of fuse-switch and overthermal-underthermal relay. Moreover, no part or component is required to be changed after disjuncting fault current.

4) Pinboard



The motion control card is an upper control unit based on PC and industrial PC, and applied in various motion control occasions (including displacement, speed, acceleration, etc).

The motion control card is a PC bus-based, high-performance stepping/ servo motor, being capable of achieving multi-axis coordinative control of several servo motors by taking advantage of high-performance microprocessor (for instance DSP) and large scale programmable devices. With the functions of pulse output, pulse counting, digital input, digital output, D/A output, etc., it is able to send continuous, high-frequency pulse train, and control the motor speed by changing the frequency of pulse sent and control the location of motor by changing the quantity of pulse sent. Its mode of pulse input includes pulse/direction and pulse/pulse. The pulse counting could be used to feed back the location of encoder, provide accurate location of machine and correct the error in the process of drive. Digital input/output point could be applied in limit switch, origin switch, etc. Library functions include S-type/T-type acceleration, line interpolation, circular interpolation, multi-axis linkage function, etc. The product is widely applied in location control system that location and length are required to be confirmed precisely, and PC-based NC control system in the field of industrial automatic control. Specifically, integrating bottom software that achieves motion control with hardware endows them with various control functions of speed and location required for controlling servo motor; these functions could be easily called via a computer.

5) Intermediate relay

It is applied in relay protection and automatic control system to increase the quantity and volume of contact points. It is used to transmit M signals in the control circuit. The structure and principle of intermediate relay are basically the same with those of AC contactor, and main differences between them lie in: A large current is allowed to pass through the main contact of the contactor, while the only low current is permitted to pass through the contacts of the intermediate relay. Therefore, the intermediate relay could be used in control circuit only. As the overload capacity is small, generally no main contact exists in an intermediate relay. So all its contacts, sufficient in quantity, are auxiliary. The intermediate relay is defined as K in the new national standard, KA in previous national standards. Generally it is powered with DC power supply. The minority is powered with AC power supply.

6) Switching power supply

24V power supply

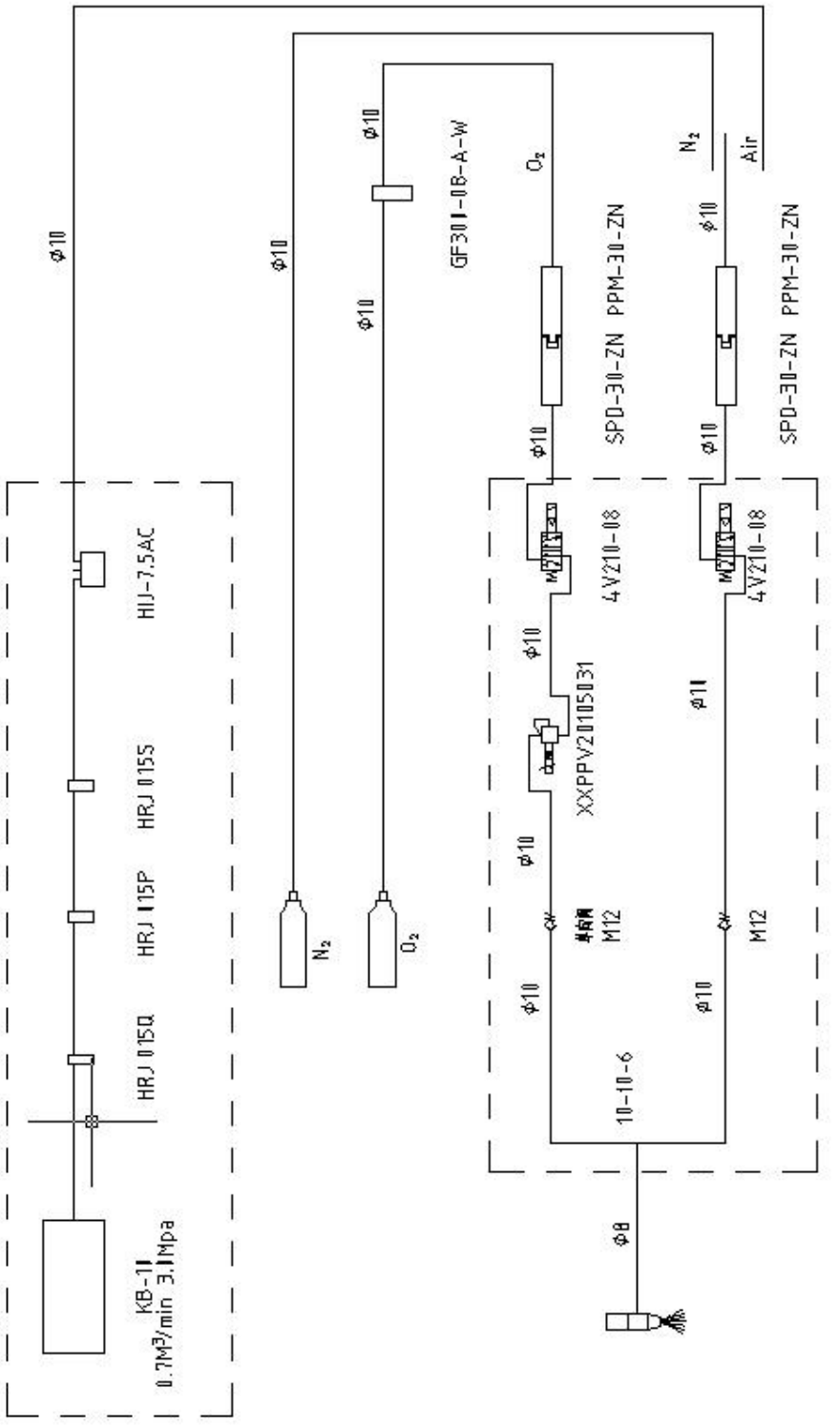
7) Filter

The power filter is a filter circuit consisting of capacitance, inductance and resistance. The filter could effectively filter out a frequency point of specific frequency in a power line or frequency other than the frequency point to obtain power signals of a specific frequency or power signals after eliminating a specific frequency.

2.3.8 Gas circuit system

The gas circuit of laser cutting machine is used to provide cutting gas for cutting head and cooling gas for ceramic body, which should be selected reasonably based on different cutting materials, as follows: 1) Oxygen is mainly applied in cutting of general carbon steel; 2)

Nitrogen is chiefly adopted to cut stainless steel; 3) Air is mainly used for cutting of sheet that conditions allowed.



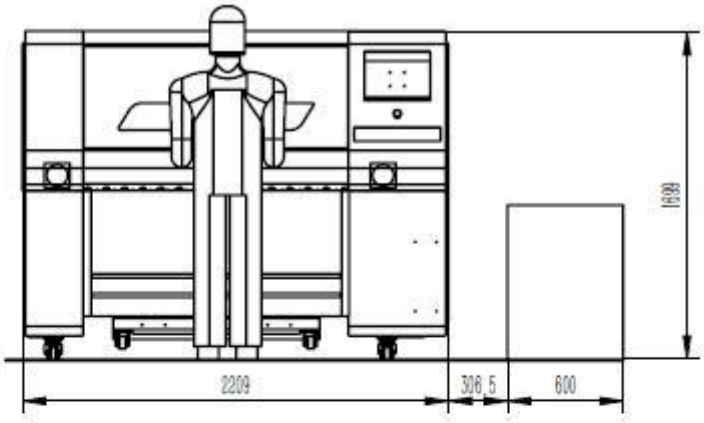
Gas Circuit Schematic Diagram of Cutting Gas

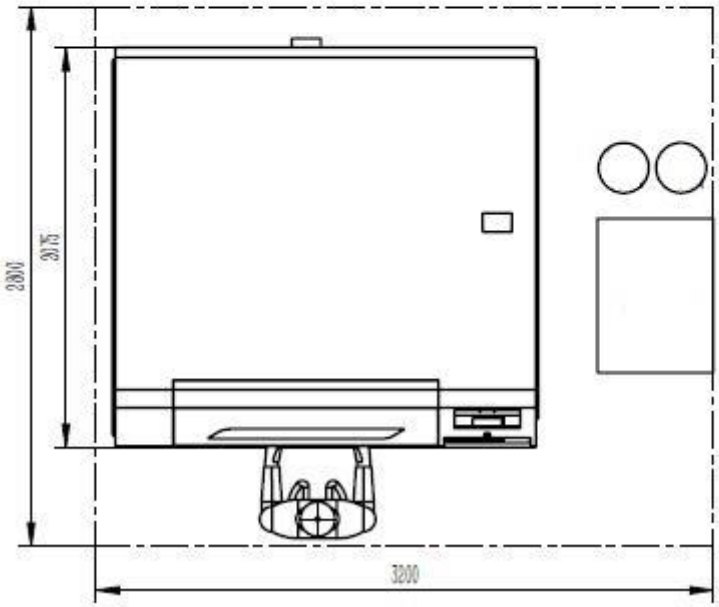
2.3.9 Cooling system

The water circuit of the laser cutting machine has two water circuits with different temperature, one for cooling the laser and the other for cooling the cutting head.

Remark: Auxiliary equipment and means above are significant for the purpose of normal operation of the whole machine tool and laser device, as well as guaranteeing steady power of laser device and good mode of laser. It is beyond the warranty coverage including low laser power, poor laser mode and other parts injured due to a user's using undesirable water, electricity and gas without permission.

2.3.10 Layout





i5 Layout

2.4 Introduction to structure of F series laser cutting machine

2.4.1 External view

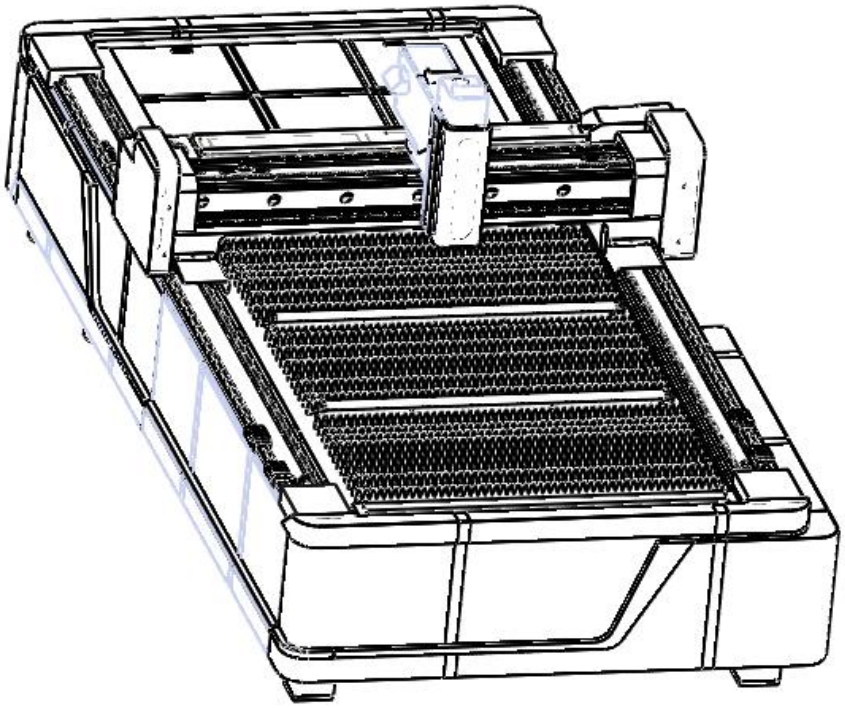


Figure 2.4.1: External view of F series cutting machine
(subject to material object)

2.4.2 Main features

1. High-performance laser device associated with stable operation system enables optimal cutting effects.
2. Perfect cooling, lubrication and dedusting systems ensure stable, efficient and durable performance of the whole machine.
3. Gantry structure and inblock cast cross beam make the device highly rigid, stable and antiknock.
4. Automatic height-adjustment performance keeps constant focal length and stable cutting quality.
5. It could cut mental in various materials and realize excellent and stable cutting effects.
6. It takes precise linear guideway and gear rack as driving elements which could realize high precision and rapid speed.
7. It is equipped with special CAD/CAM automatic programming and jacking software to save raw materials to the maximum extent.
8. Remote communication and monitoring in laser cutting process could be realized through the direct communication between network interface and numerical control system.

2.3.3 Environmental condition

h) Quality of power supply: Tri-phase unbalance factor <2.5%, line voltage fluctuation <5%.

i) Grounding protection: independent grounding of machine tool; independent grounding of tube cutting section; independent grounding of power distribution cabinet; independent grounding of laser device; ground resistance required ＜4Ω. Ground pile: shall be smashed into the ground through an angle iron or wide-diameter rebar no less than 2-3m long; simultaneously proper salt water shall be poured for better grounding effect.

j) Draughty, dust-free, non-corrosive and pollution-free site environment is required.

k) No large vibration is permitted around the installation foundation.

l) The water chilling unit is applied in dedicated devices such as cooling laser device and cutting head; for circulating cooling water, high-quality and mineral-free purified water, distilled water or deionized water is required;

m) For fear of fire hazard, appropriate fire extinguishers and reserved fire fighting access shall be provided in the processing site.

n) Over 1.2M shall be kept between workshop wall and left and rear sides of machine tool; Over 1.0M shall be reserved around the laser device.

The control unit, servo unit, displayer and control panel are core components of machine tool, which are demanding on the environment to some extent, and shall be kept away from electromagnetic wave interference, such as arc welding and electric discharge machine, for fear that the normal operation of machine tool is affected.

2.3.4 Impact on environment and energy

Since the laser device of laser cutting machine is a fiber generator, harmful flue gas and dust will be generated in the process of cutting; therefore, it is necessary to purify the flue gas exhausted from the dust exhaust apparatus before emission; simultaneously, it shall avoid fire hazard.

The laser device of laser cutting machine is a Class 4 laser product, whose beam ejected, whichever reflected through a lens or reflected diffusely, will impair human body (especially eyes); therefore, it is worth noting that operating personnel and on-site personnel shall wear protective eyeglasses, which the optional SD-4, 1064nm ones are a choice.

Remark: No system and component above shall be changed without permission for the purpose of normal operation of laser head and laser device, as well as guaranteeing steady power of laser device and good mode of laser. It is beyond the warranty coverage including low laser power, poor laser mode and other parts injured due to a user's using undesirable water, electricity and gas without permission.

2.4.5 Technical parameters

Table 2.4.5 Parameters of F Series Cutting Machine

Model		F1530	F1540	F1560	F2040	F2060	F2560
Maximum processing range		1500×3000mm	1500×4000mm	1500×6000mm	2000×4000mm	2000×6000mm	2500×6000mm
Stroke of X axis		1500mm	1500mm	1500mm	2000mm	2000mm	2500mm
Stroke of Y axis		3000mm	4000mm	6000mm	4000mm	6000mm	6000mm
Stroke of Z axis		315mm					
Positioning precision of X/Y axis		±0.03mm					
Repeated positioning precision of X/Y axis		±0.02mm					
X/Y axis maximum moving speed		100m/min					
X/Y axis maximum cutting speed		35m/min					
Maximum acceleration		1.2G					
Power of optional laser device		500W,800W,1000W,1500W,2000W					
Maximum load of working platform		600kg	700kg	1100kg	1000kg	1400kg	1800kg
Gross power	500W laser device	10.6kW					
	800W laser device	11kW					
	1000W laser device	12kW					
	1500W laser device	13.7kW					

	2000W laser device	15.6kW					
Overall size (L * W * H)		4550*2300*2000	5580*2300*2000	7600*2300*2000	5850*3000*2000	7600*3000*2000	7600*3600*2000
Weight of whole machine		3000kg	3500kg	4500kg	5500kg	7000kg	8000kg

2.4.6 Features of mechanical structure

2.4.6.1 Lathe bed part

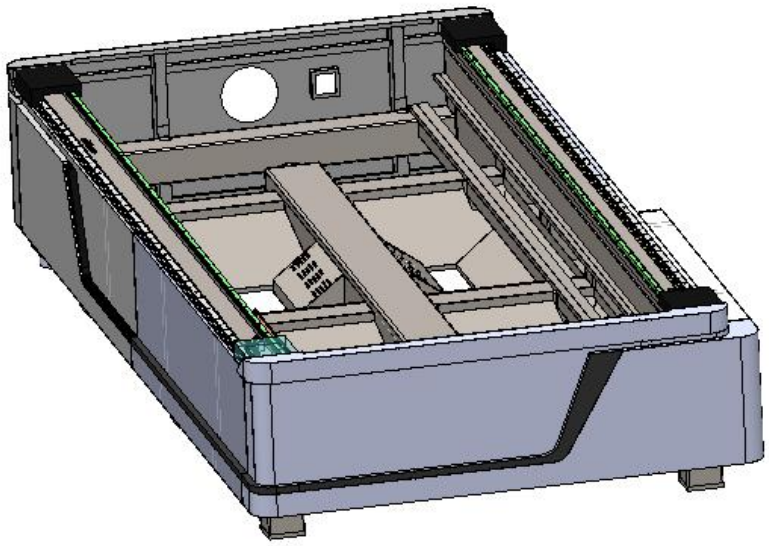


Figure 2.4.6.1: Lathe bed

The lathe bed is welded and made of high-quality carbon structural steel and formed through aging heat treatment, eliminating the residual stress of welding, steadying the size and guaranteeing the long-term precision. The lathe bed is provided with high-precision linear guideway and gear rack drive mechanism on its two sides that drive cross beam for dolly moves; both two ends of stroke are equipped with switches and buffer stopper, endowing the motion with double safety protection.

2.4.6.2 Cross beam part

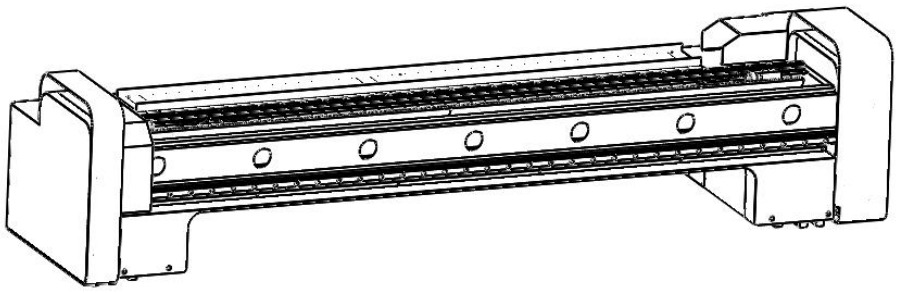


Figure 2.4.6.2: Cross Beam

The cross beam is integrally casted and made of heat-treatable hardening aluminium alloy. Since the laser cutting is non-contact, the cross beam is designed in a lightweight manner;

moreover, the low-density and high-strength aluminium alloy could meet the needs of high-speed and high-precision laser cutting.

The cross beam is provided with high-precision linear guideway and gear rack drive mechanism, allowing the Z axis device to reciprocate along the direction of X axis; both two ends of stroke are equipped with switches and buffer stopper, endowing the motion with double safety protection.

2.4.6.3 Workbench

Figure 2.4.6.3: Workbench

The workbench is integrally welded structure with high strength and stability. Three rollers driven by cylinder are installed on the workbench and can be lifted by the cylinder in the loading process, allowing sliding of work piece on the rollers and avoiding sliding of work piece on the support blades which may cause scratch; Once the work piece is positioned, the roller will go down under the drive of cylinder after the pneumatic switch is on, thus avoiding the roller from injury during cutting. The workbench is also equipped with universal balls on which the work piece rolls when fed or unloaded, avoiding the work piece from scratches, reducing the strength of labor and achieving the fast feeding and baiting of work piece.

2.4.6.4 Z axis device

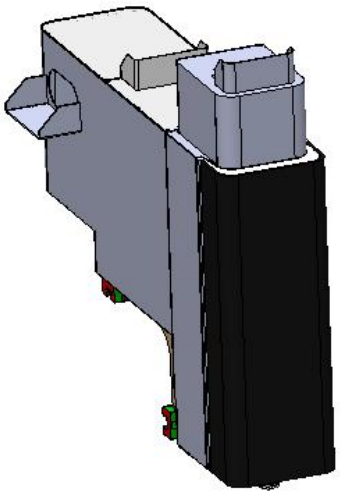


Figure 2.4.6.4: Z axis device

The Z axis device is applied in the lifting motion of cutting head. The lifting motion of cutting head is achieved by up-down reciprocating motion of Z axis slider driven by the numerical control system controlling servo motor and the motor driving ball screw. The stroke of both up and down ends is controlled by proximity switch. Both ball screw and linear guideway are high quality products, ensuring the driving precision.

The Z axis can interpolate independently as a numerical control axis, move together with the X and Y axes and switch to follow-up motion mode through the electrically-controlled part of the cutting head to meet the requirements of different situations. The follow-up motion of Z axis is controlled by the numerical control system, which is relatively high-precision and stable, thus ensuring the quality of cutting.

The capacitance sensor (mounted on the cutting head) in Z axis device will feed the signals that the distance from nozzle to the surface of profile back to the control system which would then control the motor of Z axis to drive the up-down motion of cutting head, therefore keeping a constant distance between the nozzle and profile and effectively ensuring the cutting quality. The cutting head is equipped with nut that adjusts the focal length, and the location of focus could be adjusted based on the texture and thickness of cutting material, thus good cutting section is available. Since the nozzle is one of quick-wear parts during processing, users may reserve some nozzles with different hole diameters for convenient replacement.

Z axis is equipped with linear guideway seat nozzle and lead screw seat nozzle respectively for filling lubricating grease on a regular basis.

2.4.6.5 Dust extraction system

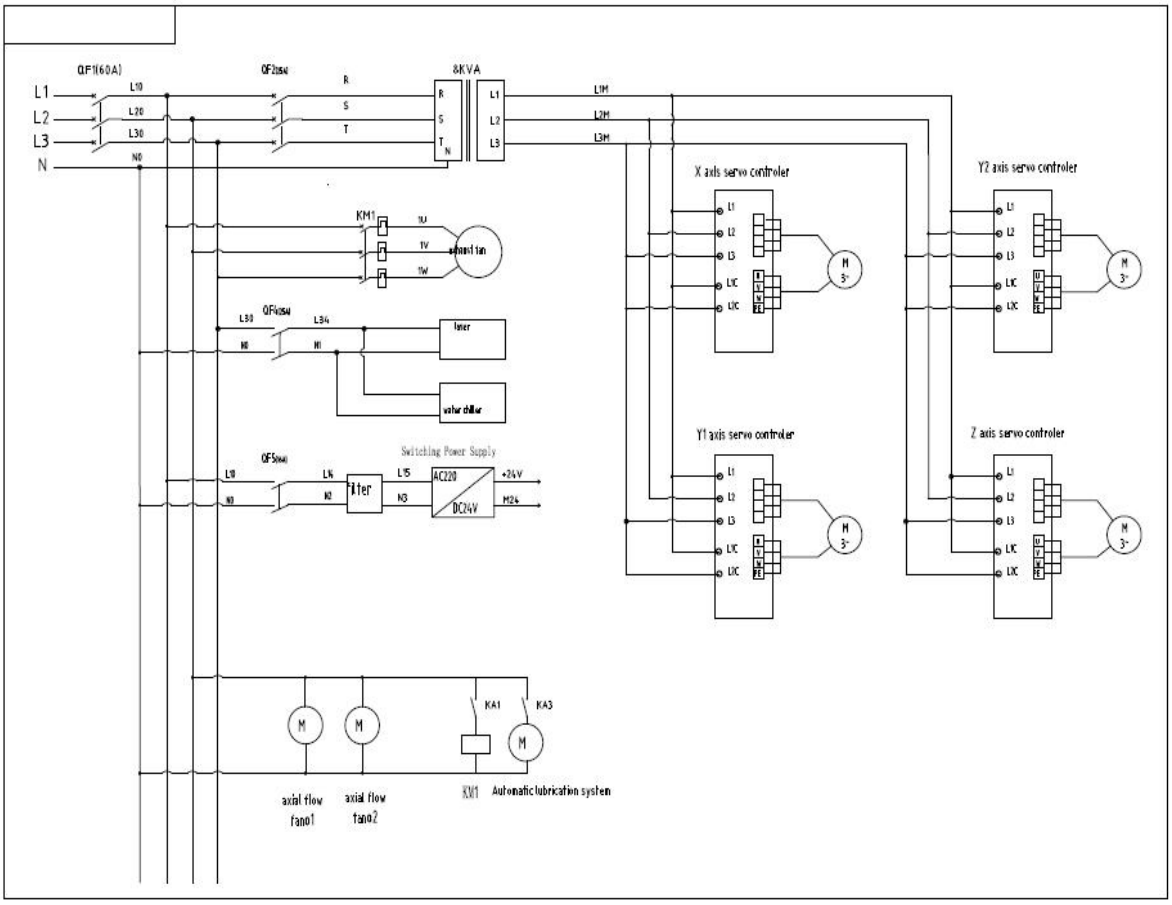
As a mode of thermal cutting process, laser cutting is conducted by taking advantage of high-energy density laser beam gathered on the surface of work piece to instantly fuse and gasify the work piece exposed to ultrafine focus spot, and then automatically cut by moving the exposure location controlled by the numerical control system; dust is unavoidable during

the processing, which would impair the operating personnel and working environment.
The laser cutting machine is equipped with a dust extraction system consisting of built-in dedusting duct in lathe bed body, large-diameter pipe and high-power fan, which is able to obviously inhale dust generated during laser cutting, thus guaranteeing the health of operating personnel.

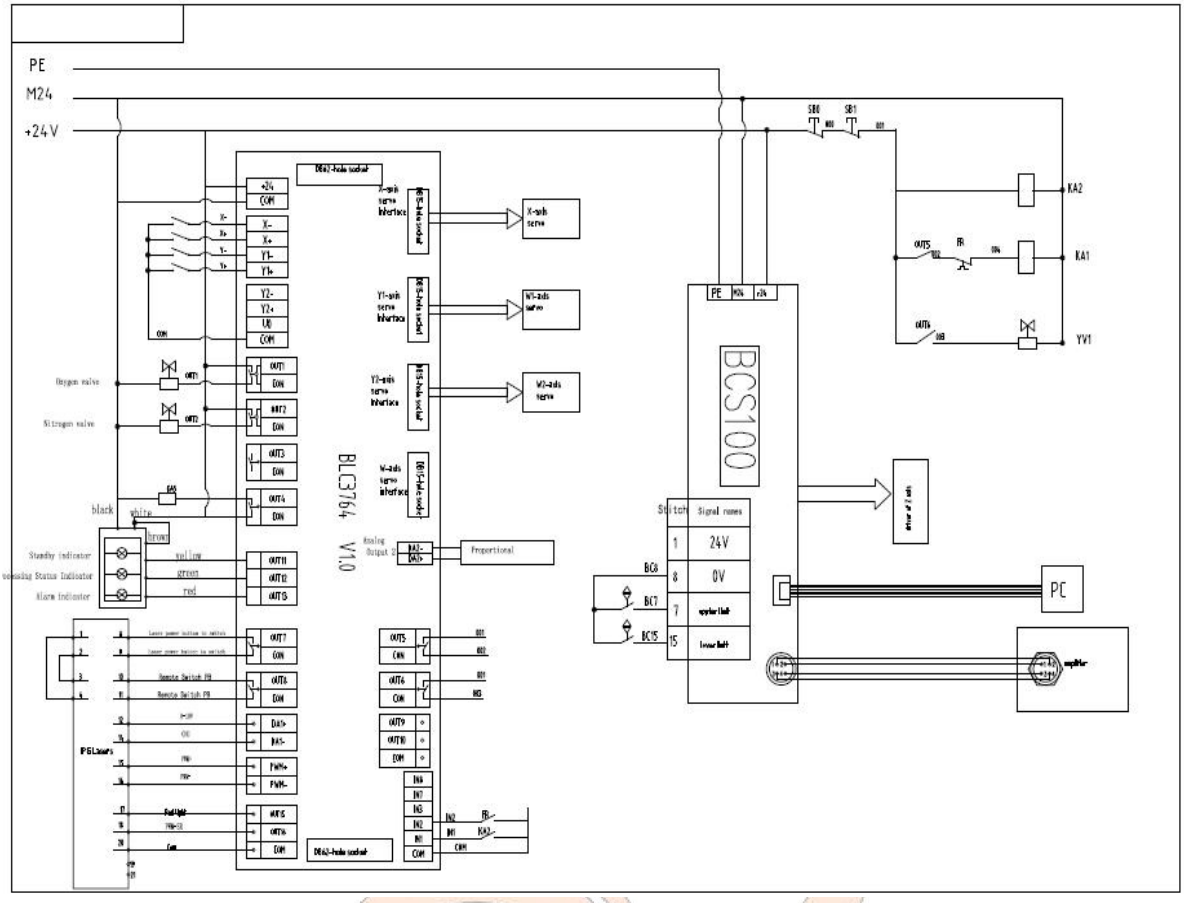
2.4.7 Electrical part

I. Schematic diagram

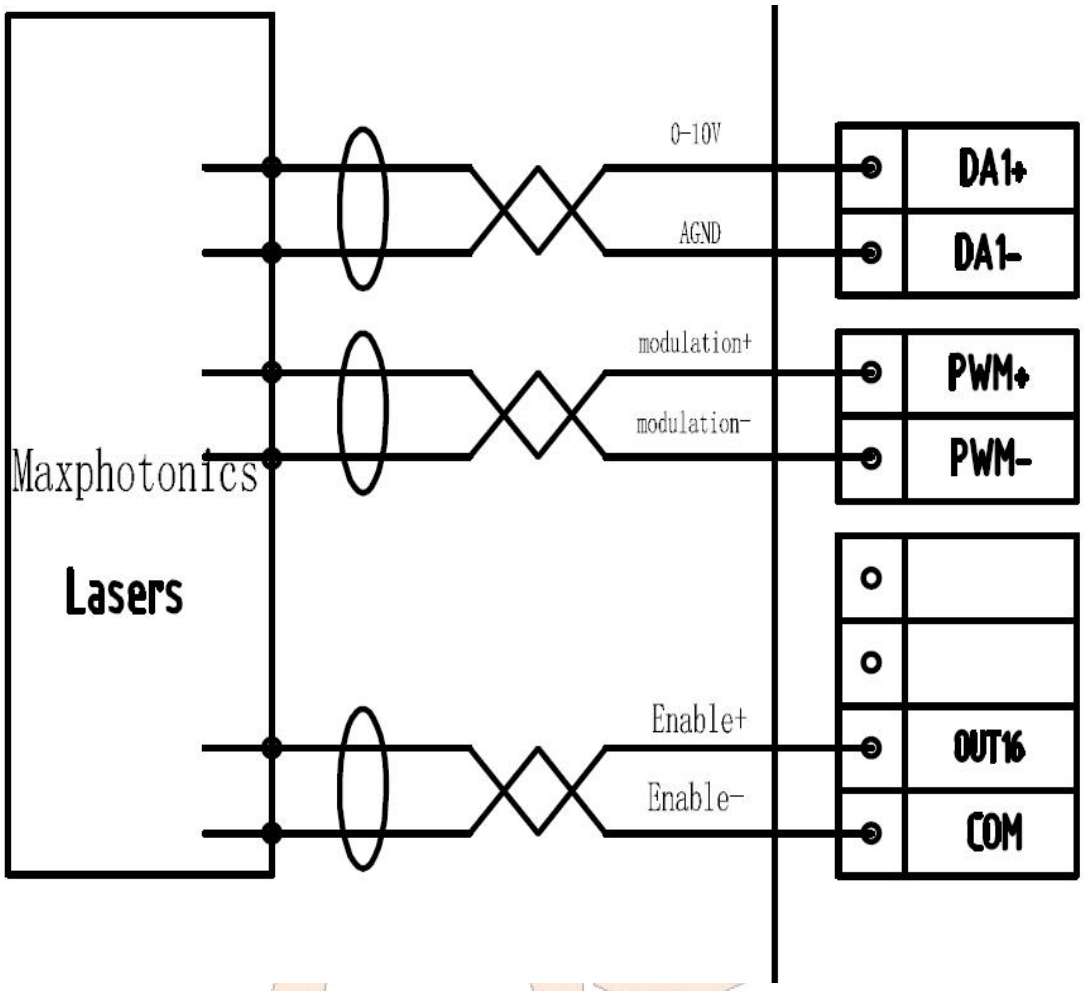
1) Major Loop



2) Control Loop



3) Connection Diagram of Laser Device


0-10V
AGND
modulation+
modulation-
Maxphotonics
Lasers
Enable+
Enable-
DA1+
DA1-
PWM+
PWM-
OUT16
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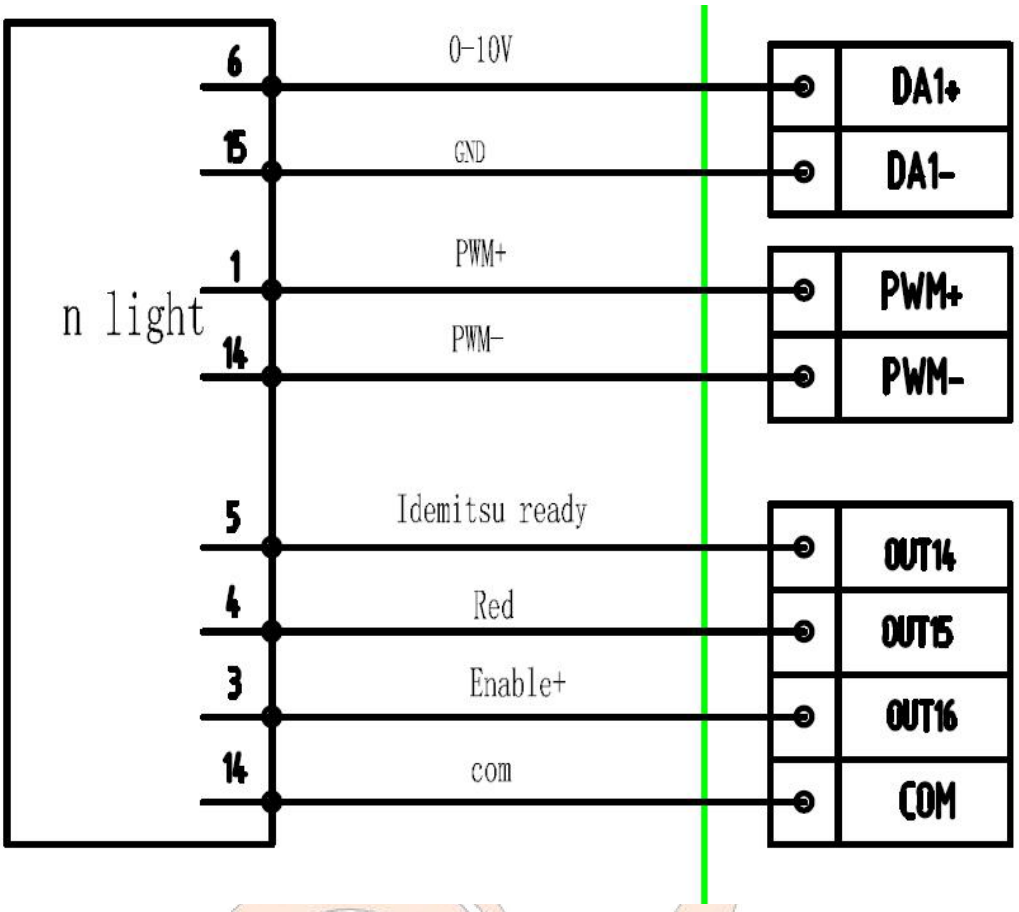
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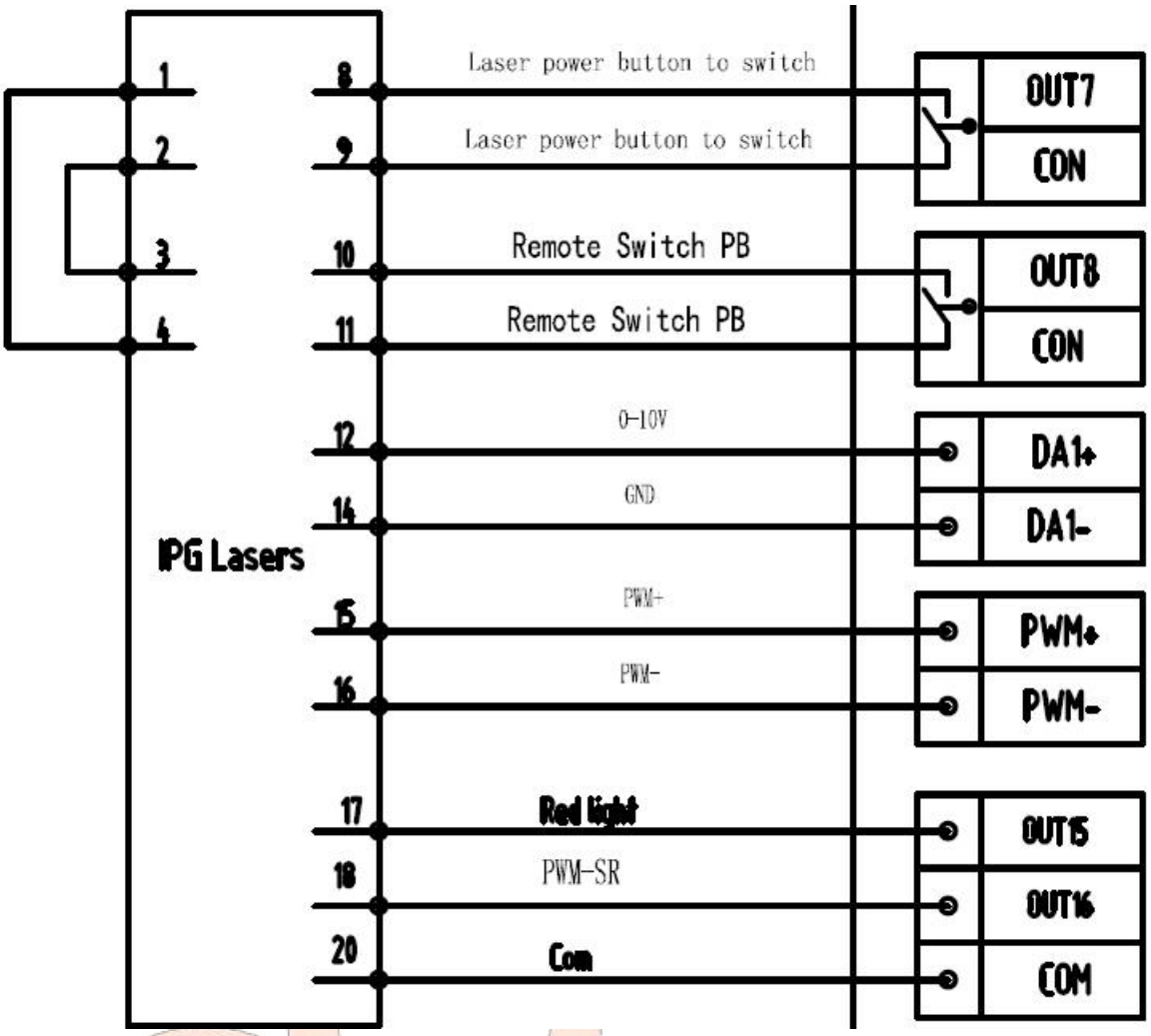
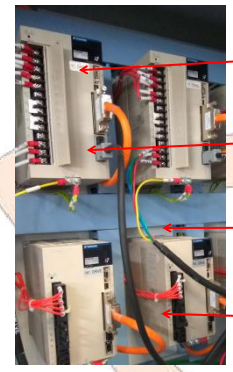


II. Basic electrical parts and their functions

1) Electrical cabinet

The majority of electrical components is mounted inside and used to supply electricity for the machine.

5) Drive



Power line, used to supply electricity for drives

Supply electricity for servo motor

A line of encoder that provides a feedback signal for servo device

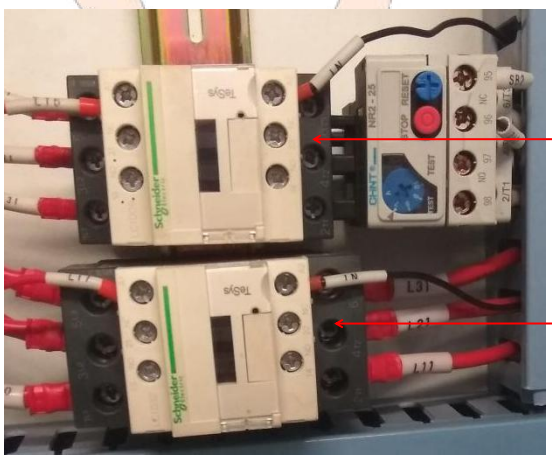
Signal line, employed to control the signal of drives

Servo drives, also called "servo controller" or "servo amplifier", just like a variable-frequency drive acting on general AC motor, is a controller to control a servo motor; as a part of the servo system, it is mainly applied in a high-precision positioning system. It currently is a cutting-edge product of drive technology, which is generally used to control a servo motor through three modes of location, speed and moment of force to achieve high-precision positioning of drive system.

6) Servo transformer

Such type of servo transformer is specifically designed for servo drive system, which could provide necessary electric energy for servo drive.

7) Contactor



Load appliances could be controlled by switching on the contacts under the action of magnetic field generated when current passes through the coil.

8) Height-adjustment device

Supply 24V electricity for height-adjustment device

Network cable,

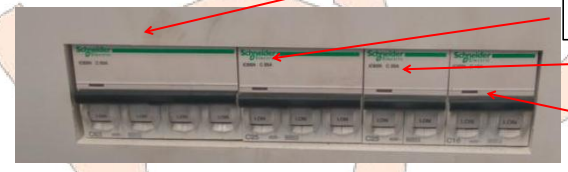
Connect drives

Limit signal

Signal line of sensor

During cutting, it is the laser head to maintain a constant distance between laser head and sheet metal, not only getting laser head protected effectively, but also achieving sophisticated techniques, including multi-stage perforation.

9) Circuit breaker



Main power switch

Main power switch of drives

Power switch of laser water chiller

System power switch

The circuit breaker could be used to distribute electric energy, start occasionally an asynchronous motor and protect power line and motor and so on; in case these devices are in overload, short circuit, undervoltage and other trouble states, it could shut down the circuit automatically, which functions as the combination of fuse-switch and overthermal-underthermal relay. Moreover, no part or component is required to be changed after disjuncting fault current.

10) Pinboard

The motion control card is an upper control unit based on PC and industrial PC, and applied in various motion control occasions (including displacement, speed, acceleration, etc).

The motion control card is a PC bus-based, high-performance stepping/ servo motor, being capable of achieving multi-axis coordinative control of several servo motors by taking advantage of high-performance microprocessor (for instance DSP) and large scale programmable devices. With the functions of pulse output, pulse counting, digital input, digital output, D/A output, etc., it is able to send continuous, high-frequency pulse train, and control the motor speed by changing the frequency of pulse sent and control the location of motor by changing the quantity of pulse sent. Its mode of pulse input includes pulse/direction and pulse/pulse. The pulse counting could be used to feed back the location of encoder, provide accurate location of machine and correct the error in the process of drive. Digital input/output point could be applied in limit switch, origin switch, etc. Library functions include S-type/T-type acceleration, line interpolation, circular interpolation, multi-axis linkage function, etc. The product is widely applied in location control system that location and length are required to be confirmed precisely, and PC-based NC control system in the field of industrial automatic control. Specifically, integrating bottom software that achieves motion control with hardware endows them with various control functions of speed and location required for controlling servo motor; these functions could be easily called via a computer.

8) Intermediate relay

It is applied in relay protection and automatic control system to increase the quantity and volume of contact points. It is used to transmit M signals in the control circuit. The structure and principle of intermediate relay are basically the same with those of AC contactor, and main differences between them lie in: A large current is allowed to pass through the main contact of the contactor, while the only low current is permitted to pass through the contacts of the intermediate relay. Therefore, the intermediate relay could be used in control circuit

only. As the overload capacity is small, generally no main contact exists in an intermediate relay. So all its contacts, sufficient in quantity, are auxiliary. The intermediate relay is defined as K in the new national standard, KA in previous national standards. Generally it is powered with DC power supply. The minority is powered with AC power supply.

9) Switching power supply

24V power supply

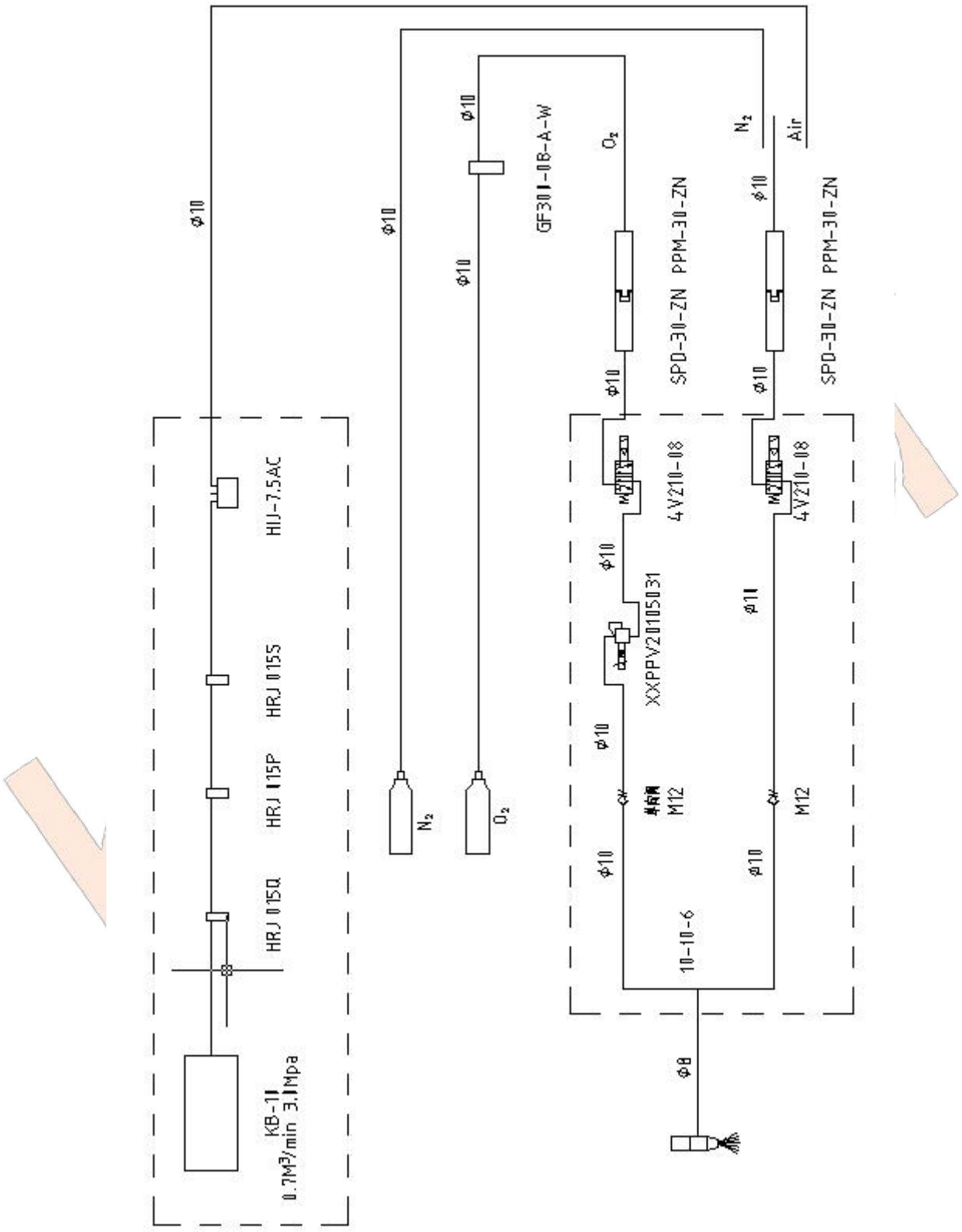
10) Filter

The power filter is a filter circuit consisting of capacitance, inductance and resistance. The filter could effectively filter out a frequency point of specific frequency in a power line or frequency other than the frequency point to obtain power signals of a specific frequency or power signals after eliminating a specific frequency.

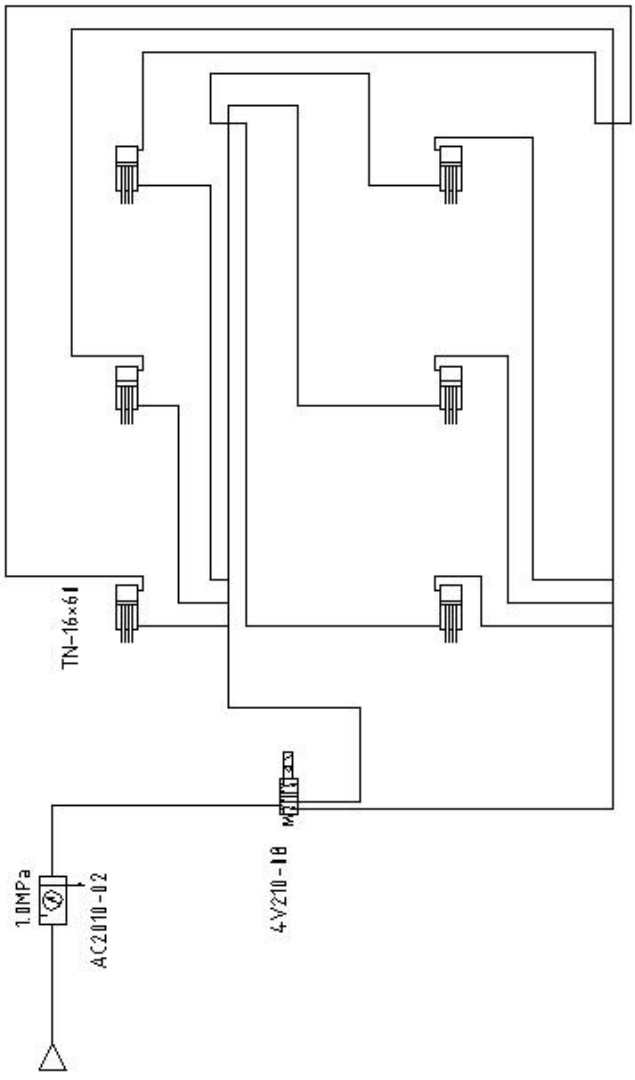
2.4.8 Gas circuit system

The gas circuit of laser cutting machine is used to provide cutting gas for cutting head and cooling gas for ceramic body, which should be selected reasonably based on different cutting materials, as follows:

1) Oxygen is mainly applied in cutting of general carbon steel;
2) Nitrogen is chiefly adopted to cut stainless steel;
3) Air is mainly used for cutting of sheet that conditions allowed.



Gas Circuit Schematic Diagram of Cutting Gas



Pneumatic Schematic Diagram

2.4.9 Cooling system

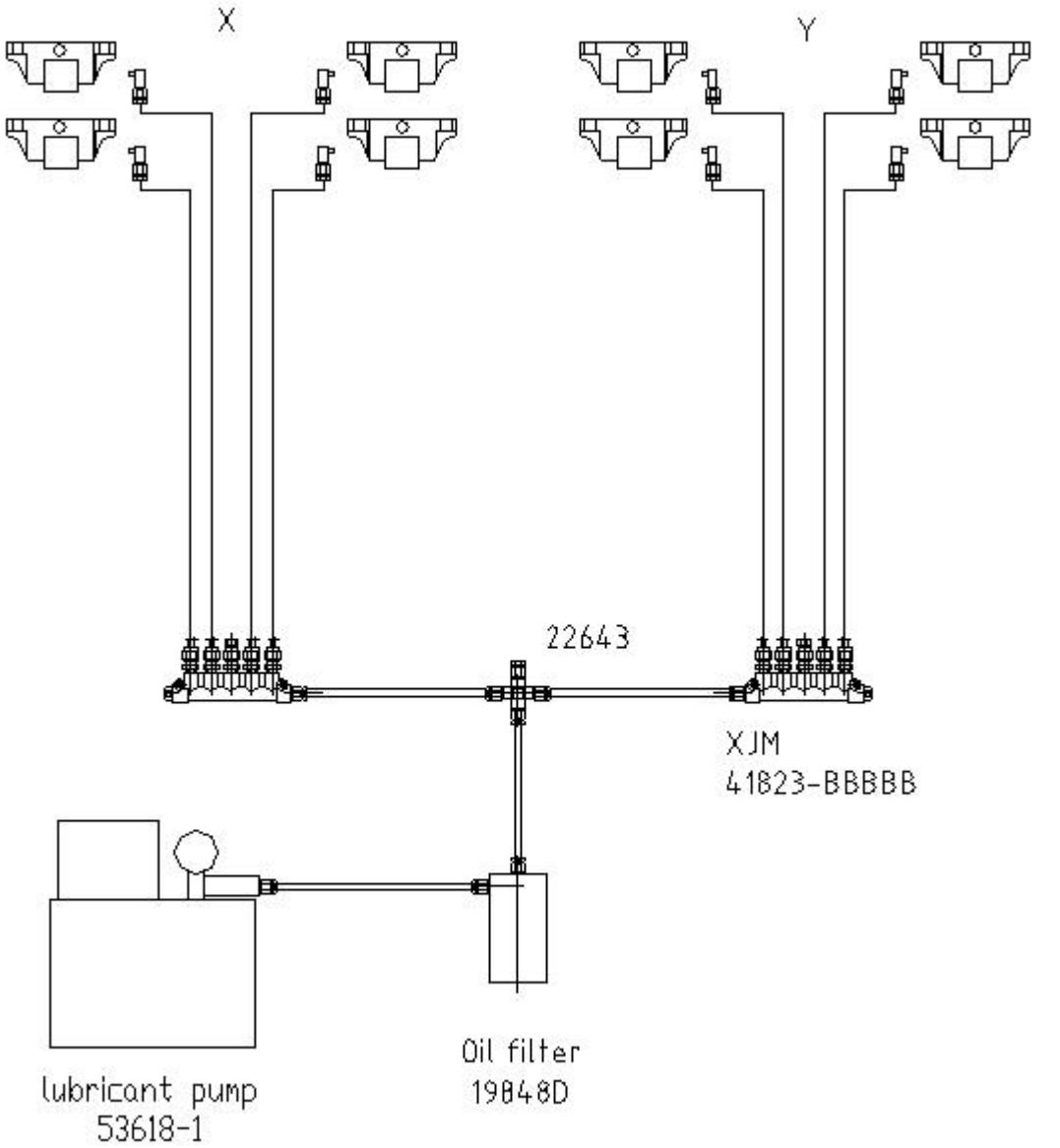
The water circuit of the laser cutting machine has two water circuits with different temperature, one for cooling the laser and the other for cooling the cutting head.

Remark: Auxiliary equipment and means above are significant for the purpose of normal operation of the whole machine tool and laser device, as well as guaranteeing steady power of laser device and good mode of laser. It is beyond the warranty coverage including low laser power, poor laser mode and other parts injured due to a user's using undesirable water, electricity and gas without permission.

2.4.10 Lubricating system

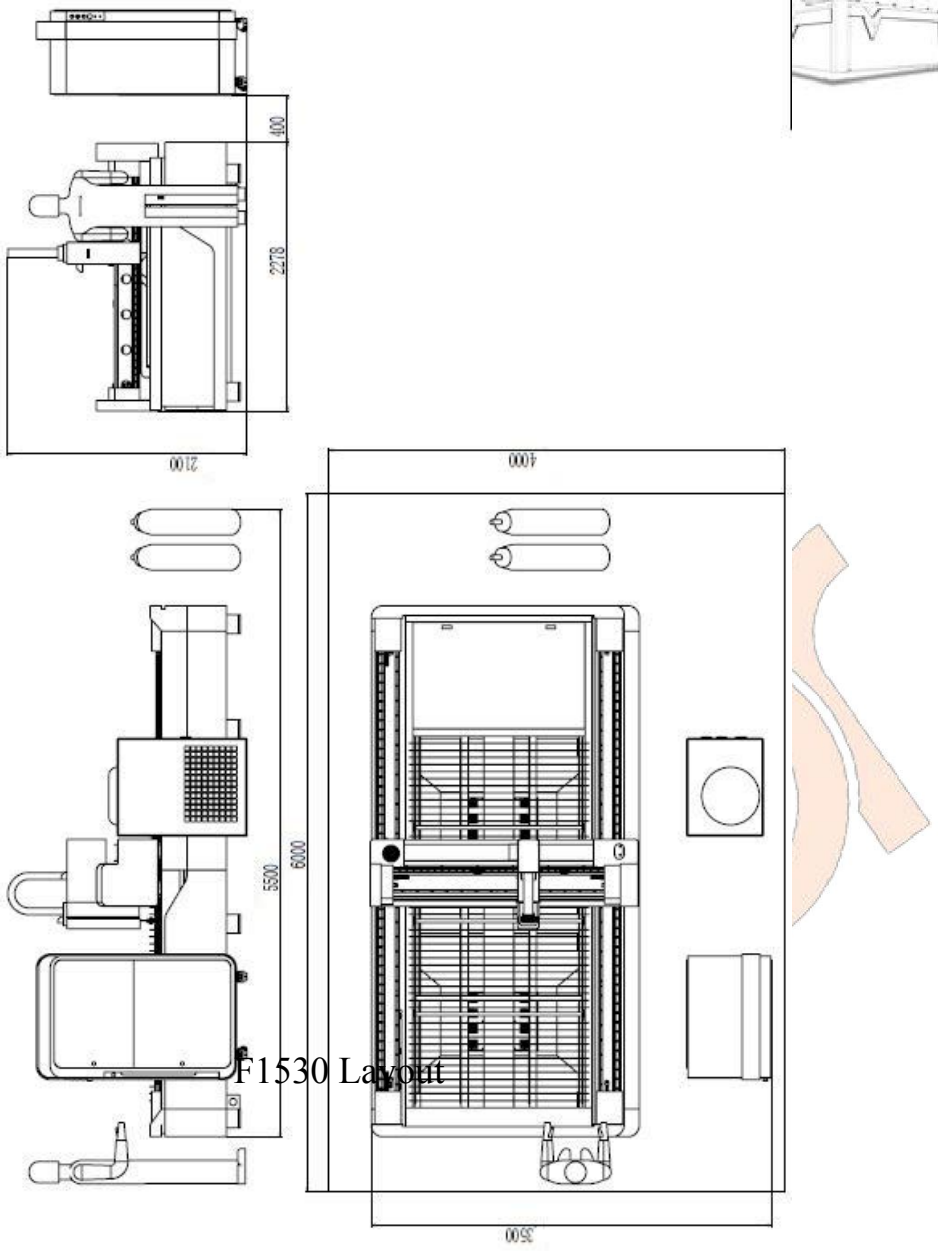
The centralized lubricating system automatically supplies lubricating oil for the sliding block,

ensuring the precision of drive system and improving the service life of linear guideway.



Schematic Diagram of Lubrication

2.4.11 Layout



F1530 Layout

2.5 Introduction to structure of E series laser cutting machine

2.5.1 External view

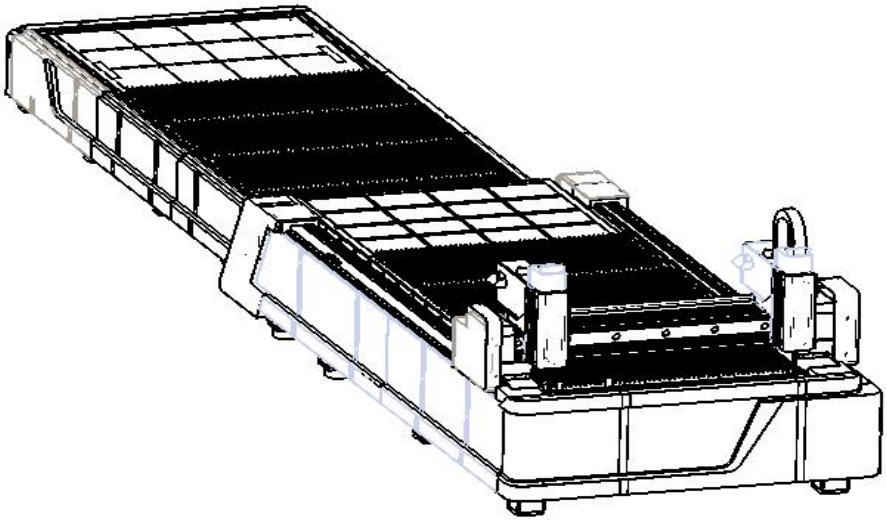


Figure 2.5.1: External view of E series cutting machine (with exchange platform)

(subject to material object)

2.5.2 Main features

1. High-performance laser device associated with stable operation system enables optimal cutting effects.
2. Perfect cooling, lubrication and dedusting systems ensure stable, efficient and durable performance of the whole machine.
3. Double countertops make plates loading and unloading available during cutting, which improves the processing efficiency.
4. Automatic height-adjustment performance keeps constant focal length and stable cutting quality.
5. It could cut mental in various materials and realize excellent and stable cutting effects.
6. Gantry structure and inblock cast cross beam make the device highly rigid, stable and antiknock.
7. It takes precise linear guideway and gear rack as driving elements which could realize high precision and rapid speed.
8. It is equipped with special CAD/CAM automatic programming and jacking software to save raw materials to the maximum extent.
9. Remote communication and monitoring in laser cutting process could be realized through Internet communication.

2.5.3 Environmental condition

o) Quality of power supply: Tri-phase unbalance factor <2.5%, line voltage fluctuation <5%.

p) Grounding protection: independent grounding of machine tool; independent grounding of tube cutting section; independent grounding of power distribution cabinet; independent grounding of laser device; ground resistance required ＜4Ω. Ground pile: shall be smashed into the ground through an angle iron or wide-diameter rebar no less than 2-3m long; simultaneously proper salt water shall be poured for better grounding effect.

q) Draughty, dust-free, non-corrosive and pollution-free site environment is required.

r) No large vibration is permitted around the installation foundation.

s) The water chilling unit is applied in dedicated devices such as cooling laser device and cutting head; for circulating cooling water, high-quality and mineral-free purified water, distilled water or deionized water is required;

t) For fear of fire hazard, appropriate fire extinguishers and reserved fire fighting access shall be provided in the processing site.

u) Over 1.2M shall be kept between workshop wall and left and rear sides of machine tool; Over 1.0M shall be reserved around the laser device.

The control unit, servo unit, displayer and control panel are core components of machine tool, which are demanding on the environment to some extent, and shall be kept away from electromagnetic wave interference, such as arc welding and electric discharge machine, for fear that the normal operation of machine tool is affected.

2.5.4 Impact on environment and energy

Since the laser device of laser cutting machine is a fiber generator, harmful flue gas and dust will be generated in the process of cutting; therefore, it is necessary to purify the flue gas exhausted from the dust exhaust apparatus before emission; simultaneously, it shall avoid fire hazard.

The laser device of laser cutting machine is a Class 4 laser product, whose beam ejected, whichever reflected through a lens or reflected diffusely, will impair human body (especially eyes); therefore, it is worth noting that operating personnel and on-site personnel shall wear protective eyeglasses, which the optional SD-4, 1064nm ones are a choice.

Remark: No system and component above shall be changed without permission for the purpose of normal operation of laser head and laser device, as well as guaranteeing steady power of laser device and good mode of laser. It is beyond the warranty coverage including low laser power, poor laser mode and other parts injured due to a user's using undesirable water, electricity and gas without permission.

2.5.5 Technical parameters

Parameters of E Series Cutting Machine

Model		E1530	E2040	E2060
Maximum processing range		1500×3000mm	2000×4000mm	2000×6000mm
Stroke of X axis		1500mm	2000mm	2000mm
Stroke of Y axis		3000mm	4000mm	6000mm
Stroke of Z axis		315mm		
Positioning precision of X/Y axis		±0.03mm		
Repeated positioning precision of X/Y axis		±0.02mm		
X/Y axis maximum moving speed		100m/min		
X/Y axis maximum cutting speed		35m/min		
Maximum acceleration		1.2G		
Exchange time of working platform		17s		
Maximum load of working platform		600kg	1000kg	1400kg
Gross power	500W laser device	11.1KW		
	800W laser device	11.6KW		
	1000W laser device	12.6KW		
	1500W laser device	14.3KW		
	2000W laser device	16.2KW		
Overall size (L * W * H)		9350*2300*2000	10400*2900*2000	13000*2900*2000
Weight of whole machine		5000kg	6500kg	8000kg

2.5.6 Introduction to main mechanical structure

2.5.6.1 Lathe bed part

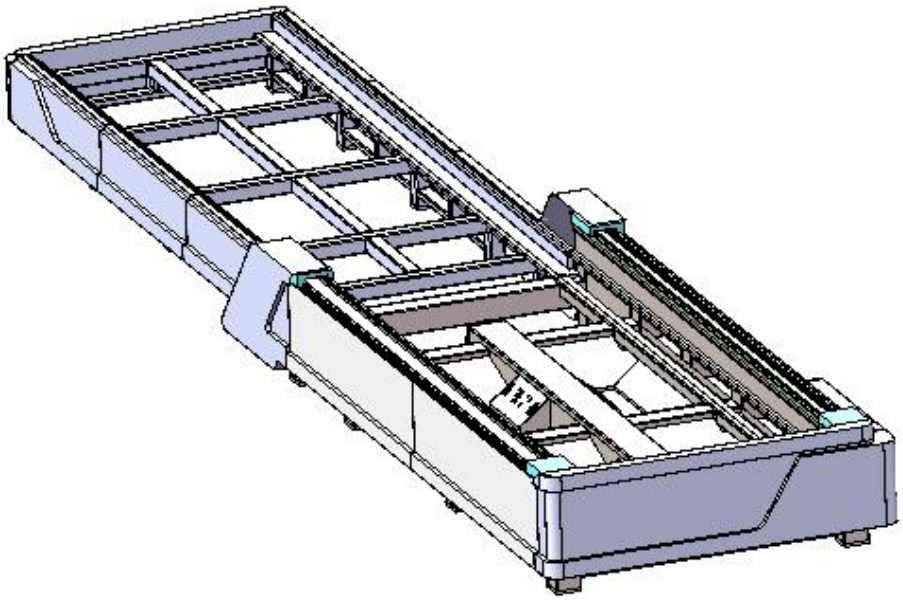


Figure 2.6.1: Lathe bed

The lathe bed consisting two sections of front and rear, is welded and made of high-quality carbon structural steel and formed through aging heat treatment, eliminating the residual stress of welding, steadying the size and guaranteeing the long-term precision.

The front and rear lathe beds are equipped with workbenches, the workbench of the former for cutting and baiting of sheet metal, that of the latter for loading and unloading of sheet metal. The front lathe bed is provided with high-precision linear guideway and gear rack drive mechanism on its two sides that drive cross beam for dolly moves; both two ends of stroke are equipped with switches and buffer stopper, endowing the motion with double safety protection.

2.5.6.2 Cross beam part

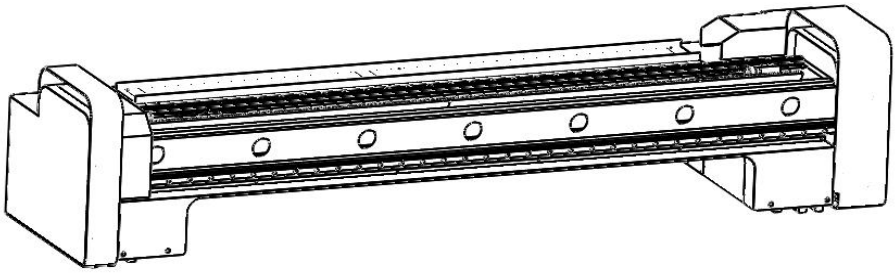


Figure 2.5.6.2: Cross Beam

The cross beam is integrally casted and made of heat-treatable hardening aluminium alloy. Since the laser cutting is non-contact, the cross beam is designed in a lightweight manner; moreover, the low-density and high-strength aluminium alloy could meet the needs of high-speed and high-precision laser cutting.

The cross beam is provided with high-precision linear guideway and gear rack drive

mechanism, allowing the Z axis device to reciprocate along the direction of X axis; both two ends of stroke are equipped with switches and buffer stopper, endowing the motion with double safety protection.

2.5.6.3 Exchanging workbench

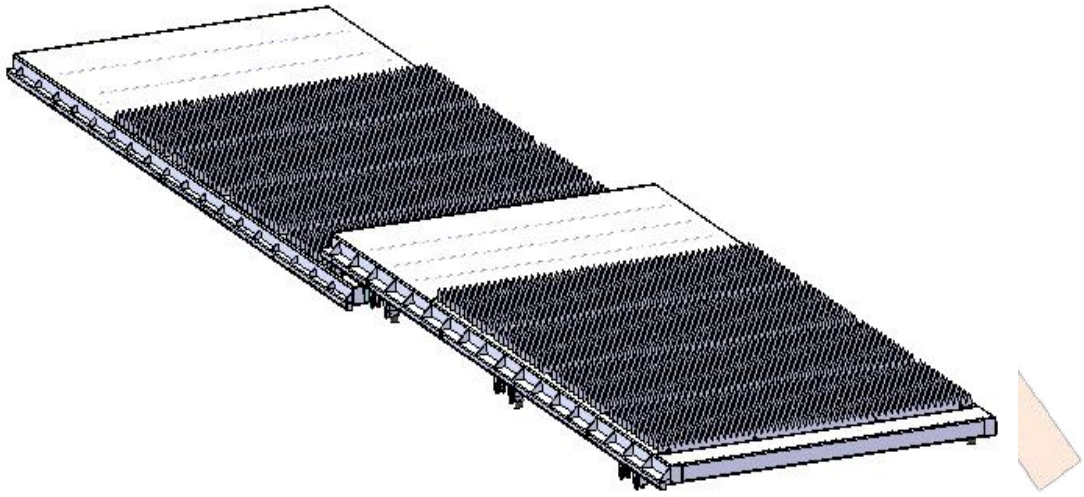


Figure 2.5.6.3: Exchanging workbench

E series fiber cutting machine is equipped with double-deck exchangeable workbench to cut and handle sheet metals respectively at the same time, thus shortening the preparation time of processing and improving the production efficiency.

The workbench is integrally welded structure with high strength and stability. It is arranged up and down. The exchange motion of workbench could be simply realized at high speed by the following steps that gear motor is driven to the gearbox via synchronous belt, two output gears in the gear box are respectively meshed with the racks of up and down workbenches, and then the gearbox will output two reversed but synchronous rotary gears.

2.5.6.4 Z axis device

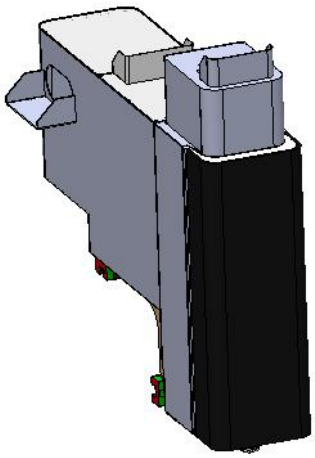


Figure 2.5.6.4: Exchanging workbench

The Z axis device is applied in the lifting motion of cutting head. The lifting motion of cutting head is achieved by up-down reciprocating motion of Z axis slider driven by the numerical control system controlling servo motor and the motor driving ball screw. The stroke of both up and down ends is controlled by proximity switch. Both ball screw and linear guideway are high quality products, ensuring the driving precision.

The Z axis can interpolate independently as a numerical control axis, move together with the X and Y axes and switch to follow-up motion mode through the electrically-controlled part of the cutting head to meet the requirements of different situations. The follow-up motion of Z axis is controlled by the numerical control system, which is relatively high-precision and stable, thus ensuring the quality of cutting.

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Z axis is equipped with linear guideway seat nozzle and lead screw seat nozzle respectively for filling lubricating grease on a regular basis.

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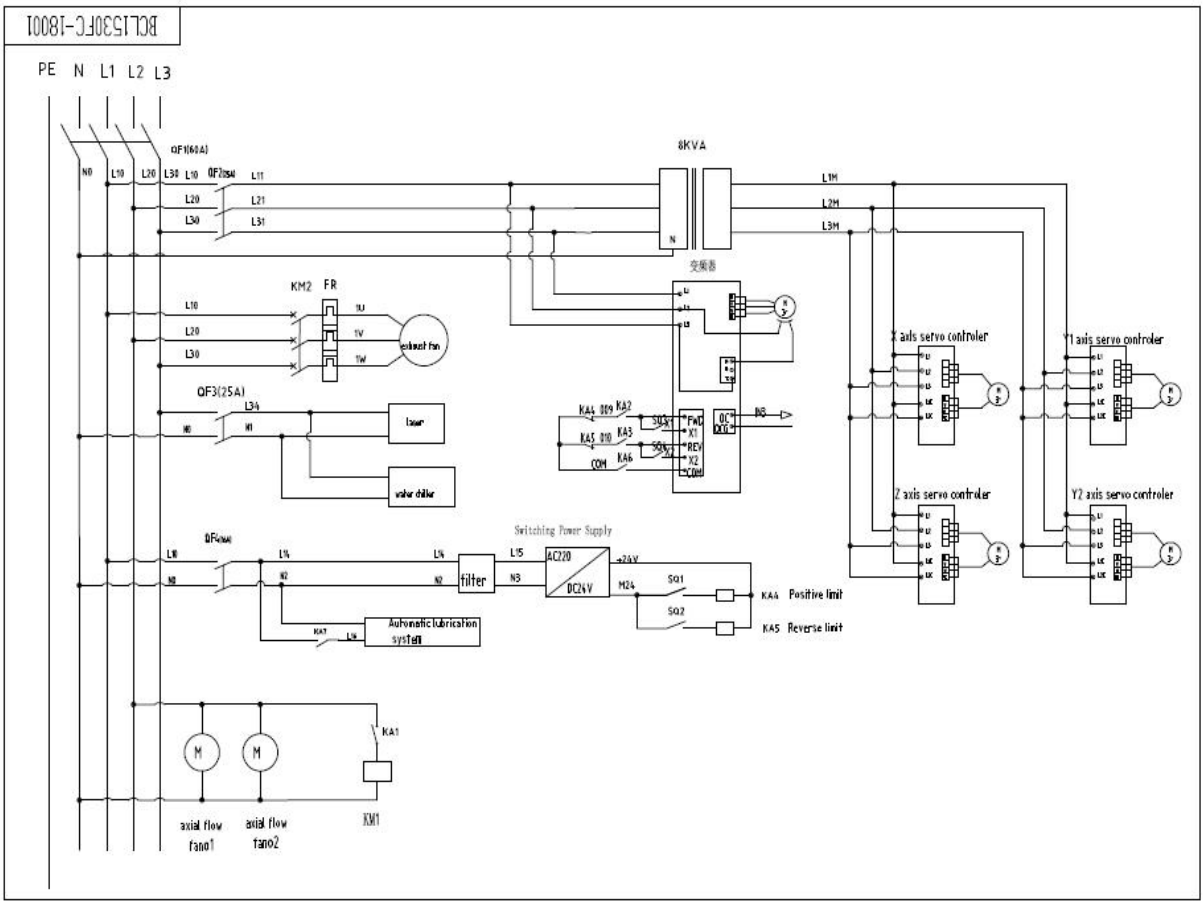
The laser cutting machine is equipped with a dust extraction system consisting of built-in dedusting duct in lathe bed body, large-diameter pipe and high-power fan, which is able to obviously inhale, gather and discharge dust generated during laser cutting, thus guaranteeing the health of operating personnel.

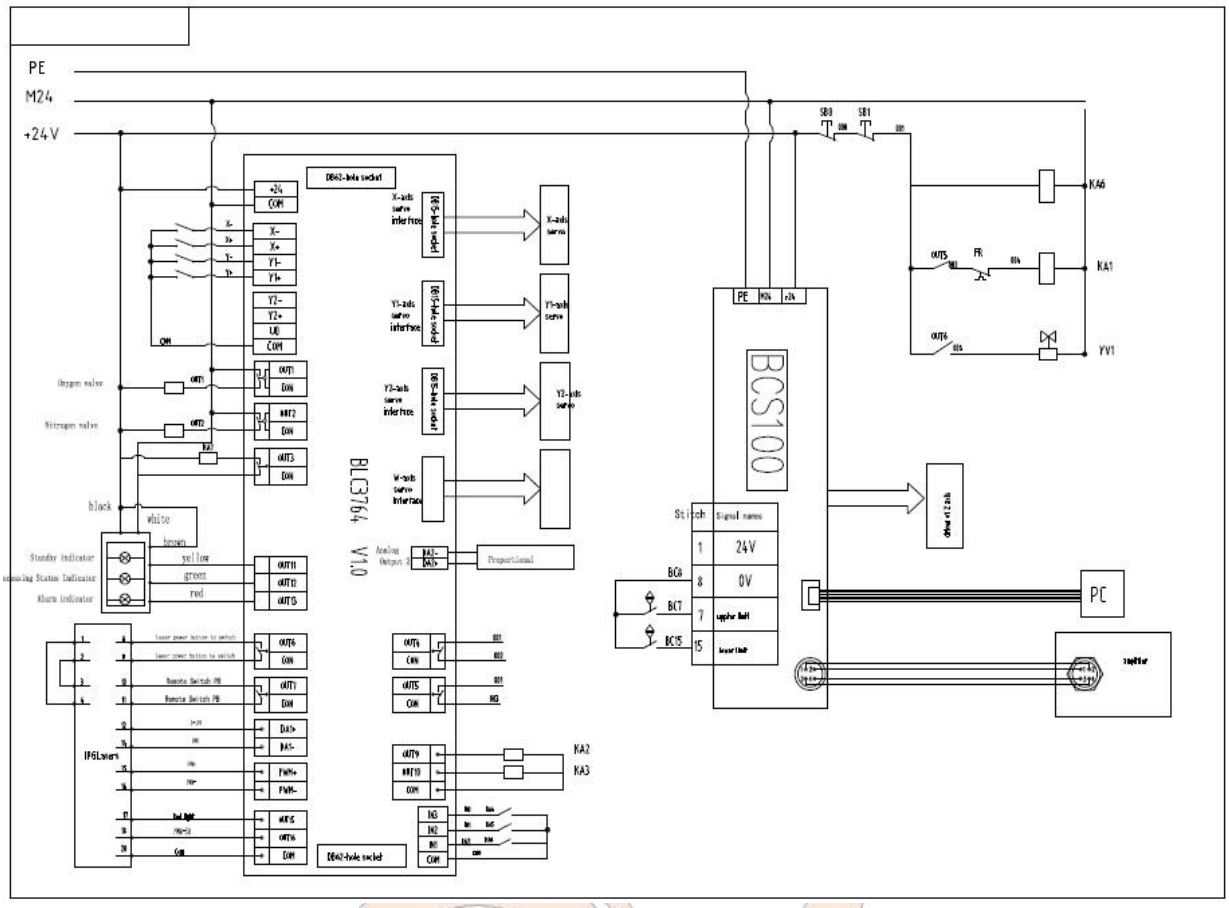
2.5.7 Electrical part

I. Schematic diagram

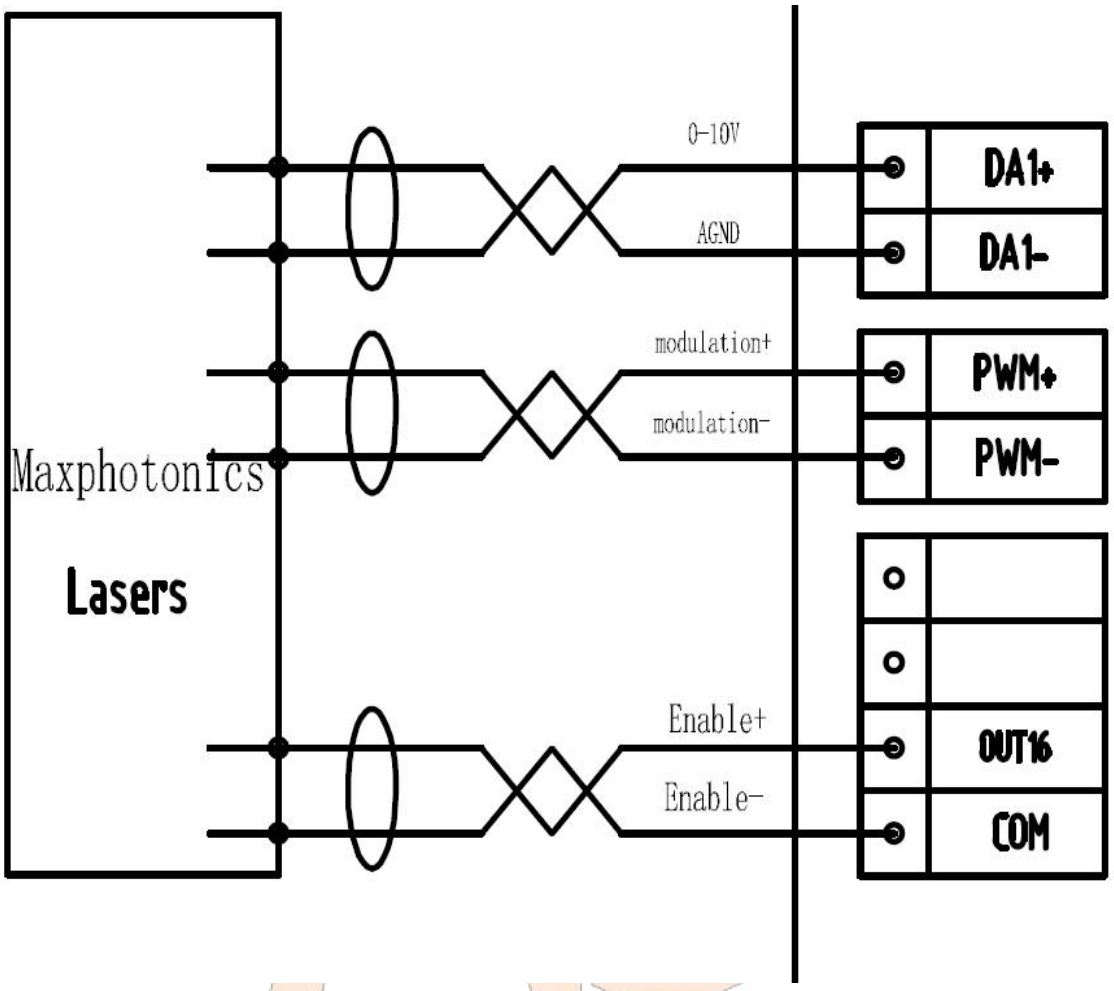
1) Major Loop



2) Control Loop



3) Connection Diagram of Laser Device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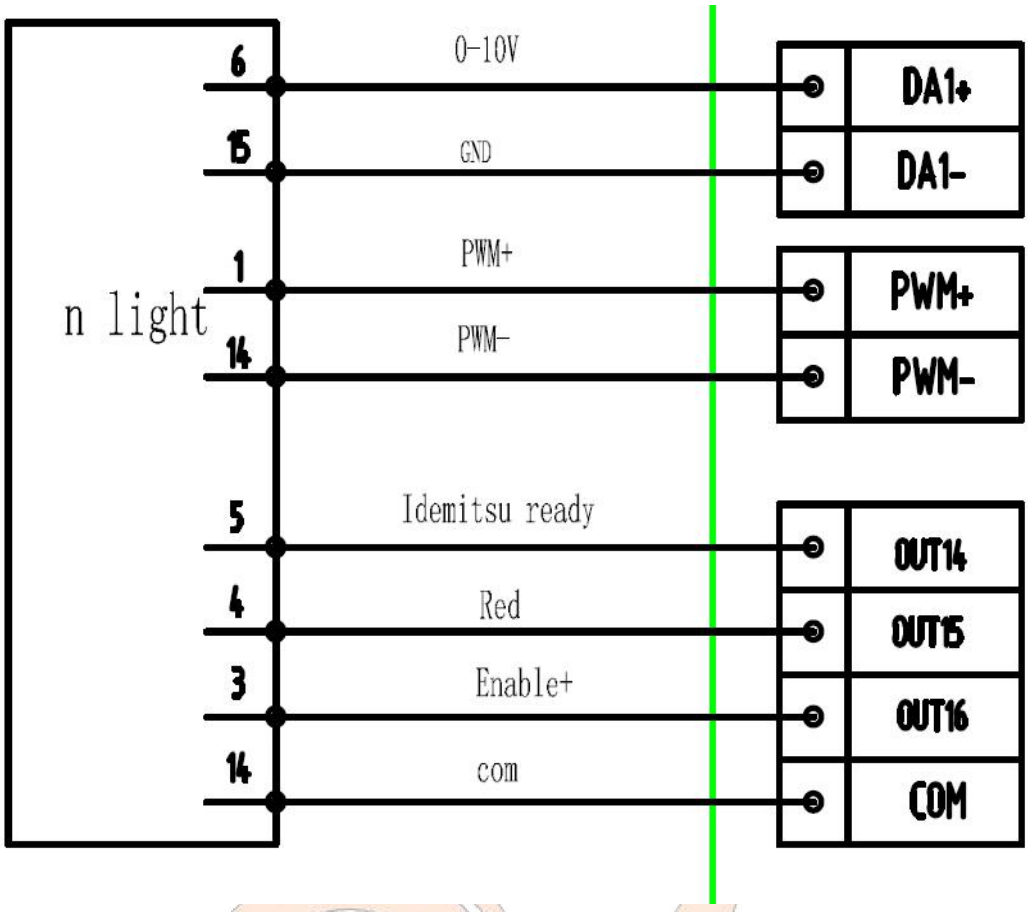
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PWM-
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PWM-
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OUT15
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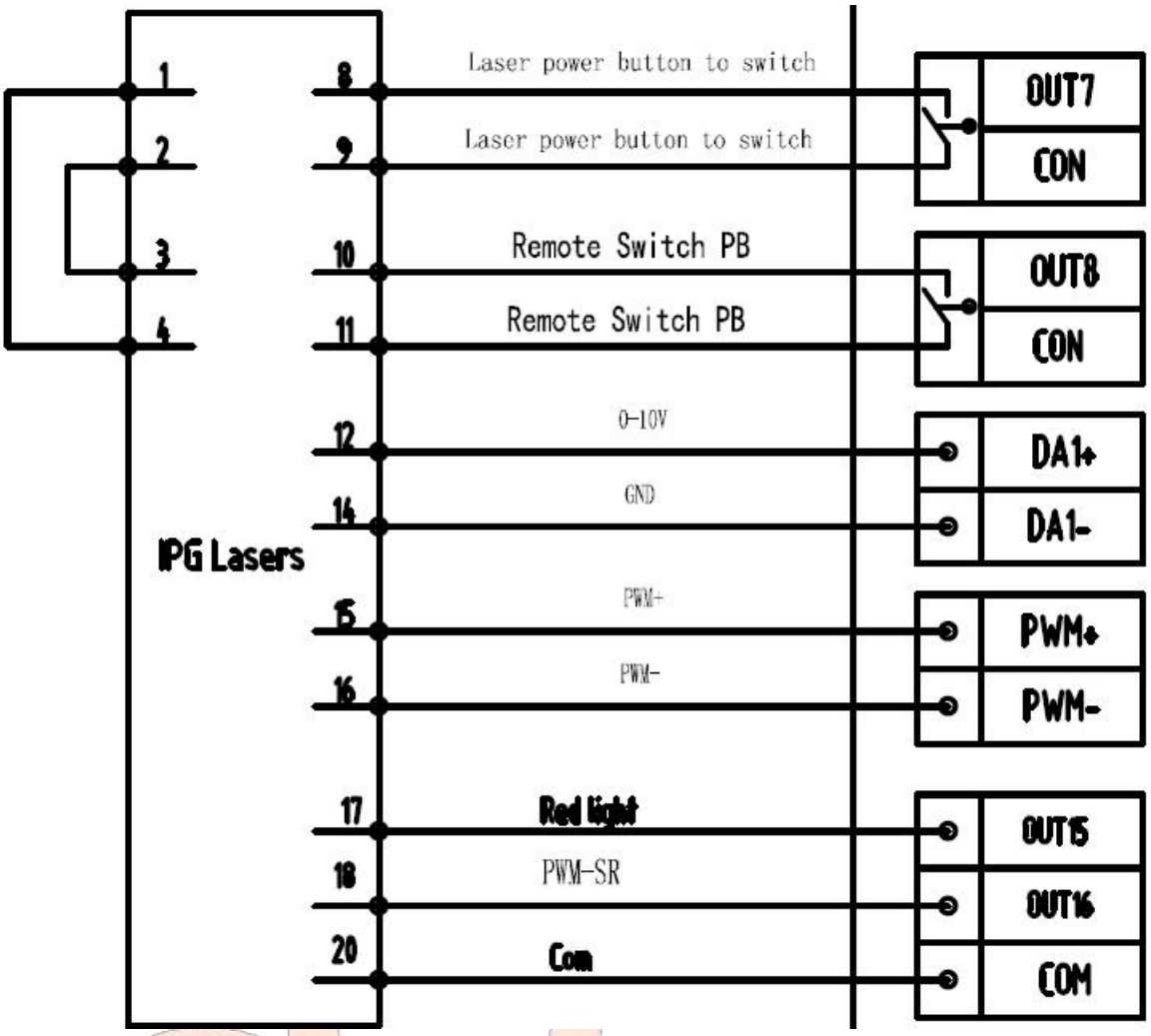

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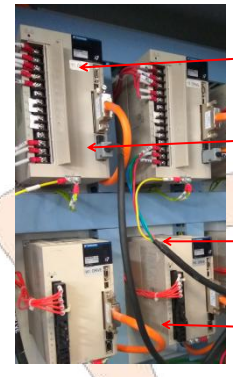


Power line, used to supply electricity for drives

Supply electricity for servo motor

A line of encoder that provides a feedback signal for servo device

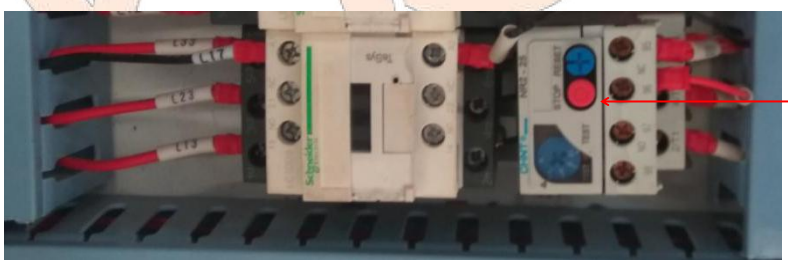
Signal line, employed to control the signal of drives

Servo drives, also called "servo controller" or "servo amplifier", just like a variable-frequency drive acting on general AC motor, is a controller to control a servo motor; as a part of the servo system, it is mainly applied in a high-precision positioning system. It currently is a cutting-edge product of drive technology, which is generally used to control a servo motor through three modes of location, speed and moment of force to achieve high-precision positioning of drive system.

3) Servo transformer

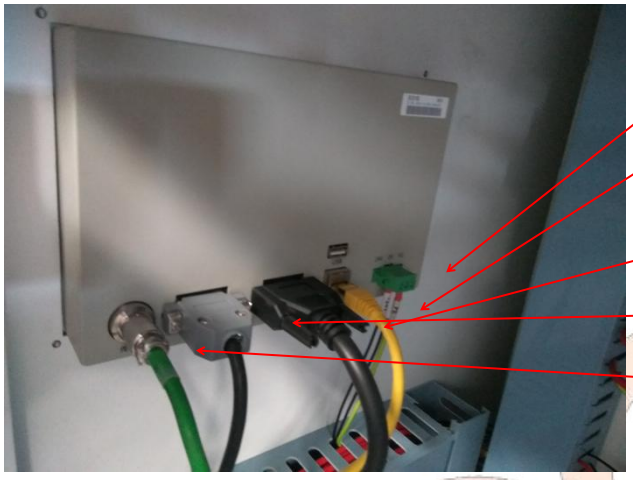
Such type of servo transformer is specifically designed for servo drive system, which could provide necessary electric energy for servo drive.

4) Contactor



Load appliances could be controlled by switching on the contacts under the action of magnetic field generated when current passes through the coil.

5) Height-adjustment device



Supply 24V electricity for height-adjustment device

Network cable, communicated with the upper computer

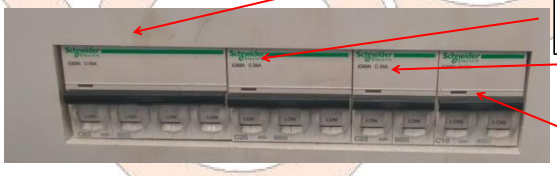
Connect drives

Limit signal

Signal line of sensor

During cutting, it is the laser head to maintain a constant distance between laser head and sheet metal, not only getting laser head protected effectively, but also achieving sophisticated techniques, including multi-stage perforation.

6) Circuit breaker



Main power switch

Main power switch of drives

Power switch of laser water chiller

System power switch

The circuit breaker could be used to distribute electric energy, start occasionally an asynchronous motor and protect power line and motor and so on; in case these devices are in overload, short circuit, undervoltage and other trouble states, it could shut down the circuit automatically, which functions as the combination of fuse-switch and

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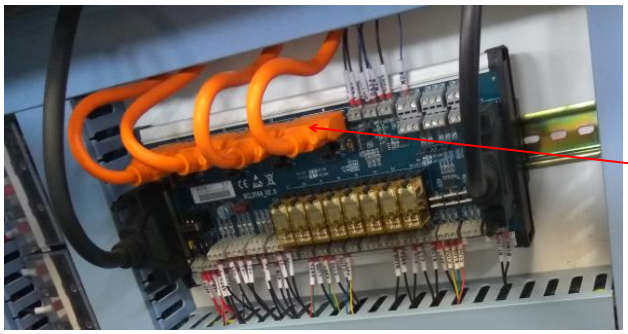
7) Pinboard



Connect drives, control signals

The motion control card is an upper control unit based on PC and industrial PC, and applied in various motion control occasions (including displacement, speed, acceleration, etc).

The motion control card is a PC bus-based, high-performance stepping/ servo motor, being capable of achieving multi-axis coordinative control of several servo motors by taking advantage of high-performance microprocessor (for instance DSP) and large scale programmable devices. With the functions of pulse output, pulse counting, digital input, digital output, D/A output, etc., it is able to send continuous, high-frequency pulse train, and control the motor speed by changing the frequency of pulse sent and control the location of motor by changing the quantity of pulse sent. Its mode of pulse input includes pulse/direction and pulse/pulse. The pulse counting could be used to feed back the location of encoder, provide accurate location of machine and correct the error in the process of drive. Digital input/output point could be applied in limit switch, origin switch, etc. Library functions include S-type/T-type acceleration, line interpolation, circular interpolation, multi-axis linkage function, etc. The product is widely applied in location control system that location and length are required to be confirmed precisely, and PC-based NC control system in the field of industrial automatic control. Specifically, integrating bottom software that achieves motion control with hardware endows them with various control functions of speed and location required for controlling servo motor; these functions could be easily called via a computer.

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9) Switching power supply

24V power supply

11) Filter

The power filter is a filter circuit consisting of capacitance, inductance and resistance. The filter could effectively filter out a frequency point of specific frequency in a power line or frequency other than the frequency point to obtain power signals of a specific frequency or power signals after eliminating a specific frequency.

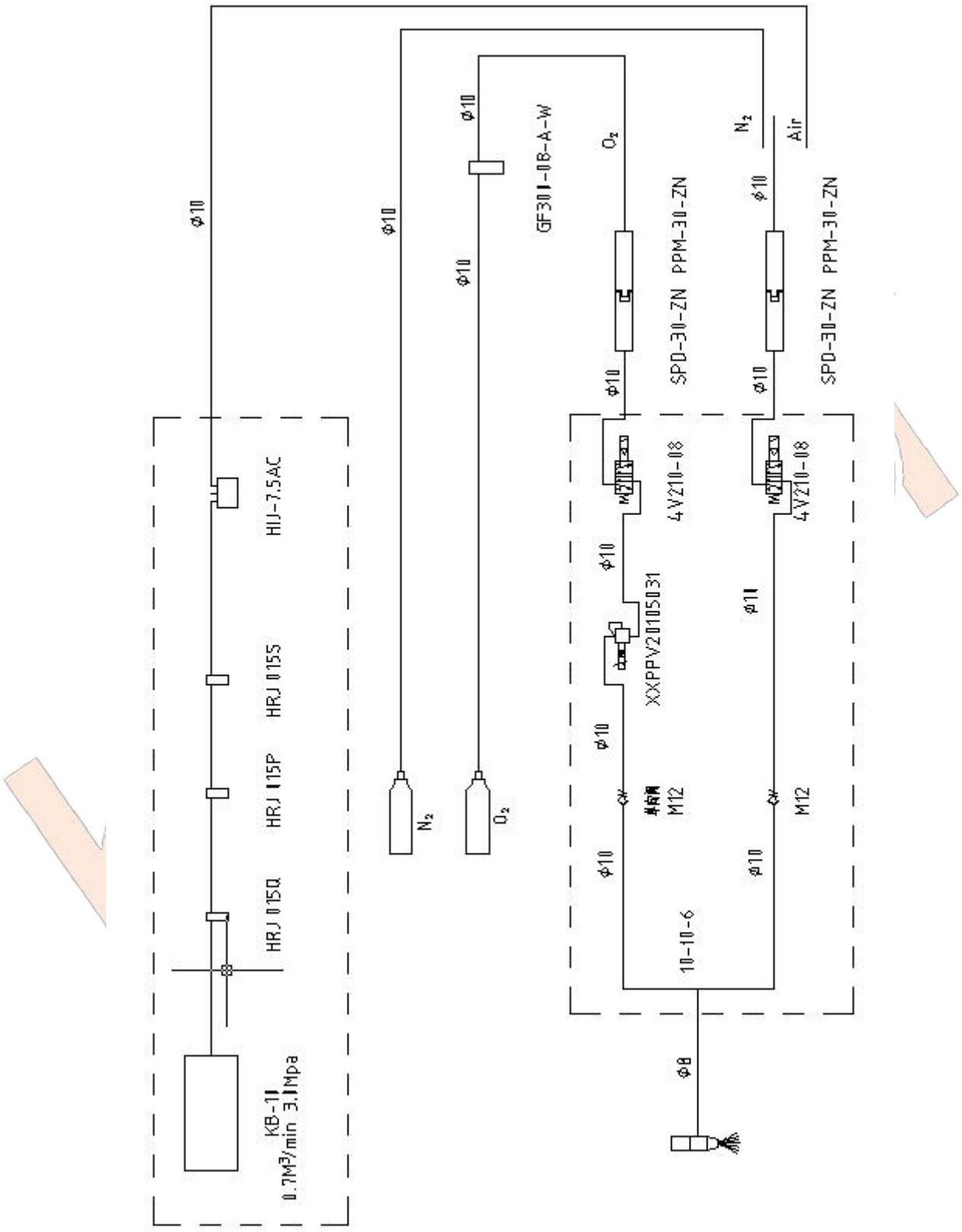
12) Variable-frequency drive

The variable-frequency drive (VFD) is a power control equipment that controls the AC motor by varying the operating power supply frequency of the motor utilizing the variable-frequency and microelectronic technologies. The VFD mainly consists of rectifier (converting AC to DC), filter, inverter (converting DC to AC), brake unit, driver unit, detection unit, micro-processing unit, etc. The VFD adjusts the voltage and frequency of output power supply by breaking the internal IGBT and outputs the required power supply voltage according to the actual demand of the motor to achieve energy-saving and speed-adjusting.

2.5.8 Gas circuit system

The gas circuit of laser cutting machine is used to provide cutting gas for cutting head and cooling gas for ceramic body, which should be selected reasonably based on different cutting materials, as follows:

1) Oxygen is mainly applied in cutting of general carbon steel;
2) Nitrogen is chiefly adopted to cut stainless steel;
3) Air is mainly used for cutting of sheet that conditions allowed.



Gas Circuit Schematic Diagram of Cutting Gas

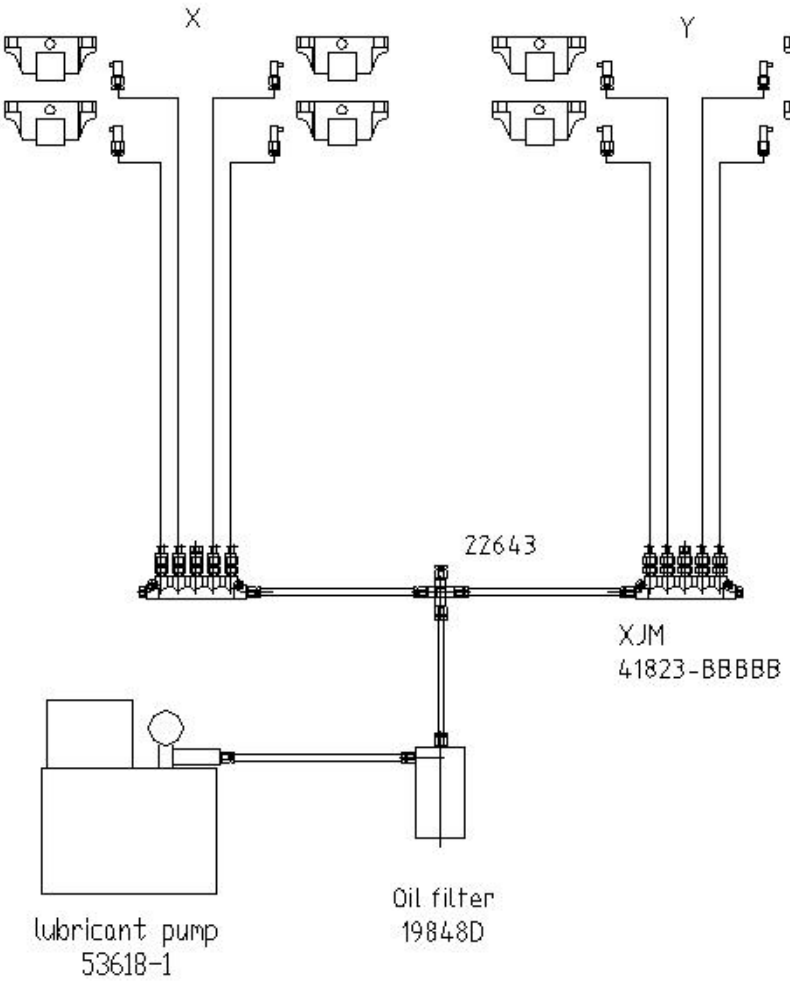
2.5.9 Cooling system

The water circuit of the laser cutting machine has two water circuits with different temperature, one for cooling the laser and the other for cooling the cutting head.

Remark: Auxiliary equipment and means above are significant for the purpose of normal operation of the whole machine tool and laser device, as well as guaranteeing steady power of laser device and good mode of laser. It is beyond the warranty coverage including low laser power, poor laser mode and other parts injured due to a user's using undesirable water, electricity and gas without permission.

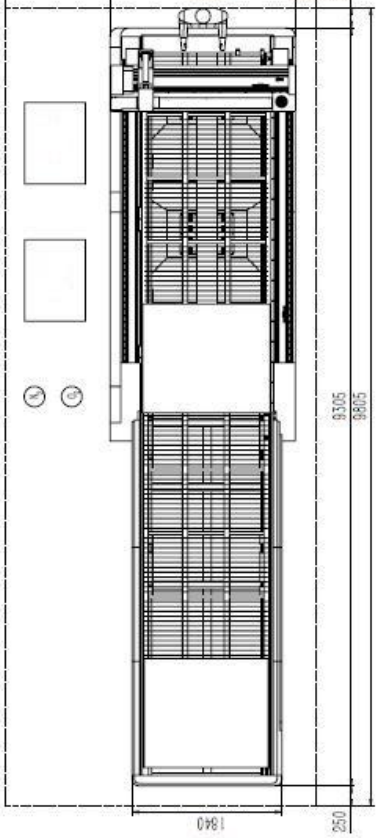
2.5.10 Lubricating system

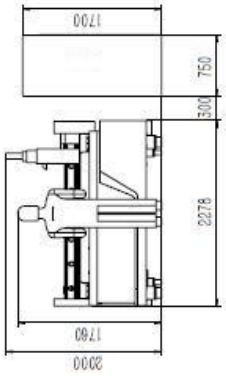
The centralized lubricating system automatically supplies lubricating oil for the sliding block, ensuring the precision of drive system and improving the service life of linear guideway.



Schematic Diagram of Lubrication

2.5.11 Layout





2.6 Introduction to structure of P series laser cutting machine

2.6.1 External view

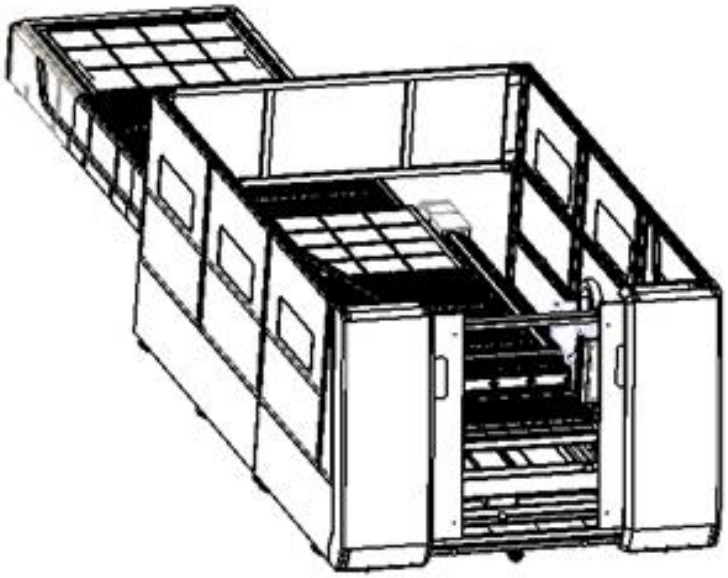


Figure 2.6.1: External view of P series cutting machine (with exchange platform and large-size enclosure protection)
(subject to material object)

2.6.2 Main features

1. High-performance laser device associated with stable operation system enables optimal cutting effects.
2. Perfect cooling, lubrication and dedusting systems ensure stable, efficient and durable performance of the whole machine.
3. Double countertops make plates loading and unloading available during cutting, which improves the processing efficiency.
4. Large-size closed enclosure improves dedusting effects and avoids optical pollution.
5. Automatic height-adjustment performance keeps constant focal length and stable cutting quality.
6. Gantry structure and inblock cast cross beam make the device highly rigid, stable and antiknock.
7. It could cut mental in various materials and realize excellent and stable cutting effects.
8. It takes precise linear guideway and gear rack as driving elements which could realize high precision and rapid speed.
9. It is equipped with special CAD/CAM automatic programming and jacking software to save raw materials to the maximum extent.
10. Remote communication and monitoring in laser cutting process could be realized through Internet communication.

2.6.3 Environmental condition

v) Quality of power supply: Tri-phase unbalance factor <2.5%, line voltage fluctuation <5%.

w) Grounding protection: independent grounding of machine tool; independent grounding of tube cutting section; independent grounding of power distribution cabinet; independent grounding of laser device; ground resistance required ＜4Ω. Ground pile: shall be smashed into the ground through an angle iron or wide-diameter rebar no less than 2-3m long; simultaneously proper salt water shall be poured for better grounding effect.

x) Draughty, dust-free, non-corrosive and pollution-free site environment is required.

y) No large vibration is permitted around the installation foundation.

z) The water chilling unit is applied in dedicated devices such as cooling laser device and cutting head; for circulating cooling water, high-quality and mineral-free purified water, distilled water or deionized water is required;

aa) For fear of fire hazard, appropriate fire extinguishers and reserved fire fighting access shall be provided in the processing site.

bb) Over 1.2M shall be kept between workshop wall and left and rear sides of machine tool; Over 1.0M shall be reserved around the laser device.

The control unit, servo unit, displayer and control panel are core components of machine tool, which are demanding on the environment to some extent, and shall be kept away from electromagnetic wave interference, such as arc welding and electric discharge machine, for fear that the normal operation of machine tool is affected.

2.6.4 Impact on environment and energy

Since the laser device of laser cutting machine is a fiber generator, harmful flue gas and dust will be generated in the process of cutting; therefore, it is necessary to purify the flue gas exhausted from the dust exhaust apparatus before emission; simultaneously, it shall avoid fire hazard.

The laser device of laser cutting machine is a Class 4 laser product, whose beam ejected, whichever reflected through a lens or reflected diffusely, will impair human body (especially eyes); therefore, it is worth noting that operating personnel and on-site personnel shall wear protective eyeglasses, which the optional SD-4, 1064nm ones are a choice.

Remark: No system and component above shall be changed without permission for the purpose of normal operation of laser head and laser device, as well as guaranteeing steady power of laser device and good mode of laser. It is beyond the warranty coverage including low laser power, poor laser mode and other parts injured due to a user's using undesirable water, electricity and gas without permission.

2.6.5 Technical parameters

Table 2.6.5 Parameters of P series Cutting Machine

Model		P1530	P2040	P2060
Maximum processing range		1500×3000mm	2000×4000mm	2000×6000mm
Stroke of X axis		1500mm	2000mm	2000mm
Stroke of Y axis		3000mm	4000mm	6000mm
Stroke of Z axis		315mm		
Positioning precision of X/Y axis		±0.03mm		
Repeated positioning precision of X/Y axis		±0.02mm		
X/Y axis maximum moving speed		100m/min		
X/Y axis maximum cutting speed		35m/min		
Maximum acceleration		1.2G		
Exchange time of working platform		17s		
Power of optional laser device		500W,800W,1000W,1500W,2000W		
Maximum load of working platform		600kg	1000kg	1400kg
All cover		Closed laser protection		
Gross power	500W laser device	11.1KW		
	800W laser device	11.6KW		
	1000W laser device	12.6KW		
	1500W laser device	14.3KW		
	2000W laser device	16.2KW		
Overall size (L * W * H)		9950*3050*2100	11000*3600*2100	13600*3600*2100
Weight of whole machine		6000kg	8000kg	9500kg

2.6.6 Introduction to main mechanical structure

2.6.6.1 Lathe bed part

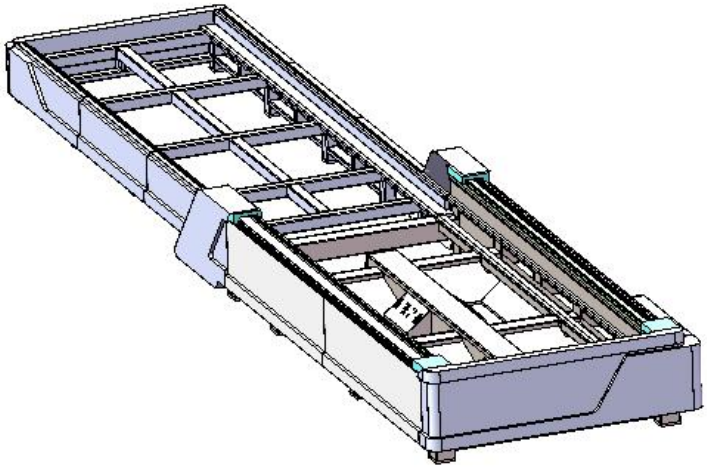


Figure 2.6.6.1: Lathe bed

The lathe bed consisting two sections of front and rear, is welded and made of high-quality carbon structural steel and formed through aging heat treatment, eliminating the residual stress of welding, steadying the size and guaranteeing the long-term precision.

The front and rear lathe beds are equipped with workbenches, the workbench of the former for cutting and baiting of sheet metal, that of the latter for loading and unloading of sheet metal. The front lathe bed is provided with high-precision linear guideway and gear rack drive mechanism on its two sides that drive cross beam for dolly moves; both two ends of stroke are equipped with switches and buffer stopper, endowing the motion with double safety protection.

2.6.6.2 Cross beam part

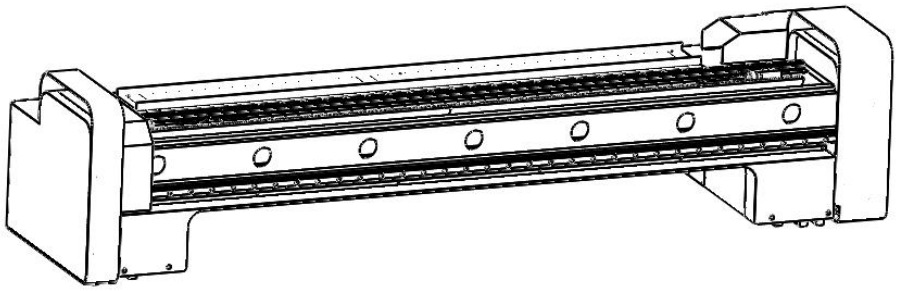


Figure 2.6.6.2: Cross Beam

The cross beam is integrally casted and made of heat-treatable hardening aluminium alloy. Since the laser cutting is non-contact, the cross beam is designed in a lightweight manner; moreover, the low-density and high-strength aluminium alloy could meet the needs of high-speed and high-precision laser cutting.

The cross beam is provided with high-precision linear guideway and gear rack drive mechanism, allowing the Z axis device to reciprocate along the direction of X axis; both two ends of stroke are equipped with switches and buffer stopper, endowing the motion with double safety protection.

2.6.6.3 Exchanging workbench

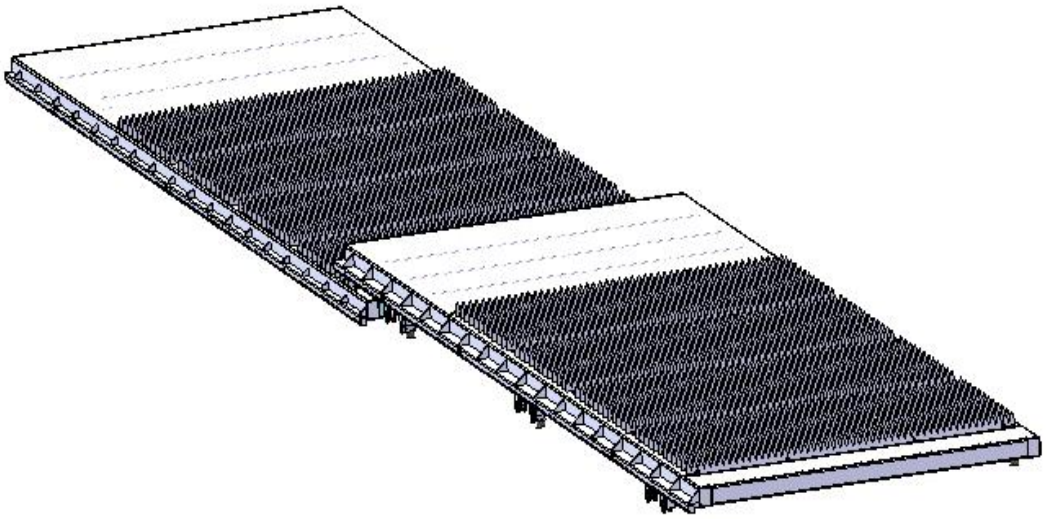
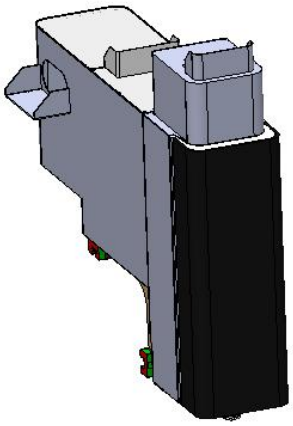


Figure 2.6.6.3: Workbench

P series fiber cutting machine is equipped with double-deck exchangeable workbench to cut and handle sheet metals respectively at the same time, thus shortening the preparation time of processing and improving the production efficiency.

The workbench is integrally welded structure with high strength and stability. It is arranged up and down. The exchange motion of workbench could be simply realized at high speed by the following steps that gear motor is driven to the gearbox via synchronous belt, two output gears in the gear box are respectively meshed with the racks of up and down workbenches, and then the gearbox will output two reversed but synchronous rotary gears.

2.6.6.4 Z axis device



The Z axis device is applied in the lifting motion of cutting head. The lifting motion of cutting head is achieved by up-down reciprocating motion of Z axis slider driven by the numerical control system controlling servo motor and the motor driving ball screw. The stroke of both up and down ends is controlled by proximity switch. Both ball screw and linear guideway are high quality products, ensuring the driving precision.

The Z axis can interpolate independently as a numerical control axis, move together with the X and Y axes and switch to follow-up motion mode through the electrically-controlled part of the cutting head to meet the requirements of different situations. The follow-up motion of Z axis is controlled by the numerical control system, which is relatively high-precision and stable, thus ensuring the quality of cutting.

The capacitance sensor (mounted on the cutting head) in Z axis device will feed the signals that the distance from nozzle to the surface of profile back to the control system which would then control the motor of Z axis to drive the up-down motion of cutting head, therefore keeping a constant distance between the nozzle and profile and effectively ensuring the cutting quality. The cutting head is equipped with nut that adjusts the focal length, and the location of focus could be adjusted based on the texture and thickness of cutting material, thus good cutting section is available. Since the nozzle is one of quick-wear parts during processing, users may reserve some nozzles with different hole diameters for convenient replacement.

Z axis is equipped with linear guideway seat nozzle and lead screw seat nozzle respectively for filling lubricating grease on a regular basis.

2.6.6.5 Dust extraction system

As a mode of thermal cutting process, laser cutting is conducted by taking advantage of high-energy density laser beam gathered on the surface of work piece to instantly fuse and gasify the work piece exposed to ultrafine focus spot, and then automatically cut by moving the exposure location controlled by the numerical control system; dust is unavoidable during the processing, which would impair the operating personnel and working environment.

The laser cutting machine is equipped with a dust extraction system consisting of built-in dedusting duct in lathe bed body, large-diameter pipe and high-power fan, which is able to obviously inhale dust generated during laser cutting, thus guaranteeing the health of operating personnel.

2.6.6.6 All cover

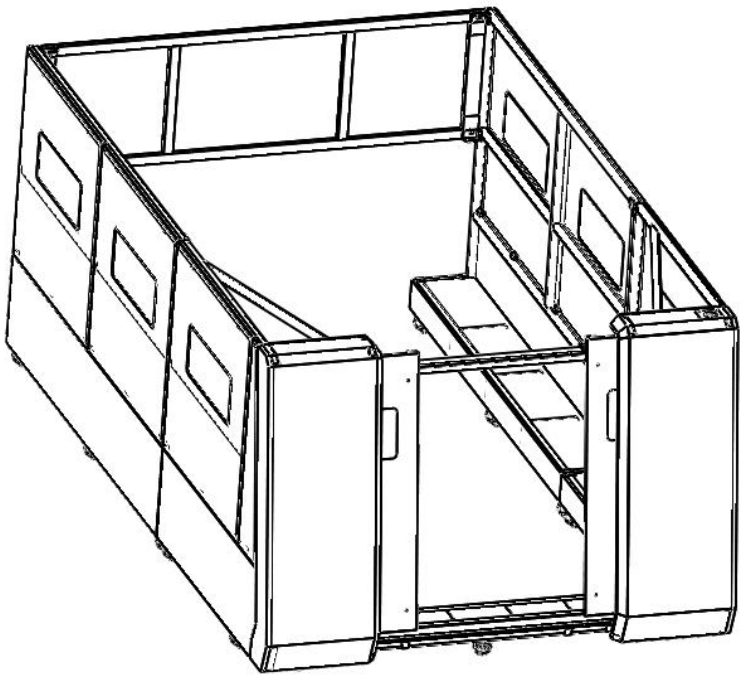


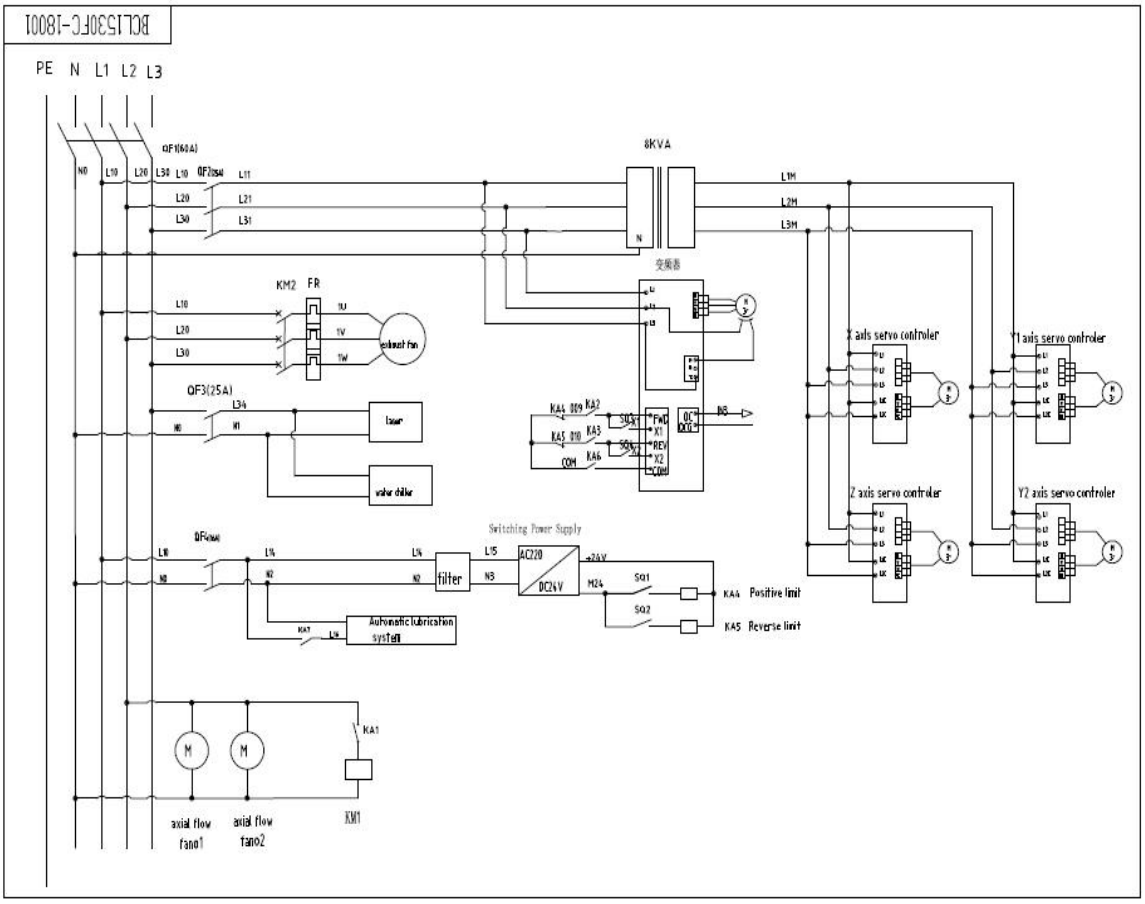
Figure 2.6.6.6: All cover

The light skeleton made of structural steel is used for all cover, achieving closed protection for the laser cutting. A sliding door is arranged on the front surface and protection glass is installed on the front and both left and right surfaces to allow observing the processing work; the all cover is able to effectively avoid laser leakage and protect the operating personnel.

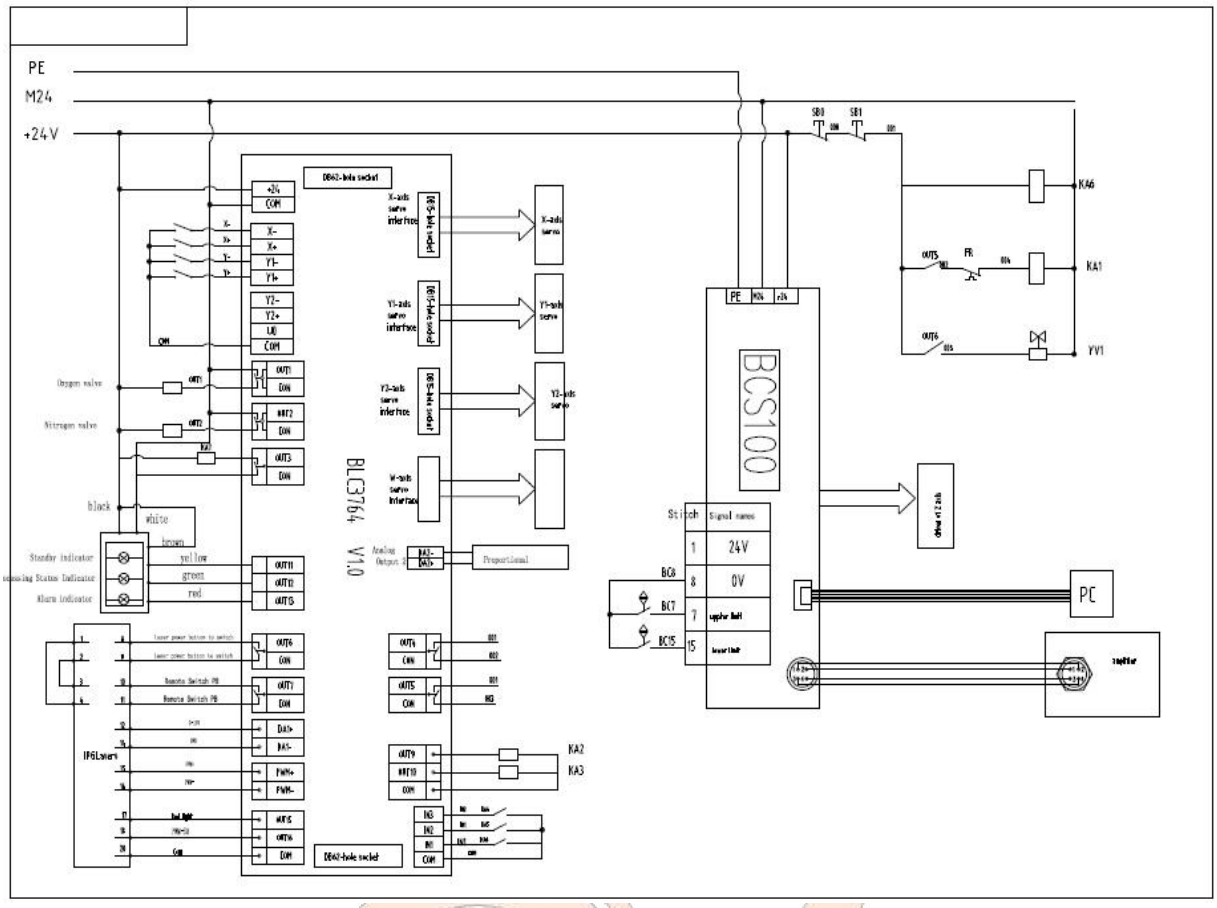
2.6.7 Electrical part

I. Schematic diagram

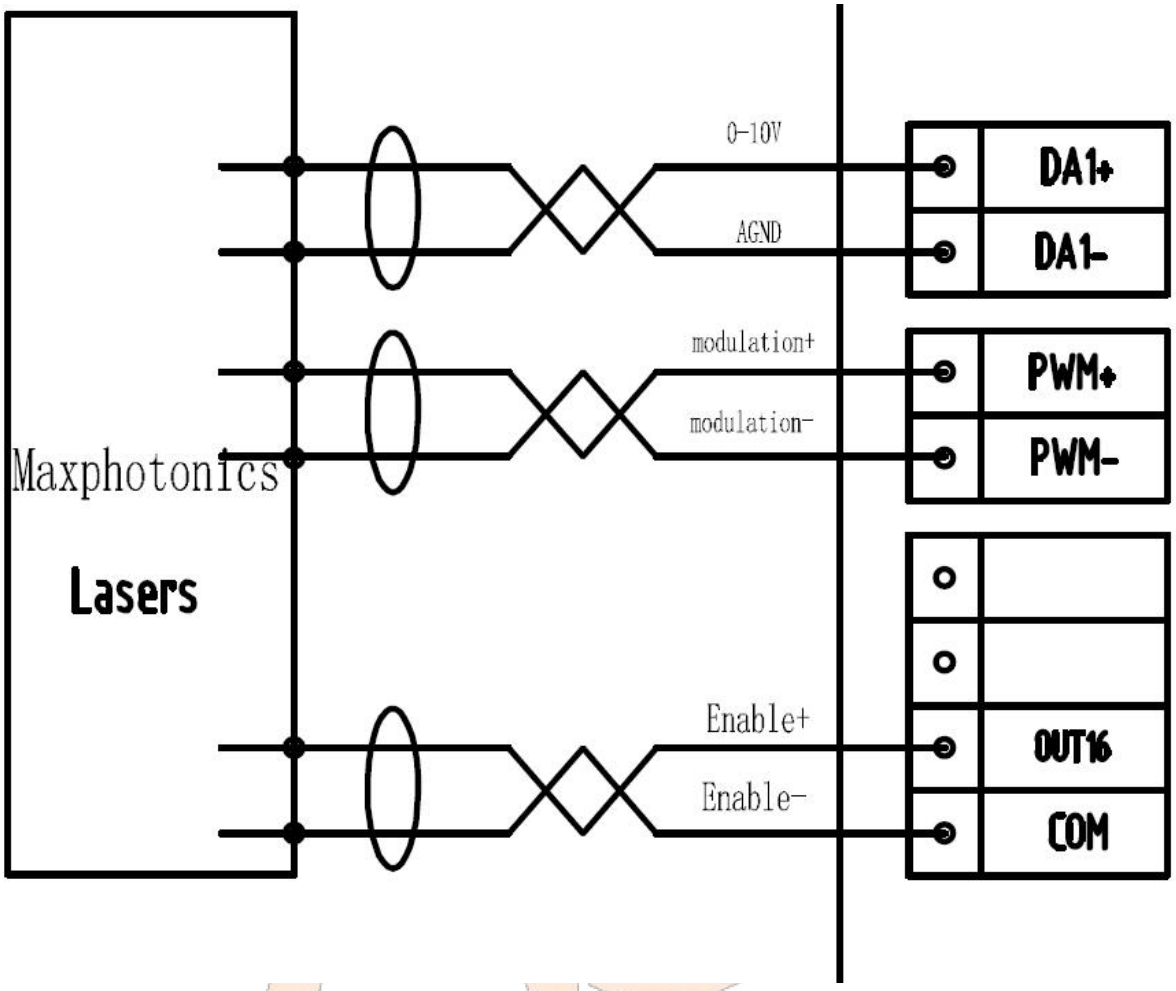
1) Major Loop

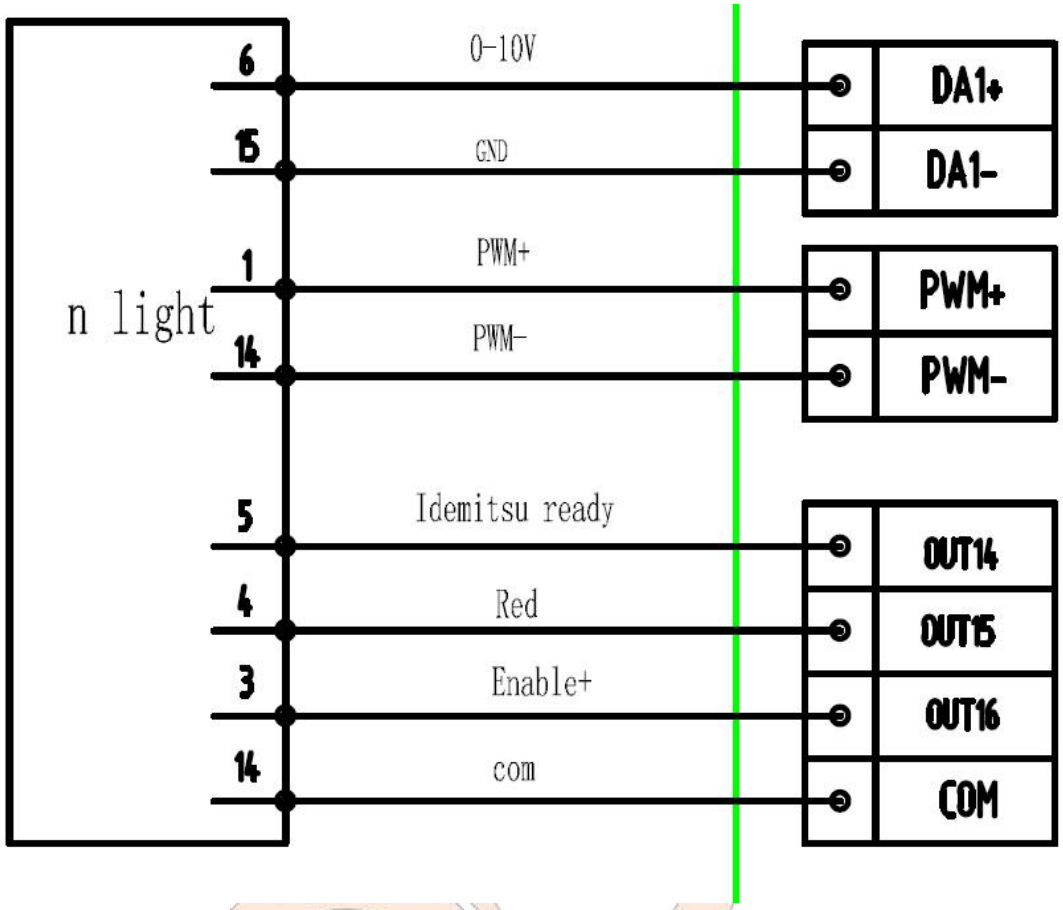


2) Control Loop



3) Connection Diagram of Laser Device


0-10V
AGND
modulation+
modulation-
Maxphotonics
Lasers
Enable+
Enable-
DA1+
DA1-
PWM+
PWM-
OUT16
COM


n light
6
15
1
14
5
4
3
14
0-10V
GND
PWM+
PWM-
Idemitsu ready
Red
Enable+
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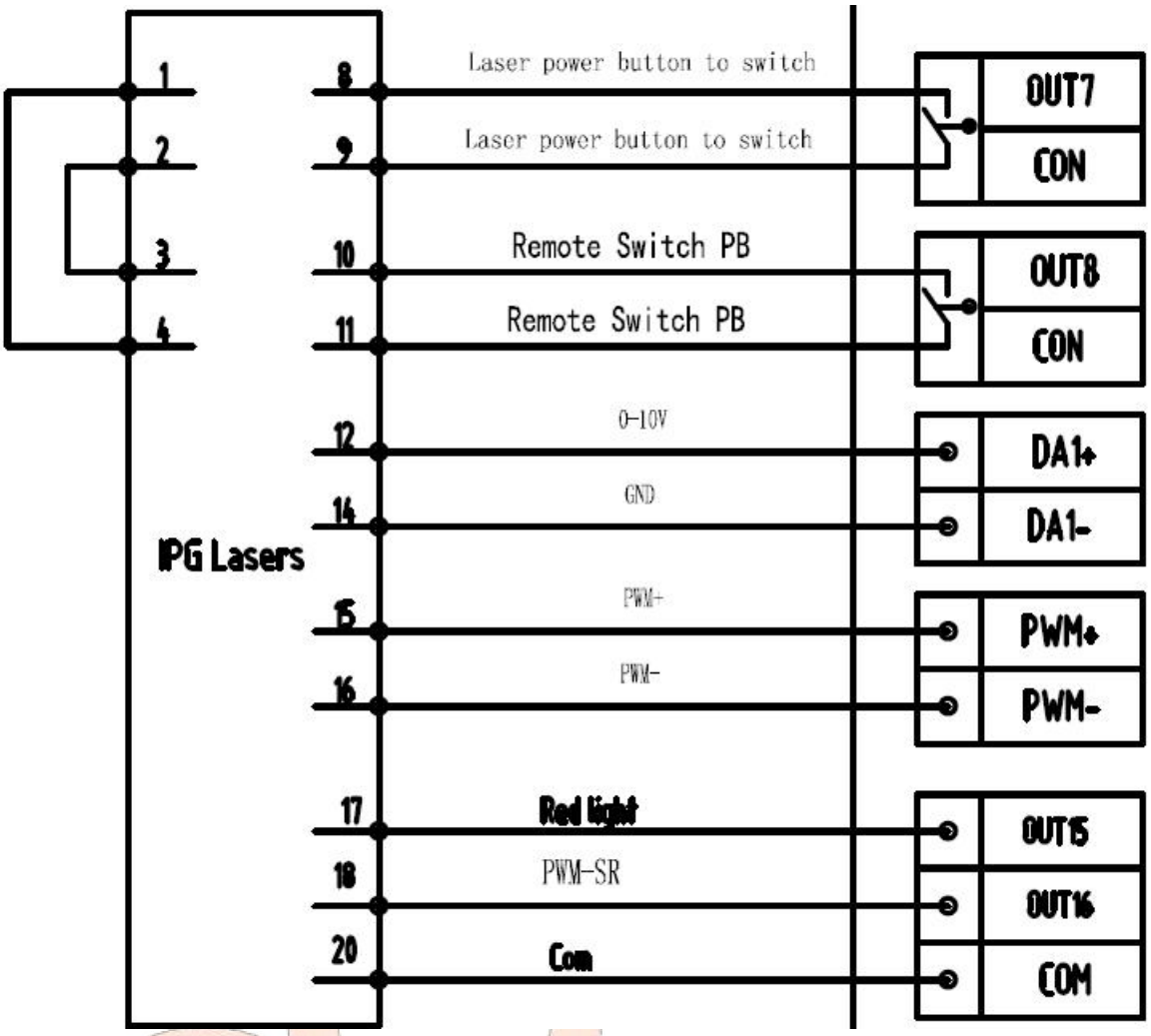
DA1+
DA1-
PWM+
PWM-
OUT14
OUT15
OUT16
COM

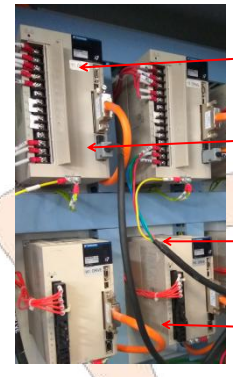


II. Basic electrical parts and their functions

1) Electrical cabinet

The majority of electrical components is mounted inside and used to supply electricity for the machine.

2) Drive



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3) Servo transformer

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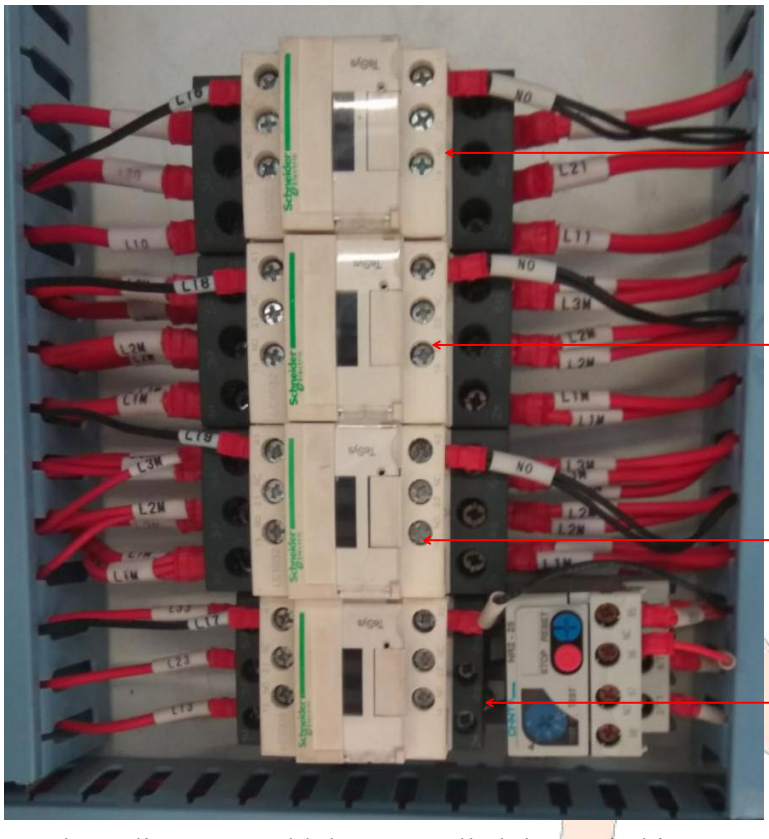
4) Contactor



Control drive power supply (LCD1D32AC/220V)

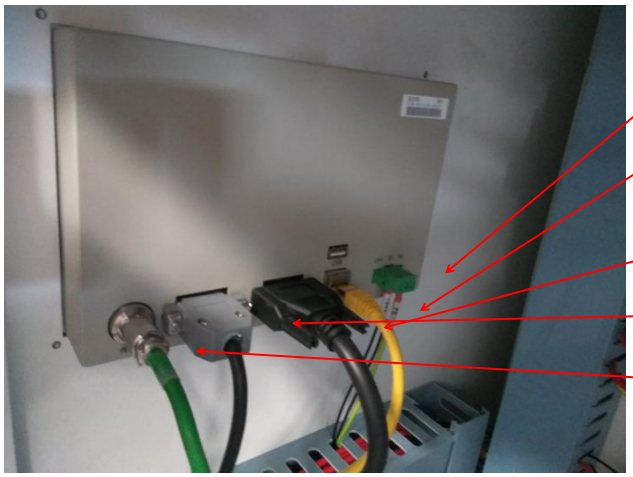
Control drive power supply (LCD1D32AC/220V)

Control drive power supply (LCD1D32AC/220V)

Control fan (LC1D09AC/220V)

Load appliances could be controlled by switching on the contacts under the action of magnetic field generated when current passes through the coil.

5) Height-adjustment device



Supply 24V electricity for height-adjustment device

Network cable, communicated with the upper computer

Connect drives

Limit signal

Signal line of sensor

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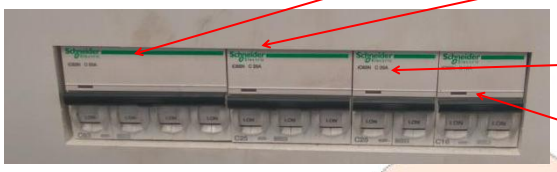
6) Circuit breaker

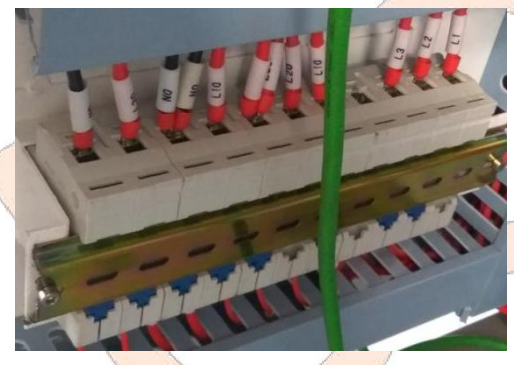


Main power

Main power switch of drives

Power switch of laser water chiller

System power switch



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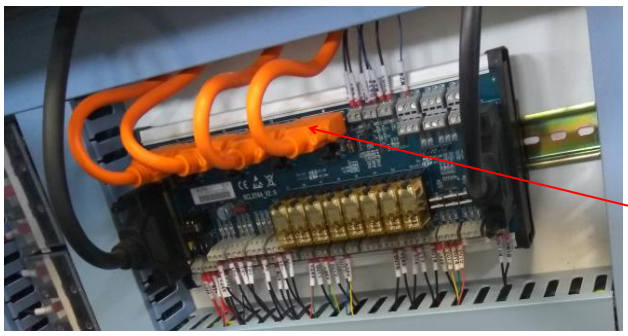
7) Pinboard



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with DC power supply. The minority is powered with AC power supply.

9) Switching power supply

24V power supply

10) Filter

The power filter is a filter circuit consisting of capacitance, inductance and resistance. The filter could effectively filter out a frequency point of specific frequency in a power line or frequency other than the frequency point to obtain power signals of a specific frequency or power signals after eliminating a specific frequency.

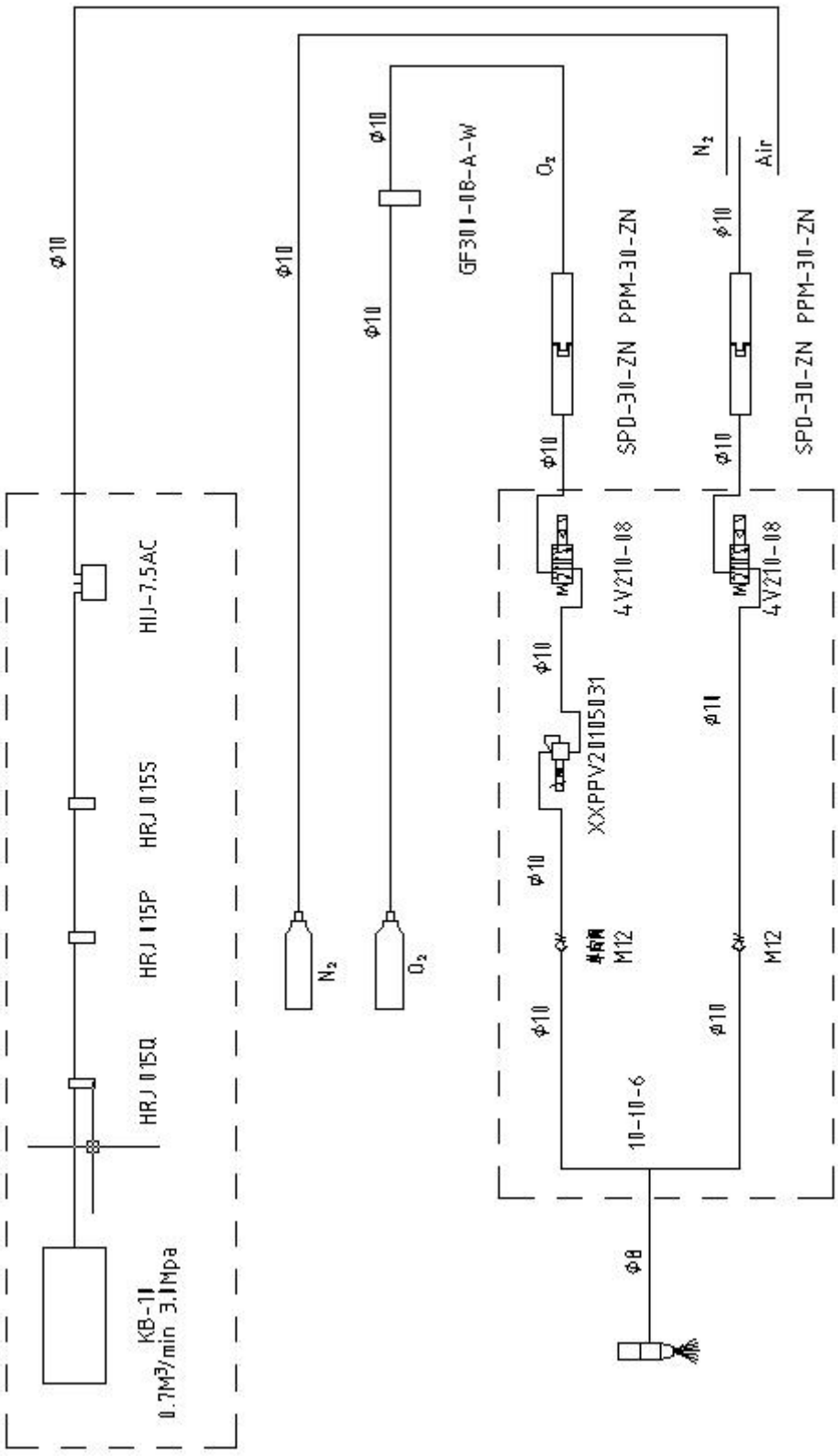
11) Variable-frequency drive

The variable-frequency drive (VFD) is a power control equipment that controls the AC motor by varying the operating power supply frequency of the motor utilizing the variable-frequency and microelectronic technologies. The VFD mainly consists of rectifier (converting AC to DC), filter, inverter (converting DC to AC), brake unit, driver unit, detection unit, micro-processing unit, etc. The VFD adjusts the voltage and frequency of output power supply by breaking the internal IGBT and outputs the required power supply voltage according to the actual demand of the motor to achieve energy-saving and speed-adjusting.

2.6.8 Gas circuit system

The gas circuit of laser cutting machine is used to provide cutting gas for cutting head and cooling gas for ceramic body, which should be selected reasonably based on different cutting materials, as follows:

1) Oxygen is mainly applied in cutting of general carbon steel;
2) Nitrogen is chiefly adopted to cut stainless steel;
3) Air is mainly used for cutting of sheet that conditions allowed.



Gas Circuit Schematic Diagram of Cutting Gas

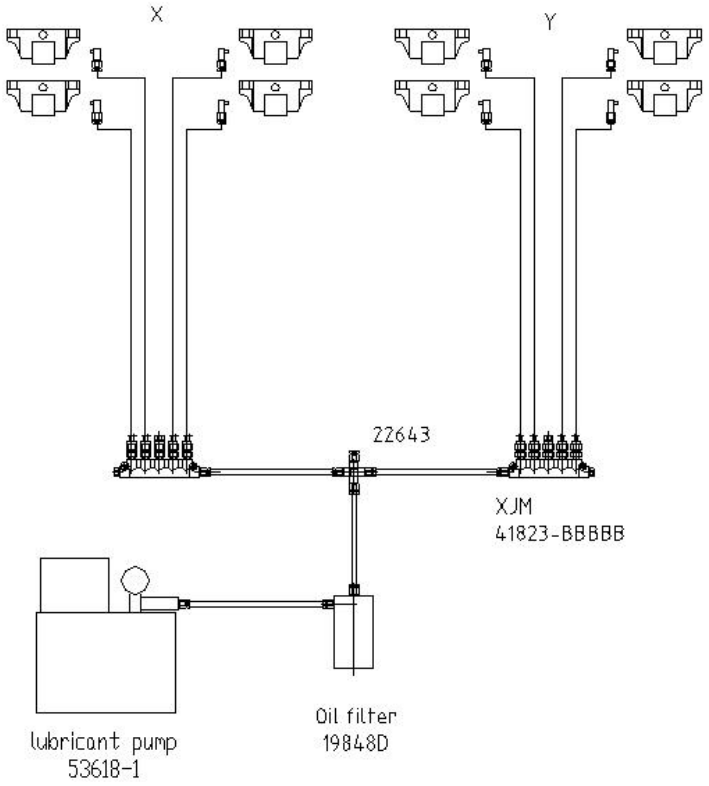
2.6.9 Cooling system

The water circuit of the laser cutting machine has two water circuits with different temperature, one for cooling the laser and the other for cooling the cutting head.

Remark: Auxiliary equipment and means above are significant for the purpose of normal operation of the whole machine tool and laser device, as well as guaranteeing steady power of laser device and good mode of laser. It is beyond the warranty coverage including low laser power, poor laser mode and other parts injured due to a user's using undesirable water, electricity and gas without permission.

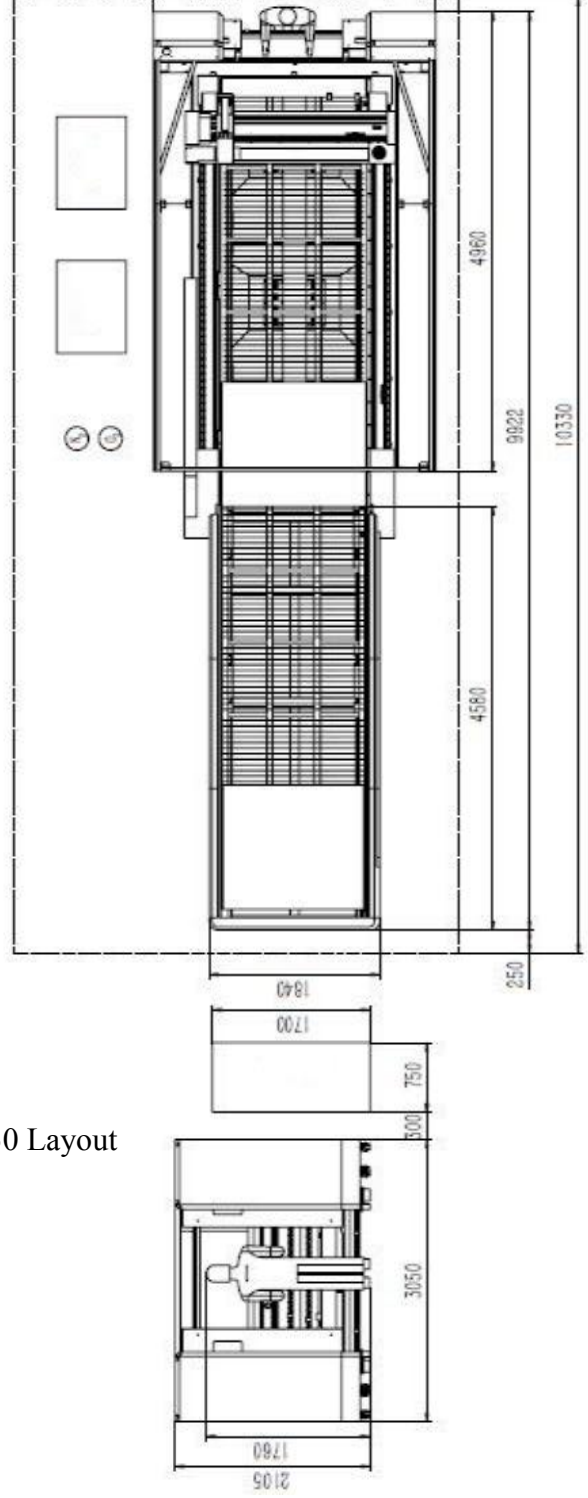
2.6.10 Lubricating system

The centralized lubricating system automatically supplies lubricating oil for the sliding block, ensuring the precision of drive system and improving the service life of linear guideway.



Schematic Diagram of Lubrication

2.6.11 Layout



P1530 Layout

2.7 Introduction to structure of F-T series laser cutting machine

2.7.1 External view

Figure 2.2-4: External View of F-T Series Plate and Tube Cutting Machine

(subject to material object)

2.7.2 Features of F-T series fiber laser cutting machine:

1. High-performance laser device associated with stable operation system enables optimal cutting effects.
2. Perfect cooling, lubrication and dedusting systems ensure stable, efficient and durable performance of the whole machine.
3. High-precision chuck ensures efficient and reliable and stably precise cutting of pipe.
4. Gantry structure and inblock cast cross beam make the device highly rigid, stable and antiknock.
5. Automatic height-adjustment performance keeps constant focal length and stable cutting quality.
6. It could cut mental in various materials and realize excellent and stable cutting effects.
7. It takes precise linear guideway and gear rack as driving elements which could realize high precision and rapid speed.
8. It is equipped with special CAD/CAM automatic programming and jacking software to save raw materials to the maximum extent.
9. Remote communication and monitoring in laser cutting process could be realized through the direct communication between network interface and numerical control system.

2.7.3 Conditions of operating environment

a. Quality of power supply: Tri-phase unbalance factor <2.5%, line voltage fluctuation <5%.
b. Grounding protection: independent grounding of machine tool; independent grounding of tube cutting section; independent grounding of power distribution cabinet; independent grounding of laser device; ground resistance required ＜4Ω. Ground pile: shall be smashed into the ground through an angle iron or wide-diameter rebar no less than 2-3m long; simultaneously proper salt water shall be poured for better grounding effect.
c. Draughty, dust-free, non-corrosive and pollution-free site environment is required.
d. No large vibration is permitted around the installation foundation.
e. The water chilling unit is applied in dedicated devices such as cooling laser device and cutting head; for circulating cooling water, high-quality and mineral-free purified water, distilled water or deionized water is required;
f. For fear of fire hazard, appropriate fire extinguishers and reserved fire fighting access shall be provided in the processing site.
g. Over 1.2M shall be kept between workshop wall and left and rear sides of machine tool; Over 1.0M shall be reserved around the laser device.
h. The control unit, servo unit, displayer and control panel are core components of machine tool, which are demanding on the environment to some extent, and shall be kept away from electromagnetic wave interference, such as arc welding and electric discharge machine, for fear that the normal operation of machine tool is affected.

2.7.4 Impact on environment and energy

Since the laser device of laser cutting machine is a fiber generator, flue gas and dust will be generated in the process of cutting; therefore, it is necessary to purify the flue gas exhausted from the dust exhaust apparatus before emission; simultaneously, it shall avoid fire hazard.
The laser device of laser cutting machine is a Class 4 laser product, whose beam ejected, whichever reflected through a lens or reflected diffusely, will impair human body (especially eyes); therefore, it is worth noting that operating personnel and on-site personnel shall wear protective eyeglasses, which the optional SD-4, 1064nm ones are a choice.
Remark: No system and component above shall be changed without permission for the purpose of normal operation of laser head and laser device, as well as guaranteeing steady power of laser device and good mode of laser. It is beyond the warranty coverage including low laser power, poor laser mode and other parts injured due to a user's using undesirable water, electricity and gas without permission.

2.7.5 Technical parameters

Table 2.7.3 Parameters of F-T Series Plate and Tube Cutting Machine

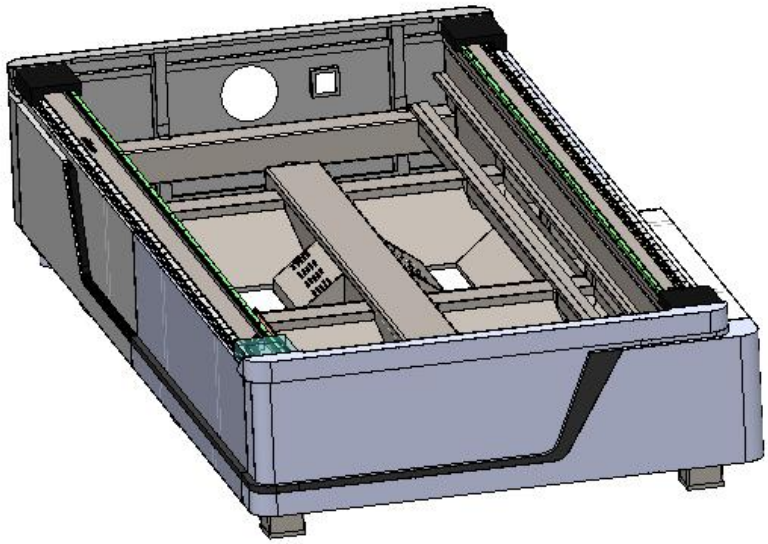
Model		F1530T	F1540T	F1560T	F2040T	F2060T	F2560T
Maximum processing range		1500×3000mm	1500×4000mm	1500×6000mm	2000×4000mm	2000×6000mm	2500×6000mm
Stroke of X axis		1500mm	1500mm	1500mm	2000mm	2000mm	2500mm
Stroke of Y axis		3000mm	4000mm	6000mm	4000mm	6000mm	6000mm
Stroke of Z axis		315mm					
Rotation angle of W axis		Unlimited					
Maximum rotation speed of W axis		80RPM					
Positioning precision of X/Y/U axis		±0.03mm					
Repeated positioning precision of X/Y/U axis		±0.02mm					
X/Y axis maximum moving speed		100m/min					
Maximum moving speed of U axis		500mm/s					
Maximum cutting speed of X/Y/U axis		35m/min					
Maximum acceleration of X/Y/U		1.2G					
Power of optional laser device		500W,800W,1000W,1500W,2000W					
Maximum length of pipe		Standard configuration is 3m (4m long P□□□□T4 and 6m long P□□□□T6 are optional)					
Range of pipe diameter (circumscribed circle)		20-200mm					
Driving mode of the chuck		Manual driving is default and electrically-driving is optional					
Maximum load of working platform		600kg	700kg	1100kg	1000kg	1400kg	1800kg
Gross power	500W laser device	13KW					
	800W laser device	14KW					
	1000W laser device	15KW					

	1500W laser device	16.7KW					
	2000W laser device	18.6KW					
Overall size (L * W * H)		5000*3300*2000	5580*3300*2000	7600*3300*2000	5850*4000*2000	7600*4000*2000	7600*4500*2000
Weight of whole machine		4200kg	4700kg	5700kg	6700kg	8200kg	10000kg

2.7.6 Main mechanical structure

The main structure consists of lathe bed for cutting plate, cross beam, Z axis, workbench, lathe bed for cutting tube, feeding mechanism, front chuck, laser device, gas circuit and water circuit, operating platform, etc.

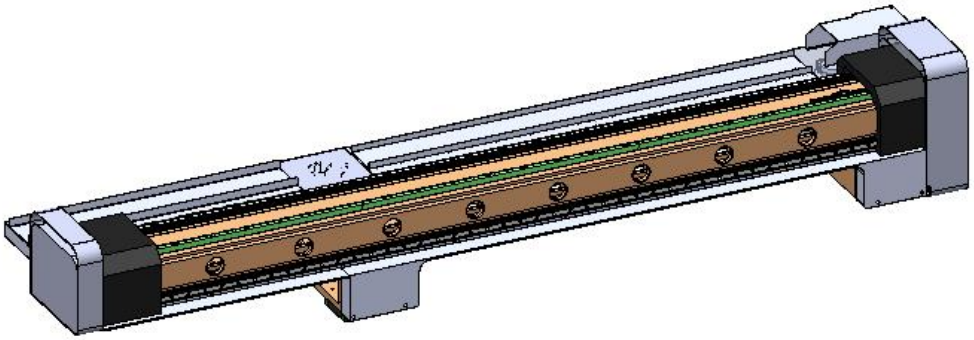
2.7.6.1 Lathe bed for cutting plate



The lathe bed structure is welded and then aging processed in the procedure of vibration aging after rough processing, semi-finish processing, vibration aging and finish processing, which thoroughly eliminates the stress and reduces the deformation of the lathe bed, ensuring long-term uniform precision of the machine tool.

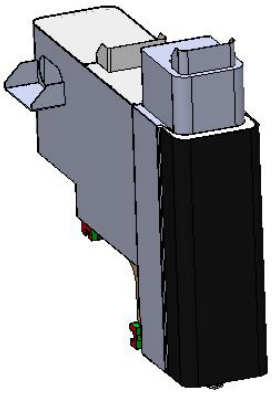
The numerical control system controls the driving of the servo motor and drives the cross beam to coaxially reciprocate along the direction of X axis, achieving rapid movement and feeding motion; The gear rack and linear guideway are equipped with a closed dust-proof device with a light dust-proof cover and good operation reliability. The gear rack and linear guideway are both precise products, effectively ensuring the driving precision; Limit switches are installed at both sides of the stroke assisted by two elastic cushions, effectively ensuring safe motion of the machine tool.

2.7.6.2 Cross beam



The cross beam is casted using the integrated high-strength aluminium alloy. The cross beam is treated by solution, artificial aging and then machine-processed, ensuring the overall rigidity and strength. The processing procedure consists of rough processing, vibration aging, semi-finish processing, vibration aging and finish processing.
The cross beam is installed on the guideway of the lathe bed. A high-quality linear guideway is installed on the cross beam and the servo motor drives the gear to rotate through the decelerator, enabling the slider on Z axis to reciprocate along Y axis; The limit switch controls the stroke together with the elastic cushions on both sides, ensuring safe operation of the system. The top and left and right sides of the cross beam are closed by the outer cover and an scalable organ type protection cover is installed between horizontal sliders, ensuring the fully closed operating environment for the gear rack and linear guideway without impact of outside environment.

2.7.6.3 Z axis device



The Z axis device is applied in the lifting motion of cutting head. The lifting motion of cutting head is achieved by up-down reciprocating motion of Z axis slider driven by the numerical control system controlling servo motor and the motor driving ball screw. The stroke of both up and down ends is controlled by proximity switch. Both ball screw and linear guideway are high quality products, ensuring the driving precision.
The Z axis can interpolate independently as a numerical control axis, move together with the X and Y axes and switch to follow-up motion mode through the electrically-controlled part of

the cutting head to meet the requirements of different situations. The follow-up motion of Z axis is controlled by the numerical control system, which is relatively high-precision and stable, thus ensuring the quality of cutting.

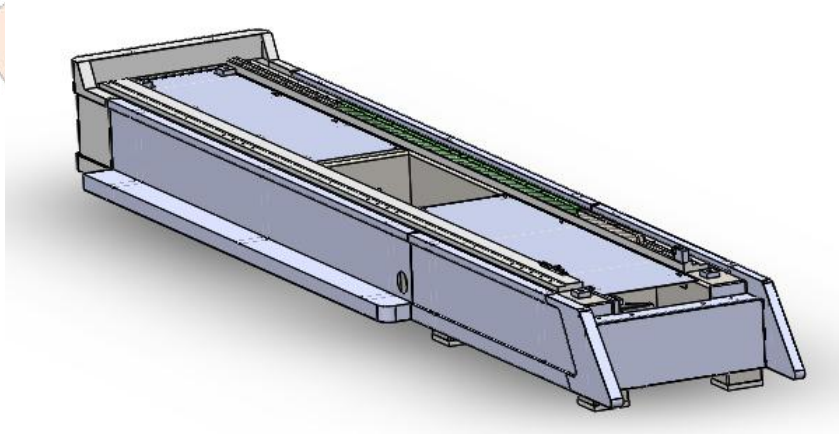
The capacitance sensor (mounted on the cutting head) in Z axis device will feed the signals that the distance from nozzle to the surface of profile back to the control system which would then control the motor of Z axis to drive the up-down motion of cutting head, therefore keeping a constant distance between the nozzle and profile and effectively ensuring the cutting quality. The cutting head is equipped with nut that adjusts the focal length, and the location of focus could be adjusted based on the texture and thickness of cutting material, thus good cutting section is available. Since the nozzle is one of quick-wear parts during processing, users may reserve some nozzles with different hole diameters for convenient replacement.

Z axis is equipped with linear guideway seat nozzle and lead screw seat nozzle respectively for filling lubricating grease on a regular basis.

2.7.6.4 Workbench

The workbench is integrally welded structure with high strength and stability. The workbench is installed with blades supporting the work piece and with bull eye ball bearings at both terminals. Three rollers are installed in the middle of the workbench and can be lifted by the cylinder, allowing rolling of work piece on the rollers and avoiding sliding of work piece on the blades which may cause scratches. Once the work piece is positioned, the roller will go down under the drive of cylinder after the pneumatic switch is on, thus avoiding the roller from being burnt during cutting. The work piece is rolling on the rollers when fed and unloaded, not supported as the traditional method (the work piece slides on blades), so this mechanism can effectively protect the smooth work piece from scratches during feeding and baiting and reduce the labor strength of the operating personnel.

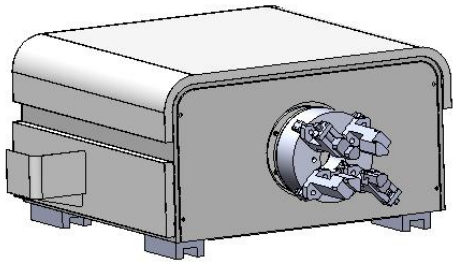
2.7.6.5 Lathe bed for cutting tube



The lathe bed structure is integrally welded and then aging processed in the procedure of vibration aging after rough processing, semi-finish processing, vibration aging and finish processing, which thoroughly eliminates the stress and reduces the deformation of the lathe bed, ensuring long-term uniform precision of the machine tool.

The numerical control system controls the driving of the servo motor and drives the feeding mechanism to coaxially reciprocate, achieving rapid movement and feeding motion; The gear rack and linear guideway are both precise products, effectively ensuring the driving precision; Limit switches are installed at both sides of the stroke assisted by two elastic cushions, effectively ensuring safe motion of the machine tool.

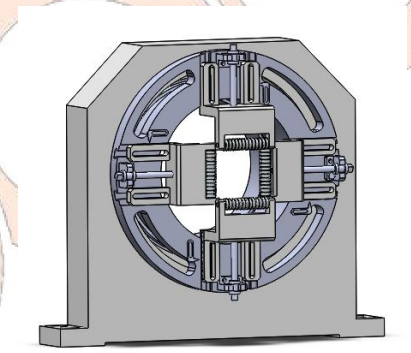
2.7.6.6 Feeding mechanism



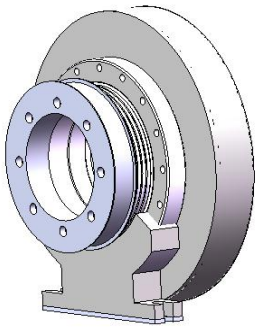
The servo motor drives the feeding mechanism to move along Y axis and the rotating servo motor drives rotation of the rear clamped chuck through the belt in cooperation with the servo motor along Y axis to cut the work piece into desired shapes. The gear rack and linear guideway are both precise products, effectively ensuring the driving precision; Limit switches are installed at both sides of the stroke assisted by two elastic cushions, effectively ensuring safe motion of the machine tool.
The slider of feeding mechanism has a closed outer cover, ensuring the fully closed operating environment of drive mechanism including the servo motor and belt without impact of the outside environment.

2.7.6.7 Front chuck

Manual chuck (standard)



The standard manual chuck mainly consists of base, rotation disc, claw, adjusting mechanism, etc. The centering position of the claw can be adjusted forward and backward by the adjusting bolt to adapt to clamped pipes with different diameters.
Electrically-driven chuck (optional)



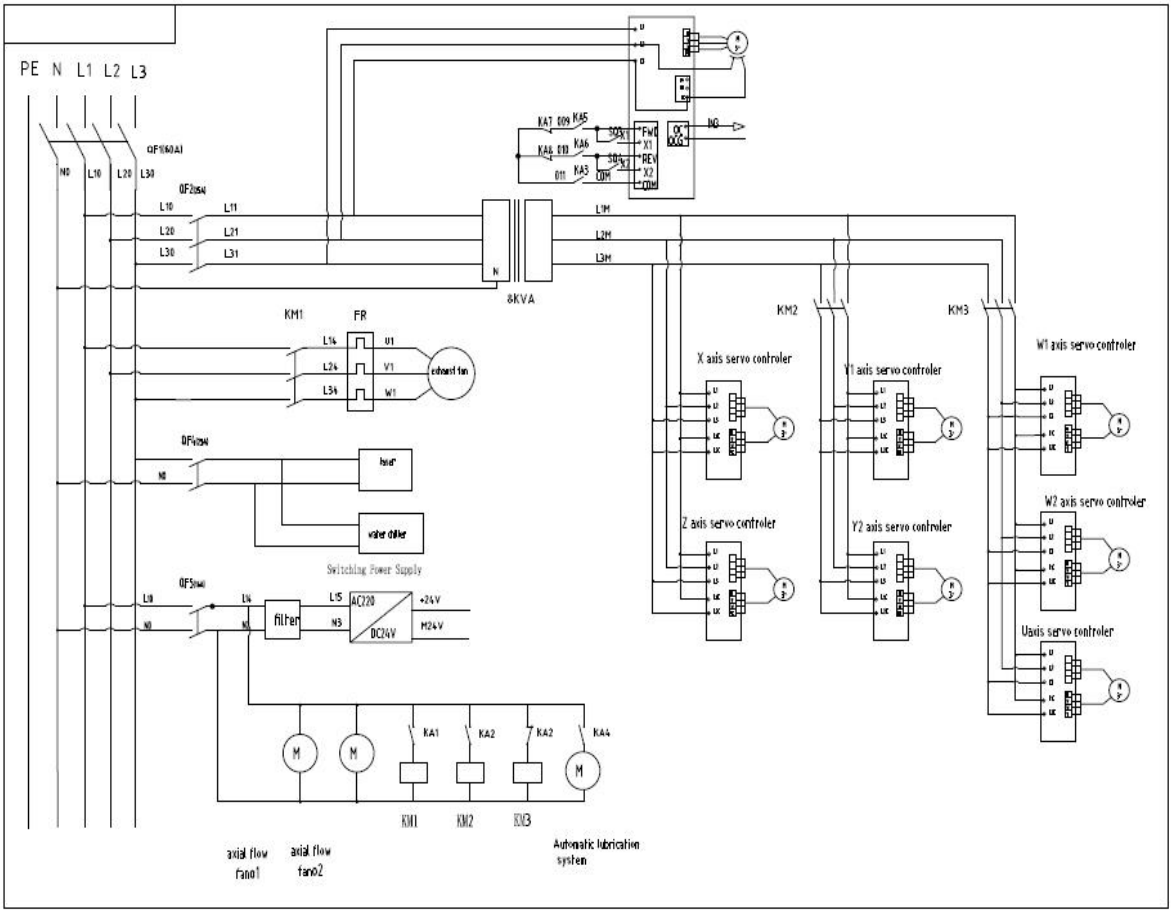
The electrically-driven chuck mainly consists of motor, drive mechanism, claw, etc. The motor drives the drive mechanism to move the claw forward and backward for centering to adapt to clamped pipes with different diameters. The clamping force can be adjusted by the current to avoid deformation of thin-wall tubes when clamped.
The clamping by electrically chuck is easy and convenient, reducing the labor strength of the operating personnel and improving the efficiency. It is more applicable to automated production.

2.7.7 Electrical part

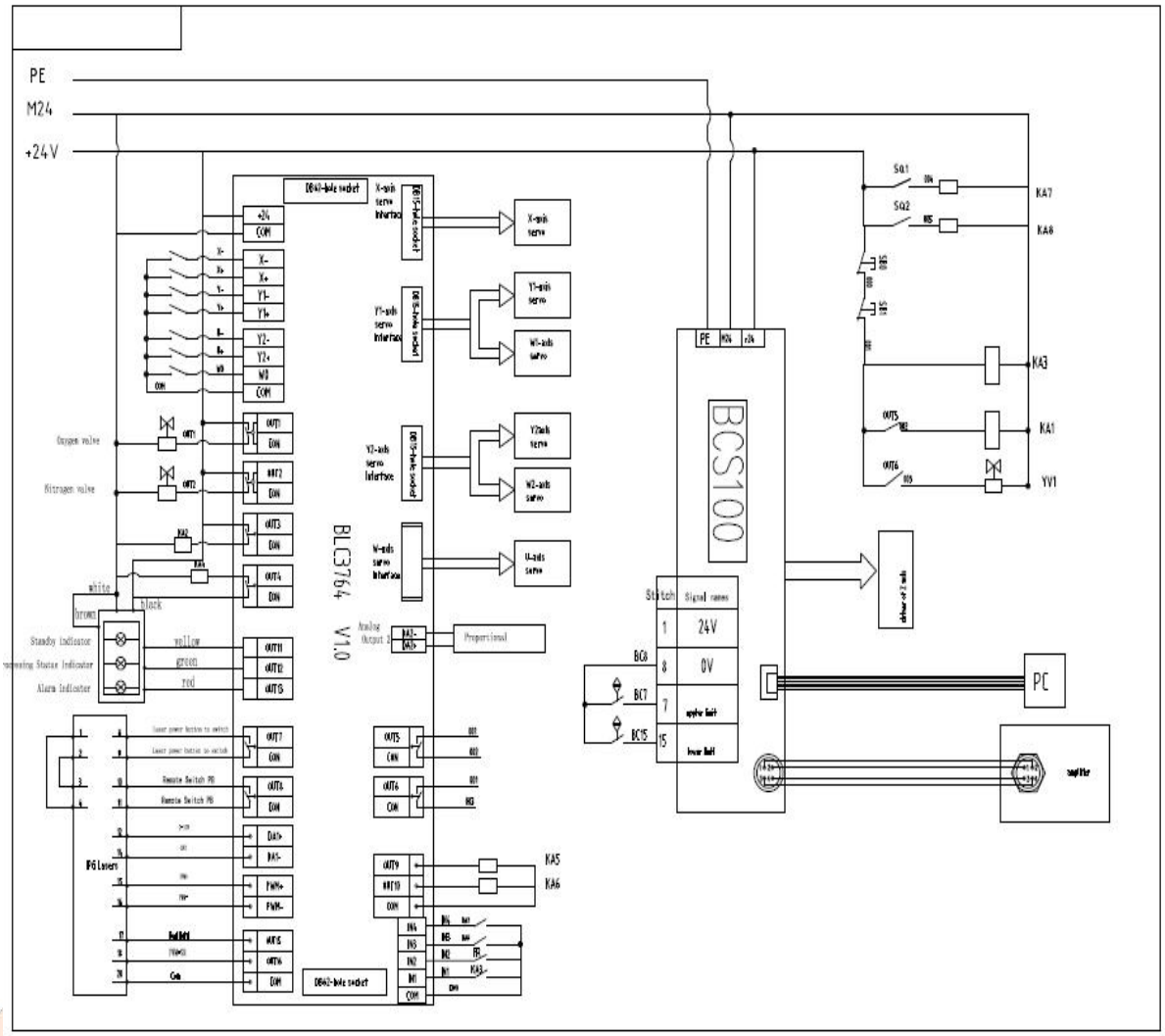
Electrical part

I. Schematic diagram

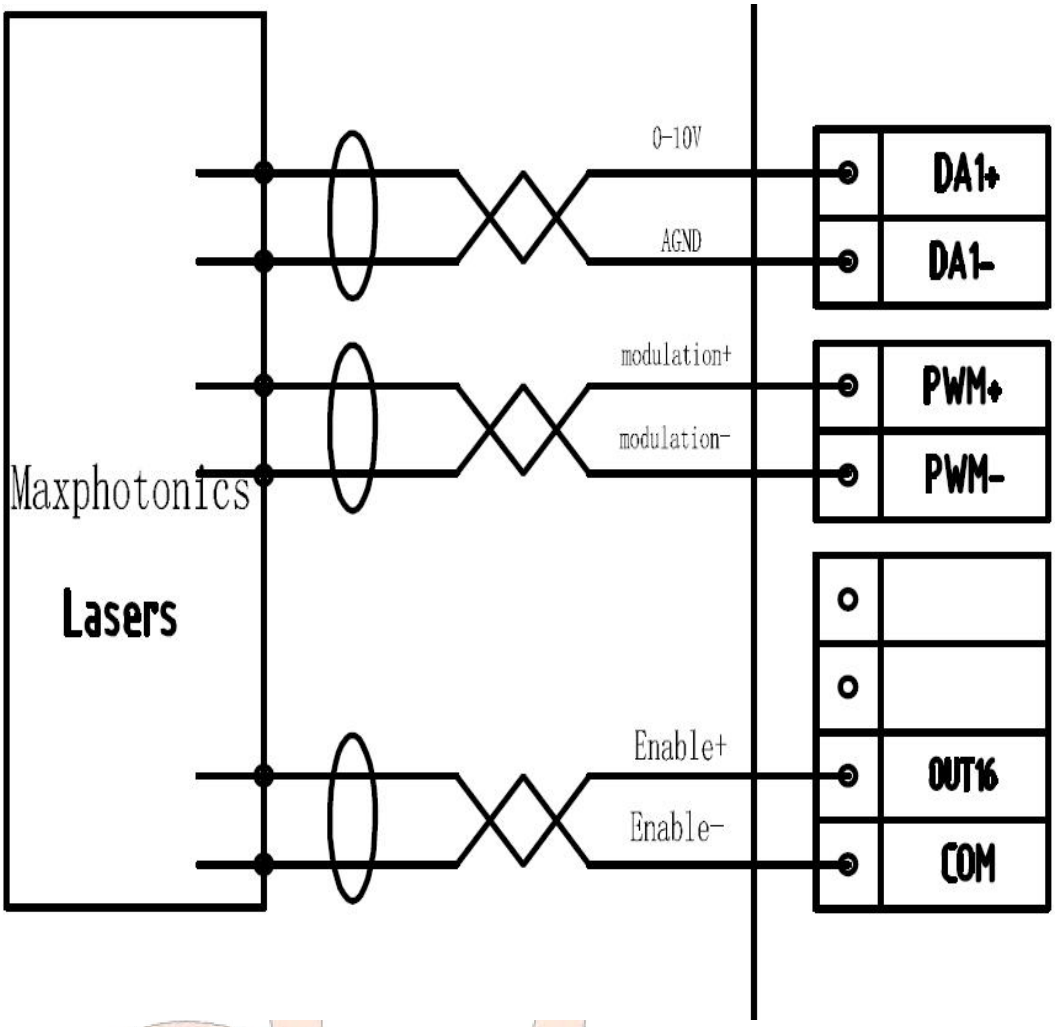
1) Major Loop

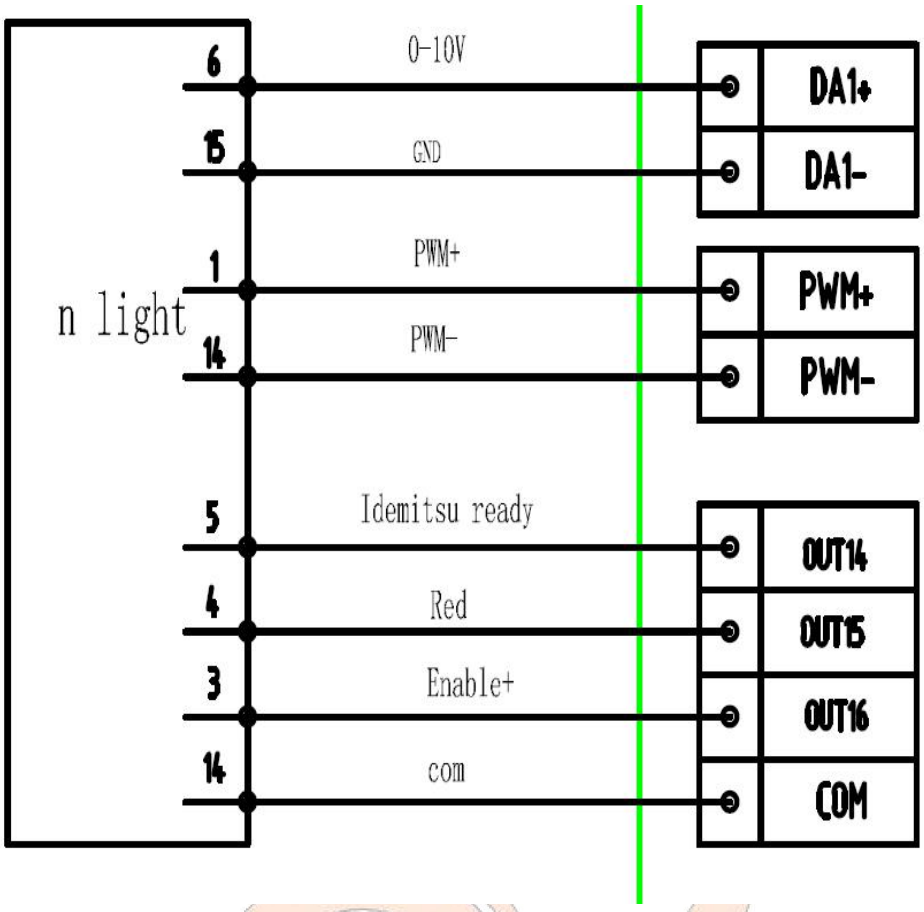


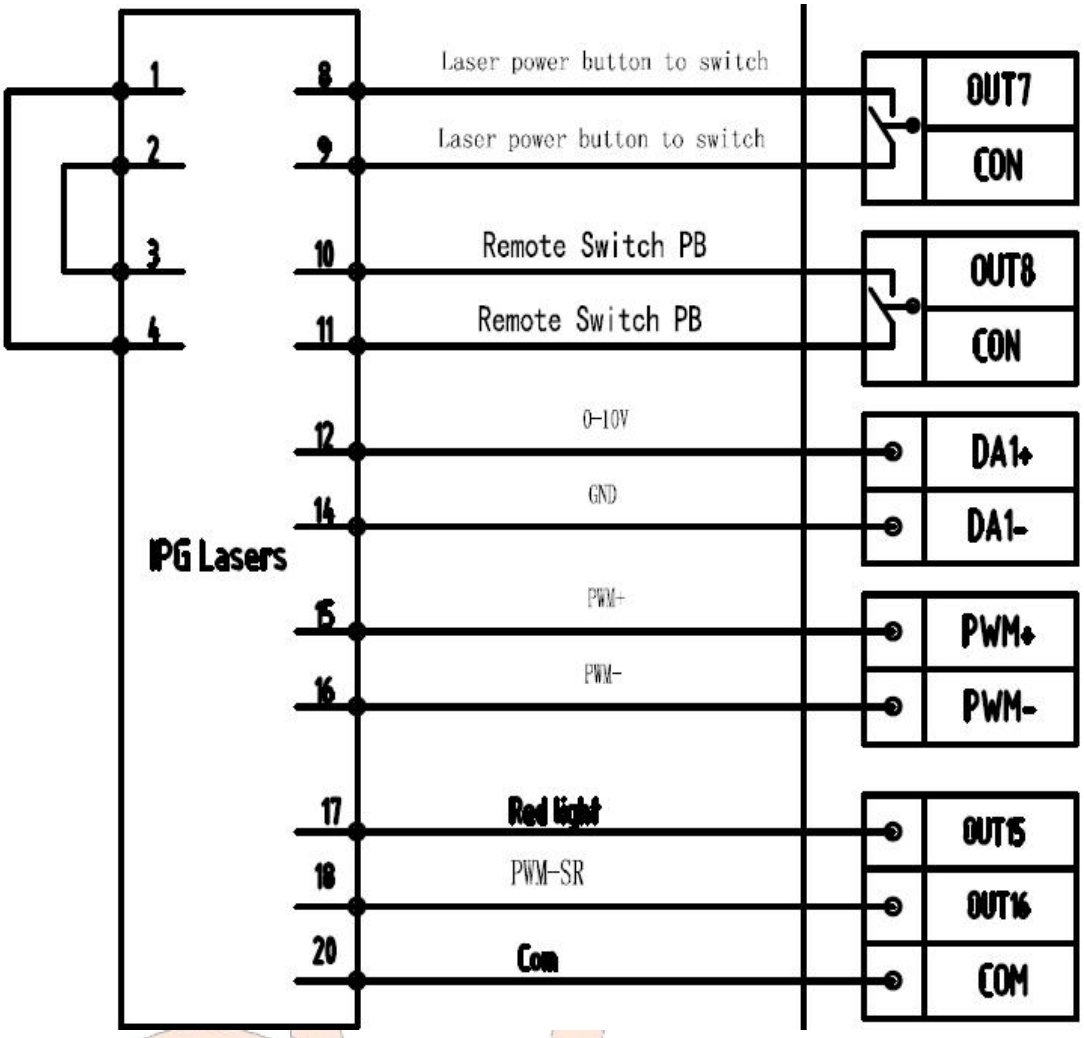
2) Control Loop



3) Connection Diagram of Laser Device


0-10V
AGND
modulation+
modulation-
Maxphotonics
Lasers
Enable+
Enable-
DA1+
DA1-
PWM+
PWM-
OUT16
COM


n light
6
15
1
14
5
4
3
14
0-10V
GND
PWM+
PWM-
Idemitsu ready
Red
Enable+
com
DA1+
DA1-
PWM+
PWM-
OUT14
OUT15
OUT16
COM

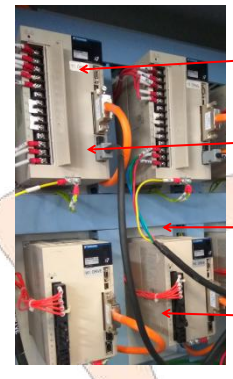


II. Basic electrical parts and their functions

1) Electrical cabinet

The majority of electrical components is mounted inside and used to supply electricity for the machine.

11) Drive



Power line, used to supply electricity for drives

Supply electricity for servo motor

A line of encoder that provides a feedback signal for servo device

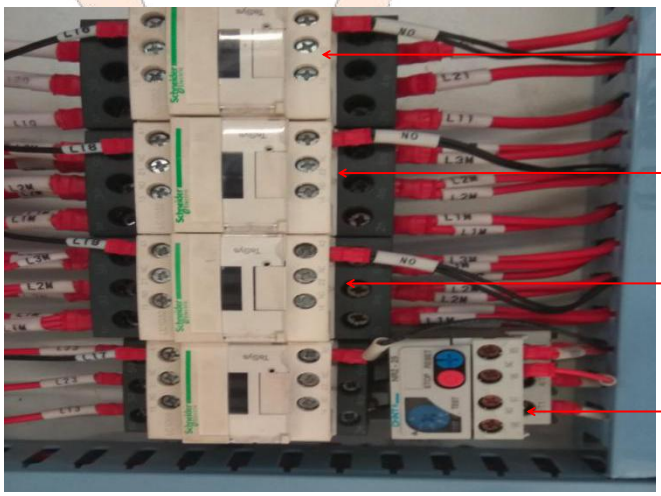
Signal line, employed to control the signal of drives

Servo drives, also called "servo controller" or "servo amplifier", just like a variable-frequency drive acting on general AC motor, is a controller to control a servo motor; as a part of the servo system, it is mainly applied in a high-precision positioning system. It currently is a cutting-edge product of drive technology, which is generally used to control a servo motor through three modes of location, speed and moment of force to achieve high-precision positioning of drive system.

12) Servo transformer

Such type of servo transformer is specifically designed for servo drive system, which could provide necessary electric energy for servo drive.

13) Contactor



Load appliances could be controlled by switching on the contacts under the action of

magnetic field generated when current passes through the coil.

14) Height-adjustment device

Supply 24V electricity for height-adjustment device

Network cable, communicated with the upper computer

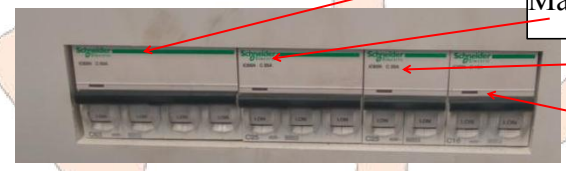
Connect drives

Limit signal

Signal line of sensor

During cutting, it is the laser head to maintain a constant distance between laser head and sheet metal, not only getting laser head protected effectively, but also achieving sophisticated techniques, including multi-stage perforation.

15) Circuit breaker



Main power switch

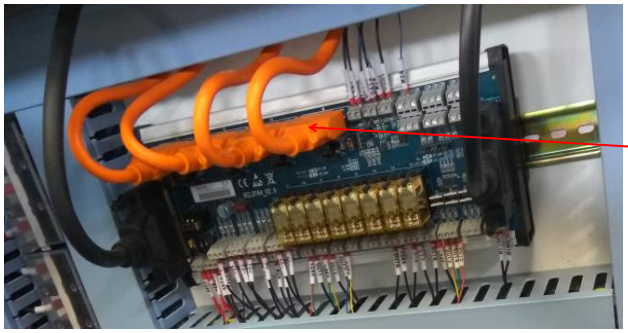
of drives

Power switch of laser water chiller

System power switch

The circuit breaker could be used to distribute electric energy, start occasionally an asynchronous motor and protect power line and motor and so on; in case these devices are in overload, short circuit, undervoltage and other trouble states, it could shut down the circuit automatically, which functions as the combination of fuse-switch and overthermal-underthermal relay. Moreover, no part or component is required to be changed after disjuncting fault current.

16) Pinboard



The motion control card is an upper control unit based on PC and industrial PC, and applied in various motion control occasions (including displacement, speed, acceleration, etc).

The motion control card is a PC bus-based, high-performance stepping/ servo motor, being capable of achieving multi-axis coordinative control of several servo motors by taking advantage of high-performance microprocessor (for instance DSP) and large scale programmable devices. With the functions of pulse output, pulse counting, digital input, digital output, D/A output, etc., it is able to send continuous, high-frequency pulse train, and control the motor speed by changing the frequency of pulse sent and control the location of motor by changing the quantity of pulse sent. Its mode of pulse input includes pulse/direction and pulse/pulse. The pulse counting could be used to feed back the location of encoder, provide accurate location of machine and correct the error in the process of drive. Digital input/output point could be applied in limit switch, origin switch, etc. Library functions include S-type/T-type acceleration, line interpolation, circular interpolation, multi-axis linkage function, etc. The product is widely applied in location control system that location and length are required to be confirmed precisely, and PC-based NC control system in the field of industrial automatic control. Specifically, integrating bottom software that achieves motion control with hardware endows them with various control functions of speed and location required for controlling servo motor; these functions could be easily called via a computer.

8) Intermediate relay

It is applied in relay protection and automatic control system to increase the quantity and volume of contact points. It is used to transmit M signals in the control circuit. The structure and principle of intermediate relay are basically the same with those of AC contactor, and

main differences between them lie in: A large current is allowed to pass through the main contact of the contactor, while the only low current is permitted to pass through the contacts of the intermediate relay. Therefore, the intermediate relay could be used in control circuit only. As the overload capacity is small, generally no main contact exists in an intermediate relay. So all its contacts, sufficient in quantity, are auxiliary. The intermediate relay is defined as K in the new national standard, KA in previous national standards. Generally it is powered with DC power supply. The minority is powered with AC power supply.

9) Switching power supply

24V power supply

13) Filter

The power filter is a filter circuit consisting of capacitance, inductance and resistance. The filter could effectively filter out a frequency point of specific frequency in a power line or frequency other than the frequency point to obtain power signals of a specific frequency or power signals after eliminating a specific frequency.

2.7.8 Gas circuit system

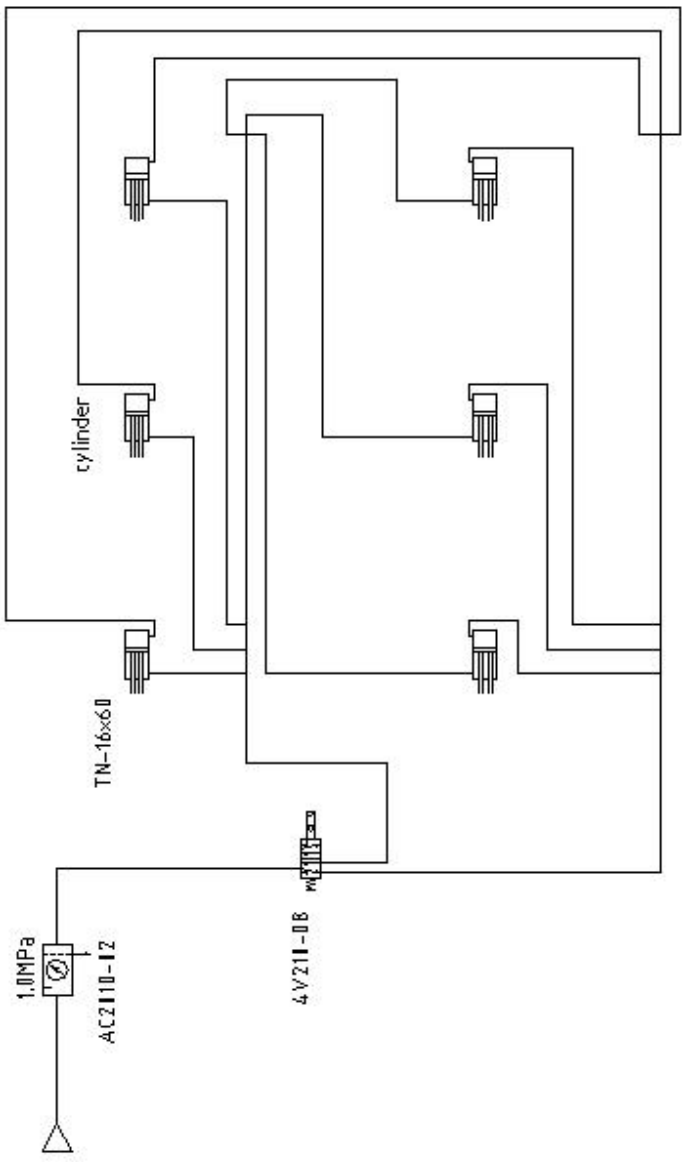
The gas circuit system of the laser cutting machine consists of two parts: one part is the cutting gas supplied to the cutting head like high purity oxygen and nitrogen. The other part is the accessory gas, specifically clean and dry compressed air mainly supplied to the auxiliary feeding cylinder of the workbench.

The gas circuit of laser cutting machine is used to provide cutting gas for cutting head and cooling gas for ceramic body, which should be selected reasonably based on different cutting materials, as follows:

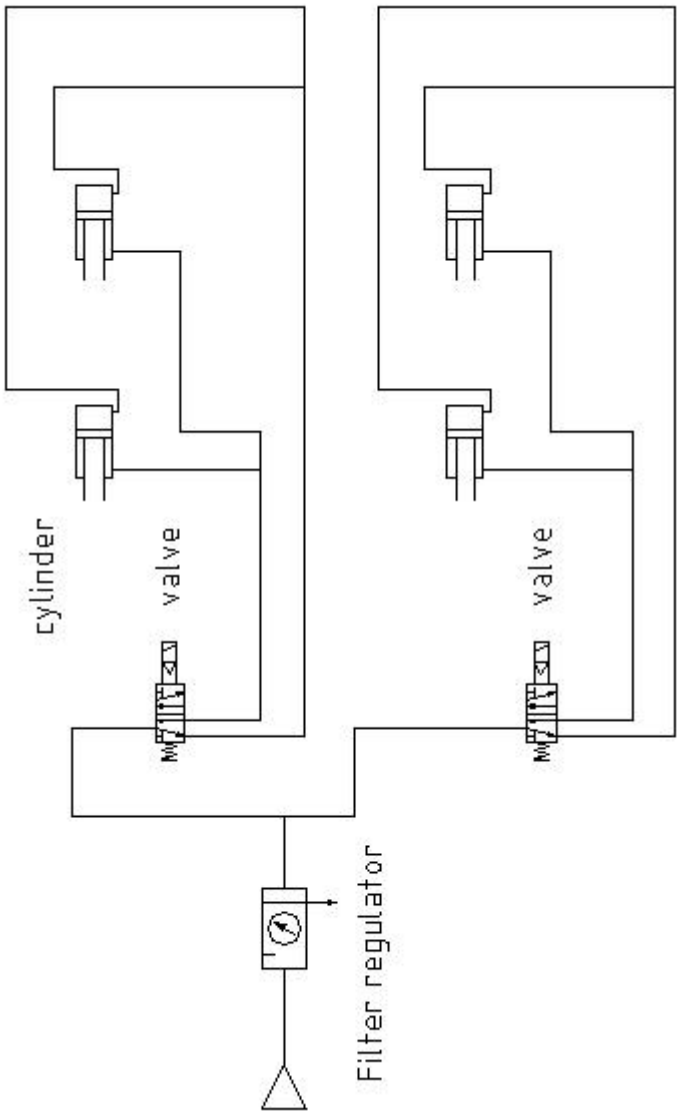
1) Oxygen is mainly applied in cutting of general carbon steel.

2) Nitrogen is chiefly adopted to cut stainless steel.

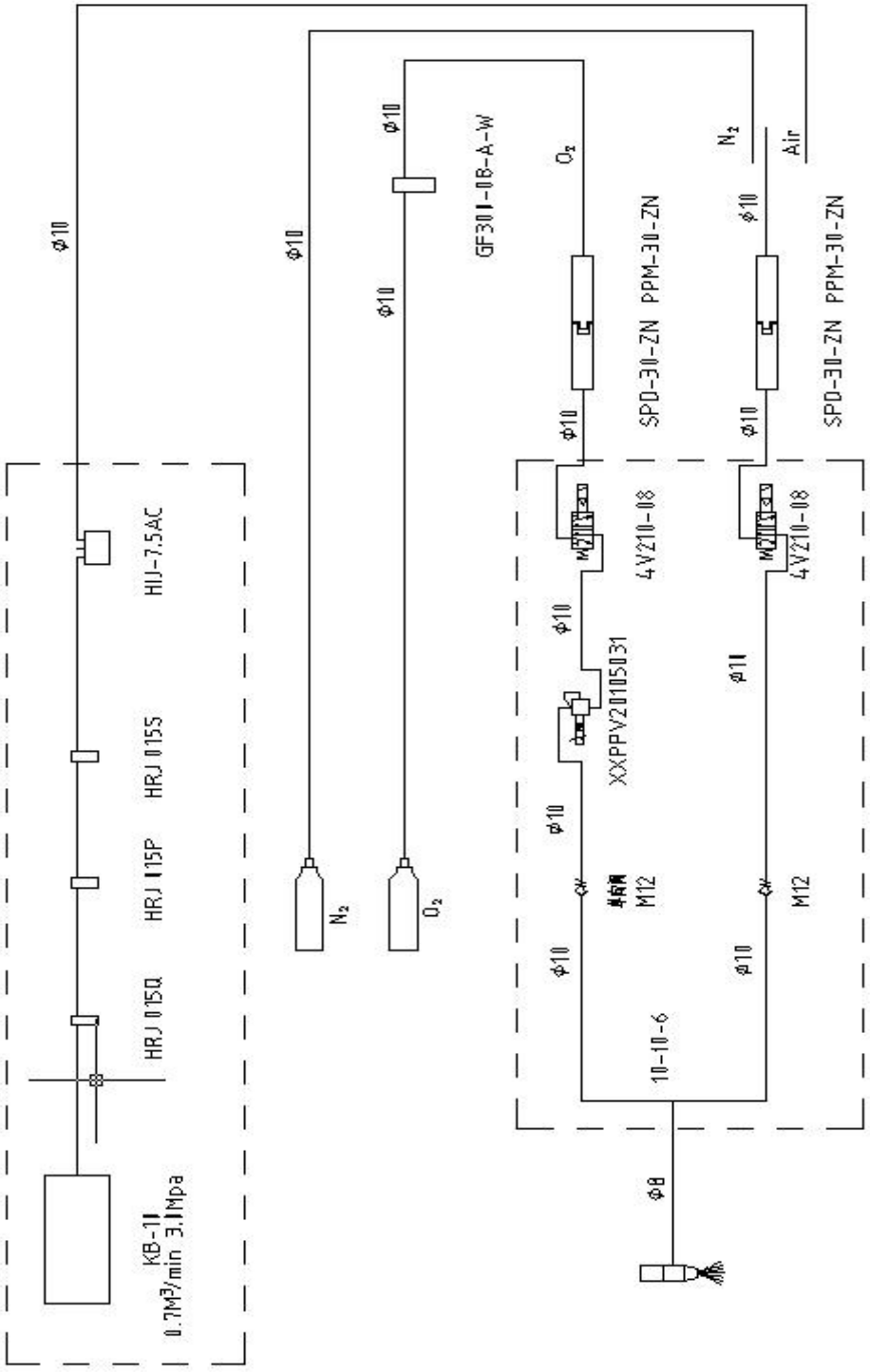
3) Air is mainly used for cutting of sheet that conditions allowed.



Pneumatic Schematic Diagram of the Plate Cutting Component



Pneumatic Schematic Diagram of the Pipe Component



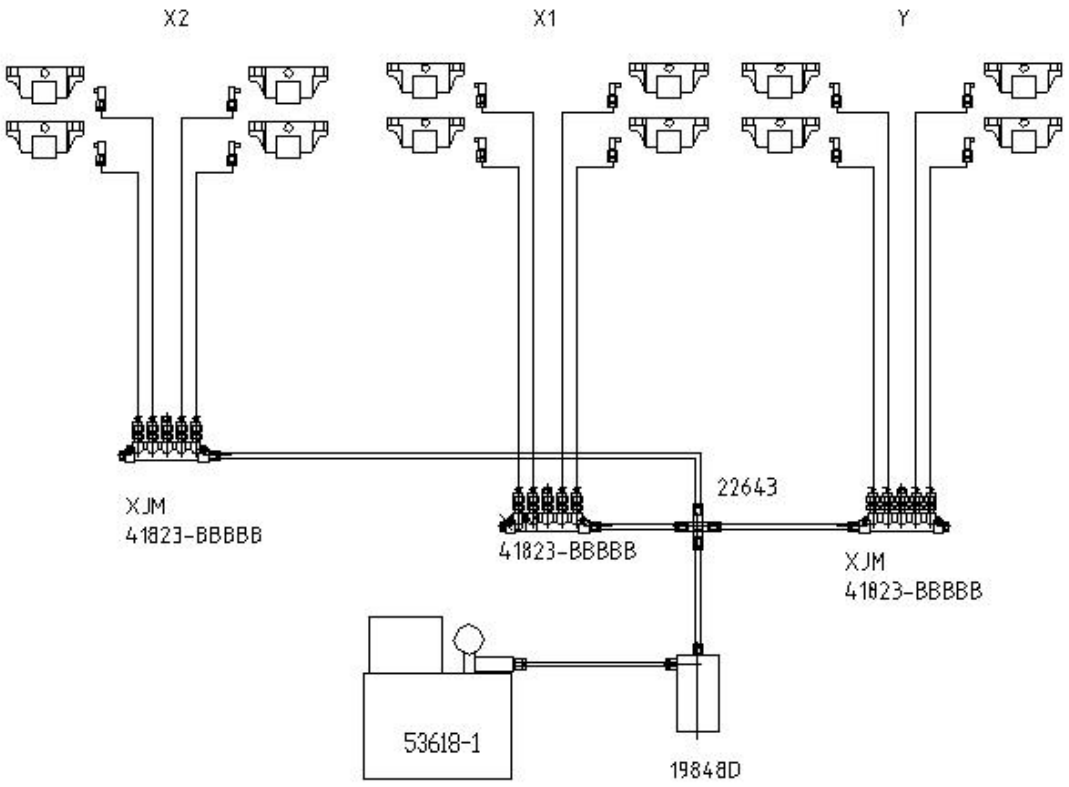
Gas Circuit Schematic Diagram of Cutting Gas

2.7.9 Cooling system

The water circuit of the laser cutting machine has two water circuits with different temperature, one for cooling the laser and the other for cooling the cutting head.

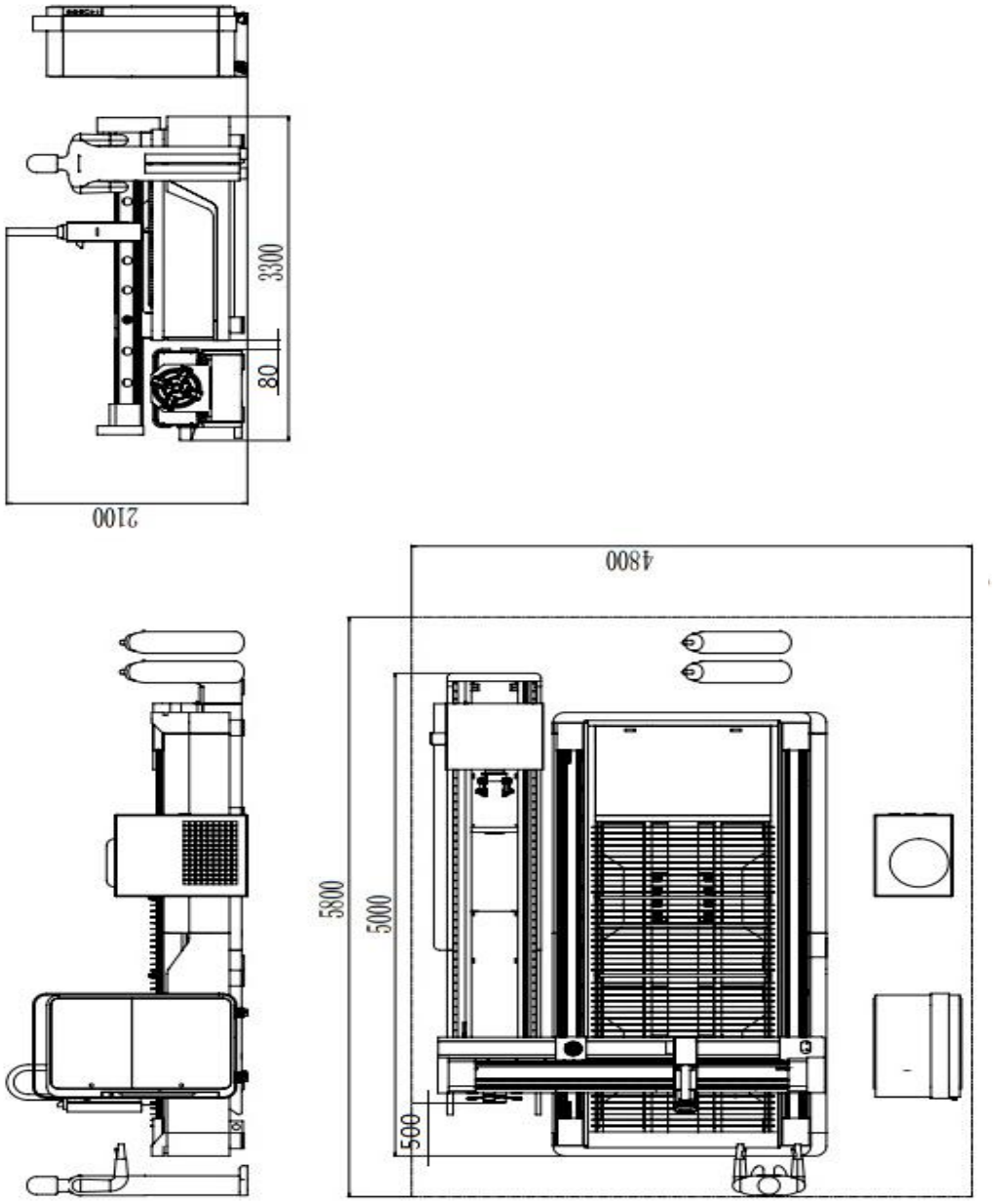
2.7.10 Lubricating system

The centralized lubricating system automatically supplies lubricating oil for the sliding block, ensuring the precision of drive system and improving the service life of linear guideway.



Schematic Diagram of Lubrication

2.7.11 Product layout



F1530T3 Layout

2.8 E-T series plate and tube cutting machine

2.8.1 External view

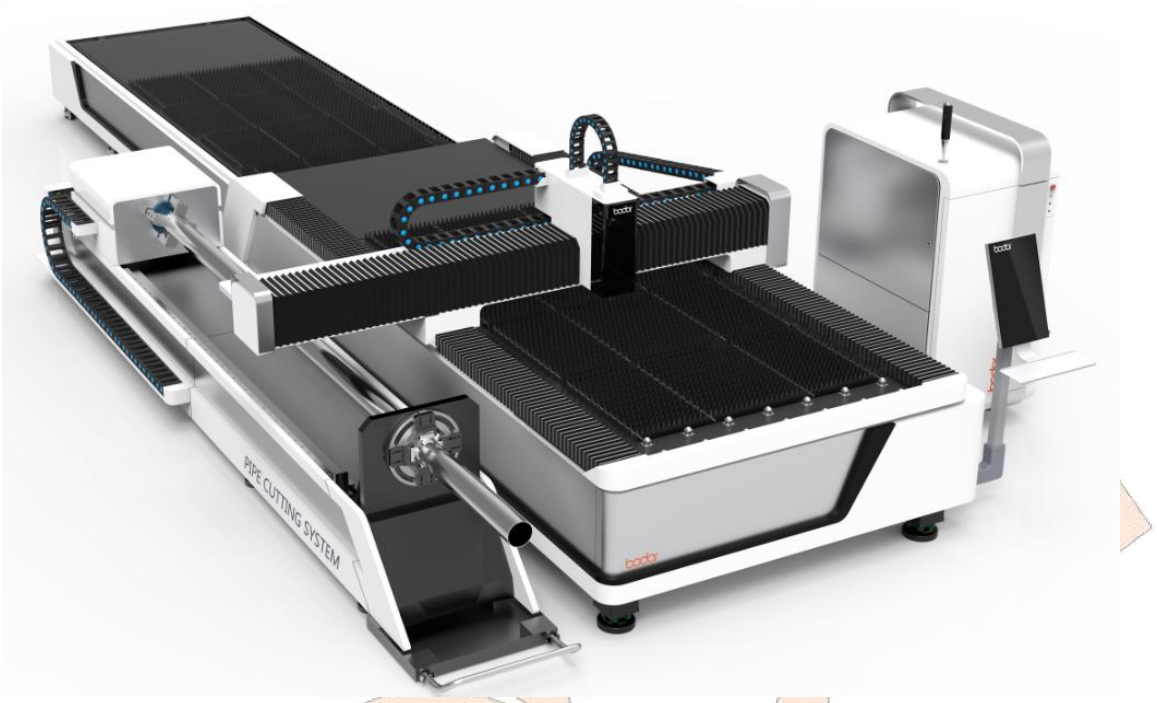


Figure 2.8.1: External View of E-T Series Plate and Tube Cutting Machine

(subject to material object)

2.8.2 Main features

1. High-performance laser device associated with stable operation system enables optimal cutting effects.
2. Perfect cooling, lubrication and dedusting systems ensure stable, efficient and durable performance of the whole machine.
3. Double countertops make plates loading and unloading available during cutting, which improves the processing efficiency.
4. High-precision chuck ensures efficient and reliable and stably precise cutting of pipe.
5. Automatic height-adjustment performance keeps constant focal length and stable cutting quality.
6. Gantry structure and inblock cast cross beam make the device highly rigid, stable and antiknock.
7. It could cut mental in various materials and realize excellent and stable cutting effects.
8. It takes precise linear guideway and gear rack as driving elements which could realize high precision and rapid speed.
9. It is equipped with special CAD/CAM automatic programming and jacking software to save raw materials to the maximum extent.
10. Remote communication and monitoring in laser cutting process could be realized through Internet communication.

2.8.3 Conditions of operating environment

a. Quality of power supply: Tri-phase unbalance factor <2.5%, line voltage fluctuation <5%.
b. Grounding protection: independent grounding of machine tool; independent grounding of tube cutting section; independent grounding of power distribution cabinet; independent grounding of laser device; ground resistance required ＜4Ω. Ground pile: shall be smashed into the ground through an angle iron or wide-diameter rebar no less than 2-3m long; simultaneously proper salt water shall be poured for better grounding effect.
c. Draughty, dust-free, non-corrosive and pollution-free site environment is required.
d. No large vibration is permitted around the installation foundation.
e. The water chilling unit is applied in dedicated devices such as cooling laser device and cutting head; for circulating cooling water, high-quality and mineral-free purified water, distilled water or deionized water is required;
f. For fear of fire hazard, appropriate fire extinguishers and reserved fire fighting access shall be provided in the processing site.
g. Over 1.2M shall be kept between workshop wall and left and rear sides of machine tool; Over 1.0M shall be reserved around the laser device.
h. The control unit, servo unit, displayer and control panel are core components of machine tool, which are demanding on the environment to some extent, and shall be kept away from electromagnetic wave interference, such as arc welding and electric discharge machine, for fear that the normal operation of machine tool is affected.

2.8.4 Impact on environment

Since the laser device of laser cutting machine is a fiber generator, flue gas and dust will be generated in the process of cutting; therefore, it is necessary to purify the flue gas exhausted from the dust exhaust apparatus before emission; simultaneously, it shall avoid fire hazard. The laser device of laser cutting machine is a Class 4 laser product, whose beam ejected, whichever reflected through a lens or reflected diffusely, will impair human body (especially eyes); therefore, it is worth noting that operating personnel and on-site personnel shall wear protective eyeglasses, which the optional SD-4, 1064nm ones are a choice.
Remark: No system and component above shall be changed without permission for the purpose of normal operation of laser head and laser device, as well as guaranteeing steady power of laser device and good mode of laser. It is beyond the warranty coverage including low laser power, poor laser mode and other parts injured due to a user's using undesirable water, electricity and gas without permission.

2.8.5 Technical parameters

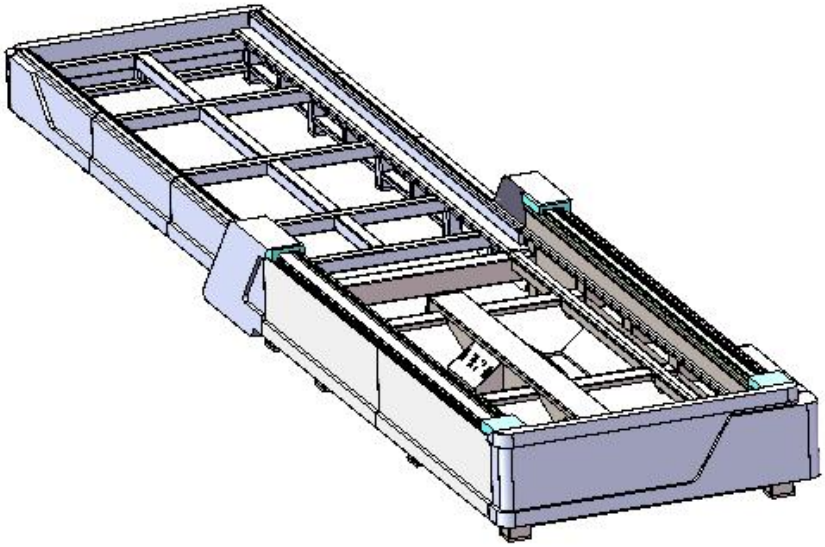
Table 2.8.3 Parameters of E-T Series Plate and Tube Cutting Machine

Model	E1530T
Maximum processing range	1500×3000mm

Stroke of X axis		1500mm
Stroke of Y axis		3000mm
Stroke of Z axis		315mm
Rotation angle of W axis		Unlimited n360
Maximum rotation speed of W axis		80RPM
Positioning precision of X/Y/U axis		±0.03mm
Repeated positioning precision of X/Y/U axis		±0.02mm
X/Y axis maximum moving speed		100m/min
Maximum moving speed of U axis		500mm/s
Maximum cutting speed of X/Y/U axis		35m/min
Maximum acceleration		1.2G
Exchange time of working platform		17s
Power of optional laser device		500W,800W,1000W,1500W,2000W
Maximum length of pipe		Standard configuration is 3m (4m long P□□□□T4 and 6m long P□□□□T6 are optional)
Range of pipe diameter (circumscribed circle)		20-200mm
Driving mode of the chuck		Manual driving is default and electrically-driving is optional
Maximum load of working platform		600kg
Gross power	500W laser device	13.5KW
	800W laser device	14.6KW
	1000W laser device	15.6KW
	1500W laser device	17.3KW
	2000W laser device	19.2KW
Overall size (L * W * H)		9350*3300*2000
Weight of whole machine		6500kg

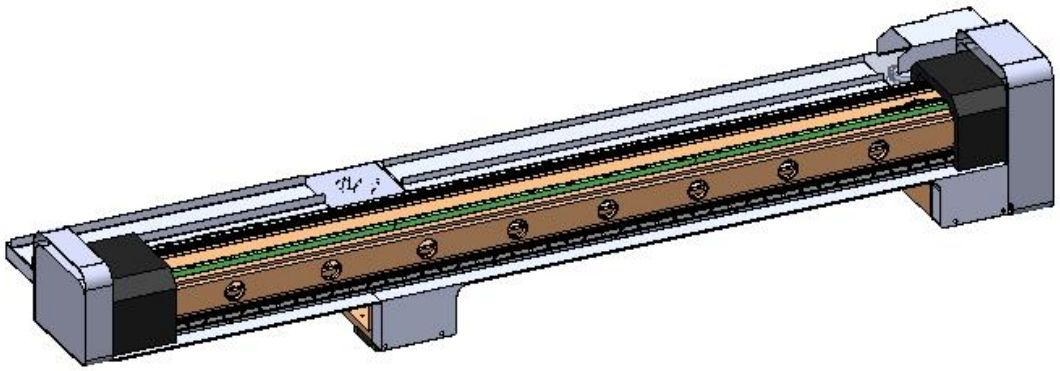
2.8.6 Introduction to main mechanical structure

2.8.6.1 Lathe bed for cutting plate



The lathe bed consisting of front and rear lathe beds is welded and then aging processed in the procedure of vibration aging after rough processing, semi-finish processing, vibration aging and finish processing, which thoroughly eliminates the stress and reduces the deformation of the lathe bed, ensuring long-term uniform precision of the machine tool.
The numerical control system controls the driving of the servo motor and drives the cross beam to coaxially reciprocate along the direction of X axis, achieving rapid movement and feeding motion; the gear rack and linear guideway are equipped with a closed dust-proof device with a light dust-proof cover and good operation reliability. The gear rack and linear guideway are both precise products, effectively ensuring the driving precision; Limit switches are installed at both sides of the stroke assisted by two elastic cushions, effectively ensuring safe motion of the machine tool.

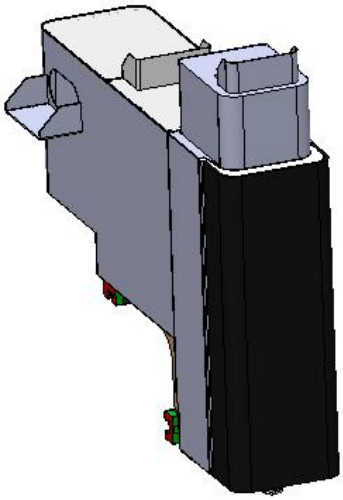
2.8.6.2 Cross beam



The cross beam is casted using the integrated high-strength aluminium alloy. The cross beam is treated by solution, artificial aging and then machine-processed, ensuring the overall rigidity and strength. The processing procedure consists of rough processing, vibration aging, semi-finish processing, vibration aging and finish processing.
The cross beam is installed on the guideway of the lathe bed. A high-quality linear guideway is installed on the cross beam and the servo motor drives the gear to rotate through the

decelerator, enabling the slider on Z axis to reciprocate along Y axis; The limit switch controls the stroke together with the elastic cushions on both sides, ensuring safe operation of the system. The top and left and right sides of the cross beam are closed by the outer cover and an scalable organ type protection cover is installed between horizontal sliders, ensuring the fully closed operating environment for the gear rack and linear guideway without impact of outside environment.

2.8.6.3 Z axis device



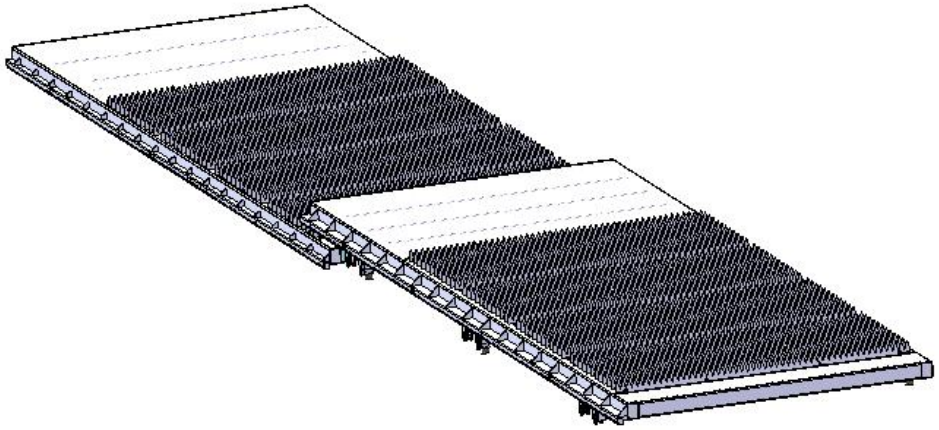
The Z axis device is applied in the lifting motion of cutting head. The lifting motion of cutting head is achieved by up-down reciprocating motion of Z axis slider driven by the numerical control system controlling servo motor and the motor driving ball screw. The stroke of both up and down ends is controlled by proximity switch. Both ball screw and linear guideway are high quality products, ensuring the driving precision.

The Z axis can interpolate independently as a numerical control axis, move together with the X and Y axes and switch to follow-up motion mode through the electrically-controlled part of the cutting head to meet the requirements of different situations. The follow-up motion of Z axis is controlled by the numerical control system, which is relatively high-precision and stable, thus ensuring the quality of cutting.

The capacitance sensor (mounted on the cutting head) in Z axis device will feed the signals that the distance from nozzle to the surface of profile back to the control system which would then control the motor of Z axis to drive the up-down motion of cutting head, therefore keeping a constant distance between the nozzle and profile and effectively ensuring the cutting quality. The cutting head is equipped with nut that adjusts the focal length, and the location of focus could be adjusted based on the texture and thickness of cutting material, thus good cutting section is available. Since the nozzle is one of quick-wear parts during processing, users may reserve some nozzles with different hole diameters for convenient replacement.

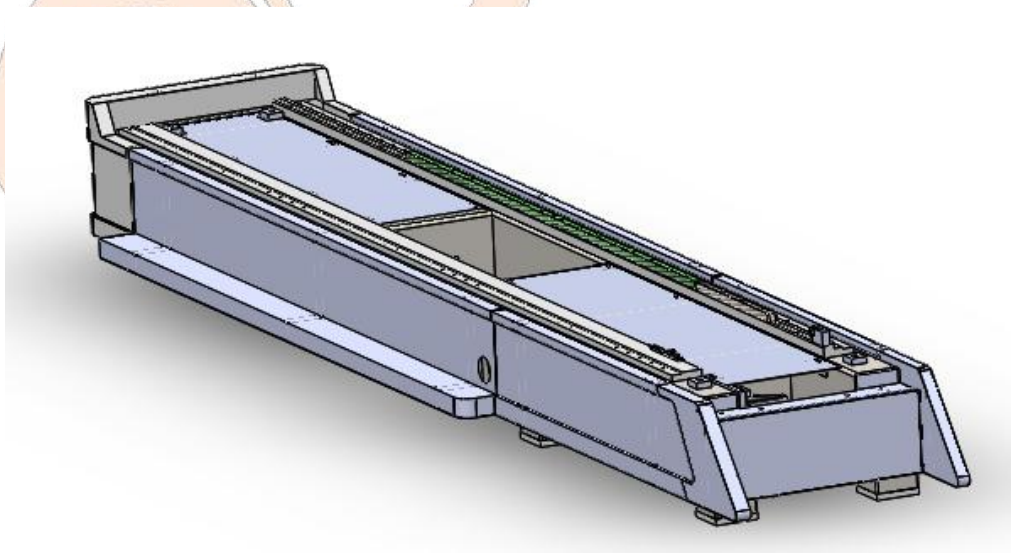
Z axis is equipped with linear guideway seat nozzle and lead screw seat nozzle respectively for filling lubricating grease on a regular basis.

2.8.6.4 Workbench



The workbench consists of upper and lower surfaces in integrally welded structure and with high strength and stability. Both the upper and lower surfaces are installed with blades to support the sheet metal, and the driving gear rack and roller are installed at the bottom of the surfaces, driving the upper and lower workbench surfaces to exchange positions along the upper guide of the lathe bed. When the plate on the front workbench is being cut, the rear workbench loads and unloads the plates having been processed or to be processed, which improves the processing efficiency.

2.8.6.5 Lathe bed for cutting tube

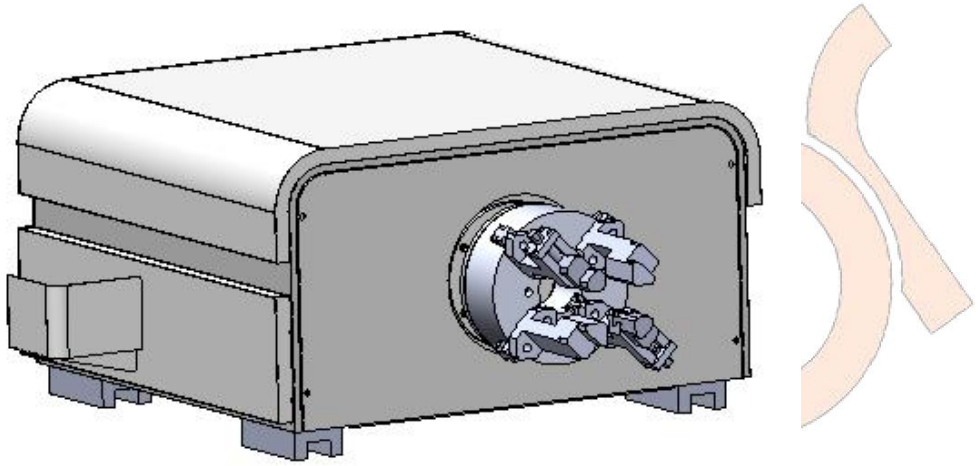


The lathe bed structure is integrally welded and then aging processed in the procedure of vibration aging after rough processing, semi-finish processing, vibration aging and finish processing, which thoroughly eliminates the stress and reduces the deformation of the lathe bed, ensuring long-term uniform precision of the machine tool.

The numerical control system controls the driving of the servo motor and drives the feeding

mechanism to coaxially reciprocate, achieving rapid movement and feeding motion; The gear rack and linear guideway are both precise products, effectively ensuring the driving precision; Limit switches are installed at both sides of the stroke assisted by two elastic cushions, effectively ensuring safe motion of the machine tool.

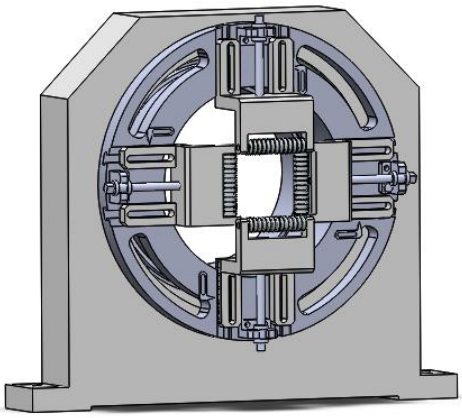
2.8.6.6 Feeding mechanism



The servo motor drives the feeding mechanism to move along Y axis and the rotating servo motor drives rotation of the rear clamped chuck through the belt in cooperation with the servo motor along Y axis to cut the work piece into desired shapes. The gear rack and linear guideway are both precise products, effectively ensuring the driving precision; Limit switches are installed at both sides of the stroke assisted by two elastic cushions, effectively ensuring safe motion of the machine tool.
The slider of feeding mechanism has a closed outer cover, ensuring the fully closed operating environment of drive mechanism including the servo motor and belt without impact of the outside environment.

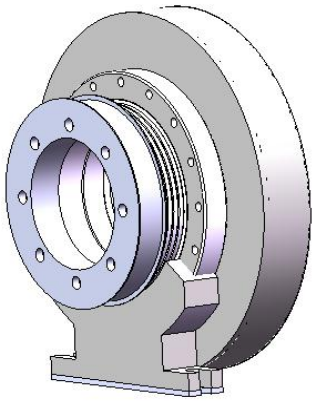
2.8.6.7 Front chuck

Manual chuck (standard)



The standard manual chuck mainly consists of base, rotation disc, claw, adjusting mechanism, etc. The centering position of the claw can be adjusted forward and backward by the adjusting bolt to adapt to clamped pipes with different diameters.

Electrically-driven chuck (optional)



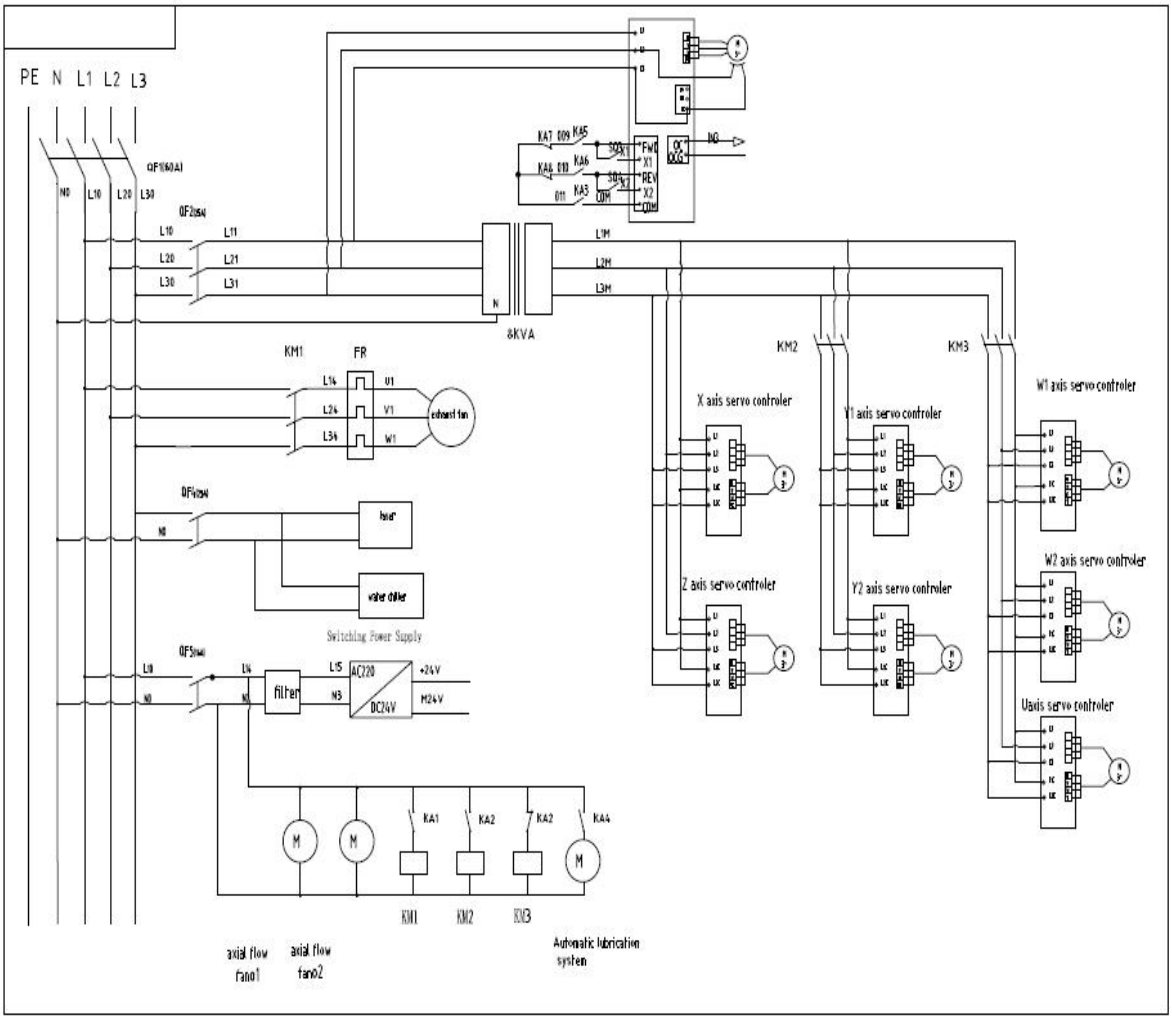
The electrically-driven chuck mainly consists of motor, drive mechanism, claw, etc. The motor drives the drive mechanism to move the claw forward and backward for centering to adapt to clamped pipes with different diameters. The clamping force can be adjusted by the current to avoid deformation of thin-wall tubes when clamped.

The clamping by electrically chuck is easy and convenient, reducing the labor strength of the operating personnel and improving the efficiency. It is more applicable to automated production.

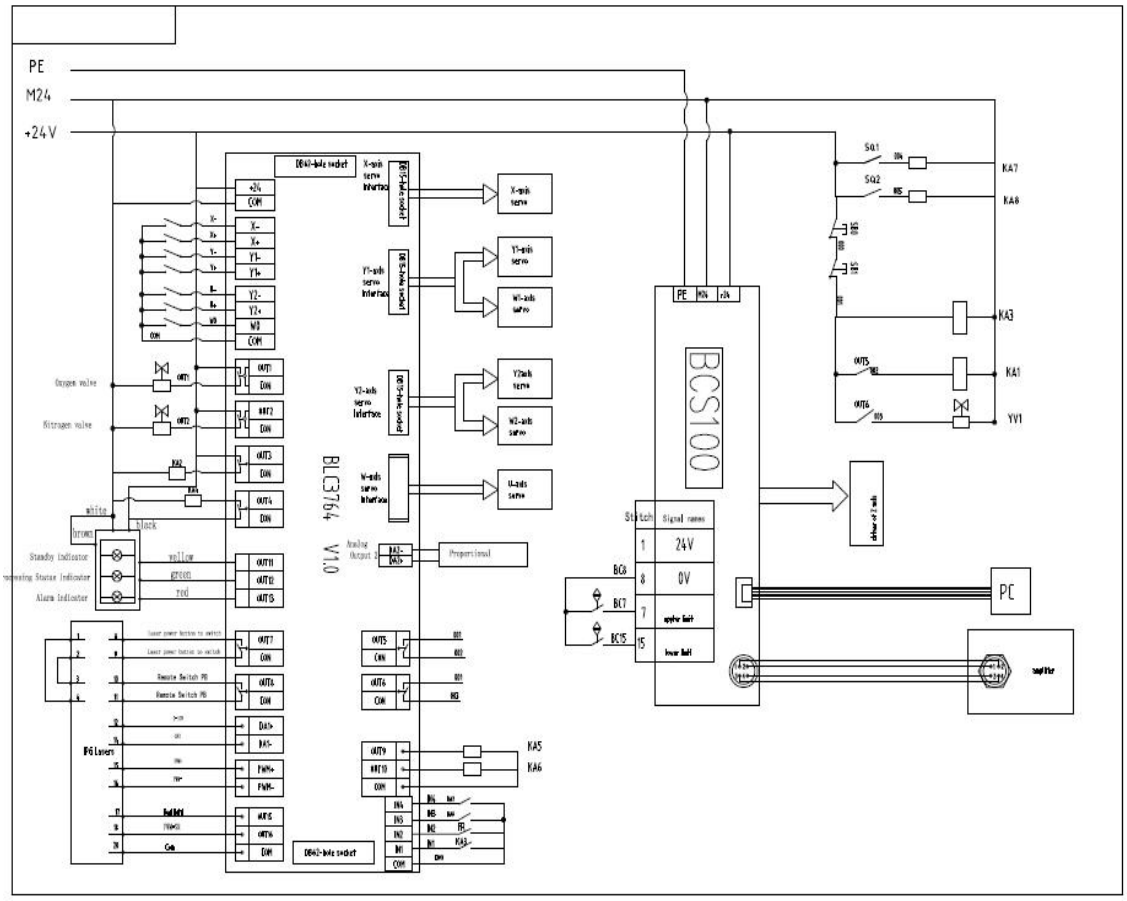
2.8.7 Electrical system

I. Schematic diagram

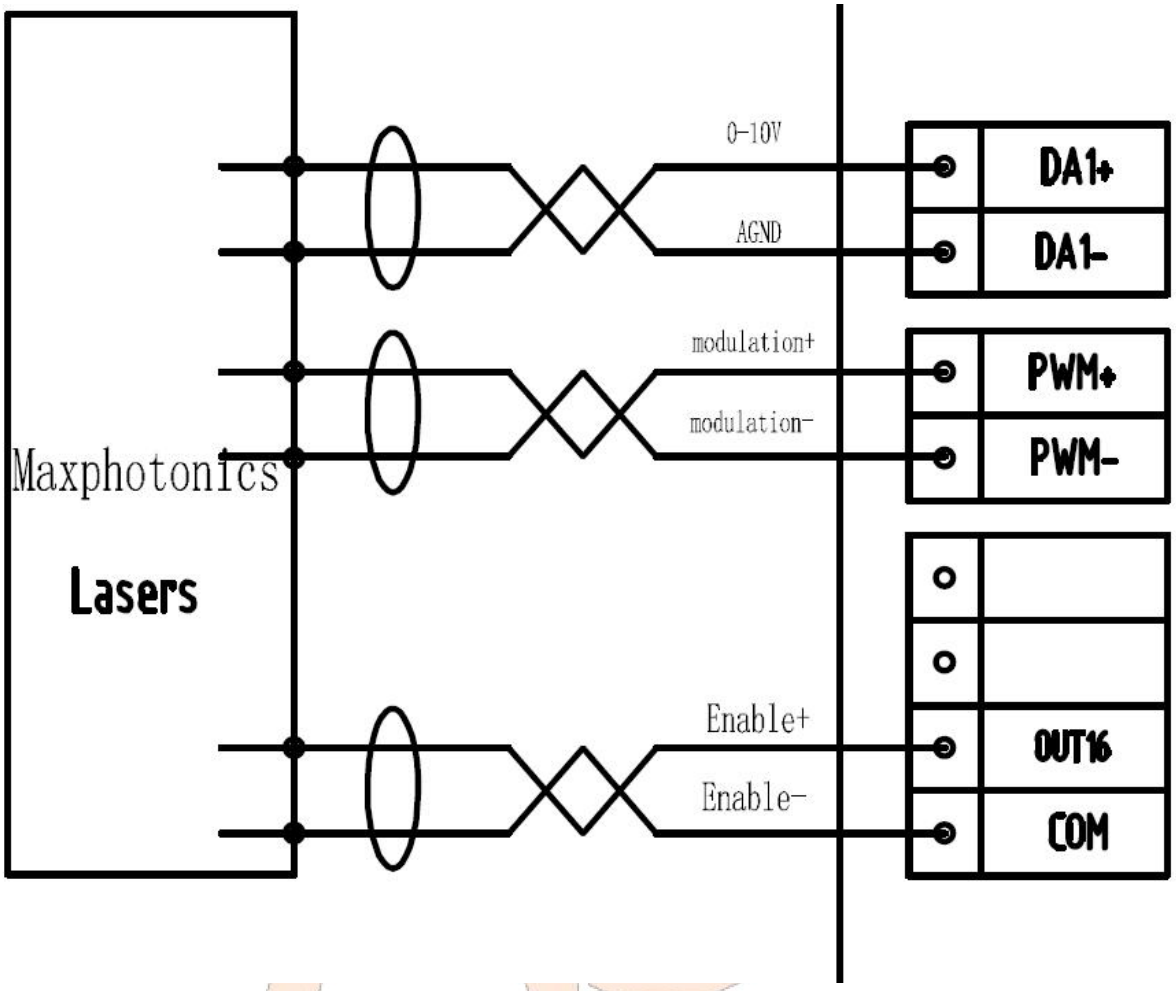
1) Major Loop

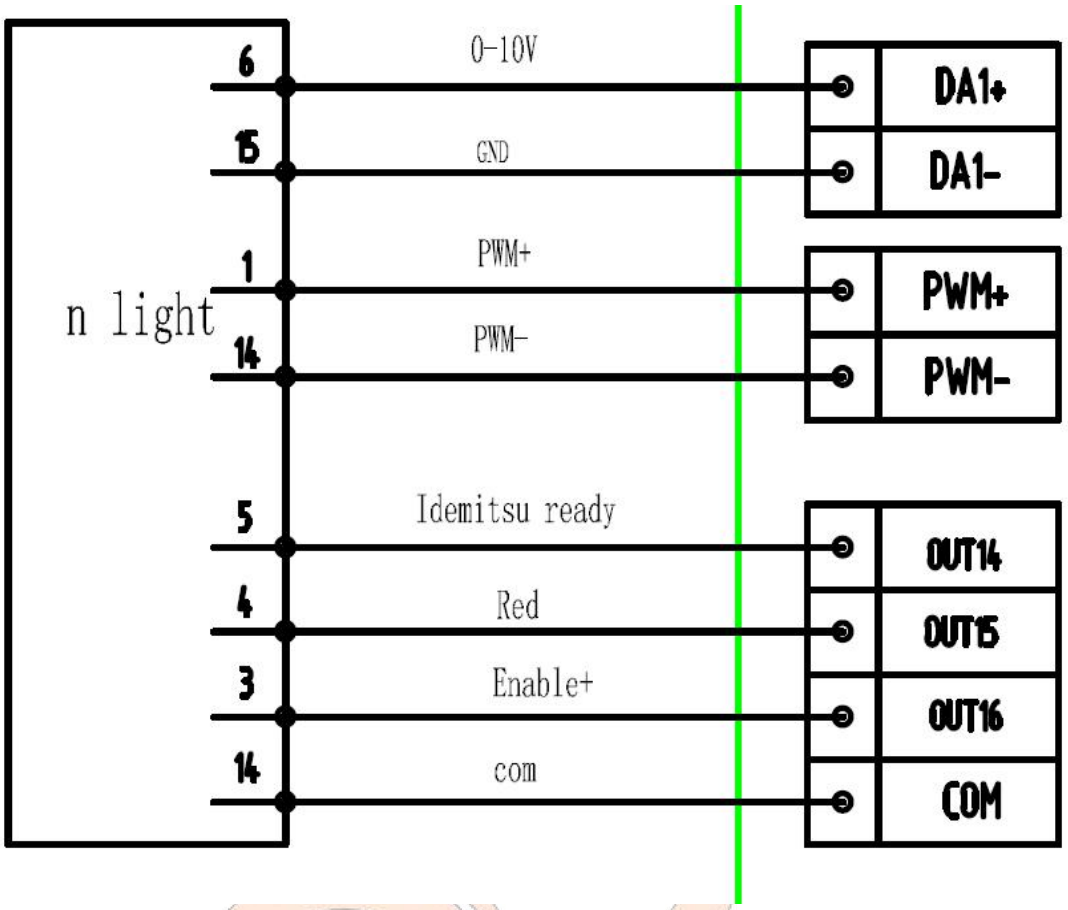


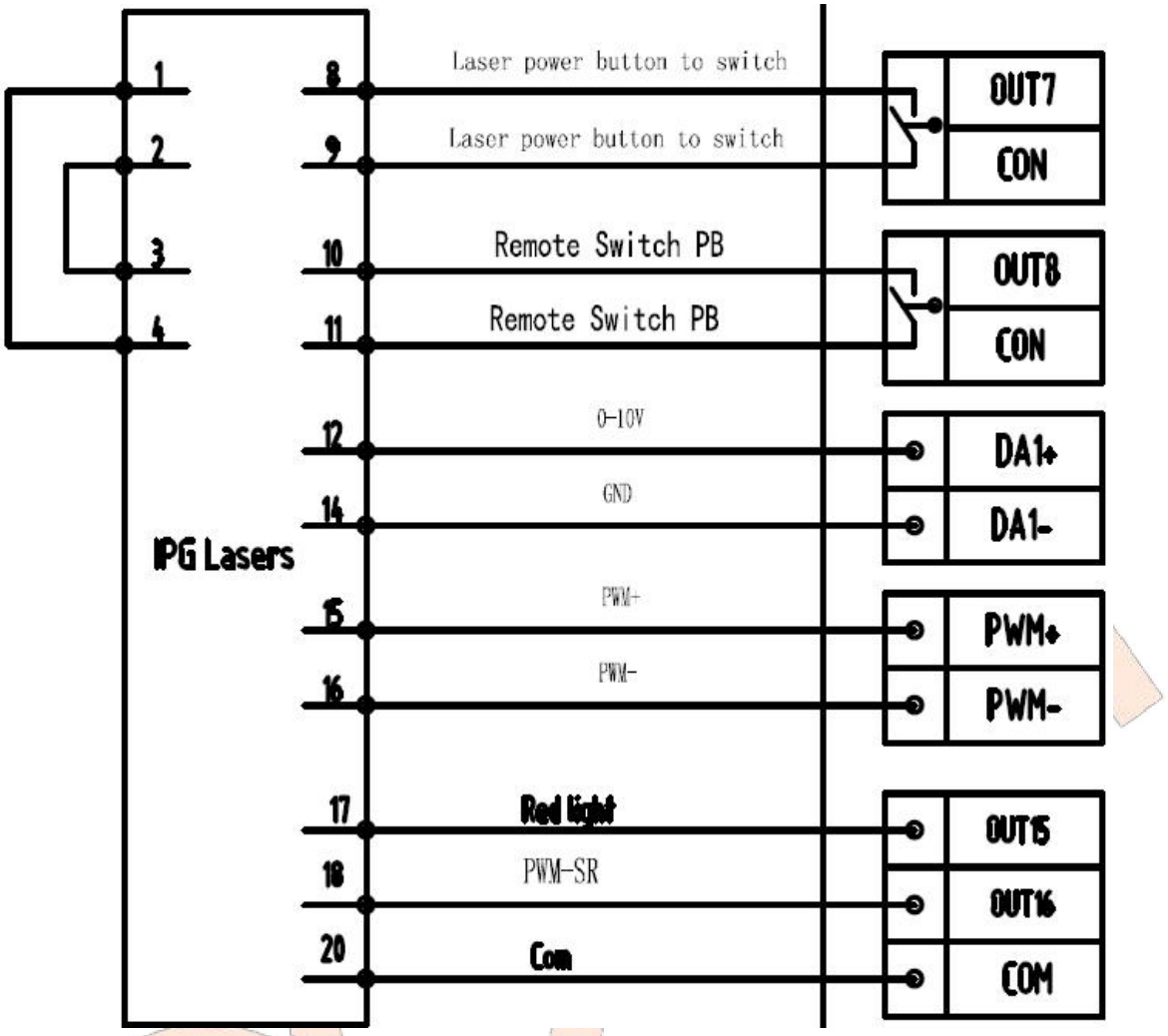
2) Control Loop



3) Connection Diagram of Laser Device


0-10V
AGND
modulation+
modulation-
Maxphotonics
Lasers
Enable+
Enable-
DA1+
DA1-
PWM+
PWM-
OUT16
COM

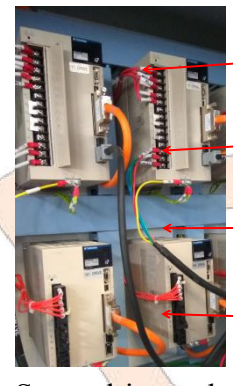

n light
6
0-10V
15
GND
1
PWM+
14
PWM-
5
Idemitsu ready
4
Red
3
Enable+
14
com
DA1+
DA1-
PWM+
PWM-
OUT14
OUT15
OUT16
COM



1) Electrical cabinet

The majority of electrical components is mounted inside and used to supply electricity for the machine.

2) Drive



Power line, used to supply electricity for drives

Supply electricity for servo motor

A line of encoder that provides a feedback signal for servo device

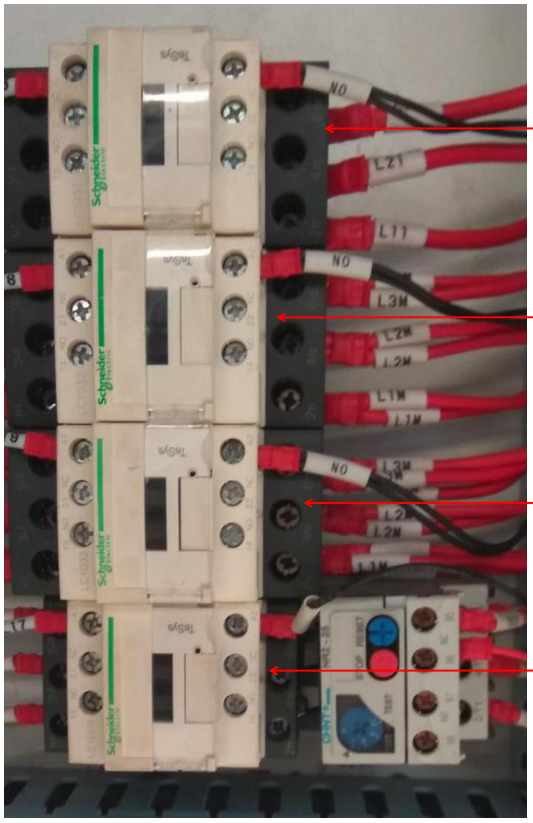
Signal line, employed to control the signal of drives

Servo drives, also called "servo controller" or "servo amplifier", just like a variable-frequency drive acting on general AC motor, is a controller to control a servo motor; as a part of the servo system, it is mainly applied in a high-precision positioning system. It currently is a cutting-edge product of drive technology, which is generally used to control a servo motor through three modes of location, speed and moment of force to achieve high-precision positioning of drive system.

3) Servo transformer

Such type of servo transformer is specifically designed for servo drive system, which could provide necessary electric energy for servo drive.

4) Contactor



Control drive power supply (LCD1D32AC/220V)

Control drive power supply (LCD1D32AC/220V)

Control drive power supply (LCD1D32AC/220V)

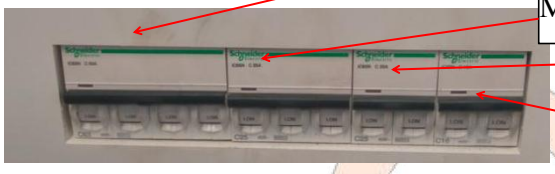
Control fan (LC1D09AC/220V)

Load appliances could be controlled by switching on the contacts under the action of magnetic field generated when current passes through the coil.

5) Height-adjustment device

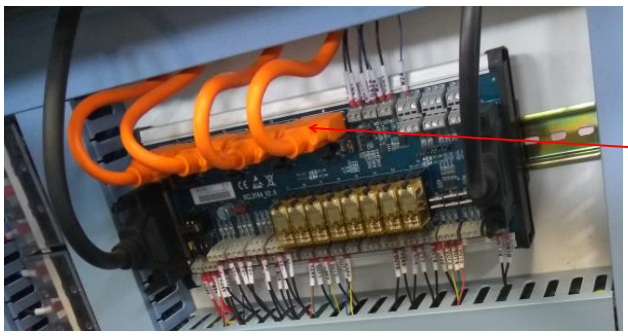
During cutting, it is the laser head to maintain a constant distance between laser head and sheet metal, not only getting laser head protected effectively, but also achieving sophisticated techniques, including multi-stage perforation.

6) Circuit breaker



The circuit breaker could be used to distribute electric energy, start occasionally an asynchronous motor and protect power line and motor and so on; in case these devices are in overload, short circuit, undervoltage and other trouble states, it could shut down the circuit automatically, which functions as the combination of fuse-switch and overthermal-underthermal relay. Moreover, no part or component is required to be changed after disjuncting fault current.

7) Pinboard



Connect drives, control signals

The motion control card is an upper control unit based on PC and industrial PC, and applied in various motion control occasions (including displacement, speed, acceleration, etc).

The motion control card is a PC bus-based, high-performance stepping/ servo motor, being capable of achieving multi-axis coordinative control of several servo motors by taking advantage of high-performance microprocessor (for instance DSP) and large scale programmable devices. With the functions of pulse output, pulse counting, digital input, digital output, D/A output, etc., it is able to send continuous, high-frequency pulse train, and control the motor speed by changing the frequency of pulse sent and control the location of motor by changing the quantity of pulse sent. Its mode of pulse input includes pulse/direction and pulse/pulse. The pulse counting could be used to feed back the location of encoder, provide accurate location of machine and correct the error in the process of drive. Digital input/output point could be applied in limit switch, origin switch, etc. Library functions include S-type/T-type acceleration, line interpolation, circular interpolation, multi-axis linkage function, etc. The product is widely applied in location control system that location and length are required to be confirmed precisely, and PC-based NC control system in the field of industrial automatic control. Specifically, integrating bottom software that achieves motion control with hardware endows them with various control functions of speed and location required for controlling servo motor; these functions could be easily called via a computer.

8) Intermediate relay

It is applied in relay protection and automatic control system to increase the quantity and volume of contact points. It is used to transmit M signals in the control circuit. The structure and principle of intermediate relay are basically the same with those of AC contactor, and main differences between them lie in: A large current is allowed to pass through the main contact of the contactor, while the only low current is permitted to pass through the contacts

of the intermediate relay. Therefore, the intermediate relay could be used in control circuit only. As the overload capacity is small, generally no main contact exists in an intermediate relay. So all its contacts, sufficient in quantity, are auxiliary. The intermediate relay is defined as K in the new national standard, KA in previous national standards. Generally it is powered with DC power supply. The minority is powered with AC power supply.

9) Switching power supply

24V power supply

10) Filter

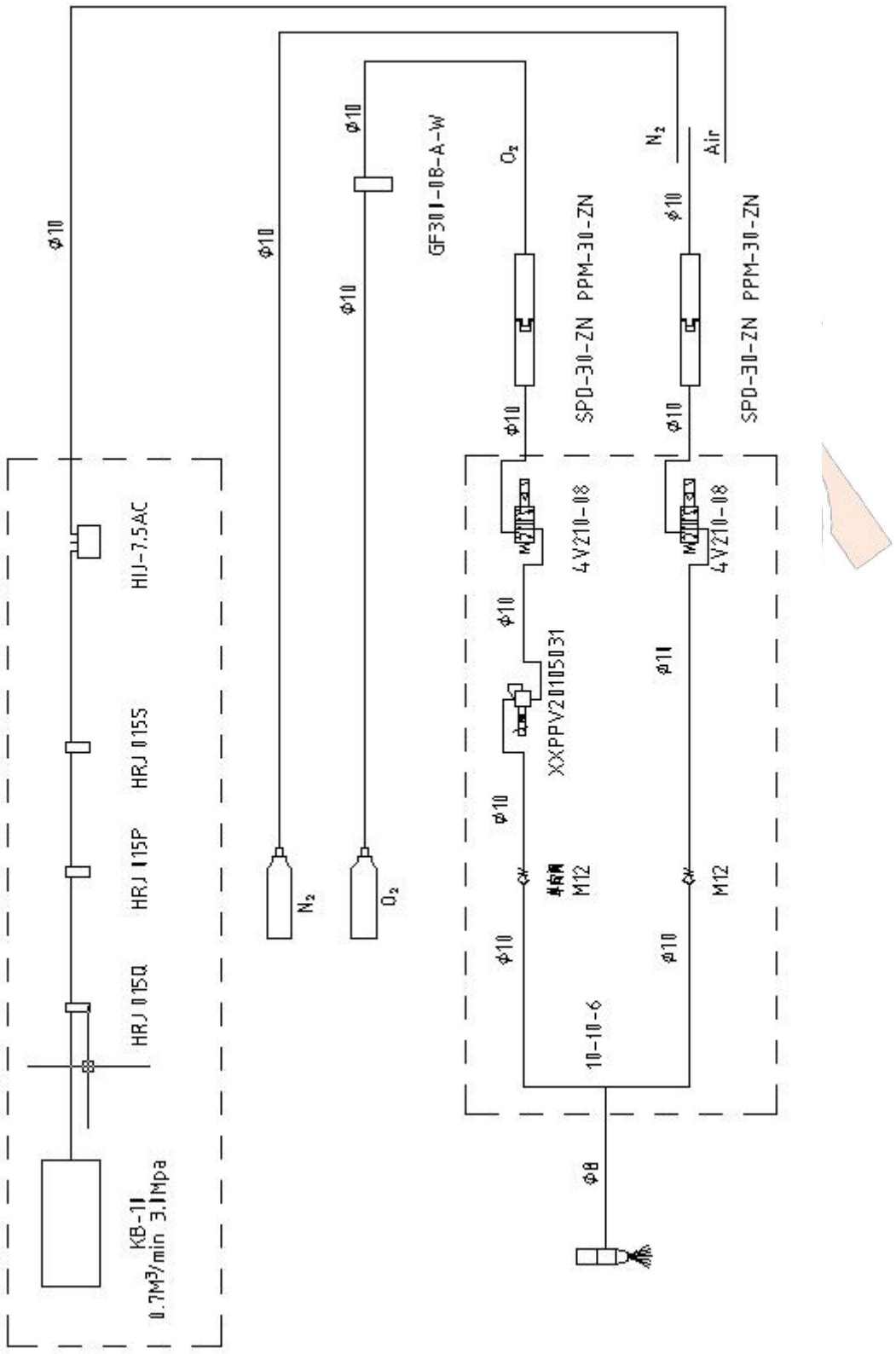
The power filter is a filter circuit consisting of capacitance, inductance and resistance. The filter could effectively filter out a frequency point of specific frequency in a power line or frequency other than the frequency point to obtain power signals of a specific frequency or power signals after eliminating a specific frequency.

11) Variable-frequency drive

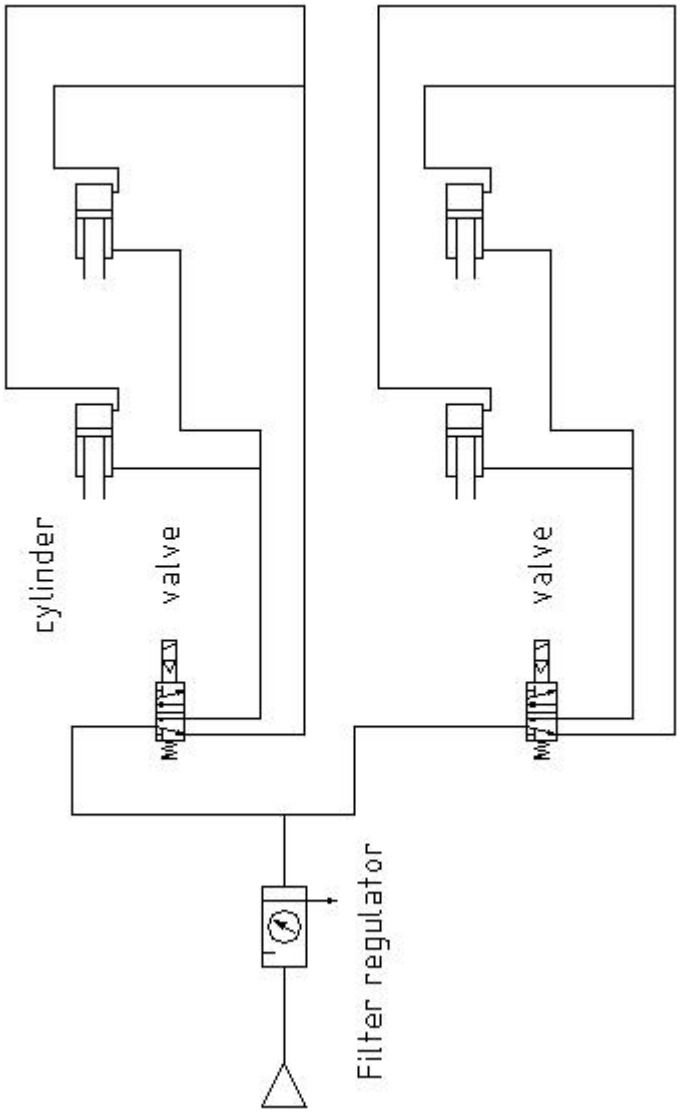
The variable-frequency drive (VFD) is a power control equipment that controls the AC motor by varying the operating power supply frequency of the motor utilizing the variable-frequency and microelectronic technologies. The VFD mainly consists of rectifier (converting AC to DC), filter, inverter (converting DC to AC), brake unit, driver unit, detection unit, micro-processing unit, etc. The VFD adjusts the voltage and frequency of output power supply by breaking the internal IGBT and outputs the required power supply voltage according to the actual demand of the motor to achieve energy-saving and speed-adjusting.

2.8.8 Gas circuit system

The cutting gas supplied by the laser cutting machine to the cutting head includes high purity oxygen and nitrogen. Oxygen is mainly applied in cutting of general carbon steel; Nitrogen is mainly used to cut stainless steel and alloy steel. Different cutting gas shall be used for variant materials.



Gas Circuit Schematic Diagram of Cutting Gas

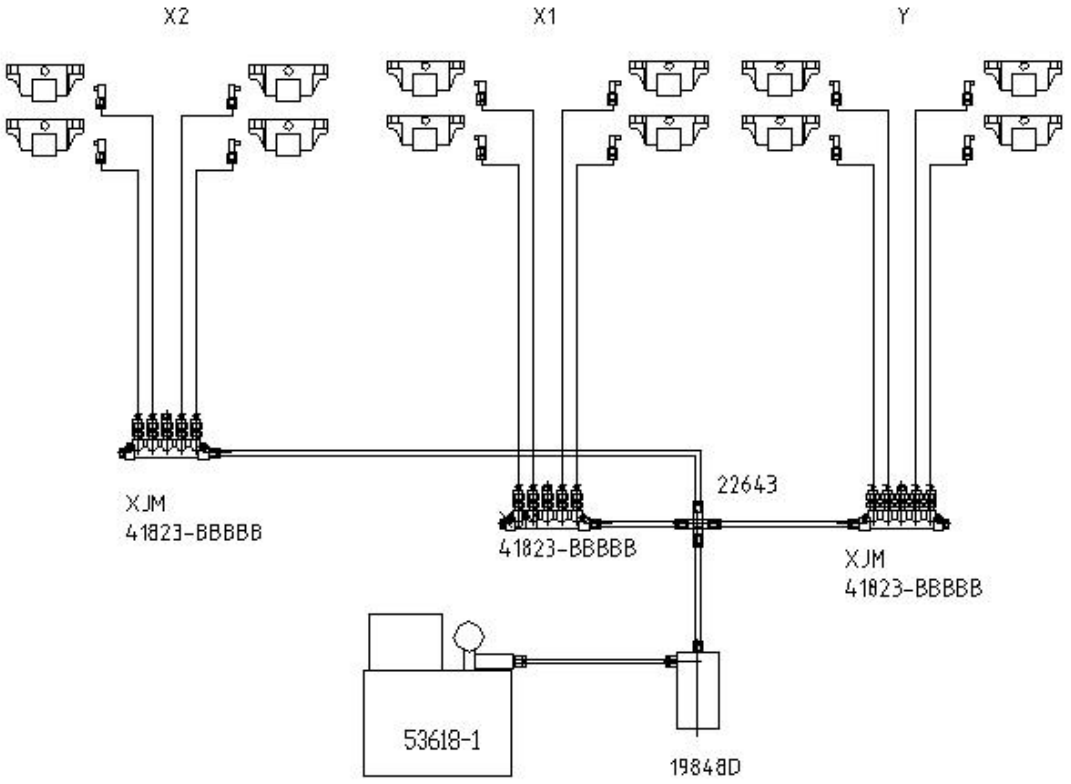


Pneumatic Schematic Diagram of the Pipe Component

2.8.9 Cooling system

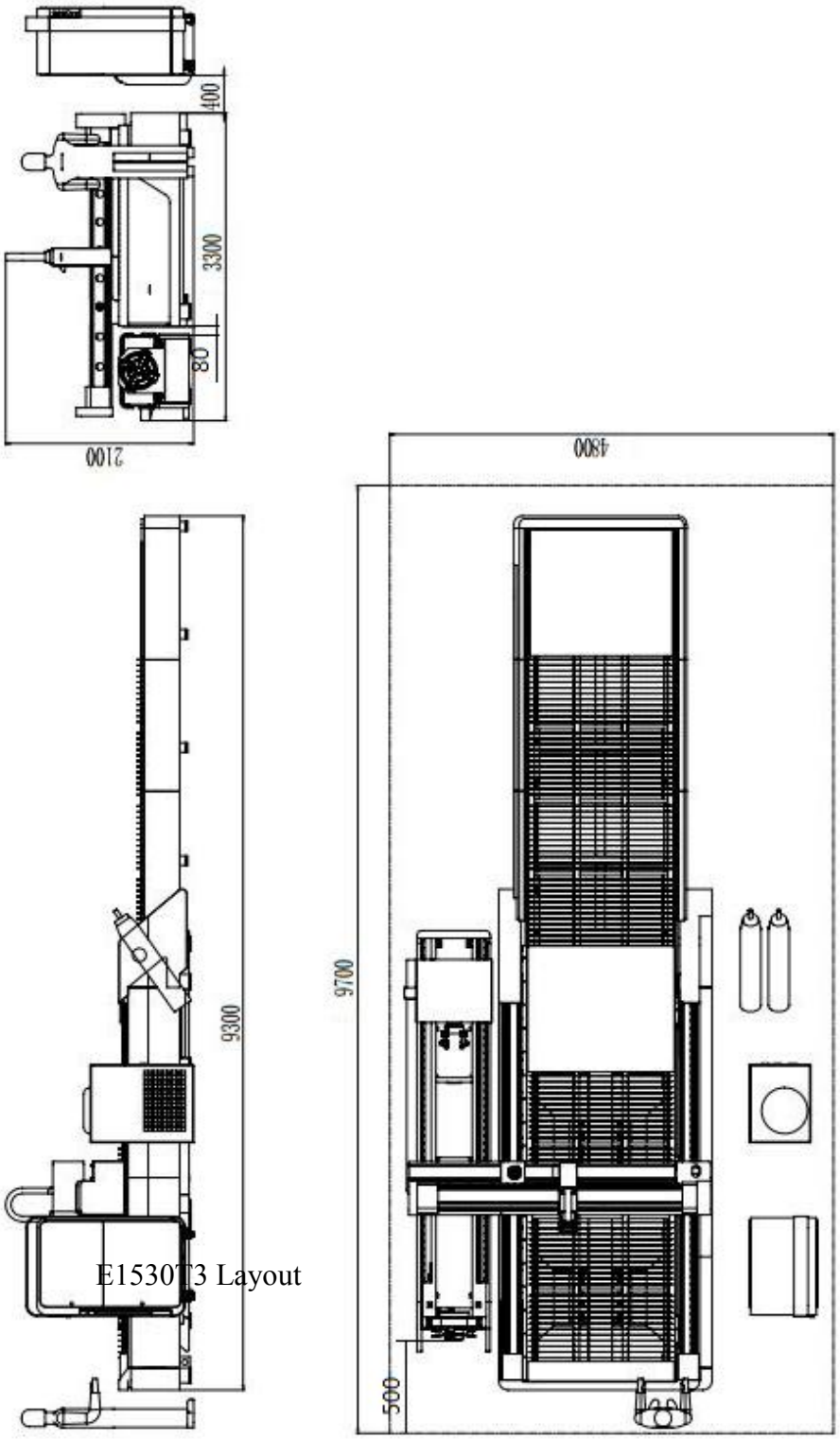
The water circuit system of the laser cutting machine consists of two parts: one part of the circuit is that the cooling water from the water chilling unit flows into the laser device, cools the laser device when flowing through the radiator in the laser device and returns to the water chilling unit; the other part is that the cooling water cools the reflector and cutting head of the optical system.

2.8.10 Lubricating system



Schematic Diagram of Lubrication

2.8.11 Product layo



E1530T3 Layout

2.9 T series pipe cutting machine

2.9.1 External view

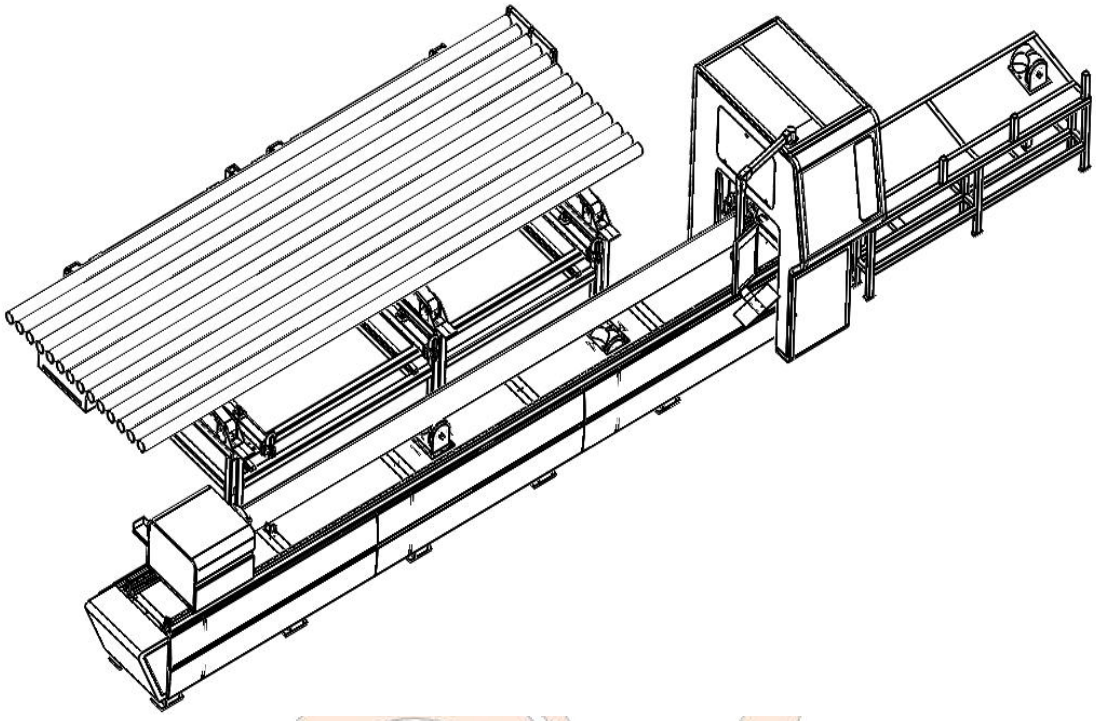


Figure 2.9.1 T Series Pipe Cutting Machine

2.9.2 Main features

1. High-performance laser device associated with stable operation system enables optimal cutting effects.
2. Perfect cooling, lubrication and dedusting systems ensure stable, efficient and durable performance of the whole machine.
3. Double electrically-driven chucks and double-servo driving design enables cutting of circular tube, square tube, rectangle tube, oval tube and I-shape steel.
4. Pneumatic roller support ensures stable rotation during cutting.
5. Automatic height-adjustment performance keeps constant focal length and stable cutting quality.
6. It takes precise linear guideway and gear rack as driving elements which could realize high precision and rapid speed.
7. It could cut mental in various materials and realize excellent and stable cutting effects.
8. It is equipped with special CAD/CAM automatic programming and jacking software to save raw materials to the maximum extent.
9. Remote communication and monitoring in laser cutting process could be realized through the direct communication between network interface and numerical control system.

2.9.3 Conditions of operating environment

a. Quality of power supply: Tri-phase unbalance factor <2.5%, line voltage fluctuation <5%.
b. Grounding protection: independent grounding of machine tool; independent grounding of tube cutting section; independent grounding of power distribution cabinet; independent grounding of laser device; ground resistance required ＜4Ω. Ground pile: shall be smashed into the ground through an angle iron or wide-diameter rebar no less than 2-3m long; simultaneously proper salt water shall be poured for better grounding effect.
c. Draughty, dust-free, non-corrosive and pollution-free site environment is required.
d. No large vibration is permitted around the installation foundation.
e. The water chilling unit is applied in dedicated devices such as cooling laser device and cutting head; for circulating cooling water, high-quality and mineral-free purified water, distilled water or deionized water is required;
f. For fear of fire hazard, appropriate fire extinguishers and reserved fire fighting access shall be provided in the processing site.
g. Over 1.2M shall be kept between workshop wall and left and rear sides of machine tool; Over 1.0M shall be reserved around the laser device.
h. The control unit, servo unit, displayer and control panel are core components of machine tool, which are demanding on the environment to some extent, and shall be kept away from electromagnetic wave interference, such as arc welding and electric discharge machine, for fear that the normal operation of machine tool is affected.

2.9.4 Impact on environment

The laser device of laser cutting machine is a Class 4 laser product, whose beam ejected or reflected diffusely, will impair human body (especially eyes); therefore, it is worth noting that operating personnel and on-site personnel shall wear protective eyeglasses, which the optional SD-4, 1064nm ones are a choice.

Remark: No system and component above shall be changed without permission for the purpose of normal operation of laser head and laser device, as well as guaranteeing steady power of laser device and good mode of laser. It is beyond the warranty coverage including low laser power, poor laser mode and other parts injured due to a user's using undesirable water, electricity and gas without permission.

2.9.5 Technical parameters

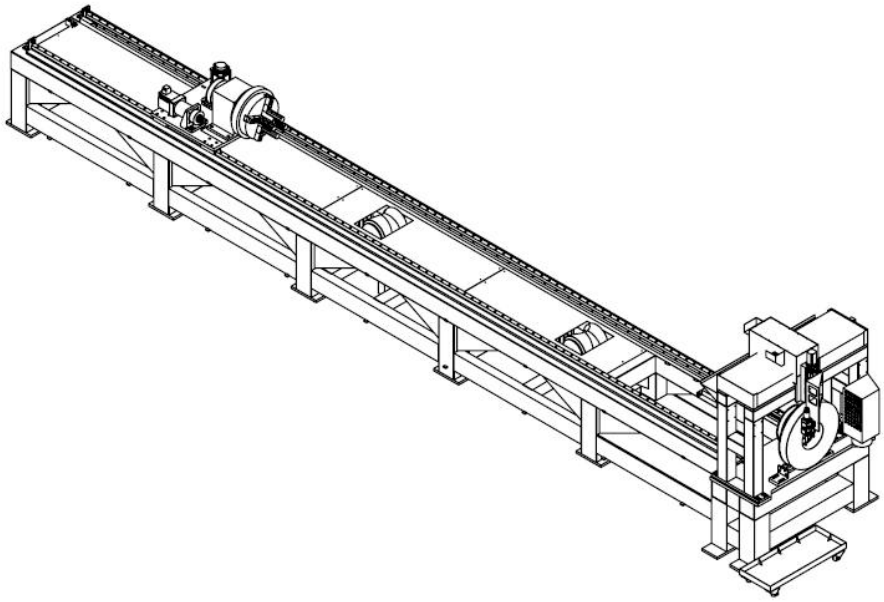
Table 2.9.5 Parameters of T Series Pipe Cutting Machine

Model		T6	T6E	T9	T9E
Processed diameter of pipe		Φ20-Φ200mm			
Processed length of pipe		6000mm		9000mm	
Stroke of X axis		250mm			
Stroke of Y axis		6500mm		9500mm	
Stroke of Z axis		150mm			
Rotation angle of W axis		Unlimited n*360			
Maximum rotation speed of W axis		80RPM			
Positioning precision of X/Y axis		±0.03mm			
Repeated positioning precision of X/Y axis		±0.02mm			
X axis maximum moving speed		40m/min			
Y axis maximum moving speed		500m/s			
X/Y axis maximum cutting speed		35m/min			
Maximum acceleration of X axis		1.2G			
Maximum acceleration of Y axis		0.6G			
Chuck type		Electrically-driven type			
Maximum load		400kg			
Power of optional laser device		500W,800W,1000W,1500W,2000W			
Semi-automatic feeding		None	Yes	None	Yes
Gross power	500W laser device	13KW	14KW	13KW	14KW
	800W laser device	14KW	15KW	14KW	15KW
	1000W laser device	15KW	16KW	15KW	16KW
	1500W laser device	17KW	18KW	17KW	18KW
	2000W laser device	19KW	20KW	19KW	20KW

Overall size (L * W * H)	12000×1800 ×2400mm	12000×4500 ×2400mm	15000×1800 ×2400mm	15000×1800 ×2400mm
Weight of whole machine	3800kg	4300kg	4500kg	6000kg

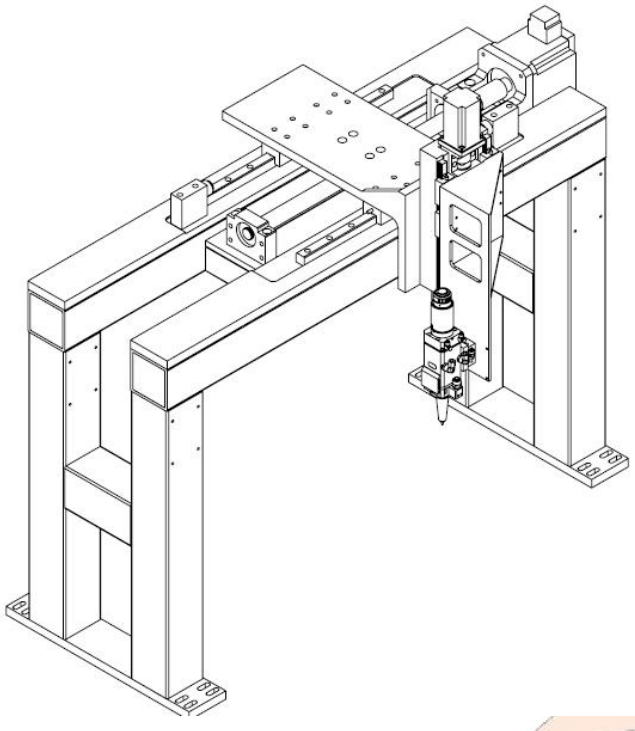
2.9.6 Introduction to main components of product

2.9.6.1 Lathe bed part



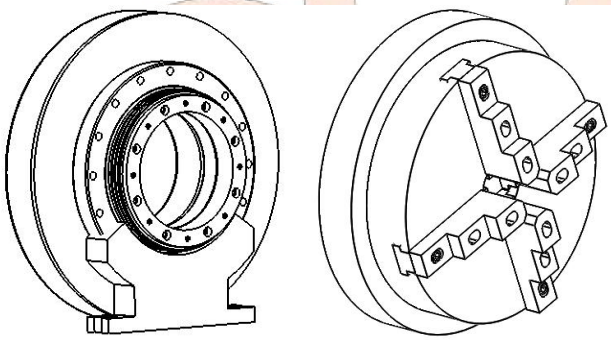
The lathe bed is an integrally welded structure and rib reinforcements are used to increase the strength and rigidity. It is formed by integral welding and then heat treated to eliminate the internal stress and significantly reduce the deformation of the lathe bed after installation.
The installation surface sizes of lathe bedway, rack, cross beam, etc. are clamped and processed one time, thus improving the processing precision and synthesized mechanical properties of lathe bed and ensuring a high cutting precision in the meanwhile.

2.9.6.2 Cross beam part



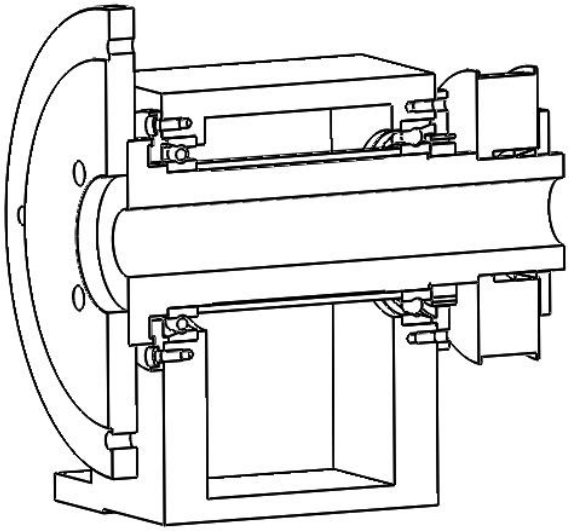
The cross beam is in gantry structure also processed by the procedure of "integral welding-heat treatment-mechanical processing" during which the advanced heat treatment is conducted after the welding to ensure the high strength, processing precision and rigidity of the beam.

2.9.6.3 Chuck part



The T series special optical fiber laser cutting machine for pipe is in the driving structure with front and back electrically-driven chucks and double servos. The chuck is clamped and released in pairs, electrically-driven, convenient and reliable in operation. In addition, the clamping force of the chuck claw can be set according to the thickness of pipe wall to avoid deformation of the processed work piece caused by excessive clamping force.

2.9.6.4 Principal axis component



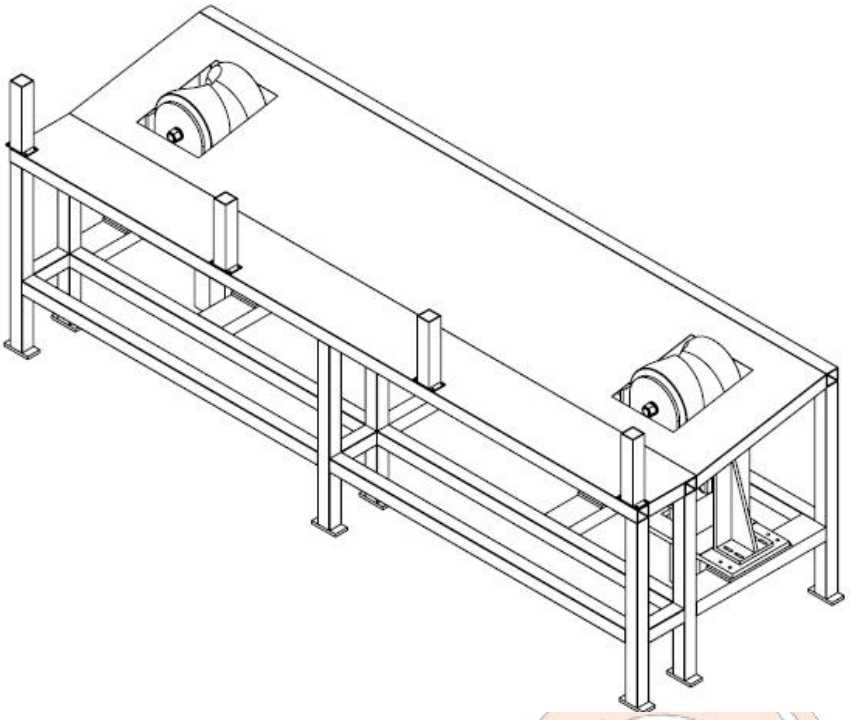
The principal axis component mainly consists of principal axis box, principal axis, connecting flange, bearing, synchronization wheel, etc. It is designed, processed and assembled in compliance with the machine tool criterion to ensure high driving precision.

2.9.6.5 Drive part

The drive mode of gear rack for Y axis, and the kind of drive combining ball screw and linear guideway for X and Z axes, as well as strict match commissioning applied in drive mechanism and servo control system ensure high-speed, precise and steady movement of various axes.

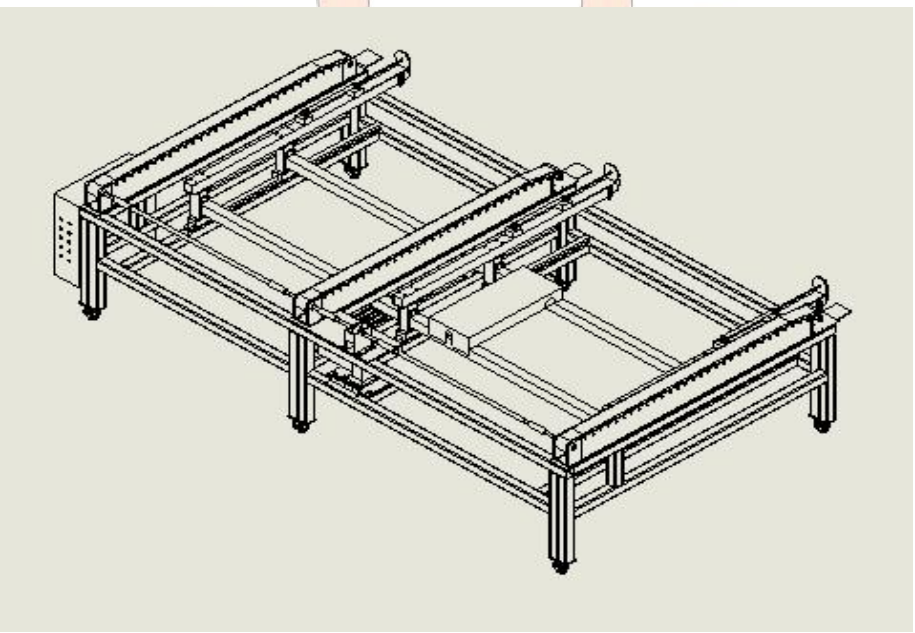
The drive part is provided with servo motor, ball screw, linear guide, decelerator and other domestic and overseas well-known brand products, improving the control and operation precision and service life of products.

2.9.6.6 Blanking device part



The blanking device part is mainly used for cutting of relatively long work piece and the roller lifting device can support the processed long work piece to further improve the cutting precision while protecting the cut work piece. The roller is a patented product independently developed by our company.

2.9.6.7 Automatic feeding device part:

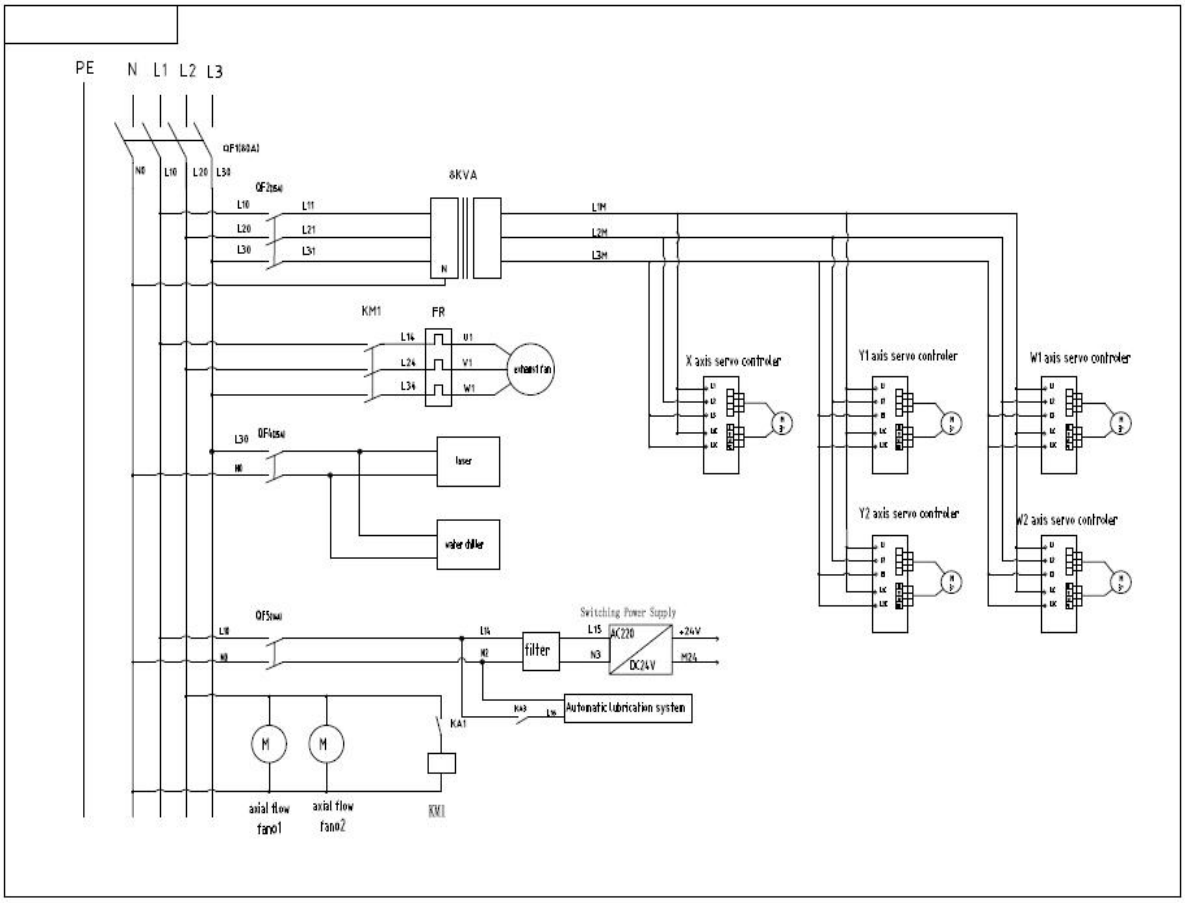


The automatic feeding device part mainly consists of welding machine on the lathe bed, power device, retractable bracket, pneumatic component, electric control cabinet, etc. It is used associated with the special optical fiber pipe cutting machine, which simplifies operation, decreases costs, improves efficiency, reduces labor strength and realizes the automatic feeding of pipe. (The function is available in T6E and T9E)

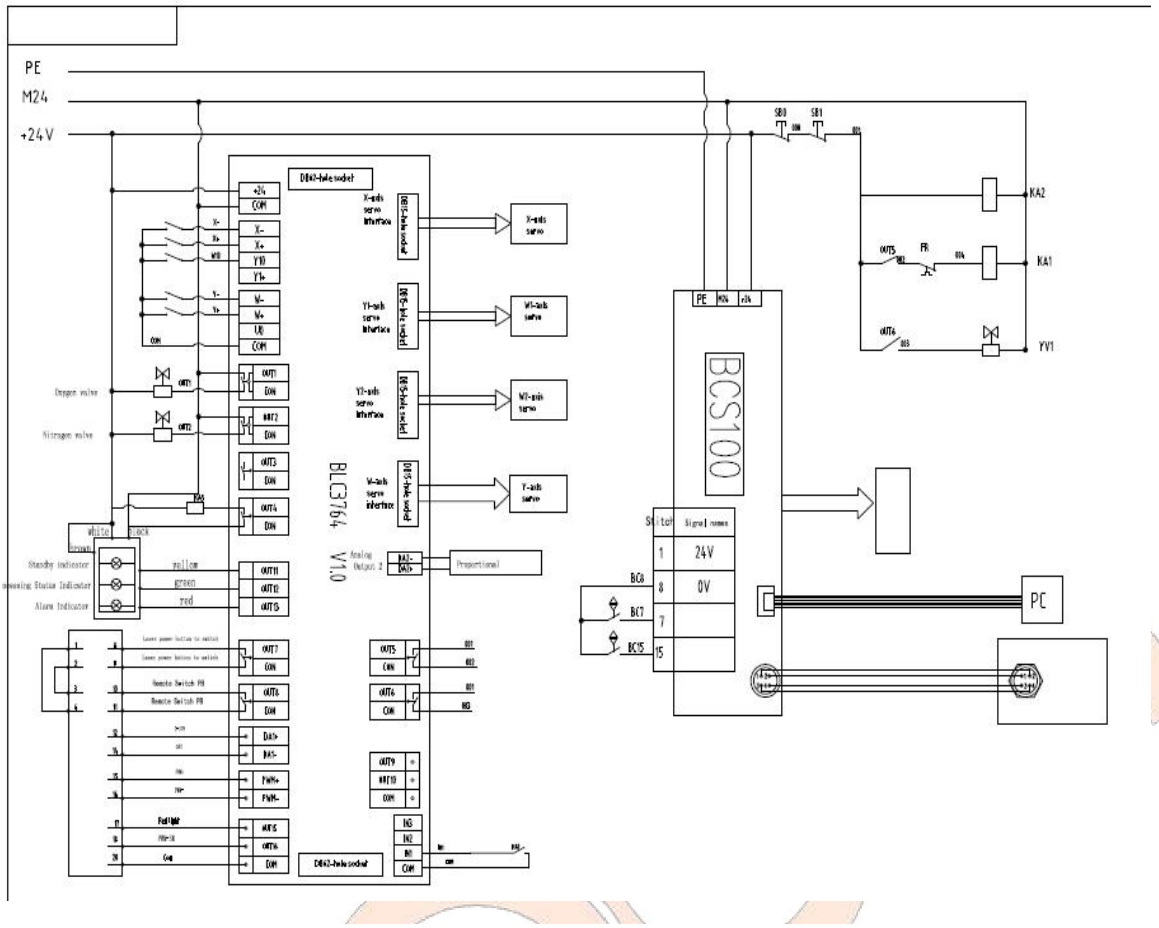
2.9.7 Electrical control

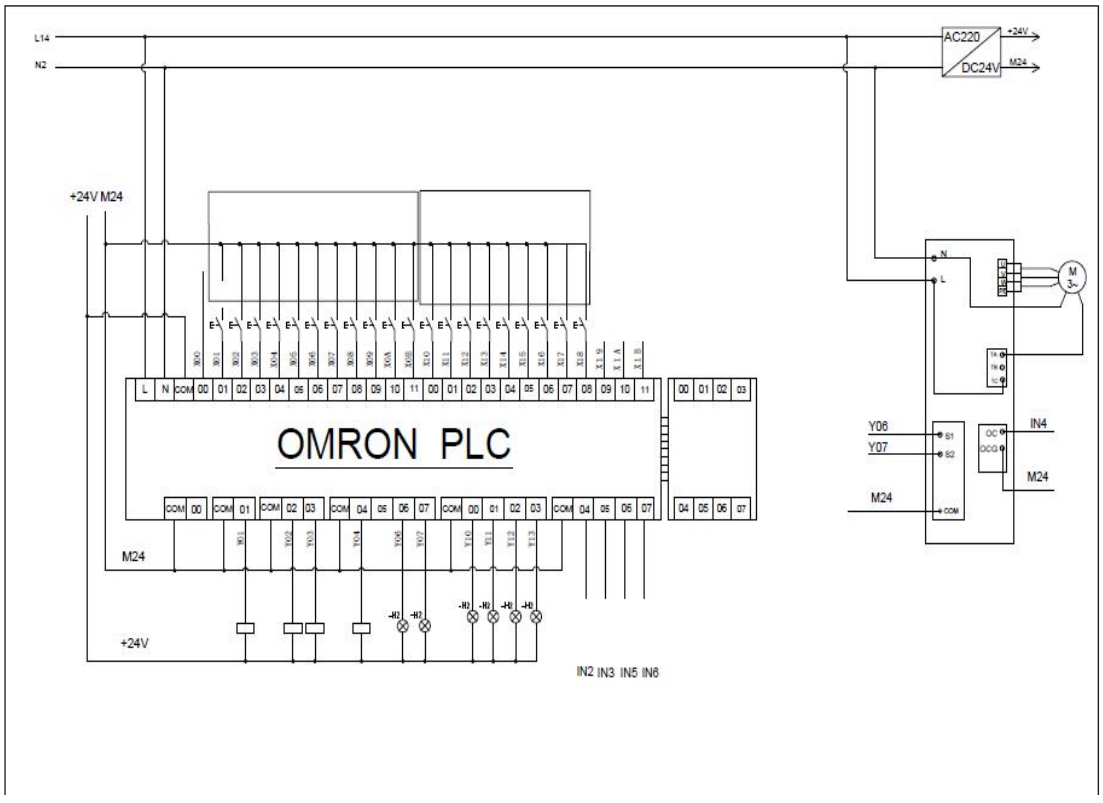
I. Schematic diagram

1) Major Loop

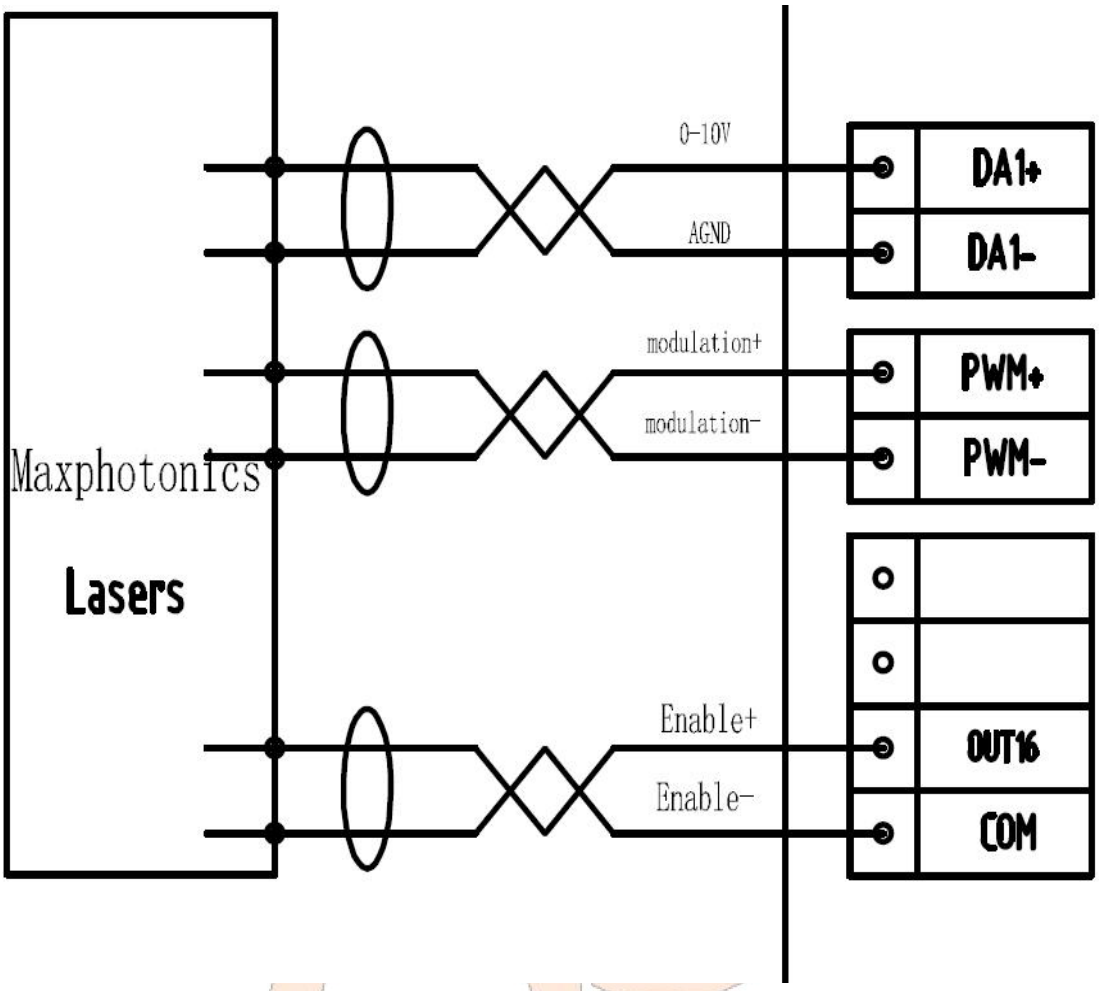


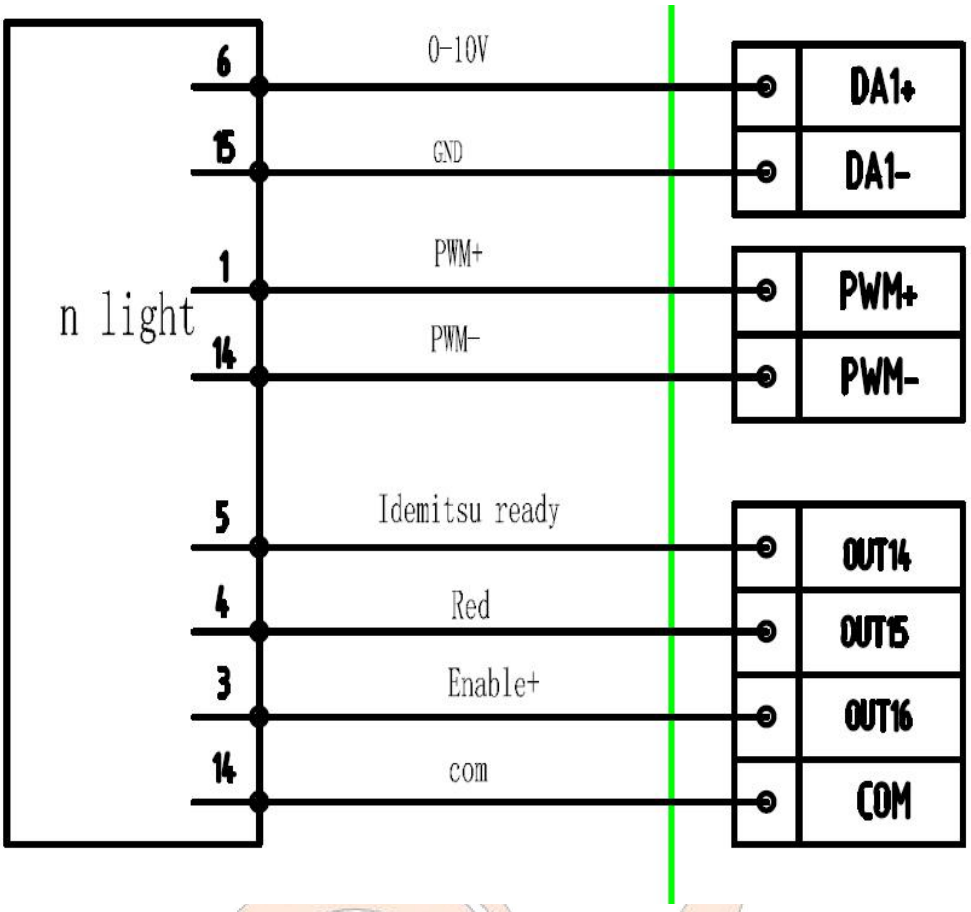
2) Control Loop

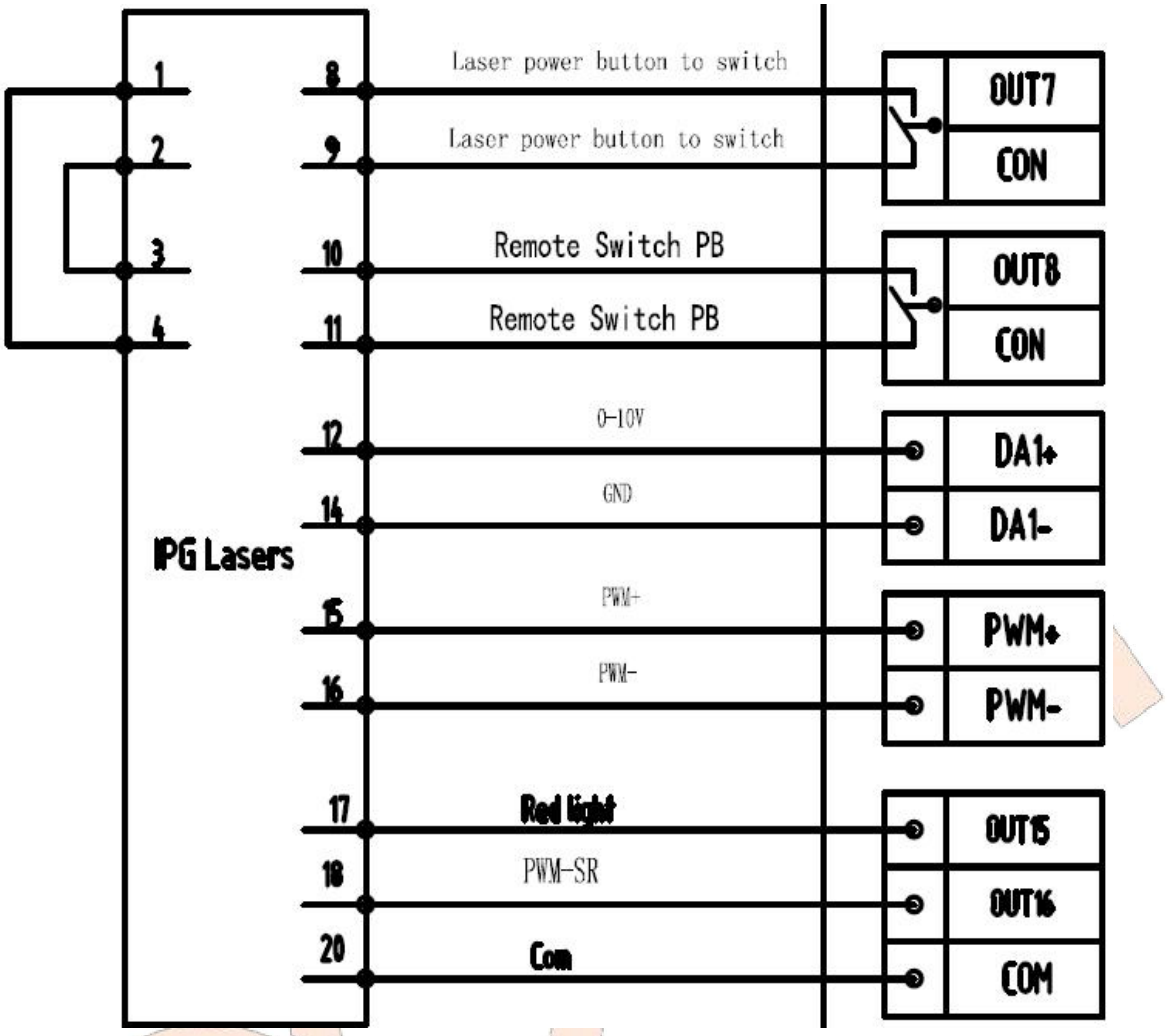




3) Connection Diagram of Laser Device


0-10V
AGND
modulation+
modulation-
Maxphotonics
Lasers
Enable+
Enable-
DA1+
DA1-
PWM+
PWM-
OUT16
COM


n light
6
15
1
14
5
4
3
14
0-10V
GND
PWM+
PWM-
Idemitsu ready
Red
Enable+
com
DA1+
DA1-
PWM+
PWM-
OUT14
OUT15
OUT16
COM

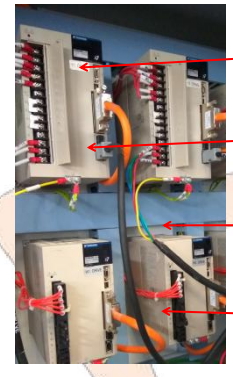


II. Basic electrical parts and their functions

1) Electrical cabinet

The majority of electrical components is mounted inside and used to supply electricity for the machine.

2) Drive



Power line, used to supply electricity for drives

Supply electricity for servo motor

A line of encoder that provides a feedback signal for servo device

Signal line, employed to control the signal of drives

Servo drives, also called "servo controller" or "servo amplifier", just like a variable-frequency drive acting on general AC motor, is a controller to control a servo motor; as a part of the servo system, it is mainly applied in a high-precision positioning system. It currently is a cutting-edge product of drive technology, which is generally used to control a servo motor through three modes of location, speed and moment of force to achieve high-precision positioning of drive system.

3) Servo transformer

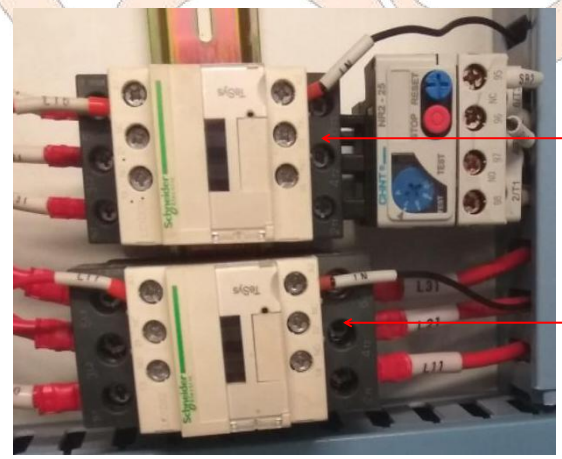
Input voltage

Connecting zero line

Output voltage

Such type of servo transformer is specifically designed for servo drive system, which could provide necessary electric energy for servo drive.

4) Contactor

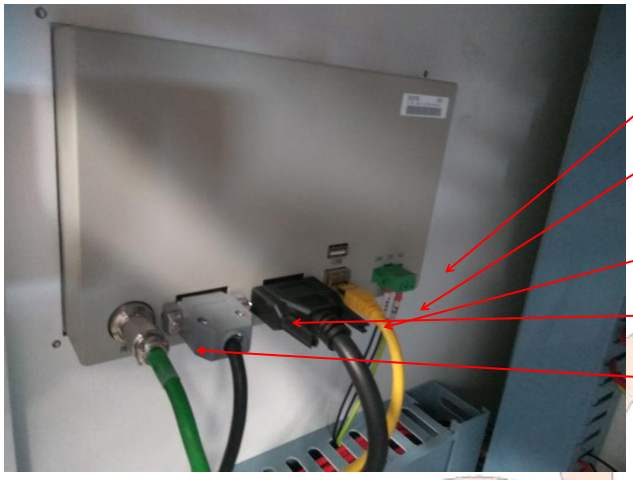


Control fan (LC1D09AC/220V)

Control drive power supply (LCD1D32AC/220V)

Load appliances could be controlled by switching on the contacts under the action of magnetic field generated when current passes through the coil.

5) Height-adjustment device



Supply 24V electricity for height-adjustment device

Network cable, communicated with the upper computer

Connect drives

Limit signal

Signal line of sensor

During cutting, it is the laser head to maintain a constant distance between laser head and sheet metal, not only getting laser head protected effectively, but also achieving sophisticated techniques, including multi-stage perforation.

6) Circuit breaker

Main power switch

drives

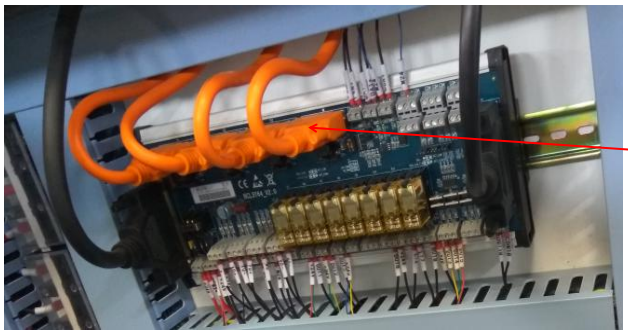
Power switch of laser water chiller

System power switch

The circuit breaker could be used to distribute electric energy, start occasionally an asynchronous motor and protect power line and motor and so on; in case these devices are in overload, short circuit, undervoltage and other trouble states, it could shut down the circuit automatically, which functions as the combination of fuse-switch and

overthermal-underthermal relay. Moreover, no part or component is required to be changed after disjuncting fault current.

7) Pinboard



The motion control card is an upper control unit based on PC and industrial PC, and applied in various motion control occasions (including displacement, speed, acceleration, etc).

The motion control card is a PC bus-based, high-performance stepping/ servo motor, being capable of achieving multi-axis coordinative control of several servo motors by taking advantage of high-performance microprocessor (for instance DSP) and large scale programmable devices. With the functions of pulse output, pulse counting, digital input, digital output, D/A output, etc., it is able to send continuous, high-frequency pulse train, and control the motor speed by changing the frequency of pulse sent and control the location of motor by changing the quantity of pulse sent. Its mode of pulse input includes pulse/direction and pulse/pulse. The pulse counting could be used to feed back the location of encoder, provide accurate location of machine and correct the error in the process of drive. Digital input/output point could be applied in limit switch, origin switch, etc. Library functions include S-type/T-type acceleration, line interpolation, circular interpolation, multi-axis linkage function, etc. The product is widely applied in location control system that location and length are required to be confirmed precisely, and PC-based NC control system in the field of industrial automatic control. Specifically, integrating bottom software that achieves motion control with hardware endows them with various control functions of speed and location required for controlling servo motor; these functions could be easily called via a computer.

8) Intermediate relay

It is applied in relay protection and automatic control system to increase the quantity and volume of contact points. It is used to transmit M signals in the control circuit. The structure and principle of intermediate relay are basically the same with those of AC contactor, and main differences between them lie in: A large current is allowed to pass through the main contact of the contactor, while the only low current is permitted to pass through the contacts

of the intermediate relay. Therefore, the intermediate relay could be used in control circuit only. As the overload capacity is small, generally no main contact exists in an intermediate relay. So all its contacts, sufficient in quantity, are auxiliary. The intermediate relay is defined as K in the new national standard, KA in previous national standards. Generally it is powered with DC power supply. The minority is powered with AC power supply.

9) Switching power supply

24V power supply

10) Filter

The power filter is a filter circuit consisting of capacitance, inductance and resistance. The filter could effectively filter out a frequency point of specific frequency in a power line or frequency other than the frequency point to obtain power signals of a specific frequency or power signals after eliminating a specific frequency.

11) Chuck control cabinet

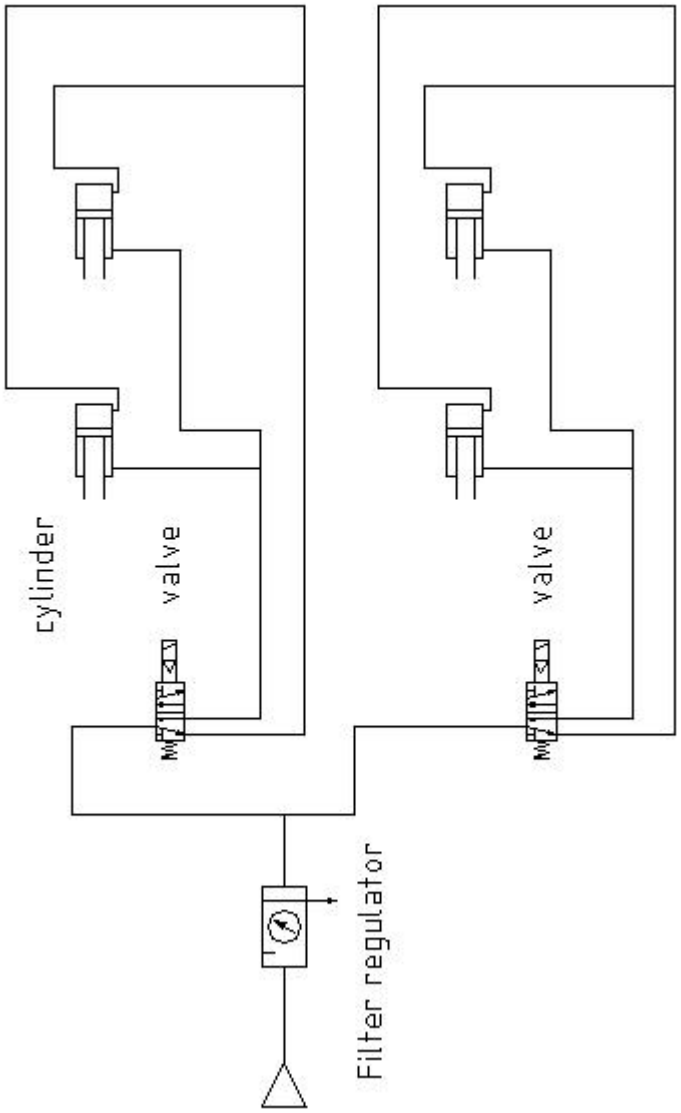
The front and back chuck control devices are installed in the cabinet to control the clamping

and release of chucks.

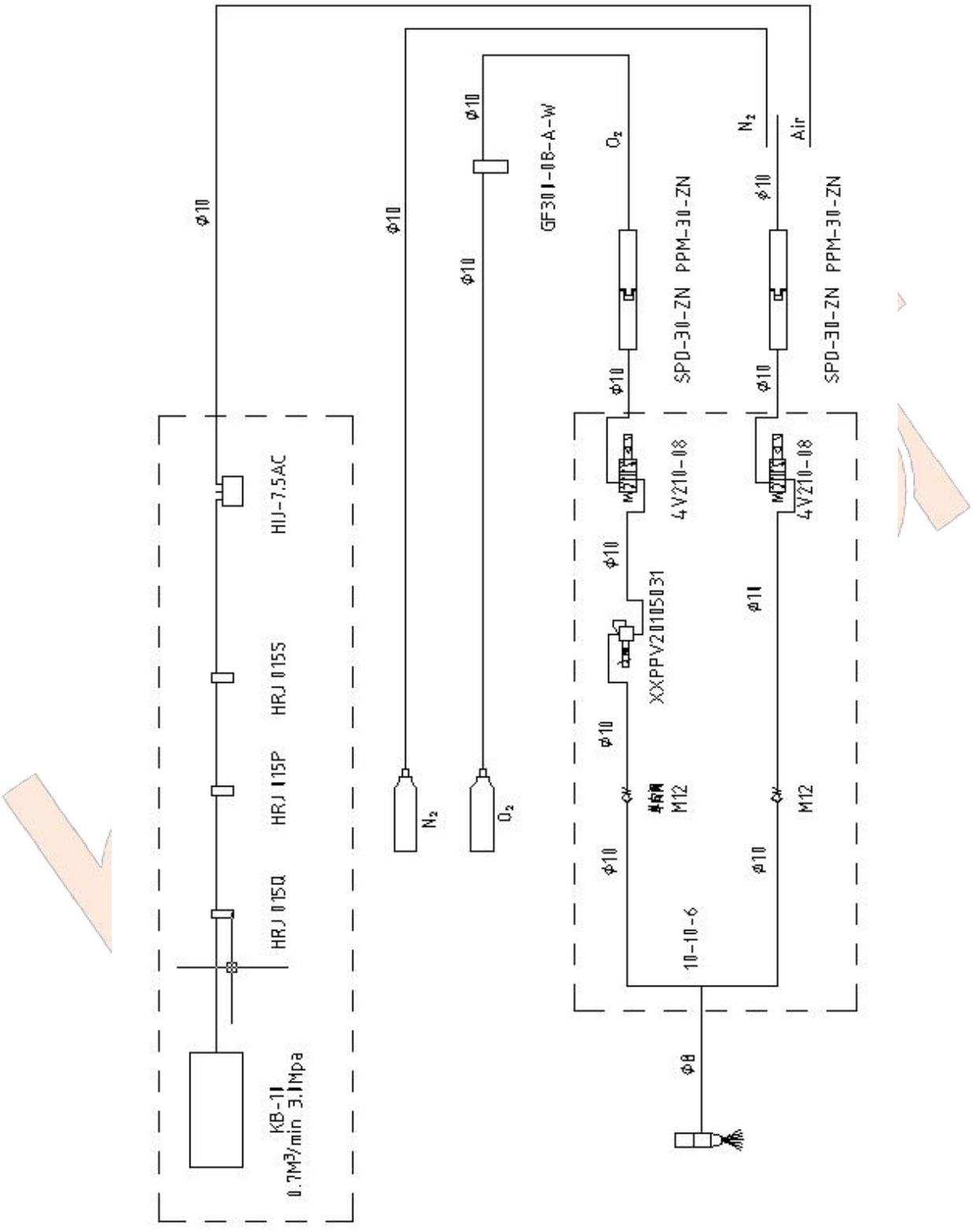
2.9.8 Gas circuit system

The gas circuit of laser cutting machine is used to provide cutting gas for cutting head and cooling gas for ceramic body, which should be selected reasonably based on different cutting materials, as follows:

1) Oxygen is mainly applied in cutting of general carbon steel;
2) Nitrogen is chiefly adopted to cut stainless steel;
3) Air is mainly used for cutting of sheet that conditions allowed.



Pneumatic Schematic Diagram



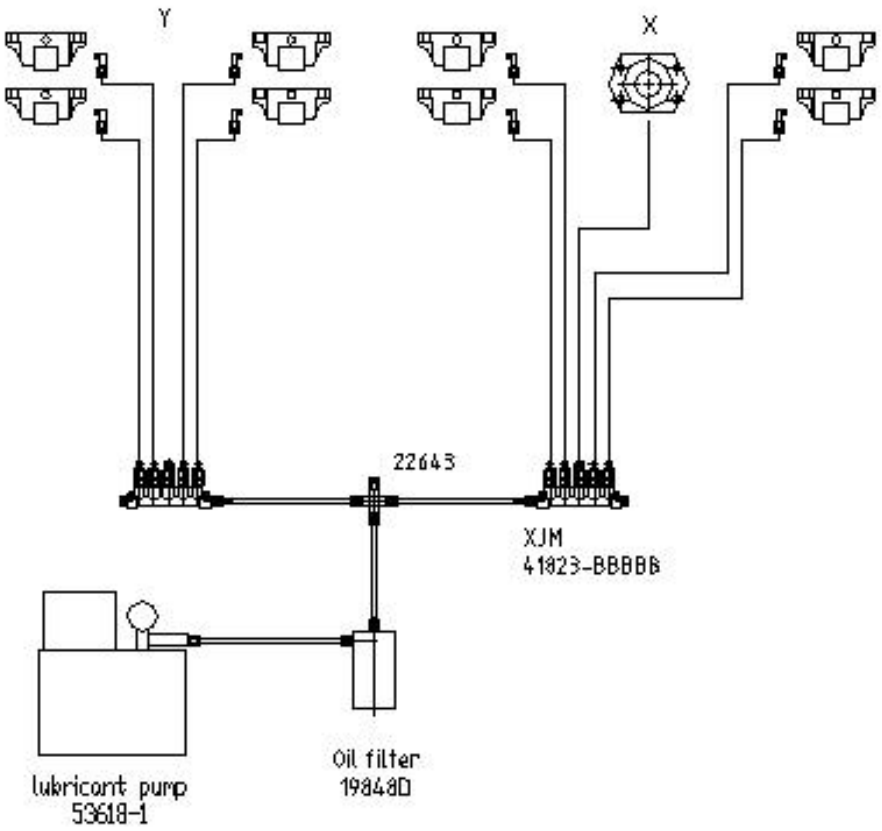
Gas Circuit Schematic Diagram of Cutting Gas

2.9.9 Cooling system

The water circuit of the laser cutting machine has two water circuits with different temperature, one for cooling the laser and the other for cooling the cutting head.

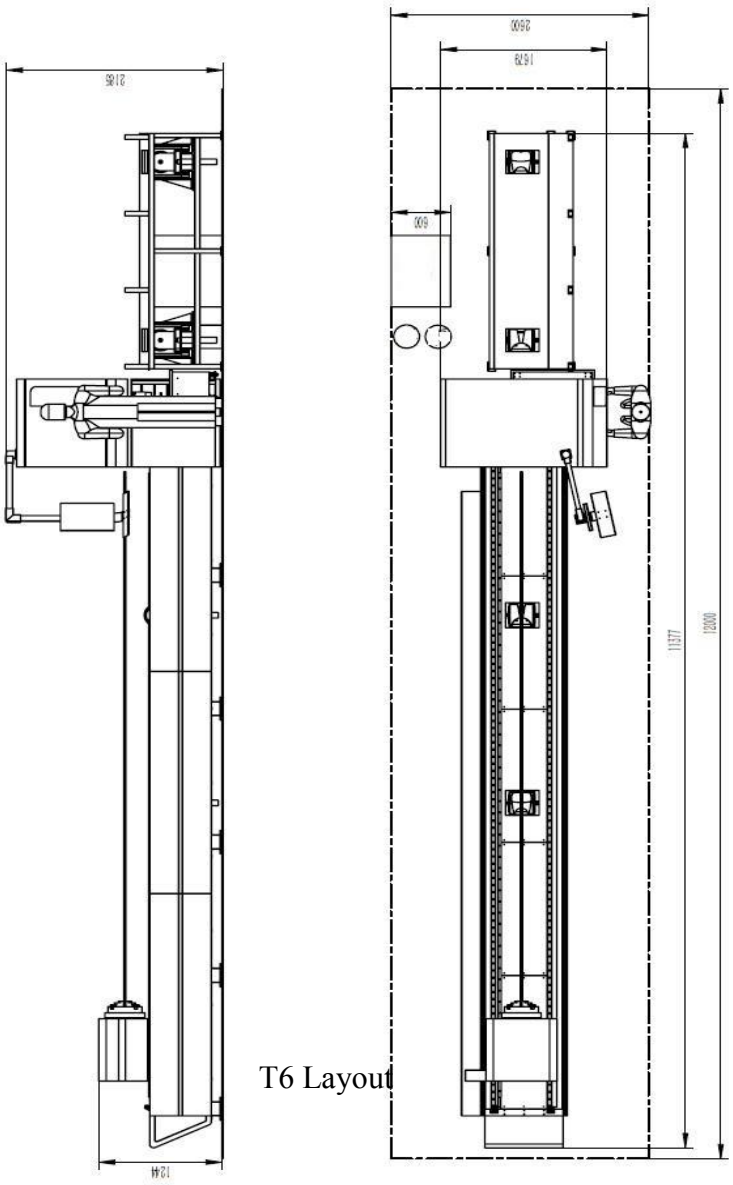
2.9.10 Lubricating system

The centralized lubricating system automatically supplies lubricating oil for the sliding block, ensuring the precision of drive system and improving the service life of linear guideway.



Schematic Diagram of Lubrication

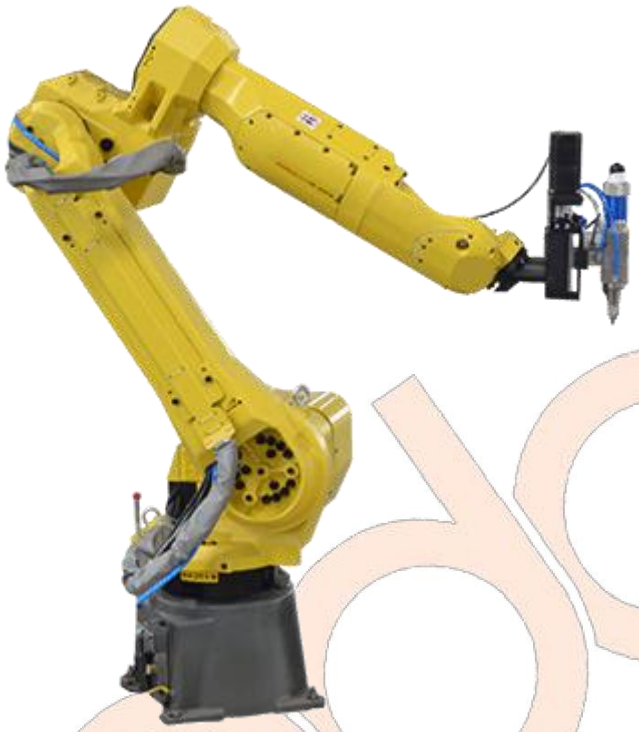
2.9.11 Layout



T6 Layout

2.10 RC series robot three-dimensional cutting machine

2.10.1 External view of product



2.10.2 Main features

1. High-performance laser device associated with stable operation system enables optimal cutting effects.
2. Perfect cooling system ensures stable, efficient and durable performance of the whole machine.
3. Flexible and convenient cutting of special-shaped work piece of metal materials with optimal and stable effects.
4. Easy implementation of factory layout realizes automatic cutting, reducing costs and improving efficiency.

1. Perfect combination of first-class optical fiber laser technology and digital control technology represents the most advanced laser cutting level;
2. The mechanical structure uses imported manipulators linked in six axes to integrate the laser beam guiding device into the robot arm and utilizes the advantages of both the stable laser and moving robot arm to realize processing of any and certain curves within the three-dimension space. The structure is easy to operate and highly intelligent, which significantly reduces the period and secures the high operation speed, precision and reliability of the equipment；
3. The special motion control software is used to ensure the cutting quality and stable operation of the equipment, contributing to more convenient cutting and simpler operation;
4. The imported precise laser cutting head with high sensibility and cutting precision cooperates with the manipulator to avoid the collision between the cutting head and the

processed sheet metal, secure the correct location of cutting focus and ensure the stable cutting quality;

5. The industrial robot and the optical fiber laser are combined in processing to complete the process at one time and produce smooth incisions that need no more extra treatment, greatly simplifying the processing procedure, reducing the labor costs and mould expenses as well as improving the product grade and added value；

6. The laser cutting head is able to bear air pressure of 1.0Mpa. The high-pressure gas circuit equipment improves the ability to cut the materials difficult to cut, such as stainless steel;

7. The introduction of industrial robot greatly reduces the system costs, expenses on power-consuming systems and system operation and maintenance and the area covered by the system;

2.10.3 Conditions of operating environment

a) Specifications of the power supply: three-phase four-wire system, 380V, 50Hz;

b) Quality of power supply: Tri-phase unbalance factor <2.5%, line voltage fluctuation <5%.

c) Grounding protection: The manipulator is grounded by a ground pile next to it or connected to the grounding wire of the power supply and the grounding resistance shall be less than 4Ω.

d) Draughty, dust-free, non-corrosive and pollution-free site environment is required.

e) No magnificent vibration is allowed around the installation site.

f) The water chilling unit is used to cool the laser device, cutting head and other special equipment and high quality purified or distilled water shall be used as the circulating cooling water.

g) For fear of fire hazard, appropriate fire extinguishers and reserved fire fighting access shall be provided in the processing site.

h) Over 1.2M shall be kept between workshop wall and left and rear sides of manipulator; Over 1.0M shall be reserved around the laser device.

i) Some environment conditions shall be met for this equipment, including free of interference from electromagnetic wave, such as the arc welding and discharge processing machine that may affect the normal operation of the equipment.

2.10.4 Impact on environment and energy

The laser device of laser cutting machine is a Class 4 laser product, whose beam ejected or reflected diffusely, will impair human body (especially eyes); therefore, it is worth noting that operating personnel and on-site personnel shall wear protective eyeglasses, which the optional SD-4, 1064nm ones are a choice.

Remark: No system and component above shall be changed without permission for the purpose of normal operation of laser head and laser device, as well as guaranteeing steady power of laser device and good mode of laser. It is beyond the warranty coverage including low laser power, poor laser mode and other parts injured due to a user's using undesirable water, electricity and gas without permission.

2.10.5 Technical parameters

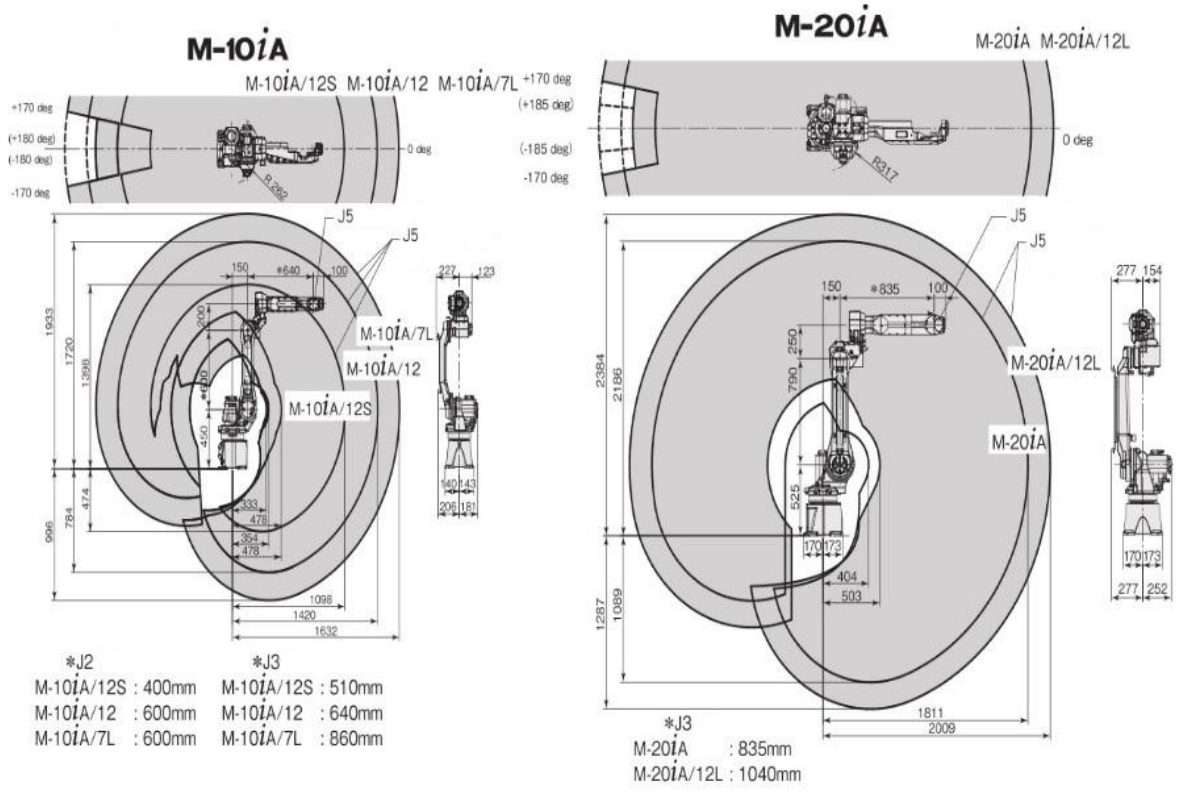
Type	RC14-LF	RC18-LF	RC20-LF
Type of laser device	Fiber laser		
Laser wavelength	1070-1080nm		
Degree of spatial freedom	6 axes		
Arm spread length	1400mm	1800mm	2000mm
Target location	Red light		
Cooling type	Water cooling		
Installation mode	Floor or suspension type		
Power of optional laser device	500W,700W,800W,1000W		

2.10.6 Introduction to robot performance

The manipulator cutting machine mainly consists of: manipulator, control system, laser device, water chilling machine, transformer, gas facilities, etc. Manipulator part: The manipulator is the most important part of the whole equipment. Other peripheral equipment includes water chilling unit, transformer system, cutting head, etc.

Operating scope and performance parameters of the robot

The basic operation scope of the RC robot cutting machine:



The basic motion parameters of the RC robot cutting machine:

Specifications

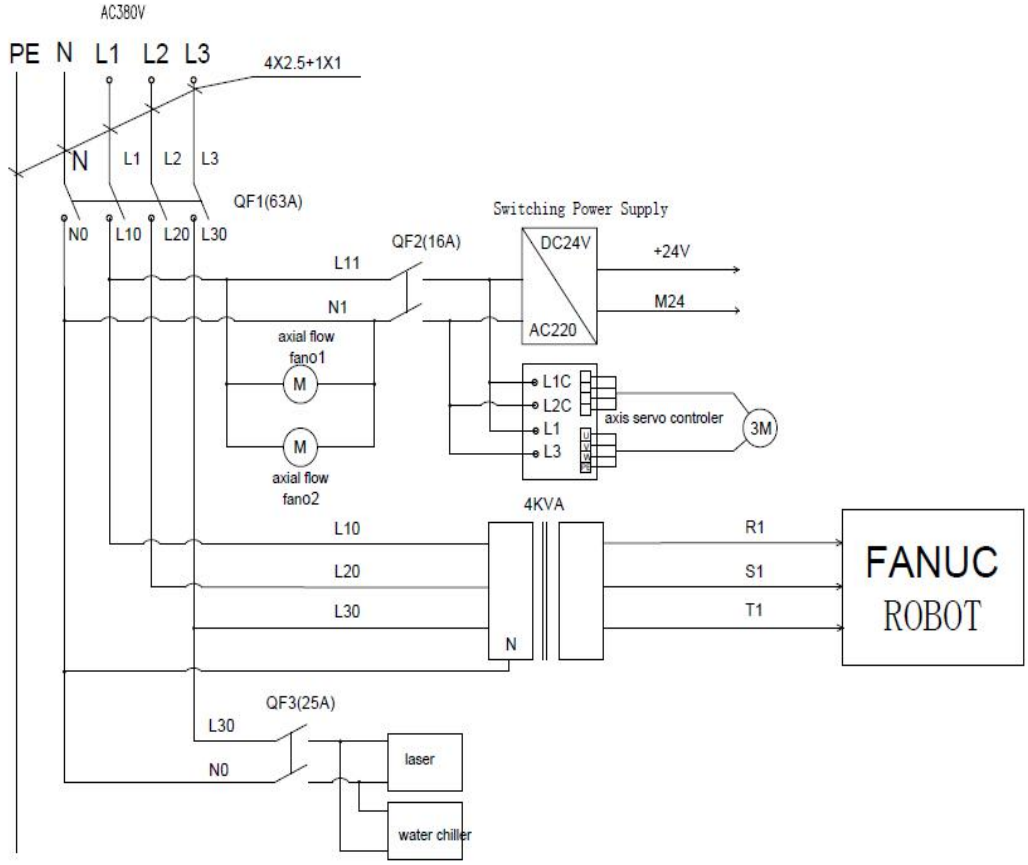
Item		Specifications				
		M-10iA/12S	M-10iA/12	M-10iA/7L	M-20iA	M-20iA/12L
Controlled axes		6 axes (J1, J2, J3, J4, J5, J6)				
Reach		1098mm	1420mm	1632mm	1811mm	2009mm
Installation		Floor, Upside-down, Angle mount				
Motion range (Maximum speed) (Note 1, 2)	J1 axis rotation	340°/360°(Option) (260°/s) 5.93 rad/6.28 rad(Option) (4.54 rad/s)	340°/360°(Option) (230°/s) 5.93 rad/6.28 rad(Option) (4.01 rad/s)		340°/370°(Option) (195°/s) 5.93 rad/6.45 rad(Option) (3.40 rad/s)	340°/370°(Option) (200°/s) 5.93 rad/6.45 rad(Option) (3.49 rad/s)
	J2 axis rotation	250°(280°/s) 4.36 rad (4.89 rad/s)	250°(225°/s) 4.36 rad (3.93 rad/s)		260°(175°/s) 4.54 rad (3.05 rad/s)	
	J3 axis rotation	340°(315°/s) 5.93 rad (5.50 rad/s)	445°(230°/s) 7.76 rad (4.01 rad/s)	447°(230°/s) 7.80 rad (4.01 rad/s)	458°(180°/s) 8.00 rad (3.14 rad/s)	460°(190°/s) 8.04 rad (3.32 rad/s)
	J4 axis wrist rotation	380°(430°/s) 6.63 rad (7.50 rad/s)			400°(360°/s) 6.98 rad (6.28 rad/s)	400°(430°/s) 6.98 rad (7.50 rad/s)
	J5 axis wrist swing	380°(430°/s) 6.63 rad (7.50 rad/s)			360°(360°/s) 6.28 rad (6.28 rad/s)	360°(430°/s) 6.28 rad (7.50 rad/s)
	J6 axis wrist rotation	720°(630°/s) 12.57 rad (11.0 rad/s)			900°(550°/s) 15.71 rad (9.60 rad/s)	900°(630°/s) 15.71 rad (11.0 rad/s)
Max load capacity at wrist		12 kg		7 kg	20 kg	12 kg
Allowable load moment at wrist	J4 axis	22.0 N·m		15.7 N·m	44.0 N·m	22.0 N·m
	J5 axis	22.0 N·m		10.1 N·m	44.0 N·m	22.0 N·m
	J6 axis	9.8 N·m		5.9 N·m	22.0 N·m	9.8 N·m
Allowable load inertia at wrist	J4 axis	0.65 kg·m²		0.63 kg·m²	1.04 kg·m²	0.65 kg·m²
	J5 axis	0.65 kg·m²		0.38 kg·m²	1.04 kg·m²	0.65 kg·m²
	J6 axis	0.17 kg·m²		0.061 kg·m²	0.28 kg·m²	0.17 kg·m²
Repeatability		± 0.05 mm			± 0.08 mm	
Mass (Note 3)		130 kg			250 kg	
Installation environment		Ambient temperature : 0 ~ 45℃ Ambient humidity : Normally 75%RH or less(No dew nor frost allowed), Short term 95%RH or less(within one month) Vibration acceleration : 4.9m/s²(0.5G) or less				

Note 1) In case of angle mounting, J1 and J2 axis motion range are restricted.
Note 2) In case of short distance motion, the axis speed may not reach the maximum value stated.
Note 3) Without controller

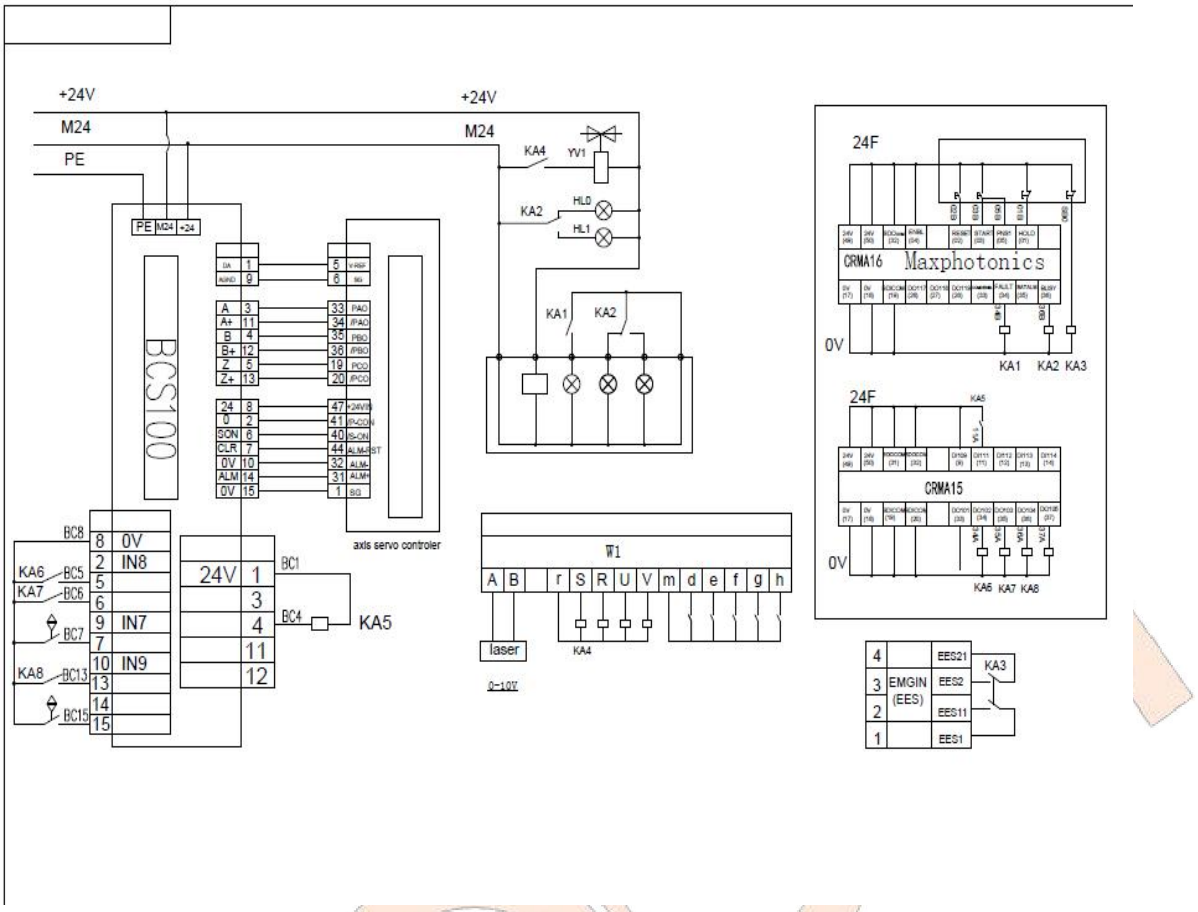
2.10.7 Electrical system

I. Schematic diagram

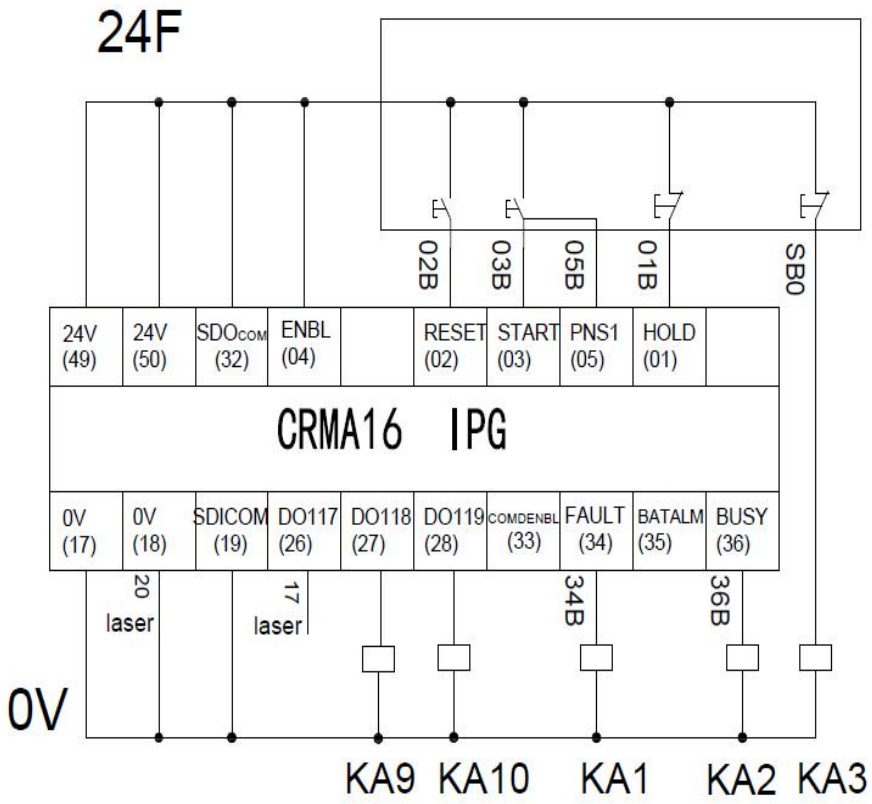
1) Major Loop

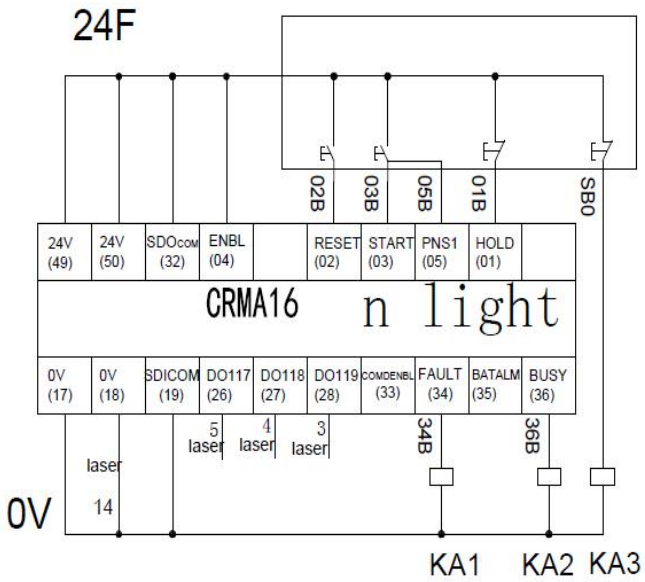


2) Control Loop



3) Connection Diagram of Laser Device


24F
02B
03B
05B
01B
SB0
24V (49)
24V (50)
SDOCOM (32)
ENBL (04)
RESET (02)
START (03)
PNS1 (05)
HOLD (01)
CRMA16 IPG
0V (17)
0V (18)
SDICOM (19)
DO117 (26)
DO118 (27)
DO119 (28)
COMDENBL (33)
FAULT (34)
BATALM (35)
BUSY (36)
20 laser
17 laser
34B
36B
0V
KA9
KA10
KA1
KA2
KA3

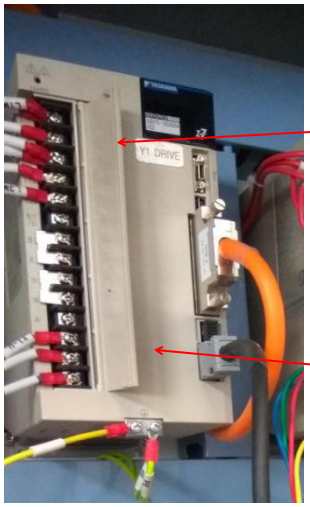


II. Basic electrical parts and their functions

1) Electrical cabinet

The majority of electrical components is mounted inside and used to supply electricity for the machine.

2) Drives



Power line, used to supply electricity for drives

Supply electricity for servo motor

Servo drives, also called "servo controller" or "servo amplifier", just like a variable-frequency drive acting on general AC motor, is a controller to control a servo motor; as a part of the servo system, it is mainly applied in a high-precision positioning system. It currently is a cutting-edge product of drive technology, which is generally used to control a servo motor through three modes of location, speed and moment of force to achieve high-precision positioning of drive system.

3) Transformer

Input voltage

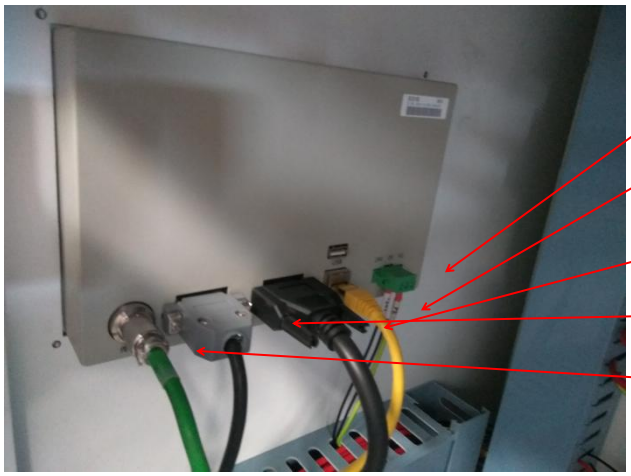
Output voltage

Grounding

The transformer is used to convert the voltage to meet the requirement of the robot drive.

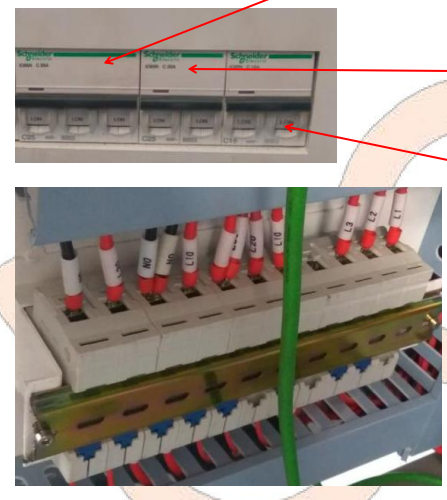
4) Height-adjustment device

Supply 24V electricity for height-adjustment device



During cutting, it is the laser head to maintain a constant distance between laser head and sheet metal, not only getting laser head protected effectively, but also achieving sophisticated techniques, including multi-stage perforation.

5) Circuit breaker



The circuit breaker could be used to distribute electric energy, start occasionally an asynchronous motor and protect power line and motor and so on; in case these devices are in overload, short circuit, undervoltage and other trouble states, it could shut down the circuit automatically, which functions as the combination of fuse-switch and overthermal-underthermal relay. Moreover, no part or component is required to be changed after disjuncting fault current.

6) Intermediate relay

It is applied in relay protection and automatic control system to increase the quantity and volume of contact points. It is used to transmit M signals in the control circuit. The structure and principle of intermediate relay are basically the same with those of AC contactor, and main differences between them lie in: A large current is allowed to pass through the main contact of the contactor, while the only low current is permitted to pass through the contacts of the intermediate relay. Therefore, the intermediate relay could be used in control circuit only. As the overload capacity is small, generally no main contact exists in an intermediate relay. So all its contacts, sufficient in quantity, are auxiliary. The intermediate relay is defined as K in the new national standard, KA in previous national standards. Generally it is powered with DC power supply. The minority is powered with AC power supply.

7) Switching power supply

24V power supply

8) FANUC control cabinet

Cycle start

Emergency stop

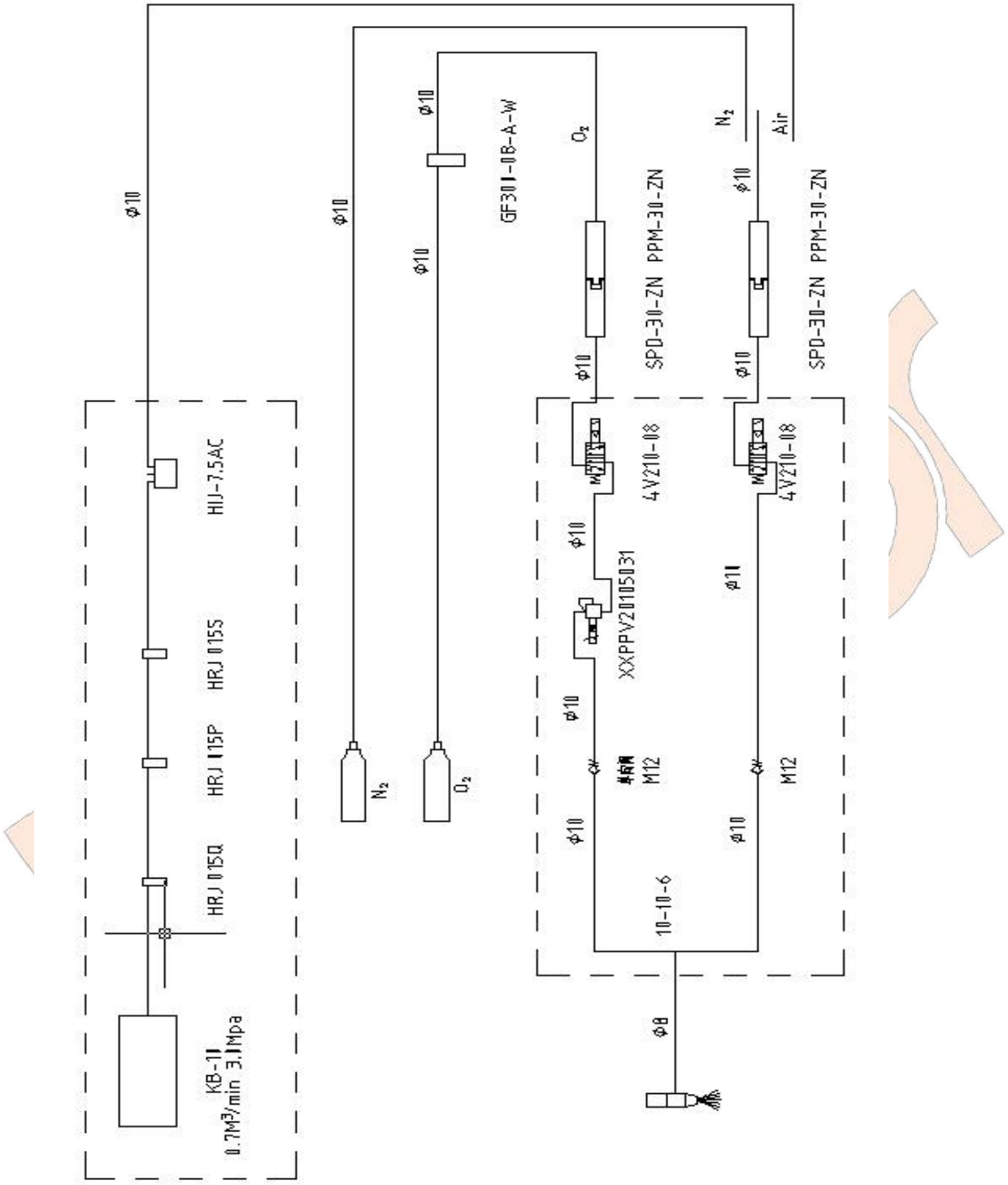
System power switch

The core control component of robot containing the FANUC system inside that provides

precise motion commands to the robot.

2.10.8 Gas circuit system

The gas circuit of laser cutting machine is used to provide cutting gas for cutting head and cooling gas for ceramic body, which should be selected reasonably based on different cutting materials, as follows: 1) Oxygen is mainly applied in cutting of general carbon steel; 2) Nitrogen is chiefly adopted to cut stainless steel; 3) Air is mainly used for cutting of sheet that conditions allowed.



Gas Circuit Schematic Diagram of Cutting Gas

2.10.9 Cooling system

The water chilling machine of the water circuit system of the cutting machine has two water circuits with different temperature, one for cooling the laser and the other for cooling the

cutting head.

Chapter III Shipment and Storage

3.1 Packaging

The main part, operating cabinet, laser device, water chilling machine and accessories of laser cutting machine are packaged with wooden boxes. Other components are all packaged with PE foam and protection film as the outer layer to prevent damage of any component of the laser cutting machine caused by collision with foreign objects.

3.2 Methods and notes for shipment and transportation

a. The transportation environment of the machine tool shall be free of rain, moisture, tilting, rat and sinking and secure good ventilation, ambient temperature of -10℃-+40℃ and relative humidity of no more than 80%. For transportation and storage of no more than 24h, the allowed maximum temperature is 70℃. Long-term outdoor storage is prohibited. If any product requires temporary storage because of any reason, in addition to the above requirements, the storage place and package shall be checked at any time to avoid damage of the machine tool.

b. No one is allowed to climb or stand on or put heavy object on the package box.

c. No one is allowed to drag or move the product by cable connected to the product.

d. It is strictly prohibited to collide or scratch the panel and display.

e. The product package box shall be free of moisture, long-term sunlight exposure or rain.

f. The machine tool shall be carefully suspended or lifted during installation and any collision is prohibited. The wire rope is not allowed to touch the machine tool and otherwise, soft object shall be used for separation.

3.3 Conditions, life and notes for storage

The storage environment of the machine tool shall be free of rain, moisture, tilting, rat and sinking and secure good ventilation, ambient temperature of -10℃-+40℃ and relative humidity of no more than 80%. For transportation and storage of no more than 24h, the allowed maximum temperature is 70℃. Long-term outdoor storage is prohibited. If any product requires temporary storage because of any reason, in addition to the above requirements, the storage place and package shall be checked at any time to avoid damage of the machine tool.

3.4 Machine tool transportation

The laser cutting machine shall be transported to the customer site by transportation vehicle, which requires preparation and implementation of the user. The route for transporting the machine tool to the customer's installation site shall be stated before delivery. The dimensions of on-site doors and openings, height of pillar, height of cable bracket and whether a vehicle or roller is allowed shall be confirmed on site.
The dimensions of machine tool on the drawing must be considered during the shipment!

3.5 Auxiliary and handling tools

The following equipment must be prepared by the user:

- Handling equipment for machine tool, laser device and accessory equipment. Lifting equipment with the recommended lifting weight of at least 5T; If a larger lifting arm is required according to the local conditions, the crane truck must have a larger lifting weight.
- Fork lift truck (with bearing of 5t).
- Bridge crane: Bearing capacity of 10T;
- Armored roller (one steerable-type and two compact-type)
- At least two hydraulic jacks with the lifting weight of at least 5T (with minimum adjustable height of 30mm).
- Crow bar (1m long) and extension pieces.
- Measures to be taken by the user:
- All transportation work shall be performed in compliance with relevant transportation rules.
- The machine tool is not allowed to be placed on dirt floor, or any damage out of control may occur at the bottom of various components! The bottom plate with standing bars of the machine tool shall be spaced with the floor by less than 100mm. The spacing must be kept during the procedure of transporting the machine tool to the installation site.
- The foundation of the installation site must comply with the requirements of the installation conditions. The slot cutting and hole-punching on the ground at the installation site must be done by the customer according to the basic plan before the machine tool arrives at the site.
- The proper lifting equipment shall be used to unload the machine tool from the transportation vehicle.
- Equipment including laser device, cooling equipment and suction device may be loaded and unloaded directly using the fork lift truck.
- When required, the machine tool shall be moved from the outdoor into the workshop by armored roller.
- The machine tool shall be moved to the installation site by the overhead crane with enough lifting capacity or armored roller.
- The hydraulic jack shall be used in cooperation with the armored roller to place the machine tool at the specified location on the installation site.

- The machine tool and associated equipment shall be placed at the pre-defined installation location.
- When the installation is completed successfully, the laser device, cooling device and compact precipitator shall be placed at the final installation site.
- The operating conditions for successfully installed equipment: Machine tool leveling: The machine tool shall be leveled by the technical personnel in accordance with the technical requirements.
- Equipment put into operation: The technical personnel shall commission the equipment and put it into operation. The commissioning covers installing the equipment components according to the installation drawing, powering on the equipment, giving demonstration and training to the employees and check the functions of the machine tool.

Postscript

Our company reserves the final interpretation right for the Manual and we will make our best effort to ensure the accuracy of it. Due to the limited knowledge of the author, the Manual may contain mistake(s) or omission(s). We will not be obliged to consequences of any form caused by such mistake(s) or omission(s). Our company will not be obliged to any direct, indirect, special, attached or relevant damage or responsibility caused by improper use of the Manual or the product. We welcome the criticism and correction from extensive readers and peers.

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