Original instructions

YAG LASER WELDER

# ML-2050A / 2051A / 2150A -CE EU

# OPERATION MANUAL

AMADA

AA06OM1170500-19

# How to Use This Document

**ATTENTION**

**In this manual, ML-2050A denotes ML-2050A-CE; ML-2051A, ML-2051A-CE; and ML-2150A, ML-2150A-CE.**

Thank you for purchasing our YAG Laser Welder ML-2050A/2051A/2150A.

This operation manual explains its method of operation and precautions for use.

Before using, read this operation manual carefully; after reading, save it in a proper place for your future reference.

This document is composed of the 4 parts of "Introduction Part", "Installation and Preparation Part", "Operating Part", and "Maintenance Part", and "Appendixes."

We recommend inexperienced users to read through the whole contents starting from "Introduction Part."

This document allows the user to understand the whole equipment image, basic configuration, and how to use the laser.

Experienced users can refer to the desired page from the table of contents.

### Organization of This Document and Its Contents

**Introduction Part:** Explains the outline and functions of the laser. Regarding the YAG Laser, this part explains the basic configuration and functional outline of this product including options so that the user can know the configuration of the laser and equipment composition, and also the name and function of each component section.

**Installation and Preparation Part:** Explains the installation of the laser and preparatory operations such as connections of its respective sections.

**Operating Part:** Explains how to operate the laser. First, this part explains how to perform each setting and how to operate the laser. Three types of control (control by control panel, control by external input/output signals, and control by external communication control) are explained in the operating method for laser welding.

**Maintenance Part:** Explains how to perform maintenance and how to handle trouble.

**Appendixes:** For reference materials, specifications, dimensional outline drawing, available output, timing chart, and list of terminology are available. In the output schedule data entry table, the user can enter registered laser output schedule data for use.

# Contents

## Operating Part 49

# For Use in Safety

## Safety Precautions

**Before using, read "Safety Precautions" carefully to understand the correct method of use.**

These precautions are shown for safe use of our products and for prevention of damage or injury to operators or others. Be sure to read each of them, since all of them are important for safety.

**A meaning of a figure sign**

| | |
|---|---|
| **DANGER** | Denotes operations and practices that may imminently result in serious injury or loss of life if not correctly followed. |
| **WARNING** | Denotes operations and practices that may result in serious injury or loss of life if not correctly followed. |
| **CAUTION** | Denotes operations and practices that may result in personal injury or damage to the equipment if not correctly followed. |
|  | Denote "prohibition."<br>They are warnings about actions out of the scope of the warranty of the product. |
|  | Denote actions which operators must take. |
|  | Denotes that the content gives notice of DANGER, WARNING or CAUTION to the operator. |

**DANGER**

**Do not touch the inside of the Laser unnecessarily.**
Since source voltage of single-phase 200/220/240 V AC is applied to the Laser, high voltages are applied to its inside. Do not touch the inside of the Laser unnecessarily with the power turned ON.

**Never disassemble, repair or modify the Laser.**
These actions can cause electric shock and fire. Do not do anything other than the maintenance described in the operation manual.

**Do not look at or touch the beam.**
Both direct laser beams and scattered laser beams are highly dangerous. If the beam enters the eye directly, it can cause blindness.

**Never burn, destroy, cut, crush or chemically decompose the Laser.**
This product incorporates parts containing gallium arsenide (GaAs).

## WARNING

**Wear protective glasses.**
Be sure to wear protective glasses having an optical density of at least 7 while using the Laser. Even if you wear them, you may lose your sight if the laser beam enters your eyes directly through protective glasses. Protective glasses attenuates the laser beam, but does not block it.

**Do not expose your skin to the laser beam.**
Your skin may be severely burnt.

**Do not touch any processed workpiece during and just after processing finished.**
The processed workpieces are very hot.

**Use only specified cables.**
Use of a cable of insufficient capacity or loose connection can cause electric shock fire.

**Do not damage the power cable or connecting cables.**
Do not tread on, twist or tense any cable. The power cable and connecting cables may be broken, and that can cause electric shock and fire. If any part needs to be repaired, consult us or your distributor.

**Stop the operation if any trouble occurs.**
Continuous operation after occurrence of a trouble such as burning smell, abnormal sound, abnormal heat, smoke, etc. can cause electric shock and fire. If such a trouble occurs, immediately consult us or your distributor.

**Ground the Laser.**
If the Laser is not grounded, you may get an electric shock when there is trouble or electricity leaks.

**Use a stopper.**
The laser beam is dangerous to human bodies. Prevent emission through the air by using a stopper (a heat-resistant, laser beam-absorbing, -scattering material).

**Persons with pacemakers must stay clear of the Laser.**
Those who use a pacemaker must not approach the Laser or walk around the welding shop while the Laser is in operation, without being permitted by his/her medical doctor. The Laser generates a magnetic field and has effects on the operation of the pacemaker while it is turned ON.

## CAUTION

**Do not splash water on the Laser.**
Water splashed over the electric parts, can cause electric shock and short circuits.

**Use proper tools (wire strippers, pressure wire connectors, etc.) for termination of the connecting cables.**
Do not cut the wire conductor. A fire or electric shock will occur.

**Install the Laser on a firm and level surface.**
If the Laser falls or drops, injury may result.

**Do not place a water container on the Laser.**
If water spills, insulation of the Laser will deteriorate, and that can cause electric leaks and fire.

**Keep combustible matter away from the Laser.**
Surface flash and expulsion can ignite combustible matter. If it is impossible to remove all combustible matter, cover it with non-combustible material.

**Do not apply the laser beam to combustible materials.**
To avoid risk of fire never apply the laser beam to flammable or combustible materials.

**Do not cover the Laser with a blanket, cloth, etc.**
Do not cover the Laser with a blanket, cloth, etc. while you are using it. The cover may be overheated and burn.

**Do not use this Laser for purposes other than metal processing.**
Use of the Laser in a manner other than specified can cause electric shock and fire.

**Protective gear must be worn.**
Put on protective gear such as protective gloves, long-sleeve jacket, leather apron, etc. Surface flash and expulsion can burn the skin if they touch the skin.

**Keep a fire extinguisher nearby.**
Keep a fire extinguisher in the processing shop in case of fire.

**Maintain and inspect the Laser periodically.**
Maintain and inspect the Laser periodically, and repair any damage before starting operation.

# Precautions for Handling

## Laser Safety Supervisor

⇒ Appoint a safety supervisor for all laser work.
The appointed safety supervisor must have sufficient knowledge and experience regarding both lasers and laser work.

⇒ The supervisor must control the keyswitch of the Laser, and must be responsible for instructing operators in safety aspects of the Laser as well as directing the laser work.

⇒ Establish and control a laser operation area.
The responsible person must isolate the laser operation area from other areas and control it by fences and display signs indicating that the area is off-limits to unauthorized personnel.

## Routine Handling

⇒ Perform inspection periodically referring to the Maintenance Part, Chapter 1 "1. Maintenance Parts and Standard Intervals of Inspection/Replacement" on page 145.

⇒ If the outside of the Laser is stained, wipe it with a dry cloth or a moistened cloth. If it is badly stained, use neutral detergent or alcohol to clean it. Do not use paint thinner, benzine, etc. which can discolor or deform the parts.

⇒ Do not put screws, coins, etc. in the Laser, since they can cause a malfunction.

⇒ Operate the switches and buttons carefully by hand. If they are operated roughly or with the tip of a screwdriver, a pen, etc. they may be broken.

⇒ Operate the switches and buttons one at a time. If two or more of them are operated at a time, the Laser may have trouble or may be broken.

⇒ The outer panels and the covers are electrically connected to the main unit by connecting cables. When the panels, covers and connecting cables are removed and installed again, make sure that all these components are put back into place correctly. Also, make sure that the cables do not block the optical path of the oscillator or get caught between the outer panel and the frame.

⇒ To prevent damage, do not bend the optical fiber beyond its minimum bending radius or apply any forms of shock to it. For the fiber's minimum bending radius, see the table below.

**Minimum bending radius of the optical fiber**

| Core Diameter | Minimum Bending Radius |
|---|---|
| φ 0.2, 0.3, 0.4 mm | 100 mm |
| φ 0.6 mm | 150 mm |
| φ 0.8 mm | 200 mm |
| φ 1.0 mm | 250 mm |

⇒ When a supervisor or operator enters the area where the laser is used, protective measures not to exceed the MPE* level must be taken.

* MPE: The maximum level of permissible exposure of the eyes or skin to laser beams. Abbreviation of Maximum Permissible Exposure.

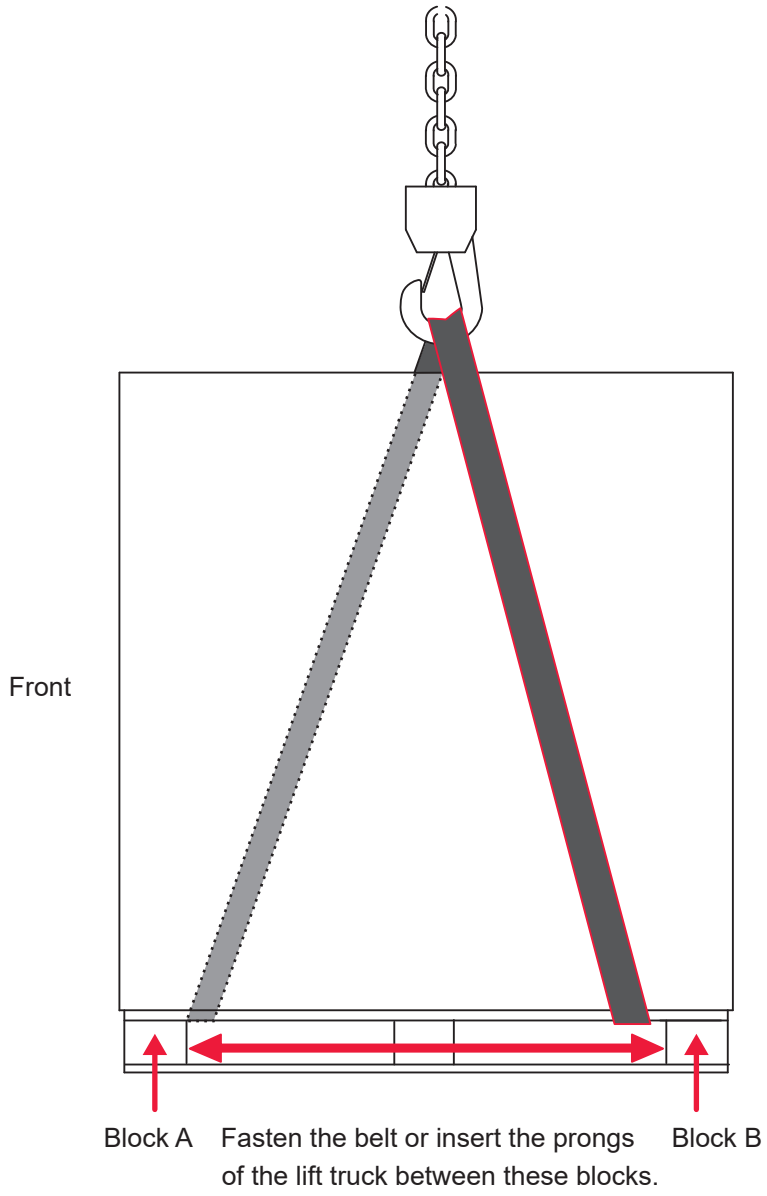
* For other information on managing laser equipment or the MPE level, refer to the following standards.

IEC Standards IEC60825-1 "Safety of laser products Part1: Equipment Classifications, requirements and use's guide"

## For Transportation

**When transporting the laser, observe the following precautions to avoid hazards.**

- ⇒ Package the Laser when transporting it.
- ⇒ The worker must wear a helmet, safety shoes and gloves for safety. (Leather gloves are recommended.)
- ⇒ When transporting the Laser, use a lift truck, crane, belt, etc., of at least 100 kg allowable load.
- ⇒ When lifting the Laser with a lift truck, crane belt, be sure to hold the Laser at the bottom of corrugated cardboard between the blocks A and B.
- ⇒ Carry the Laser with casters on flat place.

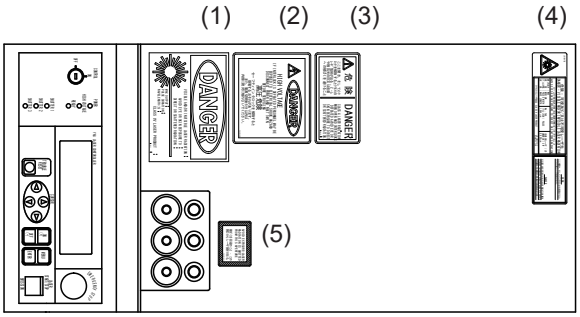


## For Disposal

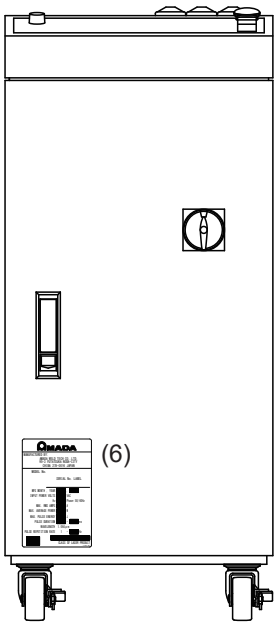
This product incorporates parts containing gallium arsenide (GaAs). At the time of disposal, separate it from general industrial waste or domestic waste and carry out the disposal in accordance with applicable laws and regulations.

# Sticking Warning/Danger Labels

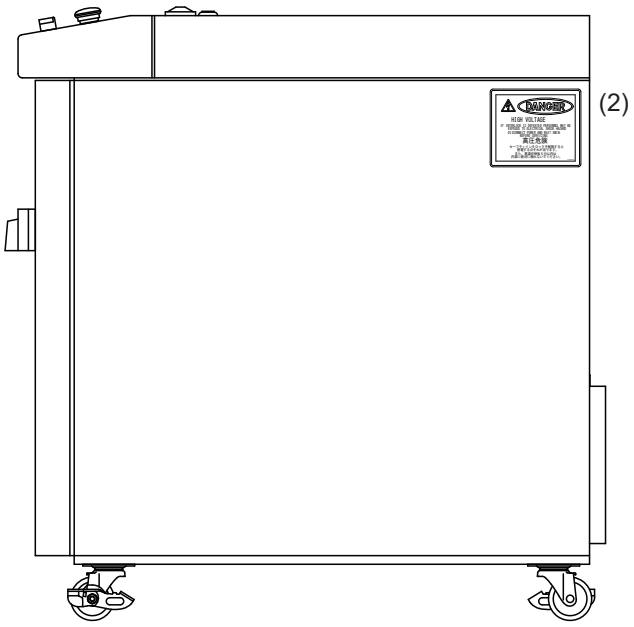
Warning/danger labels are struck on the laser. Read the precautions provided on each label for correct use. The numbers correspond to the label figure numbers on the next page.



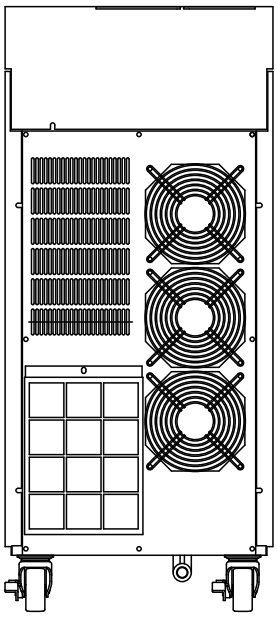

Top view




Front view

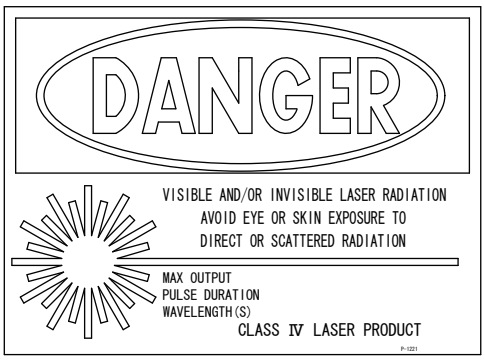



Right side view



Rear view

(1)




(2)

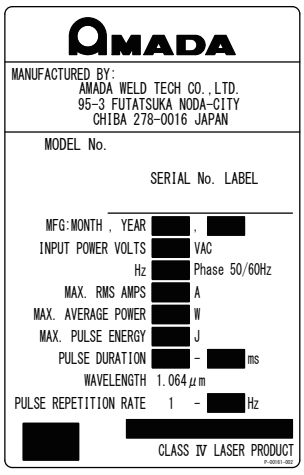

(Also stuck on the reverse side, and at the top surface of the high voltage protection cover inside of the right side surface of the main unit)

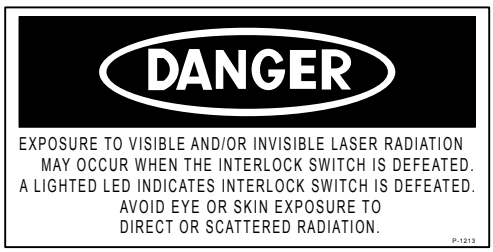
(3)


(4)


(5)


(6)

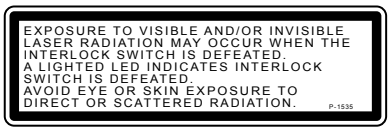





Inside of the top surface of the main unit
(top surface of the branch unit cover)

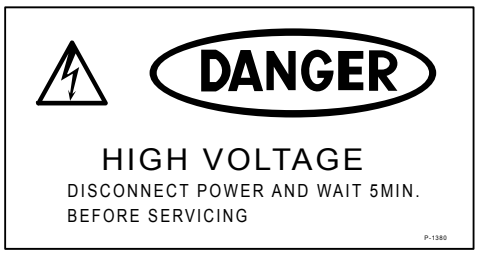

Inside of the top surface of the main unit
(top surface of the branch unit cover)


Inside of the front surface of the main unit
(under the breaker)
Inside of the right side surface of the main unit
(top surface of the frame)
Inside of the left side surface of the main unit
(top surface of the frame)
Inside of the rear surface of the main unit
(top surface of the frame)
Rear surface of the control panel



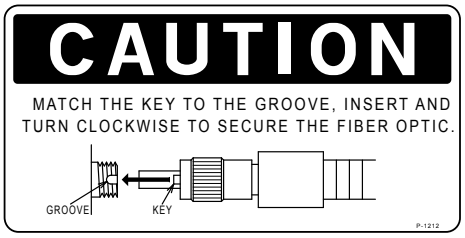

Rear surface of the control panel


Inside of the front surface of the main unit
(under the power input terminal and under the breaker)
Inside of the right side surface of the main unit
(top surface of the frame)
Inside of the left side surface of the main unit
(top surface of the frame)
Inside of the rear surface of the main unit
(top surface of the frame)
Rear surface of the control panel




Inside of the right side surface of the main unit
(top surface of the power supply unit cover)


Inside of the top surface of the main unit
(top surface of the branch unit cover)




Inside of the top surface of the main unit
(top surface of the branch unit cover)


Inside of the front surface of the main unit
(front surface of the cooling water tank)


Inside of the front surface of the main unit
(top surface of the cooling water tank)


Inside of the top surface of the main unit
(top surface of the laser chamber)

# Introduction Part

Introduction Part

# Chapter 1

# Overview of the YAG Laser Welder

## 1. YAG Laser

Laser means the equipment to generate powerful light by amplifying light (electromagnetic wave) or means this light itself. Laser can be classified into various types by light generating material. Among these types, the typical type as welding laser in the industrial field is Nd: YAG laser, which is generally called YAG laser. The name of Nd: YAG laser originates from the fact that this laser is generated by doping Neodymium with the Yttrium Aluminum Garnet crystal.

The YAG laser wavelength is 1064 nm of near infrared rays that are invisible to man. Most of laser equipment for laser welding belongs to class 4 laser that is the most hazardous in the classification of laser products specified in JIS. When YAG laser light greets the eye, it is focused by crystalline lens and reaches the retina, thereby inviting a loss of eyesight. Do not look at the YAG laser light in any case. Because both beams and scattered light are hazardous, do not touch or look at them.

To check where invisible laser is irradiated on the workpiece, red guide light is generally mounted in the laser equipment. When the output unit is provided with a CCD camera, cross lines are generally displayed on the monitor and the cross point of these cross lines is an irradiation point. In this laser, a red point appears on the workpiece when guide light is output.

# 2. Mechanism of the YAG Laser

The YAG Laser for welding consists of a power supply, cooler, oscillator, optical fiber, output unit, etc. Laser light can be transferred to a place remote from the main unit by optical fiber, so that only the optical fiber and output unit can be mounted in the manufacturing line for welding. Multiple beams of laser light can be split from single laser equipment to multiple optical fibers.

## Powersharing

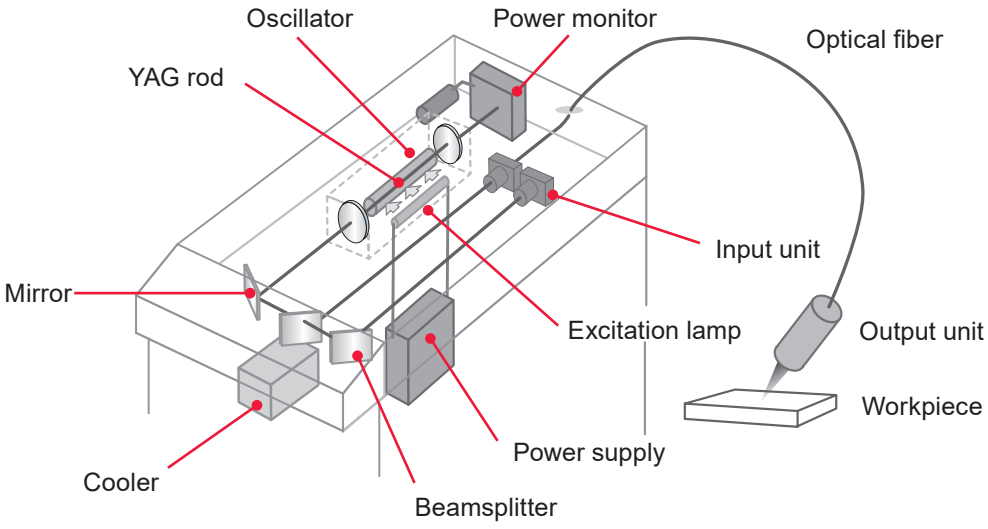
When single laser light is split into multiple beams by using a beamsplitter, multiple workpieces (or multiple positions of a single workpiece) can be simultaneously welded. This method is called "powersharing."
Supposing that the energy of a single laser light beam is 100%, 50% laser light is simultaneously irradiated when the number of deliveries is 2, or 33% laser light is simultaneously irradiated when the number of deliveries is 3. Up to 3 deliveries are available for this laser equipment at powersharing.

## Timesharing

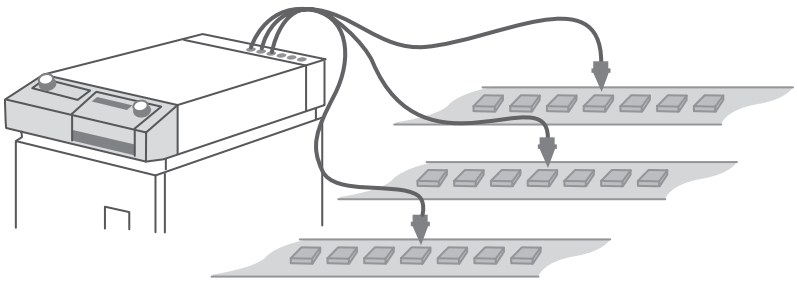
100% energy is applied to multiple workpieces by changing the reflection angle with the mirror of the timesharing unit without splitting single laser light. This welding method for multiple workpieces is called "timesharing."

For example, if when the number of deliveries is 3, laser light is irradiated once each from 3 optical fibers. Up to 3 deliveries are available for this laser equipment at timesharing.

**Common Laser Equipment Configuration**




**Example of 3 deliveries**



# 3. Functions of the ML-2050A/2051A/2150A

⇒ Laser power feedback control and optional waveform control functions

- The Laser can handle a wide variety of workpieces. Up to 32 different settings for weld schedules using waveform control are available.
- The welding schedule can be momentarily switched. This permits high-speed and high-quality welding.
- The ML-2051A uses very thin optical fiber that makes it suitable for welding with a small spot diameter.
- Up to 3 deliveries of laser output, including powersharing and timesharing, are available. (The beamsplitter and branch shutter are options.)
- Powersharing permits obtaining uniform outputs for each delivery without energy loss.

⇒ Simple operations and maintenance

- For greater convenience, the Laser is designed to allow the operator to work on the Laser from the front for cumbersome tasks such as wiring and filter replacement.
- As welding schedules are entered on the liquid crystal display, the user can perform operations easily and accurately.
- A variety of input and output signals allow the Laser to be connected to automatic machines.
- Both the laser energy (J) and its mean power (W) are monitored. If the desired energy range has been preset and the laser energy is out of the range, the trouble signal is output. This function is provided for quality control purposes.
- Use of high-precision optical fiber eliminates the optical axis adjustment usually needed every time the fiber is removed and reinstalled.
- Optical fiber detection is available to check fiber connection and breakage. (An optional output unit with fiber sensor is required.)
- Using the external communication function permits managing data such as welding schedules and monitor values in centralized form.

⇒ The factory environment can be improved by space saving.

- The laser power supply, oscillator, and cooler are integrated into a single piece for easy transport and installation of the Laser.
- The Laser does not require external cooling water or piping.

⇒ The Laser conforms to the following standards.

In compliance with IEC Standards IEC60825-1 “Safety of laser products Part1: Equipment Classifications, requirements and use’s guide”

# 4. Product Composition

## Packaging

The product is divided into the main unit and accessories and these are packed in 2 packages. The respective dimensions and mass are as follows.

| | Dimensions | Mass (including packaged products) |
|---|---|---|
| Package for main unit | Approx. 840 (H) x 440 (W) x 800 (D) mm | Approx. 76 kg |
| Package for accessories | Approx. 580 (H) x 310 (W) x 460 (D) mm | Approx. 23 kg |

## Checking the Packaged Products

Make sure that all the packaged products are included.

### Package for main unit

| Product name | Model No. | Q'ty |
|---|---|---|
| YAG Laser Welder | ML-2050A/2051A/2150A | 1 |

### Package for accessories

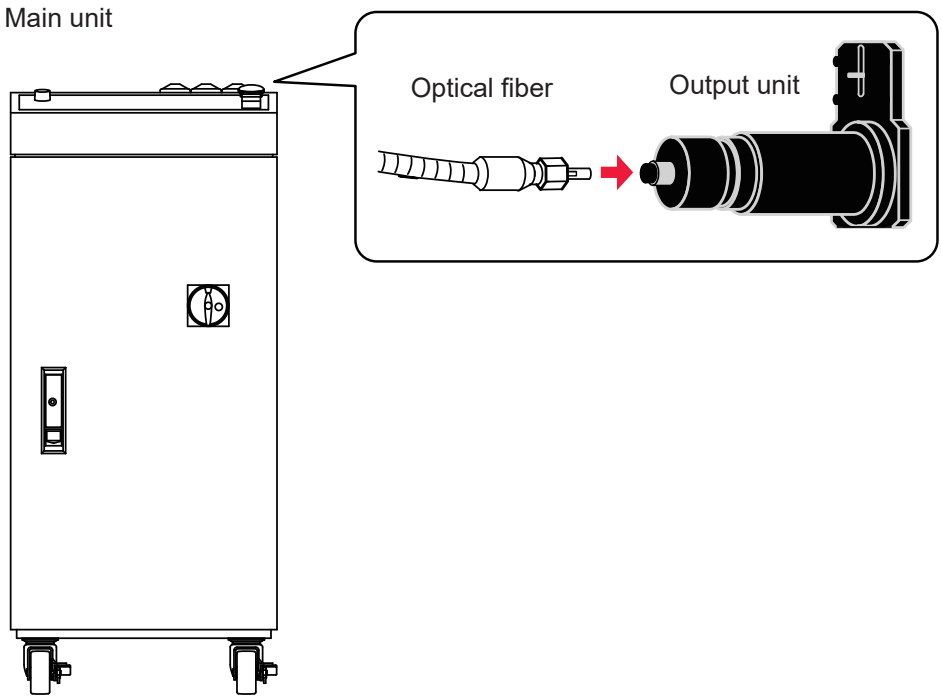
| Part name | Model No. | Q'ty |
|---|---|---|
| Flashlamp | MLD-0902 | 1 |
| Glass plate | A4-00719 | 1 |
| Ion-exchange resin refill | MLF-0020 | 1 |
| Ion-exchange resin replacing tool | MLF-0005 | 1 |
| Cooling water (Purified water, 20L) | MLU-0604-00 | 1 |
| YAG laser-protective glasses | YL-717 YAG OD7 | 1 |
| Ball point screwdriver | BS 2.5mm | 1 |
| | BSL 3mm | 1 |
| | BS 4mm | 1 |
| Water feed hand pump | TP-0002 | 1 |
| Gloves | Emboss L | 2 |
| Danger, warning, caution labels | P-00374-001 | 2 |
| | P-00474-001 | 2 |
| | P-0211 | 2 |
| | P-0212 | 2 |
| | P-0213 | 2 |
| | P-00377-001 | 2 |

| Part name | Model No. | Q'ty |
|---|---|---|
| Danger, warning, caution labels | P-1213 | 1 |
| | P-1215 | 1 |
| | L-07002-001 | 1 |
| Operation manual | AS1170499(OM1170500) | 1 |
| Power cable | A-03651-002 | 1 |

## Main Unit, Optical Fiber, and Output Unit

This product is used in combination with the optical fiber and output unit as shown below.

Main unit x 1 + Optical fiber x Number of deliveries + Output unit x Number of deliveries




The ML-2050A/2051A/2150A main unit is provided with the number of branch shutters with open-close sensor based on the number of deliveries.

| Model | Sharing method | Specification |
|---|---|---|
| ML-2□5□A-010 | Single delivery | Output to single optical fiber |
| ML-2□5□A-020 | 2-powersharing | Simultaneous outputs to 2 optical fibers |
| ML-2□5□A-030 | 3-powersharing | Simultaneous outputs to 3 optical fibers |
| ML-2□5□A-002 | 2-timesharing | Output to 1 optical fiber optionally selected from 2 optical fibers |
| ML-2□5□A-003 | 3-timesharing | Output to 1 optical fiber optionally selected from 3 optical fibers |

⇒ For the optical fiber and output unit, refer to the Operation Manual or Specification for each of them.

# Options

The following goods are options separately sold. Purchase them as required.

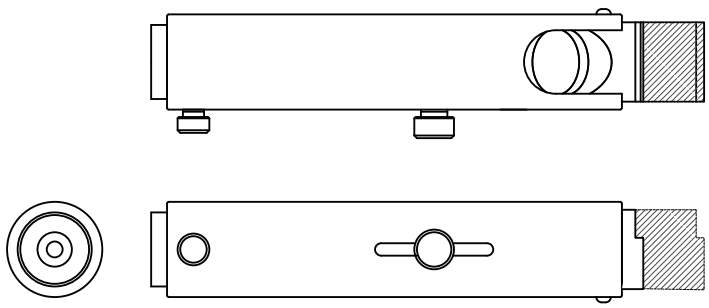
| Part name | | Model No. |
|---|---|---|
| Fiber scope | | FOS-04 |
| Laser controller | | MLE-115A-02-00 |
| Circuit cable | 3 m | C18-HD15M-HD15F-10 |
| | 15 m | C18-HD15M-HD15F-50 |
| Printer | | BL2-58SNWJC |
| RS-232C/RS-485 conversion adapter | | MSC-08S |
| AC adapter for RS-232C/RS-485 conversion adapter | | Exclusively for MSC-08 |
| RS-485 cable, 10 m | | A-05391-001 |
| RS-232C cable, 0.2 m | | KRS-9F25F02K |
| End face checker | | EC-02(LED)(50) |
| Output unit with fiber sensor | | Please contact us for information. |

⇒ For the maintenance parts separately sold, refer to the Maintenance Part, Chapter 1 "1. Maintenance Parts and Standard Intervals of Inspection/ Replacement" on page 145.

## Fiber Scope

This fiber scope is used to check the incident status to the optical fiber. Purchase it as required.

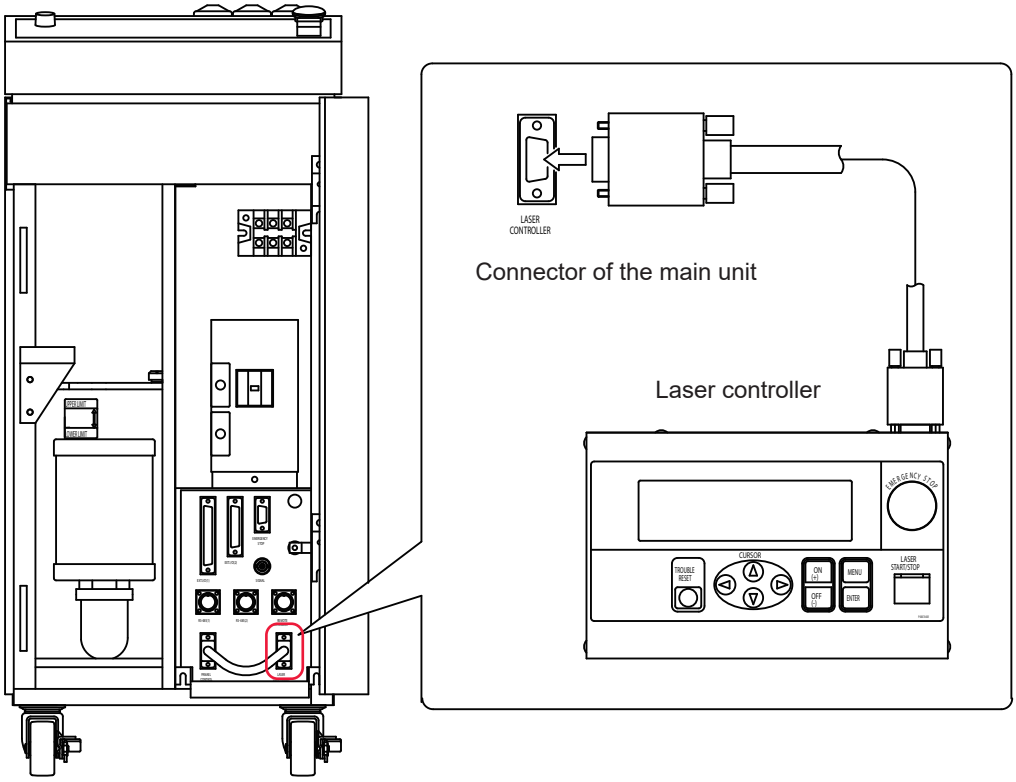
⇒ When using the fiber scope, the hatched portion shown in the following figure is not used. Remove this portion. The hatched portion is fixed with a screw.



## Laser Controller

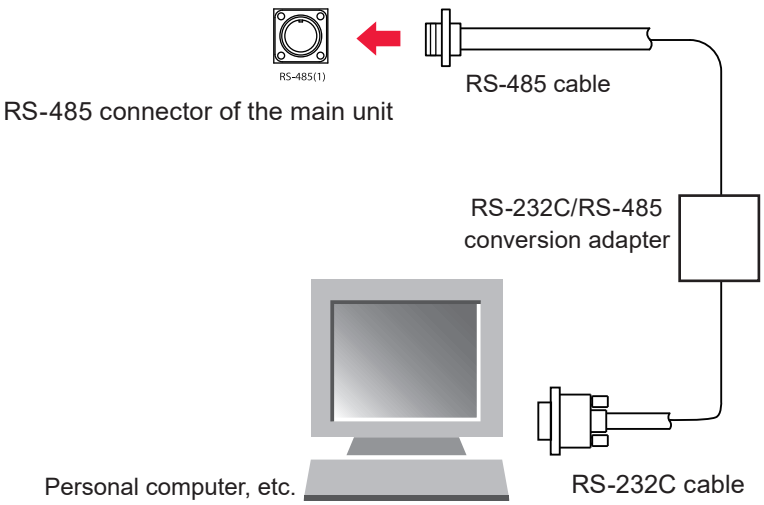
This laser controller is used to operate the laser in a place remote from the main unit. Connect this controller to the LASER CONTROLLER connector or the PANEL CONTROL connector of the main unit by using a 3 m or 15 m circuit cable. Purchase it as required.

**Main unit**



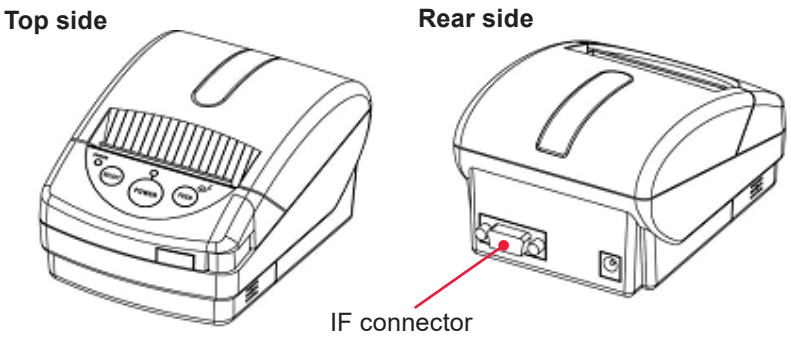

## RS-232C/RS-485 Conversion Adapter

This conversion adapter is used to control equipment by external communication. Output signals (RS-232C) of the personal computer are converted into RS-485 signals and then output to the main unit.



## Printer

When the printer (BL2-58SNWJC : SANEI ELECTRIC INC.) is connected by RS-485 cable, the output schedules of each schedule and measured values on the monitor screen can be printed out.  Purchase the printer as required.



Introduction Part

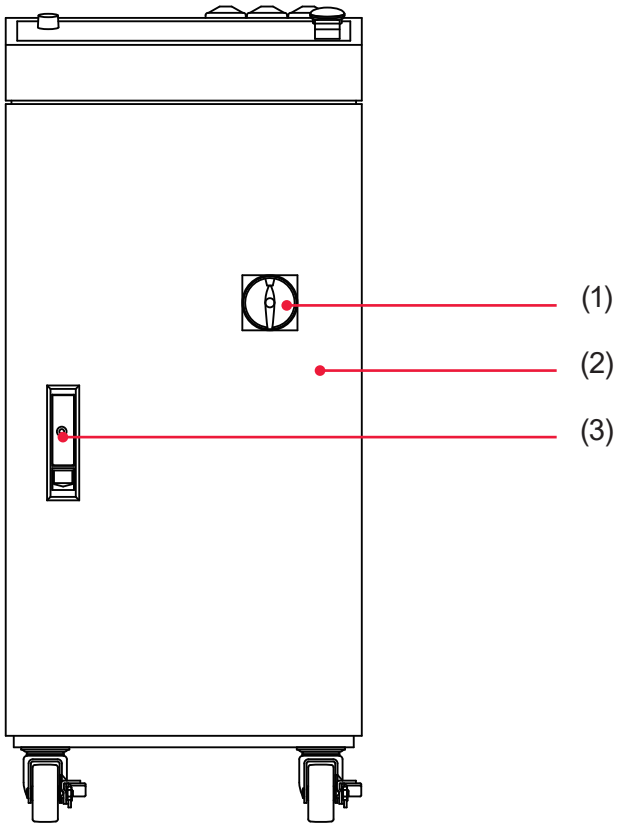
# Chapter 2

# Name and Functions of Each Section

## 1. Name and Function of Each Section on the Front Side

### Front Cover Section

**This section explains each section of the front cover of the main unit.**

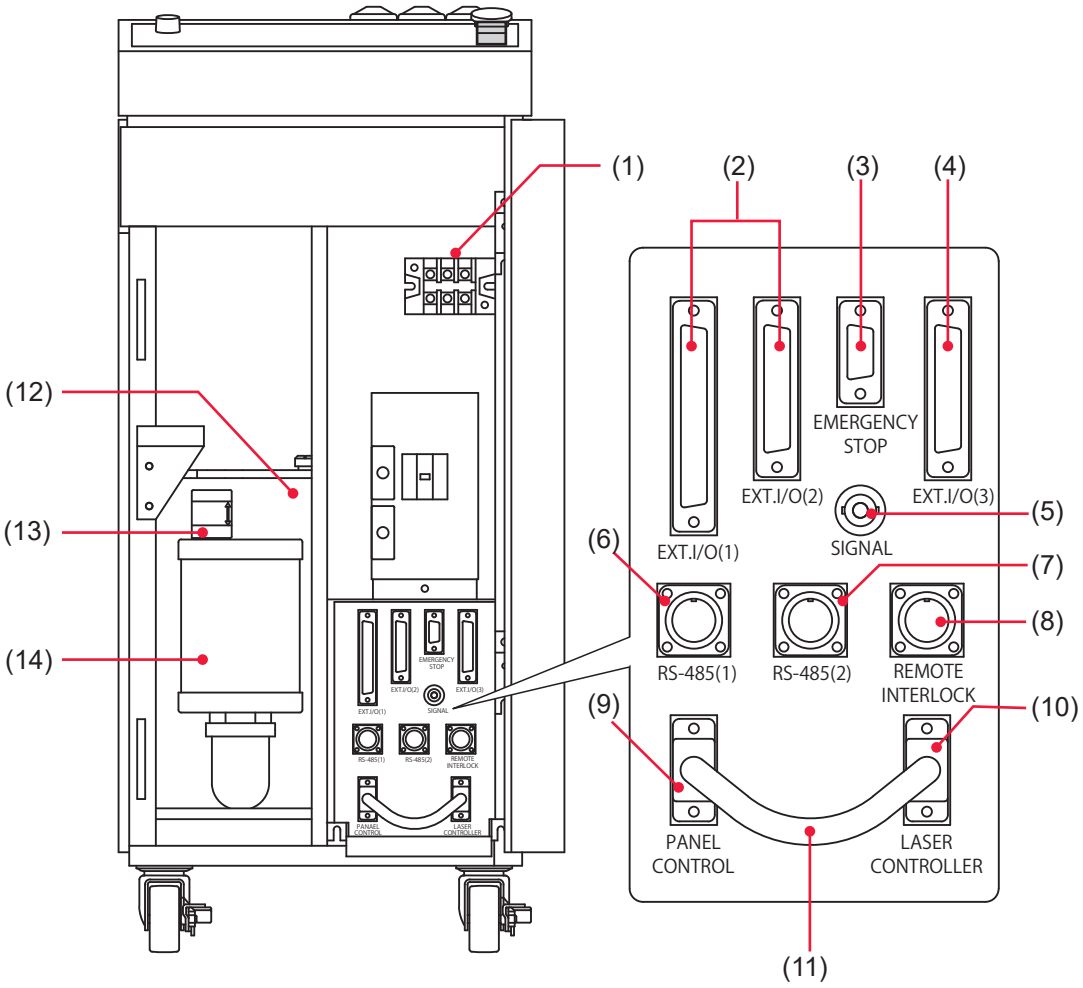



**Function of Each Section on the Front Cover**

| | |
|---|---|
| **(1) MAIN POWER Switch** | Turns ON and OFF the power supply. |
| **(2) Front Door** | This door is opened to perform maintenance including cable connections. |
| **(3) Front Door Handle** | Used to open the front door. Press the button under the handle and the handle will pop out. After closing the door, put back the handle into place and the door will lock. |

# Inside of the Front Side

**The front door is opened to perform maintenance. Each section of the inside is explained below.**




**Function of Each Section inside the Front Side**

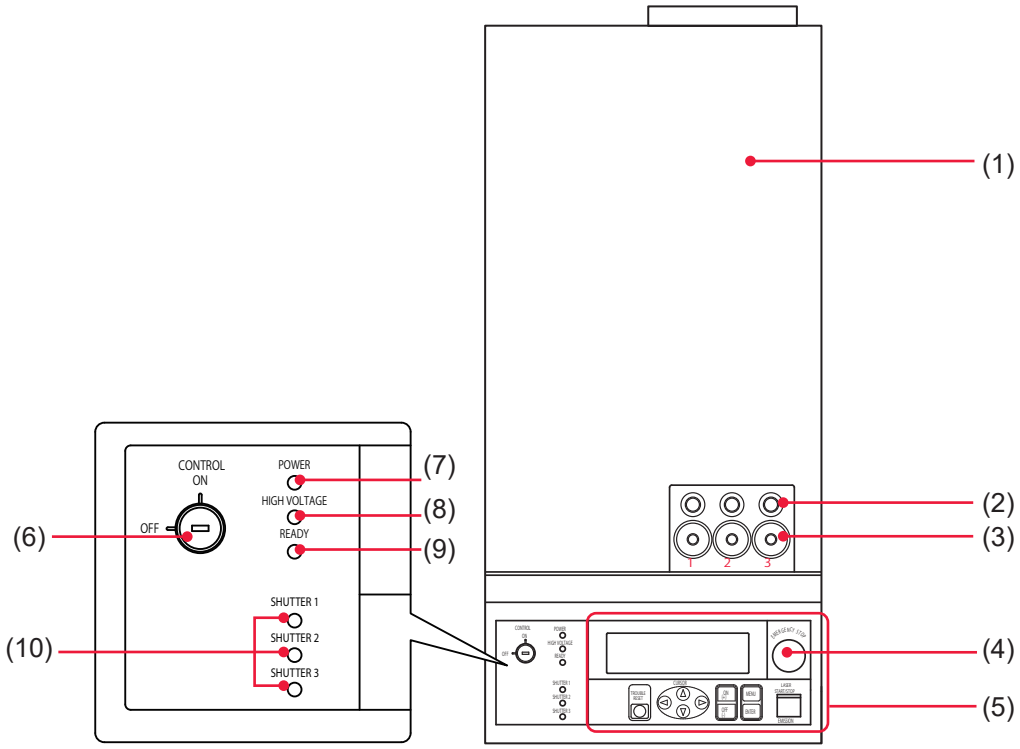
| | |
|---|---|
| **(1) Power Supply Terminals** | Connect the terminals to a single-phase power supply of 200/220/240 V AC, depending on specifications. |
| **(2) EXT. I/O (1)(2) Connectors** | Used to output signals, e.g., alarm signals and monitor judgment signals; and to input signals, e.g., start signal and schedule signals. |
| **(3) EMERGENCY STOP Connector** | Used to input and output Emergency signals. |
| **(4) EXT. I/O (3) Connector** | Used to input and output Emergency signals, and input the external interlock. |
| **(5) SIGNAL Connector** | BNC connector used to output an analog signal representing the monitor waveform of laser power. When viewing the waveform of laser output, connect to an oscilloscope. |
| **(6) RS-485 (1) Connector** | This connector is used to connect the laser to a personal computer or printer. |

| | |
|---|---|
| **(7) RS-485 (2) Connector** | This connector is used to connect the laser to a personal computer or printer. |
| **(8) REMOTE INTERLOCK Connector** | Connect it to the Remote Interlock for emergency stop. When disconnected, the resonator shutter and the branch shutters close to block the laser beam. |
| **(9) PANEL CONTROL Connector** | At delivery from the factory, the PANEL CONTROL connector and the LASER CONTROLLER connector are connected by short circuit cable. For using the optional laser controller, pull out the short circuit cable. |
| **(10) LASER CONTROLLER Connector** | This connector is used to connect the optional laser controller. Pull out the short circuit cable and connect the laser controller. Then, the laser can be operated at a remote place. (The control panel of the main unit is not operable.) |
| **(11) Short-Circuiting Cable** | Connected to the [PANEL CONTROL] Connector and [LASER CONTROLLER] Connector when shipping. |
| **(12) Cooling Water Tank** | Holds cooling water used for cooling the YAG rod, flashlamp and its power supply. |
| **(13) Water Level Label** | Shows proper level of the cooling water. |
| **(14) Ion-Exchanger** | Increases purity of the cooling water. |

# 2. Name and Function of Each Section on the Top Side

## Top Cover Section

**This section explains each section of the top cover of the main unit.**




### Function of Each Section on the Top Cover

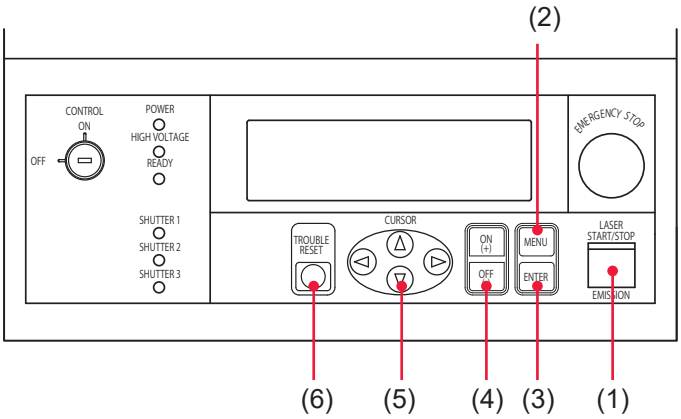
| | |
|---|---|
| **(1) Head Cover** | Cover for the laser oscillator. |
| **(2) Cable Inlet** | This is a hole to pass the cable for detection of optical fiber mounting/ breaking (option). The numbers of the output units connected to the cable inlet are 1, 2, and 3 in sequence from the left in the figure. |
| **(3) Optical Fiber Inlets** | Make the required number (number of deliveries) of holes in the rubber cap.<br>Pass the optical fibers through these holes and connect them to the laser beam input units. These inlets are on the top and rear side. |
| **(4) EMERGENCY STOP Button** | This is an emergency stop button. The power supply of the laser is cut off with this button pressed. When the pressed button is turned toward RESET (clockwise), the button is reset to the initial state. |
| **(5) Control Panel** | This panel is used to set welding schedules and operate the laser. Setting items and set values are displayed on the liquid crystal display. |
| **(6) CONTROL Keyswitch** | When the CONTROL keyswitch is turned ON with the MAIN POWER switch ON, this keyswitch is operable. When the laser is not used, turn OFF the CONTROL keyswitch and then pull out the key. The laser safety supervisor should take charge of the keyswitch. |
| **(7) POWER Lamp** | When the MAIN POWER switch is turned ON, the POWER lamp comes on so that the operator can check that the power supply has been turned ON. |

| | |
|---|---|
| **(8) HIGH VOLTAGE Lamp** | Indicates that high voltage is being supplied to the laser oscillator. |
| **(9) READY Lamp** | Lights up when charging of the capacitor bank has been completed. |
| **(10) SHUTTER Lamp (1 to 3)** | Stay(s) on while some (one) of the branch shutters 1 to 3 are (is) open. |

## Control Panel

**In the following, the buttons and keys on the control panel are explained.**

On the control panel, the operator can set welding schedules and perform laser light output operations. When the optional laser controller is connected, the same operations can be performed in a place remote from the laser by using the control panel of the laser controller.

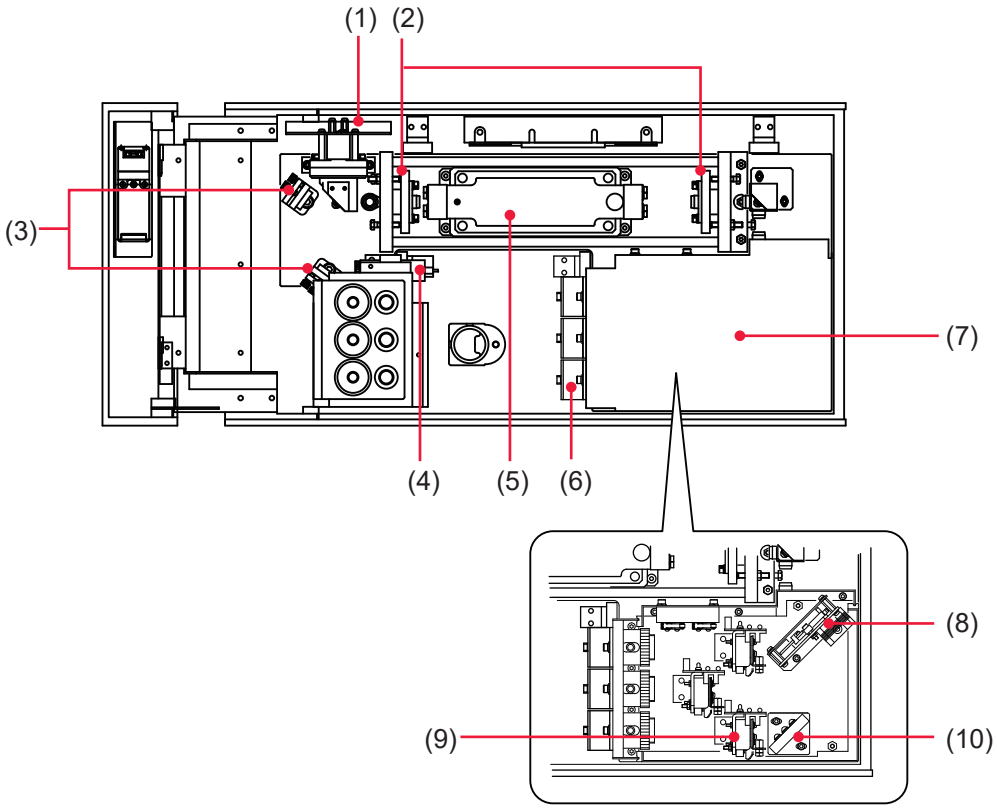



**Function of Each Section on the Control Panel**

| | |
|---|---|
| **(1) LASER START/STOP (Button)** | If you press the button when a laser light output becomes ready (*), laser light is output. If the button is pressed again while laser light is repeatedly output, the repeated output is stopped.<br>* Pin No.23 (control switching) of the EXT.I/O (1) connector is in an open-circuit status and a high voltage is supplied, and the branch shutter is open. |
| **EMISSION (Lamp)** | When a high voltage is applied to the laser oscillator section, the EMISSION lamp comes on. |
| **(2) MENU (Key)** | This switches the screen of the liquid crystal display. With this key pressed, the SCHEDULE screen, STATUS screen, or POWER MONITOR screen is selected in sequence. |
| **(3) ENTER (Key)** | This key is used to definitively set a set numeric value or ON/OFF specification.<br>After changing data, be sure to press the ENTER key to definitively set the set value. Unless the set value is not definitively set, it will go back to the pre-change value in several seconds. |
| **(4) ON (+) OFF (-) (Key)** | This key is used to specify the ON/OFF status of a setting item. This key also changes the numeric value or alphabet at the cursor position into the ascending order (ON key) or descending order (OFF key). |
| **(5) CURSOR (Key)** | This key moves the cursor (■) in the upward/downward or left/right direction on the screen. |
| **(6) TROUBLE RESET (Key)** | This key clears the trouble display and resets the screen after completion of trouble processing. |

# Laser Oscillator Section

**In the following, the laser oscillator section that is provided inside the top cover is explained.**




Inside of the branch section

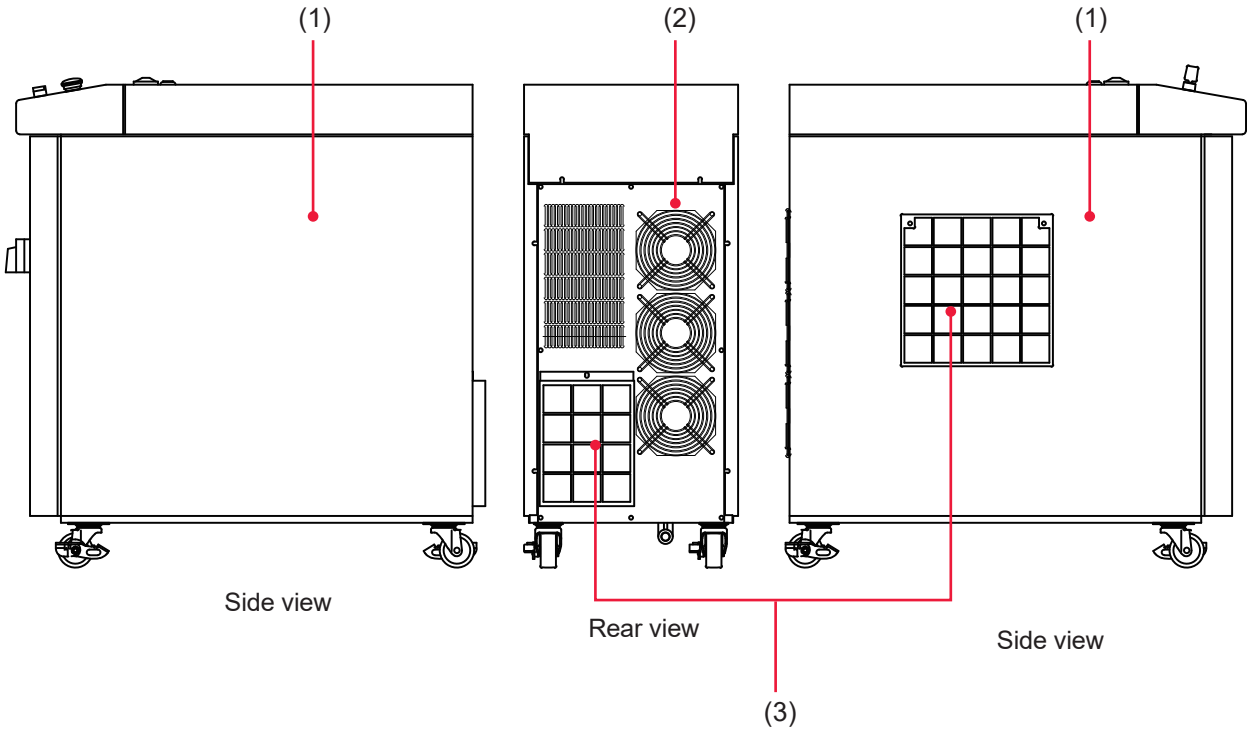
### Function of Each Section on the Laser Oscillator

| | |
|---|---|
| **(1) Power Monitor Unit** | Detects the YAG laser beam and measures its power. |
| **(2) Resonator Mirror Holder** | Holds the resonator mirror. Light excited in the Laser Chamber is amplified between the two resonator mirrors and output as a laser beam. |
| **(3) Guide Beam Reflecting Mirror** | Adjusts the guide beam (visible laser beam) so that this beam passes down the center of the YAG laser beam's optical path. |
| **(4) Guide Light Oscillator** | This oscillator outputs guide light (red visible laser).<br>Because YAG laser for welding is invisible, red guide light is used to perform oscillation adjustment, incident adjustment, welding point positioning, etc. |
| **(5) Laser Chamber** | Contains the flashlamp and the YAG rod. The flashlamp lights up to excite the YAG rod and emit laser beam. |
| **(6) Laser Beam Input Unit** (Up to 3 optional deliveries) | Connect the optical fiber to this unit. The Laser Beam Input Unit projects a laser beam from the laser chamber into the optical fiber. Depending on the specification, 1 to 3 laser beam input units are installed. |
| **(7) Branch Unit Cover** | Do not remove this cover except when installing and removing the optical fiber. |

| | |
|---|---|
| **(8) Timesharing Unit** (Only for timesharing version) | Mirror to reflect the laser light. This optical-path-switching mirror directs the laser light to the selected optical fiber. |
| **(9) Branch Shutter** (Up to 3 optional deliveries) | When closed, the laser light is blocked not to output. Depending on the specification, 1 to 3 branch shutters are installed. |
| **(10) Beamsplitter** (Up to 3 optional deliveries) | Splits a laser beam into the number of deliveries and reflects them onto each laser beam input unit. Depending on the specification, 1 to 3 beamsplitters are installed. |

# 3. Name and Function of Each Section on the Lateral Side and Rear Side

**This section explains each section on the lateral side and rear side.**




**Function of Each Section on the Lateral Side and Rear Side**

| | |
|---|---|
| **(1) Side Covers** | For both sides of the Laser. Power supply and cooler are beyond the cover. |
| **(2) Rear Cover** | For rear side of the Laser. Power supply and cooler are beyond this cover. |
| **(3) Air Filter** | At the intake of air. Prevents the Laser from dust and dirt. Cooling fan is beyond this filter. |

# Installation and Preparation Part

Installation and Preparation Part

# Chapter 1

# Installation

**This chapter explains the installation place and schedules of the laser welder, and precautions about cooling capacity and room temperature.**

⇒ When installing the laser welder, our engineer will take charge of adjustments. Accordingly, this Operation Manual does not describe the adjusting method at a startup. When the laser is transferred to another installation place, it may be necessary for our engineer to perform inspection and re-adjustments.

## 1. Installation Place

**The space required for installing the laser welder and the environment suitable for the installation are explained below.**

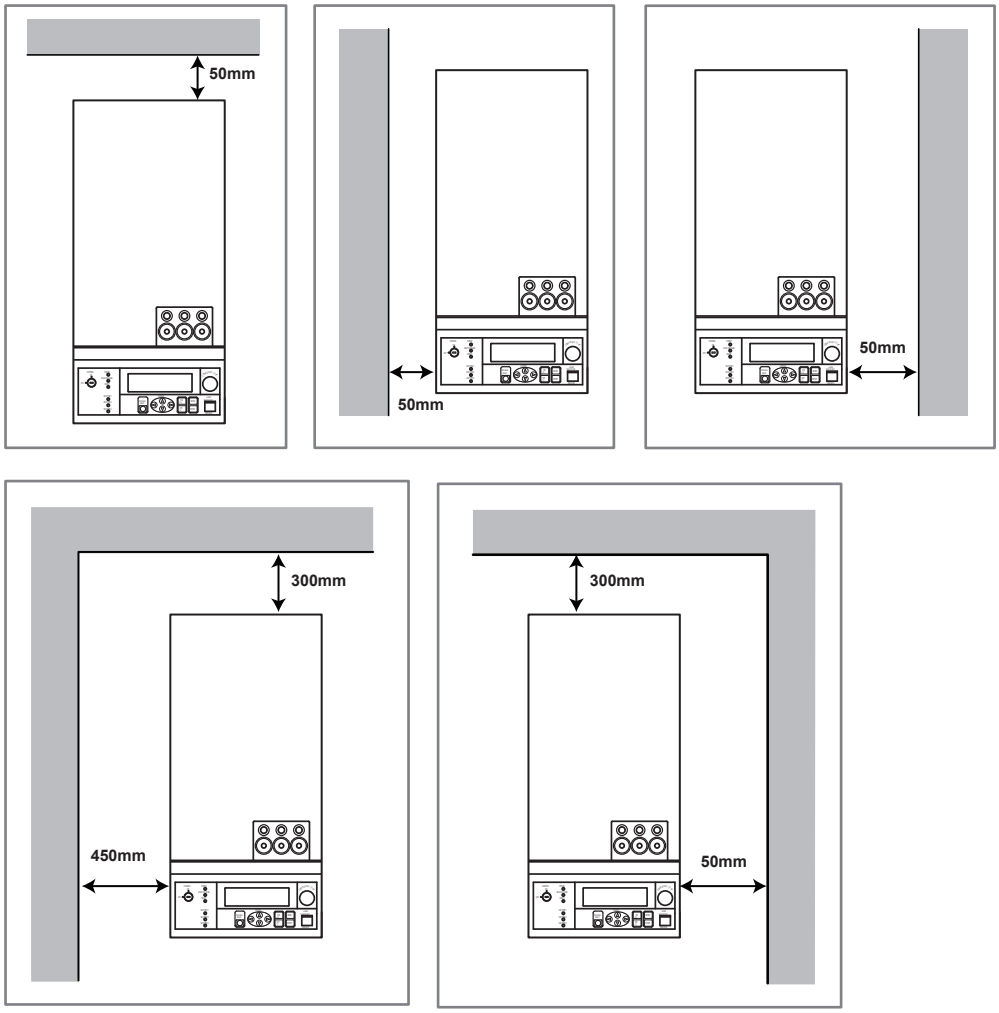
Install this laser welder in a sure place at a level with the ground surface. If the product is operated in inclined or fallen form, a failure will occur.

⇒ For the power supply side, we earnestly recommend using a leakage breaker with the rated current of 15 A or more, which is applicable to harmonics and surges.
⇒ Perform class D grounding work (Ministry of Economy, Trade and Industry "Technical Standards for Electric Equipment").

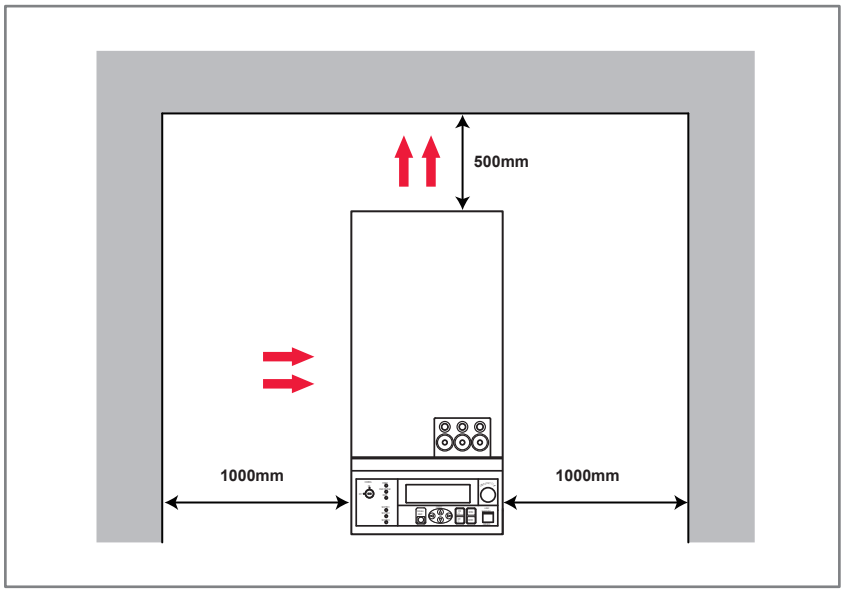
### Space Required for Installation

In the installation place of this product, a space is required in the surroundings.

Install the product in a place remote from the wall as shown in the figure on the next page. Also, at least 500 mm of space is required in front, back, right, left and upper sides to cool the internal parts at maintenance.




⇒ Air flows in the direction of the red arrow shown in the following figure. Install the product so as not to interrupt the air flow.

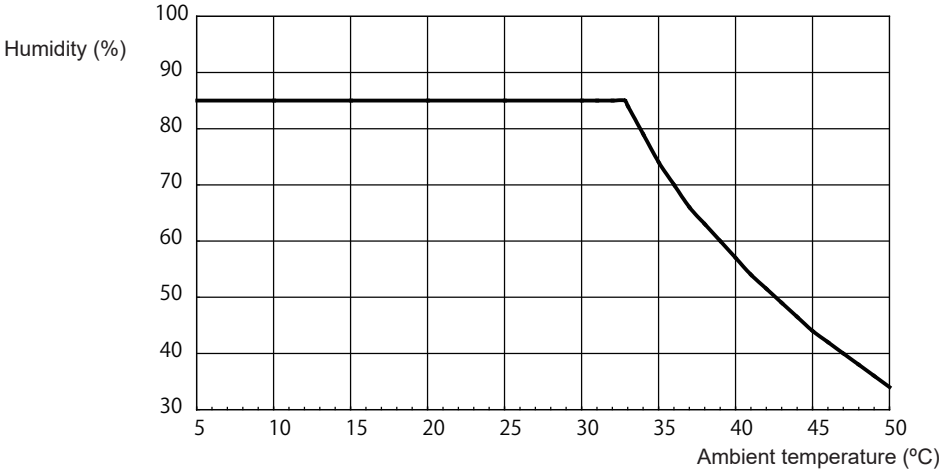


# Environment Suitable for Installation and Precautions

⇒ In laser processing, dust and fumes are generated from workpiece. Depending on the kind of workpiece, they may adversely affect a human body. Also, dust and fumes from workpiece may cause staining and burning of optical parts and lower the laser output. Furthermore, if conductive dust enters the laser equipment, a short circuit accident may occur to cause malfunction. Therefore, in laser processing, be sure to install an exhaust device such as dust collector and blower in a proper position to keep a clean environment.

⇒ Use the product in a place where the ambient temperature is 5 to 30ºC and the ambient humidity is 85%RH or less and yet a sudden temperature change does not occur. If the humidity is higher than values shown below, condensation may occur.

**Upper limit of ambient humidity**




⇒ Avoid operating the product in the following places because a failure may occur.

- Place where there is considerable dirt, dust, or oil mist,
- where the Laser may be subjected to vibration or impact,
- where the Laser may be exposed to chemicals,
- where there is a nearby high noise source,
- where moisture may be condensed on the surface of the Laser,
- where the concentration of $CO_2$, NOx or SOx is high. (Air containing more than 0.1% $CO_2$ may shorten the life of the ion-exchange resin.)

⇒ If the temperature falls below 0°C in winter, the cooling water will be frozen and the Laser may be broken. Particularly in cold districts, take care that the temperature of the Laser does not fall below 0°C. When the product is not operated for one month or longer or the temperature is 0ºC or less, bleed the equipment of cooling water completely. For bleeding, refer to the Maintenance Part, Chapter 1 "2. Maintenance of the Cooler Unit Section" on page 149 and page 154.

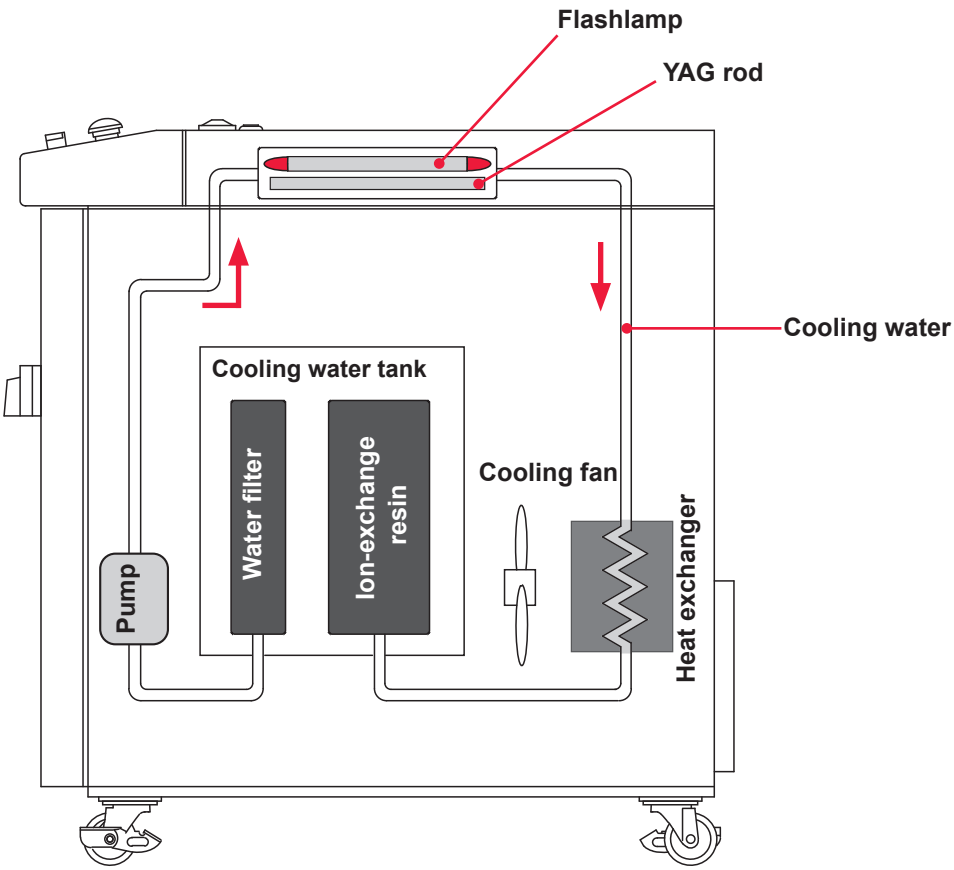
⇒ When a sudden temperature change occurs, for example, at a start of heating, condensation will be caused to the end face of the YAG rod and the surface of the mirror, thereby sticking dust there. Avoid such a sudden temperature change if possible. When there is a possibility of condensation, turn ON the power supply of the laser. In about 2 hours, start to operate the laser.

# 2. Cooling Water

Cooling water is used to cool the flashlamp and YAG rod provided in the laser chamber in the laser oscillator section. Use deionized water or purified water.

Tap water, industrial water, ground water, or ultra pure water (16 MΩ·cm minimum resistivity) may cause corrosion or clogging, resulting in fault of the equipment.

**Image diagram of cooling water circulation**

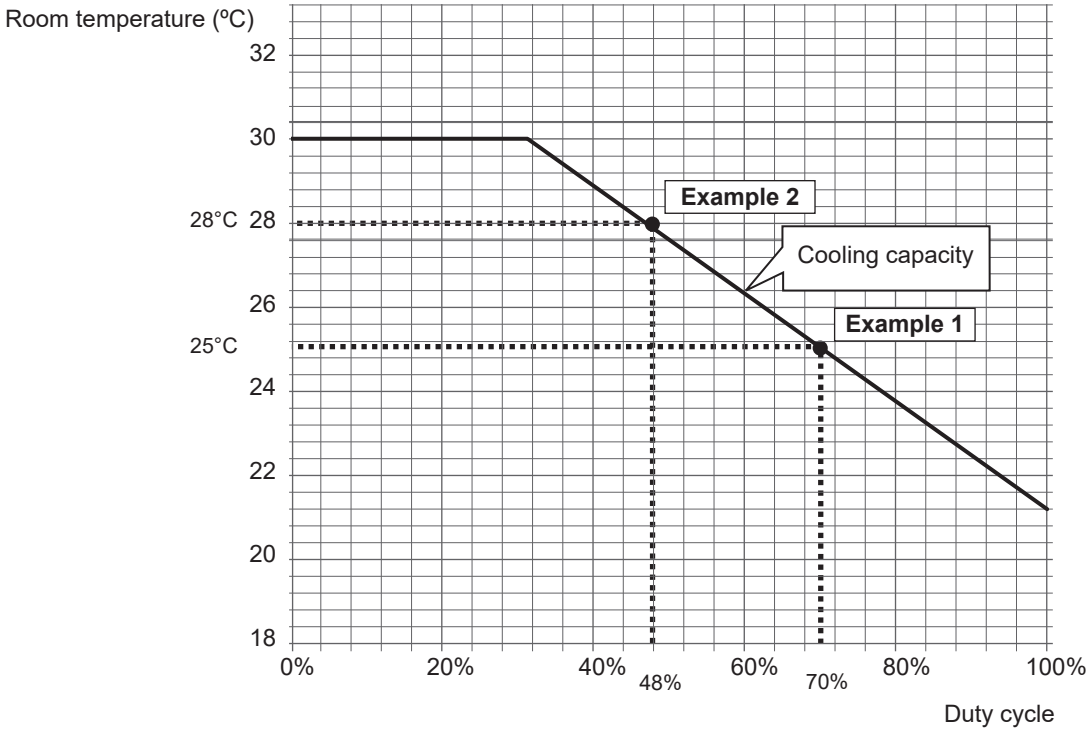


# Precautions on Cooling Capacity and Room Temperature

The following graph represents the relation between the duty cycle and the cooling capacity (upper limit of room temperature).

If the value exceeds the cooling capacity line, error No.10 HIGH TEMPERATURE OF COOLANT occurs. Also, do not operate the product in a room temperature exceeding the range of 5 to 30ºC shown in the specifications or under a condition exceeding the laser rated output even within a range shown in the graph.

The duty cycle here means the average value of LAMP INPUT PWR including the time when the flashlamp is not turned on. The LAMP INPUT PWR is displayed on the POWER MONITOR screen.




When the duty cycle is less than 100%, the following relation holds.

*Example 1*

The LAMP INPUT PWR is 100% and power is "output for 7 sec and then stopped for 3 sec."

(1 cycle: 10 sec)

Duty cycle = 100×7 / 10 = 70%

In the graph, when the duty cycle is 70%, the room temperature is about 25ºC.

To obtain the full cooling capacity, operate the product at a room temperature of 25ºC or less.

*Example 2*

The LAMP INPUT PWR is 80% and power is "output for 3 sec and then stopped for 2 sec."

(1 cycle: 5 sec)

Duty cycle = 80×3 / 5 = 48%

In the graph, when the duty cycle is 48%, the room temperature is about 28ºC.

To obtain the full cooling capacity, operate the product at a room temperature of 28ºC or less.

Installation and Preparation Part

# Chapter 2

# Connections and Preparations of Each Section

## 1. Connecting the Power Supply

**⚠ CAUTION**

**Your qualified electrician must carry out the electrical connection to main power supply. (Also follow your local accident prevention regulations, such as the German Regulation, BGVA2.)**

**⚠ CAUTION**

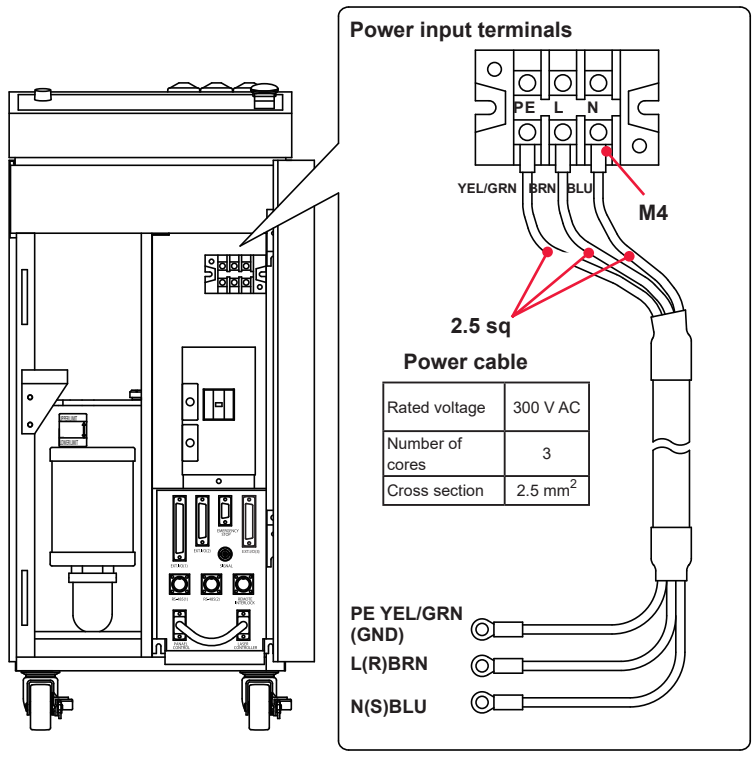
**For the power supply side, we earnestly recommend using a leakage breaker with the rated current of 15 A or more, which is applicable to harmonics and surges.**

### Item required

Phillips screwdriver

### Operating Procedure

(1) Open the front door and remove the plastic cover on the power input terminal 200 V AC/220 V AC/240 V AC (depending on the specification).
(2) Lead the attached power cable inward from the hole on the bottom plate of the main unit.
(3) While confirming the terminal colors of the power cable, connect the power cable to the PE (yellow/green), L (R) brown, and N (S) blue power input terminals.



# 2. Preparing Cooling Water

**⚠ CAUTION**

**Use deionized water or purified water for cooling water. Using tap water, industrial water, ground water, or ultra pure water (Resistivity: 16 MΩ-cm or more) causes corrosion or clogging, resulting in a failure.**

### Item required

Cooling water (6 liters), water feed pump

## Operating Procedure

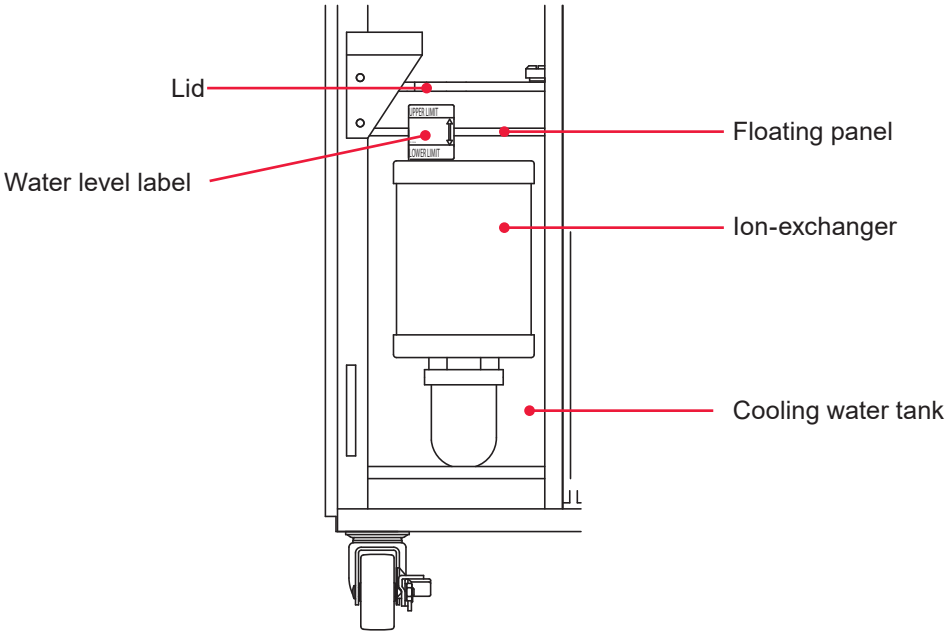
(1) Open the front door and remove the lid of the cooling water tank.

(2) Take out the floating panel in the tank.
⇒ Take care not to attach dirt onto the floating panel.

(3) Feed cooling water up to the line under the water level label "HIGH" by using the attached water feed pump.
⇒ Use the water feed pump only for cooling water and do not use other uses including kerosene.

(4) Float the floating panel on the water and install the lid of the cooling water tank as before.
⇒ The floating panel can be repeatedly used. When it is stained, wash it lightly in tap water with a soft sponge and lastly rinse it in deionized water or purified water for use.
⇒ When the cooler is operated for the first time after water feeding, the water level may a little lower. In this case, replenish cooling water again. Before feeding cooling water, be sure to take out the floating panel.

**Status where the front door of the main unit is opened**



# 3. Connecting the Optical Fiber

**This section explains the method of connecting the optical fiber.**

In this laser, a high-precision type optical fiber is adopted. Once the incident optical axis is adjusted, this optical axis does not need to be adjusted again after the fiber is mounted.

**⚠ WARNING**

- **Be sure to receive education for this work from our engineer.**
- **Before starting work, be sure to turn OFF the power supply.**

## Before Connection

Before making a connection, check the end face of the optical fiber. If it is stained or dust is attached, blow it off by air blow or wipe it out with lens cleaning paper.

For how to clean the optical fiber, refer to the Maintenance Part, Chapter 1, "3. Maintenance of the Laser Oscillator Section" on page 160.

⇒ For a check for stain, use the optional end face checker.

⇒ Use such an air blow dedicated to cameras as shown at right. If rubber is deteriorated, dust may enter the optical fiber. Use a clean air blow.

## Precautions during Operation

⇒ During operation, take care not to give shocks to the optical fiber or bend it below the minimum bending radius (in the following table).

**Minimum bending radius of the optical fiber**

| Core diameter | Minimum bending radius |
|---|---|
| φ 0.2, 0.3, 0.4mm | 100mm |
| φ 0.6mm | 150mm |
| φ 0.8mm | 200mm |
| φ 1.0mm | 250mm |

⇒ Do not tighten the ring of fiber plug too firmly; otherwise the incident laser beam may be dislocated. Tighten the ring by hand without using a tool.

## Standard Values of Maximum Incident Laser Energy and Power of the Optical Fiber

The following table shows the standard values of maximum laser energy and power that can be input into the optical fiber. Take care not to exceed these values when using the optical fiber.

**For single-delivery or timesharing**

The value becomes 1/2 at 2-powersharing and 1/3 at 3-powersharing.

<table>
<tr><th>Model<br>Core dia.</th><th>ML-2050A</th><th>ML-2051A</th><th>ML-2150A</th></tr>
<tr><td>SI φ 0.2mm</td><td>-</td><td rowspan="3">7J, 7W</td><td rowspan="2">-</td></tr>
<tr><td>SI φ 0.3mm</td><td rowspan="2">15J, 15W</td></tr>
<tr><td>SI φ 0.4, 0.6, 0.8, 1.0mm</td><td>25J, 25W</td></tr>
</table>

⇒ Use an optical fiber of φ 0.4 mm core diameter or larger for ML-2150A.

⇒ Use the SI optical fiber. The GI optical fiber cannot be used.

### Item required

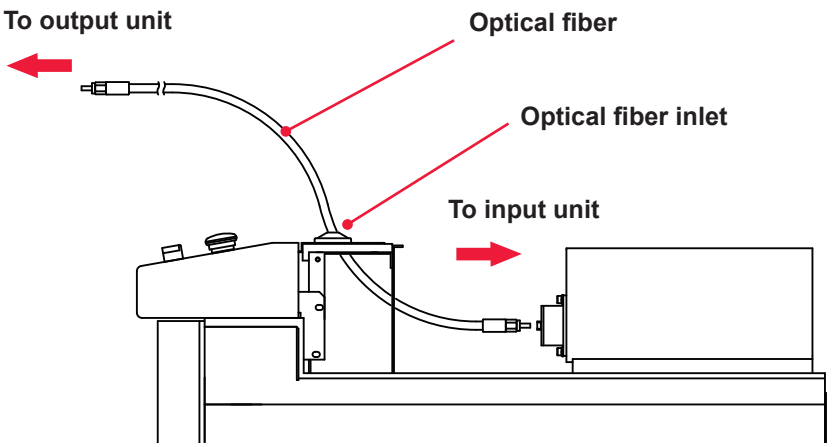
Phillips screwdriver and air blow

## 1 Connecting to Laser Beam Input Unit

(1) Remove the head cover.

(2) Pass the optical fiber with its cap attached into the Laser through one of the optical fiber inlets located on the Laser top and at its rear.

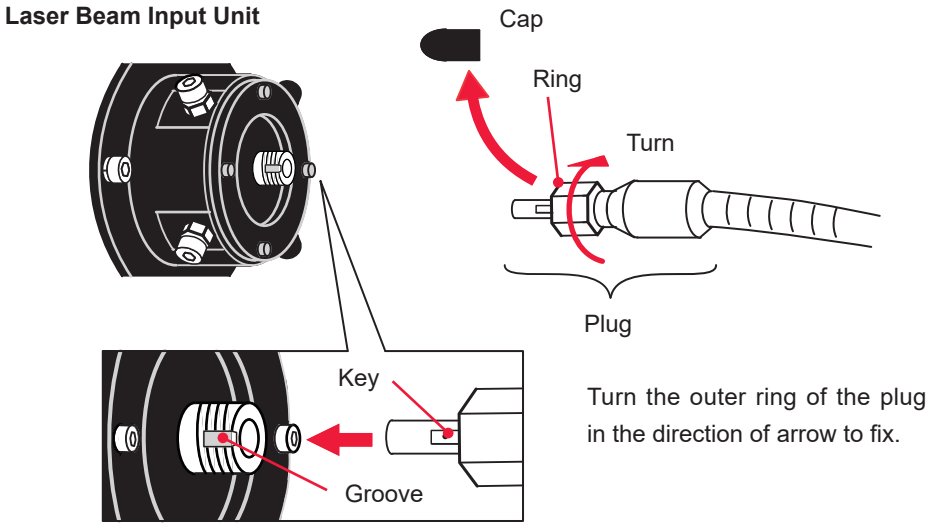
(3) Remove the cap from the end of the passed fiber and blow off any dust using an air blow.




(4) Connect the fiber to the laser beam input unit, with the key of the fiber plug aligned with the groove of the unit.

(5) Turn the outer-side ring of the plug in the direction of the arrow to fix the optical fiber.

⇒ Tighten the ring by hand without using a tool.




(6) Return the head cover and fix them.

## 2 Connecting to Laser Beam Output Unit

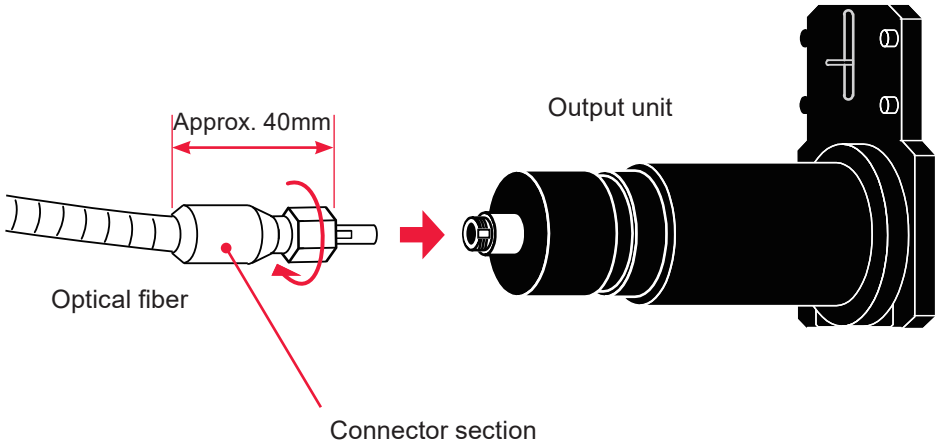
(1) Remove the cap at the end of the optical fiber and blow off dust by using the air blow.

(2) Insert the key provided on the optical fiber plug along the groove on the output unit side.

(3) Turn the outer-side ring of the plug in the direction of the arrow to fix the optical fiber.

⇒ Tighten the ring by hand without using a tool.

⇒ The connector section cannot be bent. Take care not to give excessive force to this section.




⇒ Keep the recover cap in a clean place in custody. If a dirty cap is mounted again, this will cause seizure.

# 4. Connecting the Laser Controller (Option)

When using the laser controller as a remote controller, connect the cable.

**⚠ CAUTION**

**Be sure to turn OFF the power supply before starting to connect the laser controller.**

### Item required

Laser controller and circuit cable

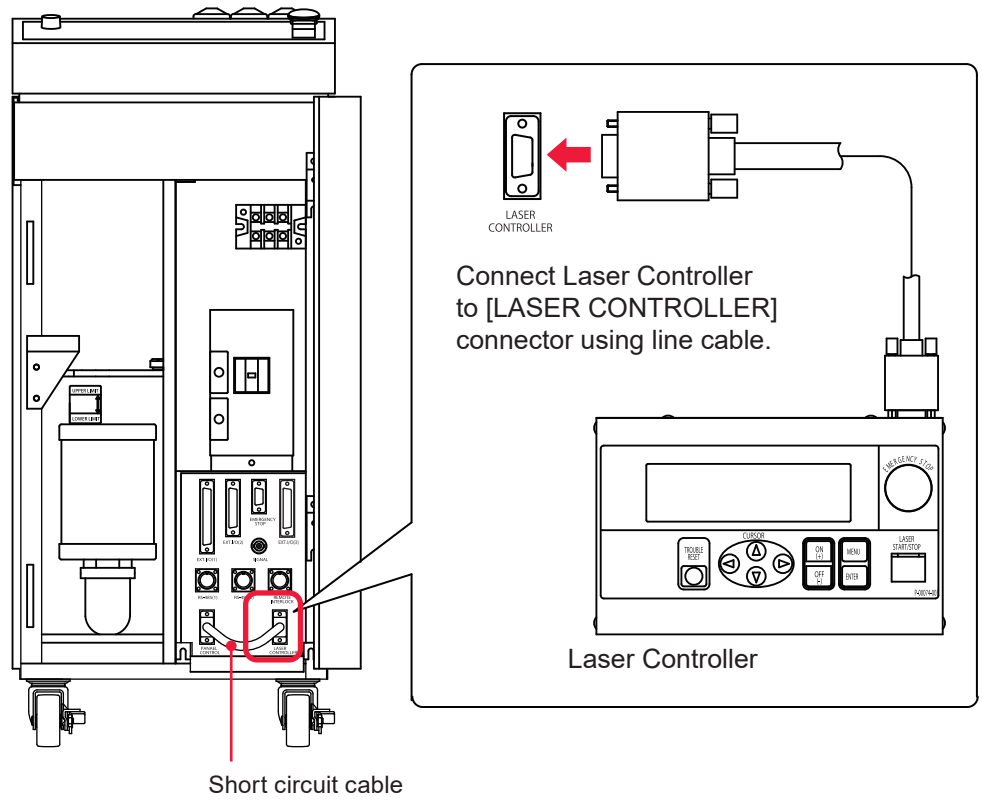
## Operating Procedure

(1) Open the front door and disconnect the short circuit cable.

(2) Connect between the main unit and the laser controller by circuit cable.

⇒ The laser controller and circuit cable are options. The circuit cable types are classified into 3 m and 15 m.

⇒ When the laser controller is connected, operations from the control panel are disabled. However, the EMERGENCY STOP button and the CONTROL keyswitch are effective.



# 5. Connecting the External Communication Conversion Adapter (Option)

To perform laser welding by external communication control (RS-485 CONTROL) using Control unit provided with RS-232C such as personal computer, the optional external communication conversion adapter "RS-232C/RS-485 conversion adapter" is required.

⇒ For making a connection to a PLC provided with RS-485, the conversion adapter for external communication is not required.

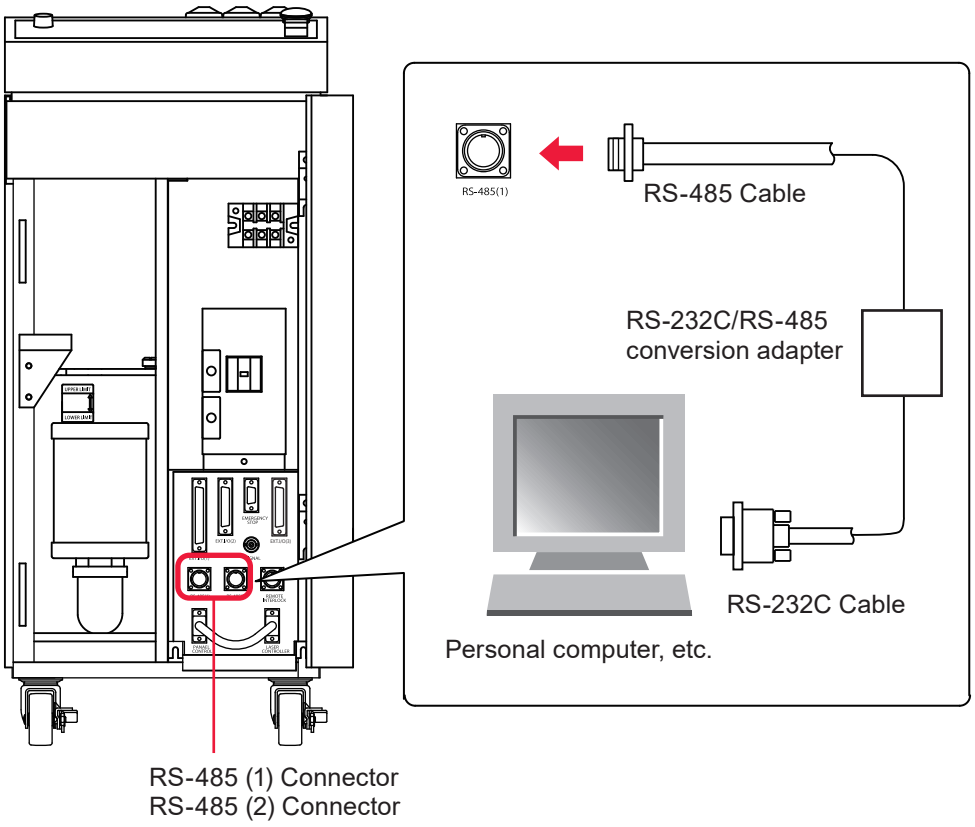
### Item required

RS-232C/RS-485 conversion adapter, RS-485 cable, and RS-232C cable

## Operating Procedure

(1) Connect the RS-485 cable to the RS-485 (1) or RS-485 (2) connector of the main unit.

(2) Connect the RS-232C cable to the RS-232C connector of the personal computer or the like through the "RS-232C/RS-485 conversion adapter."



# Operating Part

Operating Part

# Chapter 1

# Control Method, and Start and Stop

## 1. Control Method

**This section explains the control method for the laser.**

The following 3 control methods are available, namely, control from the control panel or laser controller (option) (PANEL CONTROL), control by external input/output signals connecting the PLC (*) to the laser (EXTERNAL CONTROL), and control by sending commands from the personal computer or the like (RS-485 CONTROL).

Select one of these 3 control methods according to the welding work. The selected control method is displayed on the STATUS screen.

*: PLC: Programmable Logic Controller which is a unit to perform sequence control by executing the programmed contents of control in sequence. This unit is often called sequencer (product name of Mitsubishi Electric Corporation).

### Switching the Control Method

#### Control by Control Panel (PANEL CONTROL)

When the laser is used independently or when the power supply of the PLC or personal computer connected to the laser is OFF, the laser is under control by control panel.

⇒ To switch the control by external input/output signals over to the control by control panel, turn OFF pin No.23 (control switching) of the EXT. I/O (1) connector.

⇒ To switch the control by external communication control over to the control by control panel, send a command to set the control method from the personal computer.

⇒ If the CONTROL keyswitch of the main unit is turned OFF even if another control method is used, it is reset to the control by control panel. When the CONTROL keyswitch is turned on again, the control method is switched to the control from the control panel if the external communication control is used, or the control method is set to the control by external input/output signals if the control by external input/output signals is used and pin No.23 (control switching) of the EXT. I/O (1) connector is ON (closed circuit).

#### Control by External Input/Output Signals (EXTERNAL CONTROL)

When the PLC or the like is connected to the main unit and pin No.23 (control switching) of the EXT.I/O (1) connector is turned ON (closed circuit), the control by external input/output signals (EXTERNAL CONTROL) is selected.

⇒ This control method cannot be selected by operating the control panel or personal computer.

#### Control by External Communication Control (RS-485 CONTROL)

The control by external communication control is selected by sending a command to set the control method from the personal computer or the like connected to the main unit.

⇒ This control method cannot be selected by operating the control panel or external input/output signals.

# 2. Start and Stop

**This section explains the methods of starting and stopping the laser.**

## How to Start the Laser

### Operating Procedure

(1) Turn ON the MAIN POWER switch.

(2) Turn ON the CONTROL keyswitch.

(3) Select a control method as required and perform laser welding.

⇒ For the control by control panel, set the output schedules and sharing method by operating the buttons while watching the liquid crystal screen display, and press the LASER START/STOP button to output laser light.

⇒ For the control by external input/output signals, execute the program by PLC, switch the control method, select output schedules, set the sharing method, and exert laser start/stop to output laser light.

⇒ For the control by external communication control, execute the program, switch the control method, set output schedules, set the sharing method, and exert laser start/stop to output laser light.

## How to Stop the Laser

### Operating Procedure

(1) Turn OFF the high voltage.

(2) Turn OFF the CONTROL keyswitch and pull out the key.

(3) Turn OFF the MAIN POWER switch.

⇒ The laser safety supervisor takes charge of the key of the CONTROL keyswitch.

Operating Part

# Chapter 2

# Various Settings

## 1. Setting Welding Schedules

**This section explains the method of setting various laser welding schedules by using the control panel. The set schedules can be protected so that they cannot be changed.**

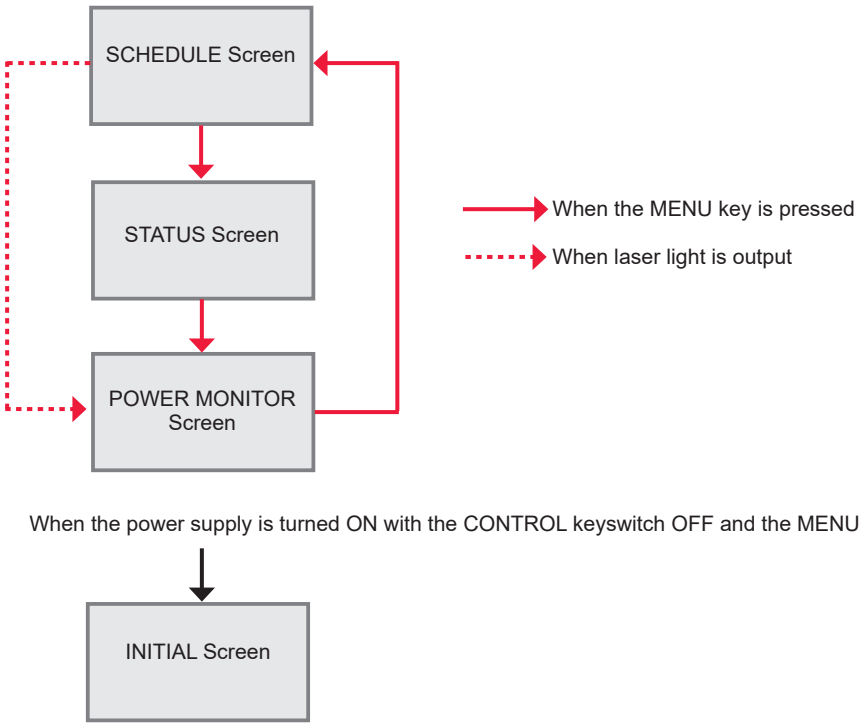
### Welding Schedule Setting Screen

**How to see the SCHEDULE, STATUS, POWER MONITOR, and INITIAL screens to set welding schedules is explained below.**

The following 4 screens that are displayed on the control panel are available. While watching these screens, perform various settings by operating keys provided on the control panel.

Pressing the MENU key switches the screen on the control panel over to the SCHEDULE screen, STATUS screen, and POWER MONITOR screen in this order. When laser light is output, the POWER MONITOR screen is automatically displayed so as to check the output energy.

Display the INITIAL screen to set the external communication function or select each function from the personal computer.



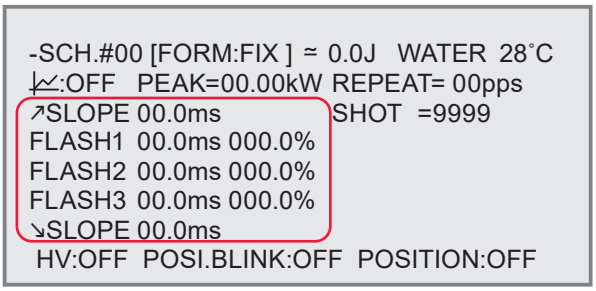
## SCHEDULE Screen

On the SCHEDULE screen, the laser light output schedules and SCHEDULE numbers are set.

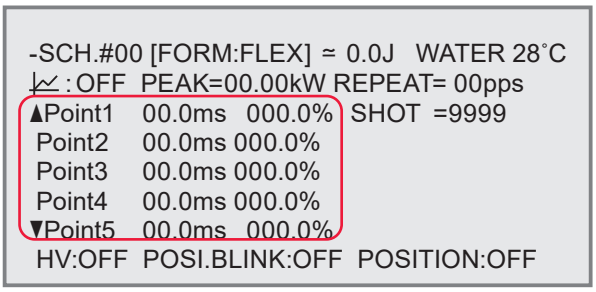
If a registered SCHEDULE number is entered, the corresponding output schedules can be called.

The setting items of laser output time and laser output value are different between fixed waveform (FIX) and flexible waveform (FLEX).

**Fixed waveform (FIX) screen**

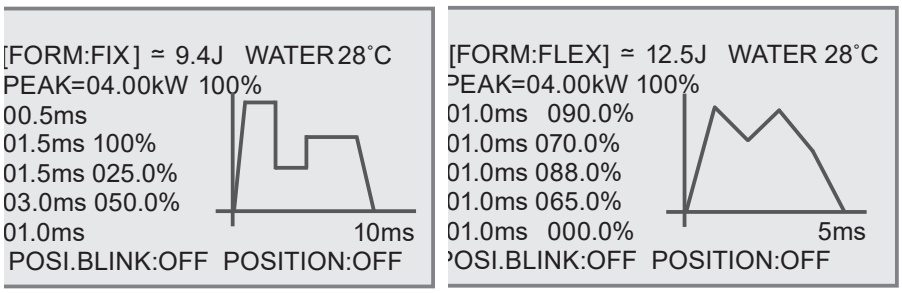



**Flexible waveform (FLEX) screen**




### How to see the displayed items

: Settable item

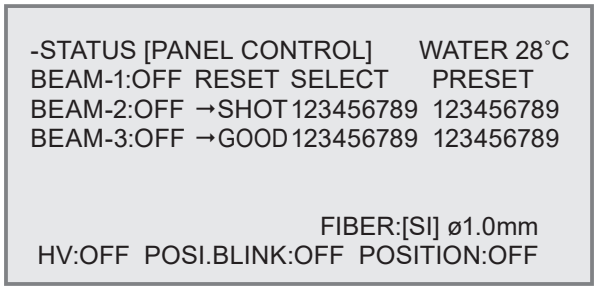
| | |
|---|---|
| **-SCH.#** | Sets the SCHEDULE number of laser light. The 32 numbers of #00 to #31 and output schedules can be set. |
| **FORM** | Switches the waveform creating method over to "FIX" (fixed waveform) or "FLEX" (flexible waveform). When the FORM setting is switched, the set value of waveform is reset to 0. |
| | Sets the graph display of laser output value to ON/OFF. When the graph display is set to ON, the laser output value set on the right side of the screen is displayed as a waveform.<br><br>Graph display of fixed waveform (FIX) Graph display of flexible waveform (FLEX)<br><br>  <br><br><br>The laser light of the same waveform as displayed on the graph is output. Accordingly, it is possible to set the laser output value while checking the waveform. When the graph display is set to ON, the lower items become invisible. When setting "REPEAT" or "SHOT", turn OFF beforehand. |

| | | |
|---|---|---|
| **PEAK** | | Sets the peak value of laser output (value when "FLASH1" to"FLASH3" are 100%). Regarding the actual laser output value, set the ratio (%) to the peak value supposing that the set peak value is the reference value (100%).<br>***<Note>***<br>The settable maximum peak value of laser output differs depending on the model.<br>ML-2050A: 4.0 kW, ML-2051A: 2.5 kW, ML-2150A: 6.0 kW |
| **Fixed waveform (FIX)** | **↗SLOPE** | Sets the up-sloping (the laser output becomes gradually stronger) time to "FLASH1." After setting "FLASH1", set this time in the range of ↗SLOPE ≤ FLASH1. |
| | **FLASH1**<br>**FLASH2**<br>**FLASH3** | To set the fixed waveform "FIX", set the laser output time (ms) of "FLASH1" (first laser) to "FLASH3" (third laser) and the laser output value (%) in the following range.<br>Laser output time (ms): 0.0 to 10.0 ms<br>Laser output value (%): 0 to 200% |
| | **↘SLOPE** | Sets the down-sloping (the laser output becomes gradually weaker) for the last FLASH.<br>Sets this time in the range of ↘SLOPE ≤ FLASH1, FLASH2, FLASH3.<br>***<Notes>***<br>- Though the setting range of laser output value (%) is 0 to 200%, it cannot be set exceeding the maximum value of "PEAK" x 100%. If 100% is set, it becomes the value set in "PEAK."<br>ML-2050A: When the maximum PEAK value is 4.0 kW, the laser output value is 0 to 100%.<br>ML-2051A: When the maximum PEAK value is 2.5 kW, the laser output value is 0 to 100%.<br>ML-2150A: When the maximum PEAK value is 6.0 kW, the laser output value is 0 to 100%.<br>- Set the laser output time so as to satisfy the expression of 0.20 ms ≤ FLASH1 + FLASH2 + FLASH3 ≤ 10.0 ms. |
| **Flexible waveform (FLEX)** | **Point1**<br>.<br>.<br>**Point20** | To set the flexible waveform "FLEX", set the laser output time (ms) and laser output value at each point of "Point1" to "Point20" in the following range.<br>Laser output time (ms): 0.2 to 10.0 ms<br>Laser output value (%): 0 to 200%<br>***<Note>***<br>Set the laser output time so as to satisfy the expression of 0.2 ms ≤ Total of all Point values ≤ 10.0 ms. |
| **REPEAT** | | Sets the number of laser light outputs per second in the range of 00 to 30 pps (pulse per second).<br>When 0 is set, the single output is set. |
| **SHOT** | | Sets the number of laser outputs in the range of 0000 to 9999.<br>The laser light output count reaches the set value, the laser output stops.<br>When this count set to 1, a single output is performed.<br>When "REPEAT" is set to a value other than 0 and "SHOT" is set to 0, laser light is continuously output until a laser stop signal is input. |
| **≅J** | | The forecast value of laser output energy (J) based on the set laser output schedules is displayed.<br>***<Note>***<br>This laser calculates the laser light output energy by laser power feedback control. However, there is a little difference between the forecast value of laser output energy and the measured value (actually measured value) depending on the optical and electrical characteristics. Use the forecast value of laser output energy as reference. |
| **HV** | | Sets the high voltage (HIGH VOLTAGE) to ON or OFF.<br>When HV is set to ON, a high voltage is supplied and the HIGH VOLTAGE lamp comes on.<br>When it is set to OFF, no high voltage is supplied and no laser light is output. |

| | |
|---|---|
| **POSI. BLINK** | Sets the guide light blinking status (POSITION BLINK) or continuous lighting to ON or OFF.<br>When POSI.BLINK is set to ON with the guide light ON, the guide light blinks. If it is set to OFF, the guide light is put to a continuous ON status. |
| **POSITION** | Sets the guide light output to ON or OFF.<br>When the guide light output is set to ON, guide light is output. When the guide light output is set to OFF, no guide light is output.<br>The time until the guide light goes out automatically can be set by "POSITION AUTO OFF" on the INITIAL screen. |
| **WATER** | Displays the cooling water temperature. The temperature is measured after SELF CHECK is completed. |

## STATUS Screen

On the STATUS screen, the laser control method is checked and it is set that the branch shutter to output laser light is opened. In addition, the total number of laser light outputs and the appropriate number of outputs are set.




### How to see the displayed items

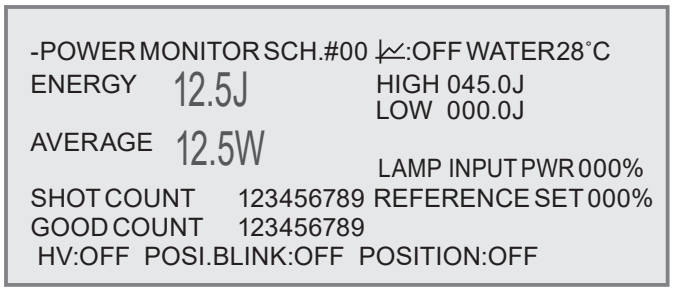
: Settable item

| | |
|---|---|
| **-STATUS** | Displays the used laser control method.<br>EXTERNAL CONTROL (external control):<br>Control is exerted by the PLC connected to the EXT.I/O connector.<br>PANEL CONTROL (internal control):<br>Control is exerted by control panel.<br>RS-485 CONTROL (external communication control):<br>Control is exerted by the personal computer connected to the RS-485 (1) or RS-485 (2) connector. |
| **BEAM-1**<br>**BEAM-2**<br>**BEAM-3** | Sets the opening/closing status of branch shutters 1 to 3 to ON or OFF.<br>When the opening/closing status is set to ON, the branch shutter is opened. |
| **RESET**<br>**SELECT**<br>**→SHOT**<br>**→GOOD** | <br><br>Resets the displayed total number of laser light outputs (SHOT COUNT).<br>Sets the displayed appropriate number of laser light outputs (GOOD COUNT). |
| **PRESET**<br>**→SHOT**<br>**→GOOD** | Sets the count-notification function.<br>When the total number of laser light outputs (SHOT COUNT) and the appropriate number of laser light outputs (GOOD COUNT) reaches the set number, a message is displayed. |
| **FIBER**<br>**SI**<br><br>**ø** | <br>Selects SI (Step Index) or GI (Graded Index) for the optical fiber mode to be used. Usually, SI is used.<br>To protect the optical fiber from overfill, set the core diameter of the optical fiber to be used in the range of φ0.2 to 1.0 mm. The maximum value of incidence to the optical fiber is calculated from the set core diameter and the lamp input power is limited. |

| | |
|---|---|
| **HV** | Sets the high voltage (HIGH VOLTAGE) to ON or OFF.<br>When HV is set to ON, the HIGH VOLTAGE lamp comes on.<br>When it is set to OFF, no high voltage is supplied and no laser light is output. |
| **POSI.BLINK** | Sets the guide light blinking status (POSITION) or continuous lighting to ON or OFF.<br>When POSI.BLINK is set to ON with the guide light ON, the guide light blinks. If it is set to OFF, the guide light is put into a continuous ON status. |
| **POSITION** | Sets the guide light output to ON or OFF.<br>When the guide light output is set to ON, guide light is output. When the guide light output is set to OFF, no guide light is output. |
| **WATER** | Displays the cooling water temperature. The temperature is measured after SELF CHECK is completed. |

## POWER MONITOR Screen

On the POWER MONITOR screen, the measured value of monitored laser light is checked and the monitor value range and the upper limit value of flashlamp input power are set.




### How to see the displayed items

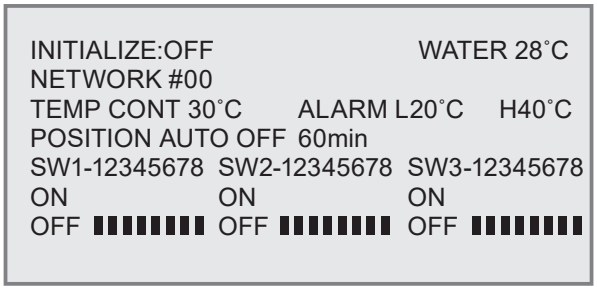
: Settable item

| | |
|---|---|
| **SCH.#** | Displays the SCHEDULE number of the current operating output setting schedules. When another SCHEDULE number is entered, only the measured value of the laser light energy that was lastly output in the corresponding SCHEDULE is displayed.<br>Regarding the set 32 SCHEDULEs, this laser stores the last energy value of output laser light in memory. |
| | Sets the graph display of laser output value to ON/OFF. When the graph display is set to ON, the laser output value set on the right side of the screen is displayed as a waveform.<br>When the graph display is set to ON, the lower items become invisible. To display them, set the graph display to OFF. |
| **ENERGY** | Displays the measured value (J) of laser energy. Each time laser light is output, the laser energy is measured and its value is displayed. In the case of a high-speed repeated output, however, the energy is displayed at certain intervals because the display timing is too quick. |
| **HIGH**<br>**LOW** | Sets the upper limit value "HIGH" and lower limit value "LOW" of the laser energy to be monitored.<br>When the laser energy comes out of the set value range, a monitor trouble is output. Press the TROUBLE RESET key to clear the trouble. |
| **AVERAGE** | Displays the average power (W) of output laser light per second. An upper/lower limit judgment is not performed. |
| **SHOT COUNT** | Displays the total number of laser light outputs.<br>Refer to this number when replacing the flashlamp.<br>To reset the display to 0, perform a reset operation on the STATUS screen. |

| | |
|---|---|
| **GOOD COUNT** | Displays the appropriate number of laser light outputs. The appropriate number of outputs means the laser light output within the allowable energy range set at "HIGH" and "LOW."<br>To reset the display to 0, perform a reset operation on the STATUS screen. |
| **LAMP INPUT PWR** | Displays the flashlamp power. The power input to the lamp is displayed by the ratio (%) to the maximum input value native to the lamp.<br>***<Note>***<br>When the laser is used in the status where a value of 80% or more is displayed, the replacement cycle of the flashlamp may be shortened. |
| **REFERENCE SET** | Sets the upper limit value of lamp input power in the range of 0 to 100%. Usually, this value is set to 100%. The set value becomes the reference value for flashlamp deterioration notice. When the set value is exceeded, a screen to notify the approach of the flashlamp replacement time is displayed. |
| **HV** | Sets the high voltage (HIGH VOLTAGE) to ON or OFF.<br>When HV is set to ON, the HIGH VOLTAGE lamp comes on.<br>When it is set to OFF, no high voltage is supplied and no laser light is output. |
| **POSI.BLINK** | Sets the guide light blinking status (POSITION) or continuous lighting to ON or OFF.<br>When POSI.BLINK is set to ON with the guide light ON, the guide light blinks. If it is set to OFF, the guide light is put into a continuous ON status. |
| **POSITION** | Sets the guide light output to ON or OFF.<br>When the guide light output is set to ON, guide light is output. When the guide light output is set to OFF, no guide light is output.<br>The time until the guide light goes out automatically can be set by "POSITION AUTO OFF" on the INITIAL screen. |
| **WATER** | Displays the cooling water temperature. The temperature is measured after SELF CHECK is completed. |

## INITIAL Screen

On the INITIAL screen, the equipment No. and communication schedules are set to use the external communication function. Specific functions are switched and the alarm range of cooling water temperature is set on this screen.




### How to see the displayed items

: Settable item

| | |
|---|---|
| **INITIALIZE** | When the initialization is set to ON, the set values are initialized. After replacing the lithium battery, rewriting the program, or replacing the CPU board, the set values may change or be lost. Accordingly, perform initialization and set the values again.<br>When it is set to ON and the ENTER key is pressed, it takes about 15 seconds until initialization is completed. The POWER lamp blinks during that time. Turn off the power supply after blinking stops. When the power supply is turned off during initialization (lamp blinking), Error No.52 MEMORY TROUBLE occurs at the time of the next power-on. At that time, set it to ON again. |

| | |
|---|---|
| **NETWORK#** | Sets the equipment No. in the range of #00 to #15 before performing remote operations from the personal computer by external communication function. |
| **TEMP CONT**<br><br>**ALARM**<br>**L**<br>**H** | Sets the control temperature of cooling water.<br><br>Sets the alarm temperature range by lower limit value (L) and upper limit value (H). Usually, it is not necessary to change the set value. When you must change it for a compelling reason, contact us for information.<br>**<Note>**<br>When the cooling water temperature is below 5ºC, Error No.11 LOW TEMPERATURE OF COOLANT occurs.<br>The laser can be used if the cooling water temperature is more than 5ºC but below the set value of L, the temperature rise is less than 0.3ºC per minute. If the leaser does not become ready in 30 minutes after turning ON the power supply, Error No.11 occurs. When the set value of "H" is exceeded, Error No.10 HIGH TEMPERATURE OF COOLANT occurs. |
| **POSITION AUTO OFF** | Sets the time required for the guide light to go out automatically in the range of 01 to 98 minutes. This can be set in units of minute.<br>When 00 is set, no guide light is output.<br>When 99 is set, the guide light does not go out automatically. |
| **SW1**<br>**SW1-1**<br><br>**SW1-2**<br><br><br>**SW1-3**<br><br><br>**SW1-4 · 5**<br>**SW1-6**<br><br><br><br>**SW1-7**<br><br><br><br>**SW1-8** | Sets the functions assigned to 1 to 8 of "SW (SWITCH) 1" to ON or OFF.<br>1: Sets the high voltage to ON or OFF. At ON, a high voltage is not output at AUTO START and the screen is displayed in the status of HV: OFF.<br>2: Switches the laser start/stop control by using the EXT.I/O connector. At ON, laser start/stop control can be exerted from the PLC connected to the EXT.I/O connector even in the status of PANEL CONTROL (internal control).<br>3: At ON, the laser output signal is output from pin No.7 of the EXT.I/O (1) connector. It is turned ON at the start of the first shot and turned OFF at the end of the last shot.<br>4 and 5: Unused.<br>6: Switches the measurement accuracy of the measured laser energy value (J). OFF: x 1 (000.0 J)/ON: x 10 (00.00 J)<br>***<Note>*** At ON, the maximum peak value of laser output "PEAK" on the SCHEDULE screen becomes 1.0 kW regardless of the model.<br>7: Switches the setting range of pulse width (laser output time ms). OFF: 00.0 ms/ON: 0.00 ms<br>***<Note>*** At ON, the maximum total value of laser output time (ms) ("FLASH1" + "FLASH2" + "FLASH3") on the SCHEDULE screen becomes 5.00 ms.<br>8: Sets to ON to change the setting of No.6 or No.7 of SW1.<br>***<Note>***<br>When the setting of No.6 or No.7 is changed, the set values of SCHEDULE are initialized. To prevent misoperation, the setting cannot be changed unless No.8 of SW1 is set to ON. When the setting of No.6 or No.7 of SW1 is changed and the ENTER key is pressed, the setting of No.8 of SW1 is returned to OFF. It takes about 15 seconds until initialization is completed. The POWER lamp blinks during that time. Turn off the power supply after blinking stops. |

**SW2**

Switches the transfer speed of external communication data type assigned to 1 to 8 of "SW (SWITCH) 2" to ON or OFF.

**SW2-1** 1: Switches the data bit length. OFF: 8 bits/ON: 7 bits

**SW2-2** 2: Sets whether a parity bit exists or not. OFF: Parity bit/ON: No parity bit

**SW2-3** 3: Sets the parity mode. OFF: Even/ON: Odd

**SW2-4** 4: Sets the stop bit. OFF: 2/ON: 1

**SW2-5 · 6** 5 and 6: Set the communication speed.

The following speeds can be set by combining ON and OFF.

| 5 | 6 | bps |
|---|---|---|
| OFF | OFF | 9600 |
| OFF | ON | 19200 |
| ON | OFF | 38400 |
| ON | ON | (9600) |

**SW2-7** 7: At ON, the automatic laser power monitor value transmission of external communication becomes ON by default.

**SW2-8** 8: Unused.

**SW3**

Switches the functions assigned to 1 to 8 of "SW (SWITCH) 3" to ON/OFF.

**SW3-1 to 4** 1,2, 3, and 4: Unused.

**SW3-5** 5: At ON, pin No.4 (End output) of the EXT.I/O (1) connector is put in a closed circuit only once after the completion of the set shots. The end signal is also output when an error occurs during laser output or the laser stop signal is input.

**SW3-6 to 8** 6, 7, and 8: Unused.

**WATER**

Displays the cooling water temperature. The temperature is measured after completion of SELF CHECK.

⇒ When the setting of SW1 to SW3 has been changed, be sure to turn OFF the power to make the setting effective before use.

# Setting Laser Light Output Schedules (SCHEDULE Screen)

**This section explains the how to set the SCHEDULE screen. On this screen, the peak value, output time, and output value of laser light and SCHEDULE number are set.**

⇒ 32 types of output schedules can be set and registered with SCHEDULE numbers of #00 to #31. To perform laser welding, enter the registered SCHEDULE numbers and laser welding can be performed in the set output schedules.

⇒ It is convenient if you enter the set output schedules in the Appendix "Output Schedule Data Entry Table" in advance.

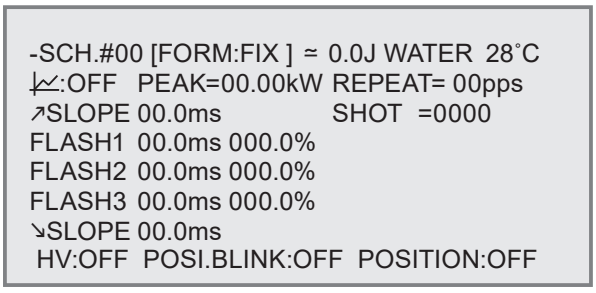
⇒ For the details of setting items, refer to "Welding Schedule Setting Screen" on page 54.

## 1 Setting Output Schedules by Fixed Waveform (FIX)

Set the output time and output value of laser light in "FLASH1" (first laser) to "FLASH3" (third laser) by "FIX." Set the laser light that becomes a fixed waveform by up to 3 divisions.

In the following example, SCHEDULE No.: #00, peak value: 4.0 kW, FLASH1: 1.5 ms/100%, FLASH2: 1.5 ms/25%, FLASH3: 3.0 ms/50%, up slope: 0.5 ms, and down slope: 1.0 ms are set as output schedules.

(1) Press the MENU key to display the SCHEDULE screen.




(2) Move the cursor to "-SCH.#" and press the ON or OFF key to set the SCHEDULE number.

(3) Move the cursor to "FORM" and press the ON or OFF key to set "FIX."

(4) Move the cursor to "PEAK" and press the ON or OFF key to set the laser output peak value.

***<Note>***

**The settable maximum peak value of laser output differs depending on the model.**

**ML-2050A: 4.0 kW / ML-2051A: 2.5 kW / ML-2150A: 6.0 kW**

(5) Move the cursor to "FLASH1" to "FLASH3" and press the ON or OFF key to set the laser output time (ms) and laser output value (%).

⇒ The laser output time is set in the range of 0.0 to 10.0 ms. Regarding the laser output value, the ratio (%) based on the case where the set laser output peak value is 100% is set.

*<Note>*

**Set the laser output time so as to result in the following value.**

**0.2 ms ≤ "FLASH1" + "FLASH2" + "FLASH3" ≤ 10.0 ms**

(6) Move the cursor to "↗SLOPE" and press the ON or OFF key to set the time require for laser light to up-slope to FLASH1 (to become gradually stronger).

*<Note>*

**Set "↗SLOPE" so as to result in the following value.**

**↗SLOPE ≤ FLASH**

(7) Move the cursor to "↘SLOPE" and press the ON or OFF key to set the time required for laser light to down-slope to the last FLASH (to become gradually weaker).

*<Note>*

**Set "↘SLOPE" so as to result in the following value.**

**↘SLOPE ≤ FLASH1, FLASH2, FLASH3**

(8) To output laser light several times for one second, move the cursor to "REPEAT" and set the number of laser light outputs per second in the range of 00 to 30 pps (pulse per second).

⇒ When 0 is set, a single output is performed.

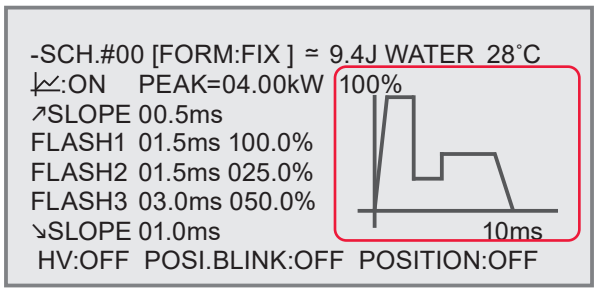
(9) To output laser light repeatedly, move the cursor to "SHOT" and set the number of laser light outputs in the range of 0000 to 9999.

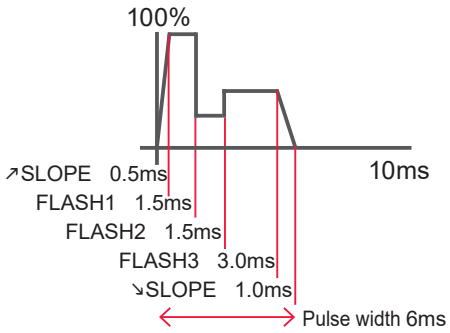
⇒ When "REPEAT" is not 0 and "SHOT" is set to 0, laser light is continuously output until a laser stop signal is input.

## 2 Checking Output Schedules

(1) Move the cursor to "📈" and press the ON key.

The set laser output time and laser output value are graphically displayed and the output laser light can be checked as a waveform.




⇒ At the leading edge of waveform, an overshoot (higher form than the set value) may occur. In this case, extend "↗SLOPE" by 0.1 to 1.0 ms.

(2) Check the output energy displayed in " ≃ ."

⇒ In " ≃ ", the forecast value of laser output energy based on the set output schedules is displayed. This value is a little different from the actually measured value (measured value displayed on the POWER MONITOR screen) provided at laser welding. However, use it as reference.

## 1 Setting Output Schedules by Flexible Waveform (FLEX)

Set the output time and output value of each point in the range of "Point1" to "Point20" by "FLEX" and set the laser light output that becomes a flexible waveform.

In this example, SCHEDULE No.: #01, peak value: 4.0 kW, Point1: 1.0 ms/90%, Point2: 1.0 ms/70%, Point3: 1.0 ms/88%, Point4: 1.0 ms/65%, and Point5: 1.0 ms/0% are set as output schedules.

(1) Press the MENU key to display the SCHEDULE screen.

```
-SCH.#00 [FORM:FLEX] ≃ 0.0J   WATER 28˚C
⊥⁄ : OFF  PEAK=00.00kW    REPEAT= 00pps
▲Point1    00.0ms   000.0%  SHOT  =0000
 Point2    00.0ms 000.0%
 Point3    00.0ms 000.0%
 Point4    00.0ms 000.0%
▼Point5    00.0ms   000.0%
 HV:OFF  POSI.BLINK:OFF  POSITION:OFF
```

(2) Move the cursor to "-SCH.#" and press the ON or OFF key to set the SCHEDULE number.

(3) Move the cursor to "FORM" and press the ON or OFF key to set "FLEX."

(4) Move the cursor to "PEAK" and press the ON or OFF key to set the laser output peak value.

***<Note>***

**The settable maximum peak value of laser output differs depending on the model.**

| **ML-2050A: 4.0 kW / ML-2051A: 2.5 kW / ML-2150A: 6.0 kW** |
|---|

(5) Move the cursor to "Point" and set the laser output time (ms) and laser output value (%) of each point.

Place the cursor to "▲" or "▼" of "Point" and press the CURSOR key (△ or ▽). Then, the screen is scrolled up or down so that the non-displayed Point can be displayed.

⇒ Set the point in the range of "Point1" to "Point20" and the laser output time in the range of 0.2 to 10.0 ms. For the laser output value, set the ratio (%) supposing that the set laser output peak value is 100%.

***<Note>***

**For setting the laser output time, enter the time from the previous Point.**
**Set the laser output time so as to result in the following value.**

| **0.2 ms ≤ Total of all Point values ≤ 10.0 ms** |
|---|

(6) To perform multiple outputs for one second, move the cursor to "REPEAT" and set the number of laser light outputs in the range of 00 to 30 pps (pulse per second).

⇒ When 0 is set, a single output is performed.

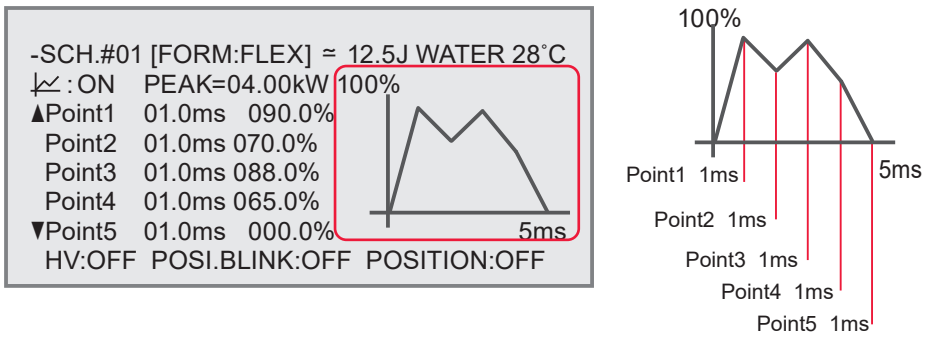
(7) To output laser output repeatedly, move the cursor to "SHOT" and set the number of laser light outputs in the range of 0000 to 9999.

⇒ When "REPEAT" is not set to 0 and "SHOT" is set to 0, laser light is continuously output until a laser stop signal is input.

## 2 Checking Output Schedules

(1) Move the cursor to "📈" and press the ON key.

The set laser output time and laser output value are graphically displayed so that the output laser light can be checked as a waveform.




⇒ At the leading edge of waveform, an overshoot (higher form than the set value) may occur. In this case, extend "Point" by 0.1 to 1.0 ms.

(2) Check the output energy displayed in " ≃ ."

⇒ In " ≃ ", the forecast value of laser output energy based on the set output schedules is displayed. This value is a little different from the actually measured value (measured value displayed on the POWER MONITOR screen) provided at laser welding. However, use it as reference.

# Setting the Output Status (STATUS Screen)

**In the following, the method of setting the STATUS screen is explained. On this screen, check the displayed control method and the set the branch shutter at the output destination to OPEN. Set or reset the number of laser light outputs.**

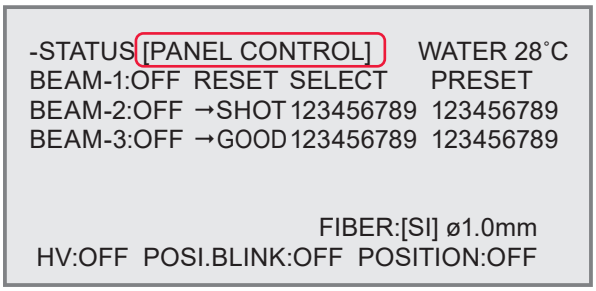
⇒ For details of setting items, refer to "Welding Schedule Setting Screen" on page 56.

## Checking the Control Method

(1) Press the MENU key to display the STATUS screen.

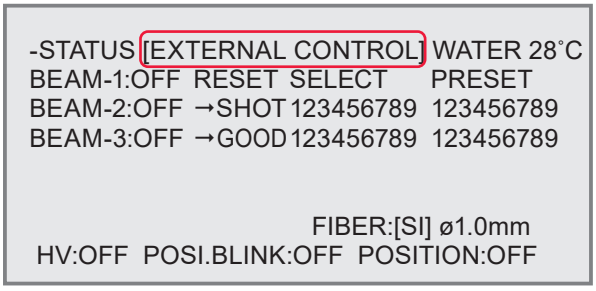
### Control by Control Panel (PANEL CONTROL)

When the laser is independently used or when the power supply of the PLC or personal computer connected to the laser is OFF, control is exerted from the control panel and "PANEL CONTROL" is displayed in "-STATUS."



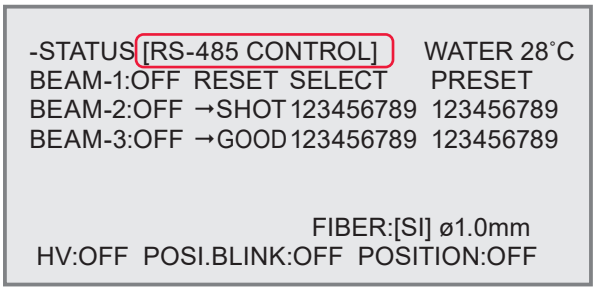

### Control by External Input Signal (EXTERNAL CONTROL)

Connect the main unit to the PLC or the like and turn ON pin No.23 (control switching) of the EXT.I/O (1) connector. Then, the control method is switched over to the control by external input/output signals (EXTERNAL CONTROL) and "EXTERNAL CONTROL" is displayed in "-STATUS."



### Control by External Communication Control (RS-485 CONTROL)

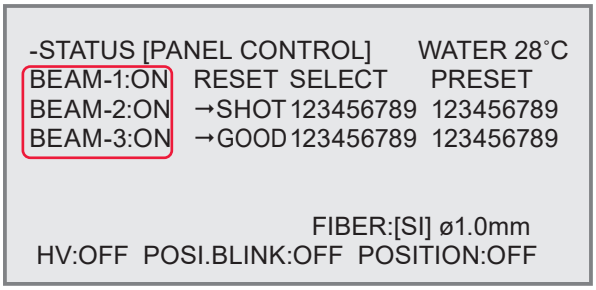
When a command to set a control method is sent from the personal computer connected to the main unit, external communication control is selected and "RS-485 CONTROL" is displayed in "-STATUS" on the STATUS screen.




## Setting the Opening/Closing Status of the Branch Shutter

To exert control from the control panel, set the opening/closing status of the branch shutter on the STATUS screen. "BEAM-1" to "BEAM-3" correspond to branch shutters 1 to 3. When the opening/closing status is set to ON, the corresponding branch shutter is opened to output laser light.

(1) Move the cursor to "BEAM-1" to "BEAM-3" and press the ON or OFF key to set the opening/closing status of the branch shutter.



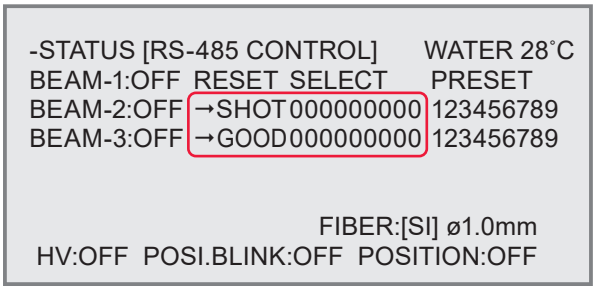

(2) Press the ENTER key.

## Resetting the Number of Laser Light Outputs

Reset the numeric values of "SHOT COUNT" (total number of laser light outputs) and "GOOD COUNT" (appropriate number of laser light outputs) displayed on the POWER MONITOR screen.

(1) Move the cursor to "→" of "→SHOT" or "→GOOD" of RESET SELECT, and press the ENTER key.

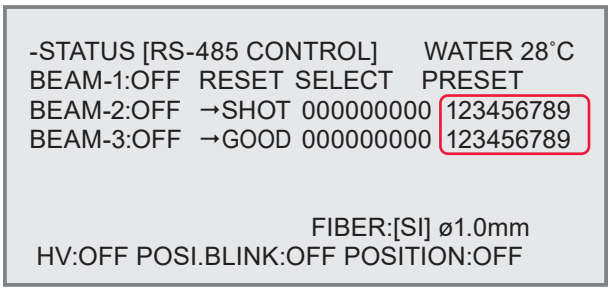
The numeric value is reset and "000000000" is displayed.



## Setting the Count-notification Function

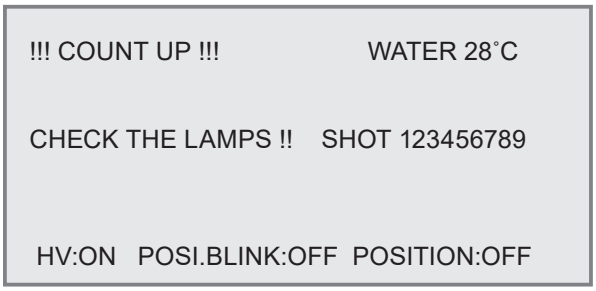
When "SHOT COUNT" (total number of laser light outputs) and "GOOD COUNT" (appropriate number of laser light outputs) that are displayed on the POWER MONITOR screen reaches the set number, a message is displayed. This function will be of assistance for maintenance or manufacturing control.

(1) Move the cursor to the numeric value of "→SHOT" or "→GOOD" of PRESET and press the ON or OFF key to set the arbitrary number of laser light.

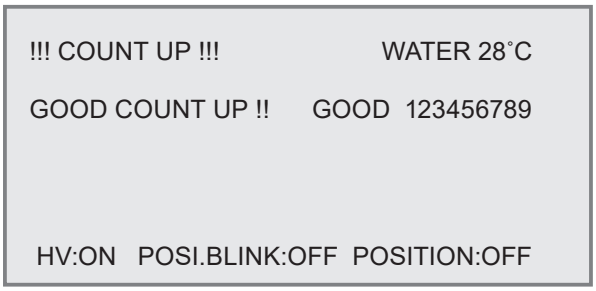



(2) Press the ENTER key to definitively set the set the number of outputs.
The set number of outputs is registered.

When "SHOT COUNT" reaches the number of outputs set in "→SHOT", a prompting screen for checking the flashlamp is displayed.




When "GOOD COUNT" reaches the number of outputs set in "→GOOD", the notifying screen for the non-defective units is displayed.

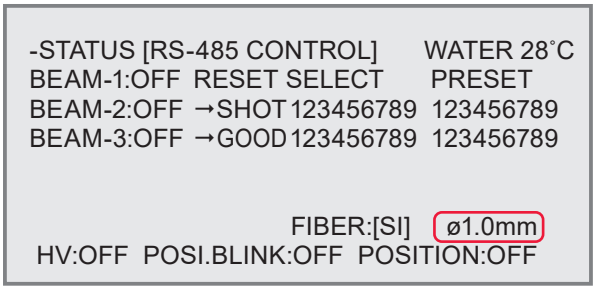



Press the TROUBLE RESET key to return the current screen to the initial screen.

## Setting the Protection of Optical Fiber

The optical fiber is protected from overfill to the optical fiber. When the core diameter to be used is set, the maximum possible incident light to the optical fiber is calculated to limit the lamp input power.

(1) Move the cursor to "φ" and press the ON or OFF key to select a core diameter.
The set value at delivery from the factory is SI: φ 1.0 mm, and the settable range is φ 0.2 to 1.0 mm.




(2) Press the ENTER key.

⇒ When the internal aperture (option) is installed in the oscillator, set a one-size larger core diameter.

⇒ If the laser output schedules (PEAK, FLASH ms/%, and REPEAT) are not matched with the set core diameter, Error No.51 FIBER SETTING ERROR or Error No.48 FIBER OVERRATE is displayed. Then, change the core diameter setting. For the laser output schedules for the core diameter, refer the Installation and Preparation Part, Chapter 2 "Standard Values of Maximum Incident Energy and Power" on page 44.

***<Notes>***

- **When the end face of the optical fiber is stained or dirty, the end face of the fiber may be damaged even if no error is displayed. When the optical fiber is not used, put the cover on it.**
- **If the GI fiber is used, the end face of the fiber may be damaged depending on the condition (energy density to be received by the end face, etc.) even if no error is displayed.**
- **When the end face of the fiber is damaged, the lens of the connected input unit or output unit may be stained. Perform inspection and cleaning. When the input unit has been dismounted, a fiber incidence adjustment is required.**

# Setting the Output Status Check Screen (POWER MONITOR Screen)

**In the following, the method of setting the POWER MONITOR screen is explained. On this screen, the measured energy value of output laser light is checked, the energy range to be monitored is set, and the upper limit value of flashlamp input power is set.**

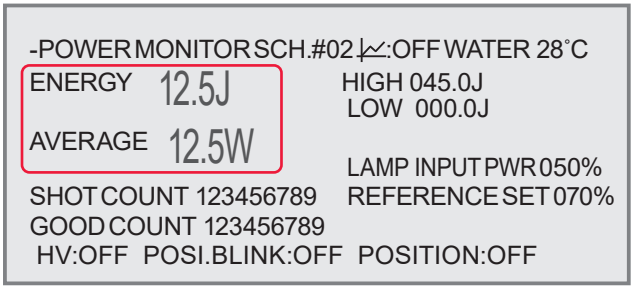
## Checking the Measured Energy Value of Laser Light

When laser light is output, the POWER MONITOR screen is automatically displayed and the measured energy value is displayed. If the registered SCHEDULE number is entered, the measured energy value of the last output laser light can be checked by the corresponding SCHEDULE number.

(1) Move the cursor to "SCH.#" and press the ON or OFF key. Then, enter the SCHEDULE number to be displayed.

(2) Press the ENTER key.

The measured energy value of the last output laser light is displayed by the entered SCHEDULE number.



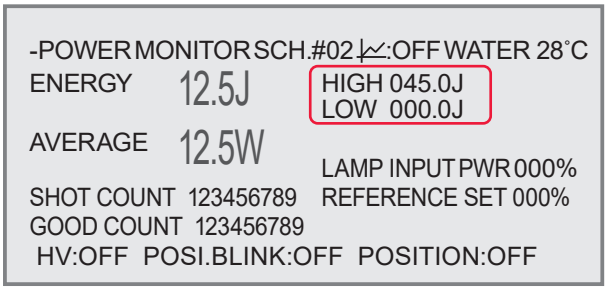

Move the cursor to "" and press the ON key. Then, laser light is graphically displayed as a waveform.

## Setting the Laser Energy Range To Be Monitored

Set the upper limit value and lower limit value of energy to be monitored. This set range is used as the allowable energy range.

(1) Move the cursor to "HIGH" and press the ON or OFF key. Then, set the upper limit value.

(2) Move the cursor to "LOW" and press the ON or OFF key. Then, set the lower limit value.




(3) Press the ENTER to definitively set the set numeric value.

The set allowable energy range is registered.

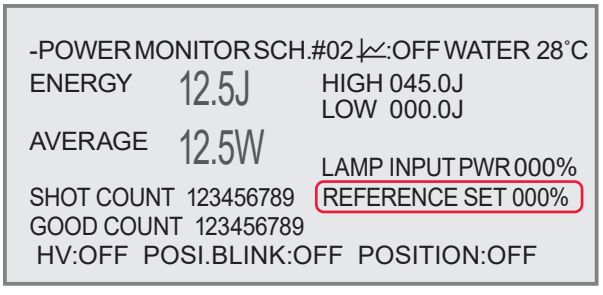
⇒ If laser light comes out of the set allowable energy range, a monitor error is output.

## Setting the Upper Limit Value of Lamp Input Power

Set the maximum value of power to be input into the flashlamp. If the power exceeds the set value, a prompting screen for replacing the flashlamp is displayed.

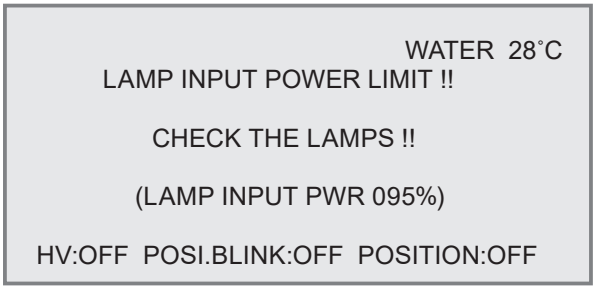
(1) Move the cursor to "REFERENCE SET" and press the ON or OFF key. Then, set the ratio (%) of the upper limit value of lamp input power.

⇒ If the equipment is used in the status where 80% or more is displayed in "LAMP INPUT PWR" (lamp input power), the flashlamp replacement cycle may be shortened.



(2) Press the ENTER key to definitively set the set numeric value.

The set ratio of the upper limit value is registered. If this upper limit value is exceeded, a prompting screen for replacing the flashlamp is displayed.




When this screen appears, output pin No.9 (upper limit of lamp input) of the external output signal EXT.I/O (1) connector is open-circuited for output.

Press the TROUBLE RESET key to clear the screen display.

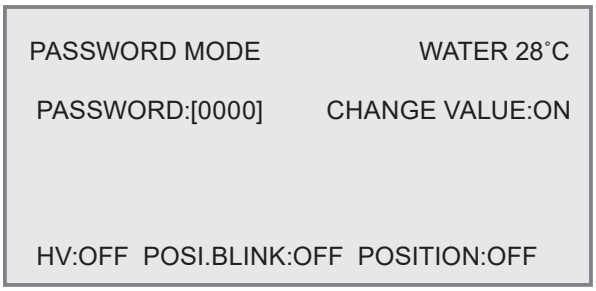
⇒ After the screen display is reset, pin No.9 of the EXT.I/O (1) connector output remains in an open circuit output state. If the power supply is less than the upper limit value of lamp input power when the flashlamp lights next time, the open circuit output state is returned to a closed circuit state. The open circuit output state is also reset by turning on the power supply again.

# Protecting Set Values (PASSWORD Screen)

**The method of protecting set values by setting the password is explained below. When the password is set and validated, set values are protected and cannot be changed by any person other than the supervisor.**

## 1 Displaying the PASSWORD Screen

(1) Press the TROUBLE RESET key and the CURSOR key (△) simultaneously on one of the SCHEDULE screen, STATUS screen, and POWER MONITOR screen.
The PASSWORD screen appears.



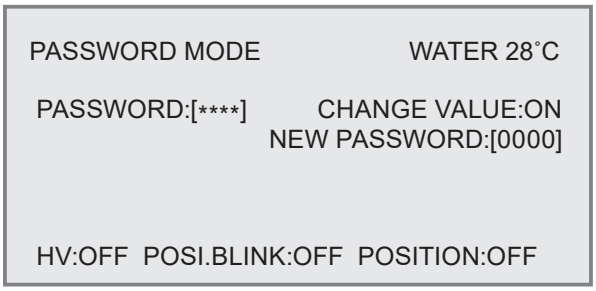

## 2 Entering the Present Password

(1) Move the cursor to "PASSWORD" and press the ON or OFF key. Then, enter the set password.

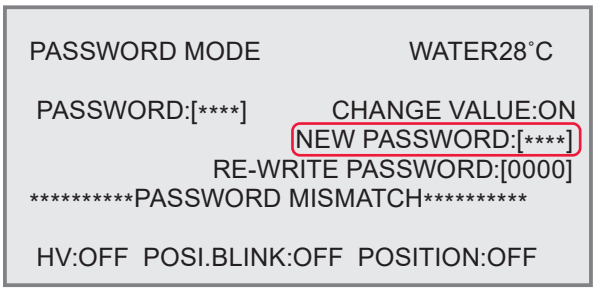
⇒ "REDS" is set as the initial value. To enter a new password after changing this password, enter "REDS."

⇒ The password to be entered must consist of 4 alphanumerical characters.

(2) Press the ENTER key.
When the entered password is correct, a new password setting screen appears.




If the entered password is incorrect, the PASSWORD MISMATCH screen appears. Then, enter the set password again. You may press the TROUBLE RESET key to go back to the initial screen, and then enter the password once again.

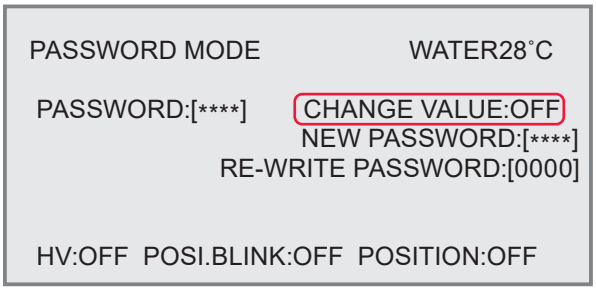



## 3 Validating the Password

(1) Move the cursor to "CHANGE VALUE" and press the OFF key.

The password is validated and some of setting items are protected and become unchangeable.

⇒ Unless "CHANGE VALUE" is turned OFF after the password is set, the setting items cannot be protected and anyone who does not know the password can change set values.



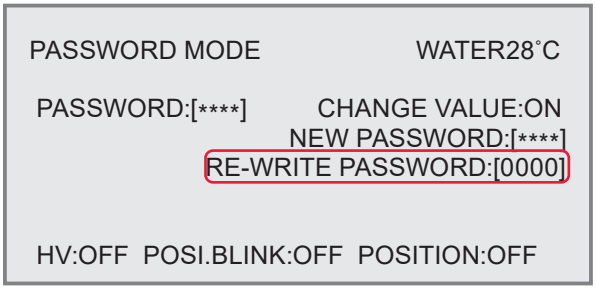

## 4 Setting a New Password

(1) Move the cursor to "NEW PASSWORD" and press the ON or OFF key. Then, enter a new password.

Enter 4 alphanumerical characters.

(2) Press the ENTER key.

A confirmation screen appears.




(3) Move the cursor to "RE-WRITE PASSWORD" and enter the same password. Then, press the ENTER key.

The set password is registered and the PASSWORD screen reappears.

If the password is not matched, the PASSWORD MISMATCH screen appears. Enter the same password again. You may also press the TROUBLE RESET key to go back to the confirmation screen and enter the password again.

The items that can be protected are as follows.

| Display Screen | Item |
|---|---|
| SCHEDULE Screen | SCH.# (Schedule number)<br>FORM (FIX/FLEX waveform switching)<br>PEAK (Laser output peak value)<br>REPEAT (Number of laser light outputs per second)<br>SHOT (Total number of laser light outputs)<br>↗SLOPE (Time for up-sloping to FLASH1)<br>FLASH1 (Output time ms and output value % of the first laser)<br>FLASH2 (Output time ms and output value % of the second laser)<br>FLASH3 (Output time ms and output value % of the third laser)<br>↘SLOPE (Time for down-sloping to the last FLASH)<br>Point1 to 20 (Output time ms and output value % of each point for FLEX) |
| STATUS Screen | RESET SELECT<br>→SHOT (Resetting the total number of laser light outputs, SHOT COUNT)<br>→GOOD (Resetting the appropriate number of laser light outputs, GOOD COUNT)<br>PRESET<br>→SHOT (Count-notification setting of the total number of laser light outputs, SHOT COUNT)<br>→GOOD (Count-notification setting of the appropriate number of laser light outputs, GOOD COUNT)<br>FIBER (Setting the SI/GI and core diameter) |
| POWER MONITOR Screen | SCH.# (Schedule number)<br>(Graphic waveform display)<br>HIGH (Upper limit value of laser energy to be monitored)<br>LOW (Lower limit value of laser energy to be monitored)<br>REFERENCE SET (Upper limit value of lamp input power) |
| Common to each screen | POSI.BLINK (Guide light blinking or lighting ON/OFF) |

(2) Press the ENTER key.
The above setting items become unchangeable and the set values are protected.

⇒ To change any set value, enter the password to display the password setting screen and turn ON "CHANGE VALUE."

# Switching the Accuracy of the Measured Laser Energy Value (J) (INITIAL Screen)

**In the following, the method of switching the measurement accuracy of the laser energy value (J) is explained.**

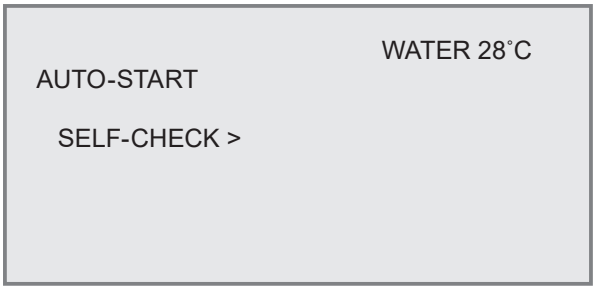
**Usually, this setting permits switching the measured value of 0.1 J increments over to 0.01 J increments, so that more minute welding work can be performed.**

## 1 Displaying the INITIAL Screen

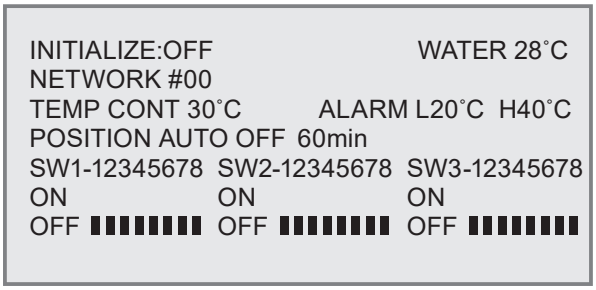
(1) Turn OFF the CONTROL keyswitch and then turn ON the MAIN POWER switch while pressing the MENU key.

⇒ Hold down the MENU key until the SELF-CHECK > screen appears.

The power supply is turned ON and the POWER lamp comes on. Then, the SELF-CHECK > screen appears.



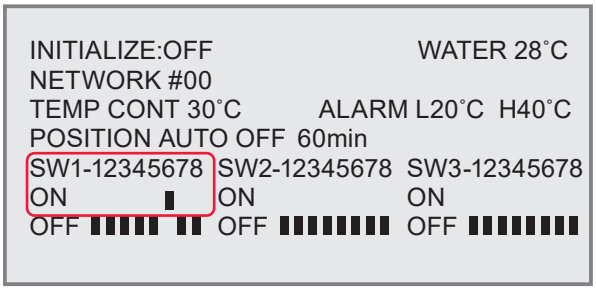

After completion of the self-check, the INITIAL screen appears.




⇒ Unless the CONTROL keyswitch is OFF, the INITIAL screen is not displayed.

## 2 Switching the Accuracy of the Measured Value (J)

(1) Move the cursor to "6" of "SW1" and press the ON key.



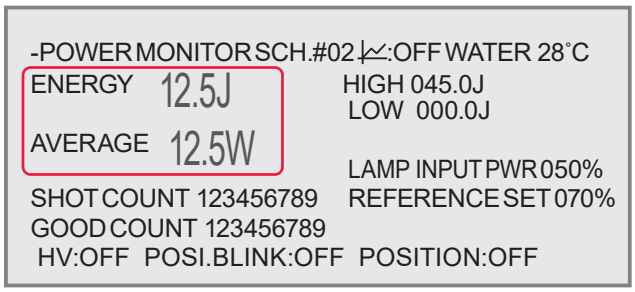
***<Note>***

**When the accuracy of the measured value is switched, the set values of SCHEDULE are initialized. To prevent misoperation, the setting cannot be changed unless No.8 of SW1 is set to ON. When the setting of No.6 of SW1 is changed and the ENTER key is pressed, the setting of No.8 of SW1 is returned to OFF. It takes about 15 seconds until initialization is completed. The POWER lamp blinks during that time. Turn off the power supply after blinking stops.**

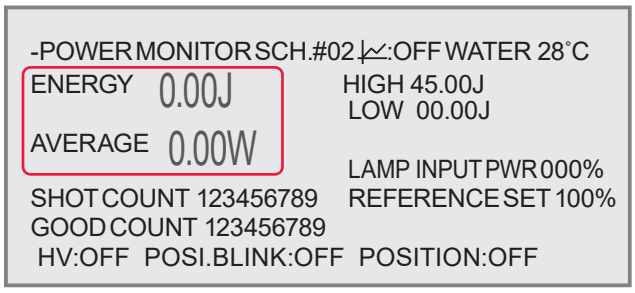
## 3 Setting the Setting Definitively

(1) Press the ENTER key to definitively perform the setting.
The accuracy of the measured value on the POWER MONITOR screen is switched.

Setting example before switching (SW1-6 OFF)




Setting example after switching (SW1-6 ON)




***<Note>***

**When No.6 of SW1 is set to ON, the settable maximum peak value of laser output "PEAK" on the SCHEDULE screen becomes 1.0 kW regardless of the model.**

# Switching the Pulse Width Setting Range (INITIAL Screen)

**In the following, the method of switching the pulse width setting range for laser light (laser output time ms) is explained.**

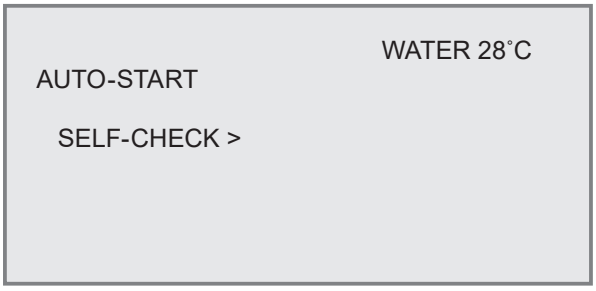
**Usually, this setting permits switching the pulse width of 0.1 ms step over to 0.02 ms step, so that more minute welding work can be performed.**

## 1 Displaying the INITIAL Screen

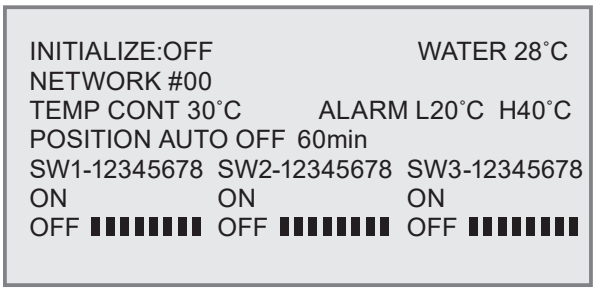
(1) Turn OFF the CONTROL keyswitch and then turn ON the MAIN POWER switch while pressing the MENU key.

⇒ Hold down the MENU key until the SELF-CHECK > screen appears.

The power supply is turned ON and the POWER lamp comes on. Then, the SELF-CHECK > screen appears.



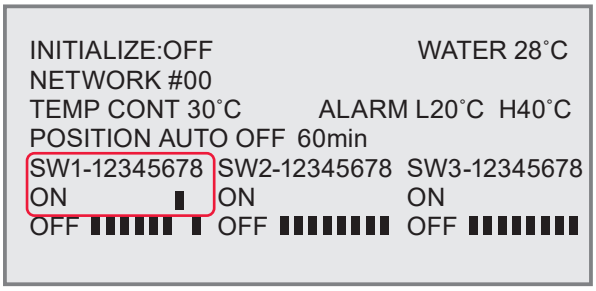

After completion of the self-check, the INITIAL screen appears.




⇒ Unless the CONTROL keyswitch is OFF, the INITIAL screen is not displayed.

## 2 Switching the Pulse Width Setting Range

(1) Move the cursor to "7" of "SW1" and press the ON key.



***<Note>***

**When the pulse width setting range is switched, the set values of SCHEDULE are initialized. To prevent misoperation, the setting cannot be changed unless No.8 of SW1 is set to ON. When the setting of No.7 of SW1 is changed and the ENTER key is pressed, the setting of No.8 of SW1 is returned to OFF. It takes about 15 seconds until initialization is completed. The POWER lamp blinks during that time. Turn off the power supply after blinking stops.**

## 3 Setting the Setting Definitively

(1) Press the ENTER key to definitively perform the setting.
The pulse width setting range on the SCHEDULE screen is switched.

Setting example before switching (SW1-7 OFF)

```
-SCH.#00 [FORM:FIX ] ≃ 11.4J WATER  28˚C
⌊⩗:OFF   PEAK=02.00kW REPEAT= 00pps
↗SLOPE 00.5ms          SHOT  =0000
FLASH1 01.6ms 040.0%
FLASH2 02.2ms 100.0%
FLASH3 01.2ms 020.0%
↘SLOPE 00.7ms
 HV:OFF  POSI.BLINK:OFF  POSITION:OFF
```

Setting example after switching (SW1-7 ON)

```
-SCH.#00 [FORM:FIX ] ≃ 11.4J WATER  28˚C
⌊⩗:OFF   PEAK=02.00kW REPEAT= 00pps
↗SLOPE 0.00ms          SHOT  =0000
FLASH1 0.00ms 000.0%
FLASH2 0.00ms 000.0%
FLASH3 0.00ms 000.0%
↘SLOPE 0.00ms
 HV:OFF  POSI.BLINK:OFF  POSITION:OFF
```

⇒ On the FLEX screen, the setting range is switched and displayed in the same way.

***<Notes>***

- **The value of "FLASH1" + "FLASH2" + "FLASH3" of the SW1-7 setting is as follows.**

| Setting | Maximum value (ms) | Minimum value (ms) | Step (ms) |
|---|---|---|---|
| ON | 5.00 | 0.20 | 0.02 |
| OFF | 10.0 | 00.2 | 00.1 |

- **Set the values of output time in 0.02 ms step after the SW1-7 setting.**

# 2. Setting the Laser Light Delivery

**This laser can output single laser light to multiple optical fibers or to a single optical fiber by the functions of the built-in beamsplitter and timesharing unit. This section explains the sharing specifications of this laser.**

## Laser Light Sharing

The laser light sharing specification is divided into powersharing and timesharing.

At powersharing, laser light is split into multiple beams by beamsplitter and then transfer them to multiple optical fibers to perform welding at multiple points at the same time. Since laser light is split into multiple beams, the respective laser outputs become weak.

At timesharing, a single laser light reflected on the mirror of the timesharing unit is transferred to a single optical fiber to perform welding. A selected branch shutter is opened, so that laser light is output as 100% energy without being split.

The ML-2050A/2051A/2150A main unit is provided with a branch shutter with opening/closing sensor and a timesharing unit according to the sharing specification. At delivery, a sharing method is initially set by the DIP switch of the main unit.

For this laser, the following 5 types of sharing specification are available.

| Sharing method | Corresponding model |
|---|---|
| Single: Output to single optical fiber | ML-2□5□A-010 |
| 2-powersharing: Output to 2 optical fibers at the same time | ML-2□5□A-020 |
| 3-powersharing: Output to 3 optical fibers at the same time | ML-2□5□A-030 |
| 2-timesharing: Output to one optionally selected out of 2 optical fibers | ML-2□5□A-002 |
| 3-timesharing: Output to one optionally selected out of 3 optical fibers | ML-2□5□A-003 |

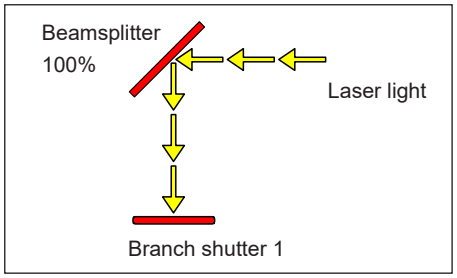
At the above timesharing, as soon as the branch shutter is opened after "BEAM-1" to "BEAM-3" are set to ON, the timesharing unit is automatically operated to split laser light.

Laser light can also be output by a sharing method other than the above so that the timesharing unit may not be operated even when the branch shutter is opened. For this purpose, set the independent control of the branch shutter by the DIP switch built in the main unit and then set the branch shutter and timesharing unit to be operated by operating the DIP switch.

⇒ For how to set the independent control of the branch shutter, refer to "Controlling Branch Shutters Independently" on page 81.

## Single

A single branch shutter is opened to output laser light only to a single optical fiber.



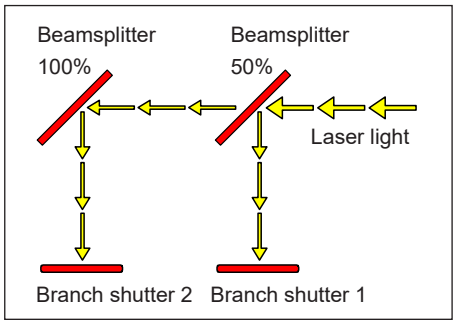

Laser light is reflected on the beamsplitter and transferred from opened branch shutter 1.

## 2-powersharing/3-powersharing

Laser light is split according to the number of built-in branch shutters and then simultaneously output. At 2-powersharing, two branch shutters are opened and laser light is split into 2 beams, and then simultaneously output.

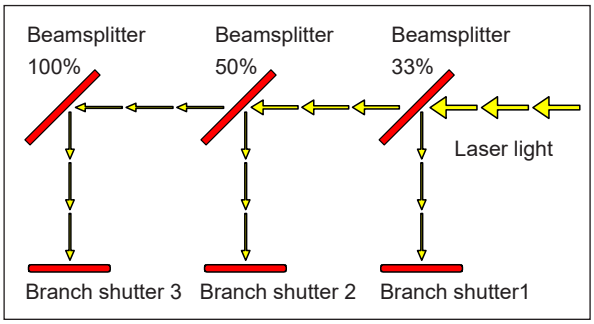
At 3-powersharing, three branch shutters are opened and laser light is split into 3 beams, and then simultaneously output.

**2-powersharing**




Laser light is reflected on the beamsplitter and split, and then simultaneously transferred from opened branch shutters 1 and 2.

**3-powersharing**

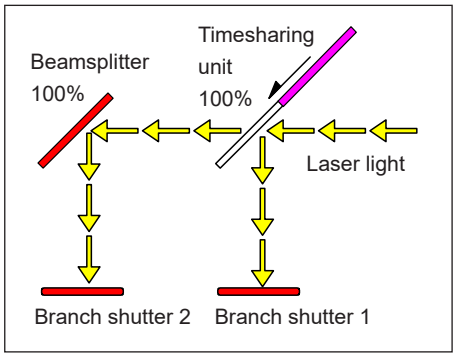



Laser light is reflected on the beamsplitter and split, and then simultaneously transferred from opened branch shutters 1, 2, and 3.

## 2-timesharing/3-timesharing

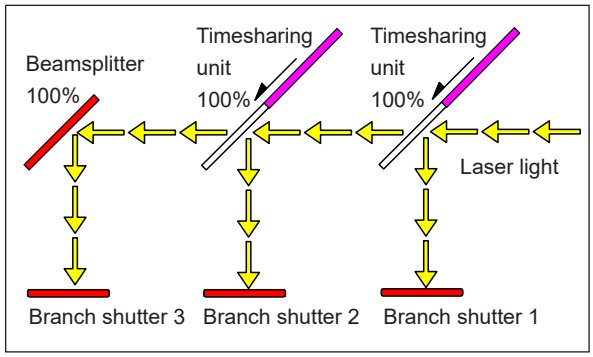
One optionally selected out of the built-in branch shutters is opened to output laser light. For example, when branch shutter 2 is opened, laser light is output to the optical fiber connected to input unit 2. If an operation is performed to open two branch shutters or more, the branch shutter with a smaller No. has priority because two or more branch shutters are not opened.

**2-timesharing**




Laser light is reflected on the beamsplitter by operated timesharing unit and transferred from opened branch shutter 2.

**3-timesharing**




Laser light is reflected on the beamsplitter by operated timesharing unit and transferred from opened branch shutter 3.

# Operating Branch Shutters on the STATUS Screen

**In the following, the method of performing open/close operations for branch shutters on the STATUS screen.**

On the STATUS screen, perform open/close operations for branch shutters to transfer laser light.

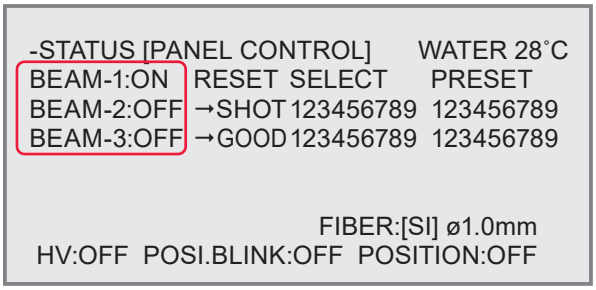
For this laser, the following 5 types of sharing specification are available. The DIP switches in the main unit are initially set according to the specifications provided at delivery.

| Sharing type | DIP switch (SW1) settings | | |
|---|---|---|---|
| | 6 | 7 | 8 |
| Single | OFF | OFF | OFF |
| 2-powersharing | OFF | OFF | ON |
| 3-powersharing | OFF | ON | OFF |
| 2-timesharing | ON | OFF | OFF |
| 3-timesharing | ON | OFF | ON |

## Operating Procedure

(1) For "BEAM-1", "BEAM-2", and "BEAM-3", move the cursor to the BEAM corresponding to the connected optical fiber and press the ON key.

"BEAM-1", "BEAM-2", and "BEAM-3" correspond to branch shutters 1, 2, and 3 and input units 1, 2, and 3.




⇒ The displayed screen differs depending on the sharing specification. "BEAM-1" is displayed at single specification. "BEAM-1" and "BEAM-2" are displayed at 2-poweresharing and 2-timesharing. "BEAM-1", "BEAM-2", and "BEAM-3" are displayed at 3-powersharing and 3-timesharing.

(2) Press the ENTER key.

The branch shutter set to ON is opened and laser light is ready to be transferred.

The branch shutter set to OFF is not opened, so laser light is intercepted.

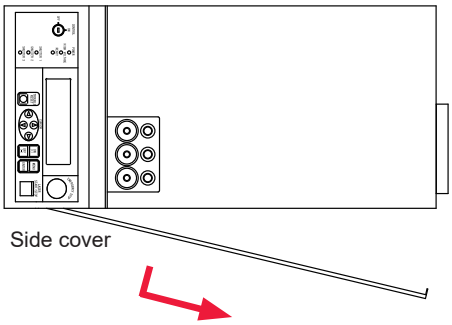
# Controlling Branch Shutters Independently

**In the following, the method of setting branch shutters to independent control by setting DIP switches.**

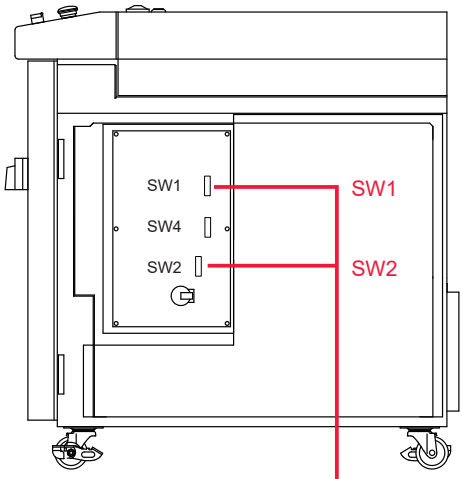
⇒ Usually, the sharing specification is changed by our engineer.

When "BEAM-1" to "BEAM-3" are set to ON and the branch shutter is opened, the branch shutter and the timesharing unit are automatically operated to transmit laser light. When branch shutters are put under independent control, the timesharing unit and the branch shutter are not operated in the interconnected form even if "BEAM" is set to ON. Accordingly, laser light can be transferred by a sharing method other than the prepared 5 types of sharing specification.

The 3 DIP switches of SW1, SW4, and SW2 are provided on the CPU board in the main unit. Set the branch shutter by SW1 and the timesharing unit by SW2. The branch shutter independent control function is assigned to No.6, No.7, and No.8 of SW1. So remove the side cover of the main unit and change the SW1 ON/OFF setting.




Loosen the screw at the rear of the cover. Pull the cover forward and then pull it out backward.

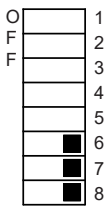



SW1 is used to set the branch shutter and SW2 is used to set the timesharing unit.

## Setting Independent Control

(1) Remove the side cover of the main unit and set No.6, No.7, and No.8 of DIP switch SW1 to ON.

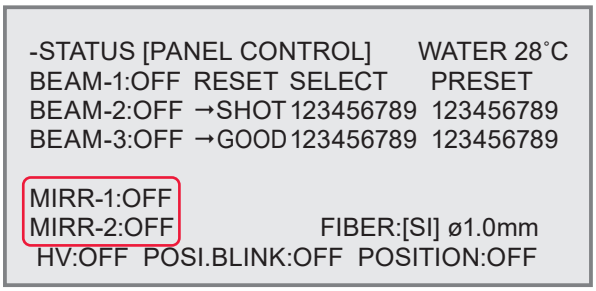
SW1
(branch shutter)




Set No.6 to ON.
Set No.7 to ON.
Set No.8 to ON.

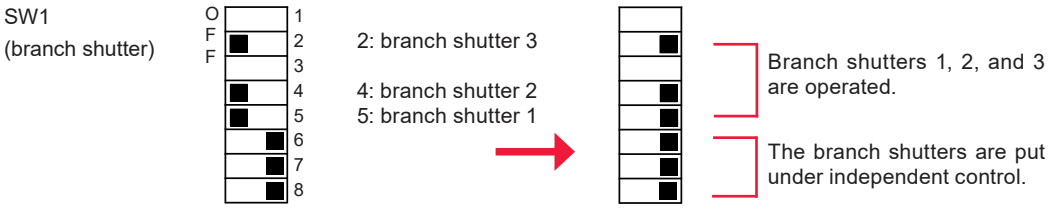
Branch shutter independent control

The independent control of the branch shutter is set and the items "MIRR-1" and "MIRR-2" to operate the timesharing unit are displayed on the STATUS screen. Laser light can be output according to an optional specification resulting from combining "BEAM-1", "BEAM-2", "BEAM-3", "MIRR-1", and "MIRR-2."




## Operating an Optional Branch Shutter

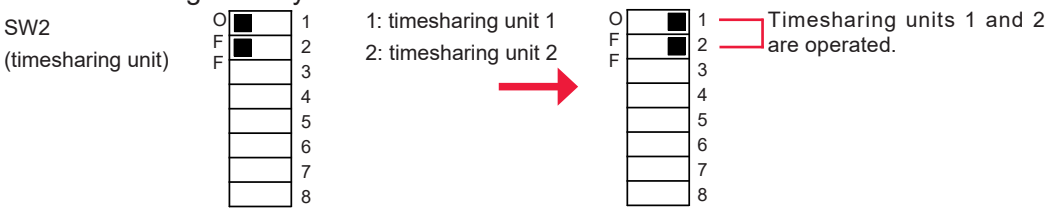
(1) Set No.6, No.7, and No.8 of SW1 to ON and the branch shutters are put under independent control. Then, turn ON the switch numbers of the built-in branch shutters by SW1.



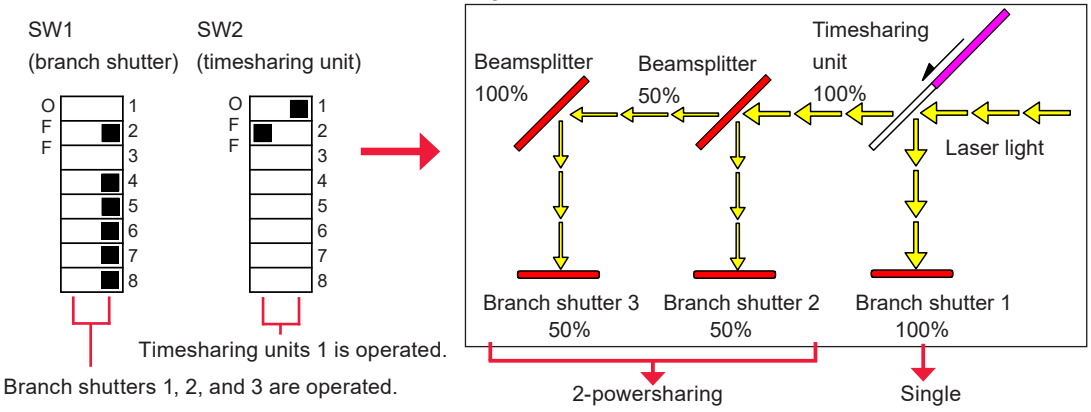

(2) On the STATUS screen, turn ON "BEAM" (branch shutter) to be operated.
The branch shutter in the ON status is operated.

## Operating an Optional Timesharing Unit

(1) Set No.6, No.7, and No.8 of SW1 to ON and the branch shutters are put under independent control. Then, turn ON the switch numbers of the built-in timesharing units by SW2.




(2) On the STATUS screen, turn ON "MIRR" (timesharing unit) to be operated.
The timesharing unit in the ON status is operated.
In the case of Single + 2-powersharing, set SW1 and SW2 as shown below. On the STATUS screen, turn ON "BEAM-1" to "BEAM-3" and "MIRR-1." Then, laser light is output in the single form from branch shutter 1 and in the 2-powersharing form from branch shutters 2 and 3.



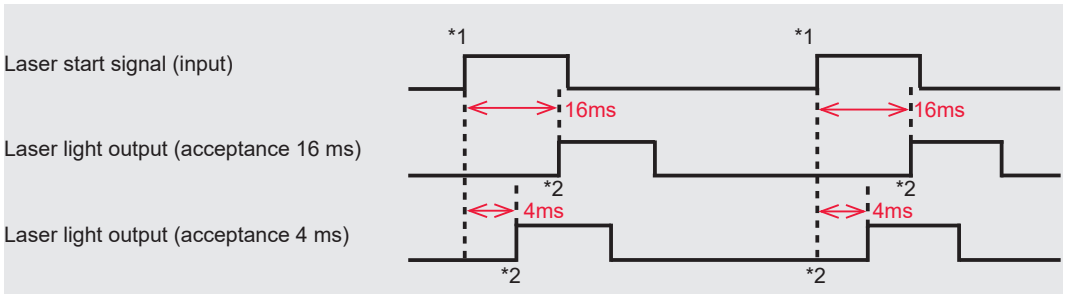
# 3. Changing the Acceptance Time for Laser Start Signal/ Schedule Signal

**This section explains how to change the acceptance time for the laser start signal and schedule signal to be input into the EXT.I/O (1) connector by setting the DIP switches provided in the side face of the main unit when EXTERNAL CONTROL is exerted by external input/output signals.**

The laser signal acceptance time means the time required until laser light is actually output after the laser start signal is input. The schedule signal acceptance time means the time required until this laser establishes schedules after a schedule signal 1, 2, 4, 8, or 16 to select a SCHEDULE number is input.

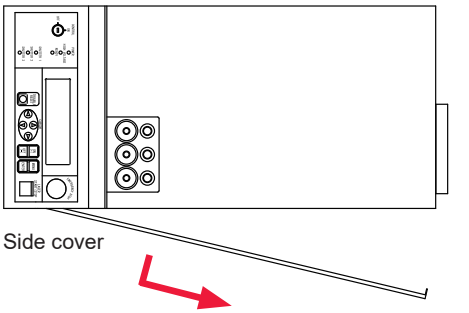
The following timing chart shows the laser light output timing when the laser signal acceptance time is 16 ms and 4 ms.

*1: Laser start signal input *2: Laser light output

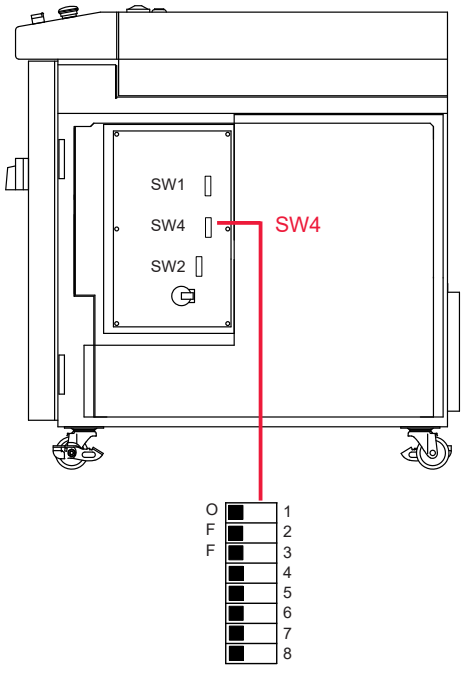



⇒ The laser start signal acceptance time and the schedule signal acceptance time are common. A different value cannot be set for the respective time.

The 3 DIP switches of SW1, SW4, and SW2 are arranged on the CPU board in the main unit. To change the acceptance time, remove the side cover and switch the ON/ OFF status of No.1 and No.2 of SW4.




Loosen the screw at the rear of the cover. Pull the cover forward and then pull it out obliquely backward.



The 4 types of acceptance time of 1 ms, 4 ms, 8 ms, and 16 ms are available. At delivery, the acceptance time is set to 16 ms. To change this setting, switch the ON/OFF status of No.1 and No.2 of SW4 as shown below.

| Acceptance time | No.1 | No.2 |
|---|---|---|
| 1ms | ON | ON |
| 4ms | OFF | ON |
| 8ms | ON | OFF |
| 16ms | OFF | OFF |

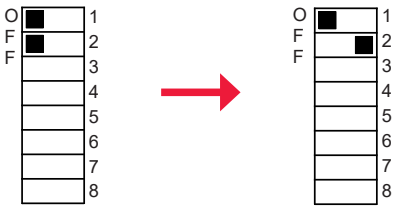
⇒ Usually, the laser start signal acceptance time is 16 ms and can be shortened as required.

## Operating Procedure

(1) Remove the side cover of the main unit and set the ON/OFF status by No.1 to No.2 of DIP switch SW4.

For example, to set the acceptance time to 4 ms, set No.1 to OFF and No.2 to ON.

SW4




In the above example, since the laser signal and schedule signal are accepted in 4 ms, the schedules are established in 4 ms after the schedule signal is input, and laser light is output in 4 ms after the laser start signal is input.

# 4. Setting the Function of the Output Unit with Fiber Sensor (Option)

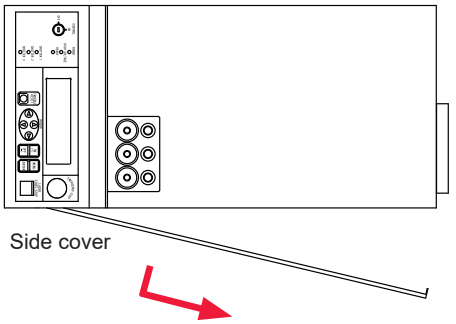
**For using the output unit with fiber sensor (option), perform a setting to make the function effective by the DIP switches provided in the side face of the main unit.**

**This section explains how to set the function of the output unit with fiber sensor.**

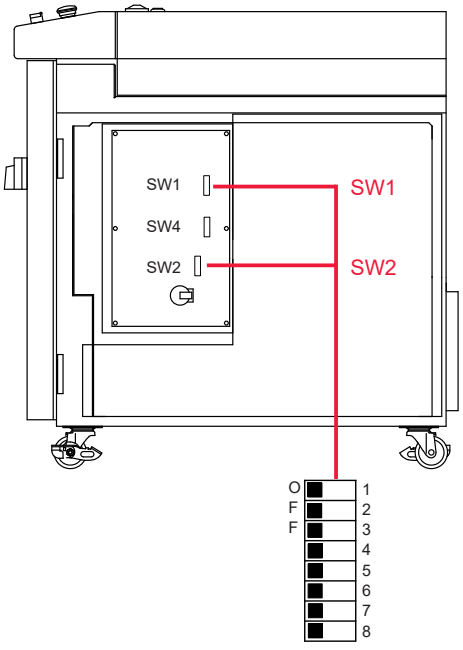
The output unit with fiber sensor is provided with the following 3 functions.

| | |
|---|---|
| Fiber breakage detection: | Detects that the fiber was broken during laser output. |
| Fiber mount check: | Check that the fiber is correctly mounted in the output unit. |
| LED ON check: | Check that the HV-ON lamp of the output unit lights when a high voltage is applied. |

The 3 DIP switches of SW1, SW4, and SW2 are arranged on the CPU board in the main unit. To set the function, remove the side cover and switch the ON/OFF status of No.3 of SW1 and No.3 to No.8 of SW2.




Loosen the screw at the rear of the cover. Pull the cover forward and then pull it out backward.



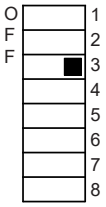
## Operating Procedure

(1) Set the fiber breakage detecting function.

Remove the side cover of the main unit and set No.3 of SW1 to ON.

The fiber breakage detecting function is set. When optical fiber breakage or end face damage is detected during laser light output, Error No.38 to 40 FIBER SENSOR 1 to 3 TROUBLE is displayed.

SW1




Set No.3 to ON.

⇒ Do not touch switches No.1 and No.2.

(2) Set the fiber mount checking function.

Out of No.3 to No.5 of SW2, set all of the output unit numbers to be used to OFF and set the others to ON.

The fiber mount checking function is set. When the optical fiber or trouble detecting cable is not connected, Error No.32 FIBER SWITCH TROUBLE is displayed.

⇒ Set the fiber mount checking function after setting No.3 of SW1 to ON to set the fiber breakage detecting function.

(3) Set the LED ON checking function.

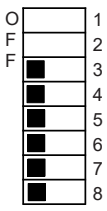
Out of No.6 to No.8 of SW2, set all of the output unit numbers to be used to OFF and set the others to ON.

The LED ON checking function is set. When the LED (HV-ON lamp) ON status of the specified output unit is not checked, Error No.33 E.INDICATOR TROUBLE (OUTPUT UNIT) is displayed.

⇒ Set the LED ON checking function after setting No.3 of SW1 to ON to set the fiber breakage detecting function.

As an example of (2) and (3) settings, set No.3 to No.8 of SW2 to OFF to use output units No.1 to No.3.

SW2




3: Checking that fiber 1 is mounted.
4: Checking that fiber 2 is mounted.
5: Checking that fiber 3 is mounted.
6: Checking that the fiber 1 HV-ON LED is ON.
7: Checking that the fiber 2 HV-ON LED is ON.
8: Checking that the fiber 3 HV-ON LED is ON.

Operating Part

# Chapter 3

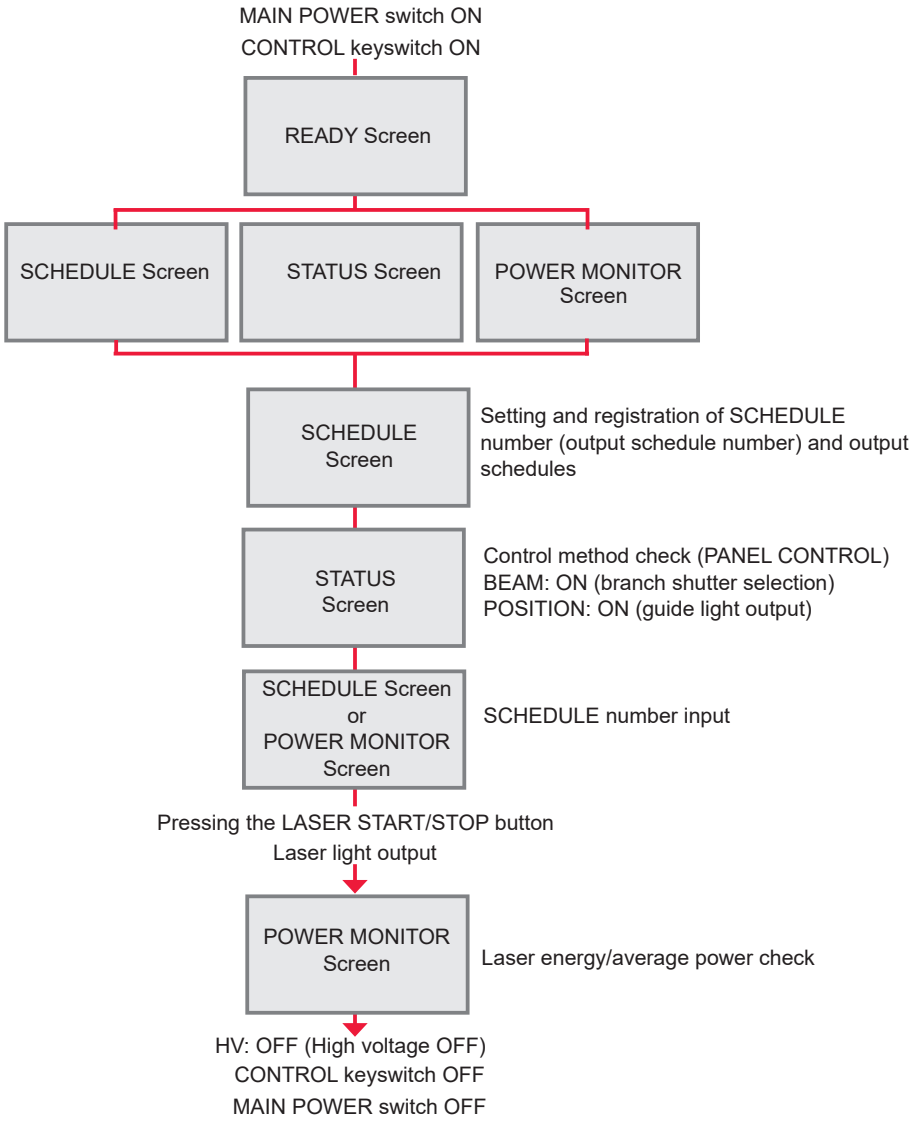
# Laser Welding by Control Panel (PANEL CONTROL)

## 1. Operation Flow

**This section explains a laser welding operation flow by control panel.**

The following methods for laser welding operations are available: control from the control panel (PANEL CONTROL), control by external input/output signals from the connected PLC (Programmable Logic Controller) (EXTERNAL CONTROL), and control by sending a command from the connected personal computer (RS-485 CONTROL).

At PANEL CONTROL, welding schedules are set by using the control panel and laser light is output.

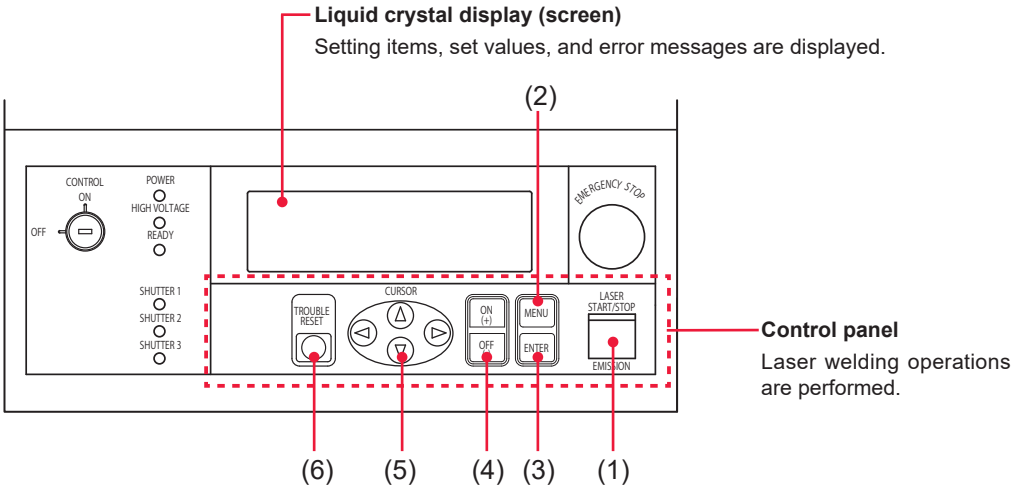


# 2. Control Panel Functions

**This section explains the functions of the control panel.**

At PANEL CONTROL, welding schedules are set by using the control panel keys and laser light is output by pressing the LASER START/STOP button. After the output, you can check the laser output energy on the POWER MONITOR screen.

⇒ When the optional laser controller is connected, laser welding operations can be performed by using the control panel of the laser controller in the same way in a place remote from the laser.
When the laser controller is used, the control panel and LASER START/STOP button of the main unit cannot be used. However, the EMERGENCY STOP button and CONTROL keyswitch can be used.




## Function of Each Section on the Control Panel

| | |
|---|---|
| **(1) LASER START/STOP (Button)** | If you press the button when a laser light output becomes ready (*), laser light is output. If the button is pressed again while laser light is repeatedly output, the repeated output is stopped.<br>* Pin No.23 (control switching) of the EXT.I/O (1) connector is in a closed circuit, a high voltage is supplied, and the branch shutter is open. |
| **EMISSION (Lamp)** | When a high voltage is applied to the laser oscillator section, the EMISSION lamp comes on. |
| **(2) MENU (Key)** | Switches the liquid crystal display screen. Each time this key is pressed, the SCHEDULE screen, STATUS screen, and POWER MONITOR screen are displayed in sequence. |
| **(3) ENTER (Key)** | Sets a set numeric value or ON/OFF specification definitively.<br>After changing data, be sure to press the ENTER key to definitively set the set value. Without this operation, the set value will return to the pre-change value in several seconds. |
| **(4) ON (+) OFF (-) (Key)** | Specifies the ON/OFF status of the setting item.<br>Changes the numeric value or alphabet at the cursor position to the ascending order (ON key) or descending order (OFF key). |
| **(5) CURSOR (Key)** | Moves the cursor (■) up and down or left and right on the screen. |
| **(6) TROUBLE RESET (Key)** | Clears the trouble display and resets the screen after completing trouble processing. |

# 3. Operating Procedure

**This section explains the operating procedure for laser welding to be controlled from the control panel.**

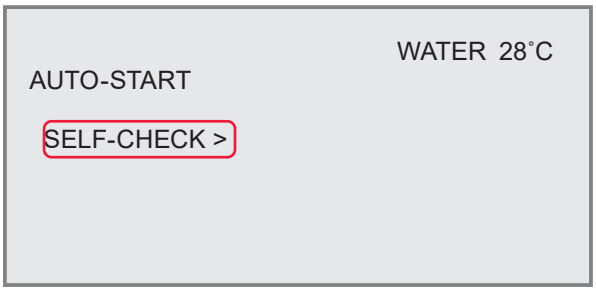
⇒ For the details of welding schedule settings, refer to Chapter 2, "1. Setting Welding Schedules" on page 53. For connector functions, refer to Chapter 4, "3. Connector Functions" on page 97.

⇒ Before turning on the power supply, put pin No.23 (control switching) of the EXT. I/O (1) connector to an open circuit to invalidate external input signals. As a result, the control by external input signals (EXTERNAL CONTROL) is invalidated and "PANEL CONTROL" is displayed in "-STATUS" on the STATUS screen.

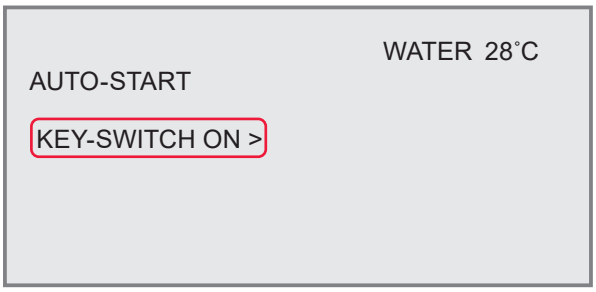
## 1 Starting the Laser

(1) Turn ON the MAIN POWER switch at the front of the main unit.

The power supply is turned ON and the POWER lamp comes on. Then, the SELF-CHECK > screen appears.

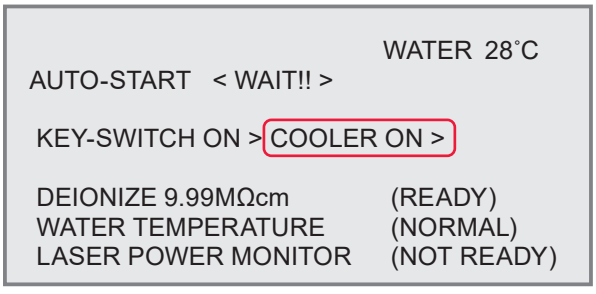



The laser checks the opening/closing status of branch shutters, memory (sum check and data range), and charge trouble automatically. If no trouble is found, the KEY-SWITCH ON > screen appears.



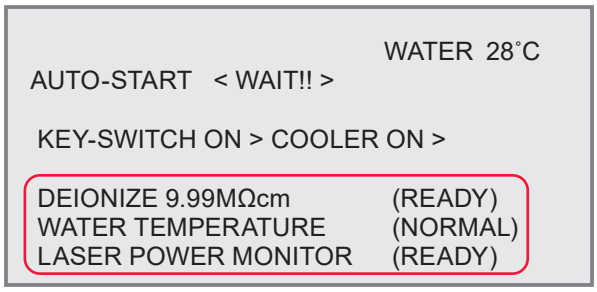

(2) Turn ON the CONTROL keyswitch.

The laser is put to an operable status and the COOLER ON > screen appears.

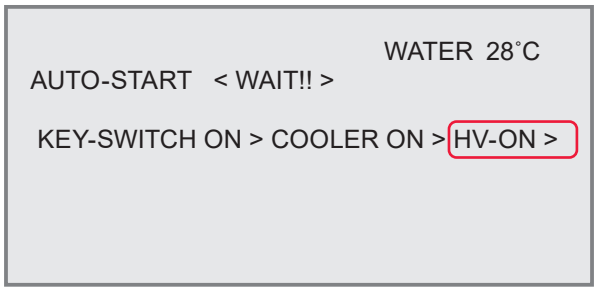


### How to See the Display Items

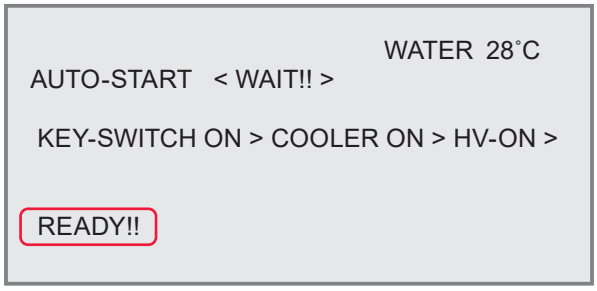
| | |
|---|---|
| **WATER** | Indicates the cooling water temperature. Upon completion of SELF CHECK, a temperature measurement is started and the measured value is indicated. |
| **DEIONIZE** | Indicates the resistivity of cooling water.<br>NOT READY: Indicated when the resistivity is below 3.00 MΩ·cm.<br>READY: Indicated when the resistivity is 3.00 MΩ·cm or more. |
| **WATER TEMPERATURE** | Indicates the cooling water temperature status.<br>LOW: Indicated when the temperature is below the specified value. (The specified value is 5ºC or a value provided at the temperature gradient of △t. It is automatically judged.)<br>NORMAL: Indicated in the range of the specified value to 40ºC.<br>HIGH: Indicated at 41ºC or more. |
| **LASER POWER MONITOR** | Indicates the sensor status of the power monitor unit.<br>NOT READY: Indicated during warming-up.<br>READY: Indicated at completion of warming-up. |




When "DEIONIZE" is (READY), "WATER TEMPERATURE" is (NORMAL), and "LASER POWER MONITOR" is (READY), a high voltage is turned ON and charging is started. Then, the HV-ON > screen appears.




After completion of charging, the READY !! screen appears for 0.5 sec.




After the READY !! screen appears, the screen (SCHEDULE screen, STATUS screen, or POWER MONITOR screen) displayed at the previous completion appears.

## 2 Setting Output Schedules

As an example, the procedure for setting SCHEDULE No.05, laser output peak value 2.50 kW, FLASH laser output time 3.6 ms/output value 80%, and up-slope 0.6 ms is explained below.

(1) Press the MENU key to display the SCHEDULE screen.

(2) Move the cursor to "-SCH.#" and press the ON or OFF key to set the SCHEDULE number.

In this example, set #05.

⇒ As the SCHEDULE number, it is possible to set 32 schedules of #00 to #31. In "FORM", the fixed waveform "FIX" or flexible waveform "FLEX" can be specified.

⇒ When the registered SCHEDULE number is entered, the set output schedules are displayed.

(3) Move the cursor to "PEAK" and press the ON or OFF key to set the laser output peak value.

In this example, set 2.50 kW.

```
-SCH.#05 [FORM:FIX ] ≃ 0.0J WATER  28˚C
 ⊥:OFF  PEAK=02.50kW REPEAT= 00pps
 ↗SLOPE 00.0ms            SHOT  =9999
 FLASH1  00.0ms 000.0%
 FLASH2  00.0ms 000.0%
 FLASH3  00.0ms 000.0%
 ↘SLOPE 00.0ms
  HV:ON  POSI.BLINK:OFF  POSITION:OFF
```

***<Note>***

**The settable maximum peak value of laser output differs depending on the model. The laser output value (FLASH %) cannot be set over "Maximum value x 100%."**

| | | |
|---|---|---|
| **ML-2050A : 4.0 kW** | **ML-2051A : 2.5 kW** | **ML-2150A : 6.0 kW** |

(4) Move the cursor to "00.0 ms" of "FLASH1" (first laser) and press the ON or OFF key to set the laser output time.

In this example, set 03.6 ms in "FLASH1."

***<Note>***

**Set the laser output time so as to result in the following value.**

| |
|---|
| **0.20 ms ≤ "FLASH1" + "FLASH2" + "FLASH3" ≤ 10.0 ms** |

(5) Move the cursor to "↗SLOPE" and press the ON or OFF key to set the time for laser light to up-slope (the laser output is gradually stronger) to FLASH1.

In this example, set 00.6 ms.

*<Note>*

**Set "↗SLOPE" so as to result in the following value.**

| ↗SLOPE ≤ FLASH1 |
|---|

**When setting "FLASH2" or "FLASH3", set the time required for laser light to down-slope (the laser output is gradually weaker) to FLASH. Set "↘SLOPE" so as to result in the following value.**

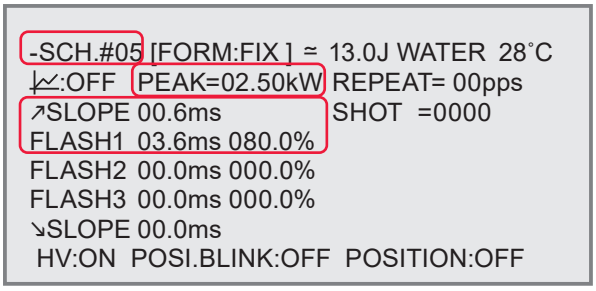
| ↘SLOPE ≤ FLASH1, FLASH2, FLASH3 |
|---|

(6) Move the cursor to "000.0%" of "FLASH1" and press the ON or OFF key to set the laser output value (%).

In this example, set 080.0% in "FLASH1."

⇒ For the laser output value, set the ratio (%) supposing that the set laser output peak value is 100%. In this example, this peak value is 80% of "PEAK=2.50 kW", so that the actual laser output value is 2.0 kW. In this case, even if "PEAK=2.00 kW" and "FLASH1 03.6 ms 100%" are set, the actual laser output value is the same.

(7) Press the ENTER key to definitively set the set welding schedules.




⇒ For setting the number of continuous laser light outputs, set the number of outputs per second in "REPEAT" in the range of 00 to 30 pps (pulse per second). When 0 is set, a single output is performed.

⇒ For setting the number of laser light outputs, set it in "SHOT" in the range of 0000 to 9999. When "REPEAT" is not set to 0 and "SHOT" is 0, laser light is continuously output until the LASER START/STOP button is pressed.

*<Note>*

**The set welding schedules are not definitively set unless the ENTER key is pressed. Be sure to press the ENTER key after completion of the setting.**

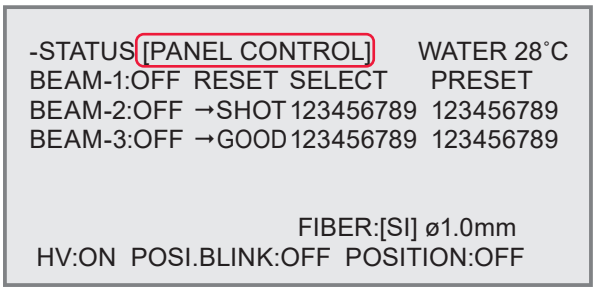
## 3 Outputting Laser Light

**⚠ WARNING**

**Be sure to put on protective glasses for YAG Laser (1064 nm) during laser light output operation. If laser light enters the eyes directly, a loss of eyesight may be caused.**

(1) Press the MENU key to display the STATUS screen.

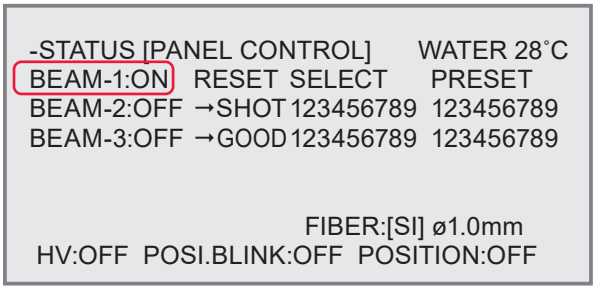
When Pin No.23 (control switching) of the EXT.I/O (1) connector is put to an open circuit, the external input signals are invalidated and "PANEL CONTROL" is displayed in "-STATUS."




(2) Adjust the workpiece and output unit positions to set an appropriate work distance (distance between the workpiece and the output position).

(3) Move the cursor to "BEAM-1" to "BEAM-3" (branch shutters 1 to 3) and press the ON key to open the branch shutter to be used.

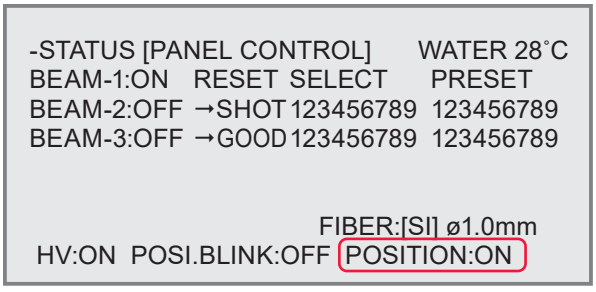
In this example, set "BEAM-1" to ON. Branch shutter 1 is opened and the corresponding SHUTTER comes on.




⇒ For powersharing, set all the BEAMs to be used to ON to open all the branch shutters.

(4) Move the cursor to "POSITION" and press the ON key to output guide light.

"POSITION" is displayed as ON and the red point of guide light is visible at the laser light irradiation position. Laser light is irradiated at the red point position.

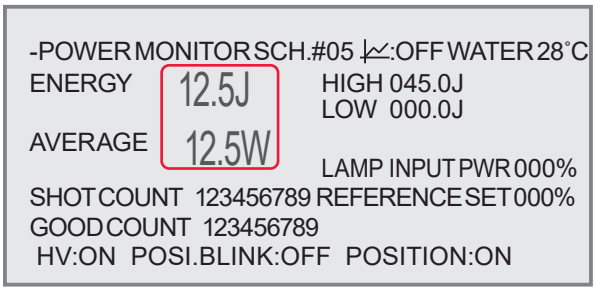



(5) Check the laser light irradiation position.

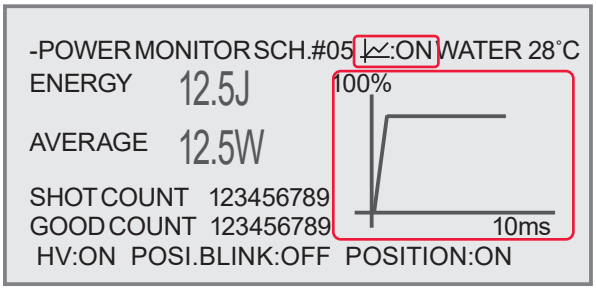
If the point to be worked deviates from the red point of guide light, adjust the position by moving the output unit or workpiece.

(6) Press the LASER START/STOP button.
Laser light is output and the POWER MONITOR screen appears.

(7) Check the laser output energy (J) and average power (W) of output laser light.




Move the cursor to "" and press the ON key. Then, the numeric values of laser output are graphically displayed and you can check them by waveform.




Press the OFF key to go back to the numeric display.

## 4 Stopping Laser Welding

**⚠ CAUTION**

**Do not turn OFF the MAIN POWER switch during a laser output or immediately after laser light is output. Otherwise, the lamp or YAG rod may be damaged due to insufficient cooling.**

(1) Move the cursor to "HV" on each screen and press the OFF key.
The high voltage is cut off.

(2) Turn OFF the CONTROL keyswitch.
The key can be pulled out.

(3) Turn OFF the MAIN POWER switch.
The power supply is turned OFF and the POWER lamp goes out.

⇒ Return the key of the CONTROL keyswitch to the laser safety supervisor so that it can be kept in custody.

Operating Part

# Chapter 4

# Laser Welding by External Input/ Output Signals (EXTERNAL CONTROL)

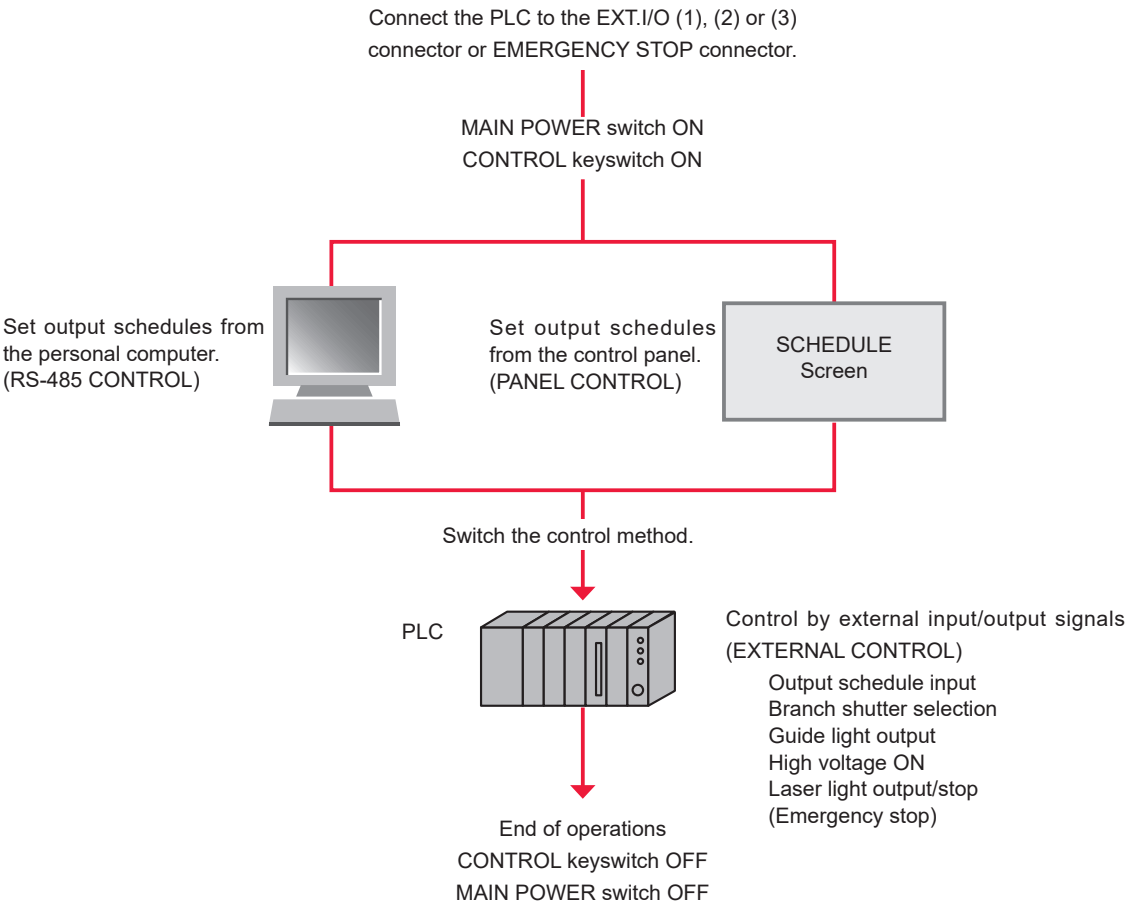
## 1. Operation Flow

**This section explains an operation flow of laser welding by external input/ output signals (EXTERNAL CONTROL).**

The following methods for laser welding operations are available: control from the control panel (PANEL CONTROL), control by external input/output signals from the PLC (Programmable Logic Controller) connected to the connector (EXTERNAL CONTROL), and control by sending a command from the connected personal computer (RS-485 CONTROL).

At the control by external input/output signals (EXTERNAL CONTROL), output schedules are set by another method (PANEL CONTROL/RS-485 CONTROL) in advance. After that, such control as schedule selection, laser light output, and emergency stop is exerted.

* PLC: Programmable Logic Controller This unit exerts sequence control by executing the programmed contents of control in sequence. This is often called Sequencer (product name of Mitsubishi Electric Corporation).

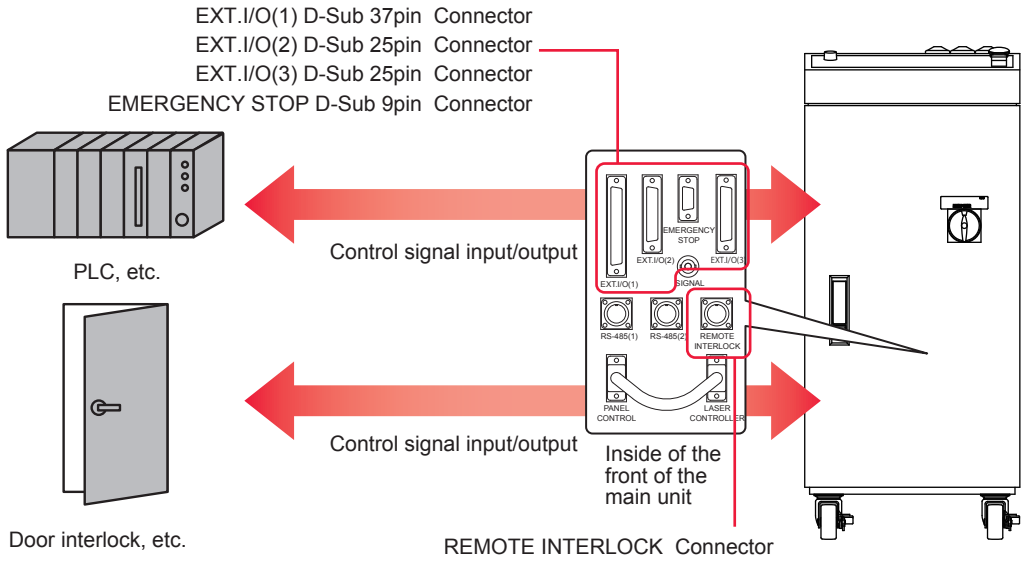


# 2. Preparations for Operations

**This section explains the devices and connectors required for laser welding by external input/output signals (EXTERNAL CONTROL).**

Connect the PLC to the EXT.I/O (1), (2) or (3) and EMERGENCY STOP connectors provided in the front of the main unit to control the main unit by executing the program from the outside. EMERGENCY STOP functions to shut off the power supply of the main unit when an emergency stop signal is received from the PLC at occurrence of an error in another unit provided on the manufacturing line.

Also, for preventing hazards, a remote interlock must be connected as a matter of duty. The REMOTE INTERLOCK connector is connected to the interlock of the door of the chamber or room for laser welding. If the door is suddenly opened, the branch shutter is closed to cut off laser light.




The plug, socket and case models of connectors are as follows.

| Connecter | Plug / Socket | Case | Manufacturer |
|---|---|---|---|
| EXT.I/O (1) | HDCB-37P(05) | HDC-CTH(10) | HIROSE ELECTRIC CO., LTD. |
| EXT.I/O (2) | HDBB-25P(05) | HDB-CTH(10) | |
| EXT.I/O (3) | HDBB-25S(05) | HDB-CTH(10) | |
| EMERGENCY STOP | HDEB-9P(05) | HDE-CTH(10) | |
| REMOTE INTERLOCK | 116-12A10-2AF10.5 | | TAJIMI ELECTRONICS CO., LTD. |

⇒ Prepare a program and its development environment for laser control on the customer side.

⇒ The model numbers of plug, socket and case are subject to change without notice. Depending on the part to be changed, the mounting screw shape may change and a necessary tool may be different. For the latest parts information, contact a nearest sales office.

# 3. Connector Functions

## Pin Arrangement and Functions

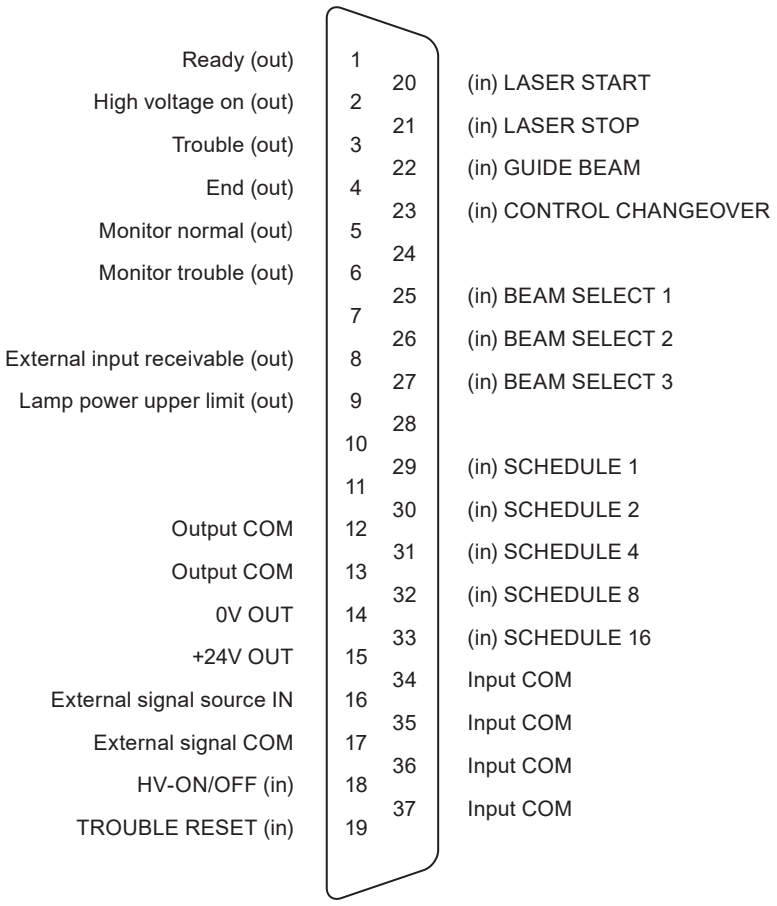
**There are 4 connectors to be connected for the control by external input/output. This section explains the arrangement and functions of the respective pins.**

### EXT.I/O (1) Connector (D-Sub 37 pin)

**The EXT.I/O (1) connector inputs welding schedules and inputs or outputs the start signal of guide light and laser light.**

⇒ Use the following product out of the attached connectors.

| Plug | Case | Manufacturer |
|---|---|---|
| HDCB-37P(05) | HDC-CTH(10) | HIROSE ELECTRIC CO., LTD. |



## Input Pins of EXT.I/O (1) Connector

⇒ Supply power to pin No.16 and pin No.17 and put the section between pin No.23 and COM in a closed circuit.

| Pin No. | Description |
|---|---|
| 14 | 0 V OUT<br>Power supply for external input signals. This pin is exclusively used for the ML-2050A/2051A/2150A. Do not use it for any other purpose. |
| 15 | +24 V OUT<br>Power supply for external input signals. This pin is exclusively used for the ML-2050A/2051A/2150A. Do not use it for any other purpose. |
| 16 | External signal source IN<br>Input terminal for the external signal power supply. Connect it to Pin 14 or Pin 15, depending on the input signal circuit. |
| 17 | External signal COM<br>Common input terminal for external signals. Connect it to Pin 15 or Pin 14, depending on the input signal circuit. |
| 18 | HV-ON/OFF<br>When this Pin 18–COM circuit is closed, the high voltage is turned ON.<br>When the circuit is opened, the high voltage is turned OFF.<br>To protect the internal circuit, the high voltage is not turned ON again unless more than 2 seconds have passed since it was turned OFF. |
| 19 | TROUBLE RESET<br>If trouble arises, an alarm is activated. When the cause of trouble has been eliminated and this Pin 19–COM circuit is closed, the alarm will be canceled. |
| 20 | LASER START<br>When Pin 21–COM circuit is closed, the laser beam is output. Make sure that the circuit is left closed for at least the time set by the DIP switch. When the signal is input repeatedly, make sure that the circuit is left open for at least 40 ms between each input and the repetition interval is within the maximum rated output. |
| 21 | LASER STOP<br>When outputting the laser using Pin 20, close this Pin 21–COM circuit.<br>For the repeated output for which the number of outputs is set in "REPEAT" on the SCHEDULE screen, the laser output is stopped by closing the section between the pin and COM during a laser output. The closed circuit time should be 1 ms or more. |
| 22 | GUIDE BEAM<br>While this Pin 22–COM circuit is closed, the guide beam is output. |
| 23 | CONTROL CHANGEOVER<br>While this Pin 23–COM circuit is closed, the external input signals are effective. |
| 24 | Unused<br>Do not connect anything. |
| 25 | BEAM SELECT 1<br>When this Pin 25–COM circuit is closed, laser beam input unit 1 is selected and the unit becomes ready to project a laser beam. |
| 26 | BEAM SELECT 2<br>When this Pin 26–COM circuit is closed, laser beam input unit 2 is selected and the unit becomes ready to project a laser beam. |
| 27 | BEAM SELECT 3<br>When this Pin 27–COM circuit is closed, laser beam input unit 3 is selected and the unit becomes ready to project a laser beam. |

| Pin No. | Description | |
|---|---|---|
| 28 | Unused<br>Do not connect anything. | |
| 29 | SCHEDULE 1 | Select a registered SCHEDULE number by combining schedule signal inputs 1, 2, 4, 8, and 16. For how to select a SCHEDULE number, refer to the following table. |
| 30 | SCHEDULE 2 | |
| 31 | SCHEDULE 4 | |
| 32 | SCHEDULE 8 | |
| 33 | SCHEDULE 16 | |

### SCHEDULE Number Selection

Set "SCH.#" by combining pin No.29 to pin No.33 (schedule signals 1, 2, 4, 8, and 16) inputs.

| Input / SCH.# | SCH 16 | SCH 8 | SCH 4 | SCH 2 | SCH 1 |
|---|---|---|---|---|---|
| 00 | | | | | |
| 01 | | | | | ● |
| 02 | | | | ● | |
| 03 | | | | ● | ● |
| 04 | | | ● | | |
| 05 | | | ● | | ● |
| 06 | | | ● | ● | |
| 07 | | | ● | ● | ● |
| 08 | | ● | | | |
| 09 | | ● | | | ● |
| 10 | | ● | | ● | |
| 11 | | ● | | ● | ● |
| 12 | | ● | ● | | |
| 13 | | ● | ● | | ● |
| 14 | | ● | ● | ● | |
| 15 | | ● | ● | ● | ● |
| 16 | ● | | | | |
| 17 | ● | | | | ● |
| 18 | ● | | | ● | |
| 19 | ● | | | ● | ● |
| 20 | ● | | ● | | |
| 21 | ● | | ● | | ● |
| 22 | ● | | ● | ● | |
| 23 | ● | | ● | ● | ● |
| 24 | ● | ● | | | |
| 25 | ● | ● | | | ● |
| 26 | ● | ● | | ● | |
| 27 | ● | ● | | ● | ● |
| 28 | ● | ● | ● | | |
| 29 | ● | ● | ● | | ● |
| 30 | ● | ● | ● | ● | |
| 31 | ● | ● | ● | ● | ● |

●: Input-pin-COM circuit closed.
Blank: Input-pin-COM circuit opened.

## Output Pins of EXT.I/O (1) Connector

| Pin No. | Description |
|---|---|
| 1 | Ready<br>When the high voltage is turned ON and the capacitor is fully charged, this Pin 1–COM circuit is closed internally. |
| 2 | High Voltage ON<br>While the high voltage is supplied, this Pin 2–COM circuit is closed internally. |
| 3 | Trouble<br>If trouble arises, this Pin 3–COM circuit is opened internally until it is reset. |
| 4 | End<br>After the lamp has flashed, this Pin 4–COM circuit is closed internally for 50 ms. |
| 5 | Monitor normal<br>When the monitor value of laser energy is in the range of "HIGH" and "LOW" set on the POWER MONITOR screen, the circuit is closed for 50 ms. |
| 6 | Monitor trouble<br>When the monitor value of laser energy is out of the range of "HIGH" and "LOW" set on the POWER MONITOR screen, the circuit is closed for 50 ms. |
| 7 | Unused<br>Do not connect anything. |
| 8 | External input receivable<br>When an external input signal is acceptable (when the section between pin No.23 and COM is in a closed circuit), the circuit is closed. In the open circuit status, an external input signal is not acceptable if it is input. |
| 9 | Lamp power upper limit<br>When the lamp input power exceeds the value set in "REFERENCE SET", the circuit is opened. |
| 10 | Unused<br>Do not connect anything. |
| 11 | Unused<br>Do not connect anything. |

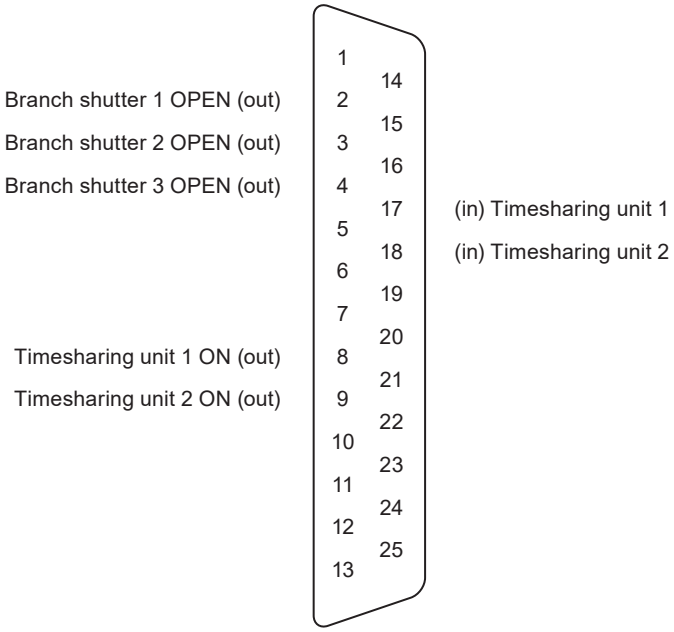
Type of output: Photo MOS relay output
Rating of output: 24 V DC, 20 mA max.

## EXT.I/O (2) Connector (D-Sub 25 pin)

**The EXT.I/O (2) connector inputs and outputs control signals for the timesharing unit and branch shutter.**

⇒ Use the following product out of the attached connectors.

| Plug | Case | Manufacturer |
|---|---|---|
| HDBB-25P(05) | HDB-CTH(10) | HIROSE ELECTRIC CO., LTD. |




## Input Pins of EXT.I/O (2) Connector

| Pin No. | Description |
|---|---|
| 15 | Unused<br>Do not connect anything. |
| 16 | Unused<br>Do not connect anything. |
| 17 | This pin is effective only for the case where the branch shutter is put under independent control by timesharing unit 1 (option).<br>When the section between this pin and COM is put in a closed circuit, timesharing unit 1 is operated so that laser light can be output from input unit 1. |
| 18 | This pin is effective only for the case where the branch shutter is put under independent control by timesharing unit 2 (option).<br>When the section between this pin and COM is put in a closed circuit, timesharing unit 2 is operated so that laser light can be output from input unit 2. |
| 19 | Unused<br>Do not connect anything. |
| 20 | Unused<br>Do not connect anything. |
| 21 | Unused<br>Do not connect anything. |
| 22 | Unused<br>Do not connect anything. |
| 23 | Unused<br>Do not connect anything. |

| Pin No. | Description |
|---|---|
| 24 | Unused<br>Do not connect anything. |
| 25 | Unused<br>Do not connect anything. |

## Output Pins of EXT.I/O (2) Connector

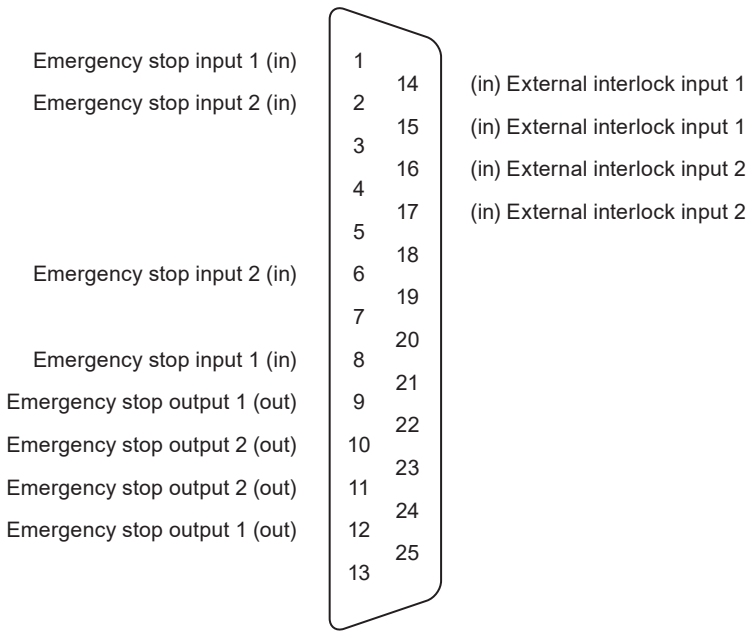
| Pin No. | Description |
|---|---|
| 1 | Unused<br>Do not connect anything. |
| 2 | Branch Shutter 1 Open<br>While branch shutter 1 is open, this Pin 2–COM circuit closes internally. |
| 3 | Branch Shutter 2 Open<br>While branch shutter 2 is open, this Pin 3–COM circuit closes internally. |
| 4 | Branch Shutter 3 Open<br>While branch shutter 3 is open, this Pin 4–COM circuit closes internally. |
| 5 | Unused<br>Do not connect anything. |
| 6 | Unused<br>Do not connect anything. |
| 7 | Unused<br>Do not connect anything. |
| 8 | Timesharing unit 1 ON<br>While timesharing unit 1 is operated, this Pin 8–COM circuit closes internally. |
| 9 | Timesharing unit 2 ON<br>While timesharing unit 2 is operated, this Pin 9–COM circuit closes internally. |

## EXT.I/O (3) Connector (D-Sub 25 pin)

**The EXT.I/O (3) connector inputs and outputs an emergency stop signal for the laser and inputs an external interlock signal.**

⇒ Use the following product out of the attached connectors.

| Socket | Case | Manufacturer |
|---|---|---|
| HDBB-25S(05) | HDB-CTH(10) | HIROSE ELECTRIC CO., LTD. |




## Input Pins of EXT.I/O (3) Connector

| Pin No. | Description |
|---|---|
| 1<br>8 | Emergency stop input 1<br>When the section between pin No.1 and pin No.8 is put in an open circuit, an emergency stop is activated, the high voltage is turned off, the branch shutter is closed, and the pump is stopped.<br>To cancel it, put the section between pin No.1 and pin No.8 and the section between pin No.2 and pin No.6 in closed circuits and then input the trouble reset signal. |
| 2<br>6 | Emergency stop input 2<br>When the section between pin No.2 and pin No.6 is put in an open circuit, an emergency stop is activated, the high voltage is turned off, the branch shutter is closed, and the pump is stopped.<br>To cancel it, put the section between pin No.1 and pin No.8 and the section between pin No.2 and pin No.6 in closed circuits and then input the trouble reset signal. |
| 14<br>15 | External interlock input 1<br>When the section between pin No.14 and pin No.15 is put in an open circuit, the branch shutter is closed.<br>To cancel it, put the section between pin No.14 and pin No.15 and the section between pin No.16 and pin No.17 in closed circuits and then input the trouble reset signal. |
| 16<br>17 | External interlock input 2<br>When the section between pin No.16 and pin No.17 is put in an open circuit, the branch shutter is closed.<br>To cancel it, put the section between pin No.14 and pin No.15 and the section between pin No.16 and pin No.17 in closed circuits and then input the trouble reset signal. |

⇒ For simple systems, do not connect anything to pins not described above.

## Output Pins of EXT.I/O (3) Connector

| Pin No. | Description |
|---|---|
| 9 | Emergency stop output 1<br>When the laser is put in an emergency stop, the section between pin No.9 and pin No.12 is put in an open circuit. |
| 12 | |
| 10 | Emergency stop output 2<br>When the laser is put in an emergency stop, the section between pin No.10 and pin No.11 is put in an open circuit. |
| 11 | |

⇒ For simple systems, do not connect anything to pins not described above.

Proper integration of the Laser with external equipment is required for compliance with applicable safety regulations. The wiring diagrams in this section show typical implementations. Failure to select and implement a correct method of wiring can render the Laser unsafe.

**⚠ CAUTION**

**ALL CONNECTIONS ARE POTENTIAL FREE DRY CONTACT CLOSURE ONLY.**
**Do not apply any voltage or current or you will damage the system.**

## Interlocks

The laser interlock mechanism is used to render the Laser safe for material handling without shutting down the laser itself. One example would be a door in a laser safety enclosure that must open for part loading and unloading. When the interlock channels are opened laser emission will cease and the laser safety shutter will close. If a laser weld operation is in process the Laser will be put into a fault condition that must be cleared before processing can start again. This interlock is designed to be connected to a laser enclosure safety door or any other device designed to protect personnel from laser radiation. A properly designed enclosure meeting the specifications of IEC60825-1 is a requirement, and the Laser will comply with IEC60825-1 when correctly installed and wired in a compliant enclosure.

The laser interlock consists of two dry contact inputs. These must be opened and closed simultaneously or a fault will occur. There is no external reset required meaning that the interlock control circuit will allow laser operation as soon as the interlocks are closed.

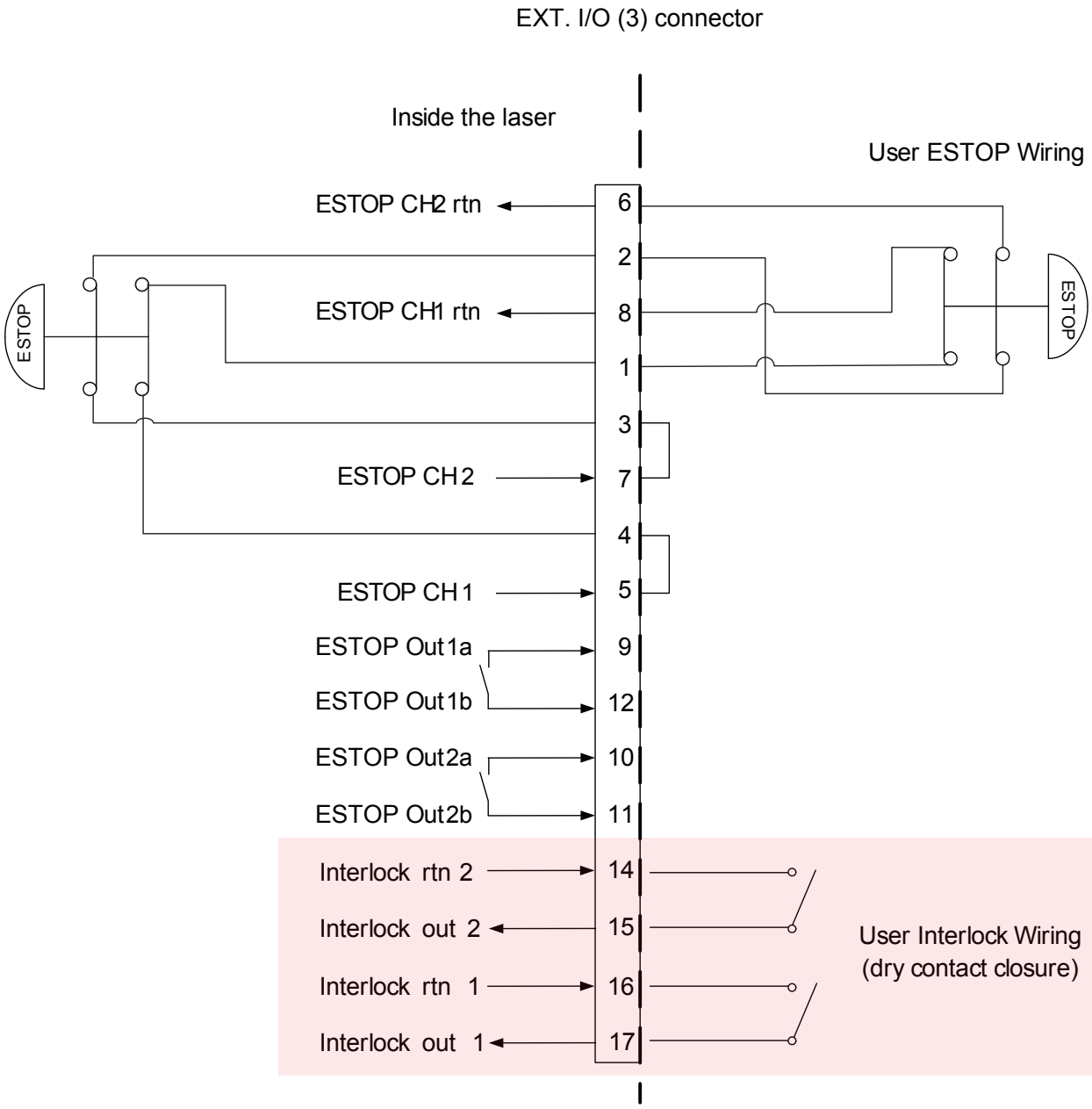
## Emergency Stop for Simple Systems

Interfacing with External Emergency Stop Circuitry

E-STOP button(s) ONLY

The Laser can be interfaced to a simple system including an enclosure and one or more external emergency stop buttons. In this situation the Laser would not be connected to any larger automation system or control any other equipment. The dual channel output relays can be monitored to verify the status of the emergency stop circuit but no external equipment other than that outlined above should be included. Reset can be performed via the EXT. I/O (1) connector.

Also, dual channel relay outputs are available.



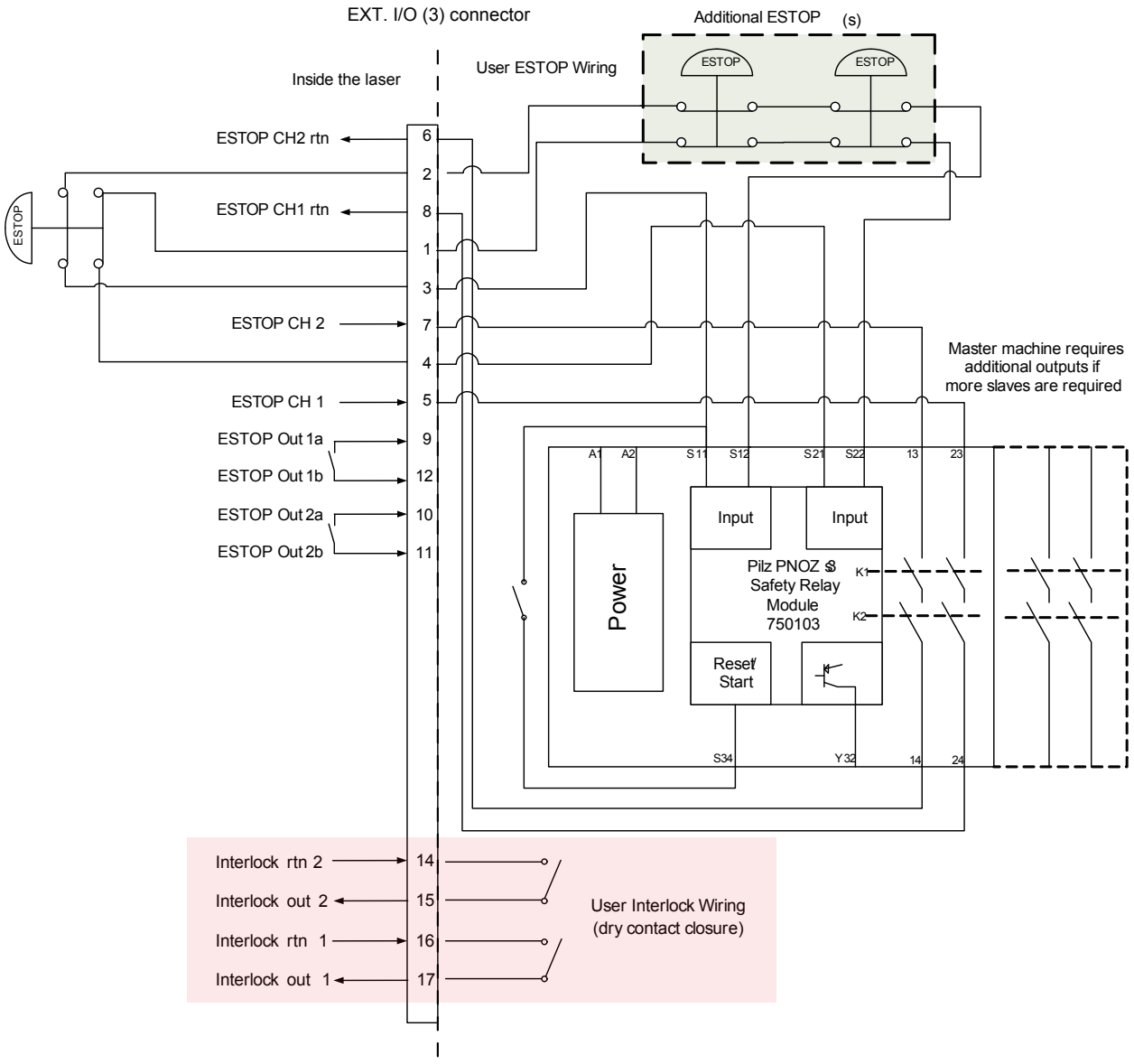

## Emergency Stop for Complicated Systems

Interfacing with External Emergency Stop Circuitry
User Supplied Safety Relay Module(s) Required

Complicated Systems are those in which more than one emergency stop sub-circuit must be linked together. An example of this would be a machine that has a Laser, parts handler with pneumatic controls, PLC, and conveyor belt all of which have ESTOP buttons where one ESTOP button stops all devices. Any situation in which more than one device must be connected together and respond identically to an emergency stop event is considered a complicated system.

Complicated systems are integrated using certified safety controllers or safety relays. In this situation one device is the “master” and the rest of the devices are the “slaves”. The Laser is considered a slave device in this configuration and its emergency stop must be controlled by the larger machine’s safety controller. The output of the external safety relay module closes the input to the Laser safety unit and allows the system to clear the emergency stop state.

In this wiring example a Pilz PNOZ family safety relay module controls the Laser and interfaces two external emergency stop buttons. In this example the Pilz device would also control additional emergency stop functions outside of the Laser using expansion contacts. The more devices which must be implemented the more expansion contacts must be added to the Safety Relay Module. Any suitable IEC13849-1 compliant safety relay controller is acceptable as long as it is implemented in this manner. The end user is responsible for verifying compliance of the machine as a whole.

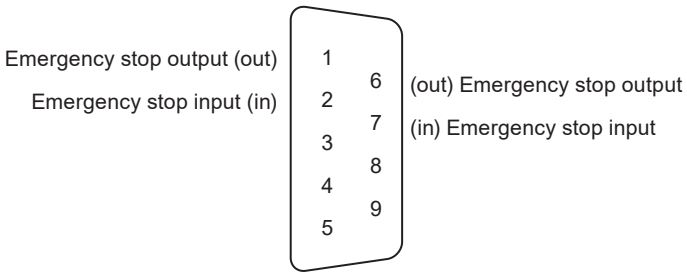


## EMERGENCY STOP Connector (D-Sub 9 pin)

**The EMERGENCY STOP connector inputs and outputs an emergency stop signal for the laser.**

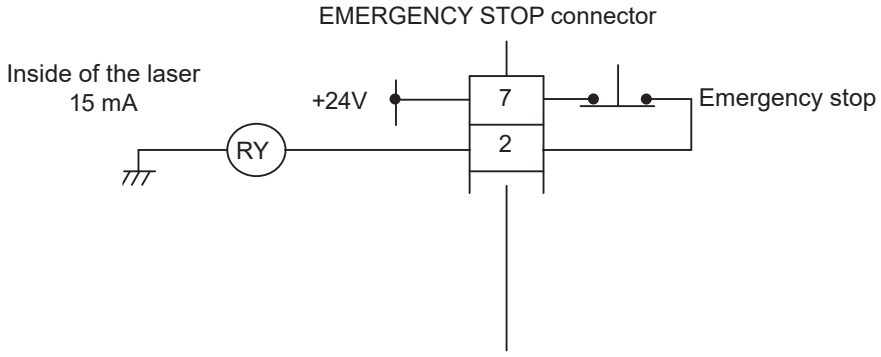
⇒ Use the following product out of the attached connectors.

| Plug | Case | Manufacturer |
|---|---|---|
| HDEB-9P(05) | HDE-CTH(10) | HIROSE ELECTRIC CO., LTD. |

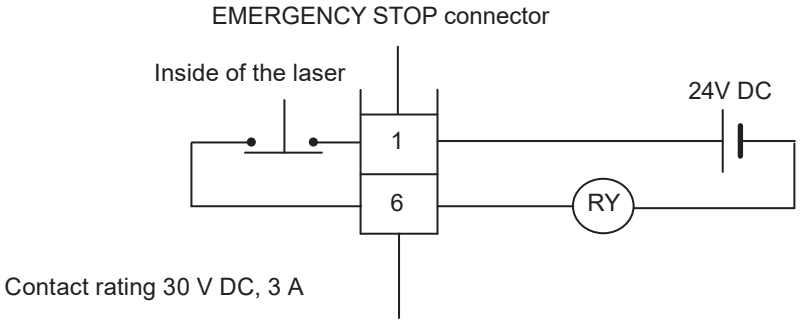



| Pin No. | Description |
|---|---|
| 1 | When the laser is put in an emergency stop, the section between pin No.1 and pin No.6 is put in an open circuit. |
| 2 | When the section between pin No.2 and pin No.7 is put in an open circuit, the power supply of the laser is cut off. |
| 6 | When the laser is put in an emergency stop, the section between pin No.1 and pin No.6 is put in an open circuit. |
| 7 | When the section between pin No.2 and pin No.7 is put in an open circuit, the power supply of the laser is cut off. |

⇒ When the section between pin No.2 (emergency stop input) and pin No.7 (emergency stop input) is put in an open circuit, the laser is put in an emergency stop status and the power supply of the laser is cut off. When the section between pin No.23 (control switching) of the EXT.I/O (1) connector and COM is put in an open circuit, this function is also effective.




At occurrence of an emergency stop, the section between pin No.1 (emergency stop output) and pin No.6 (emergency stop output) is put in an open circuit and the emergency stop output status shown in the following figure is provided.



## REMOTE INTERLOCK Connector

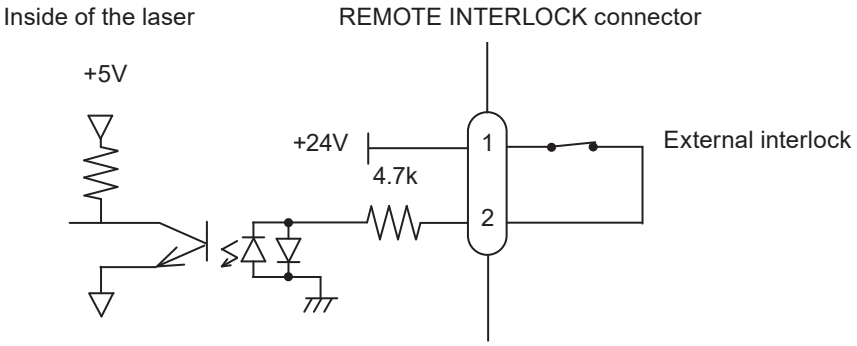
**The REMOTE INTERLOCK connector closes the branch shutter and connects the interlock to cut off laser light in an emergency.**

⇒ Use the following product out of the attached connectors.

| Plug | Case | Manufacturer |
|---|---|---|
| 116-12A10-2AF10.5 | | TAJIMI ELECTRONICS CO., LTD. |

| Pin No. | Description |
|---|---|
| 1 | When the section between pin No.1 and pin No.2 is put an open circuit, the branch shutter is closed. |
| 2 | |

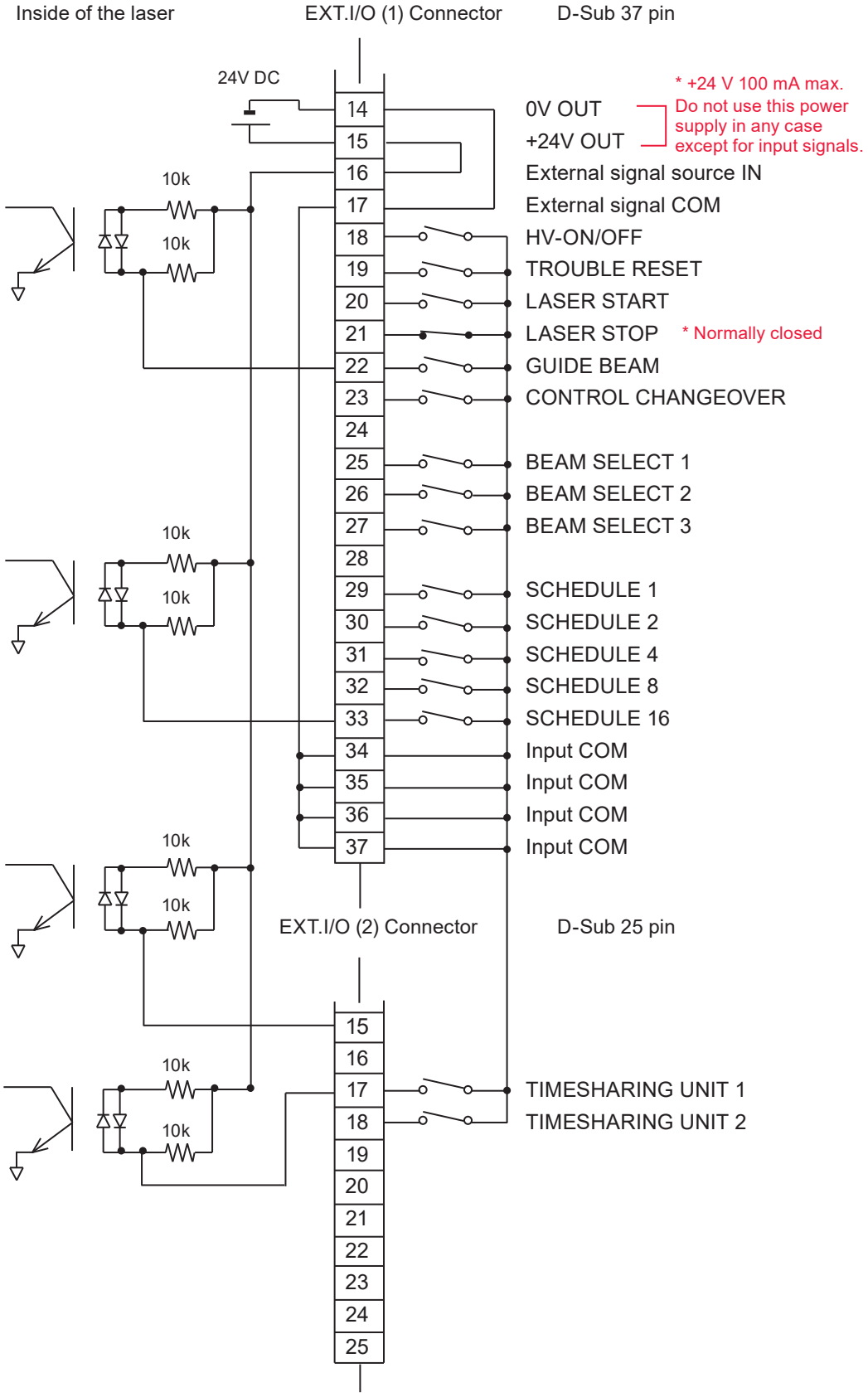
⇒ When the section between 2 pins of this connector is put in an open circuit by operating the external interlock, the branch shutter is closed to stop guide light and laser output. Connect this connector to the main interlock, chamber interlock, door interlock, or other interlock. A multiple number of these interlocks may be connected in series as required. At delivery, the connector for short circuit is installed.



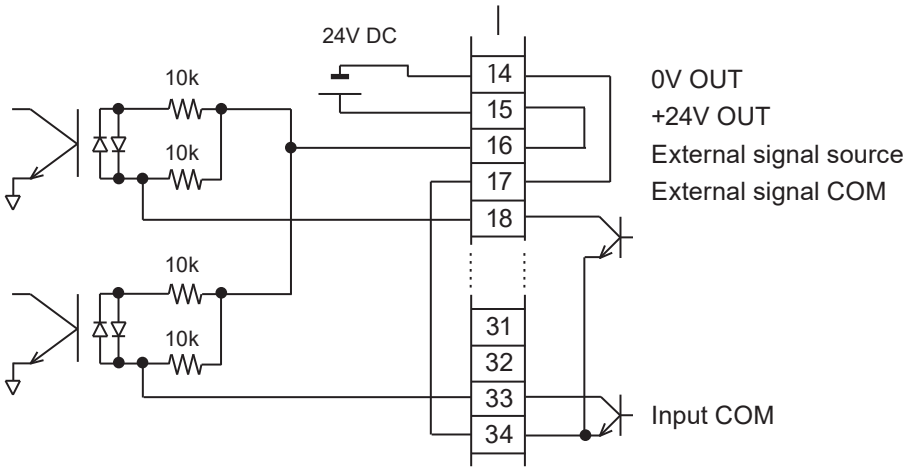
# Example Connections of External Input Signals

**An example of external input signal connections of the EXT.I/O connector is explained below.**

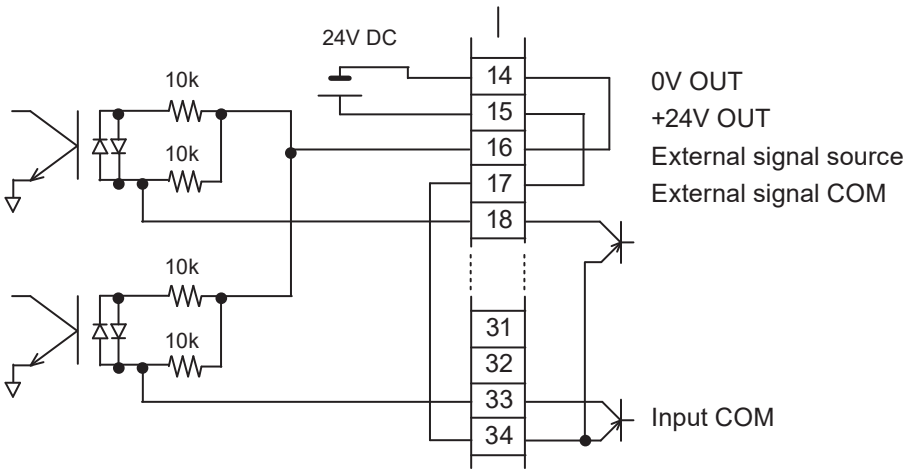
## When External Inputs are Contacts



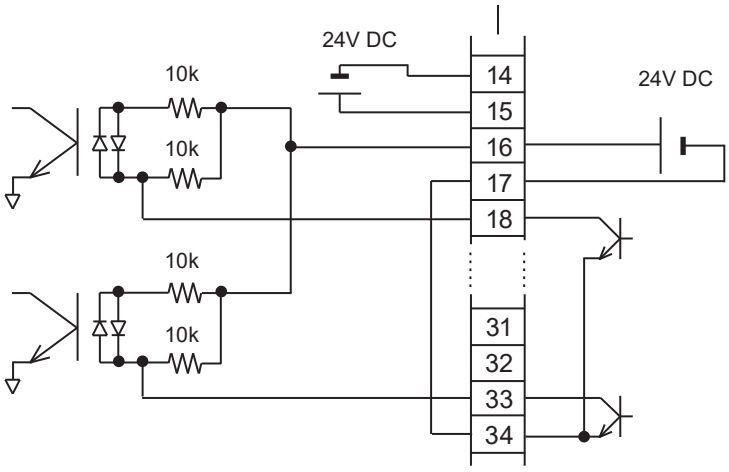
## When External Inputs are NPN Transistors




## When External Inputs are PNP Transistors

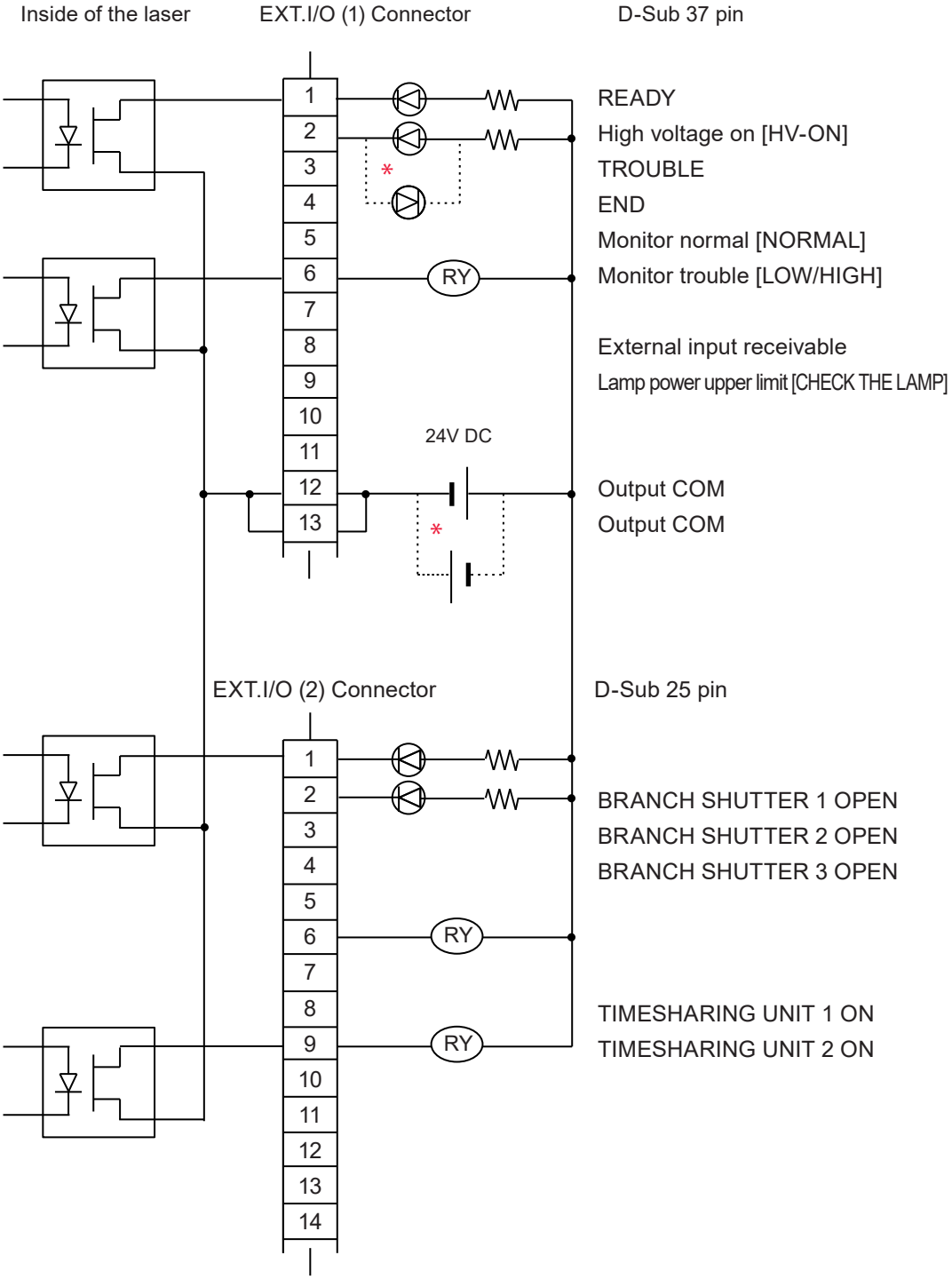



## When External Power Source is Supplied



# Example Connection of External Output Signals

**An example of external output signal connections of the EXT.I/O connector is explained below.**




Type of output: Photo MOS relay output

Rating of output: 24 V DC, 20 mA max.

* **The polarity may be positive or negative.**

# 4. Programming

**This section explains the precautions for programming laser welding by external input/output signals (EXTERNAL CONTROL).**

The timing chart of the appendix shows the input signal length and input waiting time required to correctly operate the laser. Perform actual programming referring to this timing chart.

In the following, a control flow is explained by taking the case where "Schedule 1" is first specified and then "Schedule 2" is specified to perform a single laser light output by 2-powersharing from BEAM1 and BEAM2, as an example.

## 1 Switching the Control Method

(1) Put pin No.23 (control switching) of the EXT.I/O (1) connector in a closed circuit.

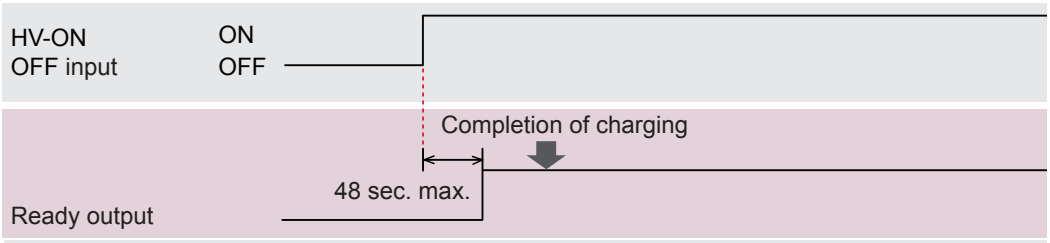
Pin No.8 of the EXT.I/O (1) connector is put in a closed circuit and the signal (external input acceptable) is returned from the laser.

⇒ Press the MENU key on the control panel to display the STATUS screen. Then, you can confirm that "EXTERNAL CONTROL" is selected as the control method.


## 2 Turning ON the High Voltage

(1) Put the section between pin No.18 of the EXT.I/O (1) connector and COM to turn ON the high voltage.

The capacitor can be charged in 48 sec. max. At completion of charging, pin No.1 of the EXT.I/O (1) connector is put in a closed circuit and the signal (Ready) is returned from the laser.




## 3 Selecting a Beam (Setting the Branch Shutter)

(1) Put the section between the pin corresponding to the beam and COM in a closed circuit. In this example, the section between pin No.25 and pin No.26 of the EXT. I/O (1) connector is put in a closed circuit to select Beam 1 and Beam 2.

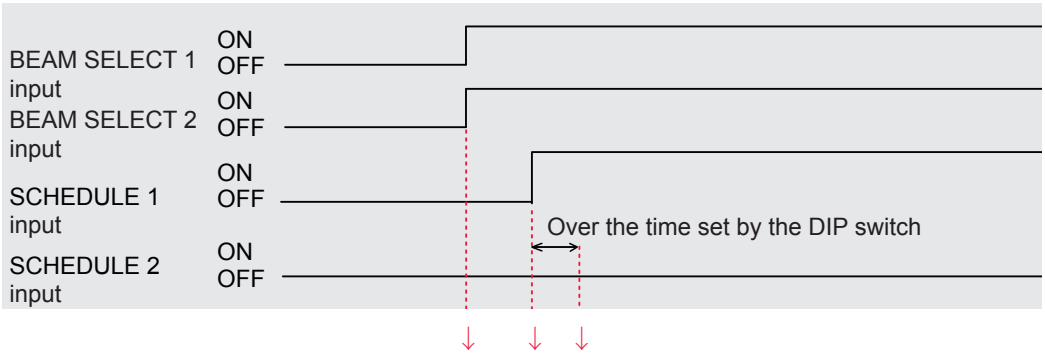
The branch shutter is opened and the corresponding SHUTTER lamp comes on.

## 4 Setting Output Schedules (SCH.#01)

(1) Set the SCHEDULE number by combining pin No.29 to pin No.33 of the EXT.I/O (1) connector. In this example, pin No.29 of the EXT.I/O (1) connector is put in a closed circuit for 16 ms or more to set SCH.#01.

⇒ Refer to "SCHEDULE Number Selection" on page 99.

⇒ At delivery, the signal acceptance time (time from a signal input till establishment of schedules) of welding schedules is set to 16 ms. Set the close circuit time referring to this value.For the signal acceptance time, 1.0 ms, 4.0 ms, 8.0 ms, or 16.0 ms can be selected by setting the DIP switch on the CPU board. For details, refer to Chapter 2, "3. Changing the Acceptance Time for Laser Start Signal/Schedule Signal" on page 83.

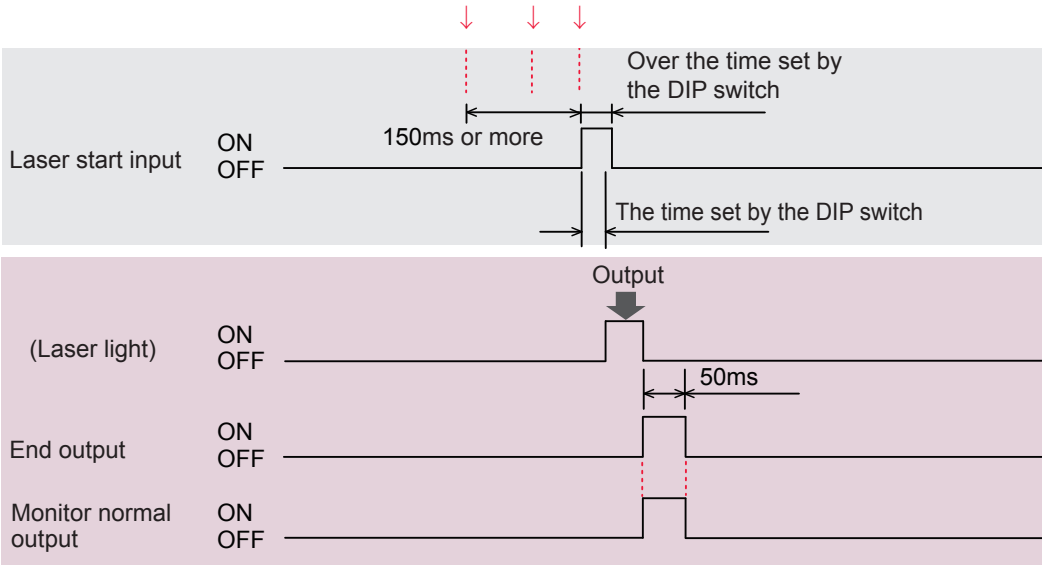



## 5 Outputting Laser Light

(1) Put pin No.20 (Laser Start) of the EXT.I/O (1) connector in a closed circuit.

Laser light is output simultaneously from Beam 1 and Beam 2.

Pin No.4 (End output) of the EXT.I/O (1) connector is put in a closed circuit for 50 ms and a signal is returned from the laser. Pin No.5 (Monitor normal output) or pin No.6 (Monitor abnormal output) of the EXT.I/O (1) connector is put in a closed circuit and a signal is returned from the laser.




⇒ Put the laser start pin in a closed circuit at least in 150 ms after inputting the beam selection signal or in more than the time set by the DIP switch after setting welding schedules.

⇒ At delivery, the laser start acceptance time (time from a signal input till an actual output of laser light) is set to 16 ms. For the laser start acceptance time, 1.0 ms,

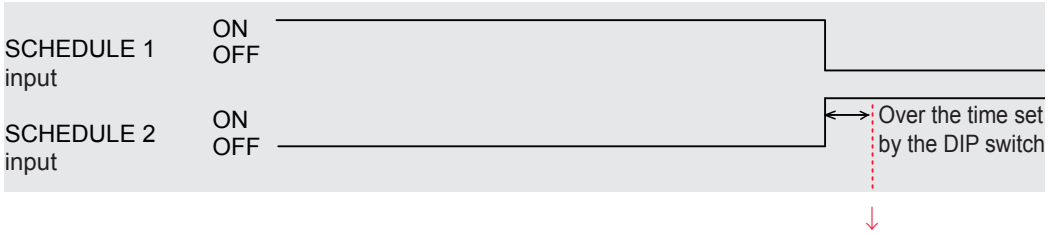
4.0 ms, 8.0 ms, or 16.0 ms can be selected by setting the DIP switch on the CPU board. For details, refer to Chapter 2, "3. Changing the Acceptance Time for Laser Start Signal/Schedule Signal" on page 83.

⇒ Be sure to put the laser start pin in a closed circuit at least the time set by the DIP switch.

## 6 Setting Output Schedules (SCH.#02)

(1) Set the SCHEDULE number by combining pin No.29 to pin No.33 of the EXT.I/O (1) connector. In this example, put pin No.29 of the EXT.I/O (1) connector to an open circuit to turn OFF SCH.#01, and put pin No.30 in a closed circuit to turn on SCH.#02.

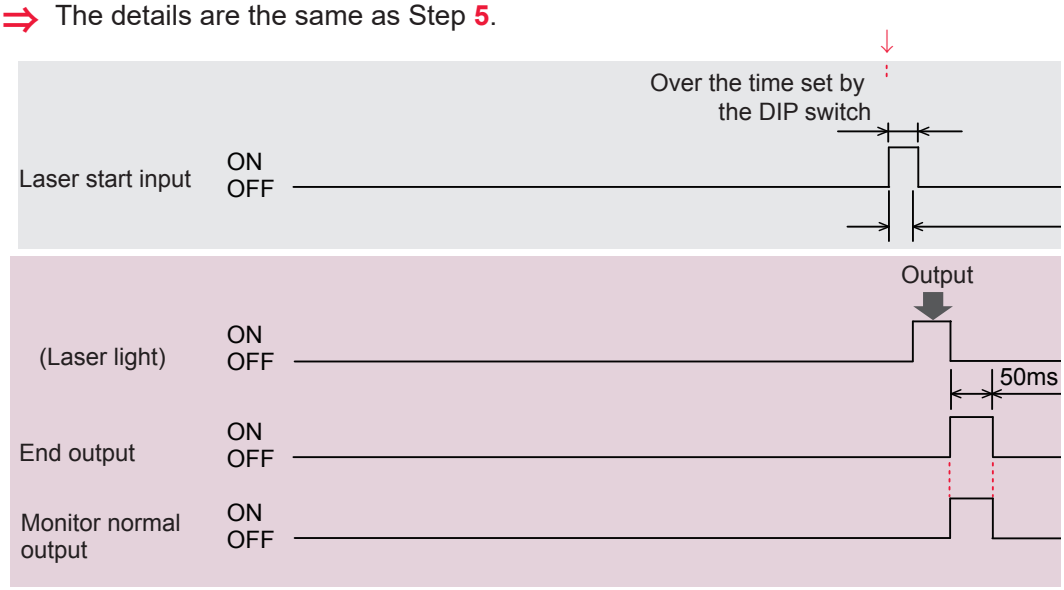
⇒ Refer to "SCHEDULE Number Selection" on page 99.




## 7 Outputting Laser Light

(1) Put pin No.20 (Laser start) of the EXT.I/O (1) connector in a closed circuit.
Laser light is output simultaneously from BEAM1 and BEAM2.

⇒ The details are the same as Step **5**.




## 8 Stopping the Operation

(1) Put the section between pin No.18 of the EXT.I/O (1) connector and COM in an open circuit to cut off the high voltage.

(2) Put pin No.23 (control switching) of the EXT.I/O (1) connector to invalidate external input signals.

## Making a Position Adjustment by Guide Light

**Make a position adjustment by guide light before welding according to the following procedure.**

(1) Adjust the workpiece and output unit positions to set an appropriate work distance (distance between the workpiece and the output position).

(2) Put the section between pin No.22 of the EXT.I/O (1) connector and COM in a closed circuit.

Guide light can be seen as a red point. Laser light is irradiated to this red point position.

(3) Check the laser light irradiation position.

If the welding point deviates from the red point of guide light, move the output unit or workpiece to adjust the position.

Operating Part

# Chapter 5

# Laser Welding by External Communication Control (RS-485 CONTROL)

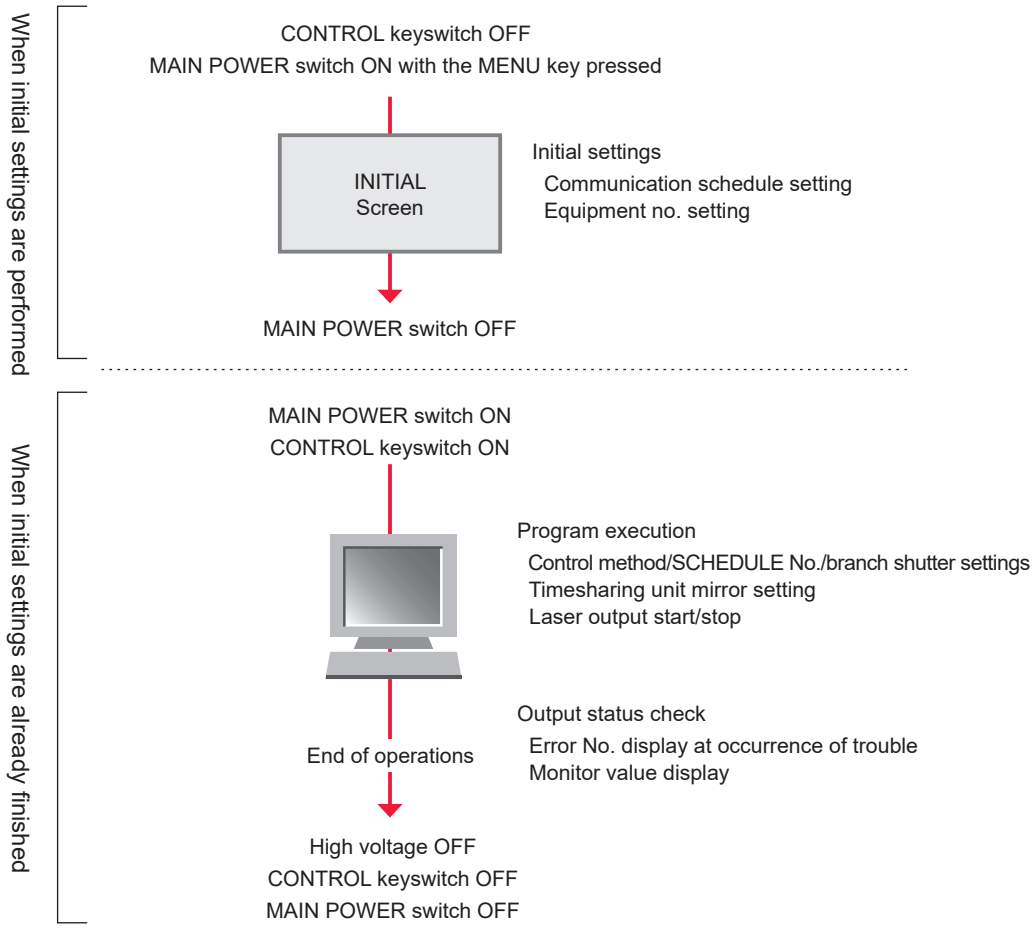
## 1. Operation Flow

**This section explains an operation flow of a laser welding by external communication control (RS-485 CONTROL).**

The following methods for laser welding operations are available: control from the control panel (PANEL CONTROL), control by external input/output signals from the PLC (Programmable Logic Controller) connected to the connector (EXTERNAL CONTROL), and control by external communication from the connected personal computer (RS-485 CONTROL).

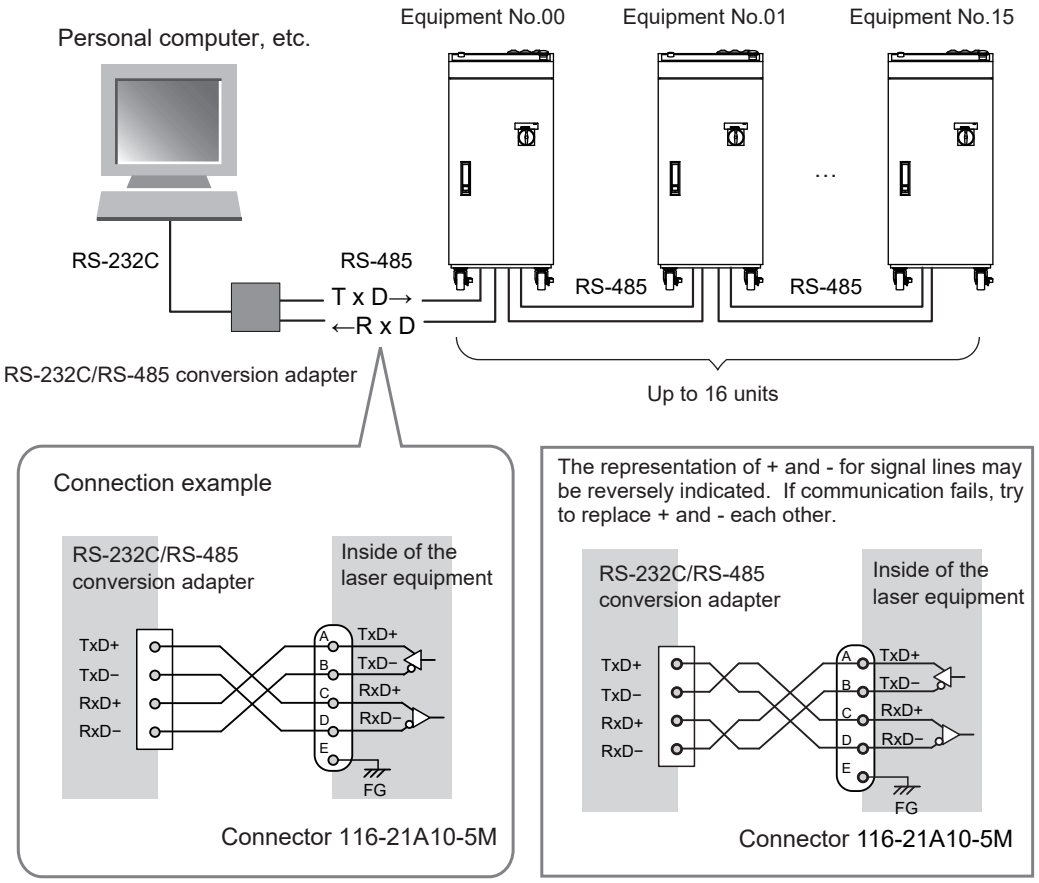
At the control by external communication (RS-485 CONTROL), the original customer-developed program is executed on the personal computer to set laser output schedules and read monitor data and various types of status.

* PLC: Programmable Logic Controller This unit exerts sequence control by executing the programmed contents of control in sequence. This is often called Sequencer (product name of Mitsubishi Electric Corporation).



# 2. Preparations for Operations

**Up to 16 laser units can be controlled from a single personal computer. The equipment configuration and connector connections are shown in the following figure.**




⇒ For controlling multiple lasers by single personal computer, it is necessary to register equipment No. (NETWORK #) for each equipment. Set equipment No. without duplication. If duplication of equipment No. exists, a data collision will occur on the communication line and the laser cannot be correctly operated.

⇒ The RS-232C/RS-485 conversion adapter is an option separately sold. Purchase it as required. For details, refer to the Introduction Part, Chapter 1 "Options" on page 22.

⇒ Prepare the program and its development environment for laser control on the customer side.

⇒ Connect the shielded portion to FG (frame ground) inside the laser equipment only when using the shielded cable. Do not use as SG (signal ground).

# 3. Initial Settings

**Perform initial settings to control laser welding by external communication (RS-485 CONTROL). Set communication schedules and equipment No. on the control panel of the laser.**

The communication schedules for data transfer are as follows.

| | | |
|---|---|---|
| Data transfer system | Conforming to RS-485, asynchronous, full duplex | |
| Transfer rate | 9600, 19200, 38400 bps | |
| Data type | Start bit | 1 |
| | Data bit | 8 or 7 |
| | Stop bit | 2 or 1 |
| | Parity bit | Even/odd/none |
| Character code | ASCII | |

⇒ For setting the transfer rate, data type, and equipment No., display the INITIAL screen on the control panel of each equipment to be connected to a personal computer, etc. and set them on this screen.

## Setting Communication Schedules

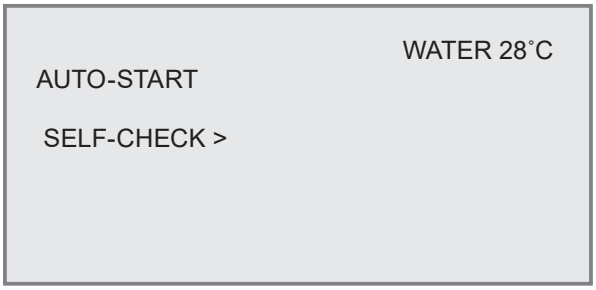
**Display the INITIAL screen on the control panel of the laser and then set communication schedules.**

### 1 Displaying the INITIAL Screen

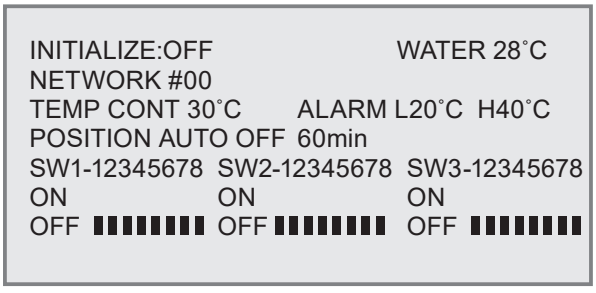
(1) Turn OFF the CONTROL keyswitch, and turn ON the MAIN POWER switch while holding down the MENU key.

⇒ Hold down the MENU key until the SELF-CHECK > screen appears.

The power supply is turned ON, the POWER lamp comes on, and the SELF-CHECK > screen appears.




At completion of the self check, the INITIAL screen appears.



⇒ Unless the CONTROL keyswitch is OFF, the INITIAL screen does not appear.

## 2 Specifying Communication Schedules

(1) Set communication schedules by setting 1 to 6 of "SW2" to ON or OFF. Move the cursor to the switch to be changed and press the ON key or OFF key for this setting.

1: Data bit length (OFF: 8 bits, ON: 7 bits)
2: Parity bit (OFF: Parity bit, ON: No parity bit)
3: Parity mode (OFF: Even, ON: Odd)
4: Stop bit (OFF: 2, ON: 1)
5/6: Communication speed (as shown in the following table depending on the combination of ON and OFF)

| SW2-5 | SW2-6 | bps |
|---|---|---|
| OFF | OFF | 9600 |
| OFF | ON | 19200 |
| ON | OFF | 38400 |
| ON | ON | (9600) |

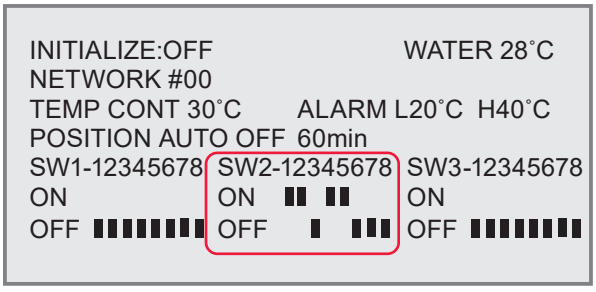
7/8: Unused

In this example, each item is set as shown below.

| Switch No. | Setting | Setting example |
|---|---|---|
| 1 (Data bit) | ON | 7bit |
| 2 (Parity bit) | ON | None |
| 3 (Parity mode) | OFF | Even |
| 4 (Stop bit) | ON | 1bit |
| 5/6 (Communication speed) | 5: ON 6: OFF | 38400bps |

## 3 Setting the Set Value Definitively

(1) Press the ENTER key to definitively set the set value.
Communication schedules are set by SW2 on the INITIAL screen.




*<Note>*

**When any SW2 switch setting has been changed, turn OFF the power supply before a laser output, and then turn it ON again.**

# Setting Equipment No.

**Display the INITIAL screen on the control panel of the laser and set equipment No. (NETWORK #).**

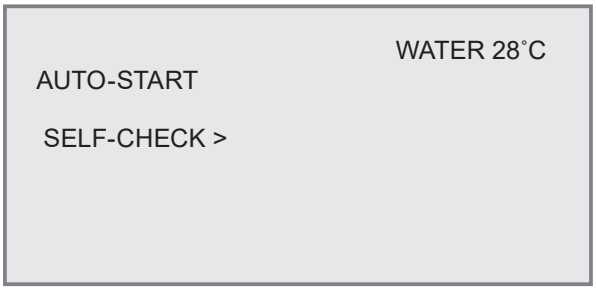
⇒ For controlling multiple lasers by single personal computer, it is necessary to register equipment No. (NETWORK #) for each equipment. Set equipment No. without duplication. If duplication of equipment No. exists, a data collision will occur on the communication line and the laser cannot be correctly operated.

## 1 Displaying the INITIAL Screen

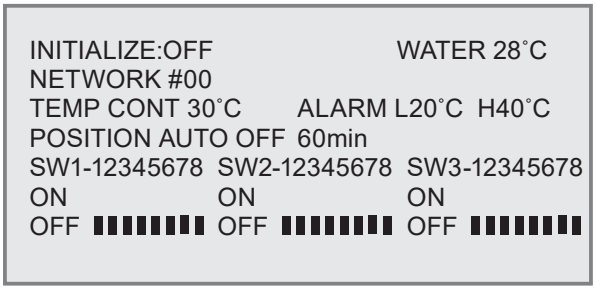
(1) Turn OFF the CONTROL keyswitch and turn ON the MAIN POWER switch while holding down the MENU key.

⇒ Hold down the MENU key until the SELF-CHECK > screen appears.

The power supply is turned ON, the POWER lamp comes on, and the SELF-CHECK > screen appears.




At completion of the self check, the INITIAL screen appears.




⇒ Unless the CONTROL keyswitch is OFF, the INITIAL screen does not appear.

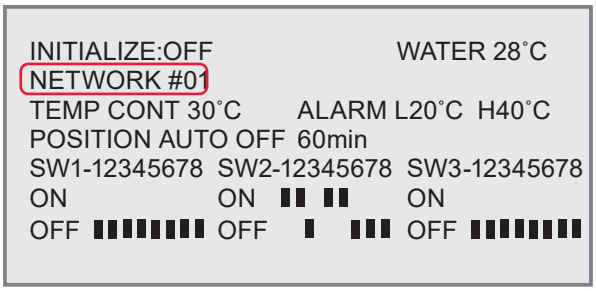
## 2 Specifying Equipment No.

(1) Move the cursor to "NETWORK #" and press the ON or OFF key to set equipment No. in the range of 00 to 15.

⇒ For details of each item on the INITIAL screen, refer to Chapter 2 "1. Setting Welding Schedules" on page 58.

## 3 Setting the Set Value Definitively

(1) Press the ENTER key to definitively set the set value.
NETWORK # of INITIAL screen is set.



# 4. Commands

**This section explains the commands that are used to control laser welding by external communication.**

## Code Table

The codes for external communication with a personal computer and the text structure are as follows. For details, refer to "Setting Data" on page 125 to "Reading Error No. at Occurrence of Trouble" on page 136.

**Control Codes (Hexadecimal Codes)**

ACK: 06H NAK: 15H STX: 02H ETX: 03H

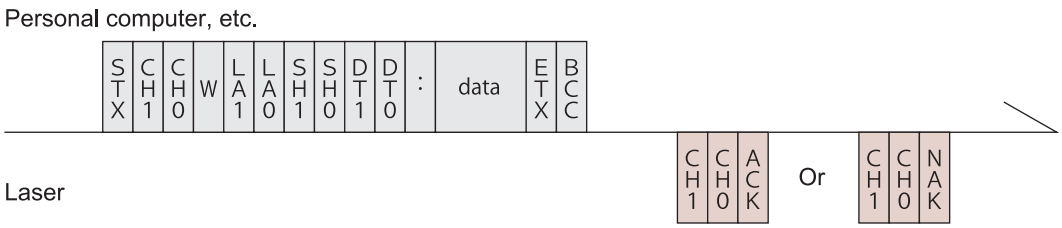
BCC (block check code) ... 1-byte horizontal even parity up to ETX excluding STX

| Code | Contents | Text structure | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W | Setting data | PC to laser | STX | CH1 | CH0 | W | LA1 | LA0 | SH1 | SH0 | DT1 | DT0 | : | data | ETX | BCC | | |
| | | Laser to PC | CH1 | CH0 | ACK | Or | | | CH1 | CH0 | NAK | Write data is out of the setting range or external communication control is not performed. | | | | | | |
| R | Reading data | PC to laser | STX | CH1 | CH0 | R | LA1 | LA0 | SH1 | SH0 | DT1 | DT0 | ETX | BCC | | | | |
| | | Laser to PC | STX | data | | ETX | BCC | Or | | | | CH1 | CH0 | NAK | The schedule No. or data No. is out of the range. | | | |
| WS | Setting the control method, SCHEDULE No., branch shutter, etc. | PC to laser | STX | CH1 | CH0 | W | S | SH1 | SH0 | cnt | s1 | s2 | s3 | ... | s9 | mon | ETX | BCC |
| | | Laser to PC | CH1 | CH0 | ACK | Or | | | CH1 | CH0 | NAK | The specified status cannot be provided or external communication control is not performed. | | | | | | |
| WM | Setting the timesharing unit | PC to laser | STX | CH1 | CH0 | W | M | m1 | m2 | m3 | m4 | m5 | ETX | BCC | | | | |
| | | Laser to PC | CH1 | CH0 | ACK | Or | | | CH1 | CH0 | NAK | The specified status cannot be provided or external communication control is not performed. | | | | | | |
| RS | Reading the control method, SCHEDULE No., branch shutter, etc. | PC to laser | STX | CH1 | CH0 | R | S | ETX | BCC | | | | | | | | | |
| | | Laser to PC | STX | SH1 | SH0 | cnt | s1 | s2 | s3 | s4 | s5 | s6 | s7 | s8 | s9 | mon | rdy | ETX | BCC |
| RM | Reading the timesharing unit status | PC to laser | STX | CH1 | CH0 | R | M | ETX | BCC | | | | | | | | | |
| | | Laser to PC | STX | SH1 | SH0 | cnt | m1 | m2 | m3 | m4 | m5 | ETX | BCC | | | | | |
| $0 | Laser start command | PC to laser | STX | CH1 | CH0 | $ | 0 | ETX | BCC | | | | | | | | | |
| | | Laser to PC | CH1 | CH0 | ACK | Or | | | CH1 | CH0 | NAK | The HV is OFF, the voltage does not reach the specified value, trouble occurs, or external communication control is not performed. | | | | | | |

| Code | Contents | Text structure | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $9 | Laser stop command | PC to laser | STX | CH1 | CH0 | $ | 9 | ETX | BCC | | | |
| | | Laser to PC | CH1 | CH0 | ACK | Or | | | CH1 | CH0 | NAK | External communication control is not performed. |
| C0 | Trouble reset command | PC to laser | STX | CH1 | CH0 | C | 0 | ETX | BCC | | | |
| | | Laser to PC | CH1 | CH0 | ACK | Or | | | CH1 | CH0 | NAK | External communication control is not performed. |
| C1 | SHOT COUNT reset command | PC to laser | STX | CH1 | CH0 | C | 1 | ETX | BCC | | | |
| | | Laser to PC | CH1 | CH0 | ACK | Or | | | CH1 | CH0 | NAK | External communication control is not performed. |
| C2 | GOOD COUNT reset command | PC to laser | STX | CH1 | CH0 | C | 2 | ETX | BCC | | | |
| | | Laser to PC | CH1 | CH0 | ACK | Or | | | CH1 | CH0 | NAK | External communication control is not performed. |
| C3 | Reading trouble | PC to laser | STX | CH1 | CH0 | R | T | ETX | BCC | | | |
| | | Laser to PC | STX | E1 | E0 | , | E1 | E0 | , | ..... | E1 | E0 | ETX | BCC |

# Setting Data

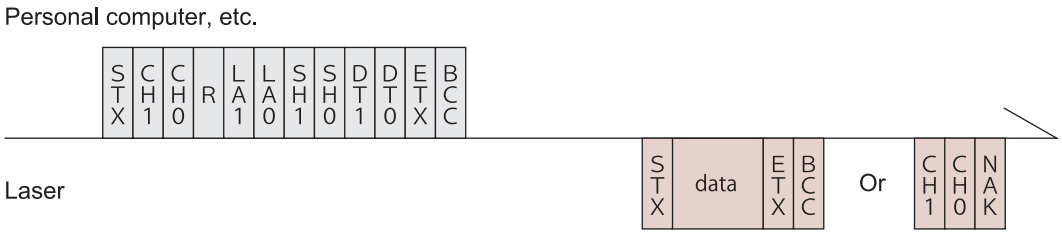
**The command (code: W) to set welding schedules by specifying equipment No. and schedule No. is explained below.**




| | |
|---|---|
| CH1/CH0 | Equipment No. (CH1 = tens digit, CH0 = units digit) |
| LA1/LA0 | Classification No. of the setting (LA1 = tens digit, LA0 = units digit)<br>99 Settings for the cooler (Set the schedule No. [SH1/SH0] to 00.)<br>84 Schedule settings for both FIX and FLEX<br>85 Schedule settings for FIX<br>86 Schedule settings for FLEX, TIME 01 to 10<br>87 Schedule settings for FLEX, TIME 11 to 20<br>88 Schedule settings for FLEX, WATT 01 to 10<br>89 Schedule settings for FLEX, WATT 11 to 20 |
| SH1/SH0 | Schedule No. (SH1 = tens digit, SH0 = units digit)<br>Enter the No. of the schedule you want to change within the data range of 00 to 31.<br>If □□ (spaces) are entered, the currently selected schedule is used. |
| DT1/DT0 | Data No. (DT1 = tens digit, DT0 = units digit)<br>• For detailed information on the data No., see "Set Value/Monitor Value Table" on page 127.<br>• If “99” is entered, data is written in a batch.<br>data: (Data No.1), (Data No.2), (Data No.3), ... (the last Data No.)<br>Insert [,] between individual data.<br>The monitor data (WATER, SHOT COUNT, GOOD COUNT, ENERGY) will not be written. |
| ACK or NAK | When the setting data is within the setting range, [ACK] is returned. When this data is out of the setting range, [NAK] is returned. This command is effective only for external communication control. For the other control methods, [NAK] is returned. |

# Reading Data

**The command (code: R) to read the set values and monitor values of welding schedules by specifying equipment No. and schedule No. is explained below.**




| | |
|---|---|
| CH1/CH0 | Equipment No. (CH1 = tens digit, CH0 = units digit) |
| LA1/LA0 | Classification No. of the setting (LA1 = tens digit, LA0 = units digit)<br>99 Settings for the cooler (Set the schedule No. [SH1/SH0] to 00.)<br>84 Schedule settings for both FIX and FLEX<br>85 Schedule settings for FIX<br>86 Schedule settings for FLEX, TIME 01 to 10<br>87 Schedule settings for FLEX, TIME 11 to 20<br>88 Schedule settings for FLEX, WATT 01 to 10<br>89 Schedule settings for FLEX, WATT 11 to 20<br>95 Laser power monitor — Shot count, Good count, average<br>00 Laser power monitor — Energy, number of waveform data, etc.<br>01 Laser power monitor — Waveform data 000 to 004<br>: :<br>22 Laser power monitor — Waveform data 105 to 109 |
| SH1/SH0 | Schedule No. (SH1 = tens digit, SH0 = units digit)<br>Enter the No. of the schedule you want to read within the data range of 00 to 31.<br>If □□ (spaces) are entered, the currently selected schedule is used. |
| DT1/DT0 | Data No. (DT1 = tens digit, DT0 = units digit)<br>• For detailed information on the data No., see "Set Value/Monitor Value Table" on page 127.<br>• If “99” is entered, data is read in a batch.<br>data: (Data No.1), (Data No.2), (Data No.3), ... (the last Data No.)<br>Insert [,] between individual data. |
| ACK or NAK | The Laser returns a [NAK] if the classification No., schedule No., or data No. falls outside the specified range. |

## Set Value/Monitor Value Table

⇉ The items marked * are monitor values. These values can be read out but cannot be set.

⇉ The value in ( ) indicates the unit.

⇉ The unit of time setting depends on the setting of "7" of SW1 on the INITIAL screen. When setting to ON, set the values in increment of 2.

### 99 Settings for Cooler (Set the schedule No. [SH1/SH0] to 00.)

| Data No. | Item | Data Range |
|---|---|---|
| 01* | Coolant temperature | 000 – 999 (× 1°C) |
| 02 | [TEMP CONT] on the [INITIAL] screen<br>Control temperature | 00 – 99 (×1°C) |
| 03 | [H] of ALARM on the [INITIAL] screen<br>Coolant temperature high alarm | 00 – 99 (×1°C) |
| 04 | [L] of ALARM on the [INITIAL] screen<br>Coolant temperature low alarm | 00 – 99 (×1°C) |
| 05* | Coolant resistivity | 000 – 999 (× 0.01MΩ) |

### 84 Schedule Settings for both FIX and FLEX

| Data No. | Item | Data Range |
|---|---|---|
| 01 | [FORM] on the [SCHEDULE] screen<br>Selection of waveform setting method<br>0: FIX 1: FLEX | 0 – 1 |
| 02 | Set waveform display on the [SCHEDULE] screen<br>0: OFF 1: ON | 0 – 1 |
| 03 | [PEAK] on the [SCHEDULE] screen<br>Laser output peak value | ML-2050A: 0000 – 0400 (×0.01kW)<br>ML-2051A: 0000 – 0250 (×0.01kW)<br>ML-2150A: 0000 – 0600 (×0.01kW) |
| 04 | [REPEAT] on the [SCHEDULE] screen<br>Pulse repetition rate | 000 – 030 |
| 05 | [SHOT] on the [SCHEDULE] screen<br>Number of consecutive shots | 0000 – 9999 |
| 06 | [HIGH] on the [POWER MONITOR] screen<br>Energy monitor upper limit setting | 0000 – 9999 (×0.1J) |
| 07 | [LOW] on the [POWER MONITOR] screen<br>Energy monitor lower limit setting | 0000 – 9999 (×0.1J) |
| 08 | Power monitor waveform display on the [POWER MONITOR] screen<br>0: OFF 1: ON | 0 – 1 |
| 09 | [REFERENCE SET] on the [POWER MONITOR] screen<br>Lamp input power upper limit setting | 000 – 100 (×1%) |

### 85 Schedule Settings for FIX

| Data No. | Item | Data Range |
|---|---|---|
| 01 | [↗SLOPE] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |

| Data No. | Item | Data Range |
|---|---|---|
| 02 | [FLASH 1] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |
| 03 | [FLASH 2] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |
| 04 | [FLASH 3] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |
| 05 | [↘SLOPE] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |
| 06 | Unused | Fixed to 0000 |
| 07 | [FLASH 1] WATT on the [SCHEDULE] screen | 0000 – 2000 (×0.1%) |
| 08 | [FLASH 2] WATT on the [SCHEDULE] screen | 0000 – 2000 (×0.1%) |
| 09 | [FLASH 3] WATT on the [SCHEDULE] screen | 0000 – 2000 (×0.1%) |
| 10 | Unused | Fixed to 0000 |
| 11* | [ ≃ ] on the [SCHEDULE] screen<br>Approximate laser output energy of the set waveform | 0000 – 9999 (×0.1J) |

## 86 Schedule Settings for FLEX — TIME 01 to 10

| Data No. | Item | Data Range |
|---|---|---|
| 01 | [Point 1] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |
| 02 | [Point 2] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |
| 03 | [Point 3] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |
| 04 | [Point 4] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |
| 05 | [Point 5] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |
| 06 | [Point 6] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |
| 07 | [Point 7] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |
| 08 | [Point 8] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |
| 09 | [Point 9] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |
| 10 | [Point 10] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |
| 11* | [ ≃ ] on the [SCHEDULE] screen<br>Approximate laser output energy of the set waveform | 0000 – 9999 (×0.1J) |

## 87 Schedule Settings for FLEX — TIME 11 to 20

| Data No. | Item | Data Range |
|---|---|---|
| 01 | [Point 11] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |
| 02 | [Point 12] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |
| 03 | [Point 13] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |
| 04 | [Point 14] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |
| 05 | [Point 15] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |
| 06 | [Point 16] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |
| 07 | [Point 17] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |
| 08 | [Point 18] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |
| 09 | [Point 19] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |
| 10 | [Point 20] TIME on the [SCHEDULE] screen | 000 – 100 (×0.1ms/×0.01ms) |
| 11* | [ ≃ ] on the [SCHEDULE] screen<br>Approximate laser output energy of the set waveform | 0000 – 9999 (×0.1J) |

### 88 Schedule Settings for FLEX — WATT 01 to 10

| Data No. | Item | Data Range |
|---|---|---|
| 01 | [Point 1] WATT on the [SCHEDULE] screen | 0000 – 2000 (×0.1%) |
| 02 | [Point 2] WATT on the [SCHEDULE] screen | 0000 – 2000 (×0.1%) |
| 03 | [Point 3] WATT on the [SCHEDULE] screen | 0000 – 2000 (×0.1%) |
| 04 | [Point 4] WATT on the [SCHEDULE] screen | 0000 – 2000 (×0.1%) |
| 05 | [Point 5] WATT on the [SCHEDULE] screen | 0000 – 2000 (×0.1%) |
| 06 | [Point 6] WATT on the [SCHEDULE] screen | 0000 – 2000 (×0.1%) |
| 07 | [Point 7] WATT on the [SCHEDULE] screen | 0000 – 2000 (×0.1%) |
| 08 | [Point 8] WATT on the [SCHEDULE] screen | 0000 – 2000 (×0.1%) |
| 09 | [Point 9] WATT on the [SCHEDULE] screen | 0000 – 2000 (×0.1%) |
| 10 | [Point 10] WATT on the [SCHEDULE] screen | 0000 – 2000 (×0.1%) |
| 11* | [ ≃ ] on the [SCHEDULE] screen<br>Approximate laser output energy of the set waveform | 0000 – 9999 (×0.1J) |

### 89 Schedule Settings for FLEX — WATT 11 to 20

| Data No. | Item | Data Range |
|---|---|---|
| 01 | [Point 11] WATT on the [SCHEDULE] screen | 0000 – 2000 (×0.1%) |
| 02 | [Point 12] WATT on the [SCHEDULE] screen | 0000 – 2000 (×0.1%) |
| 03 | [Point 13] WATT on the [SCHEDULE] screen | 0000 – 2000 (×0.1%) |
| 04 | [Point 14] WATT on the [SCHEDULE] screen | 0000 – 2000 (×0.1%) |
| 05 | [Point 15] WATT on the [SCHEDULE] screen | 0000 – 2000 (×0.1%) |
| 06 | [Point 16] WATT on the [SCHEDULE] screen | 0000 – 2000 (×0.1%) |
| 07 | [Point 17] WATT on the [SCHEDULE] screen | 0000 – 2000 (×0.1%) |
| 08 | [Point 18] WATT on the [SCHEDULE] screen | 0000 – 2000 (×0.1%) |
| 09 | [Point 19] WATT on the [SCHEDULE] screen | 0000 – 2000 (×0.1%) |
| 10 | [Point 20] WATT on the [SCHEDULE] screen | 0000 – 2000 (×0.1%) |
| 11* | [ ≃ ] on the [SCHEDULE] screen<br>Approximate laser output energy of the set waveform | 0000 – 9999 (×0.1J) |

⇒ Data No.11 is set to the same value for 86, 87, 88, and 89.

### 95 Laser Power Monitor — SHOT COUNT, GOOD COUNT, AVERAGE

| Data No. | Item | Data Range |
|---|---|---|
| 01* | [SHOT COUNT] on the [POWER MONITOR] screen<br>Total number of outputs until the present | 000000000 – 999999999 |
| 02* | [GOOD COUNT] on the [POWER MONITOR] screen<br>Number of outputs of appropriate energy | 000000000 – 999999999 |
| 03* | [AVERAGE] on the [POWER MONITOR] screen<br>Average power of output laser light | 0000 – 9999 (×0.1W) |

### 00 Laser Power Monitor — Energy, number of waveform data, etc.

| Data No. | Item | Data Range |
|---|---|---|
| 01* | Schedule No. of laser power monitor data | 00 – 31 |
| 02* | [LAMP INPUT PWR] on the [POWER MONITOR] screen<br>Lamp input power | 000 – 999 (×1%) |
| 03* | [ENERGY] on the [POWER MONITOR] screen<br>Laser Energy | 0000 – 9999 (×0.1J) |
| 04* | Number of laser power monitor waveforms<br>Total number of transmitted data with classification No. between 00 and 22. | 000 – 108 |
| 05* | Flash pulse width | 000 – 100 (×0.1ms) |

### 01 Laser Power Monitor — Waveform data 000 to 004

: :

### 22 Laser Power Monitor — Waveform data 105 to 109

| Data No. | Item | Data Range |
|---|---|---|
| 01* | Schedule No. of laser power monitor data | 00 – 31 |
| 02* | Laser power monitor waveform data 1/5 | 0000 – 9999 (×0.1kW) |
| 03* | Laser power monitor waveform data 2/5 | 0000 – 9999 (×0.1kW) |
| 04* | Laser power monitor waveform data 3/5 | 0000 – 9999 (×0.1kW) |
| 05* | Laser power monitor waveform data 4/5 | 0000 – 9999 (×0.1kW) |
| 06* | Laser power monitor waveform data 5/5 | 0000 – 9999 (×0.1kW) |

⇒ If the pulse width becomes long, the total number of waveform data can be controlled to 108 or less by extending the measurement interval.

(Example)

* When the pulse width is 00.5 to 05.0 ms, a measured value is sent at intervals of 0.05 ms.
* When the pulse width is 05.1 to 10.0 ms, a measured value is sent at intervals of 0.10 ms.

⇒ Since the number of data to be sent each time is limited to 5, it is necessary to change the classification No. according to the "number of waveform data of the laser power monitor" sent by "R00 nn 04" to perform repeated reading.

# Setting the Control Method, SCHEDULE No., Branch Shutter, etc.

**The command (code: WS) to set the control method, SCHEDULE No., branch shutter, high voltage ON/OFF status, guide light ON/OFF status, automatic laser power value transmission ON/OFF status, etc. by specifying equipment No. is explained below.**

Personal computer, etc.

| STX | CH1 | CH0 | W | S | SH1 | SH0 | cnt | s1 | s2 | s3 | s4 | s5 | s6 | s7 | s8 | s9 | mon | ETX | BCC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

Laser

| CH1 | CH0 | ACK |
|---|---|---|

Or

| CH1 | CH0 | NAK |
|---|---|---|

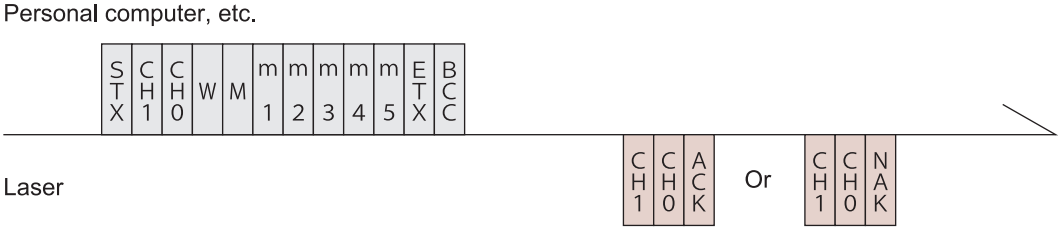
| | |
|---|---|
| CH1/CH0 | Equipment No. (CH1 = tens digit, CH0 = units digit) |
| SH1/SH0 | Schedule No. (SH1 = tens digit, SH0 = units digit)<br>The data range is 00 to 31, and the schedule No. to be changed is entered.<br>For □□ (spaces), the current schedule No. in use is entered. |
| cnt | Control method<br>0: Control by control panel<br>1: Control by external input/output signals (Output schedules are set on the control panel.)<br>2: Control by external communication control<br>3: Maintenance mode<br>4: (Missing number)<br>5: Control by external input/output signals (Output schedules are set on the personal computer.)<br>* The cnt value that can be set from the personal computer is "0" and "2." If another value or □ (space) is set, the control method cannot be changed. It is impossible to set "Control by external input/output signals" or "Maintenance mode."<br>* The maintenance mode is used for our engineer to perform maintenance. Usually, this mode is not used by customer. In the maintenance mode, the control method cannot be changed.<br>* When the CONTROL keyswitch is turned OFF, the control method is returned to "0: Control by control panel" (when the control by external input/output signals is OFF).<br>* To change the control method, blank all the other items.<br>**When the control by external input/output signals (EXTERNAL CONTROL) is ON**<br>The control by external input/output signals has priority over the other control methods. When "0" or "2" is entered from the personal computer, the control method is as shown in the following table. The order of setting does not matter. |

| Control by external input/output signals | Set value | Control method to be set |
|---|---|---|
| At OFF | 0 | 0: Control by control panel |
| | 2 | 2: Control by external communication control |
| At ON | 0 | 1: Control by external input/output signals (Output schedules are set on the control panel.) |
| | 2 | 5: Control by external input/output signals (Output schedules are set on the personal computer.) |

| | |
|---|---|
| | * When the external input/output control is turned OFF at "1: Control by external input/output signals (Output schedules are set on the control panel)", the control method is changed to "0: Control by control panel."<br>* When the external input/output control is turned OFF at "5: Control by external input/output signals (Output schedules are set on the personal computer)", the control method is changed to "2: Control by external communication control." |
| s1 | HV (high voltage) (0: OFF 1: ON □: Current status kept) |
| s2 | LD (guide light) (0: OFF 1: ON □: Current status kept) |
| s3 | Unused (fixed to □) |
| s4 | Branch shutter 1 (0: OFF 1: ON □: Current status kept) |
| s5 | Branch shutter 2 (0: OFF 1: ON □: Current status kept) |
| s6 | Branch shutter 3 (0: OFF 1: ON □: Current status kept) |
| s7 | Unused (fixed to □) |
| s8 | Unused (fixed to □) |
| s9 | Unused (fixed to □) |
| mon | Automatic laser power monitor value transmission (0: OFF 1: ON □: Current status kept)<br>Each time the flashlamp comes on, "00 Laser Power Monitor-Energy, number of waveform data, etc." on page 130 is sent. In the case of a high-speed repeated output, however, the data is sent at certain intervals because the communication is too quick.<br>Even if the control method is changed in "cnt", the data is sent automatically until the power supply is turned OFF. |
| ACK or NAK | Valid only at external communication control. If there is any setting that cannot be changed, all are invalidated and [NAK] is returned. |

## Setting the Mirror of the Timesharing Unit

**The command (code: WM) to set the mirror of the timesharing unit is explained below.**

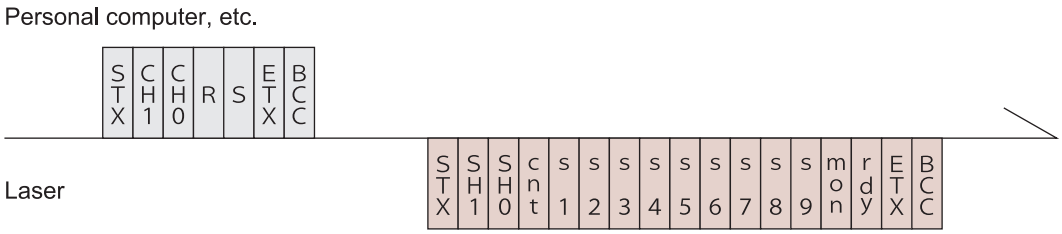



| | |
|---|---|
| CH1/CH0 | Equipment No. (CH1 = tens digit, CH0 = units digit) |
| m1 | Timesharing unit 1 (0: OFF 1: ON □: Current status kept) |
| m2 | Timesharing unit 2 (0: OFF 1: ON □: Current status kept) |
| m3 | Unused (fixed to □) |
| m4 | Unused (fixed to □) |

| | |
|---|---|
| m5 | Unused (fixed to □) |
| ACK or NAK | Valid only at external communication control. If there is any setting that cannot be changed, all are invalidated and [NAK] is returned. |

## Reading the Control Method, SCHEDULE No., Branch Shutter, etc.

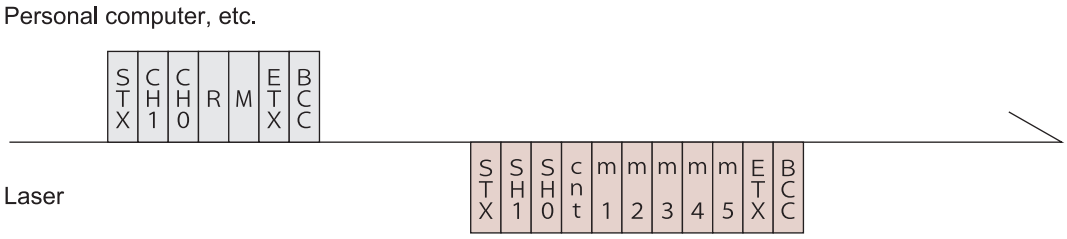
**The command (code: RS) to read the control method, SCHEDULE No., branch shutter, high voltage ON/OFF status, guide light ON/OFF status, automatic laser power value transmission ON/OFF status, etc. is explained below.**




| | |
|---|---|
| CH1/CH0 | Equipment No. (CH1 = tens digit, CH0 = units digit) |
| SH1/SH0 | Schedule No. (SH1 = tens digit, SH0 = units digit) |
| cnt | Control method<br>0: Control by control panel<br>1: Control by external input/output signals (Output schedules are set on the control panel.)<br>2: Control by external communication control<br>3: Maintenance mode<br>4: (Missing number)<br>5: Control by external input/output signals (Output schedules are set on the personal computer.) |
| s1 | HV (0: OFF 1: ON) |
| s2 | LD (0: OFF 1: ON) |
| s3 | Unused (fixed to 0) |
| s4 | Branch shutter 1 (0: OFF 1: ON) |
| s5 | Branch shutter 2 (0: OFF 1: ON) |
| s6 | Branch shutter 3 (0: OFF 1: ON) |
| s7 | Unused (fixed to 0) |
| s8 | Unused (fixed to 0) |
| s9 | Unused (fixed to 0) |
| mon | Automatic laser power monitor value transmission (0: OFF 1: ON)<br>Each time the flashlamp comes on, "00 Laser Power Monitor-Energy, number of waveform data, etc." on page 130 is sent. |
| rdy | READY status (0: Laser start disabled 1: Laser start enabled) |

# Reading the Timesharing Unit Status

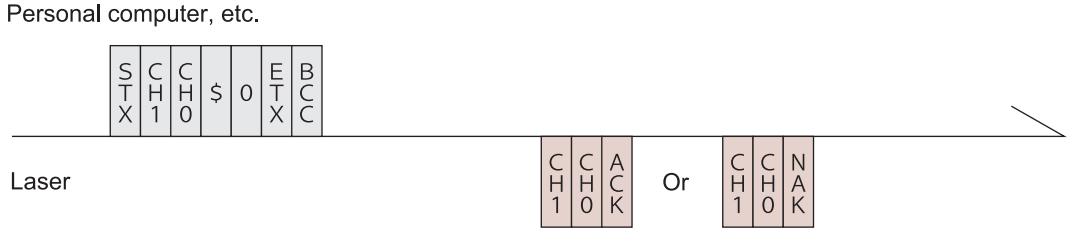
**The command (code: RM) to read the timesharing unit status is explained below.**




| | |
|---|---|
| CH1/CH0 | Equipment No. (CH1 = tens digit, CH0 = units digit) |
| SH1/SH0 | Schedule No. (SH1 = tens digit, SH0 = units digit) |
| cnt | Control method<br>0: Control by control panel<br>1: Control by external input/output signals (Output schedules are set on the control panel.)<br>2: Control by external communication control<br>3: Maintenance mode<br>4: (Missing number)<br>5: Control by external input/output signals (Output schedules are set on the personal computer.) |
| m1 | Timesharing unit 1 (0: OFF 1: ON) |
| m2 | Timesharing unit 2 (0: OFF 1: ON) |
| m3 | Timesharing unit 3 (0: OFF 1: ON) |
| m4 | Unused (fixed to 0) |
| m5 | Unused (fixed to 0) |

# Starting a Laser Light Output

**The command (code: $0) to start a laser light output is explained below.**

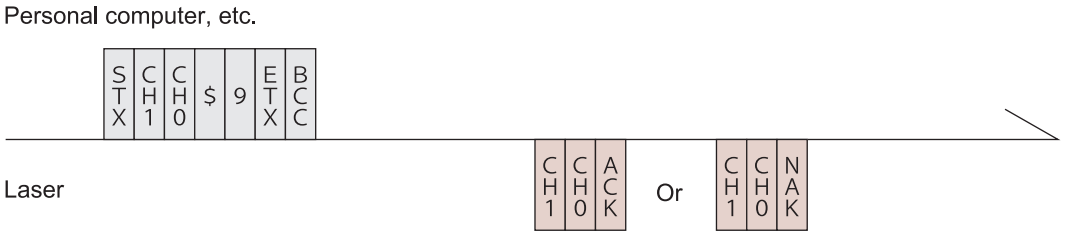



| | |
|---|---|
| CH1/CH0 | Equipment No. (CH1 = tens digit, CH0 = units digit) |

| | |
|---|---|
| ACK or NAK | If the Laser is ready for use, it returns an [ACK]. If not, the Laser returns a [NAK].<br><br>The Laser is not ready for use when:<br>• An alarm is activated.<br>• HV is OFF.<br>• The Laser is not charged to the set voltage.<br>• The Laser is not in external communication control mode. |

## Stopping a Laser Light Output

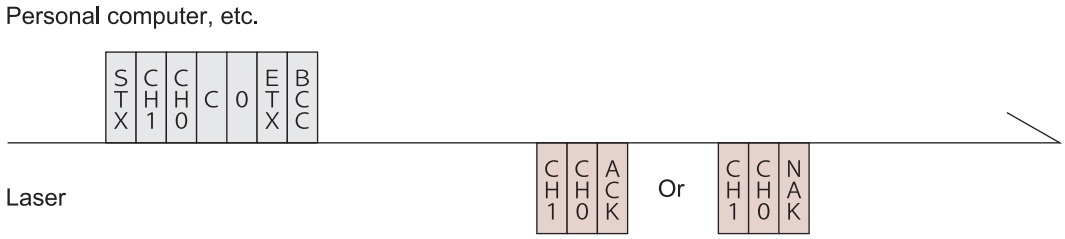
**The command (code: $9) to stop a laser light output is explained below.**




| | |
|---|---|
| CH1/CH0 | Equipment No. (CH1 = tens digit, CH0 = units digit) |
| ACK or NAK | The Laser accepts the command only when in external communication control (RS-485 CONTROL) mode. It returns a [NAK] when in any other control method. |

## Stopping an Error Signal Output

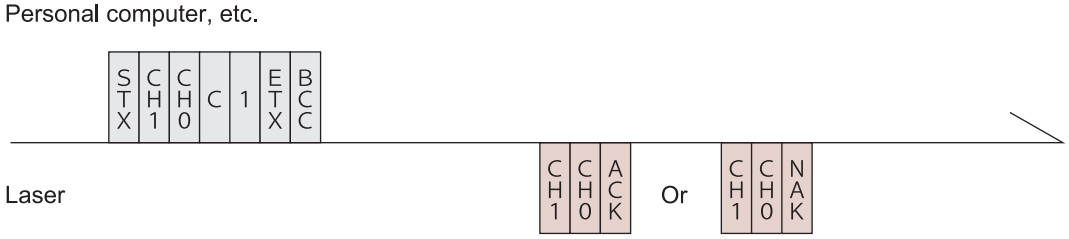
**The command (code: C0) to stop an error signal output is explained below.**




| | |
|---|---|
| CH1/CH0 | Equipment No. (CH1 = tens digit, CH0 = units digit) |
| ACK or NAK | The Laser accepts the command only when in external communication control (RS-485 CONTROL) mode. It returns a [NAK] when in any other control method. |

## Resetting the Total Number of Outputs

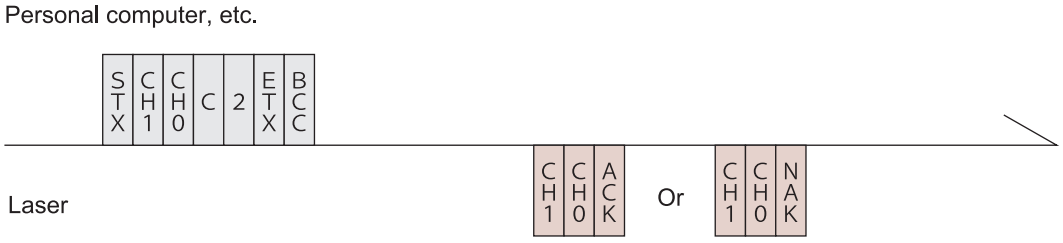
**The command (code: C1) to reset the total number of outputs (SHOT COUNT) is explained below.**




| | |
|---|---|
| CH1/CH0 | Equipment No. (CH1 = tens digit, CH0 = units digit) |
| ACK or NAK | The Laser accepts the command only when in external communication control (RS-485 CONTROL) mode. It returns a [NAK] when in any other control method. |

## Resetting the Appropriate Number of Outputs

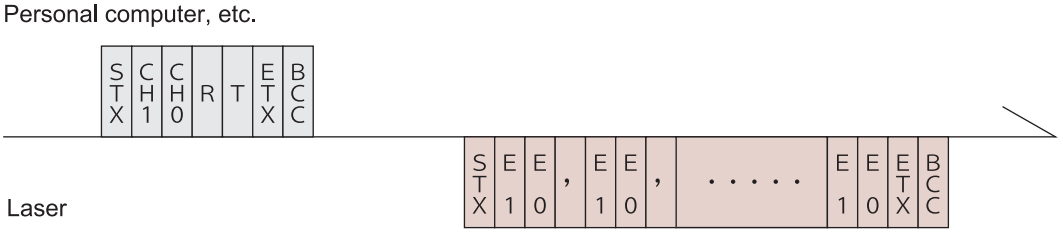
**The command (code: C2) to reset the appropriate number of outputs (GOOD COUNT) is explained below.**




| | |
|---|---|
| CH1/CH0 | Equipment No. (CH1 = tens digit, CH0 = units digit) |
| ACK or NAK | The Laser accepts the command only when in external communication control (RS-485 CONTROL) mode. It returns a [NAK] when in any other control method. |

## Reading Error No. at Occurrence of Trouble

**The command (code: RT) to read error No. at occurrence of trouble is explained below.**




| | |
|---|---|
| CH1/CH0 | Equipment No. (CH1 = tens digit, CH0 = units digit) |

| | |
|---|---|
| E1/E0 | Error No. (E1 = tens digit, E0 = units digit)<br>All error numbers are transmitted. If no error has occurred, the error No. is to be [00].<br>For the contents corresponding to error No., refer to "Table of Error Contents" on page 137. |

## Table of Error Contents

| No. | Contents | No. | Contents |
|---|---|---|---|
| 00 | Normal | 32 | Optical fiber not connected |
| 01 | Side cover, rear cover opened | 33 | Emission indicator fault (OUTPUT) |
| 02 | Head cover, lamp replacing cover opened | 34 | Emission indicator fault (PRG. UNIT) |
| 03 | Emergency stop | 35 | Low backup battery voltage |
| 04 | Low level of coolant | 36 | |
| 05 | | 37 | |
| 06 | | 38 | Optical fiber 1 broken |
| 07 | | 39 | Optical fiber 2 broken |
| 08 | Discharge resistor overheat | 40 | Optical fiber 3 broken |
| 09 | | 41 | |
| 10 | High temperature of coolant | 42 | |
| 11 | Low temperature of coolant | 43 | |
| 12 | Low flow rate of coolant | 44 | External interlock activated |
| 13 | Low resistivity of coolant | 45 | Not charged |
| 14 | Simmer trouble | 46 | Power monitor unit overheating |
| 15 | Charge trouble | 47 | Over-duty-cycle |
| 16 | Condenser bank fault | 48 | Fiber overrated |
| 17 | | 49 | Out-of-range setting |
| 18 | | 50 | Out-of-range setting (lamp input power) |
| 19 | Branch shutter 1 fault | 51 | Out-of-range input power to fiber |
| 20 | Branch shutter 2 fault | 52 | Memory trouble |
| 21 | Branch shutter 3 fault | 53 | Power feedback system fault |
| 22 | | 54 | Caution - coolant resistivity |
| 23 | | 55 | |
| 24 | | 56 | Laser power above upper limit |
| 25 | | 57 | Laser power below lower limit |
| 26 | | 58 | |
| 27 | | 59 | Timesharing unit 1 fault |
| 28 | | 60 | Timesharing unit 2 fault |
| 29 | Discharge unit temperature error | 61 | |
| 30 | Discharge unit overpower error | 62 | |
| 31 | Branch cover open | 63 | |

# Chapter 6

# Printing Set Values and Measured Values

**When the Printer Model BL2-58SNWJC (option) manufactured by SANEI ELECTRIC INC. is connected to the laser by using an RS-485 cable, the output schedules of each SCHEDULE and the measured values of the POWER MONITOR screen can be printed.**

## 1. Printing Set Values

⇒ If the power supply is OFF, turn ON the MAIN POWER switch and then turn ON the CONTROL keyswitch. While one of the SCHEDULE screen, STATUS screen, and POWER MONITOR screen is displayed, perform the following operations.

### 1 Displaying the PRINTOUT MODE Screen

(1) Press the TROUBLE RESET key and the CURSOR key (▽) simultaneously.
The PRINTOUT MODE screen appears.

```
-PRINTOUT MODE                WATER  28˚C

SCH.#00
                  1:SCHEDULE
                  2:POWER MONITOR

 HV:ON  POSI.BLINK:ON  POSITION:OFF
```

### 2 Specifying SCHEDULE

(1) Move the cursor to "SCH.#" and press the ON or OFF key to set the SCHEDULE No. of the output schedules to be printed.

(2) Press the ENTER key.

### 3 Executing Printing

(1) Move the cursor to "1: SCHEDULE" and press the ENTER key.
The output schedules of the specified SCHEDULE are printed.

**Example**
**FORM:FIX (fixed waveform setting)**

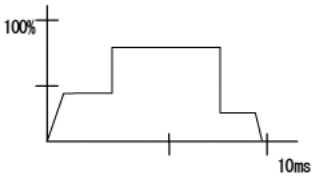
```
[SCHEDULE]
-SCH.#00 [FORM:FIX]

PEAK POWER = 01.00kW

U-SLOPE = 01.0ms
FLASH 1 = 03.0ms 040.0%
FLASH 2 = 05.0ms 080.0%
FLASH 3 = 02.0ms 020.0%
D-SLOPE = 00.5ms

REPEAT  =  001pps
SHOT    = 0430

ESTIMATED VALUE =  5.3J
```




**Example**
**FORM:FLEX (flexible waveform setting)**

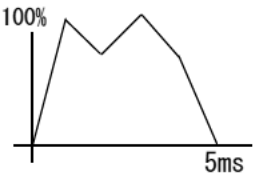
```
[SCHEDULE]
-SCH.#01 [FORM:FLEX]

PEAK POWER = 04.00kW

Point1  = 01.0ms 090.0%
Point2  = 01.0ms 070.0%
Point3  = 01.0ms 088.0%
Point4  = 01.0ms 065.0%
Point5  = 01.0ms 000.0%
Point6  = 00.0ms 000.0%
Point7  = 00.0ms 000.0%
Point8  = 00.0ms 000.0%
Point9  = 00.0ms 000.0%
Point10 = 00.0ms 000.0%
Point11 = 00.0ms 000.0%
Point12 = 00.0ms 000.0%
Point13 = 00.0ms 000.0%
Point14 = 00.0ms 000.0%
Point15 = 00.0ms 000.0%
Point16 = 00.0ms 000.0%
Point17 = 00.0ms 000.0%
Point18 = 00.0ms 000.0%
Point19 = 00.0ms 000.0%
Point20 = 00.0ms 000.0%

REPEAT  =  001pps
SHOT    = 1120

ESTIMATED VALUE =  12.5J
```



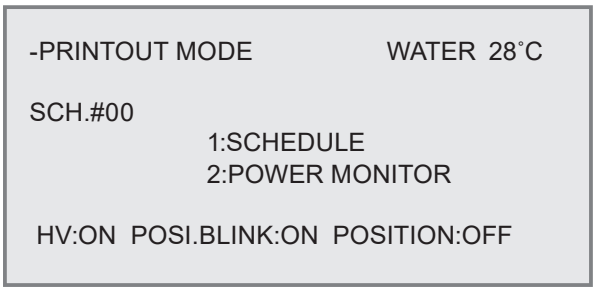
# 2. Printing Measured Values

⇒ If the power supply is OFF, turn ON the MAIN POWER switch and then turn ON the CONTROL keyswitch.

⇒ To print measured values, set welding schedules and output laser light actually. At this time, "⌊" (graphic display of measured waveform) of the POWER MONITOR screen must be turned ON to display the measured waveform. After making sure that the measured waveform is displayed, perform the following operations.

## 1 Displaying the PRINTOUT MODE Screen

(1) Press the TROUBLE RESET key and the CURSOR key (▽) simultaneously.
The PRINTOUT MODE screen appears.



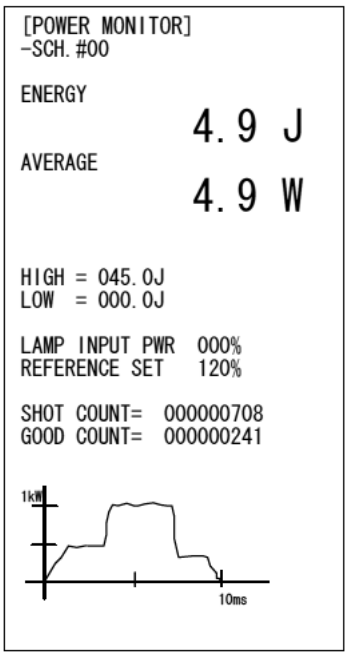

## 2 Executing Printing

(1) Move the cursor to "2: POWER MONITOR."

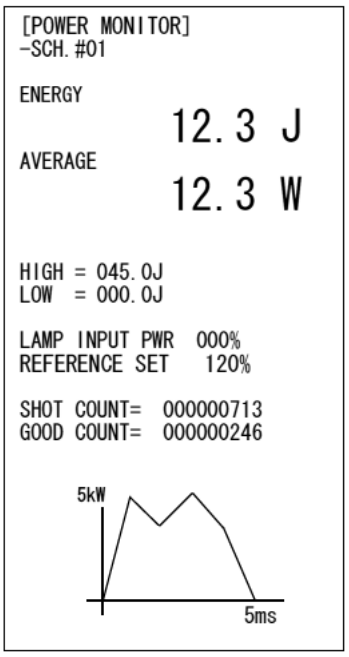
(2) Press the ENTER key.
The previously output measured values are printed.

⇒ The measured values and output waveform that can be printed are only the previous laser output data. Measured values under other schedules cannot be printed in succession by specifying SCHEDULE No.

**Example**
**FORM:FIX (fixed waveform setting)**




**Example**
**FORM:FLEX (flexible waveform setting)**



# Maintenance Part

Maintenance Part

# Chapter 1

# How to Perform Maintenance

## NOTE

**Before starting maintenance, read the following items and take extreme care.**

**⚠ WARNING**

- **Before starting maintenance operations, be sure to turn OFF the power supply. If a high voltage is already applied, turn OFF the power supply and then start these operations at least in 5 minutes.**
- **Turning ON the power supply for an operation check during maintenance puts the YAG Laser in oscillation. Take extreme care about it.**
- **The operator and those who may receive YAG laser light during maintenance must put on protective glasses.**

**⚠ CAUTION**

- **Use our genuine maintenance parts.**
- **For defect caused by non-genuine maintenance parts or use of non-genuine maintenance parts, the repair is charged even if it is still within the maintenance contract period or the warranty period.**

## 1. Maintenance Parts and Standard Intervals of Inspection/Replacement

**The performance of maintenance parts will be gradually deteriorated while they are used, and they may have to be repaired or replaced. Perform inspection periodically referring to the following table.**

⇒ The model numbers of maintenance parts are subject to change without notice. For the latest parts information, contact a nearest sales office.

| Part name | Model No. | Operation interval (standard) (*1) | Contents of operation (*2) |
|---|---|---|---|
| Flashlamp | MLD-0902 | 1 million shots (*3) | Replace |
| Ion-exchange resin refill | MLF-0020 | 6 months | Replace |
| Cartridge (Ion-exchanger) (With one bag of ion-exchange resin) | MLF-0024-00 | 3 years | Replace |

| Part name | | Model No. | Operation interval (standard) (*1) | Contents of operation (*2) |
|---|---|---|---|---|
| Water filter | | MLF-0006-00 | 6 months | Clean |
| | | | 3 years | Replace |
| Floating panel | | Z-01835-001 | 1 year | Replace |
| Cooling water (Purified water, 20L) | | MLU-0604-00 | 6 months | Replace |
| Lithium battery (*4) | | CR 2450 | 3 years | Replace |
| Air filter | Rear | MF-13 10t × 135 × 180 | Every week | Clean |
| | | | 1 year | Replace |
| | Side | MF-13 15t × 200 × 210 | Every week | Clean |
| | | | 1 year | Replace |
| Protective glass | | Specified glass for output unit | Everyday | Clean |
| | | | — | Replace (*5) |
| Glass plate | | A4-00719 | Every two replacements of lamp | Replace |
| O-ring for chamber cover | | AS568-244(1517-22) | 3 years | Replace |
| O-ring for rod holder | | P12 | 5 years | Replace |
| O-ring for rod | ML-2050A | S-6 | 3 years | Replace |
| | ML-2051A | S-4 | 3 years | Replace |
| | ML-2150A | S-8 | 3 years | Replace |
| Branch shutter (*6) | | A-06090-002 | 5 million times | Replace |
| Timesharing unit (*7) | | A-03445-001 | 1 million times | Replace |
| Pump | | TEN-70PZ-H12-UA | 5 years | Replace |
| Cooling fan motor | Rear | 9G1224H102 | 4.5 years | Replace |
| | Side | R1225×24BPLB1 | | |
| Output unit lens | | Supplied lens with output unit | 1 year | Clean |
| | | | — | Replace |
| Optical fiber | | Specified fiber | If gets dirty | Clean |
| | | | If damaged (*8) | Repair, Replace |

For the hatched portion, our engineer takes charge of maintenance work.

*1: The operation interval means the maintenance time or expected life of the part, and is different from the guarantee period.

*2: Part replacement is performed when any damage or defect is found or the usable period ends.

*3: The number of flashes as an indication of the life of the lamp (lowering of light quantity, cracks in the lamp, and a lighting failure) differs greatly depending on the laser output conditions and the laser irradiation interval. When the flashlamp is used in a single shot or with a long standby time as compared with continuous flash in repetition of several shots to several tens of shots per second, the number of flashes may become one-tenth or less. This is why the normal pulse laser lamp flows a low current after turned on and be ready to flash immediately, but when the time of ready state where this low current flows is long, the tip of the lamp electrode tends to be deteriorated earlier. Also, the lamp electrode is deteriorated earlier when the lamp is used with nearly maximum output energy. Therefore, the number of flashes may become one-tenth or less as compared with continuous irradiation.

*4: When the laser is stopped for a long time (for about one month), the usable period of the lithium battery is shortened.

*5: We do not specify a degree of parallelism of our standard protective glass. Therefore, the condensing position may be shifted before and after replacing the protective glass due to individual differences. The protective glass having a very small positional deviation is also available. Contact us as needed.

*6: An expected life of the branch shutter is 5 million times. Switching ON and OFF of the branch shutter according to the ON/OFF state of the laser can lead to shortening the operation interval. The branch shutter can be used for a longer time by setting it to ON at startup of the equipment and keeping it ON during the laser operation in principle.

*7: An expected life of the timesharing unit is 1 million times. When the timesharing unit is operated over the operation interval, the optical fiber may be damaged by the optical axis deviation due to degradation in stop accuracy of the timesharing unit. We recommend a periodic inspection.

*8: The optical fiber may be damaged if it is used when dust or oil mist is attached on its end face.

# 2. Maintenance of the Cooler Unit Section

**This section explains how to perform cleaning for the air filter and water filter, and how to perform maintenance for the ion-exchanger. This section also explains how to drain water from the cooling water tank and laser chamber, which is required at another maintenance.**

## Cleaning the Air Filter

The air filter on the side face of the main unit is provided at the air inlet to the cooler unit section. Perform cleaning every week.

### Item required

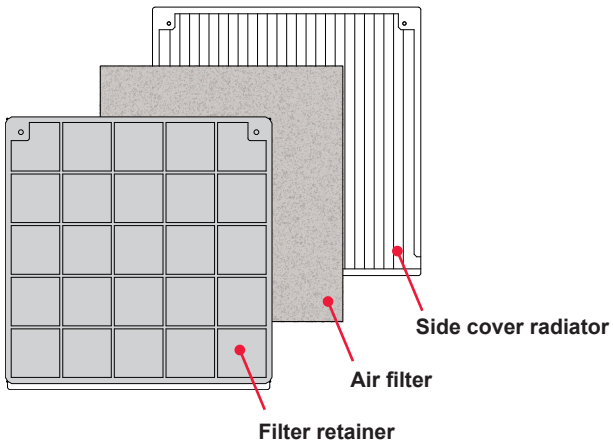
Phillips screwdriver

### Operating Procedure

(1) Remove the filter retainer from the side on phillips screwdriver.

(2) Take out the filter and wash it in tap water.
⇒ If it is stained badly, use neutral detergent.

(3) Air dry the filter naturally, then re-place it and secure it with the filter retainer.



# Draining Water from the Cooling Water Tank

Before replacing the ion-exchange resin for refilling, replacing the ion-exchanger, and replacing cooling water (once every 6 months), drain water from the cooling water tank to make the tank empty. When moving or transporting the equipment or when the equipment is stopped for one month or more, make the cooling water tank empty in advance.

### Item required

Water feed pump and bucket

## Operating Procedure

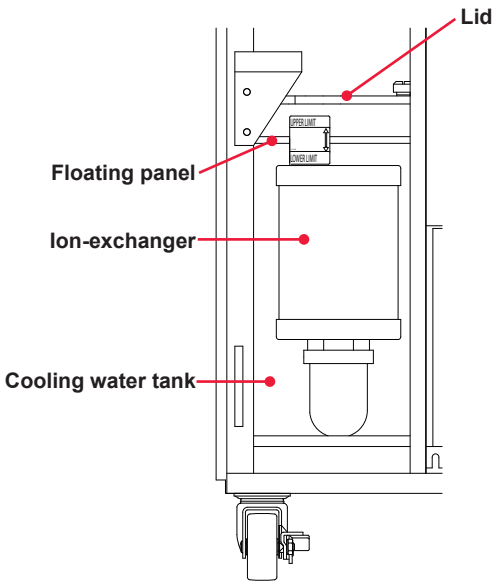
(1) Open the front door.

(2) Open the lid of the cooling water tank and take out the floating panel.
⇒ Keep the panel clean during the exchanging work.

(3) Pump out water in the tank.

(4) Return the floating panel in the tank. Return and secure the tank lid.

The Laser front (With front door opened)



# Changing the Ion-Exchange Resin and Replacing the Ion-Exchanger

The ion-exchange resin in the ion-exchanger has a function to keep high purity by removing the ion generated by deteriorated cooling water. Change the ion-exchange resin with a new one within 6 months after use.

For the ion-exchanger of this laser, the cartridge type is adopted. This type can be repeatedly used if the content (ion-exchange resin) is changed.

Replace the ion-exchanger every 3 years.

⇒ Keep the ion-exchange resin for change in a cool place without being exposed to direct sunlight if possible. Do not freeze the ion-exchange resin to avoid lowering its performance.

### Item required

Ion-exchanger mounting/removing tool, ion-exchange resin for change (or cartridge), cooling water (6 liters), Phillips screwdriver, water feed pump, and gloves (vinyl)

## 1 Removing the Ion-Exchanger

(1) Open the cover of the cooling water tank and take out the floating panel.

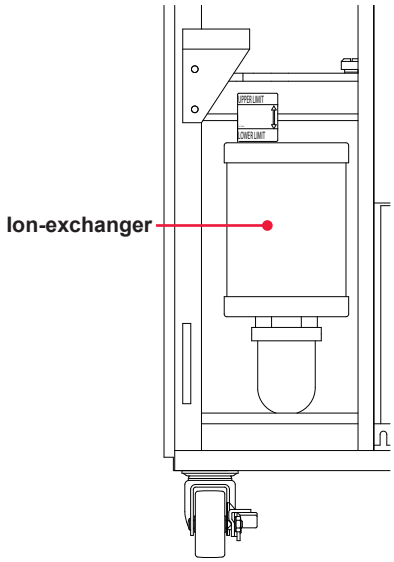
⇒ Keep the panel clean during the exchanging work.

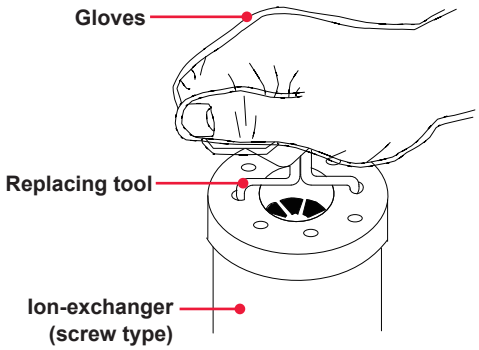
(2) Pump out water in the tank.

(3) Turn the ion-exchanger in the tank to the left with the replacing tool to remove it.

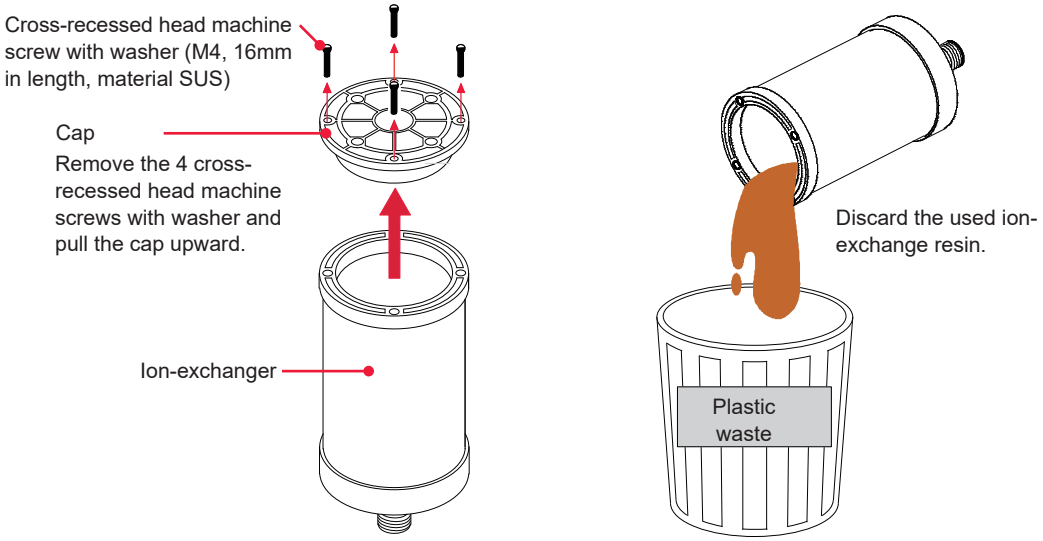
⇒ For changing with a new ion-exchange cartridge (with resin for change), proceed to Step **3**.

**The Laser front (With front door opened)**



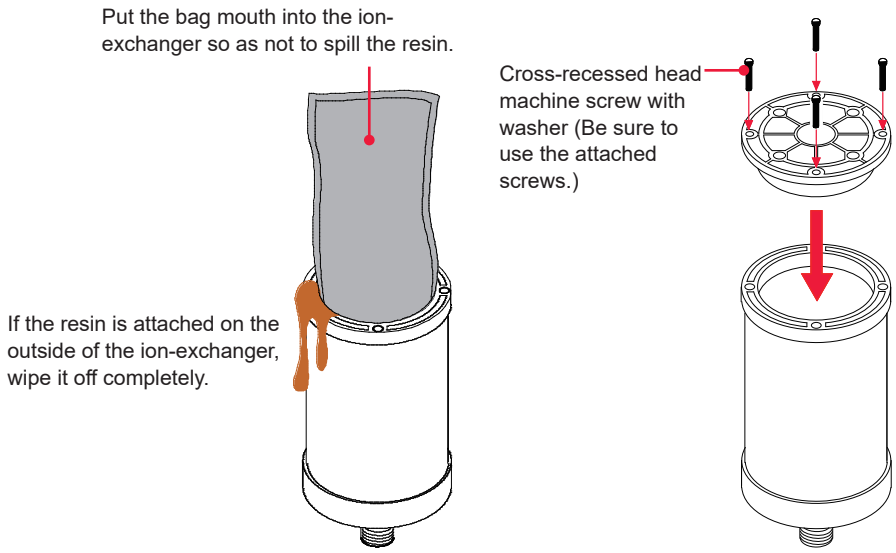
(4) Remove the cap of the ion-exchanger and discard the used ion-exchange resin.




⇒ Dispose of the used ion-exchange resin together as plastic waste.

## 2 Mounting a New Ion-Exchange Resin

(1) Put a new ion-exchange resin into the ion-exchanger and set the cap as it was.




**<Notes>**

- **If the ion-exchange resin is left in the air, it will be deteriorated. Immediately after the package is opened, put the ion-exchange resin into the ion-exchanger and return (dip) it into the cooling water tank.**
- **Take care not to spill the ion-exchange resin. Wipe off the ion-exchange resin attached on the mouth of the ion-exchanger.**

## 3 Installing the Ion-Exchanger

(1) Insert the ion-exchanger and turn it clockwise with the mounting/removing tool.

**<Note>**

**Use the mounting/removing tool for installing the ion-exchanger. If the mounting/removing tool is too tightened, the thread portion may be broken.**

(2) Put cooling water up to the line under HIGH of the water level label with the attached water feed pump.

(3) Float the floating panel on the water surface in the tank as it was and install the lid of the cooling water tank.

⇒ The floating panel can be repeatedly used. Because its material is polyethylene foam, dispose of the floating panel properly.

⇒ If the ion-exchanger is used without the floating panel in the tank, the ion-exchange resin will be deteriorated more quickly. Be sure to put the floating panel into the tank.

# Cleaning the Water Filter

The water filter is provided in the cooling water tank and filtrates cooling water.
Perform cleaning for the water filter every 6 months. Replace it every 3 years.

### Item required

Gloves (vinyl), water feed pump, cooling water (6 liters), and mounting/removing tool

## 1 Moving the Water Filter

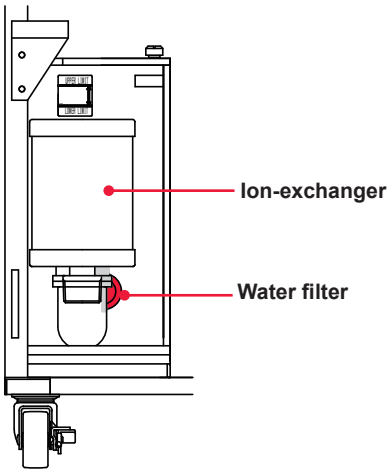
(1) Open the cover of the cooling water tank and take out the floating panel.
⇒ Keep the panel clean during the exchanging work.

(2) Pump out water in the tank.

(3) Turn the ion-exchanger in the tank to the left with the replacing tool to remove it.

(4) Pull the water filter toward you to remove it.

The Laser front (With front door opened)




## 2 Washing the Water Filter

(1) Wash the water filter with tap water, then rinse it with deionized water or purified water.

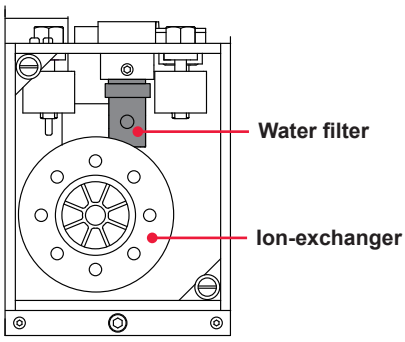
(2) Re-place the water filter and insert it to the end. At this time, be careful not to remove the O-rings.

(3) Insert the ion-exchange resin cartridge and turn it to the right with the replacing tool to fix it.

(4) Supply the cooling water, with the attached hand pump, till it reaches HIGH-line on the water level label.

(5) Return the floating panel in the tank.
Return the cover of the cooling water tank and secure it.

Cooling water tank (Top view)



# Bleeding the Laser Chamber and Others of Water

When replacing the flashlamp, bleed the laser chamber of water beforehand.

When the laser is not used for one month or more or when the room temperature of the installation place goes down below 0ºC for a compelling reason, bleed the laser chamber of water and also bleed the cooling water tank and ion-exchanger of water to discharge cooling water completely.

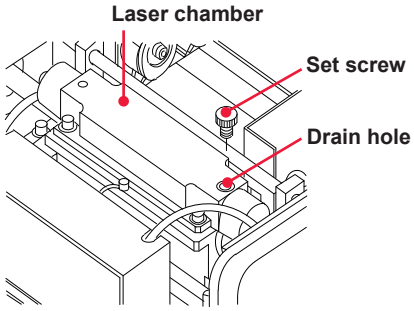
**Item required**

Gloves (vinyl), water feed pump, and clean cloth

## Bleeding the Laser Chamber of Water

(1) Remove the set screw of the drain hole of the laser chamber.
If air is admitted from the drain hole, the water in the chamber and hose drops into the tank.

(2) Set the set screw of the drain hole as it was.




## Bleeding the Cooling Water Tank/Ion-Exchanger of Water

(1) Remove the cover of the cooling water tank and remove the floating panel from the tank.

(2) Drain water from the tank using the attached hand pump.

(3) Remove the ion-exchanger and drop the staying water into the tank.
⇒ Put the removed ion-exchanger on a clean cloth.

(4) Using the attached hand pump, drain water from the pipe from which you have removed the cartridge and from the tank.

(5) Re-place the cartridge into the pipe.

(6) Restore the floating panel to the tank and re-secure the cover of the tank.

⇒ To prevent a failure or accident due to water leakage, be sure to set the removed set screw of the drain hole as it was.

# 3. Maintenance of the Laser Oscillator Section

## Replacing the Flashlamp

The flashlamp is provided in the laser chamber and used for excitation at laser oscillation. We recommend replacing the flashlamp when the number of laser outputs reaches about 1,000,000 shots, as standard.

**⚠ CAUTION**

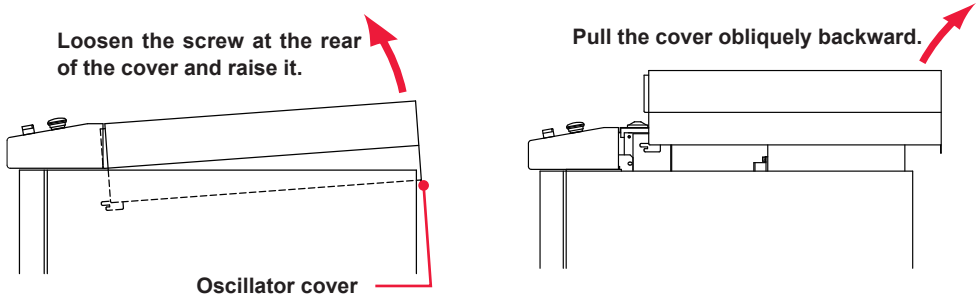
**When replacing the flashlamp, turn OFF the power to the Laser and wait for at least 5 minutes.**

### Item required

Gloves (vinyl), clean cloth, alcohol, Phillips screwdriver, ball-point screwdrivers 2.5 mm and 4 mm, and flashlamp (new product)

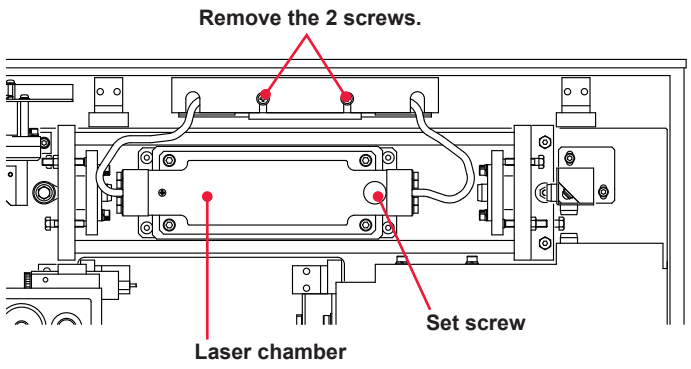
### 1 Removing the Laser Chamber

(1) Turn OFF the power supply of the laser and remove the oscillator cover.
⇒ Remove this cover, at least, in 5 minutes after turning OFF the power supply.

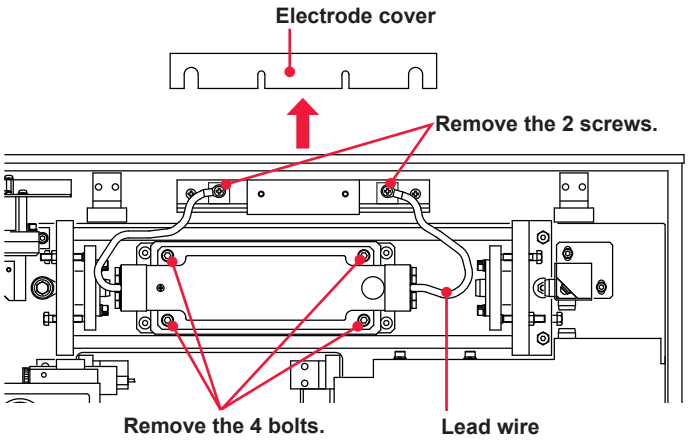


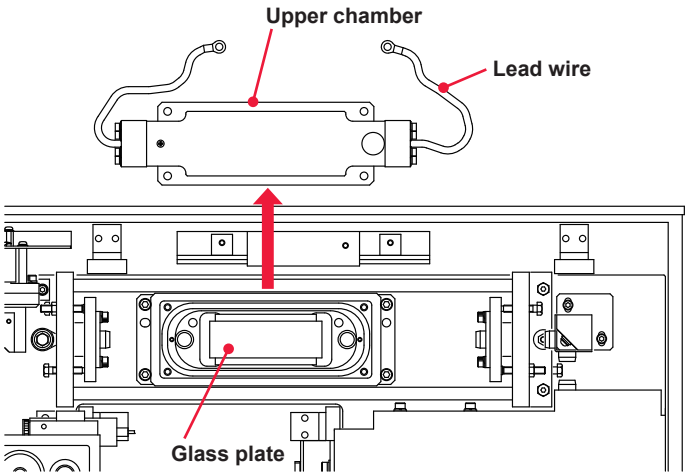

(2) Turn the set screw of the water drain of the laser chamber by hand to remove it, and bleed the chamber of water. After bleeding, tighten the set screw as it was.

(3) Remove the 2 screws and remove the electrode cover.



(4) Remove the 2 screws and then remove the lead wire of the flashlamp. Remove the 4 bolts and then remove the upper chamber. Put it upside down on a clean cloth so that its inside may be visible.




The laser chamber consists of an upper part and a lower part. In the lower chamber, the glass plate is put on the reflector.

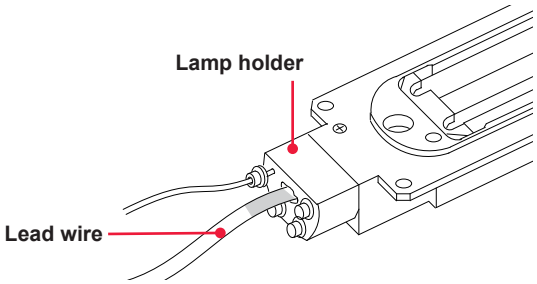
⇒ Put the removed reflector and other parts on a clean cloth so that oil and dust may not stick on them.

**<Notes>**

- **Handle the laser chamber with extreme care to void attaching a flaw or dust onto the mirror face inside the reflector. Such a flaw or dust will reduce the laser output.**
- **Do not touch the glass portion of the flashlamp directly with a hand or do not blemish it. The flashlamp will be damaged. Before installing the flashlamp, clean the glass portion of the lamp by using alcohol.**

## 2 Replacing the Flashlamp

(1) Remove the lamp holders on both sides. Straighten the lead wire of the flashlamp and pull out the lamp holder along the lead wire. Pull out the O-rings on both sides of the flashlamp in the same way.



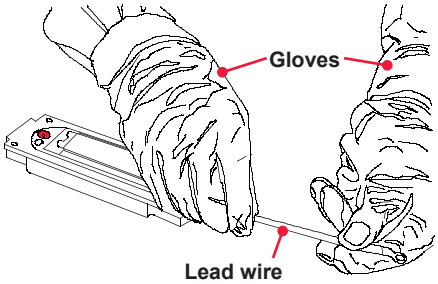

(2) Slowly pull out the flashlamp from either side. At this time, straighten the lead wires so that their terminals will not scratch the reflector panel.

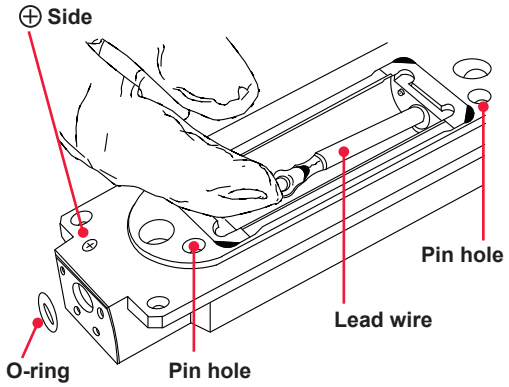
**<Notes>**

- **Take care not to blemish the reflector surface by terminal of the lead wire.**
- **Take care not to damage the flashlamp by striking it against the metal portion of the chamber.**

(3) Straighten the lead wires of the new flashlamp and insert them in the upper chamber.

⇒ Set the polarity of the lamp correctly. Set it so that the terminal of the lead wire marked in red may be positioned on the + side of the upper chamber. If the polarity of the lamp is reversed at installation, the service life will be shortened. Be sure to check the polarity.




(4) Pass the O-ring attached to the flashlamp from the lead wires on both sides and set each of them in the flashlamp.

⇒ Make sure that the O-ring is not damaged. If the O-ring is damaged, water leakage will occur. In such a case, replace the O-ring with a new one.

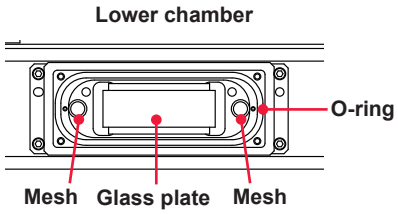
(5) After pushing the O-ring by the lamp holder, install the lamp holders on both sides in the same way. After making sure that the O-ring is set in the groove, tighten the bolt.

# 3 Installing the Laser Chamber

(1) Install the assembled upper chamber according to the lower chamber. Adjust the pin hole of the upper chamber to the pin of the lower chamber and fix it with 4 bolts.

⇒ Tighten the 4 bolts with the standard tightening torque of 500 cN•m (50 kgf•cm).

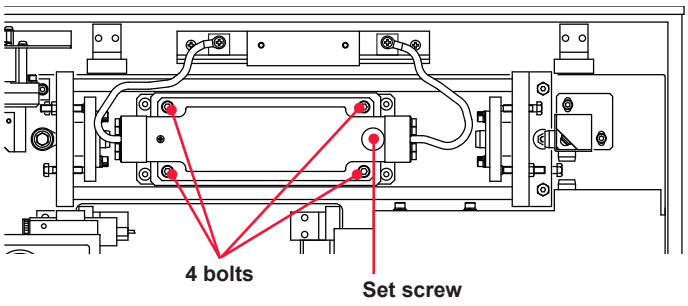
⇒ Make sure that the glass plate is put on the upper part of the reflector of the lower chamber, that the O-ring is free from any flaw, and that the mesh, and that O-ring are properly set in the groove.





(2) Connect the lead wires of the flashlamp to the screw terminals, then install the electrode cover.

(3) Make sure that the 4 bolts fixing the upper chamber and lower chamber and the set screw of the water drain hole of the upper chamber are tightened.




(4) Install the oscillator cover.

## Making an Incident Beam Adjustment of the Optical Fiber

Since this laser adopts a high-precision optical fiber, no adjustment is required when the fiber is mounted or dismounted once an incident beam adjustment is finished. However, after a laser oscillation adjustment or optical adjustment is made or after the beamsplitter, input unit, YAG rod, or laser chamber is removed, or after the φ0.2 mm optical fiber is replaced, an incident beam adjustment must be made.

⇒ For the incident beam adjusting method, contact us for information.

**<Note>**

**Use an optical fiber specially intended for incident beam adjustment. If any other type of optical fiber is used, the optical axis of incident beam may be dislocated in installing, detaching or replacing the fiber, which will result in damage to the end of the fiber.**

## Cleaning the Optical Part of the Output Unit

When the lens of the output unit becomes dirty, perform cleaning.

**Item required**

Air blow, screw ring spanner (NRS-50) (*), ethanol, and lens cleaning paper

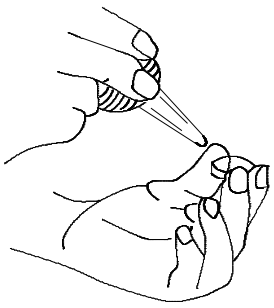
*: This item may not be required depending on the output unit in use.

⇒ For maintenance of the optical part, do not use any material or apparatus other than the above mentioned ones.
⇒ Handle the optical parts with care, because, unlike machined parts, the optical parts cannot be used if they are cut or burnt.
⇒ For performing maintenance of the optical part of the input unit, contact us for information.

### When Foreign Particles or Dust Sticks

(1) Hold the optical part horizontally by the sides.

(2) Blow off any dirt and dust with an air blow.



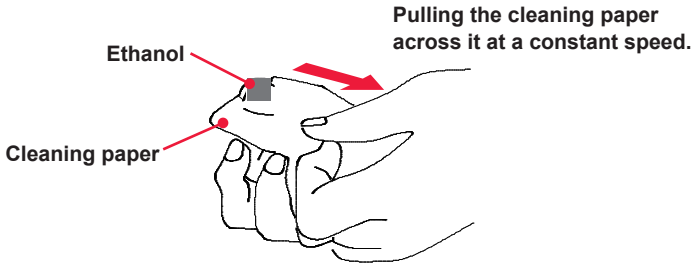
### For Blur or Other Dirt

(1) Hold the optical part horizontally by the sides.

(2) Place a drop of ethanol on the center of the cleaning paper.

(3) Place the wet part of the cleaning paper onto each optical part.

(4) Holding one end of the cleaning paper, wipe each optical part by pulling the cleaning paper across it at a constant speed from one side to the other.




⇒ If any clearance is produced between the cleaning paper and the optical part or ethanol is left during wiping, this will result in unevenness.

## Cleaning the Optical Fiber

When the optical fiber is dirty, perform cleaning.

**⚠ WARNING**

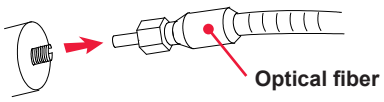
- **Be sure to receive education for this work from our engineer.**
- **Before starting work, be sure to turn OFF the power supply.**

### Items required

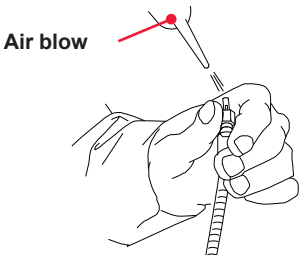
Air blow, lens cleaning paper, and end face checker

## Operating Procedure

(1) Remove the optical fiber from the input unit or output unit.




(2) Blow off foreign particles by using the air blow.
If the foreign particles on the end face cannot be eliminated, wipe it lightly with the cleaning paper.




(3) Make sure with the end face checker that any flaw or foreign particle is not attached on the end face.

⇒ If the end face of the optical fiber is rubbed hard, this will result in a flaw.
Be careful about it.

# 4. Maintenance of the Power Supply Section

## Replacing the Lithium Battery for Backup

Replace the lithium battery for backup provided on the CPU board in the main unit. The service life of the battery is about 3 years. Replace it within 3 years.

**ATTENTION**

**Follow your local environmental regulations for battery disposal because Lithium Battery contains dangerous materials.**

### Item required

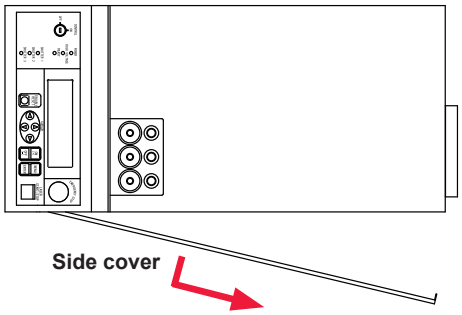
Phillips screwdriver and lithium battery CR2450

⇒ At battery replacement, the registered output schedule data may be lost. We recommend recording the data into the attached output schedule data entry table before replacement.

### Operating Procedure

(1) Turn OFF the MAIN POWER switch and wait for 5 minutes or more.

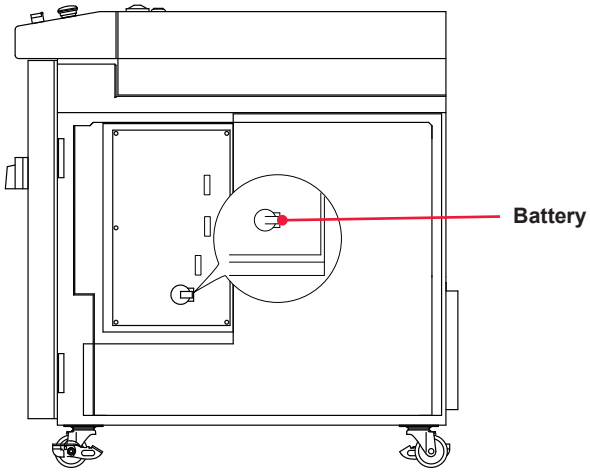
(2) Remove the left side cover as viewed from the rear side.




**Loosen the screw at the rear of the cover and pull it forward, and then pull it obliquely backward.**

(3) Remove the battery on the CPU board and install a new battery instead.

⇒ Set the battery minding the polarity.




(4) Install the side cover.

# Replacing the Battery of the Control Board of the Control Panel

Replace the lithium battery on the control board provided under the control panel. Replace it every 3 years.

**ATTENTION**

**Follow your local environmental regulations for battery disposal because Lithium Battery contains dangerous materials.**

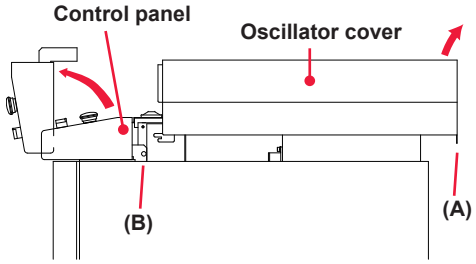
## Item required

Phillips screwdriver and lithium battery CR2450

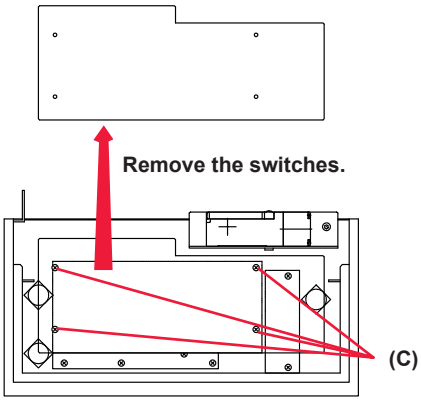
## Operating Procedure

(1) Loosen the two screws (A) on the back and remove the oscillator cover.

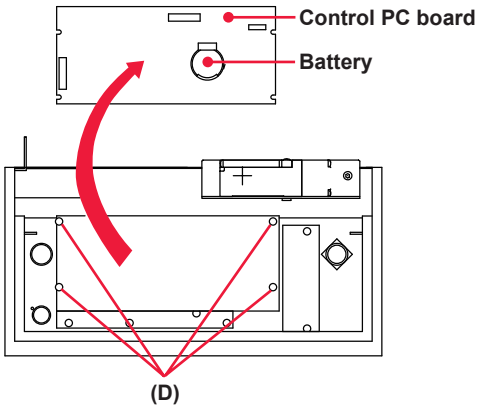
(2) Remove the screw (B) and open the control panel.




(3) Remove the four screws (C) to remove the protective plate.

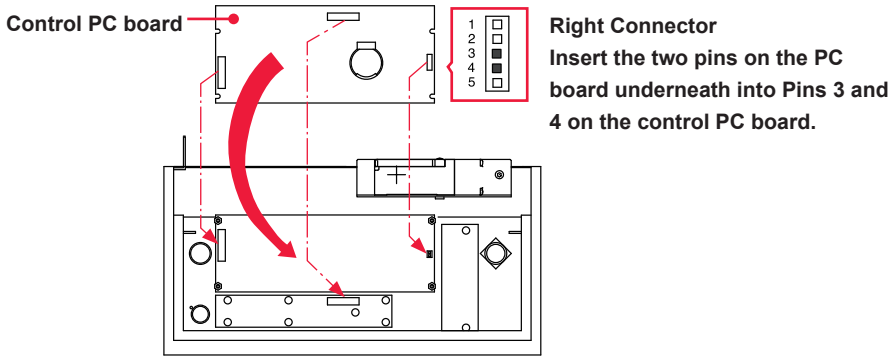



(4) Remove the four screws (D) and remove the control PC board.
The control PC board is connected with connector to a PC board beneath it. Draw the control PC board straight up.



(5) Replace the battery behind the PC board with a new battery.

(6) Re-place the control PC board.
When re-placing the control PC board, align the connectors of the control PC board with those of the PC board beneath it. Be careful to avoid bending the connector pins.




## Cleaning the Air Filter

The air filter at the rear of the main unit is provided at the air inlet of the power supply section. Perform cleaning for this air filter at this portion every week.

### Items required

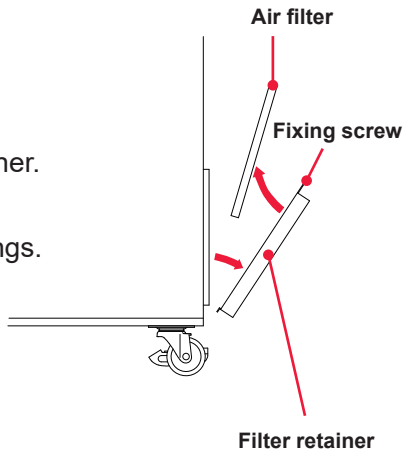
Phillips screwdriver

### Operating Procedure

(1) Remove the filter retainer from the rear.

(2) Take out the filter and wash it in tap water.
Then, dry the air filter completely.
When the air filter is very dirty, use a neutral cleaner.

(3) Install the air filter by using the filter pressure fittings.



Maintenance Part

# Chapter 2

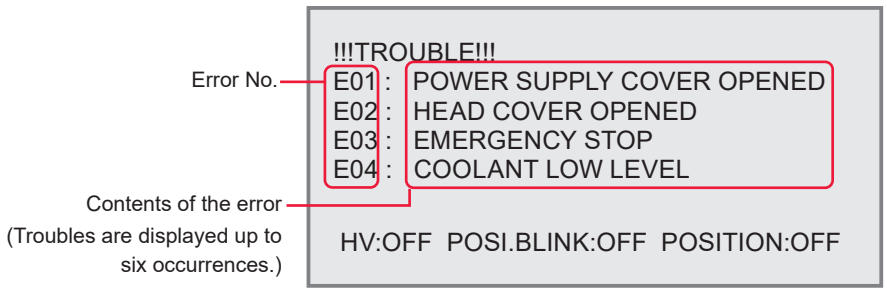
# Inspection and Measure To Be Taken at Occurrence of an Error

## 1. Error Display and How to Take a Measure

**When an error occurs in the laser, the contents of the error are displayed on the control panel screen as shown below. In the following, how to take a measure is explained in the order of Error No. At occurrence of an error, read this chapter carefully and perform inspection of the laser and take a proper measure.**

* If you have any unclear point, contact the distributor or us for information.

⇒ When there is any related page in this Operation Manual, the reference page is shown.



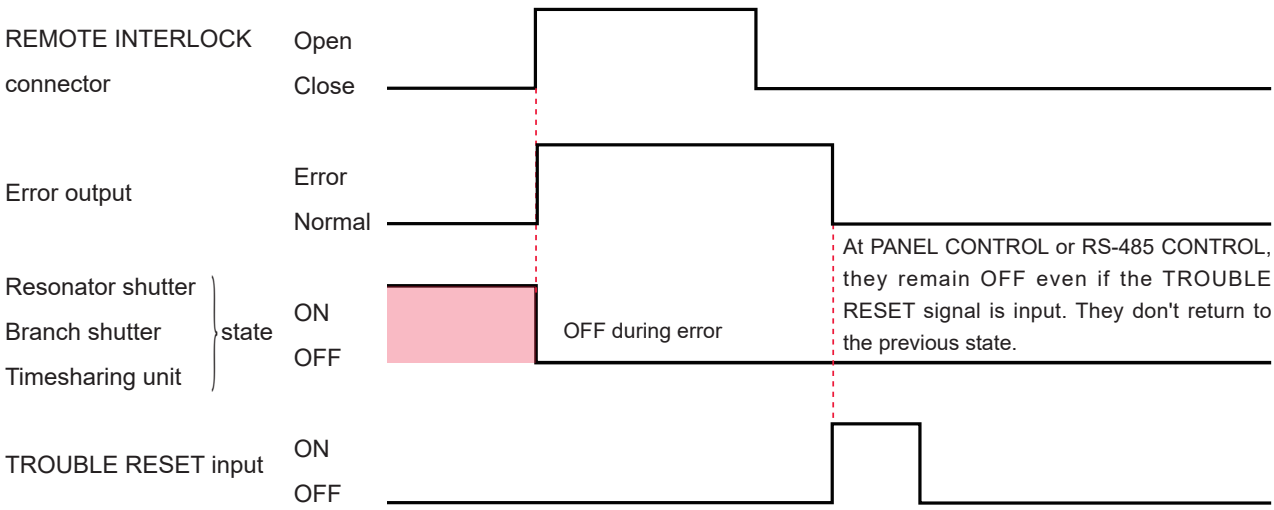

| No. | Display on control panel | High voltage | Alarm output | Measures |
|---|---|---|---|---|
| 00 | COMMUNICATION LINE ERROR | - | - | Trouble occurs in the communication line between the power supply for the Laser and control panel. If there is a noise source near the Laser, move it far away or suppress the noise. |
| 01 | POWER SUPPLY COVER OPENED | OFF | ON | The side cover or rear cover is removed or their mounting screws are loosened. Secure the covers with the screws. |
| 02 | HEAD COVER OPENED | OFF | ON | The head cover or lamp replacing cover is removed. Mount them. |
| 03 | EMERGENCY STOP | OFF | ON | An emergency stop signal is input. Close the emergency stop circuit on the [EXT.I/O (3)] or [EMERGENCY STOP] connector. Further, reset the EMERGENCY STOP button on the control panel. |

| No. | Display on control panel | High voltage | Alarm output | Measures |
|---|---|---|---|---|
| 04 | COOLANT LOW LEVEL | OFF | ON | Cooling water volume is insufficient.<br>Add cooling water. If the equipment is swayed, the coolant level may change. Stabilize the equipment. |
| 08 | DISCHARGE RESISTOR TEMP | OFF | ON | Frequent repetitions of HV-ON/OFF may cause this trouble.<br>Wait for a while till the discharge resistor cools; press [TROUBLE RESET]. When this alarm is not reset even after the above measures, consult us. |
| 10 | HIGH TEMPERATURE OF COOLANT | OFF | ON | Check air intake or exhaust for clogging. Clean air filter of intake as necessary.<br>Close the front door firmly.<br>If the ambient temperature exceeds 30°C, lower it to 30°C or less. → P.39 and P.59 |
| 11 | LOW TEMPERATURE OF COOLANT | OFF | ON | If the ambient temperature is low, it takes time to raise the cooling water temperature. Wait until the cooling water temperature rises after the power supply is turned ON. → P.59 |
| 12 | LOW FLOW RATE OF COOLANT | OFF | ON | The cooling water flow rate is low.<br>The water filter or the wire net in the oscillator is clogged. Dust off the wire net or the water filter, or replace the water filter. |
| 13 | DEIONIZE TROUBLE<br>(****MΩ · cm) | OFF | ON | Purity of the cooling water is low.<br>Allow the cooler to operate for 50–60 minutes. If this trouble still occurs, replace the ion-exchange resin. |
| 14 | SIMMER TROUBLE | OFF | ON | Check the flashlamp for malfunction. If faulty, replace it. Resistivity of the cooling water may be low. Referring to 13, take measures for the cooling water. |
| 15 | CHARGE TROUBLE | OFF | ON | Too much time is required to charge the capacitor in the laser power supply or the charged voltage is too high.<br>Check if the capacity of the power supply or power cable is insufficient. |
| 16 | BANK ALARM | OFF | ON | This signal is output for the control of the bank when a trouble of undercharge, overcharge, no-voltage or overvoltage occurs.<br>In this case, consult us. |
| 19<br>20<br>21 | BRANCH SHUTTER 1 TROUBLE<br>BRANCH SHUTTER 2 TROUBLE<br>BRANCH SHUTTER 3 TROUBLE | OFF | ON | A laser start signal is input while the timesharing unit is operating.<br>Extend the time from input of beam select signal to input of laser start signal. If the trouble will continue even after the above measures, life of rotary solenoid (driving part) may have run out; replace it. |

| No. | Display on control panel | High voltage | Alarm output | Measures |
|---|---|---|---|---|
| 29 | DISCHARGE UNIT TEMP | OFF | ON | Check discharge unit for absence of cooling water; and fan motor on the rear for not running. |
| 30 | DISCHARGE UNIT OVERPOWER | OFF | ON | Laser oscillation efficiency lowered. Service life of lamp, deviation of oscillation, stained YAG rod and mirror, fault of sensor unit may cause this trouble.<br>If the trouble will continue even after lamp has been replaced, consult us. |
| 31 | BRANCH UNIT COVER OPENED | OFF | ON | The branch unit cover plate is removed, or its mounting screws are loosened.<br>Secure the cover plate with the screws. |
| 32 | FIBER SWITCH TROUBLE | OFF | ON | An optical fiber or a trouble detecting cable is disconnected. → P.86<br>Connect them securely. |
| 33 | E.INDICATOR TROUBLE (OUTPUT UNIT) | OFF | ON | Emission indicator fault on output unit and/ or control panel. → P.86<br>Consult us. |
| 34 | E.INDICATOR TROUBLE (PROGRAM UNIT) | OFF | ON | |
| 35 | MEMORY BATTERY LOW | - | ON | Voltage level of memory backup lithium battery is low.<br>Replace it. |
| 38<br>39<br>40 | FIBER SENSOR 1 TROUBLE<br>FIBER SENSOR 2 TROUBLE<br>FIBER SENSOR 3 TROUBLE | OFF | ON | A fiber cable may be broken; or end face, damaged. → P.86<br>Check the all fiber cables for breakage. |
| 44 | EXTERNAL INTERLOCK OPENED | - | ON | The REMOTE INTERLOCK connector circuit is opened.<br>Close it and turn on the [TROUBLE RESET] input to turn off the [TROUBLE] output and fault code indication. Refer to "Operation for Closing Interlock" on page 169. |
| 45 | LASER START IS NOT READY | - | ON | A start signal is input before charging is finished. Extend the inputting interval of the start signal. |
| 46 | POWER MONITOR TEMP | - | ON | The power monitor unit may be broken.<br>Consult us. |
| 47 | OVERRATE | - | ON | The flashlamp power is too high.<br>Lower the set value of [PEAK], pulse width or [REPEAT]. |
| 48 | FIBER OVERRATE | - | ON | Incident beam exceeds the limit. → P.68<br>Lower the set value of [PEAK], pulse width or [REPEAT]. |
| 49 | SETTING ERROR (TOO SHORT DURATION) | - | ON | Pulse width setting is below 0.20 ms; set it to 0.20 ms or above. |

| No. | Display on control panel | High voltage | Alarm output | Measures |
|---|---|---|---|---|
| 50 | SETTING ERR<br>(OVERLIMIT OF MAX PWR) | - | ON | Output schedule setting ([PEAK], pulse width, [REPEAT]) exceeds the capacity. The set value is reset to the value before the change. |
| 51 | FIBER SETTING ERROR | - | ON | Output schedule setting ([PEAK], pulse width, [REPEAT]) to fiber exceeds the capacity. The set value is reset to the value before the change. → P.68 |
| 52 | MEMORY TROUBLE | - | ON | The voltage of the memory backup lithium battery is low. → P.58<br>Replace it. |
| 53 | POWER FEEDBACK TROUBLE | - | ON | Trouble with laser power feedback system.<br>Consult us. |
| 54 | DEIONIZE CAUTION<br>(****MΩ•cm) | - | - | Purity of the cooling water is low. Allow the cooler to operate for 50–60 minutes.<br>If this trouble still occurs, replace the ion-exchange resin cartridge. |
| 56 | OVERLIMIT OF LASER POWER | - | - | Monitored value exceeds ENERGY HIGH. Check the ENERGY HIGH setting.<br>If monitored value is abnormal, consult us. |
| 57 | UNDERLIMIT OF LASER POWER | - | - | Monitored value is below ENERGY LOW. Check the ENERGY LOW setting.<br>If monitored value is abnormal, consult us. |
| 59<br>60 | BRANCH MIRROR 1 TROUBLE<br>BRANCH MIRROR 2 TROUBLE | OFF | ON | START signal is input while the timesharing unit is operating.<br>Extend the time from [BEAM SELECT] to [LASER START]. If this trouble continues even after the measures, service life of rotary solenoid (driving part) may have run out. Replace it. |

## Operation for Closing Interlock




# 2. Troubles not Displaying Fault Code

| States of Laser | Measures |
|---|---|
| Laser output increases though monitor displays normal value. (When processing result changes) | Adjust laser output setting.<br>If the laser does not improve though the setting is adjusted, optical axis of resonator may have been dislocated.<br>For adjusting the axis, consult us. |
| Laser output decreases though monitor displays normal value. (When processing result changes) | |

# Appendixes

# Specifications

| | | ML-2050A | ML-2051A | ML-2150A |
|---|---|---|---|---|
| **Oscillator** | Maximum rated output | 15 W | 7 W | 25 W |
| | Max. output energy | 15 J/P<br>(Pulse width 5ms) | 7 J/P<br>(Pulse width 5ms) | 25 J/P<br>(Pulse width 5ms) |
| | Max. peak power | 4 kW | 2.5 kW | 6 kW |
| | Pulse width | Standard: 0.2 to 10.0 ms (0.1 ms steps)<br>Fine setting: 0.20 to 5.00 ms (0.02 ms steps) | | |
| | Pulse repetition rate | 1 to 30 pps | | |
| | Oscillation wavelength | 1.064 µm | | |
| | Positioning guide beam | Built-in visible laser (Red) | | |
| | Output stability *1 | ±3% | | |
| **Power Supply** | Power supply | Single-phase 200 V, 220 V, 240 V AC +10%,-15%,<br>50/60 Hz | | |
| | Max. input current | 7 A | | |
| | Max. apparent power | 1.4 kVA | | |
| | Breaker rated current (to be supplied by customers) | For the power supply side, we earnestly recommend using a leakage breaker with the rated current of 15 A or more, which is applicable to harmonics and surges. | | |
| | Ground | Class D (ground resistance: 100 Ω max.) | | |
| **Cooler** | Heat exchange method | Forced air cooling | | |
| | Heat-exchanging ability | 850 W (731 kcal/h) | | |
| **Control Panel** | Schedule setting (Up to 32 schedules can be set by combining) | - Laser output waveform - Power monitor<br>- Repetition rate - Number of repetitions<br>- Upper/lower limit alarm (Energy monitor [J]) | | |
| | Monitor | Energy monitor (J)<br>Average power (W) | | |
| | Counter | 9-digit total (preset) counter<br>9-digit good (preset) counter | | |
| | Alarm indication | Messages are displayed on liquid crystal display. | | |
| **Operating Environment** | Ambient temperature | 5° to 30°C | | |
| | Ambient humidity | 85%RH or less (non-condensing)<br>***<Note>*** For the upper limit of ambient humidity, refer to page 37. | | |
| **Others** | Mass | Approx. 70 kg | | |
| | Dimensions | 700 (H) x 310 (W) x 665 (D) mm | | |
| | Noise level (A) | Less than 70 dB | | |

*1 Under the schedule below:

| Model Type | Laser Output Energy per Pulse | Peak Power |
|---|---|---|
| ML-2050A<br>ML-2150A | 5 J minimum | 1 kW minimum |
| ML-2051A | 0.5 J minimum | 0.4 kW minimum |

## Minimum bending radius of the optical fiber

| Core diameter | Minimum bending radius |
|---|---|
| φ 0.2, 0.3, 0.4mm | 100mm |
| φ 0.6mm | 150mm |
| φ 0.8mm | 200mm |
| φ 1.0mm | 250mm |

## Standard Values of Maximum Incident Laser Energy and Power of the Optical Fiber

The following table shows the standard values of maximum laser energy and power that can be input into the optical fiber. Take care not to exceed these values when using the optical fiber.

**For single-delivery or timesharing**

The value becomes 1/2 at 2-powersharing and 1/3 at 3-powersharing.

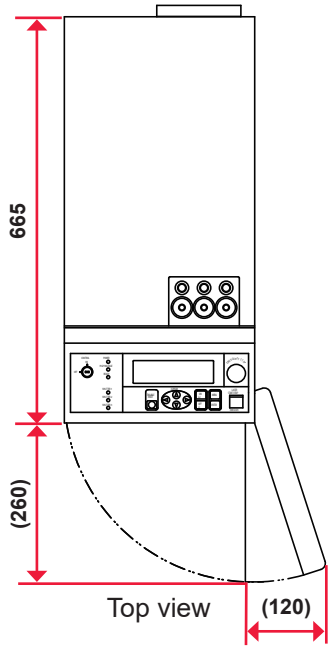
<table>
<tr><th>Model<br>Core dia.</th><th>ML-2050A</th><th>ML-2051A</th><th>ML-2150A</th></tr>
<tr><td>SI φ 0.2mm</td><td>-</td><td rowspan="3">7J, 7W</td><td rowspan="2">-</td></tr>
<tr><td>SI φ 0.3mm</td><td rowspan="2">15J, 15W</td></tr>
<tr><td>SI φ 0.4, 0.6, 0.8, 1.0mm</td><td>25J, 25W</td></tr>
</table>

⇒ Use an optical fiber of φ 0.4 mm core diameter or larger for ML-2150A.

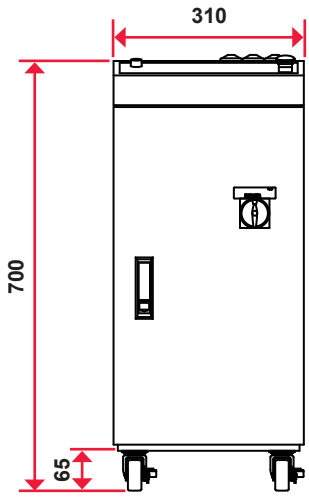
⇒ Use the SI optical fiber. The GI optical fiber cannot be used.

# Dimensional Outline Drawings

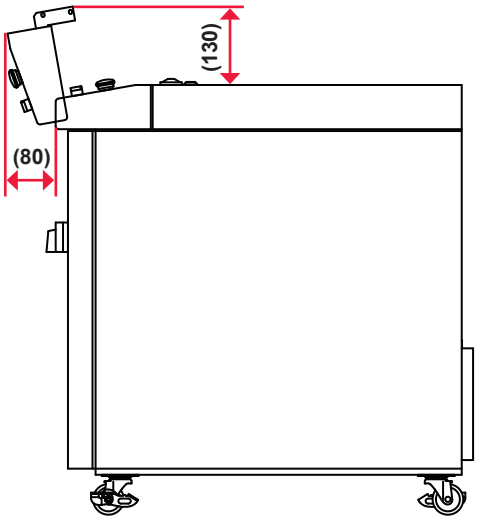
Unit: mm



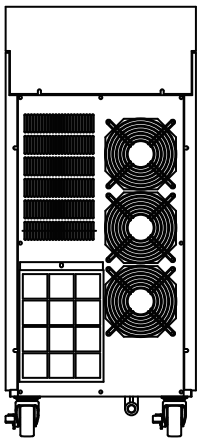

Top view



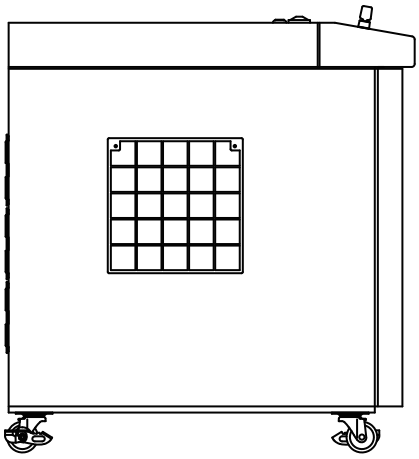

Front view




Right side view



Rear side view



Left side view

# Available Output

**The available upper-limit output depends on the setting of peak power and pulse width (laser output time ms). It is graphically shown for each model.**

To obtain the maximum rated output with a short pulse width setting, it is necessary to increase the peak power or repetition. Set conditions such as the pulse width and repetition not to exceed the upper-limit output.

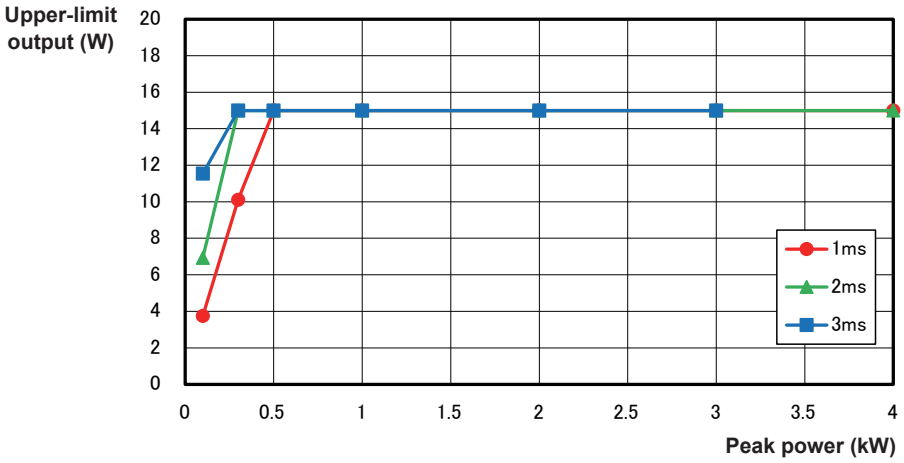
The specification for each model is as follows.

| Model | ML-2050A | ML-2051A | ML-2150A |
|---|---|---|---|
| Maximum rated output | 15 W | 7 W | 25 W |
| Maximum output energy | 15 J/P (pulse width 5 ms) | 7 J/P (pulse width 5 ms) | 25 J/P (pulse width 5 ms) |
| Maximum peak power | 4 kW | 2.5 kW | 6 kW |
| Pulse width | Standard: 0.2 to 10.0 ms (in 0.1 ms steps)<br>Resulting from a setting change: 0.20 to 5.00 ms (in 0.02 ms steps) | | |

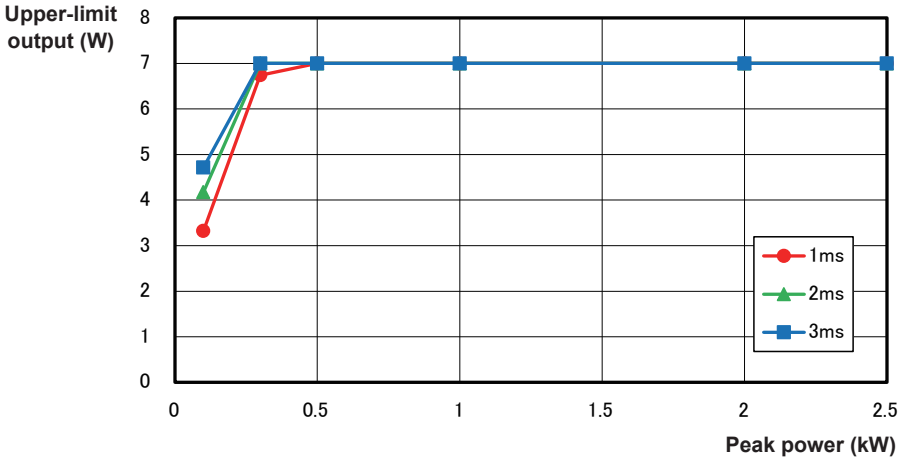
⇒ The graphical numeric value is for reference. The value changes according to each flashlamp, equipment, or set waveform.

⇒ To use the flashlamp for a longer time, we recommend the setting of 80% or less of the value shown in the graph below. The setting can be 100% of the value, but the lamp life and the replacement interval of the O-ring for YAG rod may become shorter.

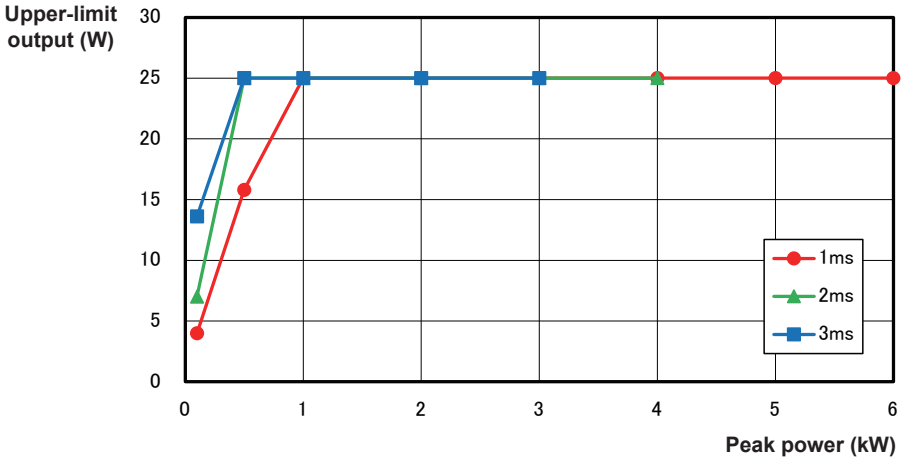
## ML-2050A



## ML-2051A




## ML-2150A



# Timing Chart

**An example of timing chart for the case where a high voltage is supplied to this laser and laser light is output up to a monitor output is shown below. In each timing chart, the equipment operation is represented on the axis of ordinates and the lapse of time is represented on the axis of abscissas to show the change status based on changes with the lapse of time at each operation and the time required for a certain operation.**

The following 5 types of timing chart are mentioned for your reference.

2-powersharing

Operation by control panel (PANEL CONTROL)

Operation by external input signals (EXTERNAL CONTROL)

2-timesharing

Operation by external input signals (EXTERNAL CONTROL)

Repeated operation (EXTERNAL CONTROL)

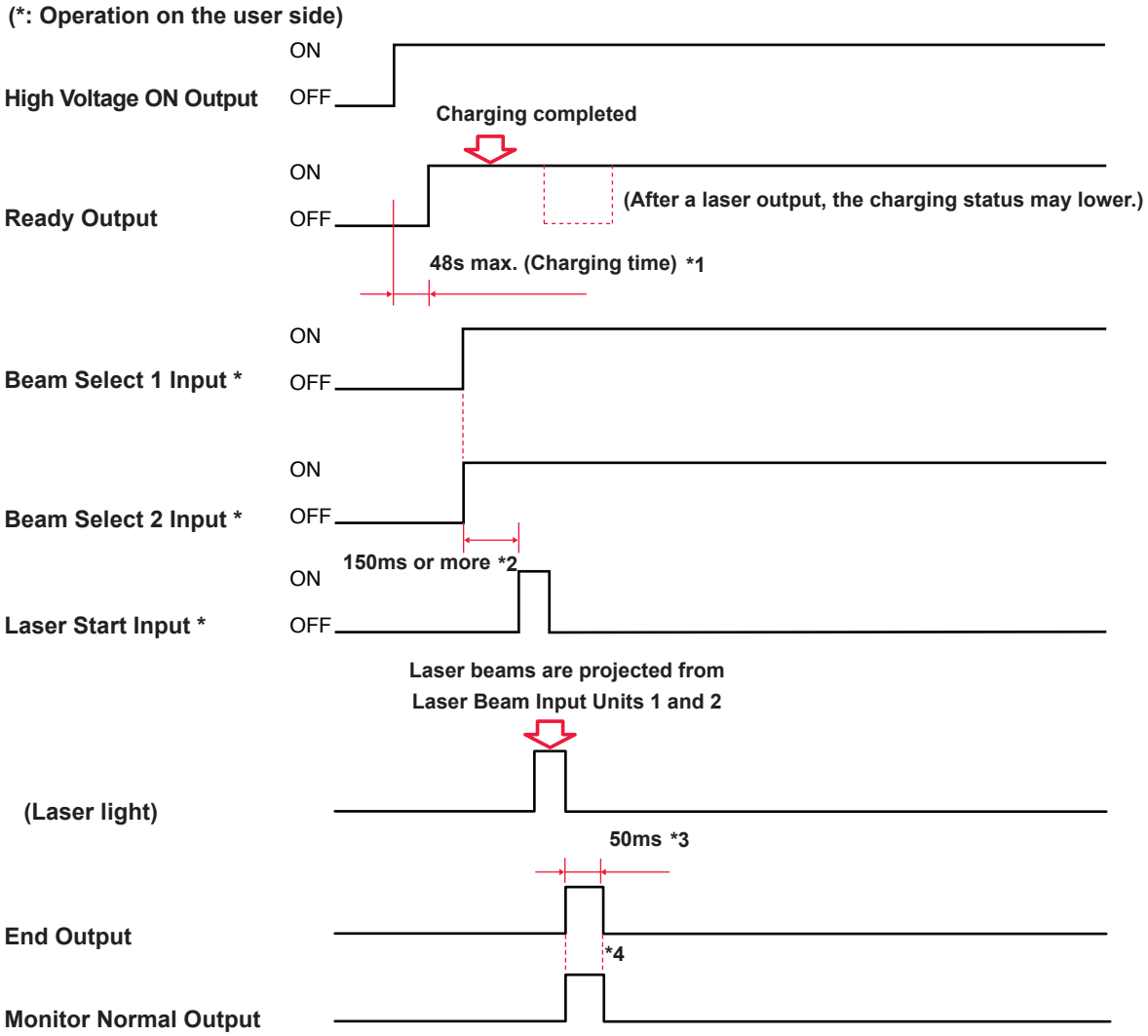
Repeated operation (20 pps or more) (EXTERNAL CONTROL)

⇒ The control method is switched by putting pin No.23 of the EXT.I/O (1) connector in an open circuit or a closed circuit.
For PANEL CONTROL in which control is exerted by control panel, put this pin in an open circuit. For EXTERNAL CONTROL in which control is exerted by external input/output signals, put this pin in a closed circuit.

⇒ For the control panel, laser light is output by pressing the LASER START/STOP button and stopped by pressing this button once again.
For external input/output signals, laser light is output by putting pin No.21 of the EXT.I/O (1) connector in a closed circuit and stopped by putting this pin in an open circuit.

## 2-powersharing ... Operation by control panel (PANEL CONTROL)

The following diagram shows the lapse of time in the case where BEAM1 and BEAM2 to are set to ON on the control panel and laser light is simultaneously output from input unit 1 and input unit 2 after the branch shutter is opened.

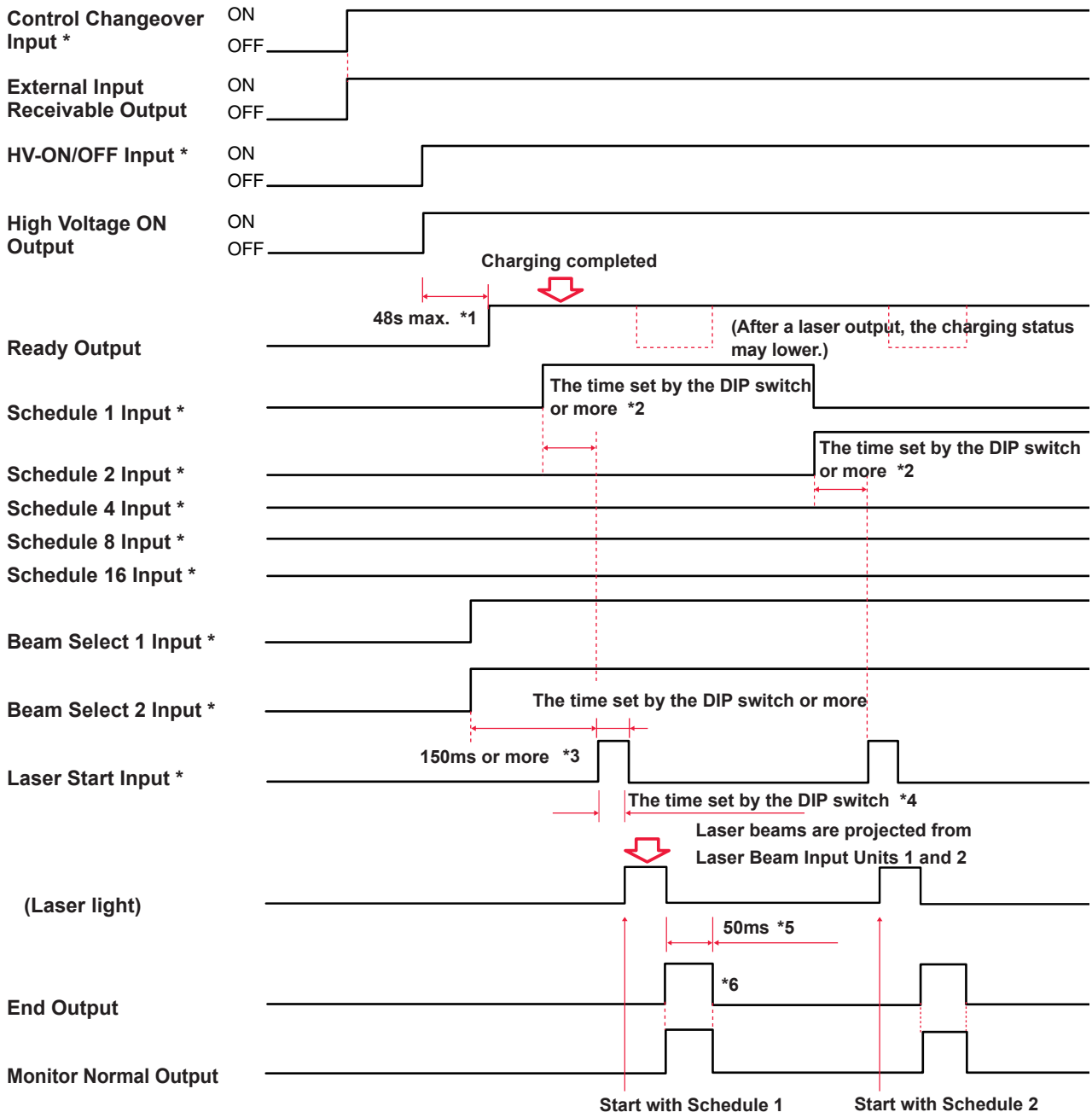



| | | |
|---|---|---|
| *1 | 48s max. | Charging time. When a high voltage is turned ON and charging is completed, the READY status is provided. |
| *2 | 150 ms or more | Shutter operation time. After beam selection, a laser start input signal is input after the lapse of certain time for shutter operation. |
| *3 | 50ms | Time required for the end signal to be output after a laser output. |
| *4 | 50ms | Time required for outputting a signal to indicate whether the laser energy is within the set upper limit value (HIGH) and lower limit value (LOW) of monitor output. |

## 2-powersharing ... Operation by external input signals (EXTERNAL CONTROL)

The following diagram shows the lapse of time in the case where a signal is sent from the PLC and schedule signal input, BEAM1 and BEAM2 are selected, and then laser light is simultaneously output from input unit 1 and input unit 2 by opening the branch shutter.

**(*: Operation on the user side)**



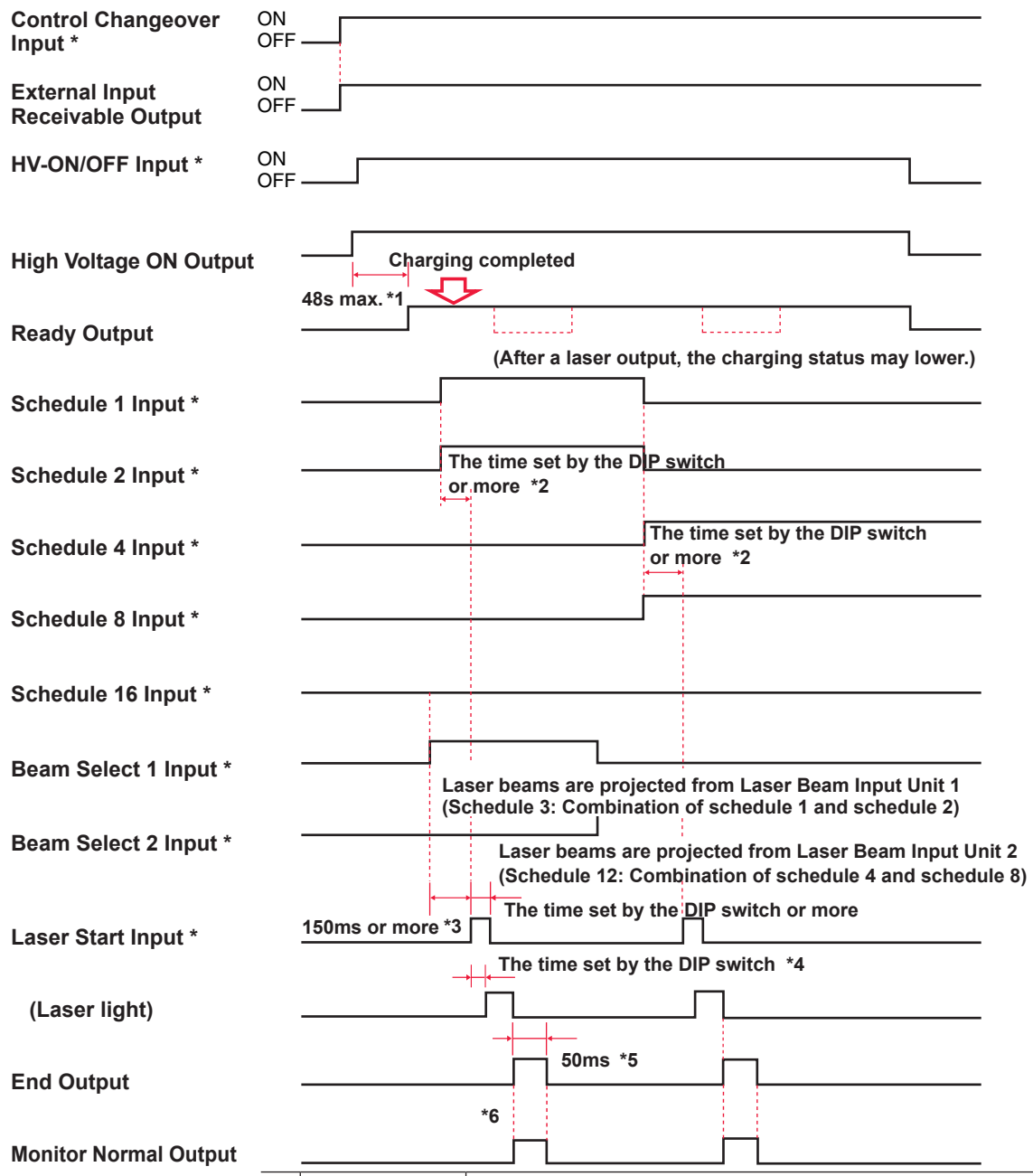

| | | |
|---|---|---|
| *1 | 48s max. | Charging time. When a high voltage is turned ON and charging is completed, the READY status is provided. |
| *2 | | Schedule signal acceptance time (time from a schedule signal input till establishment of schedules) |
| *3 | 150ms or more | Shutter operation time |
| *4 | | Laser start signal acceptance time (time from a signal input till an output) |
| *5 | 50ms | Time required for the end signal to be output after a laser output. |
| *6 | 50ms | Time required for outputting a signal to indicate whether the laser energy is within the set upper limit value (HIGH) and lower limit value (LOW) of monitor output. |

In Items *2 and *4, the time is usually 16 ms but can be shortened by changing the DIP switch setting.

## 2-timesharing ... Operation by external input signals (EXTERNAL CONTROL)

The following diagram shows the lapse of time in the case where a schedule signal input, BEAM1 and BEAM2 are selected and laser light is output from input unit 1 and input unit 2 respectively with a time difference by opening the branch shutter.

**(*: Operation on the user side)**

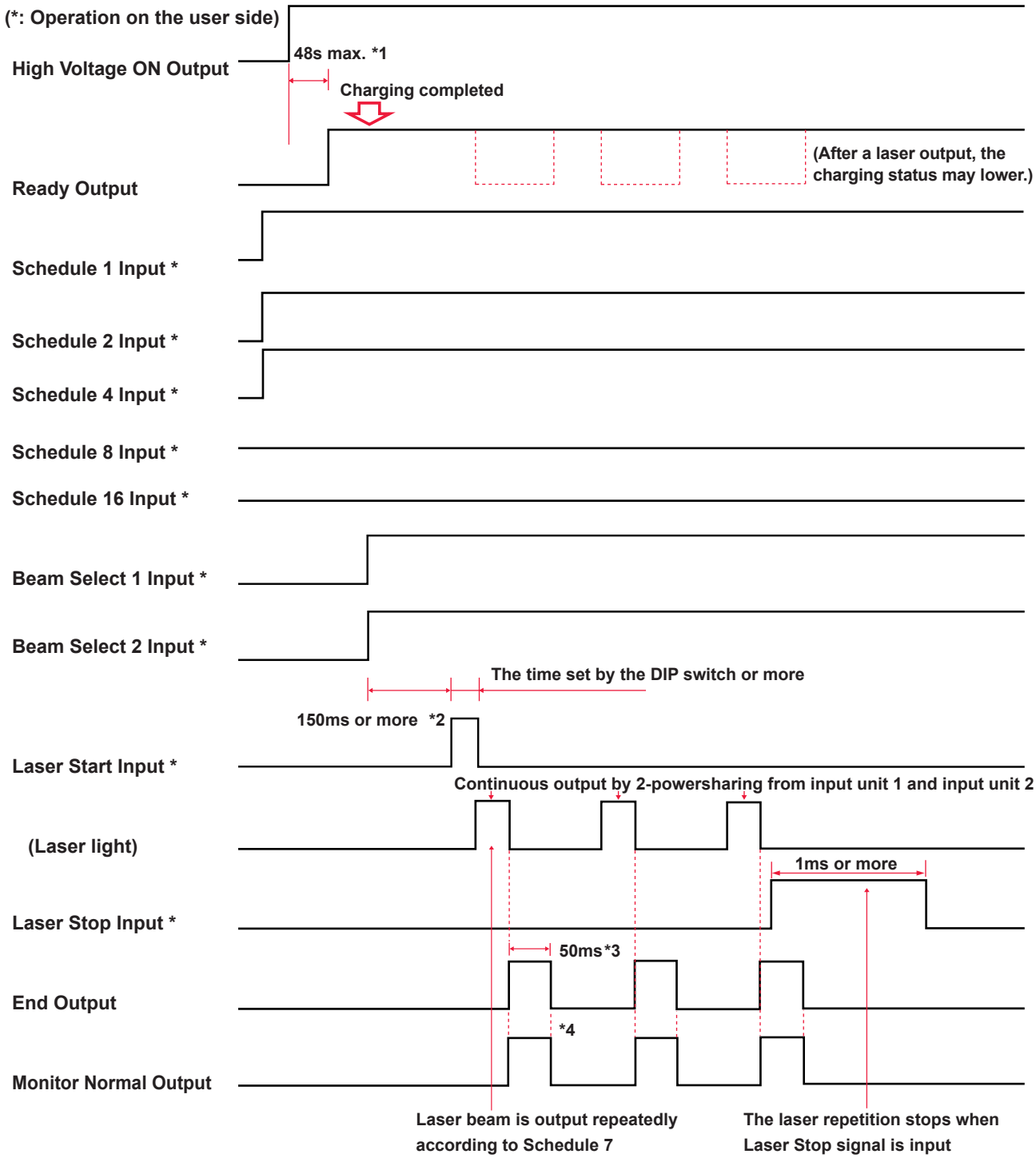



| | | |
|---|---|---|
| *1 | 48s max. | Charging time. When a high voltage is turned ON and charging is completed, the READY status is provided. |
| *2 | | Schedule signal acceptance time (time from a schedule signal input till establishment of schedules) |
| *3 | 150ms or more | Shutter operation time |
| *4 | | Laser start signal acceptance time (time from a signal input till an output) |
| *5 | 50ms | Time required for the end signal to be output after a laser output. |
| *6 | 50ms | Time required for outputting a signal to indicate whether the laser energy is within the set upper limit value (HIGH) and lower limit value (LOW) of monitor output. |

In Items *2 and *4, the time is usually 16 ms but can be shortened by changing the DIP switch setting.

## Repeated operation (EXTERNAL CONTROL)

The following diagram shows the lapse of time in the case where a signal is sent from the PLC and schedule signal input, BEAM1 and BEAM2 are selected, and then laser light is simultaneously output from input unit 1 and input unit 2 by opening the branch shutter.

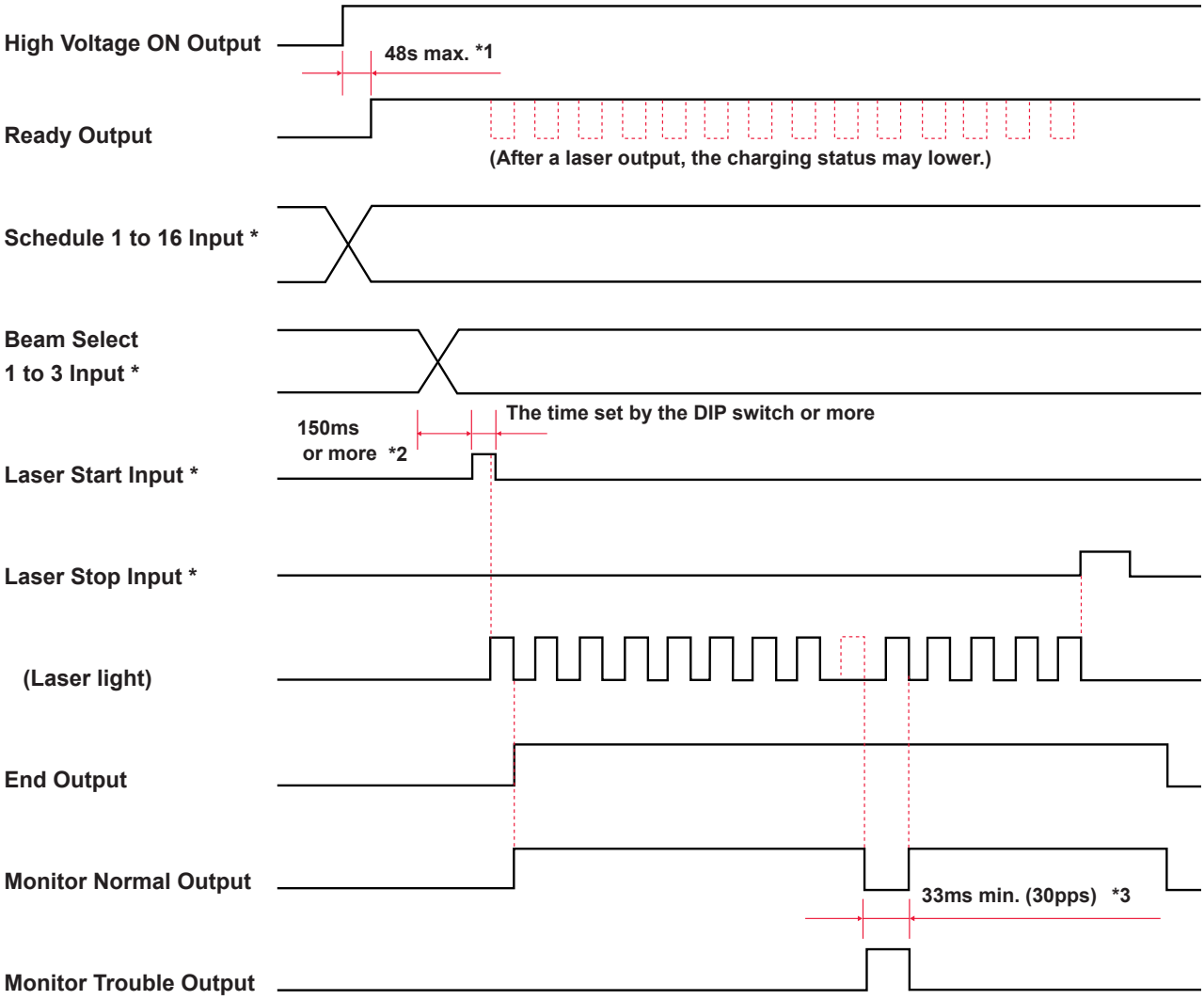



| | | |
|---|---|---|
| *1 | 48s max. | Charging time. When a high voltage is turned ON and charging is completed, the READY status is provided. |
| *2 | 150ms or more | Shutter operation time |
| *3 | 50ms | Time required for the end signal to be output after a laser output. |
| *4 | 50ms | Time required for outputting a signal to indicate whether the laser energy is within the set upper limit value (HIGH) and lower limit value (LOW) of monitor output. |

## Repeated operation (20 pps or more) (EXTERNAL CONTROL)

The following diagram shows the lapse of time in the case where laser is output according to the number of repeated outputs of 20 pps or more.

**(*: Operation on the user side)**




| | | |
|---|---|---|
| *1 | 48s max. | Charging time. When a high voltage is turned ON and charging is completed, the READY status is provided. |
| *2 | 150ms or more | Shutter operation time |
| *3 | 33ms min. | Monitor error output time. Minimum error output time for 30 pps. |

# Explanation of Terminology

The following table explains the terminology related to laser welding. General terms and the terms peculiar to this laser are included. When there is any related page in this Operation Manual, the reference page is shown.

| | |
|---|---|
| **A** | |
| ACK | Control code that is used for communication between computers. Affirmative response that is sent from the computer of transmission destination to the transmission source. Abbreviation of acknowledgement (affirmative response). → P.123 |
| Asynchronous system | Communication system in which the transmitting timing is not matched with the receiving timing. In the synchronous system, timing information is transmitted at data transmission and the receiving side receive the data by using this timing information. In the asynchronous system, the receiving side receives only data. |
| **B** | |
| BCC | Control code that is used for communication between computers. Error check character that is added to check a transmission error for each block of the communication text. Abbreviation of Block Check Character. → P.123 |
| Beamsplitter | Mirror to reflect laser light, which is incorporated in the laser oscillator section. → P.31 and P.78 |
| Branch shutter | Shutter to cut off laser light, which is incorporated in the laser oscillator section. When the shutter is set to Open, laser light is output. → P.31 and P.66 |
| **C** | |
| COM (Common) | Common line. This means a connecting point where the multiple points are connected to the same common point. The electric circuit includes an A contact, B contact, and Common. The common contact is connected to the A contact and B contact commonly. Abbreviation of Common. |
| Common | Common line. This means a connecting point where multiple points are commonly connected to the same point in the circuit or wiring. The electric circuit includes an A contact, B contact, and Common. The common contact is connected to the A contact and B contact commonly. This is abbreviated as COM. |
| Core diameter | External diameter of the core that is provided in the center of the optical fiber to transmit light. Its value can be determined from laser light transmission and equipment characteristics. → P.43 and P.68 |
| CPU board | Wiring board that mounts the CPU (Central Processing Unit) to control the equipment. |
| **D** | |
| Data bit | Bit to indicate one-character data that is used for asynchronous communication. → P.119 |
| Deionized water | Water in which an ion ingredient has been removed through the ion-exchange resin. For cooling water of this laser, deionized water or purified water is used. → P.38 |
| DIP switch | Setting switch of an electronic device mounted on an electronic circuit board. The device operation is controlled by turning this switch ON or OFF. In this laser, 3 types of DIP switch are mounted on the CPU board. DIP switch is an abbreviation of Dual In-line Package switch. → P.80 |
| **E** | |
| ETX | Control code that is used for communication between computers. → P.123 |
| Excitation | Phenomenon in which the electrons around an atom proceed from the ground status to a one-upper status. In the case of laser, excitation means that the atoms or molecules in the laser medium proceed from a low energy status to a high energy status when energy is given from the outside. |

| | |
|---|---|
| **F** | |
| FIX | Fixed waveform that is a laser light output means to be used by this laser.<br>Laser light with a fixed waveform by up to 3 divisions in the case where output time and the output value are set in the range of the first laser and the third laser. → P.61 |
| Fixed waveform | Laser output method by this laser. This is called FIX. Laser light with a fixed waveform by up to 3 divisions in the case where output time and the output value of each point are set in the range of the first laser and the third laser. → P.61 |
| Flashlamp | Exciting lamp provided in the laser oscillator. When the flashlamp comes on, laser is generated by exciting the YAG rod. → P.18, P.30, and P.154 |
| FLEX | Flexible waveform that is a laser light output means to be used by this laser.<br>Laser light with a flexible waveform in the case where output time and the output value of each point are set in the range of Point 1 and Point 20. → P.63 |
| Flexible waveform | Laser light output method of this laser. This is called FLEX. Laser light with a flexible waveform in the case where output time and the output value of each point are set in the range of Point 1 and Point 20. → P.63 |
| Full duplex | Communication system in which data can be send and received simultaneously from both sides in two-way communication. The data transfer system of this laser is an asynchronous full duplex system. → P.119 |
| **G** | |
| GI | Optical fiber type. Abbreviation of Graded Index. The GI type means one of multi-mode optical fibers (MMF: Multi Mode Optical Fiber) in which the refractive index distribution in the core changes moderately. Index means the refractive index. Usually, the model for this laser is the SI (Step Index) type. → P.56 |
| Grounding | Electrical connection between an electric device and the ground. This is also called earth or ground. |
| Grounding work | Specified in Article 18 "Interpretation of Technical Standard of Electric Equipment." The grounding work for device connected to a low-voltage circuit of 300 V or less is performed in compliance with class D, and that of more than 300 V is performed in compliance with class C. → P.35 |
| Guide light | Auxiliary light to check the laser light irradiating position and make a positional adjustment. Light with a wavelength of 380 nm to 780 nm that can be seen by man. This is also called visible laser. In this laser, guide light is output by guide light oscillator. → P.30 |
| **H** | |
| Harmonic | Waveform having 3 to 40 times of frequency of the basic frequency (50/60 Hz). → P.41 |
| **I** | |
| Input unit | Unit to transmit laser light to the optical fiber. → P.30 and P.44 |
| Interlock | Circuit to prevent hazards, which stops the machine operation when a material comes close to a place where a hazardous unit or equipment is provided. |
| Ion-exchange resin | Synthetic resin to exchange ions in media (mainly water) in contact. In this laser, this resin removes the ions that are generated as cooling water is deteriorated, in order to keep the cleanliness. → P.149 |
| **L** | |
| L | Line terminal. This is a terminal to be connected to a line conductor of the external circuit. Abbreviation of Live. → P.41 |

| | |
|---|---|
| Laser | LASER is an abbreviation of Light Amplification by Stimulated Emission of Radiation, which is light artificially generated by laser oscillator. Laser is classified into solid laser, liquid laser, and gas laser by medium. YAG Laser is typical solid laser. |
| Laser chamber | This is a laser oscillation vessel. It includes a flashlamp and a YAG rod. The laser chamber is a part of the laser oscillator. |
| Laser light | Light artificially generated by laser oscillator. This laser light is widely used for electronic devices, optical communication, medial treatment, metal working, and other fields. As a matter of feature, laser light goes straight, its wavelength is fixed and the phase (wave peak and hollow) is the same, so high energy can be obtained by concentrating light to one point. |
| Laser power feedback | Control function that is adopted for this laser. The measured value and average power of output laser energy is returned to the input side so that they can be checked immediately after a laser output. |
| Laser safety supervisor | Person who is responsible for laser safety management, having an enough knowledge to execute laser hazard assessment and safety management. Regarding the facilities or place in which the laser product exceeding class 3B of JIS C 6802 "Safety Standard for Laser Products" is operated, it is necessary to appoint the laser safety supervisor and prepare a management area. Since most laser welder comes under class 4 of the highest hazard, the laser safety supervisor must be appointed. → P.9 |
| Leakage breaker | Safety device to shut off the circuit at detection of a leakage current that flows from the power supply to the ground. |
| **N** | |
| N | Neutral point terminal. This is a terminal to be connected a neutral point of the circuit. Abbreviation of Neutral. → P.41 |
| NAK | Control code that is used for communication between computers. Negative response that is sent from computer of the transmission destination to the transmission source. Abbreviation of Negative Acknowledgement. → P.123 |
| Nd: YAG laser | Name of laser that is generated by adding neodymium (Nd) to Yttrium-Aluminum-Garnet crystals. Laser light with a wavelength of 1064 nm that is generally called YAG laser is oscillated. YAG is an abbreviation of Yttrium-Aluminum-Garnet. |
| **O** | |
| Optical fiber | Cable to transmit light that is made of quarts glass or thin plastic fiber. This cable consists of a core of the center and a clad covering the surroundings, and light is propagated in the core. The mode is classified into 2 types, namely, multi mode and single mode by the number of light propagation modes, and the multi-mode optical fiber is divided into step index (SI) and graded index (GI) by refractive index distribution of the core. |
| Oscillator | In the laser welder, the oscillator means a unit to amplify and oscillate laser light. This unit consists of a laser medium, excitation source, amplifier, etc. Laser is amplified and oscillated when the laser medium is excited by excitation source. |
| Output unit | Unit to output the laser light transmitted by optical fiber to the workpiece. The optical fiber connected to the input unit is connected. → P.18 and P.45 |
| **P** | |
| Parity | Method to check whether data is correctly transmitted or received in data communication. A data error is detected by using bit information or parity bit that is added to the data. Parity means Odd and Even. |
| Parity bit | Data that is added to the source data to detect an error in data communication. The receiving side collates with the parity bit by checking whether the number of 0s or 1s in the obtained bit train is odd or even. When an error is found, data is retransmitted or processing is interrupted. → P.119 |
| PE | Protective earthing terminal. This is a terminal that is provided to ground a device. Abbreviation of Protective Earth. → P.41 |

| | |
|---|---|
| Peak power | At laser welding, the peak power means the energy amount per time (value resulting from dividing the pulse energy by pulse width) and its unit is watt (W). |
| Peak value | Laser output peak value. "PEAK" value that is set on the SCHEDULE screen in this laser. → P.55 |
| Photo MOS relay | Full solid relay that adopts a light emitting diode on the driving side and MOS (Metal-Oxide Semiconductor) FET (Field-Effect Transistor) for the contact. → P.100 |
| PLC | Device that exerts sequence control by executing the programmed contents of control in sequence. This is often called Sequencer (product name of Mitsubishi Electric Corporation). Abbreviation of Programmable Logic Controller. |
| Powersharing | Laser light delivery specification. Single laser light is split into multiple beams by beamsplitter so that laser light is output simultaneously to multiple optical fibers. → P.78 |
| pps | Number of pulses per second. Abbreviation of pulse per second. |
| Protective glasses | Protective glasses that the operator puts on to protect the eyes from laser light. The protective glasses are divided into some types by wavelength of laser light. |
| Pulse width | Time during which laser light is irradiated. |
| Purified water | Water that has been purified by distillation, filtration, or deionization. Water whose electric resistivity is 1 to 3 MΩ-cm. For cooling water of this laser, deionized or purified water is used. |
| **R** | |
| R | Symbol of power supply terminal. This terminal is used in a pair with S.<br>In some cases, U or V is used instead. → P.41 |
| Rated current | Maximum effective current value when a current can be continuously output.<br>This value indicates that it is prohibited to cause a current to continuously flow exceeding this level. |
| Remote interlock | Interlock function to shut off the laser output in an emergency as a means for using the laser device safely. In this laser, the REMOTE INTERLOCK connector is connected to the door of the room so that laser light may be shut off when the door is opened. → P.108 |
| Resistivity | Electric resistance generally used as a scale to indicate the hardness of current flow for a material. Its unit is ohm (Ω). The value that indicates this resistance by unit volume (1 cm x 1 cm x 1 cm) is volume resistivity and its unit is ohm centimeter (Ωcm). |
| Resonator mirror | Mirror composing resonators in the laser oscillator section. The light that has been excited by laser chamber is amplified between 2 resonator mirrors into a laser beam. → P.30 |
| RS-232C | Serial communication standard that is standardized by Electric Industries Alliance (EIA) of the United States. This is used for a connection between a data line terminator such as MODEM and a data terminal unit such as PC. Many different devices are based on this standard, so that this standard is used for various fields. Abbreviation of Recommended Standard-232C. → P.118 |
| RS-485 | Serial communication standard that is standardized by Electric Industries Alliance (EIA) of the United States. RS-485 meets the requirement for multi-connection for multiple units of up to 32 units by bus type multi-point connection. Abbreviation of Recommended Standard-485. → P.118 |
| RxD | Pin for received data out of signal lines of the communication connector. → P.118 |
| **S** | |
| S | Symbol of power supply terminal. This terminal is used in a pair with R.<br>In some cases, U or V is used instead. → P.45 |
| SCHEDULE | This word means a laser light output schedule in this laser. Thirty-two types of SCHEDULE can be set and each schedule can be registered with a SCHEDULE number. → P.61 |
| Sequencer | A type of PLC (Programmable Logic Controller) that exerts sequence control by executing the programmed contents of control, being a product name of Mitsubishi Electric Corporation. |

| | |
|---|---|
| SI | Optical fiber type that is used in this laser. Abbreviation of Step Index. The SI type is one of multi-mode optical fibers (MMF: Multi Mode optical Fiber) in which the refractive index distribution in the core is uniform. The index means the refractive index. → P.56 |
| Single phase | Electric current whose magnitude and direction change periodically, having the same phase. This single phase is used as a 100 V power supply for electric lamps and plug sockets. |
| sq (square) | Unit that represents a sectional area of cable. Square millimeter. → P.45 |
| Start bit | Bit to indicate the beginning of data in the asynchronous communication mode in which synchronization is performed for each data such as control character and symbol. The bit to indicate a separation between characters is called stop bit. → P.119 |
| STX | Control code that is used for communication between computers. → P.123 |
| Surge | Abnormal overvoltage or overcurrent applied momentarily to the electric circuit. → P.41 |
| **T** | |
| Timesharing | Laser light delivery specification. When the incorporated timesharing unit is operated, laser light is output to a single optical fiber. This function is provided in the timesharing specification of this laser. → P.78 |
| Timesharing unit | Unit that mounts mirrors to reflect laser light. Laser light is output to the selected optical fiber when the mirror is operated. This unit is incorporated in the laser oscillator section according to the timesharing specification of this laser. → P.31 |
| TxD | Pin for send data out of signal lines of communication connector. → P.118 |
| **U** | |
| Ultra pure water | Water whose purity is unlimitedly close to the ideal water $H_2O$ with a purity of 100%. This water is treated by a combination of strictly quality-controlled ion-exchange resin, active carbon, membrane filter, UF, UV, etc. As standard, when the resistivity is 16 to 17 Ω-cm or more, the water is called pure water. |
| **Y** | |
| YAG rod | This means a laser medium that is excited by flashlamp, which is composed of a transparent crystal which is made by adding Neodymium (Nd3+) to Yttrium-Aluminum-Garnet. This rod is inserted in the laser chamber in this laser. → P.18 and P.30 |
| **W** | |
| Work distance | Distance from the laser light output position to the target workpiece for laser welding. |

## Output Schedule Data Entry Table [FORM:FIX] - 1

| ITEM | | SETTING RANGE | No. / UNIT | SCHEDULE | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 |
| ↗SLOPE | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| FLASH1 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| FLASH2 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| FLASH3 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| ↘SLOPE | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| PEAK | | **ML-2050A:** 00.00 - 04.00<br>**ML-2051A:** 00.00 - 02.50<br>**ML-2150A:** 00.00 - 06.00 | kW | | | | | | | | | | | | | | | | |
| REPEAT | | 00 - 30 | pps | | | | | | | | | | | | | | | | |
| SHOT | | 0000 - 9999 | | | | | | | | | | | | | | | | | |
| ENERGY | HIGH | 000.0 - 999.9 | J | | | | | | | | | | | | | | | | |
| | LOW | 000.0 - 999.9 | J | | | | | | | | | | | | | | | | |

NETWORK # _____

## Output Schedule Data Entry Table [FORM:FIX] - 2

| ITEM | | SETTING RANGE | No. / UNIT | SCHEDULE | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| ↗SLOPE | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| FLASH1 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| FLASH2 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| FLASH3 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| ↘SLOPE | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| PEAK | | **ML-2050A:** 00.00 - 04.00<br>**ML-2051A:** 00.00 - 02.50<br>**ML-2150A:** 00.00 - 06.00 | kW | | | | | | | | | | | | | | | | |
| REPEAT | | 00 - 30 | pps | | | | | | | | | | | | | | | | |
| SHOT | | 0000 - 9999 | | | | | | | | | | | | | | | | | |
| ENERGY | HIGH | 000.0 - 999.9 | J | | | | | | | | | | | | | | | | |
| | LOW | 000.0 - 999.9 | J | | | | | | | | | | | | | | | | |

NETWORK # _____

## Output Schedule Data Entry Table [FORM:FLEX] - 1

| ITEM | | SETTING RANGE | No. / UNIT | SCHEDULE (Enter No. optionally.) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POINT 1 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| POINT 2 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| POINT 3 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| POINT 4 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| POINT 5 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| POINT 6 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| POINT 7 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| POINT 8 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| POINT 9 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| POINT 10 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| POINT 11 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| POINT 12 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| POINT 13 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| POINT 14 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| POINT 15 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |

## Output Schedule Data Entry Table [FORM:FLEX] - 2

| ITEM | | SETTING RANGE | No. / UNIT | SCHEDULE (Enter No. optionally.) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POINT 16 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| POINT 17 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| POINT 18 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| POINT 19 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| POINT 20 | TIME | 00.0 - 10.0 | ms | | | | | | | | | | | | | | | | |
| | % | 000.0 - 200.0 | % | | | | | | | | | | | | | | | | |
| PEAK<br>**ML-2050A:**<br>**ML-2051A:**<br>**ML-2150A:** | | 00.00 - 04.00<br>00.00 - 02.50<br>00.00 - 06.00 | kW | | | | | | | | | | | | | | | | |
| REPEAT | | 00 - 30 | pps | | | | | | | | | | | | | | | | |
| SHOT | | 0000 - 9999 | | | | | | | | | | | | | | | | | |
| ENERGY | HIGH | 000.0 - 999.9 | J | | | | | | | | | | | | | | | | |
| | LOW | 000.0 - 999.9 | J | | | | | | | | | | | | | | | | |

NETWORK # _____

# Index

## M



## N



## O



## P

## R



## S



## T



## V



## W



## Y