ROCAMED

MH01

30W Holmium YAG LASER (2100 nm)

SERVICE MANUAL

Rx Only

CE 0459

ROCAMED
9, avenue Albert II - MC 98000 Monaco

Content of the Service Manual

This Service Manual provides service engineers/technicians with information on the following topics:

- **Safety Instructions**
- **Laser System Description**
- **Installation Instructions**
- **Optical System**
- **Electronic System**
- **Cooling System**
- **Troubleshooting**
- **Customer Service**
- **Appendices with technical drawings**

Service personnel are encouraged to familiarize themselves with the laser system and its operation. Make sure that all components within the laser can be identified. Follow the Troubleshooting Chapter to restore the performance of the laser if it does not meet or even exceeds the defined criteria.
The service manual includes the detailed descriptions of all the relevant components and procedures needed for the correct way of using this laser system along with additional electrical schematics and technical illustrations.
Upon request, the Manufacturer will provide additional circuit diagrams, component part lists, descriptions, calibration instructions, or other information not already contained within the technical guide, to assist the qualified technical personnel in resolving the issues.

 **Warning:** *Use of any controls, adjustments or performance procedures other than those specified herein may result in hazardous radiation exposure.*

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1 GENERAL INFORMATION

The Medical Device MH01 is a **30 Watt** Holmium YAG (CTH:YAG) laser for surgical and dermatologic procedures emitting at **2100 nm** laser wavelength.

The Laser System is provided with an integrated cooling circuit (no external water connection is required for cooling), a green pilot beam (aiming beam) and an automatic RFID fiber recognition system, which detects whether the connected fiber has been correctly connected to the Device.

The automatic fiber recognition also detects the type of the connected optical fiber, thus enabling the parameters range approved for the specific optical laser fiber. This feature prevents working at excessive power settings.

1.1 Distributor and Manufacturer Information

Distributed by:

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Manufactured by:

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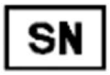
1.2 **Symbols**

Symbol	*Description*
CE 0459	Identification in conformity with medical devices directive 93/42/EEC **only valid** if the **product and/or packaging is marked with this symbol**. Products of category IIa and above, as well as sterile products or products with measuring function of category I, are additionally identified with the code no. of the notified body (0476).
	Follow instructions for use
	Manufacturing date
	Serial Number
	Manufacturer
	Operating Instruction
Class 4	Laser classification
Class 3R	Aiming beam laser classification
NOHD	Nominal Ocular Hazard Distance
NHZ	Nominal Hazard Zone
MPE	Maximum Permissible exposure
OD	Optical Density
I	Pulsed laser indication
L	Degree of protection for laser googles
Vrms	Root Mean Squared Voltage
WEEE	Waste of electrical and electronic equipment
CW	Continuous wave pulse
T	Type T fuse
EO	Sterilization method: Etylene Oxide
Ø	Diameter
SMA	Type of laser fiber connector
T on	Pulse duration (pulse ON)
T off	Pause duration between one pulse and the following
CTH:YAG	Chromium, Thulium, Holmium-doped YAG laser crystal
	ON of key switch logic interface
	OFF of key switch logic interface

1.3 Technical Specifications

This Laser Device has the following classification:

Type	MH01
Product category	Surgical laser for medical use
Classification according Medical Device Directive 93/42/EEC	Class IIb
Laser Classification according IEC / EN 60825-1:2007	Class 4
Aiming beam classification according IEC / EN 60825-1:2007	Class 3R
Mains	100-120 Vac; 50/60Hz; 16 A 200-240 Vac; 50/60Hz; 10 A
Type of protection against electric shock	Class I
Degree of protection against the ingress of liquid	IP 20 (Not protected)
Degree of protection against electric shock	Type BF
Mode of operation	Continuous
Dimension	332 (W) X 967 (D) X 938 (H) mm
Weight	60 kg
Operative temperature	10° - 30° C
Storage temperature	Min. 5° C / max. 40° C
Transport temperature (without water)	Min. -5° C / max 70° C
Humidity	30% - 85%
Pressure	from 800 hPa to 1060 hPa
Cooling system	Integrated water cooling system with water/air heat exchanger

WARNING!
Equipment not suitable for use in the presence of flammable mixtures.

IMPORTANT!
For shipment and storage below +5°C, the cooling system must be emptied.

NOTE!
To prevent damage during transport or shipment of the products we recommend using the original packaging material.

2 SAFETY AND TECHNICAL REQUIREMENTS

As with any electrical equipment, there are potential hazards involved with the operation and servicing of this laser system. Before using the laser, operators and technicians should be aware of the following types of hazards: optical, electrical and fire. This section of the Service Manual describes these potential hazards and suggests precautions in order to avoid them.

2.1 General Safety Information

- For a safe use of the device it is necessary to know all the safety rules according to the international standards.
- This manual contains important information about the safe use of the device
- All the persons operating with this equipment have to know the operation instructions and the safety instructions specified in this manual.
- Only authorized individuals with appropriate laser training and knowledge should service the laser system.
- The laser device has to be closed. Only authorized personnel can open the external covering panels.
- Only authorized personnel providing technical service can have access to the internal components of the system.
- All the warning labels have to be continually in good condition.

2.2 Laser Classification and Working Area

This Laser System is a therapeutic device classified as a Class 4 laser following the International Standard IEC EN 60825-1.

This Laser has to be used in a specific working area defined and delimited following the international standards (IEC EN 60825-1):

 **Warning:** RESTRICTED ACCESS TO THE WORKING AREA.

The external personnel/visitors should:

- Be guided by internal personnel;
- Always wear the protective goggles inside the working area when the laser system is turned on.

2.3 Interference with other devices

This Laser Device does not include any type of direct connection with other external or internal device. This Laser Device can be disturbed by the interference of external electromagnetic fields generated by other electrical devices in the closest proximity of the laser device.

 **Warning:** *Mobile phones and similar electrical devices must be switched off when the laser device is working.*

2.4 Potential hazards

2.4.1 *Eye hazard*

The MH01 laser generates laser light at a wavelength of 2100 nm delivered by the optical fiber. Higher energy values can be generated from the laser head especially during service operations. At these wavelengths and energy levels, serious and permanent eye damage can occur in cases when there is a direct or even indirect optical exposure.

The laser beam emitted by this Laser Device can cause vision loss. Any energy transmitted by this Laser Device that enters the eye will be focused directly to the retina. Direct absorption of laser energy by retina can result in temporary clouded vision clouds, retinal lesion, long-term scotoma and long-term photophobia.

A risk exists in any case of:

- Direct laser radiation
- Reflected laser radiation
- Diffused laser radiation

Following the Standard IEC / EN 60825-1, the MPE (Maximum Permissible Exposure), NOHD (Nominal Ocular Hazard Distance) and OD (Optical Density) are calculated.

The formulas and the numerical coefficients are specified in sect. 3, chap. 13, tab. 6, fig. 1, 2, 5, 6, 7, 8 of EN 60825-1:2007 standard.

Beam Diameter	Pulse Duration	Divergence Full angle (rad)	Peak Power P_0	EMP	NOHD	OD
200 µm	800 µs	0.44	2 J @ 10 Hz	100 J/m²	0.44 m	1.23
272 µm	800 µs	0.44	3 J @ 10 Hz	100 J/m²	0.44 m	1.23
365 µm	800 µs	0.44	3 J @ 10 Hz	100 J/m²	0.44 m	1.23
550 µm	800 µs	0.44	3 J @ 10 Hz	100 J/m²	0.44 m	1.23
800 µm	800 µs	0.44	3 J @ 10 Hz	100 J/m²	0.44 m	1.23
1000 µm	800 µs	0.44	3 J @ 10 Hz	100 J/m²	0.44 m	1.23
200 µm	800 µs	0.44	2 J @ 5 Hz	200 J/m²	0.34 m	1
272 µm	800 µs	0.44	3.5 J @ 5 Hz	200 J/m²	0.34 m	1
365 µm	800 µs	0.44	4 J @ 5 Hz	200 J/m²	0.34 m	1
550 µm	800 µs	0.44	4 J @ 5 Hz	200 J/m²	0.34 m	1
800 µm	800 µs	0.44	4 J @ 5 Hz	200 J/m²	0.34 m	1
1000 µm	800 µs	0.44	4 J @ 5 Hz	200 J/m²	0.34 m	1
200 µm	800 µs	0.44	1.5 J @ 20 Hz	50 J/m²	0.44 m	1.23
272 µm	800 µs	0.44	1.5 J @ 20 Hz	50 J/m²	0.44 m	1.23
365 µm	800 µs	0.44	1.5 J @ 20 Hz	50 J/m²	0.44 m	1.23
550 µm	800 µs	0.44	1.5 J @ 20 Hz	50 J/m²	0.44 m	1.22
800 µm	800 µs	0.44	1.5 J @ 20 Hz	50 J/m²	0.44 m	1.22
1000 µm	800 µs	0.44	1.5 J @ 20 Hz	50 J/m²	0.44 m	1.22

 **Warning:** *All the personnel present in the laser working area must wear the protective goggles in order to avoid serious eye injuries.*

Avoid direct look into the fiber or handpiece, even while wearing protective goggles.

End user must use protective goggles with the specifications according to the EN 207:
I 2100 LB2

Service personnel must use protective goggles with the specifications according to the EN 207:
I 2100 LB4

Always check the goggles condition.

Before wearing the protection goggles make sure that the goggles protection glass is in good condition.

Warning: *These lasers emit laser light each time the flashlamp fires. Do not look directly at laser resonator during the time the flashlamp fires, otherwise severe and permanent eye damage may occur. Make sure to wear the correct protective laser eyewear for the specified wavelength.*

Please adhere to the following precautions in order to avoid eyes damage during the operations with the laser:

- Make sure that everyone who is present during service procedures to wear the appropriate protective eyewear recommended by the Manufacturer.
- Never look directly into the laser light, even while wearing protective eyewear.
- Label the service rooms clearly to avoid unexpected entries during service operations.
- Limit entry to the treatment or service room only to trained employees
- Cover windows and other openings in the service room
- Take off reflective objects, such as jewelry, bracelets, rings or watches, which could reflect the laser beam to an area other than the intended service area.
- Put the laser into the Standby mode when the laser is not in use.
- Ensure that everyone present during service procedures knows how to shut down the laser system in case of an emergency.

2.4.2 *Skin hazard*

The skin can resist the higher values of laser energy but also the skin can be burned by a laser beam. If there is a need, the special protection clothing should be used.

If somebody is hurt from the laser beam:

- Turn off the laser device
- Immediately ask for a physician's assistance
- Inform the responsible person in charge of laser maintenance and safety

Warning: *The MH01 laser radiation is invisible to the human eye and can cause third degree burns.*

2.4.3 *Electrical hazard*

Warning: *Even when the laser is turned off and the AC line cord is disconnected, High DC Voltages on various laser components, such as capacitors bank may exist. This can present a potentially fatal electrical hazard during service procedures. Proceed with caution!*

Take the following precautions to avoid an electrical shock during the service:

- Always turn the laser off and disconnect the AC line cord from the receptacle before removing the protective cover of the laser system.
- With the laser turned off, allow the dump resistors to dissipate the energy in the capacitor bank to a safe level, approximately 45 seconds. Monitor the voltage on the capacitors bank with a DVM probe to ensure the safe level and check if HV charging indicator, close to capacitor bank, is still blinking. Wait for its complete power off. If you are still not sure, ground the capacitor bank with a shorting stick for at least five seconds.

 **Warning:** *Do not attempt to short it directly (i.e. with a screwdriver) or a potentially fatal electrical shock can occur.*

- If it is necessary to test or adjust any electrical component while the system is on, be careful not to touch any electrical components with bare fingers. Use only appropriate probes, insulated tools or insulating HV gloves.
- Become familiar with the electrical schematics and layouts of the system before attempting to provide the technical service.
- If the AC must be connected during the service routines, be very cautious around mains connected components, such as power supply feeds, circuit breakers, key switches, etc.

 **Warning:** *In case that the laser system must be tested opened, take care that hands or metals are not placed inside the system. After testing the system, make sure that all the panels are appropriately closed.*

2.4.4 *Fire hazard*

The laser radiation of this device is able to melt, burn or vaporize almost all the materials.
Fire hazard can occur due to the nature of the laser treatment. The absorption of emitted laser energy, no matter how shallow, may raise the temperature of any material. Certain precautions are required against the risk of combustible materials in and around the working area (ex. alcohol, gasoline, drapes or any other ignitable materials, etc.). It is recommended that a fire extinguisher is present in the proximity of the laser system.

When the laser beam contacts any exterior surface, the surface absorbs the laser energy, which raises the surface temperature, whether the surface is skin, hair, clothes or any flammable substance. Service personal must take the following precautions:

- Keep a minimum amount of any combustible materials (e.g. alcohol) in the service room. If it is possible, stock them away from the operating area during the technical service.
- Always keep a small fire extinguisher and water in the service room.
- Never direct the laser beam onto any surface except a power meter or an appropriate beam dump.

2.4.5 *Hot water hazard*

The laser system uses a cooling circuit to cool down the laser medium. Especially after long sessions or powerful treatments this cooling water can be very hot and could cause scalding injuries.

- Do not perform any maintenance on the water system while it is hot.
- Always let the system cool down before changing the water filter or deionizer or before adding demineralised water.

2.4.6 *Emission of toxic gas or vapor*

 **Warning:** *The laser radiation emitted by this laser device can melt, burn or vaporize all type of materials.*

2.5 Environmental precautions

Follow the environmental requirements to properly maintain the laser system.

 **Warning:** *Warm air may adversely affect the performance of the cooling unit.*

- Most of the heat dissipated by the laser exits on the rear part. If the laser is used in conjunction with air-cooling, place the cooling unit away from the rear part of the laser.
- Make sure that any warm air that may deflect from the laser is kept away from the cooling unit as well.
- Keep the air free of corrosive substances, such as salts and acids. These pollutants may damage electrical wirings and optical surfaces.
- Keep dust and hair particles to a minimum possible level. Shave patient's skin in a separate room.
- Dust and hair particles can cause permanent damage to optical components.
- Keep humidity in the laser room in the range 30% -85%.
- Keep the operating room temperature from 10° to 25°C: use of the laser at maximum power and room temperature higher than 25 °C can lead to immediate stop of operations due to over temperature interlock or inner components' damage.
- Do not place the laser unit close to heating vents or other sources of temperature variation.

3 DEVICE DESCRIPTION AND INSTALLATION

3.1 Laser System Overview

For servicing procedures, it is useful to identify three main sub-systems composing the MH01 laser system.

1. **ELECTRIC SYSTEM,** which comprises:
   - **Power Electronics:** basically an high voltage power supply, which converts and rectifies the AC mains current to provide regulated power for the flash lamp simmer current and main triggering pulse.
   - **Control Electronics** with touchscreen display, which regulates the functions of the laser and allows parameter selection by the user.

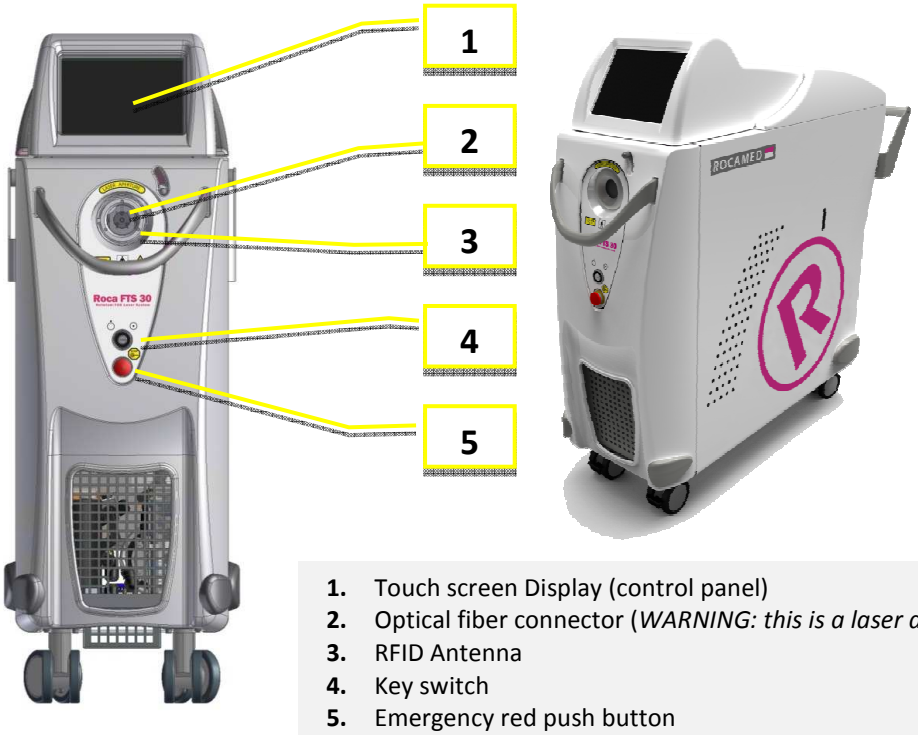
2. **COOLING SYSTEM**, consisting of an internal water flow circuit together with water-to-air heat exchanger to cool off the device, which is monitored by control electronics. The water cooling is absolutely necessary to remove the heat generated in the pumping chamber in order to avoid damage to the pumping chamber's components.

3. **OPTICAL SYSTEM**, which comprises:
   - **Ho:YAG laser source,** based on a Ho:YAG rod, capable of generating laser pulses at 2100 nm with a frequency up to 25 Hz. This is located on the **optical bench** in the inner upper part of the system.
   - **Optical delivery system**, transmitting the energy from laser to patient via an **optical fiber**. The fiber is connected to the laser source via a special SMA connector. A mechanical switch is depressed when the fiber is attached, allowing use of the laser. If the switch is not depressed, the laser cannot operate (this triggers the "alarm fiber" condition).

*The **OPTICAL, ELECTRIC and COOLING SYSTEMS** are described in **Chapter 5, 6 and 7**, respectively.*

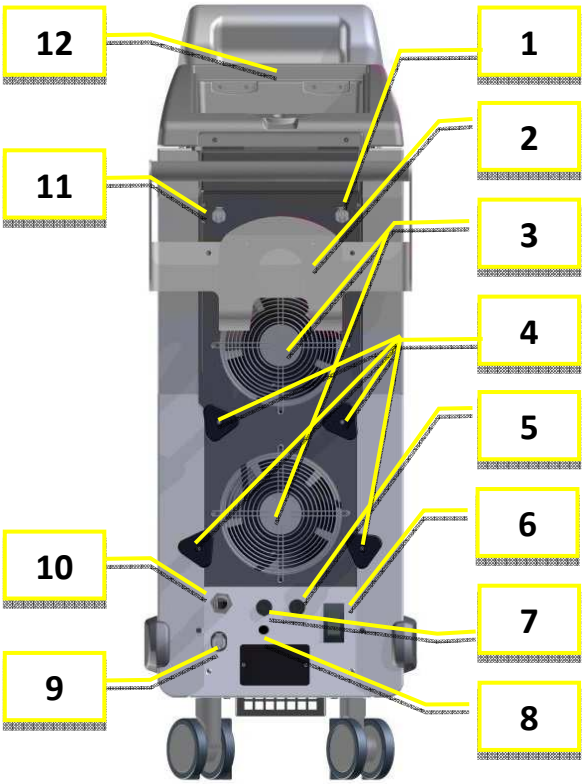
In this Chapter the Device main components and connections are described.

3.1.1 *Device front view*



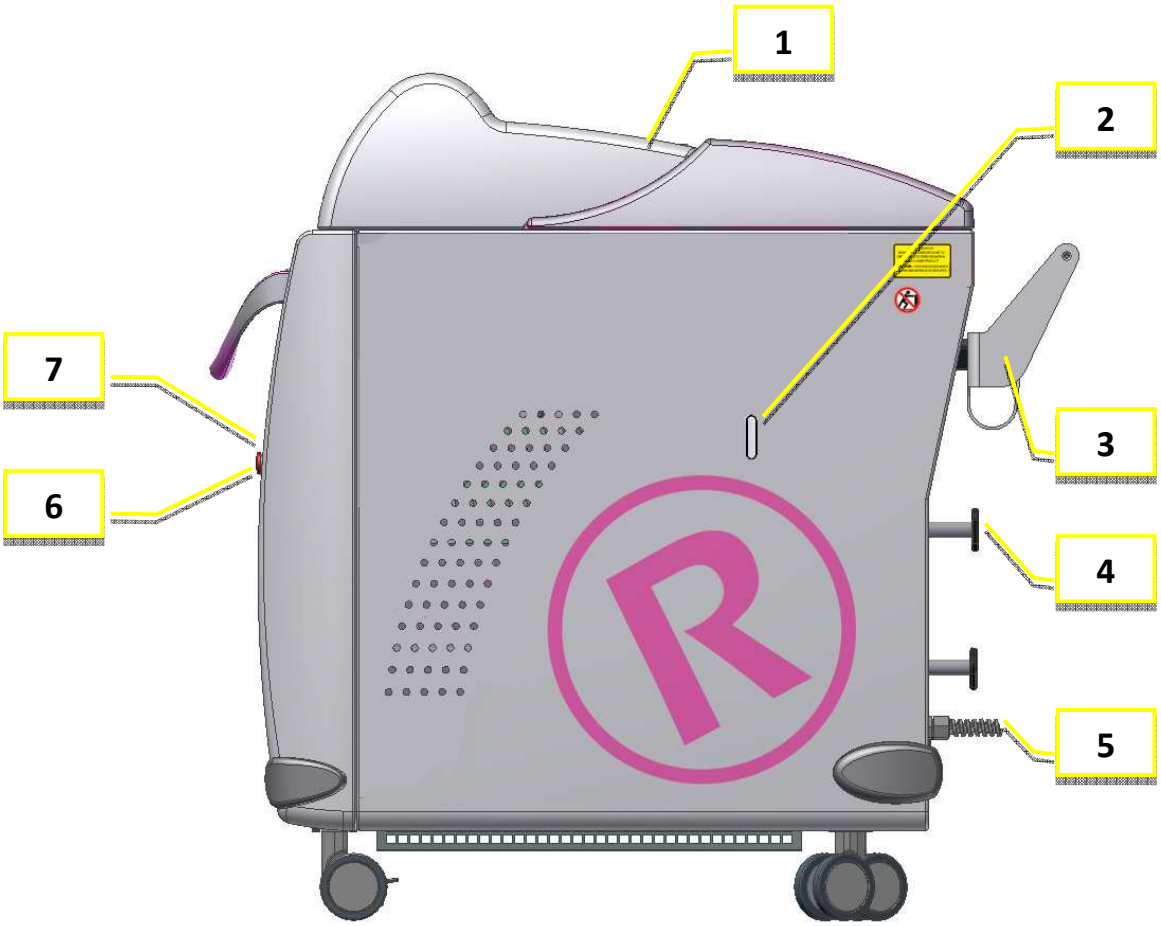
1. Touch screen Display (control panel)
2. Optical fiber connector (*WARNING: this is a laser aperture*)
3. RFID Antenna
4. Key switch
5. Emergency red push button

3.1.2 *Device rear view*



1. Hydraulic circuit loading connector
2. Fiber Box support
3. Fans Area
4. Cord storage
5. Footswitch connector
6. Power/mains switch
7. Interlock connector
8. ROCAMED ENDOFLOW® Connection
9. Hydraulic circuit drain connector
10. Power supply cord
11. Bleeding
12. Blast Shield Access

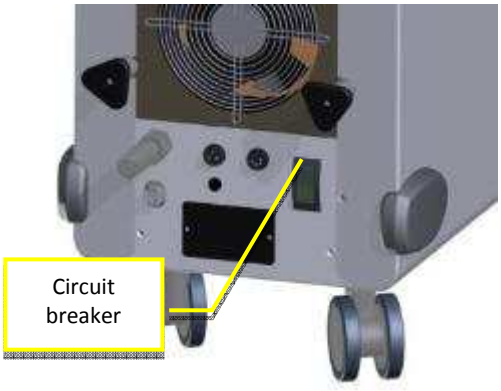
3.1.3 *Device side view*



1. Blast Shield Access
2. Water Level
3. Fiber Box support
4. Cord storage
5. Power supply cord
6. Emergency red push button
7. Key switch

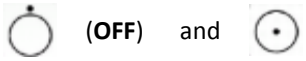
3.2 Device Power Controls

The device power controls include the **circuit breaker** (on the rear panel), the **key switch** and the **red emergency push button** (on the upper front panel of the device).
The **footswitch**, connected on the rear panel of the device, enables laser emission when the system is in READY mode.



- **Circuit Breaker**
  The circuit breaker feeds the Device. There are two positions on the switch: I and O. To switch the device on, put the switch to I position. To switch the device off, put the switch to O position.

- **Key Switch**
  The key switch turns the device on. There are wo positions of the switch:

 (**OFF**) and (**ON**).

To turn the device on, insert the key and turn it to the **ON** position. To turn the device off, turn the key to the **OFF** position and remove the key, in order to prevent unauthorized use of the Device.

- **Emergency Stop Button**
  The emergency stop button allows the immediate shutdown of the device. In case of an emergency, push the emergency stop button. To reset the emergency stop button, twist and pull it out.

3.3 Installation Procedure (for the Distributor or the Authorized Personnel)

WARNING!
The technical assistance and service of MH01 must be restricted by qualified personnel only.
It is recommended that all the external staff that are in contact with the device must be informed about all the safety standards.

IMPORTANT!
Condensate accumulation may cause damage to the laser device.
Always allow a cooled laser device (e.g. after being transported) to warm up in the operating room under the required ambient conditions for several hours before its use.

WARNING!
Equipment not suitable for use in potentially explosive atmospheres.

IMPORTANT!
Check that the line/mains voltage is the same as the voltage specified on the identification plate. Connect the device only with the supplied power cable or a power cable meeting the same specifications.
Make sure that the vent slots are not blocked.

The installation procedure must be performed each time the device is installed for the first time or after being transported by means of cars, elevators, trucks, air cargo, etc.
During installation the device must be checked for proper operation and possible malfunctions after transportation of the laser device must be corrected.
The installation procedure includes also a training course from the distributor to the user concerning the use of the medical device.

The first turn on procedure typically takes several hours, during this time the access to the installation site is forbidden. The case is normally shipped to the distributor.

It is extremely important that the packed materials be checked immediately upon their arrival, if possible, in the presence of the shipper's delivery employee, as follows:

- Open the packaging and put the laser device in a proper site for a general check.

- Execute the following operations for the general check:
  - Check the labels of the device
  - Remove the label "Caution no water inside"
  - Connect the remote door interlock (rear panel)
  - Connect the footswitch (front panel of the device)
  - Fill the system cooling liquid **with bidistilled or deionized water only**
  - Connect the laser device to the power supply
  - Turn on the system
  - Check the system and verify if alert messages are displayed
  - Connect the RFID Fibers and wait that the MH01 system recognizes type and the number of uses of employed fibers

- Check the system and verify if alert messages are displayed
- Change the status of the MH01 laser system in Ready
- Check the system and verify if alert messages are displayed
- Change the status of the MH01 laser system in Standby
- Turn off the system

- After the general check:
  - Remove the optical fiber
  - Remove the footswitch
  - Remove the interlock
  - Remove the key

  Note: *ROCAMED advises wrapping the device with a large quantity of protective plastics.*

  Note: *The shipment of device to the final destination of the customer is under the responsibility of the distributor.* ROCAMED *is not responsible for possible damage caused during this phase.*

- Install the device in the room indicated by the customer in the following way:
  - Connect the device to the power supply
  - Connect the interlock connector
  - Connect the footswitch
  - Check the laser device

- Perform further controls or additional tests.
- Perform a training to the end user on the following items:
  - Proper fiber attachment
  - Operation of the device

  WARNING: *Do not start any action with the laser device before the official personnel have performed the installation procedure. The warranty is not comprehensive of any damage to the laser device before the installation.*

3.4 Set-up Procedures

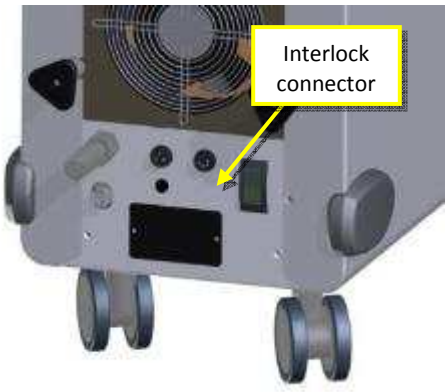
Warning: *To avoid risk of electric shock, this equipment must only be connected to a supply mains with protective earth.*

NOTE: *Arrange the connection lines for power supply, footswitch, door contact and laser fibers in such a way that they do not represent a risk of stumbling or any other potential hazard.*

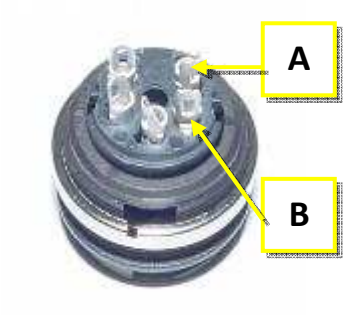
3.4.1 *Remote interlock connection*

The MH01 Laser Device is equipped with a remote door interlock connection (following the IEC/EN 60825-1 Standard), which prevents emission of laser radiation when the access door to the treatment area is open.

A suitable micro-switch has to be wired to the remote door interlock cable and mounted on the doorframe so that a contact closure is activated when the door to the treatment room is closed.
Before operation, check that the remote door interlock cable leading to the door-mounting micro-switch is connected to the remote door interlock receptacle on the back of the laser unit. In case of multiple access doors, each one has to have its dedicated switch, all of them sequentially connected.



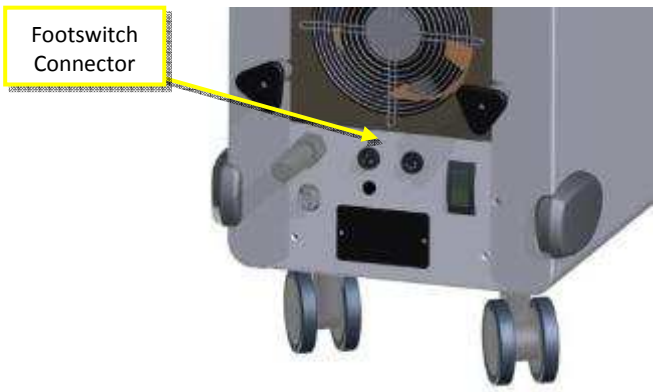
The interlock connector (male) is connected to the device in the following way:



The external micro-switch shall be connected to contacts A and B.

3.4.2 *Footswitch connection*

The footswitch is used to start the laser emission.



Double (Options) or Single pedal
Connect the footswitch to the dedicated device socket (rear panel).

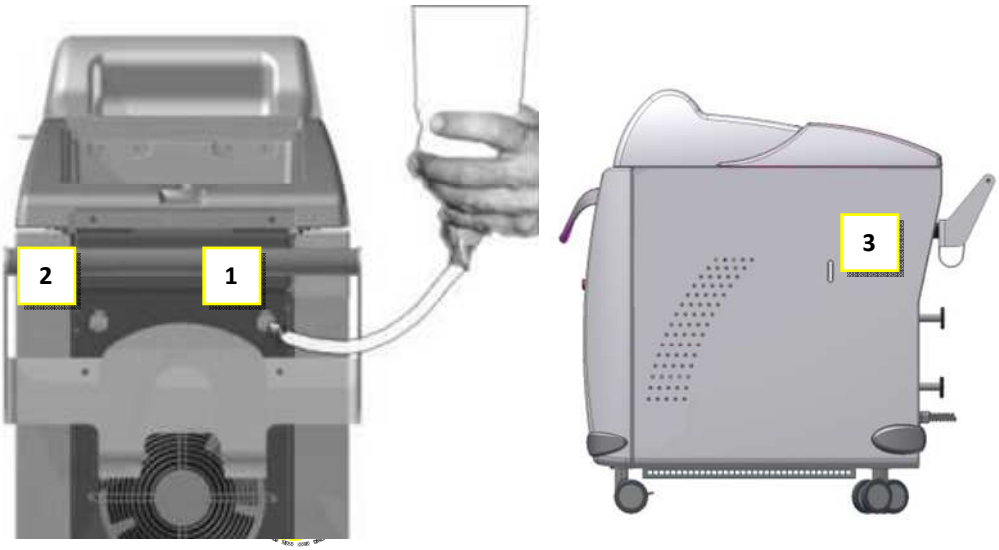
3.4.3 *Filling the Hydraulic Circuit*

Warning: *Use only bidistilled or deionized water.*

The procedure for filling the hydraulic circuit is the following:

- Turn ON the system
- Insert the blue tube supplied in the bleeding connector **(2)**
- Insert the suitable bottle with the previously filled bidistilled or deionized water to the quick hydraulic circuit loading connector **(1)**
- Check for the water level on graduate scale on the left side of the system **(3)**
- Fill the water tank over the minimum (MIN) level
- Do not exceed the maximum (MAX) level
- Remove the bleeding tube after the filling

WARNING: *Do not activate the system with the bleeding tube connected.*



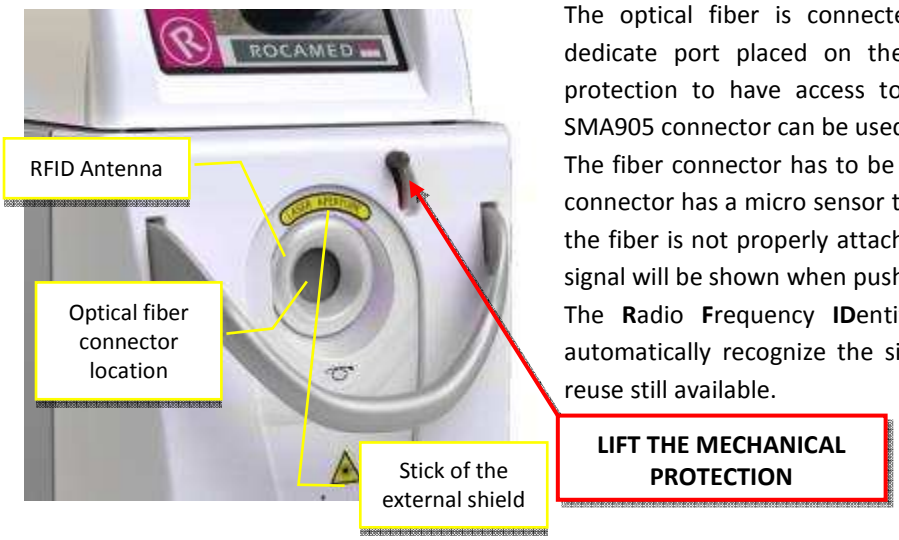
IMPORTANT! *Check periodically the water level using the graduate scale and refill as necessary following the above instruction.*

3.4.4 *Emptying the Hydraulic Circuit*

The procedure for emptying the hydraulic circuit is the following:

- Turn off the System
- Insert the blue tube supplied in the water drain connector **(4)**
- Place a container to collect the water released from the tube
- When the emptying is over remove the tube and push in red cap to close the Air Purge

3.4.5 *Optical Fiber Connection*



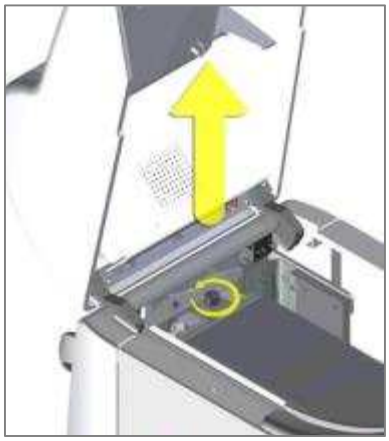
The optical fiber is connected to the laser device through a dedicate port placed on the front panel: lift the mechanical protection to have access to the fiber place (only fibers with SMA905 connector can be used with MH01).

The fiber connector has to be tighten clockwise until it stops. The connector has a micro sensor that prevents the use of the device if the fiber is not properly attached. In this case on display an alarm signal will be shown when pushing the footswitch.

The **R**adio **F**requency **ID**entification (RFID) system is able to automatically recognize the size of the fiber and the number of reuse still available.

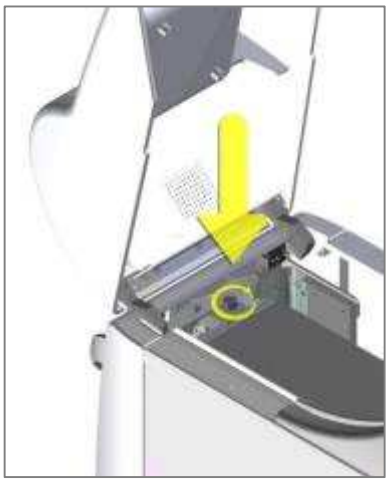
3.4.6 *Blast shield replacement*

Warning: *This operation must be done with clean hands and extreme caution to avoid optical damage of the device.*



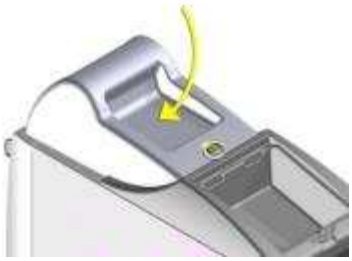
The blast shield replacement must be executed in the following way:

1. Turn the device off, disconnecting the equipment from mains
2. Open the Upper cover with the dedicated key to access to the blast shield area
3. Remove the blast shield unscrewing the knob



4. Check the protective glass for any visible damage
5. In case of damage, substitute the whole blast shield paying attention not to touch the protective glass with hands.

6. Close the protective door screwing well the doorknob
7. In case of assistance, please contact Service Department.



3.4.7 *Removing the System Covers*

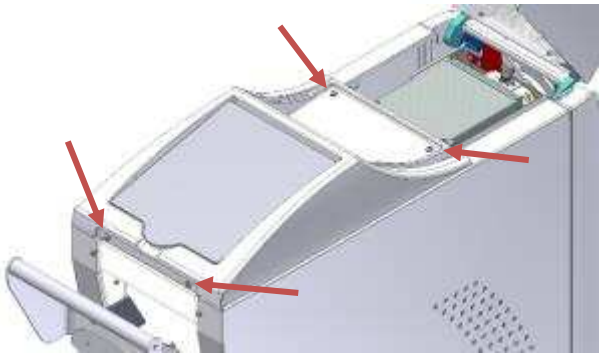
The OPTICAL, ELECTRIC and COOLING systems can be reached by removing the external cover panels of the laser device.

Warning: *Only trained and authorized Service Personnel can remove the external cover panels and access to the internal part of the device.*

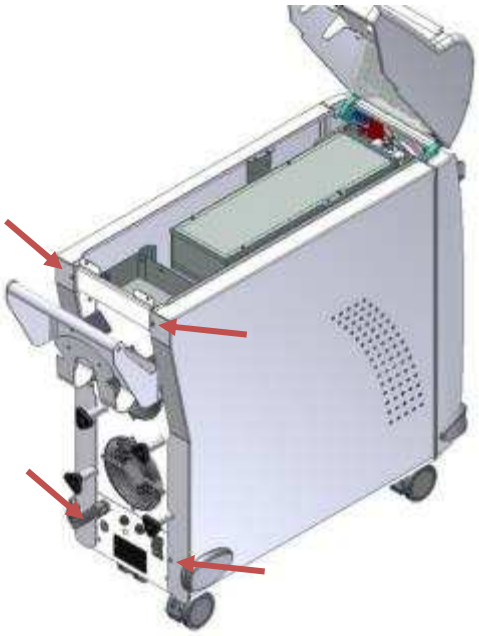
Please, refer to the instruction below for removing the System covers:

1. Remove the optical fiber from the front panel and its mechanical support (stick and spring) from the upper panel

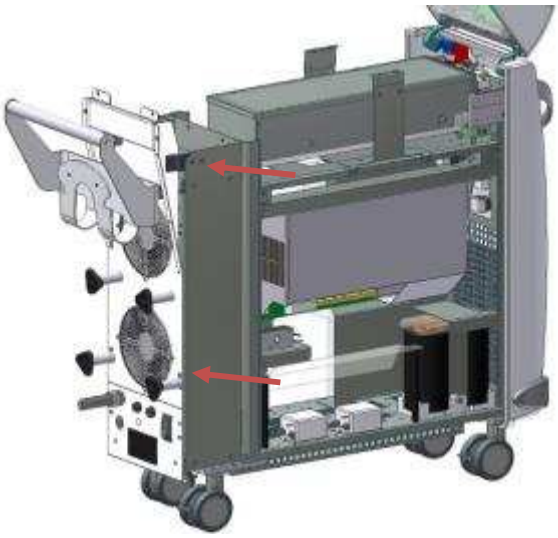
2. Lift the front cover panel (with the touchscreen display) and unscrew the four fixing screws of the rear upper cover



3. Remove the side panels by unscrewing the four fixing screws (two for each side), as shown in the figure

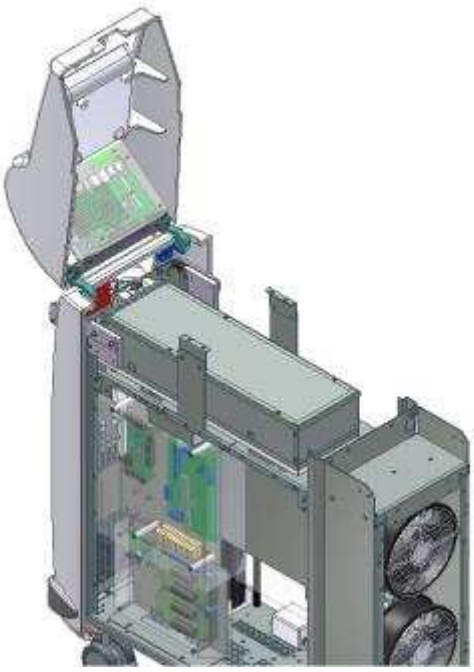


4. Remove also the rear panel by unscrewing the fixing screws shown in figure



5. System bare structure without the upper, side and rear panels.

   For the location of the internal optical, cooling, power and control electronics components, please refer to Figure 3.2 and to the corresponding Chapters.



In Figure 3.1, the location of the Microswitch controlling the position of the upper front panel is shown, while Figure 3.2 highlights the location of each sub-system inside the device.

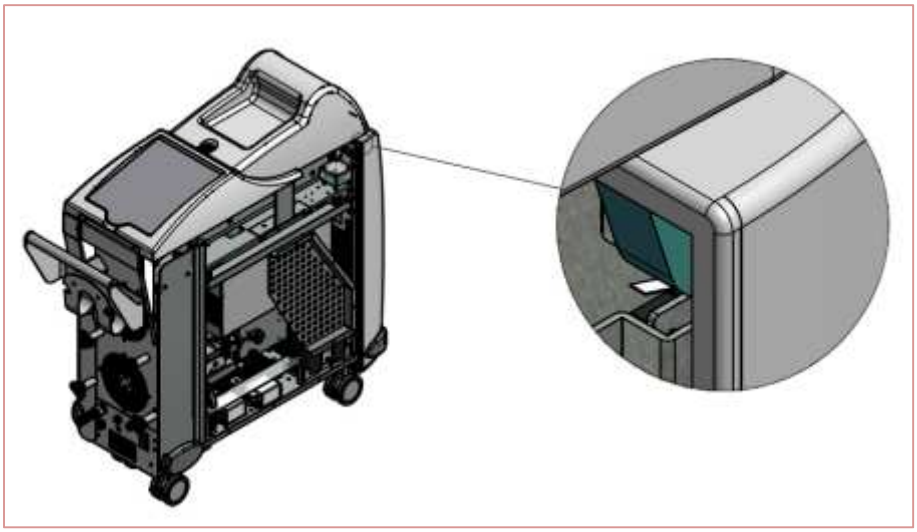


Figure 3.1: Position of the microswitch for the upper cover panel.

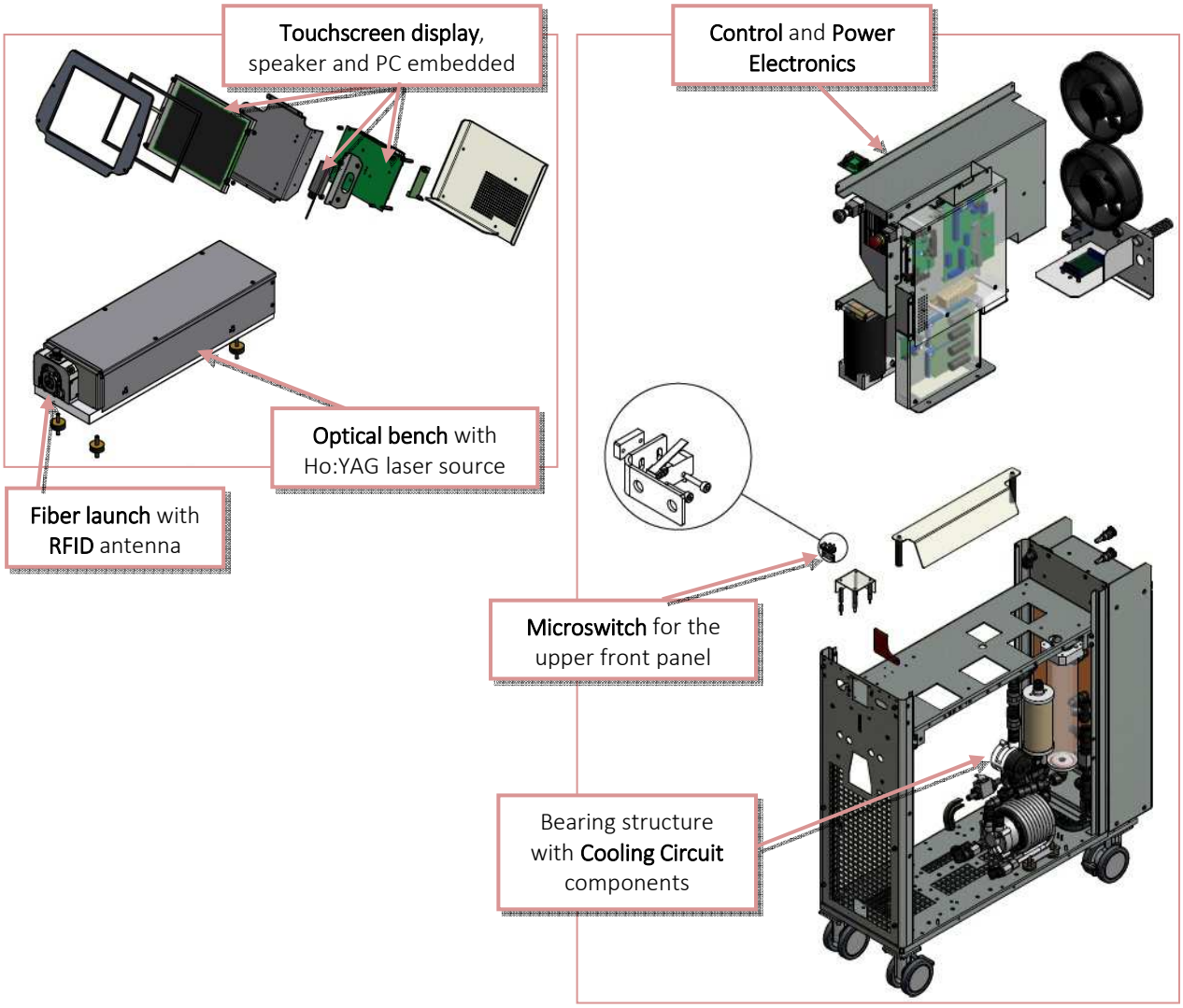


Figure 3.2: Inner part of the MH01 laser system. The optical, cooling, power and control electronics sub-systems are shown.

3.4.8 *Laser first start-up*

Check the laser device, calibration and standard operation:

- Follow procedure given in Chapter 4 for start-up the laser;
- Check the correct operation of key-switch and emergency button;
- Check the laser operation as follows:
    - Select Lithotripsy Application and press OK.
    - Wait few seconds till the main screen will appear. In case of Alarm, please refer to Troubleshooting Chapter. Be sure also that the aiming beam exits from the optical fiber.
    - If the aiming beam is not seen, the fiber may not be well inserted or it is defective. If defective, the fiber should not be used anymore.
- Select 600 μm optical fiber
- Go in Ready mode: do not press the footswitch at this stage but simply check the system operation at different settings (changing frequency and energy).
- If energy warning HIGH or LOW is displayed, go to Troubleshooting Section
- If everything is OK, press the footswitch and check the laser emission from the optical fiber.
- Do not fire the laser immediately at the maximum power but check emission starting from lower output power levels and increasing step by step.
- If everything is OK, use an external power meter to compare the energy settled on the display with the one coming out from the optical fiber. As reference, perform the energy measurements reported in the Optical test of the Product Sheet of the system.

Example

Optical test **Configuration: Lithotripsy** **Test fiber: 600 µm**	
PRF(Hz)	**Displayed energy**
	1 J
10	**Measured energy**

- If the measured energies are low or don't match with the displayed ones (±20%), go to Troubleshooting Section (a fiber realignment procedure could be necessary)
- Perform further controls or additional tests
- If everything is OK, turn off the system and complete the Installation Check Sheet.

4 OPERATING INSTRUCTION

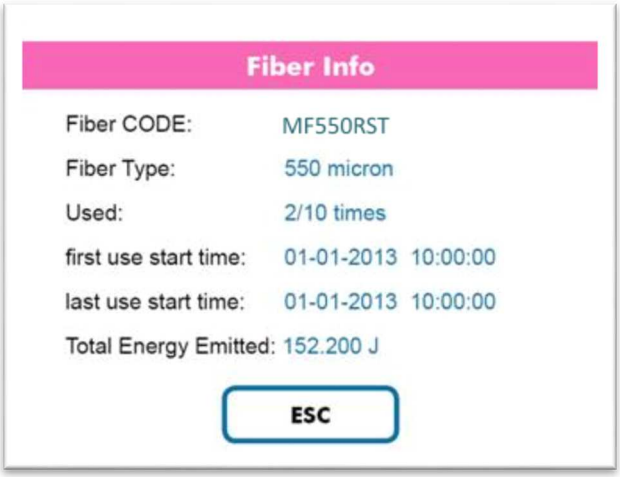
4.1 USER MODE: Start up procedure

Assuming that the set up procedure has been completed:

- Be sure that the red emergency push button is unpressed
- Switch on the main switch on the rear panel
- Turn the key (clockwise) in order to start up the system

The Loading screen appears:
After a few seconds the main screen will be displayed.

Connect the fiber. The system recognizes automatically type and uses of the fiber connected showing the information data on the display *(in the example first use of a reusable 550 µm fiber)*:

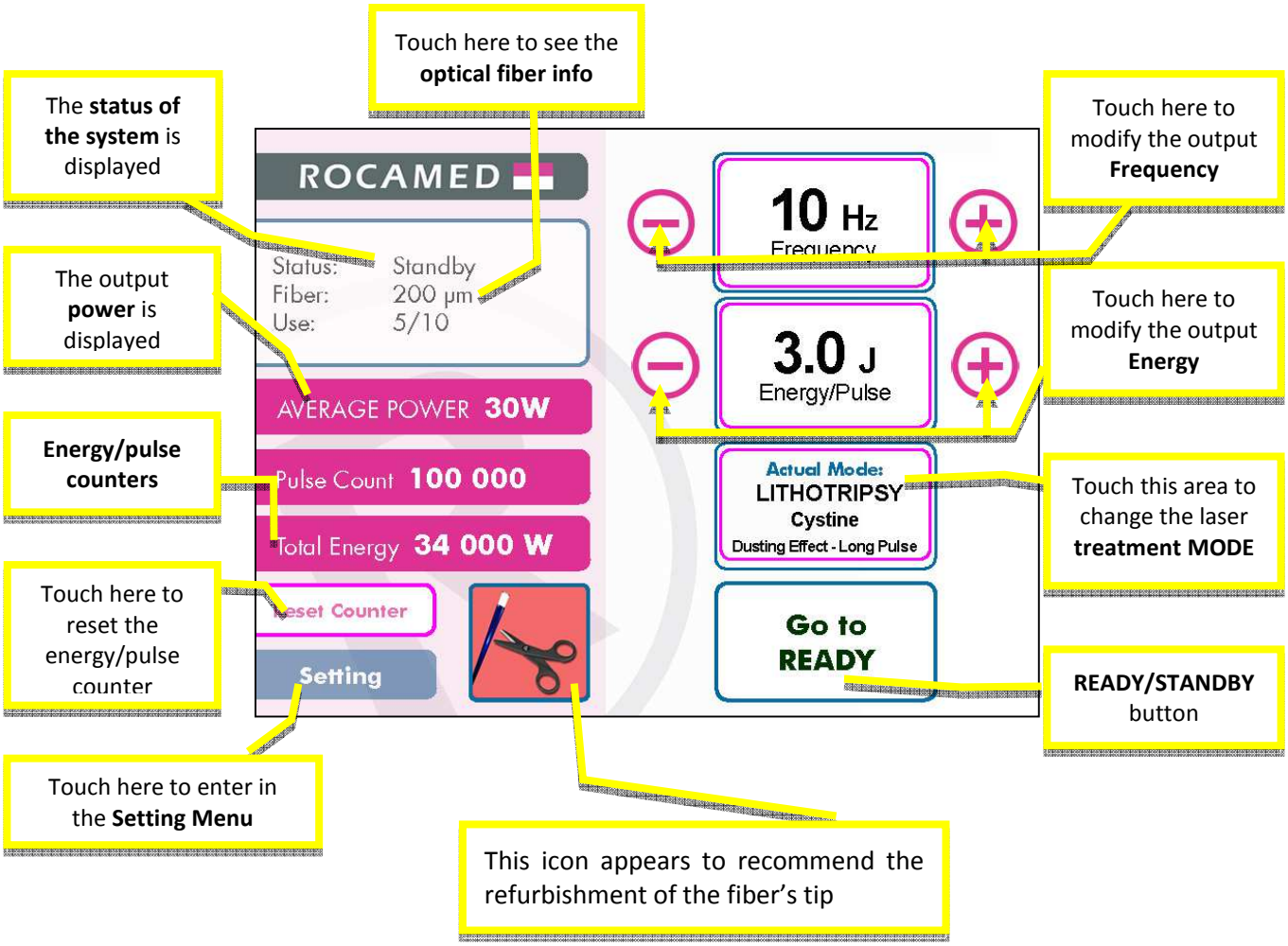


Warning: *The optical fiber size visualized on the display must be the same of the used optical fiber size. Before starting the laser emission, please control that the optical fiber size matches with the indications impressed on the connector of the fiber.*

After a few seconds the main menu will be present the main screen.

4.2 Main Screen

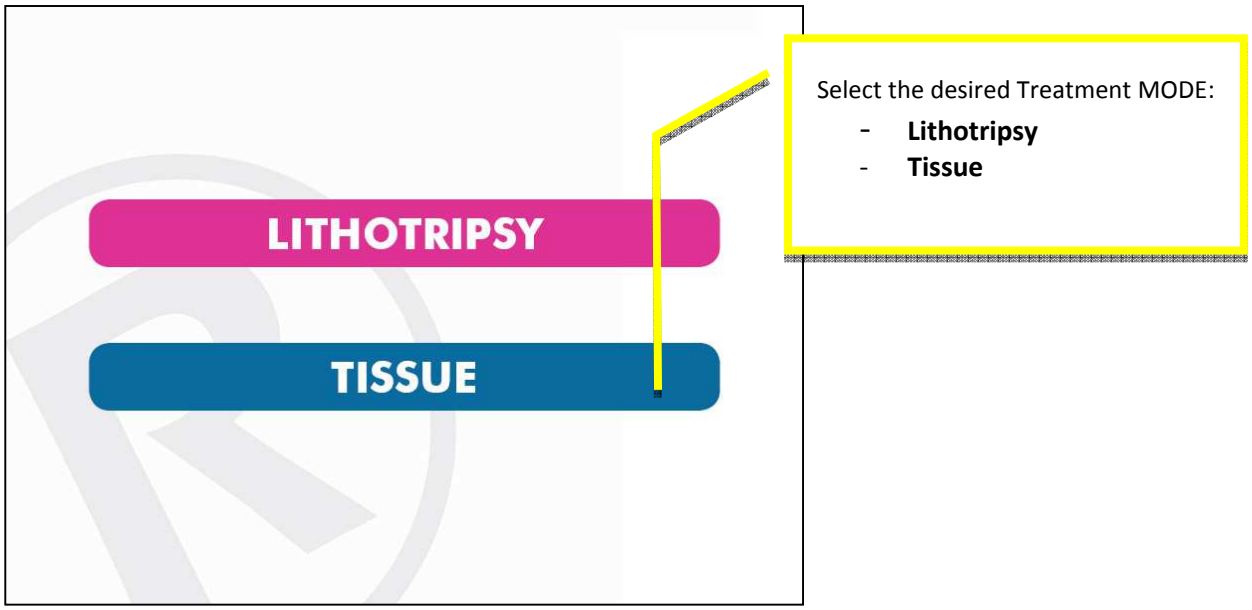
The Main Display Screen functions are detailed in the Figure below.



The Main Display Screen contains the controls and displays the parameters for operating and monitoring the laser. It is essential that the Operator understands and uses these controls properly.

4.2.1 *Mode*

Press THE MODE Area to change the treatment. The following screen shows up:



4.2.2 *Frequency*

The repetition rate is selected touching the frequency area: it can be ***increased /decreased*** by touching the **» / «** button. The laser sound emission will changes accordingly.

If the energy set is too high for the selected frequency, the laser will automatically decrease the value of pulse energy.

4.2.3 *Energy*

The treatment energy available is displayed on the screen. It can be ***increased /decreased*** by touching the **» / «** button.

If the energy set is too high for the selected frequency, the laser will automatically decrease the value of pulse energy.

4.2.4 *Fiber INFO*

When a RFID ROCAMED Fiber is connected and the RFID system is active, the system recognizes the type of the fiber and any of the previous uses. When the RFID System recognizes the fiber the Info Fiber Panel will appear. If a non-authorized fiber is connected, the RFID system will not recognized it. If an expired Optical Fiber (disposable/reusable) is connected to the laser system, an error message will appear.

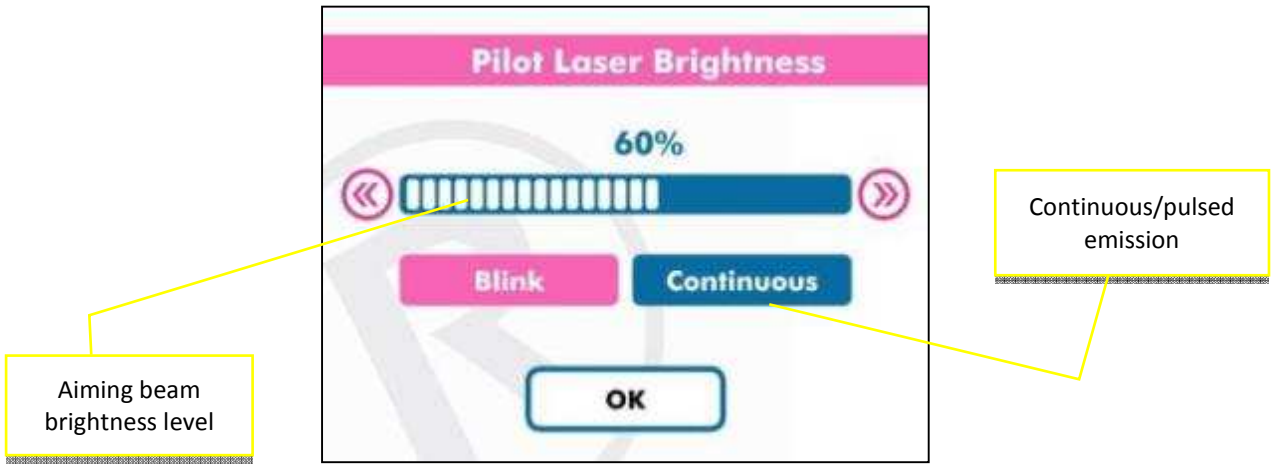
Pressing on the fiber info area the Fiber Info Panel will appear, where the following information are displayed:

- Code of the fiber
- Fiber Type
- Uses
- First use time (data)
- Last use time (data)
- Total Energy emitted (J)

Press ESC to return to the main Screen.

4.2.5 *Pilot laser*

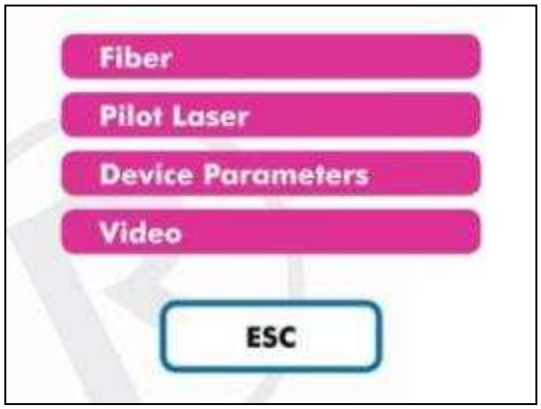
The aiming beam brightness is adjustable by software from a minimum value of 1% to a maximum of 100%. It is also possible to select the aiming beam emission mode as “pulsed” (“blink”), or “continuous”.



When the aiming beam emission corresponds to your desire, press OK to confirm and return to the main screen.

4.3 **Setting Menu**

When pressing on the SETTING button, following panel will appear, where the User can enter one of the following functions:



- **Fiber ***
- **Pilot Laser Brightness**
- **Device Parameters** (see next Section)
- **Video** (tutorial)

*NOTE: It is possible to access the “Fiber” information, “Pilot Laser Brightness”, also by using the shortcut area from the Main Screen.

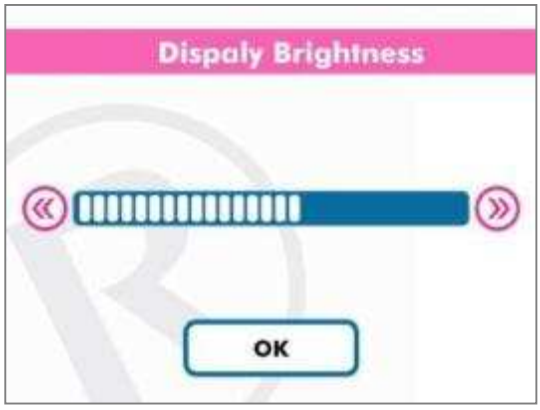
Press “Esc” to exit to the Main Screen.

4.3.1 *Device Parameters*

The available functions in the Device Parameters panel are the following:

- **Service** (Only for Technical Service) – See **Section 4.8**
- **Display**
- **Audio**
- **Device Info**
- **Language**

Press “Esc” to return to the Main Screen.



Display:

The display brightness can be increased/decreased by touching buttons » / « .
Press OK to confirm and return to the main screen.

Audio:

The Volume is adjustable by software from a minimum value of 1% to a maximum of 100%, by touching buttons » / « . It is also possible to activate or deactivate the keyboard sound by the Key Sound button.
Press OK to confirm and return to the main screen.

Device Info:

The Device Info Panel shows the following information:

- Device Number
- Firmware Version (FW)
- Software Version (SW)
- Hardware Version (S)
- Flash Lamp Usage

Press “Esc” to return to the Main Screen

Language:

Select the desired language and press ESC to return to the main screen.

4.4 Laser emission

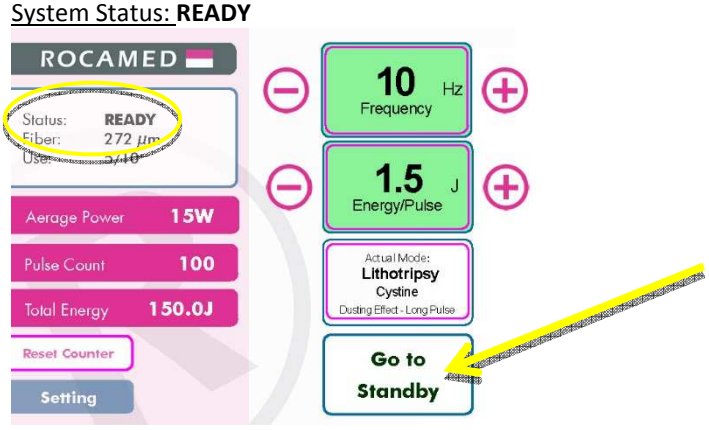
Once selected the suitable values for the working parameters, the User can start the laser emission as follows.

Press the READY/STANBY button area or push the dedicate pedal of the double footswitch (optional), changing the status from STANDBY to READY.

- System Status: **STANDBY**

Touch the READY/STANDBY button to enter in **READY** mode.

- System Status: **READY**



Touch the READY/STANDBY button[1] to enter in **STANDBY** mode.

IMPORTANT: *Please read the Chapter: 2 - LASER SAFETY before continuing using the laser!*

Along with the first change from Standby to Ready mode the **Warning Safety Screen** will appear:

Touch the display to exit from the "Warning Safety Screen".

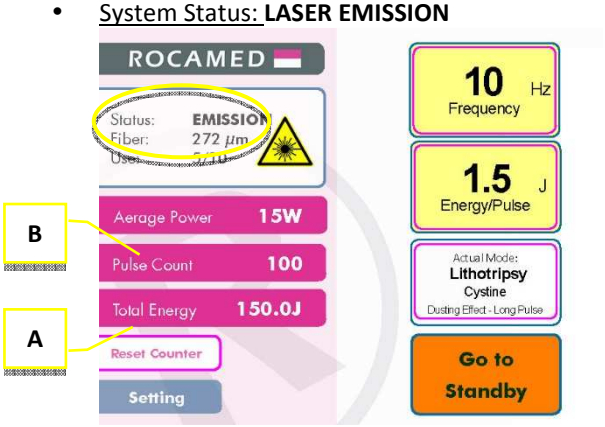
When an Optical Fiber is connected and the *RFID system is active*, the system will display the type of the fiber before passing from the Standby to the Ready Status.

NOTE: If the fiber is missing or an invalid fiber is inserted, when touching the READY/STANDBY button a popup Error Message will appear (see Alarm and Warnings Section).

In READY mode it is still possible to change the laser output parameters, energy and frequency, by the dedicate buttons.

[1] The dedicated button of the double footswitch can be used to change the system status from STANDBY to READY and vice versa. The footswitch (only with double footswitch – Optional) or the READY/STANDBY display area can be used interchangeably for the same function.

- System Status: **LASER EMISSION**



In READY mode, laser emission is enable by pressing the footswitch. The output values of frequency/energy are shown on the display.

Warning: *All the personnel present in the laser working area must wear all the protective items.*

During the emission the values of Total Energy **(A)** emitted and Lasing Time **(B)** will increase.

At the end of the treatment, release the footswitch and enter in STANDBY mode by pressing the READY/STANDBY area on the display, or the dedicated pedal of the double footswitch (optional):

For starting a new treatment press the READY/STANDBY button on the display, or the dedicated pedal of the double footswitch (optional).

NOTE: *If the footswitch is left unused for a long time in READY mode the laser device will enter automatically the STANDBY mode.*

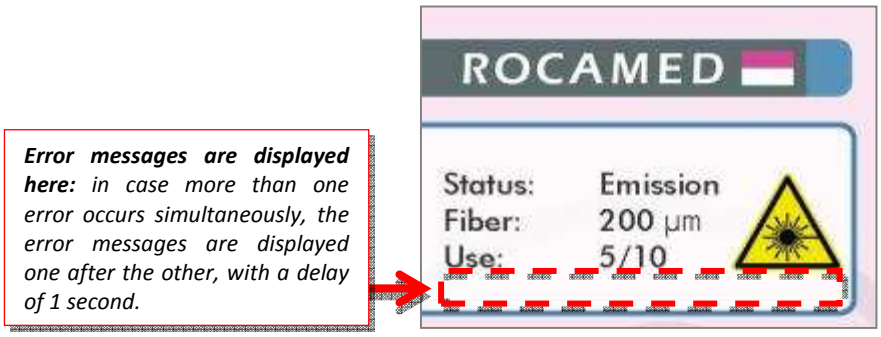
4.5 Shutdown Procedure and Protection Against Unauthorized Use

Once finished using the device and the laser is in Standby mode, you can proceed with its shutdown as follows:

- Disconnect the optical fiber from the device and cover with the appropriate plug the fiber output on the laser device;
- Turn the key switch to position ○ and *remove the key to prevent unauthorized use*;
- On the rear panel, turn the main switch OFF and disconnect the power cable;
- Disconnect the remote interlock;
- Disconnect the footswitch;
- Keep the device and accessories in a dry and safe place.

4.6 Alarms and Warnings

There are different alarms and warnings that could be displayed on the touchscreen, in the system status area under the fiber number of uses (see red dashed area below):



Error messages are displayed here: *in case more than one error occurs simultaneously, the error messages are displayed one after the other, with a delay of 1 second.*

A list of all the possible error messages is reported in the Table 4.1.

IMPORTANT*!*

Some alarms cause the laser system to stop: the power electronics are cut off through a suitable switch and the device is put in a safe mode or is restarted.

Warning: *Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.*

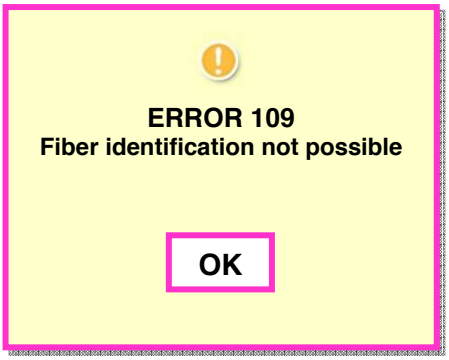
Error Message	Possible Cause	Actions
Flow-switch fault	The flow switch does not work properly.	• Check the impeller of the flow switch and replace the it if needed.
Low water flow	The cooling water flow is too low.	• If water level is low or if water bubbles are present, fill the reservoir with distilled water only. • Check that cooling water flows freely in the circuit. • Check if tubes are truncated or twisted.
Water over-temp.	The temperature of the cooling water is too high.	• Check if the fans are working properly. • If water level is low, fill the reservoir with distilled water only. • Call Service.
Wrong simmer	Flashlamp simmering voltage is wrong.	• Call Service.
No simmer	Simmering error: the flashlamp does not simmer.	• The flashlamp must be replaced. • Call Service.
Remote interlock open	This alarm appears in READY mode. Interlock is not properly connected.	• Please check the Interlock connection. • Try to unplug and plug it in the proper way.
No fiber attached	This alarm appears in READY mode. Optical fiber is not properly connected.	• Please check the fiber connection. • Try to unplug and plug it in the proper way. • Check the blast shield.
MPS over-temperature	Main Power Supply over-temperature error.	• Operating temperature of the laser system must be <30°C. • If Error Message does not disappear with the system in STANDBY mode, call Service.
MPS voltage fault	Main Power Supply has a wrong voltage on the capacitors.	• Call Service.
MPS no end of charge	Main Power Supply not able to fully charge the capacitors bank.	• Call Service.
Shutter off open	The command sent by the microprocessor was “Shutter close”, but the shutter remains “open”.	• Call Service.
Shutter does not open	The command sent by the microprocessor was “Shutter open”, but the shutter remains “close”.	• Check the 24Vdc supplied by the Routing board to the shutter. • Call Service.
Pedal not connected	This alarm appears in READY mode. The footswitch is not connected or it is connected in a wrong way.	• Please check the footswitch connection. • Try to unplug and plug it in the proper way. • Replace the footswitch.
Pedal pressed	This alarm appears in STANDBY mode when trying to enter in READY mode and the footswitch is already pressed.	• Release the footswitch and touch the screen to enter in READY mode.
Energy <80%	This warning appears every time there are energy fluctuations of the order of -20% and it stops when the energy value is stable.	• Wait until the energy set is equal to the output energy. • If the error message persists, call Service.
Energy >120%	This warning appears every time there are energy fluctuations of the order of +20% and it stops when the energy value is stable.	• Wait until the energy set is equal to the output energy. • If the error message persists, call Service.
No energy	Output laser energy too low or even	• If the error message persists, call

	zero.	Service.
Energy >200%	Output laser energy too high. This warning cause the system to stop to prevent dangerous laser energy emission.	• If the error message persists, call Service.
Door Open	This alarm appears in READY mode and forces the system to enter in STANDBY mode: the microswitch of the upper front panel reveals that the openable upper panel is open.	• Close the upper panel. • Check the microswitch. • Call Service.

Table 4.1: MH01 errors list.

For further information, please see the TROUBLESHOOTING Chapter 8.

NOTE: If the fiber is missing or an invalid fiber is inserted, when touching the READY/STANDBY button a **popup Error Message** will appear:



The RFID system is not able to recognize the fiber.

4.6.1 *Buzzer*

The device is equipped with an internal buzzer that emits an acoustic signal with a fixed duration. It is active in READY mode when the footswitch is pressed: the signal is emitted synchronously with the laser pulses.

4.7 Laser Parameters

The following tables provide indications of maximum laser output for each possible combinations,

$$Power\ (W) = Energy\ (J) \times Frequency\ (Hz)$$

The size of the fiber has to be taken in consideration to detect power limits.

	For all fiber dimension*			LITHOTRIPSY – Fragmentation											
	200 mJ	300 mJ	400 mJ	500 mJ	600 mJ	700 mJ	800 mJ	1 J	1.2 J	1.5 J	1.8 J	2 J	2.5 J	3 J	3.5 J	4J
3 Hz				1,5 W	1,8 W	2,1 W	2,4 W	3 W	3,6 W	4,5 W	5,4 W	6 W	7,5 W	9 W	10,5 W	
5 Hz				2,5 W	3 W	3,5 W	4 W	5 W	6 W	7,5 W	9 W	10 W	12,5 W	15 W	17,5 W	20 W
8 Hz				4 W	4,8 W	5,6 W	6,4 W	8 W	9,6 W	12 W	14,4 W	16 W	20 W	24 W		
10 Hz				5 W	6 W	7 W	8 W	10 W	12 W	15 W	18 W	20 W	25 W	30 W		
12 Hz				6 W	7,2 W	8,4 W	9,6 W	12 W	14,4 W	18 W	21,6 W	24 W	30 W			
15 Hz				7,5 W	9 W	10,5 W	12 W	15 W	18 W	22,5 W						
20 Hz				10 W												
25 Hz	5 W	7,5 W	10 W													

	For all fiber dimension*			LITHOTRIPSY – Dusting											
	200 mJ	300 mJ	400 mJ	500 mJ	600 mJ	700 mJ	800 mJ	1 J	1.2 J	1.5 J	1.8 J	2 J	2.5 J	3 J	3.5 J	4J
3 Hz																
5 Hz				2,5 W	3 W	3,5 W	4 W	5 W	6 W	7,5 W	9 W	10 W	12,5 W	15 W		
8 Hz				4 W	4,8 W	5,6 W	6,4 W	8 W	9,6 W	12 W	14,4 W	16 W	20 W			
10 Hz				5 W	6 W	7 W	8 W	10 W	12 W	15 W	18 W	20 W	25 W			
12 Hz				6 W	7,2 W	8,4 W	9,6 W	12 W	14,4 W	18 W	21,6 W	24 W				
15 Hz				7,5 W	9 W	10,5 W	12 W	15 W	18 W	22,5 W						
20 Hz				10 W												
25 Hz																

	For all fiber dimension*			Tissue – Resection/Cutting											
	200 mJ	300 mJ	400 mJ	500 mJ	600 mJ	700 mJ	800 mJ	1 J	1.2 J	1.5 J	1.8 J	2 J	2.5 J	3 J	3.5 J	4J
3 Hz																
5 Hz																
8 Hz				4 W	4,8 W	5,6 W	6,4 W	8 W	9,6 W	12 W	14,4 W	16 W	20 W	24 W		
10 Hz				5 W	6 W	7 W	8 W	10 W	12 W	15 W	18 W	20 W	25 W	30 W		
12 Hz				6 W	7,2 W	8,4 W	9,6 W	12 W	14,4 W	18 W	21,6 W	24 W	30 W			
15 Hz				7,5 W	9 W	10,5 W	12 W	15 W	18 W	22,5 W						
20 Hz				10 W												
25 Hz																

	For all fiber dimension*			Tissue - Coagulation											
	200 mJ	300 mJ	400 mJ	500 mJ	600 mJ	700 mJ	800 mJ	1 J	1.2 J	1.5 J	1.8 J	2 J	2.5 J	3 J	3.5 J	4J
3 Hz																
5 Hz				2,5 W	3 W	3,5 W	4 W	5 W	6 W	7,5 W	9 W	10 W	12,5 W	15 W		
8 Hz				4 W	4,8 W	5,6 W	6,4 W	8 W	9,6 W	12 W	14,4 W	16 W	20 W			
10 Hz				5 W	6 W	7 W	8 W	10 W	12 W	15 W	18 W	20 W	25 W			
12 Hz				6 W	7,2 W	8,4 W	9,6 W	12 W	14,4 W	18 W	21,6 W	24 W				
15 Hz				7,5 W	9 W	10,5 W	12 W	15 W	18 W	22,5 W						
20 Hz				10 W												
25 Hz																

4.8 Service (Only for Technical Service)

The Service Area can be reached by the Main Menu button as follows:

MENU → DEVICE PARAMETERS → SERVICE

This functionality must be used by specialized technicians only, adequately qualified and trained in Laser technology.

- **Insert the Password and press OK to access to the Service Area**, the following screen will appear:

The SERVICE MENU screen contains all the parameters for the physical setting and controlling of the laser source: each application has its own set of laser parameters. To change application press the Button CHANGE APPLICATION. Please refer to the next Section for further details.

4.8.1 *The SERVICE Menu*

The Service General Parameters are listed in this screen:

Before modifying any parameter we strongly suggest to save the current parameters by touching the button SAVE ON FILE at the top of the screen. The saved parameters can be recalled by touching the button READ FROM FILE. These functions are only archive functions and the parameters have no operational utility for the laser:

In order to enable the changes it is necessary to press the button SAVE IN EEPROM.

If any parameter is modified (but not yet saved in EEPROM) the previous parameter value can be recalled by pressing the button READ FROM EEPROM.

In this screen it is possible also to select the energy and frequency of the laser pulses, enter in READY mode (with the button CHANGE STATUS), and enable LASER EMISSION by pressing the footswitch.

All the Service Parameters are listed below. Some parameters in this menu are factory-adjusted and they do not need to be changed: if required, they can be changed upon authorization of* ROCAMED *Service Department. They are indicated with ⃠ symbol.

- **User auto adjust:** This parameter enables the system to auto track the laser energy in the User mode. If enabled (1), the microprocessor compares the energy value set on the touchscreen with the energy acquired by the internal photodiode. Then it adjusts the output voltage of the Compact Power Supply whenever there is a discrepancy between the two energy values (±20%). In this way the energy of the laser beam is always monitored and equals to the set value.

- **Ready always pulsing:** ⃠ It keeps the voltage on the flashlamps at the value needed for the set energy without flashing, till the footswitch is not pressed.

- **Vmin (0-1000):** ⃠ It set the minimum value of the voltage charging the capacitors bench. It is expressed in bits (usually=100);

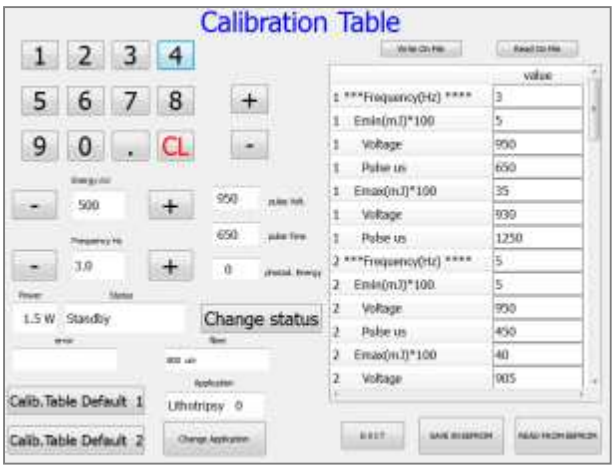
- **Vmax (0-1000):** ⃠ It set the maximum value of the voltage charging the capacitors bench. It is expressed in bits (usually=990);

- **Tmin us:** ⃠ It defines the minimum pulse duration in µs (100).

- **Tmax us:** ⃠ It defines the maximum pulse duration in µs (1800)**.**
- **PHD offset:** ⃠ Correction factor for the energy monitoring photodiode.
- **PHD full scale:** ⃠ It set the saturation energy (full scale) of the photodiode in Joule (5.00 J).
- **Thermaliz. Pulses (us):** ⃠ It defines the pulse duration for the initial, under-threshold pulses, which are used to thermalize the laser system.
- **Thermaliz. Mode:** ⃠ Higher Frequency.
- **V ADC offset:** ⃠ Parameter for the control of the ADC offset.
- **V ADC fullscale:** ⃠ Parameter for the control of the ADC offset.
- **H2O NTC value:** ⃠ Control the water temperature with an NTC resistance.
- **H20 NTC beta:** ⃠ Parameter for the control of the water temperature with an NTC resistance.
- **Reset all service parameters.**
- **Pedal Ready button:** To enable / disable the second button on the double footswitch (if present).
- **EOC polarity:** ⃠ "End Of Charge" polarity. It is used to change the polarity of the capacitors bench charger. In some systems it is used to monitor and control the flashlamps' timing only after the FULL charging of the capacitors.
- **Flow-meter Hz per l/m:** ⃠ Control parameter for the flow meter (if present).
- **Enable overload error:** ⃠ (YES).
- **Enable charger V error:** ⃠ (YES).
- **Energy warning:** ⃠ (YES).

4.8.2 *The Calibration Tables*

If the button **Calibration Table Edit** is pressed the following screen will appear:

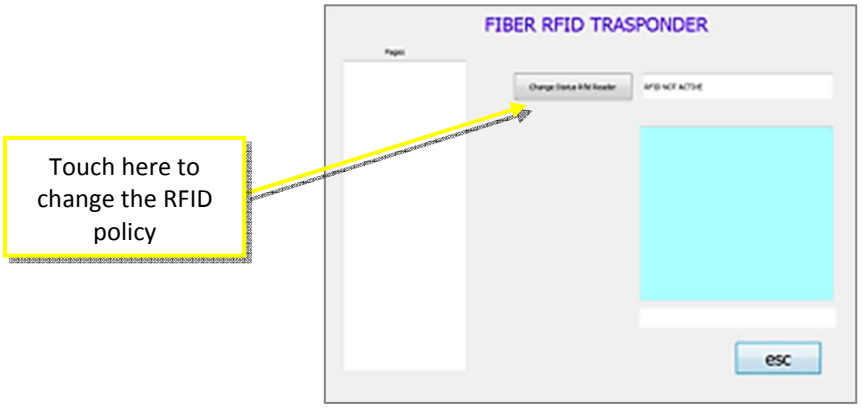


This screen shows the value of the set of parameters (Frequency, Energy, Voltage, Pulse duration) for each application, for ensuring the laser output power indications reported in the tables of Section 4.7 *Laser Parameters.*
As for the SERVICE General Parameters, in order to enable the changes, it is necessary to press the button SAVE IN EEPROM.

4.8.3 *Fiber RFID management (Password accessible area)*

<u>This parameter is Factory-adjusted and is accessible only by inserting a password.</u>

Digit the password “RFID” and press OK to access the RFID status (RFID ACTIVE / RFID NOT ACTIVE):



4.8.4 *Diagnostics*

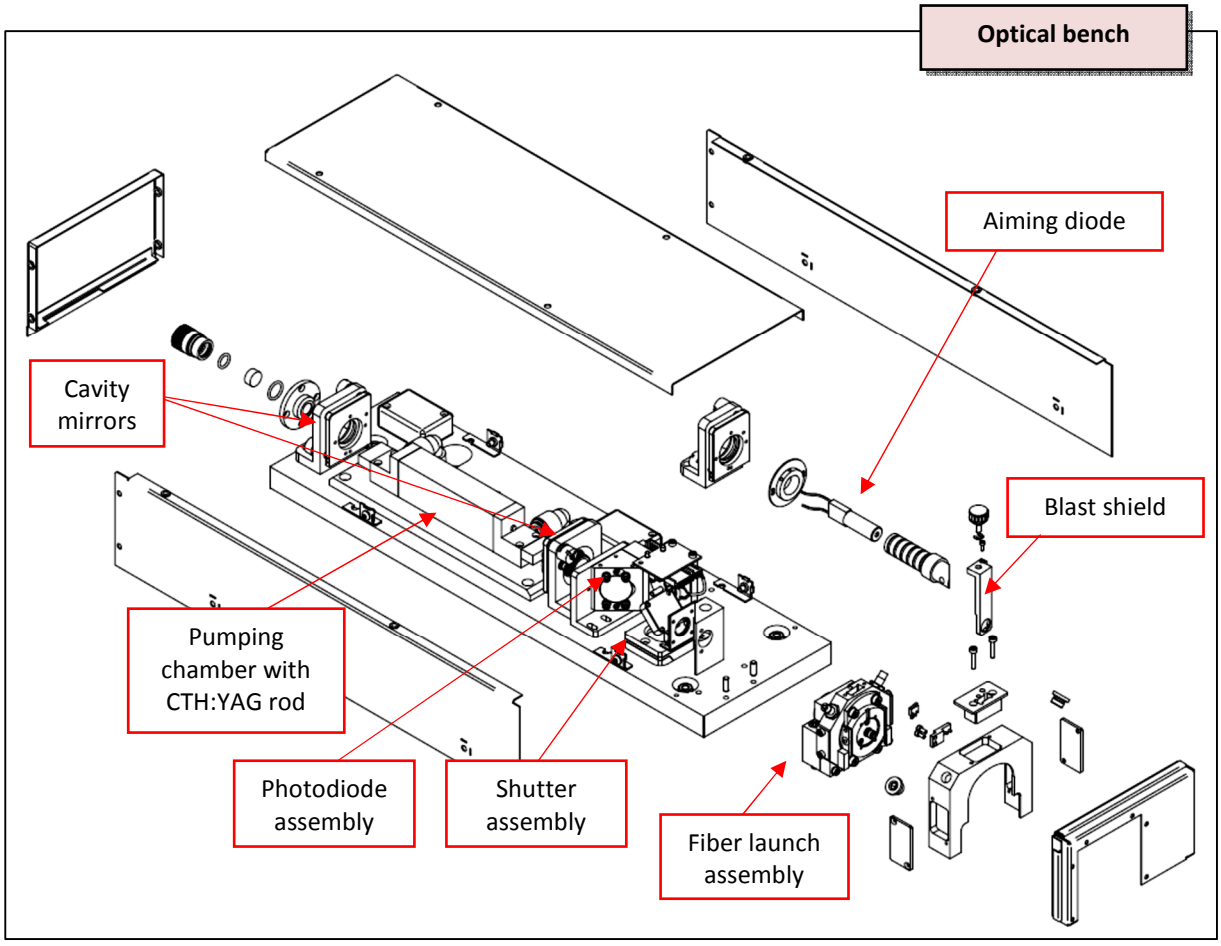
Without the Service Password it is possible to access the Diagnostics Panel by pressing on the “Diagnostic” button in the Service Screen.

This screen summarizes the general status of the system.
Press “Esc” to return to the Main Screen.

5 OPTICAL SYSTEM

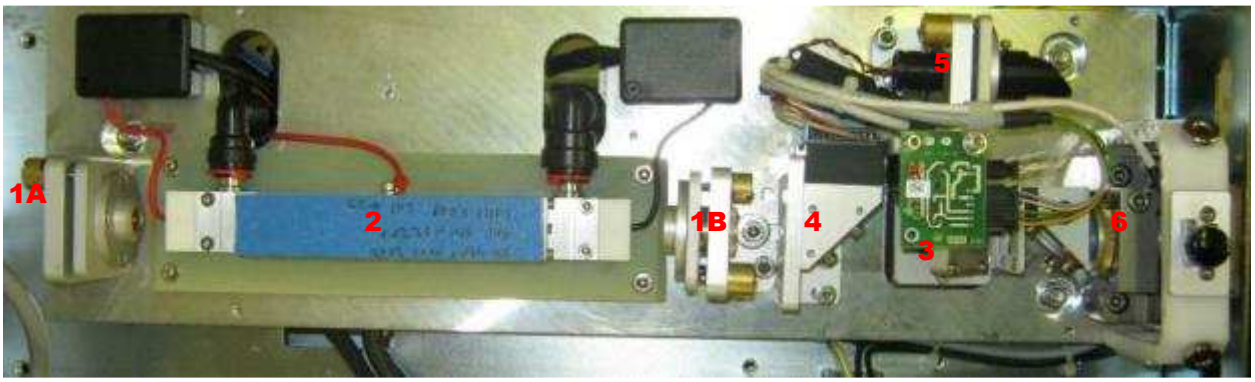
5.1 Optical System layout

The optical system is located in the upper part of the laser system, under the upper panel and it comprises of the optical components placed on the optical bench. Refer to the figure below for an overview:



The **RFID antenna** for the optical fiber automatic recognition is placed in front of the fiber launch assembly and is controlled by the RFID interface board QSMM11-01 placed beside the optical bench box (see to Section 6.2.7).

5.2 Optical Bench Components



Optical bench – top view

The optical components located inside the laser system are all placed on the optical bench. The optical bench contains:

- **Laser resonator:** made of two cavity mirrors assemblies, **1A** (rear mirror) and **1B** (output coupler), and a pumping chamber **(2)**
- **Beam shutter (3)**
- Energy monitoring **photodiode** assembly **(4)** with sampling beam window
- **Aiming beam** assembly **(5)**
- **Fiber launch** assembly **(6)**

The **delivery system** consists of an **optical fiber** connected on the laser system front panel.

A metal cover (upper panel) is mounted over the optical bench to protect the optics from dust contamination. It also protects the Operator/Service Technician from optical hazards. Unless required for troubleshooting, the laser should fire with the cover removed. If the cover is removed, it should be mounted as soon as possible: *never left the system without the optical bench cover on.*

5.2.1 *Laser resonator*

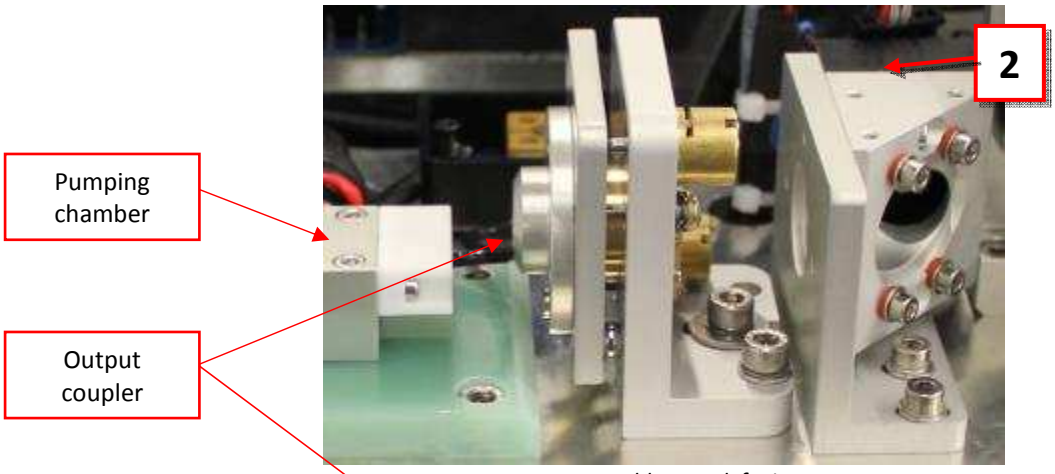
The laser resonator contains the pumping chamber and two mirrors: **output coupler** and **rear mirror**. The pumping chamber includes the **flashlamp** and the **CTH:YAG laser rod**.

The laser rod output facets are AR coated to prevent back reflections and concave to compensate the strong thermal lens when the rod is pumped. The rear mirror is HR mirror. The distance between resonator mirrors is about 20 cm. The CTH:YAG rod is 4 mm (diameter) x 125 mm (length); the emission wavelength is 2080 nm.

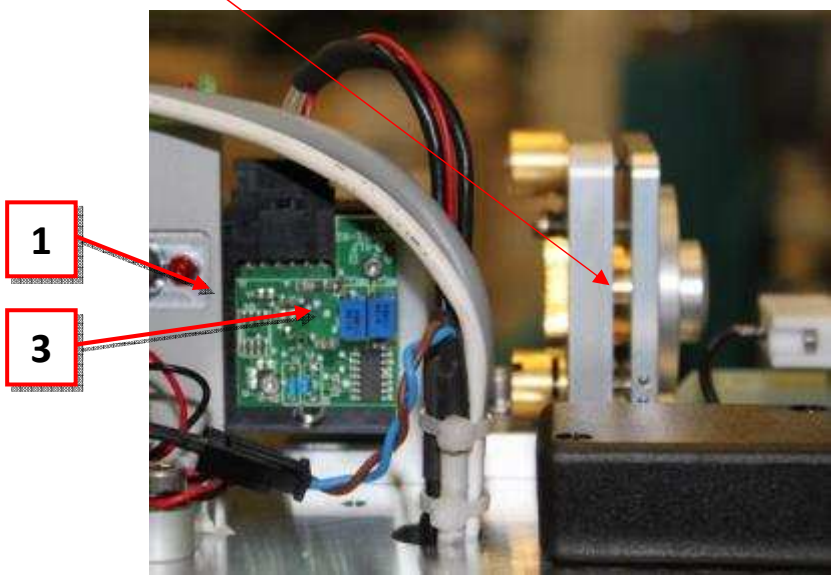
When the laser is pulsed, a high current discharge (200 A at Vmax~700 Volts) through the flashlamp generates the intense light required to excite the laser rod.
The laser operation is accomplished accordingly with selectable application modes and by setting, in the Main Menu, the laser pulse energy (J) and repetition rate (frequency, Hz).
Depending on the selected pulse energy and frequency, the pulse durations of flashlamp and laser pulse are different: the shorter the flashlamp pulse, the lower is the laser pulse energy. Laser pulse duration depends on the flash duration and cannot be directly controlled. Only the flash duration is controlled by the software and is set at the Factory for the best performance of the laser.

5.2.2 *Energy monitoring Photodiode*

The laser beam emitted by the resonator passes through a sampling window (AR/AR @2080 nm, 45° AOI) which reflects a very small portion of the beam towards the photodiode which monitors the laser pulse energy. Photodiode (PHD) assembly is shown below:



PHD assembly – top left view



PHD assembly – right side view

With referring to the figures above (top-left and right side view, respectively), **(1)** is the photodiode board locked to the sied of the the black mounting which shields the PHD against flashlamp light, **(2)** is the housing of the sampling window, **(3)** is the trimmer which must be adjusted for the PHD calibration.

The response of this energy meter is linear for the whole range of energy values. The photodiode signal is sent to the Microprocessor, which shows the energy value on display, by a shielded coaxial cable RG174.

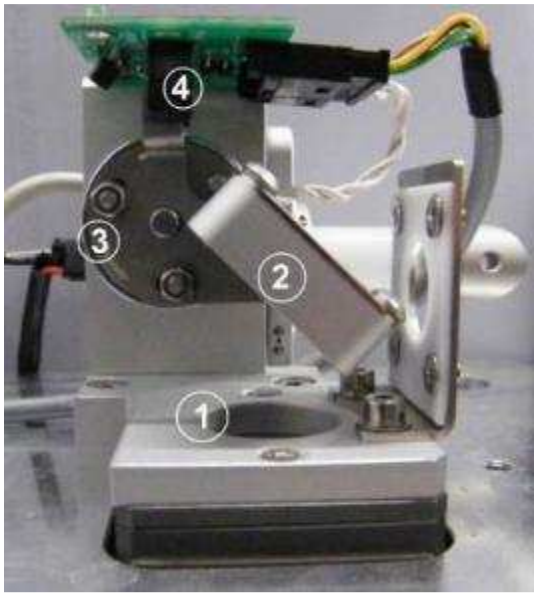
With the optical shutter being closed, the energy is measured online. The measured energy, averaged on 8 shots, is stored by the Microprocessor and displayed on the control panel display.
The photodiode is an InGaAs enhanced for high responsivity at 2 µm.

5.2.3 *Beam Shutter*

The beam shutter is an electromechanical device which includes a high reflectivity mirror, 45° AOI and a beam sink. When closed, the laser beam coming out of the resonator, passes through the energy monitoring photodiode assembly and is reflected into the beam sink. In this way the beam energy can be monitored but laser beam is prevented to get into the optical fiber.
When in Ready mode, by pressing the footswitch, the shutter opens and laser beam can reach the fiber launch assembly, being focused into the fiber optics.

The shutter assembly is shown below, where:

1. Beam sink
2. HR mirror: it is shown in the closed or rest position, it is horizontal when open
3. Electromechanical actuator
4. Optical switch board (optical fork) for the shutter position sensing.

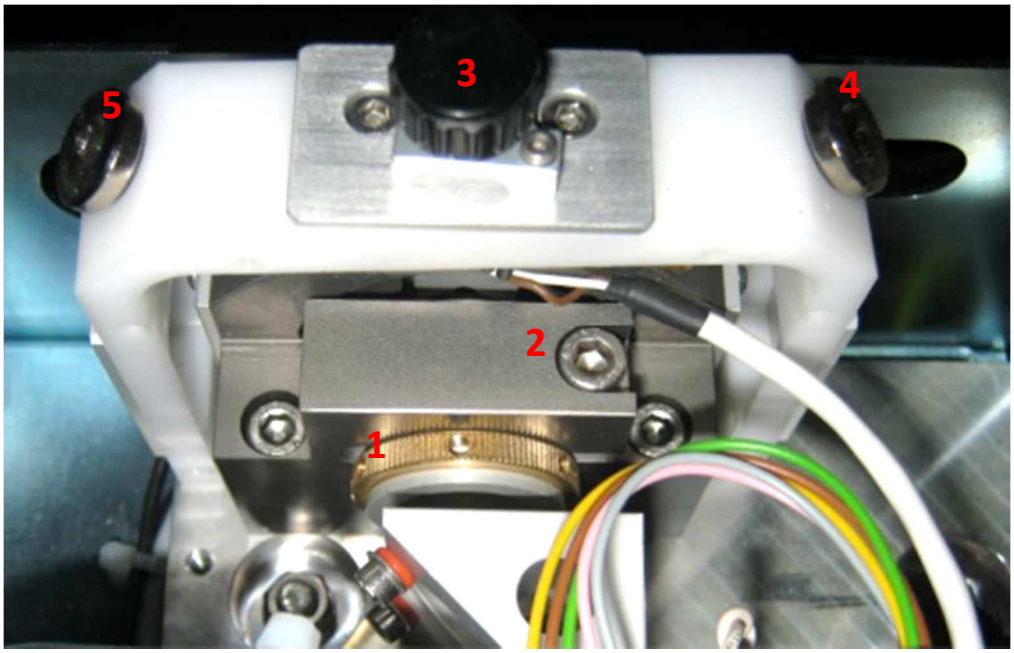


Shutter assembly

The beam shutter is controlled by footswitch and by firmware. It cannot be opened unless the firmware command is present and the footswitch is pressed. An optical switch (optical fork), included into a small card mounted on the top of the shutter assembly, is used to sense the position of the shutter flag. When the shutter is closed (mirror reflects the beam into the sink) the sensor does not detects infrared light from the led side of the optical switch. When the shutter is energized and moved out of the beam path, the infrared light of phototransistor is detected by the sensor. Firmware returns an alarm if the shutter flag is detected in wrong position during operations, e.g. if it is opened when the footswitch is not being pressed.

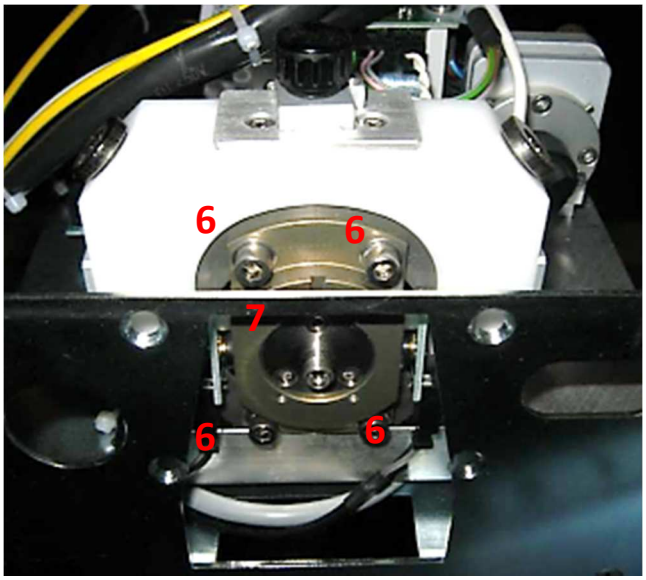
5.2.4 *Fiber Launch assembly*

The beam launching into the fiber is accomplished through a focusing lens, 15 mm focal length, 15 mm diameter, AR/AR coated at 2 µm. The lens can be adjusted in z position and in 45° tilted x-y position for an optimal coupling of the laser beam into the fiber.
The fiber launch assembly is shown in the figure below, the resonator side:



1.	Lens shaft, M1 thread for z-adjusting and locking ring
2.	Screw for z position locking
3.	Blast shield mount
4.	45° tilted x-adjusting screw cover, to be removed to access to the adjustment screw
5.	45° tilted y-adjusting screw cover, to be removed to access to the adjustment screw

In figure below the front view of the fiber launch assembly is given. The fiber receptacle (connector) is in accordance with the SMA standard:



6.	Screws for x-y position locking
7.	Fiber receptacle

The fiber alignment procedure will be described in following sections. However it must me pointed out that before acting on screws **4** and **5** for y-x adjusting respectively, the screws **6** must be loosened.

5.2.5 *Optical Fiber*

The types and sizes of optical fibers depend on the application. For Service purposes only, three fibers are useful for alignment of the launch assembly:

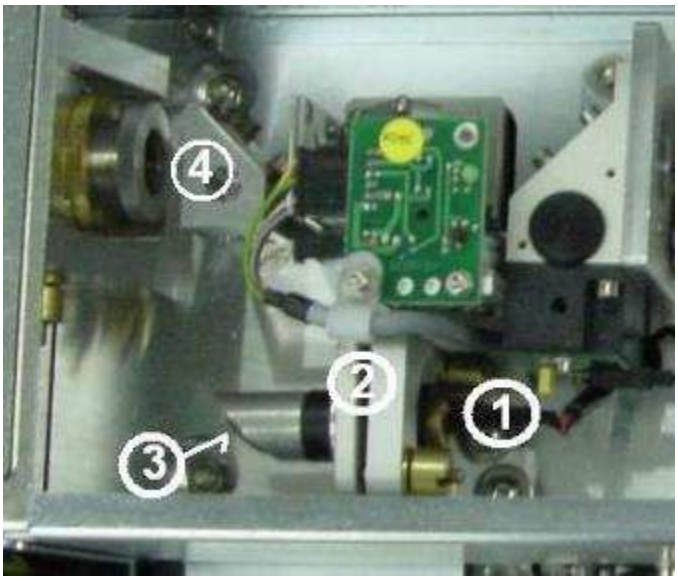
- 1 mm core diameter
- 600 µm core diameter
- 400 µm core diameter.

All of these fibers must be equipped with standard SMA connector (free standing type).
The alignment procedure will be described in the following sections.

5.2.6 *Aiming Beam assembly*

The aiming beam assembly is shown below, where:

1.	Aiming laser, emitting at 532 nm (standard)
2.	Aiming laser, tilting mount;
3.	90° folding mirror
4.	Aiming beam launch optics: AR/AR at 2080 nm, HR at 532 nm (635 nm), 45° AOI



Aiming beam assembly

The aiming beam is superimposed to the 2 µm laser beam before the focusing lens, by means of the two folding mirrors (**3** and **4**). The alignment into the fiber is accomplished by the tilting mount (**2**, fine tilting), folding mirror (rough alignment by rotating the mirror mounting around the aiming laser axis) and superimposition optics **4** (rough alignment by rotating the optics assembly around a vertical axis).

The aiming laser output power is up to 5 mW in case of green laser (532 nm). The aiming laser power can be adjusted by “PILOT” software setting on the display.

5.3 Standard Maintenance Procedures of the Optical System

The optical system needs a few periodic maintenance procedures:

- flashlamp replacement
- optical components cleaning

Besides those procedures, some others are required in case that specific failures occur (on non-periodic basis):

- mirror(s) replacement
- laser rod replacement
- window(s) replacement
- focussing lens replacement and realignment of the fiber optics

5.3.1 *Flashlamp replacement*

The flashlamp must be replaced in case of breakage which can occur if water is let inside the cavity when the environment temperature goes below 0°C and the water freezes. In this case probably also the pump cavity would be damaged.
Otherwise, flash lamp must be periodically replaced when the laser efficiency has decreased and this is not related to the other reasons (like dirty or damaged optics or contaminated water). The lamp lifetime depends on the operating conditions and with higher average power, the lamp lifetime will be shorter.
The flashlamp replacement does not require the cooling loop being emptied, even though the pump cavity must be removed from its position inside the resonator.

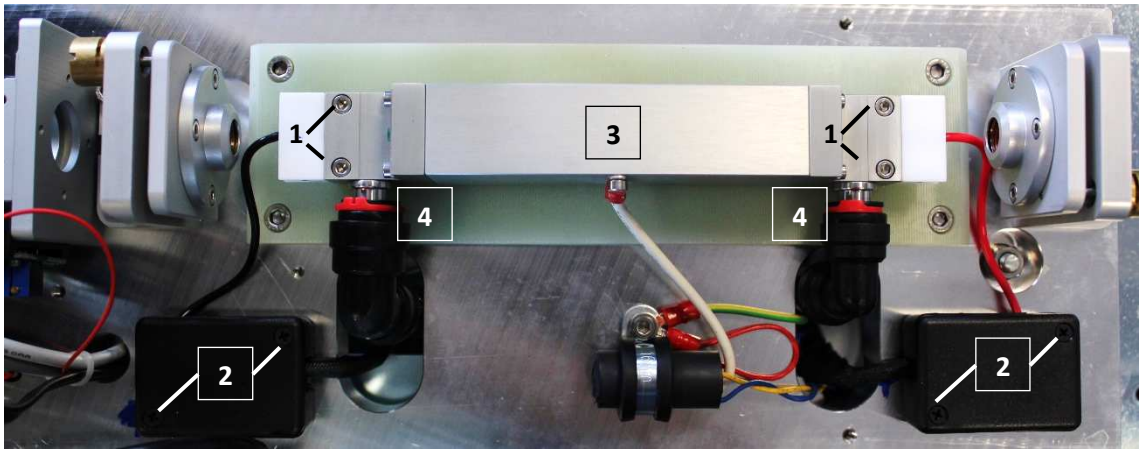
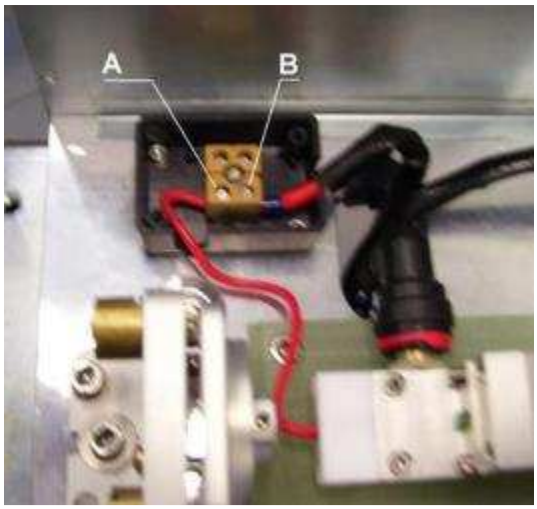


Figure 5.1: Flashlamp replacement.

Looking at Figure 5.1, the first step is to remove all the electrical connections. In figure, connection **(3)** is for the trigger transformer which can be easily removed by unscrewing it.

Then, in order to disconnect the flashlamp, the four screws **(2)** must be removed so that the plastic caps of the black-box connections can be also removed. Inside the each box there is a connection as shown below:



The lamp wire can be disconnected simply by unscrewing **A**, while **B** should not be unscrewed. The same procedure must be repeated for the other lamp wire.

When the electrical connections have been removed, the cooling pipes should be disconnected: looking at Figure 5.1, the red safety lock rings **(4)** must be pulled away, then the quick fittings can be extracted by pressing back the locking ring while pulling back the whole fitting. This must be done with the pump cavity still locked on its basis. Please be careful that some water can drop from the cavity and pipes when disconnected.

Warning: *Take care to dry water from any electrical connection.*

Finally, the pump cavity can be removed from the laser, by unscrewing the fixing screws **(1)** from the green plate. Then place the pump cavity over a table where the lamp replacement should be performed easily.

The lamp is kept inside the cavity by two white plastic pieces (item **(1)** in the figure below), which press the sealing O-rings:

In order to remove the lamp it is necessary to follow the procedure below:

1. Straighten the lamp wires taking care not to break the bulb
2. Remove the white plastic pieces which press the O-rings by removing the fastening screws
3. Pull the bulb from a side while pressing it from the other side; O-rings can be used again unless they are in poor condition
4. Insert carefully the new lamp keeping straight its wires and taking care to avoid any Mechanical stress to the wired electrodes
5. Insert the O-rings
6. Insert the white plastic pieces and fasten the screws

7. Before placing the cavity back in its position, it is necessary to bend the lamp wires because the resonator mirrors are very close to the pump cavity and lamp wires cannot be let straight.

   The bending must be performed with great care because during the wire bending the bulb can break.

8. Before bending the first wire section closer to the bulb, it must be kept still while the other part is being bended. The final wires configuration is like shown in Figure 5.1.
9. When in position, the pump cavity can be fastened by screws (**1** in Figure 5.1**Erreur ! Source du renvoi introuvable.**), then water pipes should be connected again (do not forget the safety lock red rings).
10. Finally set all the electrical connections.

Warning: *Take care about the connections' polarity: reversed polarity causes a fast degradation of the flashlamp.*

After the lamp replacement, the laser must be switched on in Standby mode and keeping the configuration opened, it must be checked for any water leakage from inlet and outlet pipe connections and from the lamp sealing O-rings. In case of any leakage, check the related sealing before operating the system. Check also the lamp simmering operation (in Stand By mode a small current is set into the lamp and the rod is slightly enlightened). Then enter the Ready mode, checking if the lamp is flashing.

5.3.2 *Cleaning of optical components*

The resonator mirrors, rod end-faces, sampling beam photodiode window, and aiming beam launch optics must be cleaned in case of dust or moisture on the surfaces.

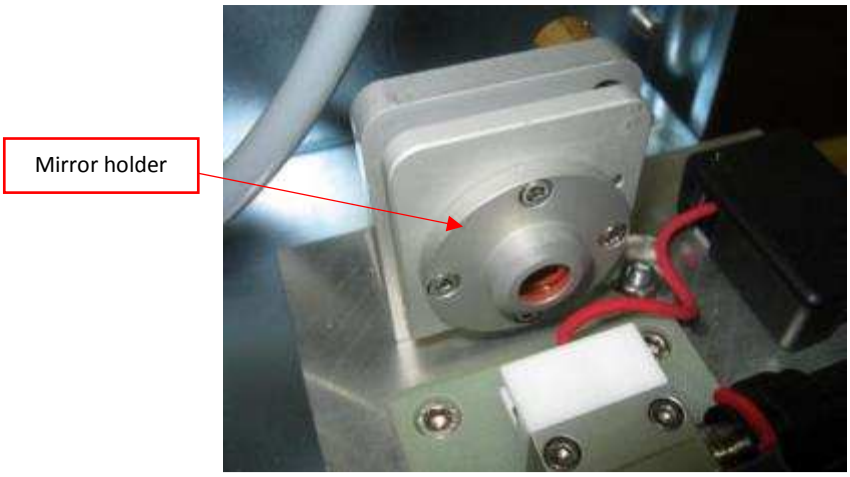
The cleaning must be performed without removing components from their holders, otherwise a complex procedure for realignment should be followed. Cleaning can be done just using a paper tissue damped with acetone. The surface must be carefully and gently wiped, avoiding any possible damage.

Warning: *Be sure not to move the component (part) while cleaning it.*

Only the focusing lens can be removed for cleaning but this lens typically damages when being dirty, so it has to be replaced. This will be discussed in a following section.

5.3.3 *Replacement of resonator mirrors*

The resonator mirrors can be damaged when dust or moisture contaminate optical surfaces. The laser beam hitting the dirty surface causes the damage of the optical coating. Only one mirror a time can be replaced while, the other one must be left in its original position.
The mirror mounting is shown in the figure below:



Rear cavity mirror mounting

The damaged mirror can be removed by unscrewing the mirror holder shown above. When removed from the mirror mounting, the mirror holder looks like in Figure 5.2(a). In Figure 5.2(b) the mirror is shown after it has been extracted from the holder.

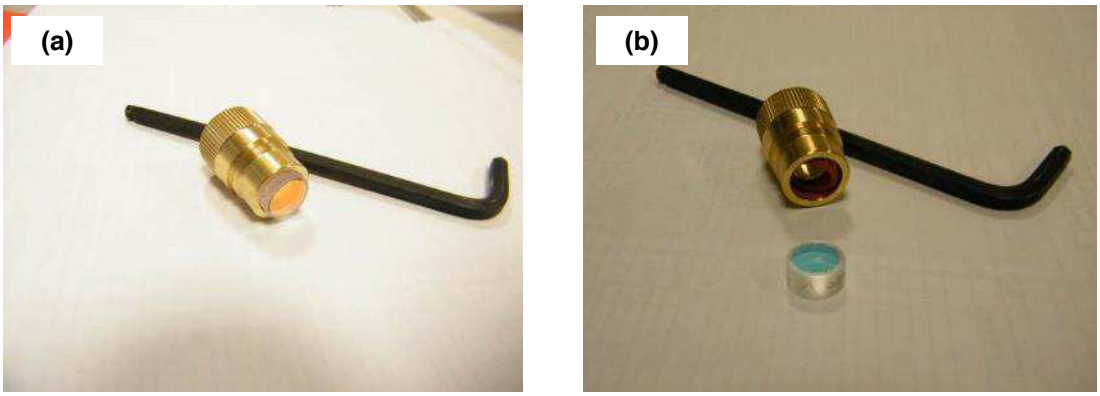


Figure 5.2: Cavity mirrors.

The new mirror should be placed into the mirror holder, pushing it onto the O-ring which is inside the holder. A second, larger O-ring is placed into a groove of the holder and it wraps the mirror on the barrel.

Warning: *During the procedure take care to handle the mirror with a soft tissue, do not press the mirror directly with fingers, tissue must be always kept in between the fingers and the mirror's surface.*

Warning: *Do not tighten the locking screw too much. Check that the rubber dumper is between the screw and the mirror. If a dumper is missed, make a new one by cutting a small section (2 mm long) of an O-ring. The iron screw should not be tightened directly over the mirror surface, otherwise mirror will crack.*

Warning: *Do not let any fingerprint of the mirror surface; check the cleaning of the mirror and if necessary, clean it with acetone and a soft paper tissue.*

Finally, insert from the back the mirror holder into the mirror mounting and screw it completely.
Due to the mechanical accuracy of the mirror assembly, when the holder with the new mirror has been fastened, the resonator should be still aligned and no re-alignment should be necessary. However if a small adjustment would be necessary, the easiest procedure is:

1. Switch on the laser in Service Menu,
2. Disable energy adjust: MENU → SERVICE → GENERAL PARAMETERS (Password "Q")
3. Set the pulse repetition rate at 10 Hz,
4. Set the energy level at 0.5J
5. Put laser in READY
6. Check the internal energy reading to be higher than 0.15
7. If internal energy reading is 0.15 or lower, increase the energy setting till You see internal energy reading around 0.2J
8. Act on both vertical and horizontal adjustments of the substituted mirror to observe an increase of internal energy reading
9. As soon as the internal energy reading increases, reduce the energy setting to lower energy to have always >0.2J internal energy reading
10. Repeat steps 8 and 9 till You see internal energy reading > 0.2J at 0.5Jenergy setting
11. Optimize both vertical and horizontal alignment of the substituted mirror to maximize the internal energy reading
12. Set 1.5J energy setting and maximize internal energy reading with fine adjustment of both vertical and horizontal alignment of the substituted mirror
13. Set 3J energy setting and maximize internal energy reading with final adjustment of both vertical and horizontal alignment of the substituted mirror
14. Place a calibrated power meter for 2100nm at the output of a large core fiber (at list 600µm)
15. Set 0.5J energy setting
16. Enter the Ready mode and measure the output power
17. Verify that the external measure correspond to the internal energy reading (within+/-10%)
18. If yes, set 1.5J and repeat points 16 and 17
19. If yes, set 3 and repeat points 16 and 17
20. Looking at the power emitted by the fiber, try to maximize it by slightly tilting the new mirror

When the output of the fiber is being maximized, this means that resonator is again aligned.
With this, the replacement mirror procedure is completed.

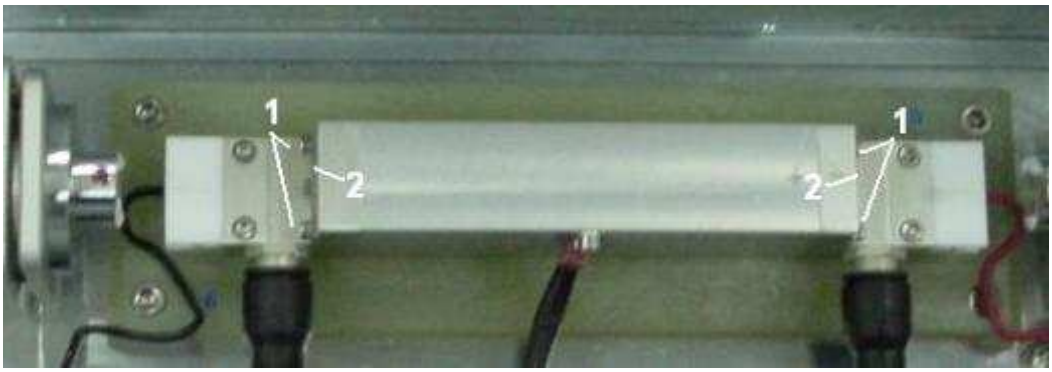
After this procedure, if You see mismatch between internal and external energy measure, a recalibration of the internal energy meter should be necessary *(please contact the Service Department).*

After this procedure a check and eventual fine correction of fiber alignment checking with the smallest core fibers should be necessary.

5.3.4 *Replacement of laser rod*

The replacement of laser rod is necessary when an end-face is damaged by laser beam. This can happen in presence of dust or moisture on the rod face(s).

The replacement procedure is the same as in the case of the flashlamp replacement (see Section 5.3.1), so the procedure for removing the pump cavity should be followed and then it should be placed again into the resonator.



For removing the damaged rod, loosen the four screws **(1)** and remove the two plates which press the rod O-rings **(2).** Then the rod can be extracted from the pump cavity by gently pushing it from one side.

Warning: *Take care about the O-rings, do not miss them: they have special size which matches the pump cavity and can be supplied by the Manufacturer only.*

The new laser rod must be inserted into the pump cavity by handling it from one side. Push the rod into the cavity hole by right side till it reach the output hole on the left side of the cavity (right and left side can be reversed, orientation is not important).

Warning: *Avoid putting fingers directly on the rod end faces. Use a soft tissue between fingers and rod to push it into the cavity.*

When the rod face is close to the output hole of the cavity (e.g. in the left side), the rod must be passed through the output hole.

Warning: *Push the rod very gently and slowly. Avoid any shock to the rod. Take care while passing rod's end face through the cavity hole.*

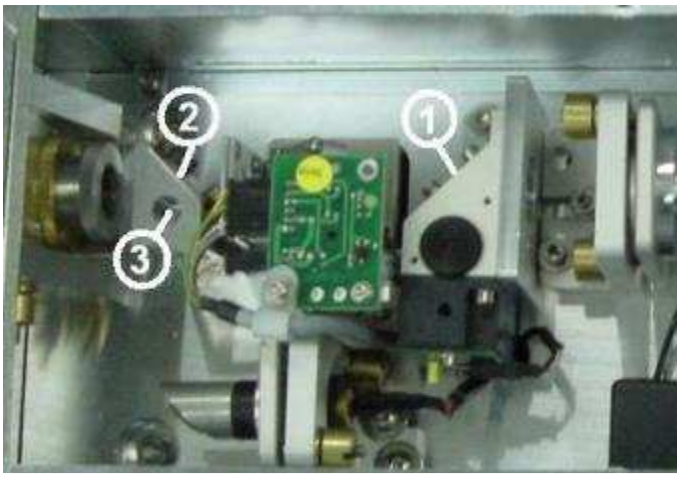
When the rod is inside the cavity, O-rings must be placed on both sides of it. While doing this please take care about the rod faces avoiding to scratch them and putting fingers directly on the end surfaces.
Finally, the two plates **(2)** must be placed and screws **(1)** must be tightened in order to press the O-rings.

Before placing again the pump cavity into the resonator, check the status of the rod faces and if dirty or wet, clean up them following the procedure given in Section 5.3.2.

5.3.5 *Replacement of windows*

There are two windows in the bench (see figure below):

1. Sampling beam window which reflects a smallest percentage of the output beam toward the monitoring photodiode;
2. Window AR coated at 2 microns and HR coated at the aiming beam wavelength; it directs the guide beam into the focussing optics.



Both windows can be replaced in case of damage.

The most important one is **(1)** because, if damaged, distorts the energy reading of the photodiode. Moreover, as this reading depends at certain extent on the optical alignment, the window must be replaced without removing the whole assembly.
Therefore the replacement of the photodiode window must be accomplished following the same procedure given in Section 5.3.3 for the resonator mirrors replacement. The only difference is that the window is kept in position by three screws, locking it frontally and not by only one, locking it transversally.

The same holds for the window **(2)** which reflects the aiming beam into the focussing optics. In this case replacement of this optics without removing the whole assembly can make easier the replacement procedure. Otherwise the windows assembly can be totally removed, the window can be easily replaced and then the whole assembly must be positioned and tilted on the optical bench plane (tilting adjustment is done about the fixing screw **(3)** in the figure above, in order to maximize the aiming beam output from the fiber.

5.3.6 *Replacement of the focussing lens*

In Section 5.2.4 the focusing assembly for launching the beam into the optical fiber has been described: the lens holder can slide for z-adjustment and the threaded ring (locking ring) gives the reference position for the lens z-position.

The focussing lens can be damaged by the laser beam when dust, particles and/or moisture contaminate the lens' surface. For the lens replacement, the shaft **(1)** must be removed from the assembly, then it can be disassembled by unscrewing the locking ring.

In Figure 5.3, **(1)** is the lens shaft, **(2)** is the locking ring, **(3)** is a spacer ring and **(4)** is the focussing lens. No O-ring is mounted inside the shaft. New lens must be first inserted into the shaft, then the spacer must be put immediately after the lens and finally the locking ring must be screwed for packing all. The correct assembling sequence is shown in Figure 5.3.

The focusing lens is a plane-convex lens, whose size, thickness and material cannot be changed, as the focal plane position strongly depends on these characteristics.

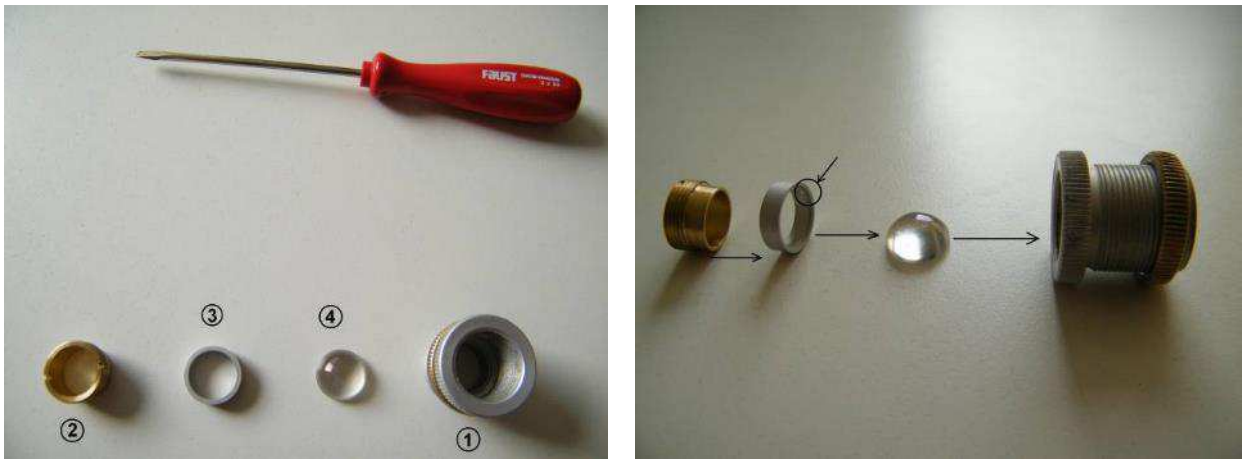


Figure 5.3: Lens shaft (1), locking ring (2), spacer ring (3) and focusing lens (4).

Warning: *Be sure to put the lens into the shaft with convex surface oriented to the laser resonator and the plane surface to the fiber, otherwise, back reflections due to residual reflectivity of the surface, can damage the laser. Moreover, in case of reverse lens mounting, the position of the focal plane changes, preventing the correct fiber launching.*

After the lens replacement, z-position of the lens must be optimized; then beam focusing and fiber alignment must be checked as well.
Therefore, the shaft with new lens must be re-inserting in the original position (individuated by the position of the reference ring against the fiber launch mount.

5.3.7 *Optical fiber realignment*

Now proceed with the realignment/optimization procedure:

- The laser must be switched on and set in the Standby mode. Energy self-adjustment must be excluded (see software description in Service Mode). Then, looking back at the fiber launch assembly, screws **(2)** must be loosened.
- Laser parameters must be set for a low power emission. For example, a good starting point is 3 Hz of frequency and 0.3-0.5 ms of pulse duration (pulse duration can be set in Service menu only). In any case laser emission should be less than 100 mJ/pulse.
- 1 mm fiber must be connected to the fiber launching assembly.
- Now laser can be set in Ready mode. The power meter head must be placed in front of the fiber output face. Laser emission is controlled by pressing the footswitch.
- The first step in the optical fiber alignment is the x-y position optimization. This is accomplished by adjusting the x-screw **(4)** and the y-screw **(5)** while looking at the power meter at the end of the optical fiber. Small adjustments must be performed, trying to optimize the power measured by the power meter.
- Also z-position must be optimized but just ±180° rotation range should be checked starting from the shaft position previously being set.
- When x-y-z position seems good, all the steps must be tried again at 10 Hz (pulse duration/pulse energy must be kept low as before).
- When the position seems optimized at 10 Hz, locking screws **(2)** must be tightened, laser must be in Standby mode, and 1 mm fiber must be replaced with 600 µm fiber. With this optical fiber all the previous optimization steps must be repeated, taking into account that the fiber is already roughly aligned and only small changes in x-y-z position will be necessary.
- Finally repeat again all the steps with the 400 µm optical fiber.
- When the alignment is completed, locking screws **(2)** must be definitely tightened.

- The last step is checking the operation at higher power. Therefore, starting from 1 mm fiber, laser power must be increased by raising the laser pulse energy from 0.3 J up to 2.5 J/pulse, while keeping the frequency at 10 Hz. While increasing the energy step by step, the temperature of the optical fiber connector must be sensed by fingers: connector heating means that some power is wasted because the fiber launch is not optimized. In this case go back and repeat all the procedure. While increasing the power, output from the optical fiber must be continuously monitored with the power meter and compared with the energy measurement displayed in the upper right corner of the touchscreen.

By increasing power, the step-by-step procedure must be repeated first with 600 µm and then with 400 µm fiber.

 **Warning:** *In case of damage of the optical fiber, check the status of the focusing lens: laser sputtering from the SMA fiber connector can in principle reach the lens, leading to the optical damage of the lens.*

 **Warning:** *Frequently check the status of the input face of the optical fiber used for the alignment. Power measurement made with a damaged fiber can be misleading during the alignment procedure.*

6 ELECTRIC SYSTEM

6.1 Introduction

The electronics of MH01 laser system is composed of three distinct subsections:

1. **Control electronics**, including I/O interface and all low level logics which are used to process signals from the laser sensors and to produce commands to operate the system. It also contains low voltage power supply for aiming beam.

   Specifically, the control electronics provides:
   - Control of human interface: touchscreen display, LEDs, buzzer and footswitch.
   - Control of power supply, including control and monitoring of the capacitor bank voltage.
   - Monitoring of safety interlocks: external, fiber optic sensors, optional tools sensors.
   - Interfacing with built-in power meter (internal energy meter, calibration check port).

   In particular, the control electronics subsystem contains the following boards:
   - Touchscreen TFT LCD **display 8.4'' + PC embedded**
   - **Microcontroller board** (QSCM08-7)
   - **Interface board** (QS05-2A)
   - **Signal routing board** (QS05-2B)
   - Isolation board (QSGM11-09)
   - Energy meter board (photodiode)
   - Aiming beam power supply (QSGM08-04)
   - RFID driven board (QSMM11-01)

2. **Power electronics,** containing all devices involved to produce and deliver high voltage to laser head and low voltage to all subsystems. In this group we also include the capacitor's charge sniffer, used to detect residuals charge on capacitor bank.

The Power electronics provides following features:
- Supply Vac line voltage, through line input loop (emergency button and key switch)
- Supply low voltages to all electronic devices
- Simmer the flashlamp
- Produce and regulate high voltage to charge capacitor bank
- Discharge stored energy from capacitors bank to the flashlamp

The power electronics contains the following boards:
- Compact H.V.P.S./discharger
- PFC modules
- Capacitor bank
- Trigger transformer
- Capacitors charge sniffer

3. **Sensors**, including all sensors displaced inside the machine:
   - Fiber sense interlock
   - Flowswitch
   - Thermoswitch
   - Shutter optical fork

6.1.1 *Electric System overview and Block Diagram*

In the figure below, the main components are:

1	Compact HVPS/discharger	**7**	Microcontroller and Interface boards
2	Capacitors bench	**8**	Signal Routing board
3	Sensor of charge	**9**	Aiming beam supply board
4	Line filters	**10**	Fiber sensor board
5	Low Voltages terminals	**11**	RFID driven board
6	PFC modules	**12**	Insolation board

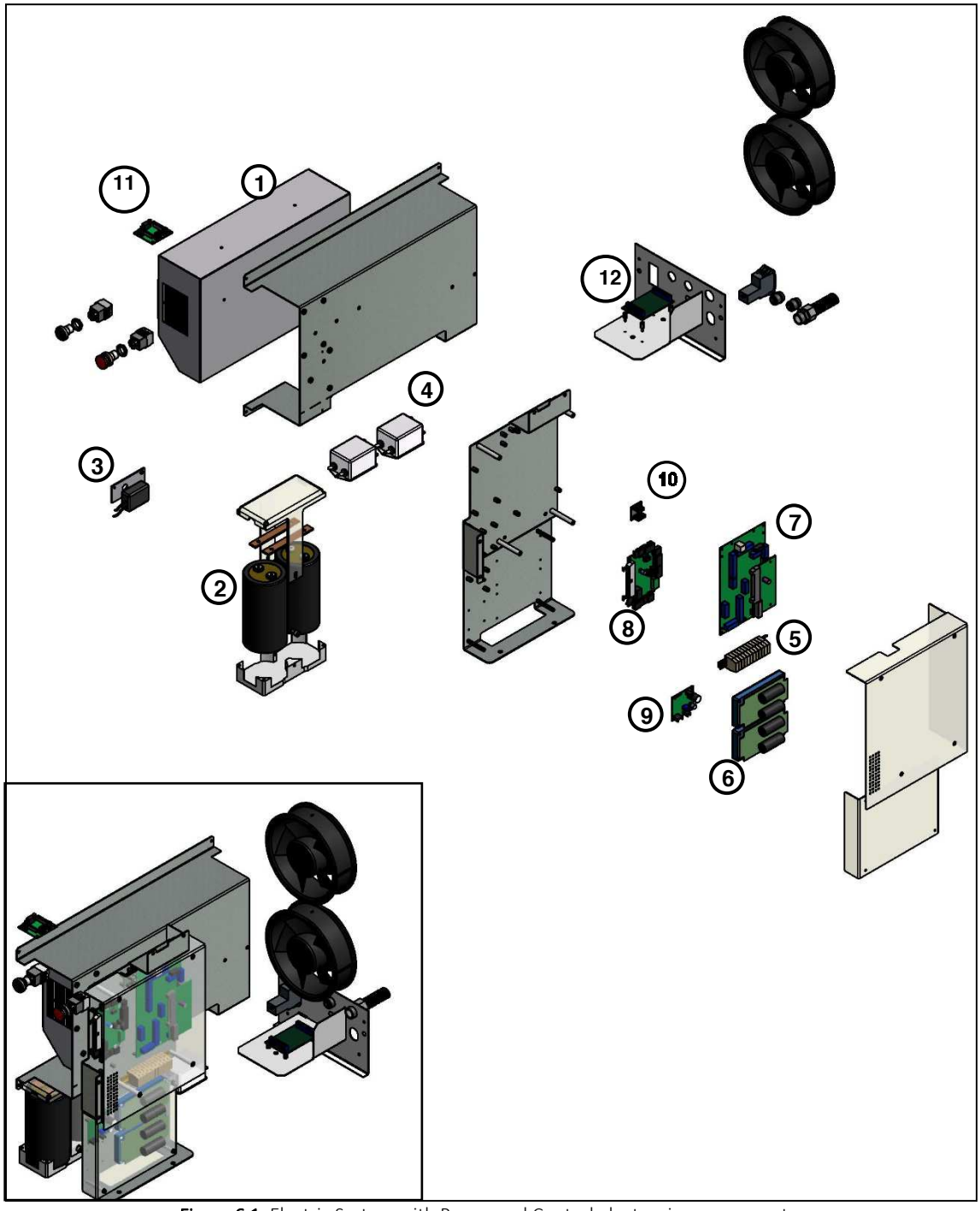
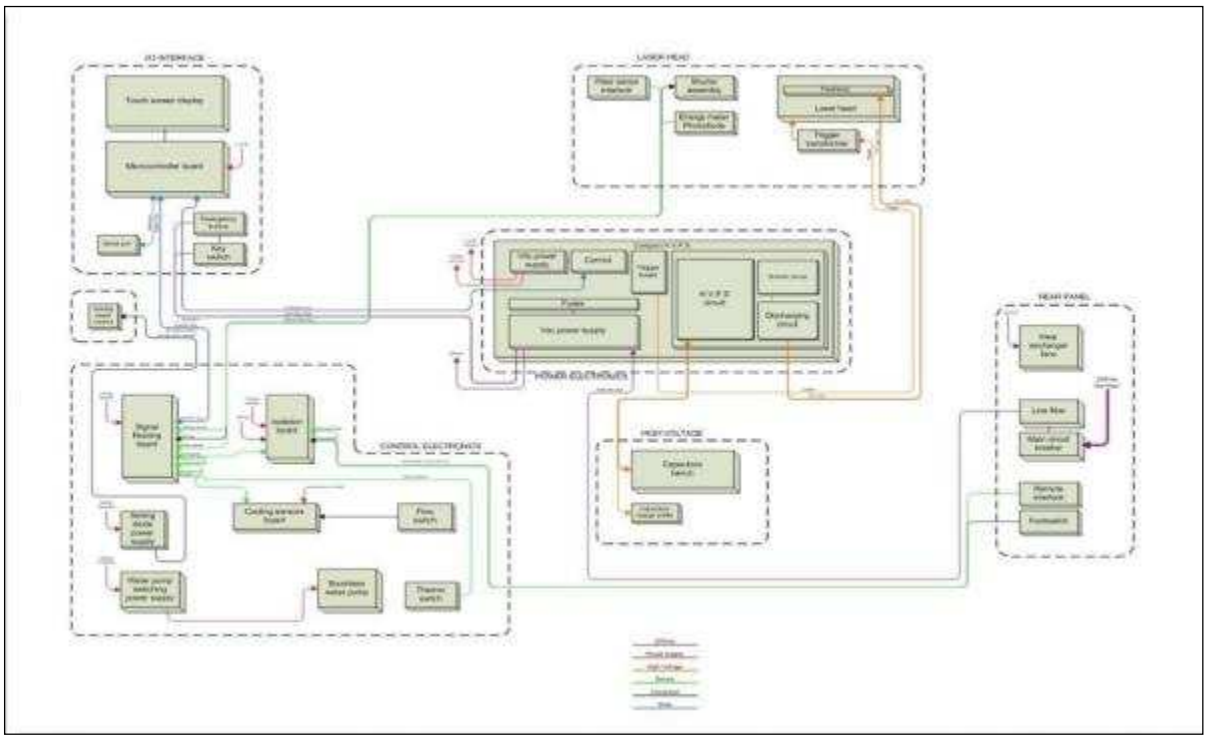


Figure 6.1: Electric System with Power and Control electronics components.

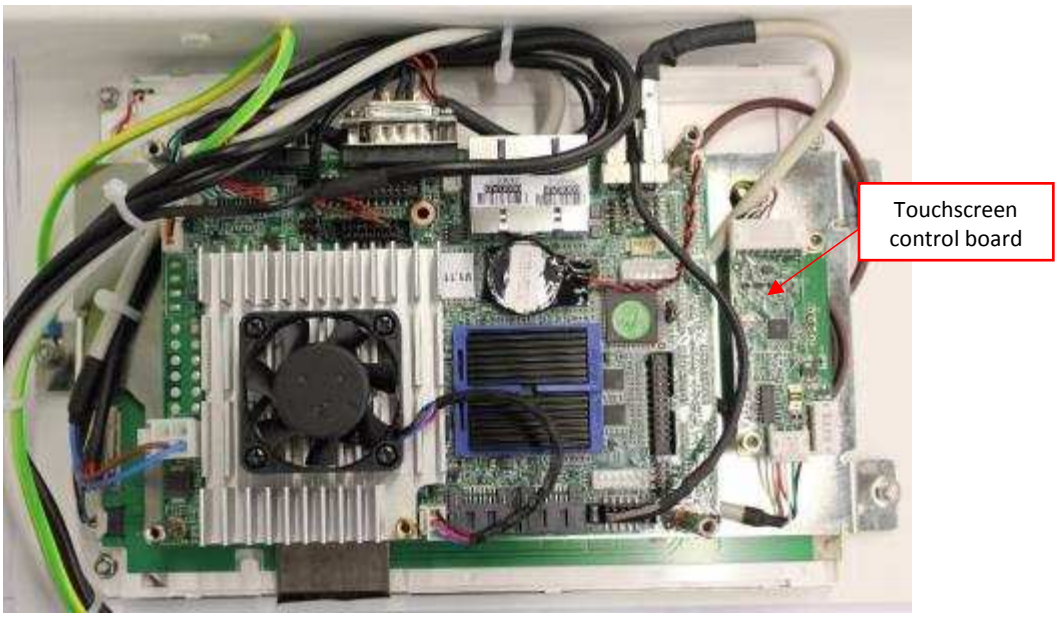
A basic block diagram of the electronic system is shown in the following figure.



6.2 Control Electronics components

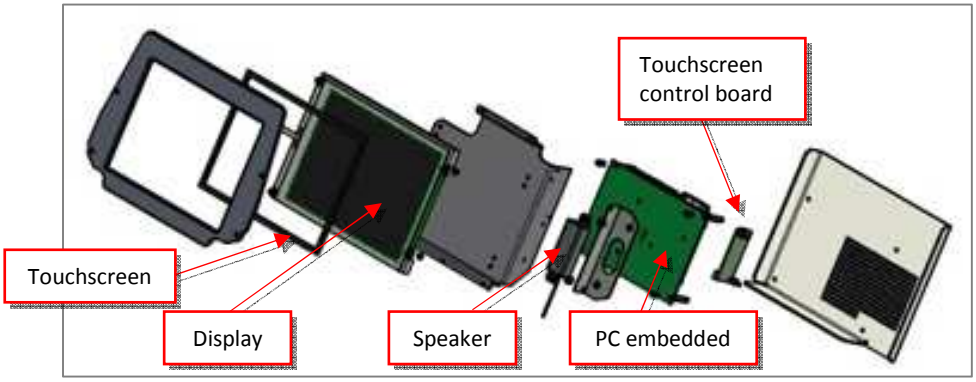
6.2.1 *Touchscreen display and PC embedded board*

On the back of the front panel the Touchscreen display (8.4'') and the PC embedded are mounted:



PC embedded and Touchscreen board

On the Disply frame the following components are locateted (see figure below):



Touchscreen Display frame

The Audio amplifier board (connected to the Speaker) is located on the Control Electronics panel under the Lexan cover, on the side of the Device (see next Section).

6.2.2 *Microcontroller Board and Control Electronics panel*

The **Microcontroller board** is located on the side of the device, together with the other boards and, in order to access it, the side panel and Lexan cover must be removed:

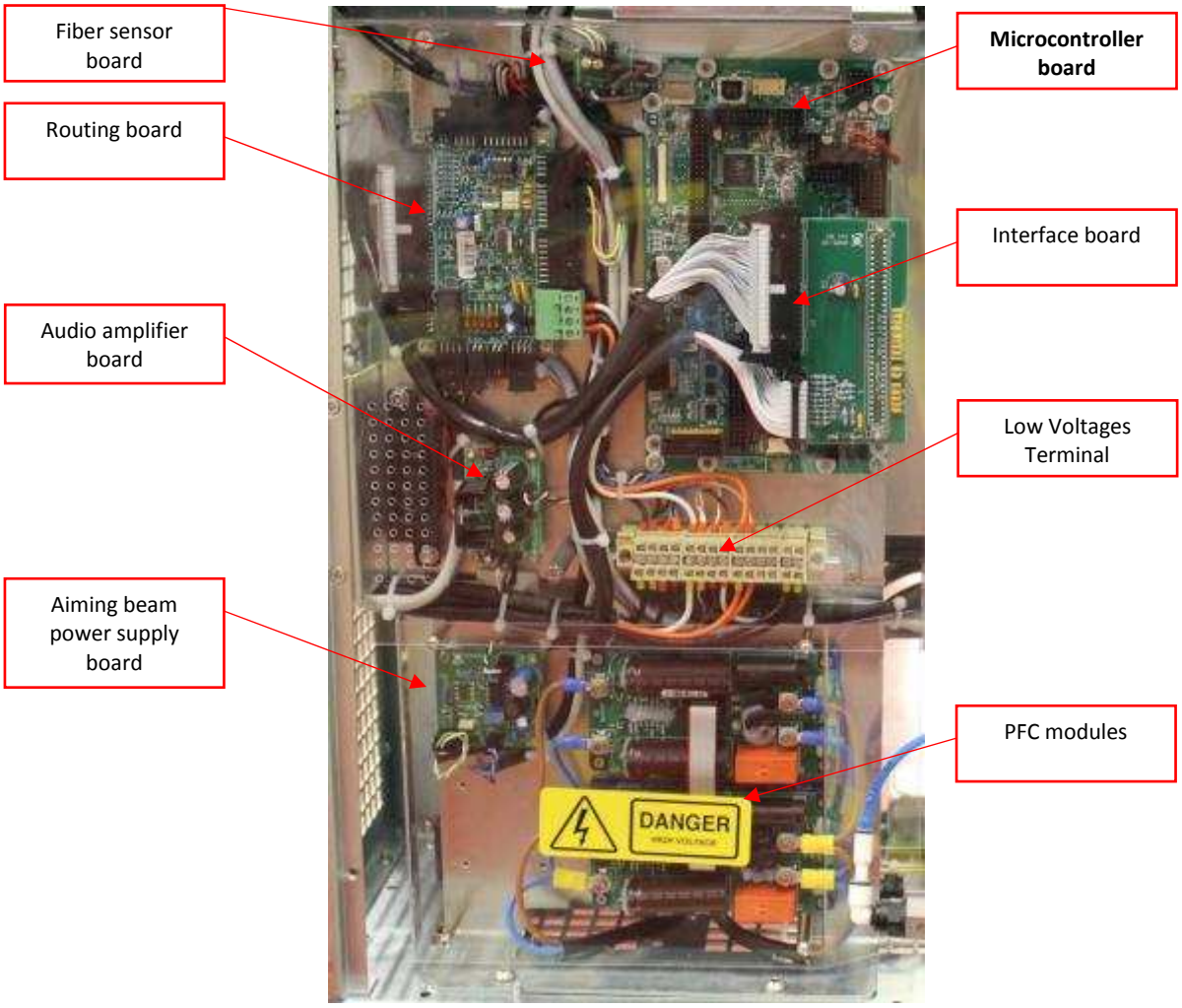
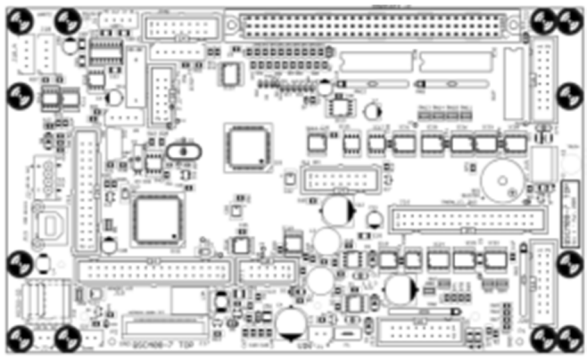


Figure 6.2: Control electronics panel and PFC modules.

The **Microcontroller board** (QSCM08-7) is the logic core of the control electronics and contains the following parts mounted on it:

- A Microchip Pic32MX460F512L microcontroller with internal watch-dog, internal flash memory with resident software (firmware)
- An external eeprom memory storing service calibration parameters and application protocols (sets of user parameters both preset and user saved)
- A flash memory storing presentation images
- Driver ICs for graphic and touch-panel interface
- Switching power supply for graphic lcd display
- Analog inputs and digital I/Os

The Pic is programmed with the operative firmware. Accordingly, with conditions of external sensors, it provides correct sequence to operate the system or to display error messages and stop the machine. It is possible to flash the Pic with new software versions by using a serial port installed on rear panel, wired to this board through a connector J11 (6-pin Amp type).



The Microcontroller does not communicate directly with all parts of the system. It is interfaced through an **interface board** (QS05-2A), plugged into J15A (64-pin female connector).

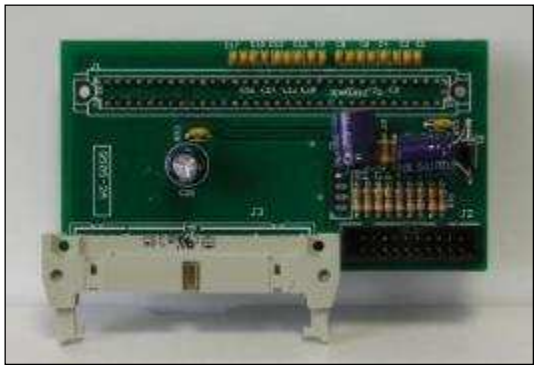
There are four diagnostic LEDs to indicate operating conditions of the board:

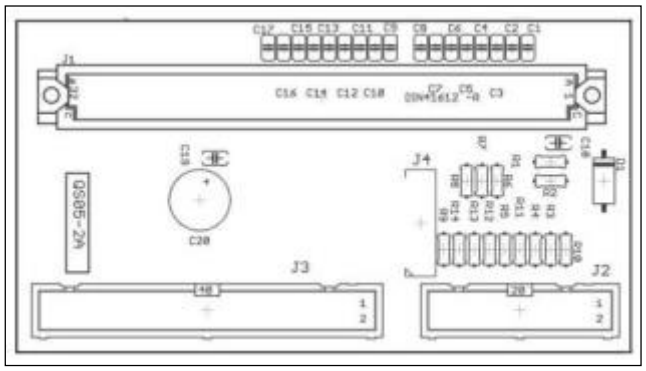
- LD1, green, (Board power supply) is **ON** when +24Vdc is supplied to the controller board
- LD2, green, (Microcontroller and Display power supply) is **ON** when 3.3Vdc is supplied to the microcontroller and touchscreen lcd
- LD3, green, (Microcontroller power supply) is **ON** when 5.0 Vdc is supplied to the microcontroller
- LD4, yellow, (Software installed) is:
  - ***FLASHING*** when software has been successfully installed and is running properly
  - ***OFF*** when software has not been correctly installed or there is a failure in the board.

Microcontroller board connector pinouts:

J1 AMP2	supply +12V (GND left)
J4 AMP6	Programming bootloader with PicKit3 MCLR
J13 USB-B	HEX file uploading via HIDBootloader.exe Images files upload via HidTest.exe.
J17	Display led connection
J2	Backlight LED 12V 84 mA display
J15	Touch panel display
J22 DIN41612	QS05-2A routing

6.2.3 *Interface board*

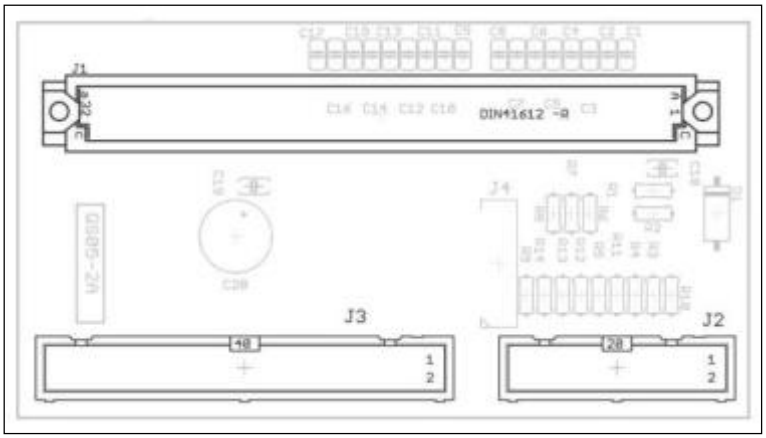




The **Interface board** (QS05-2A) provides two different connections: the 40-pin male connector (J3), interfacing the controller with signal routing board (QS05-2B), and the 20-pin male connector (J2), interfacing it directly with the H.V.P.S/discharger.

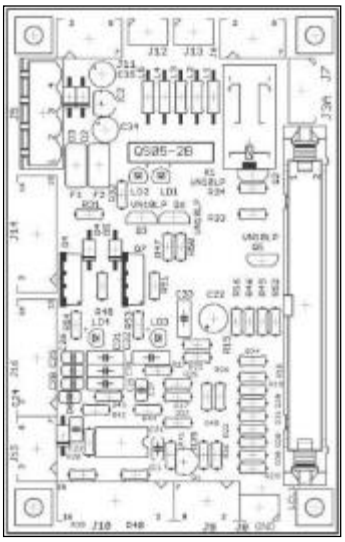
The board connector pinouts include:

- J1 (64 pins, Din 41612 type) bidirectional, controller board QS03-1A
- J2 (20 pins, flat cable, male) bidirectional, compact H.V.P.S
- J3 (40 pins, flat cable, with safety clips, male, 90°) bidirectional, signal routing board QS05-2B



Interface board connector pinout

6.2.4 *Signal routing board*



The **Signal Routing board** QS05-2B makes the interconnection between microcontroller board and the rest of the system. It is localized on the side of the laser, in the control electronics area (Figure 6.2).
Its function is to manage the bidirectional communication between microcontroller and sensors - actuating devices displaced into the system. It also used to transfer energy measurement signal, from energy meter located on optical bench, to the cpu.

The on-board relay K1 is used to enable footswitch and remote interlock functions, through Isolation board mod. 246, only when the Ready mode is selected.

The collected signals come from the following sensors or devices:

- Photodiodes (from energy monitoring)
- Thermoswitch (from cooling circuit)
- Fiber sense interlock (from optical bench)
- Shutter sense optical forks (from optical bench)
- Flowswitch (through Cooling Sensor board QSGM07-13)
- Conductivity (through Cooling Sensor board QSGM07-13)
- Footswitch (through Isolation board mod. 246)
- Remote Interlock (through Isolation board mod. 246)

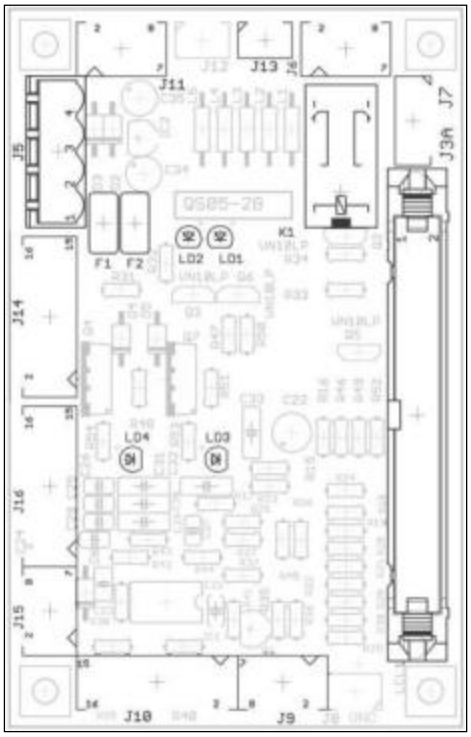
The commands sent from cpu to the system are the following:

- HVPS/discharger trigger pulse
- Shutter command (to spring coil)

Four diagnostic LEDs are placed on board in order to indicate power supply voltage presence and shutter status.

- LD1, green, (Board power supply) is **ON** when +12Vdc is supplied to the board
- LD2, green, (Board power supply) is **ON** when +24Vdc is properly supplied to the board
- LD3, green, (Shutter state) is **ON** when shutter is pressed.
- LD4, green (Intracavity shutter state) is not used in this platform.

The two fuses, F1 and F2, are also present on low voltage supply lines to protect the board from accidental short-circuits or incoming over voltages.

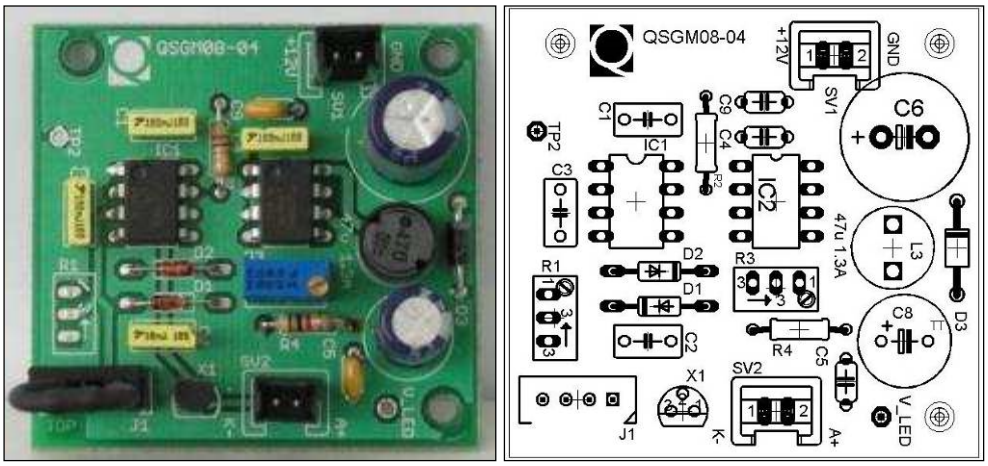


Signal routing board connectors pinout

The board connector pinouts include:

- J1 not present
- J2 not present
- J3A (40 pins, flat cable, with safety clips, male, 90°) bidirectional, controller board QS03-1A
- J4 not present
- J5 (4 pins, Molex type, male) input, +24Vdc power supply
- J6 (8 pins, Amp type, male) input, isolation board mod. 246 - signals
- J7 (4 pins, Amp type, male) output, isolation board mod. 246 – enable
- J8 (2 pins, Amp type, male) not used
- J9 (8 pins, Amp type, male) not used
- J10 (16 pins, Amp type, male) input, energy meter photodiode
- J11 (8 pins, Amp type, male) input, cooling sensor board QSGM07-13
- J12 (2 pins, Amp type, male) not used
- J13 (2 pins, Amp type, male) input, thermoswitch
- J14 (16 pins, Amp type, male) not used
- J15 (8 pins, Amp type, male) input, fiber sensor board QSGM09-01
- J16 (16 pins, Amp type, male) bidirectional, shutter board QS05-2H

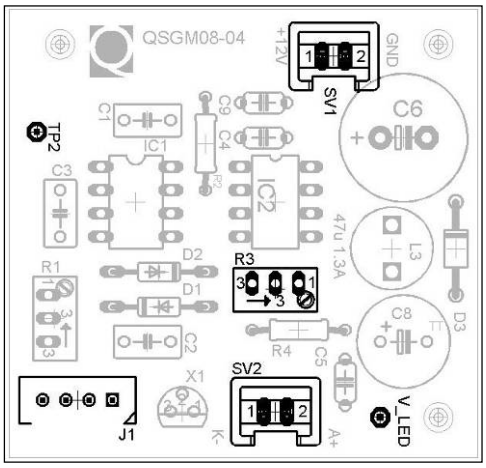
6.2.5 *Aiming beam power supply board*



The **Aiming beam power supply board** QSGM08-04 provides low voltage to the aiming diode.
The board is located on right side of the system, on the control electronic area and it is supplied with +12Vdc.
Accordingly, for the aiming diode type mounted on the optical bench, an offset voltage must be setup, in order to avoid any possible flickering of the diode's light. For this purpose, a 5 KOhm trimmer (R3) is mounted on board and two test points are present as well.

In order to regulate the diode offset voltage, place DVM tips between V_Led test point (+Vdc) and TP2 (Gnd) and trim R3 until the following values are being measured:

<u>+3.15Vdc for 5mW output diode</u>



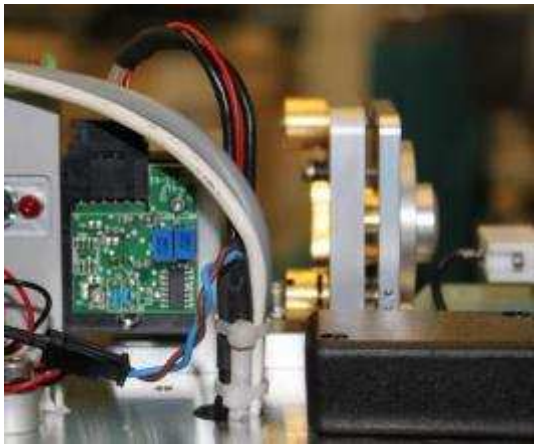
Aiming diode power supply main component pinouts

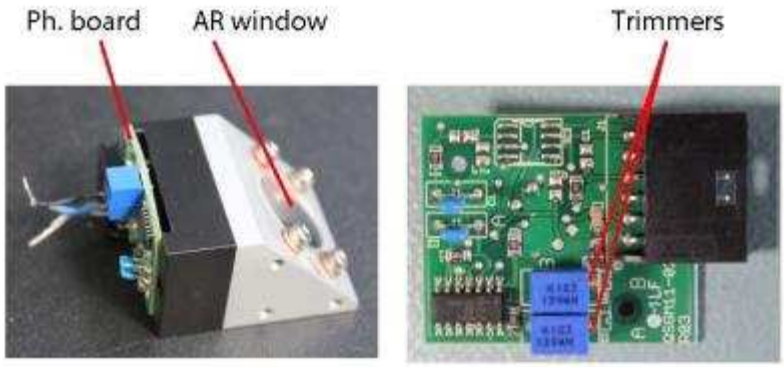
The board connectors, test points and trimmer pinouts include:

- SV1 (2 pins, Amp type, male) input, +12Vdc power supply
- SV2 (2 pins, Amp type, male) output, aiming diode
- J1 (4 pins, Amp type, male) input, microcontroller
- R3 trimmer (5Kohm, 20 turns, vertical) diode offset voltage setup

6.2.6 *Energy meter (photodiode)*

The photodiode board is mounted on the side of the photodiode assembly as in the figure below:





The energy meter assembly is the device used in the system to measure energy coming out from the laser head. It is an opto-electronic device, based on a photodiode and a coated window, and it is located on the optical bench, just between the output coupler and shutter assembly.
The main scope of the photodiode is to send out the energy value of the laser beam to the microprocessor.

Out from the laser head, the laser beam passes through a 45° coated window and, and out of it, a little portion (≤ 0.3%) is captured by the photodiode through a partial hole into a plastic block. An electric signal, directly proportional to the energy read, is generated by the diode and sent to the Signal routing board. Then, this signal will be used by the microcontroller to perform the energy tracking.

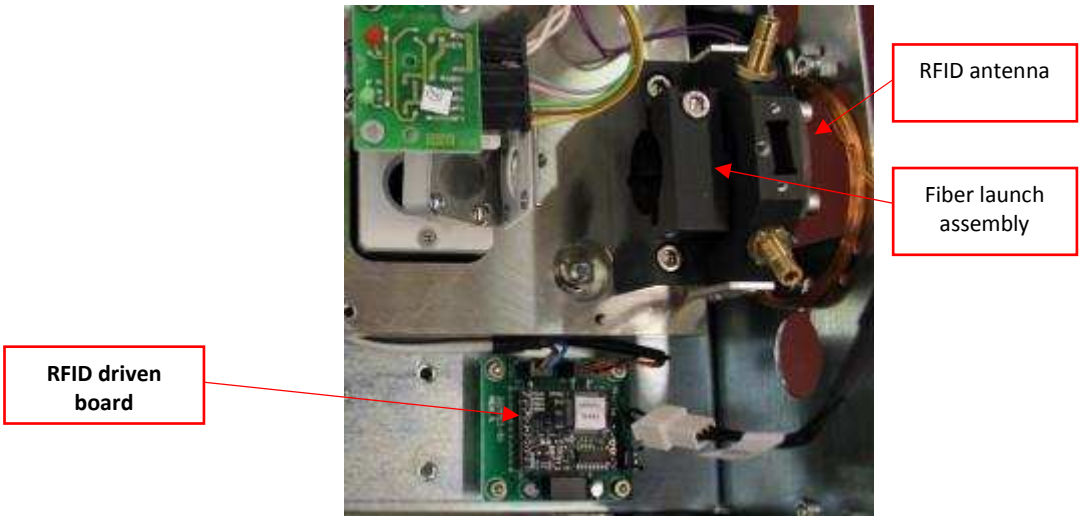
When the "Energy Check" is enabled, the program compares the energy value set on display with that one coming from the photodiode. Then it adjusts the output voltage of the Compact H.V.P.S. every time there is a discrepancy between the two energy values. In this way the energy of the laser beam is always monitored and equal to the set value. Energy meter can be adjusted in order to provide a correct energy reading: **use the trimmer screw** (see figure above) **to calibrate the photodiode.** The clockwise turns will decrease the value while counter-clockwise turns will increase it.

The energy meter calibration procedure is described in Section 6.5.1.

6.2.7 *RFID driven board*

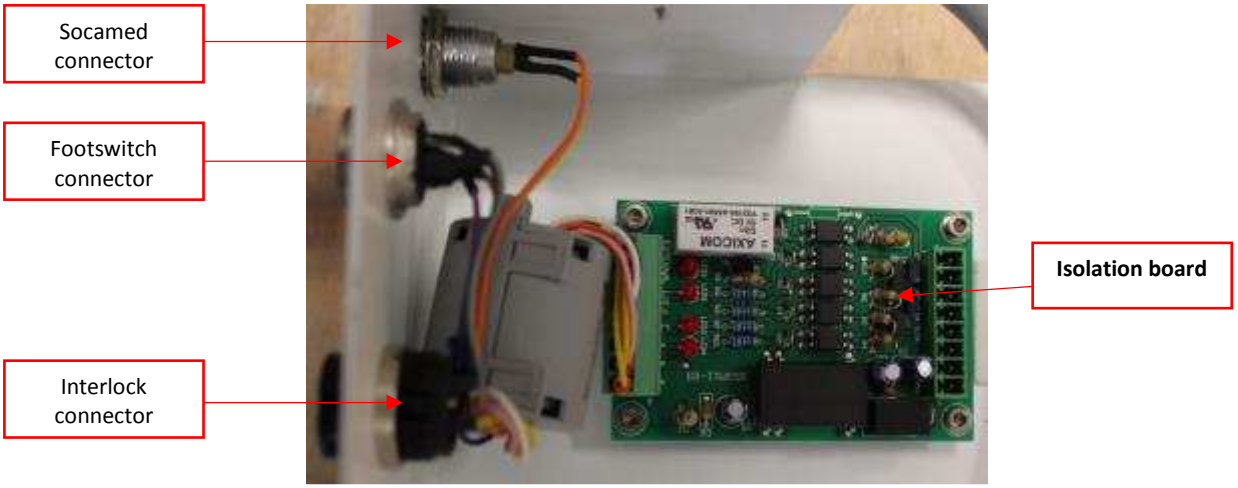
This Laser System is provided with an RFID (Radio Frequency Identification) technology for the automatic identification of the optical fibers. **The RFID system keeps record of the number of uses (correlated with the required sterilization cycles) that the fiber undergoes.**

The board is located close to the fiber launch assembly, as shown in the figure below:



6.2.8 *Isolation board*

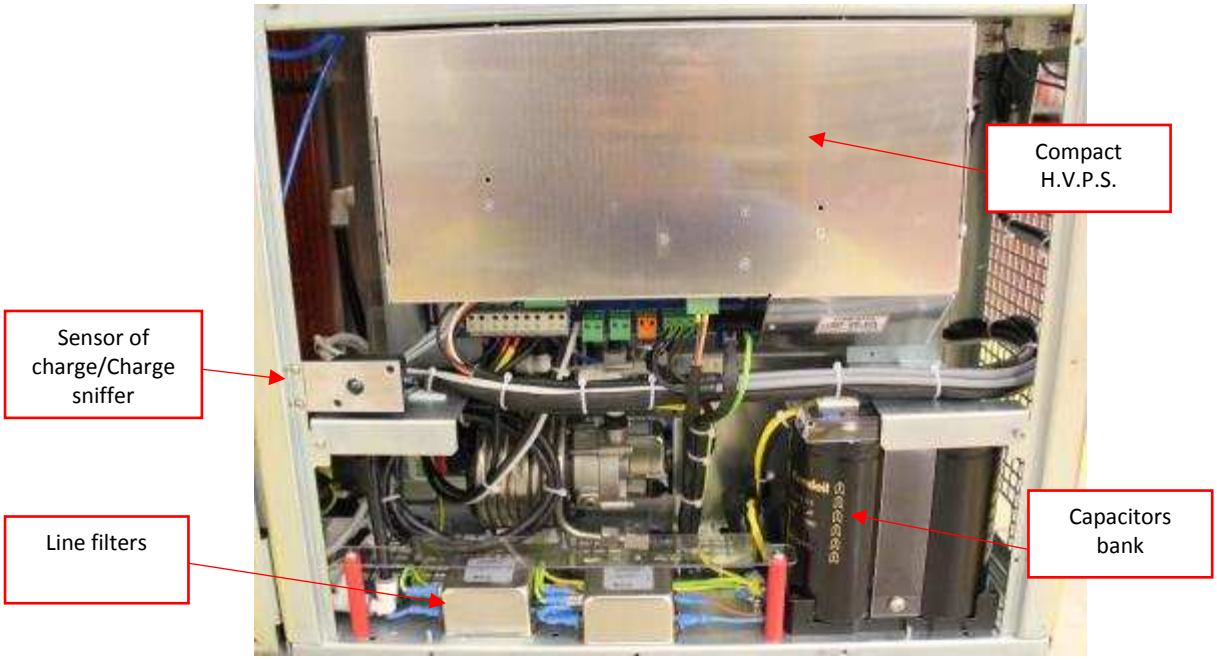
The **Isolation board,** supplied by 220V ac, is used to provide double isolation between human interface elements (footswitch and remote interlock) and the whole system. It is localized on back side of the system, close to the footswitch and remote interlock connector.



The isolation board has not any control from microcontroller board and does not provide any feedback.

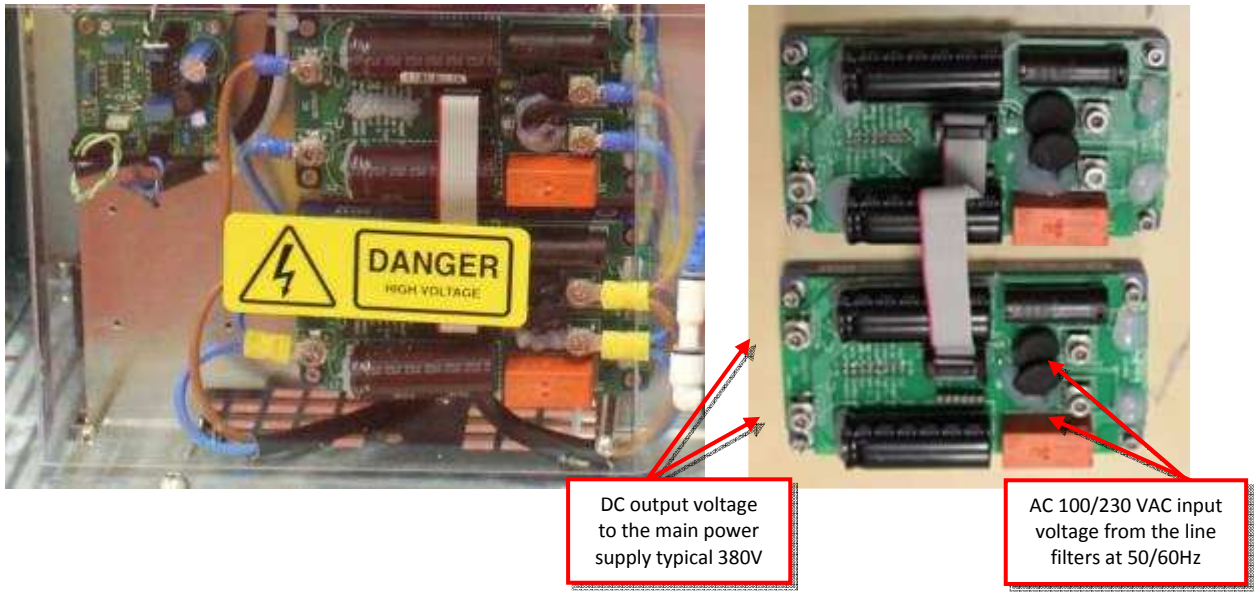
6.3 Power Electronics components

In the following figure an overview of the power electronics components is shown:



6.3.1 *PFC power modules*

After the line filters, the two **PFC AC/DC power modules** are placed, under the Lexan cover below the control electronics box (item **6** in Figure 6.1):



This electronic device has the following input parameters:

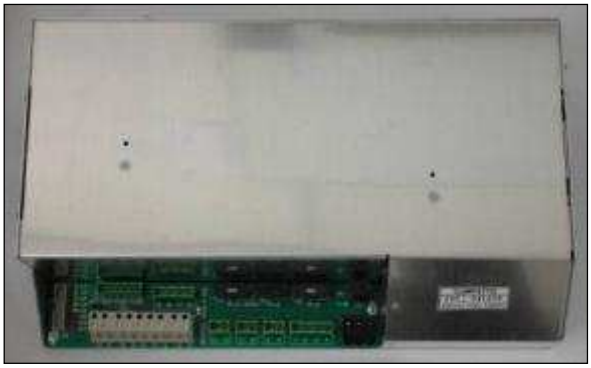
Input Voltage ..... 85 to 265 Vac
Input Frequency ..... 50/60 Hz
Efficiency ..... 92% typical (VI = 115 Vac); 94% typical (VI = 230 Vac)
Total Harmonic Distortion .....Less than10%

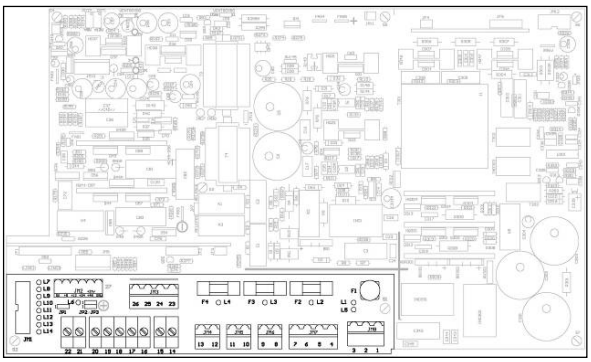
The PFC modules operate with the following characteristics and output parameters:

- Unity power factor
- High efficiency - up to 96%
- Universal input voltage and frequency range
- Up to 1200W output power
- In parallel with current sharing within 3%
- < 10% harmonic distortion conforming to EN61000-3-2
- 85°C base plate operating temperature
- High reliability - over 1 million hours MTBF
- Power fail warning signal
- PLD feature
- Enable output to control AMPSS® DC-DC converters
- 125Khz fixed Switching frequency

Output Voltage .....375 V ± 1% typical (IO = 2A); 393 V typical (IO = 0A)
Current Share Accuracy ..... 3% typical
Overvoltage Protection .....417 V typical
Power Limit .....VIN=85Vac; Pmax=750W
VIN=180Vac; Pmax= 918W
VIN=230Vac; Pmax= 1200W

6.3.2 *Compact H.V.P.S. (High Voltage Power Supply)*





The heart of power electronics subsystem is the **Compact H.V.P.S**., a modular inverter, capacitor charging/discharging power supply. It is located on the left side of the system, over the capacitor bank, held in place by a C-shaped metallic panel.
The H.V.P.S. is internally composed of five different sections, each one accomplishing most of the high voltage related operations:

- *Control* section, manages all the operations and communicates with controller board
- *Charging* section, produces energy conversion for the laser source
- *Discharging* section, delivers high voltage to the laser source
- *Igniter/Simmer* section, simmers the flashlamp
- *Services* section, distributes main line voltage to all the system's loads
- *Low voltage power supply* section, supplies low voltages to control electronics and sensors

Once the rear circuit breaker is switched on, the main line voltage is present on H.V.P.S at JM8. Turning the key on, through keyswitch/emergency button loop on JM7 the *Services* section provides to distribute this voltage to all the loads by connectors JM4, JM5 and JM6, starting the whole system.
Main voltage is then also distributed by *Services* to the internal *Low Voltage Power Supply* section, which steps it down and rectifies it giving three direct outputs: +5Vdc, +12Vdc and +24Vdc, which are used to supply all control

electronics boards, sensors and actuators and a switched +24Vdc output (available enabling ENAAUX signal) used for the water pump supply.

When turning on the unit, once self-diagnostic procedure has been cleared by software, the microcontroller takes control of H.V.P.S., communicating with its *Control* section through connector JM1. System then enters the Standby mode and H.V.P.S simmers the flashlamp. The flashlamp used in this system is a discharging gas (Xenon) flashlamp.
The simmering procedure starts with having an *Igniter* section producing a sequence of pulse trains (trigger pulses) that are sent to the laser head, through an external transformer that steps them up from initial 200V to max 20.000V. The gas filled in the flashlamp can be considered like a dielectric and purpose of pulse trains is to crack its intrinsic resistivity.
The two trigger channels are available from H.V.P.S, in order to ignite up two flashlamps, but in this system only one channel is used.
During this sequence, an initial simmering voltage of 1000Vdc is present across HV flashlamp terminals. Taking advantage from the momentary drop of voltage due to the trigger pulse trains, it will be possible to crack resistivity of the flashlamp. As a result, an arc will be created and an idle current will pass through the lamp. At this moment simmering voltage drops down from 1000Vdc to around 120Vdc and once it reaches this secondary value, *Simmer* section takes control of current across the flashlamp. From that point, every forced increase of voltage across the lamp will produce a big current flow and, as consequence, an intensive lighting emission.

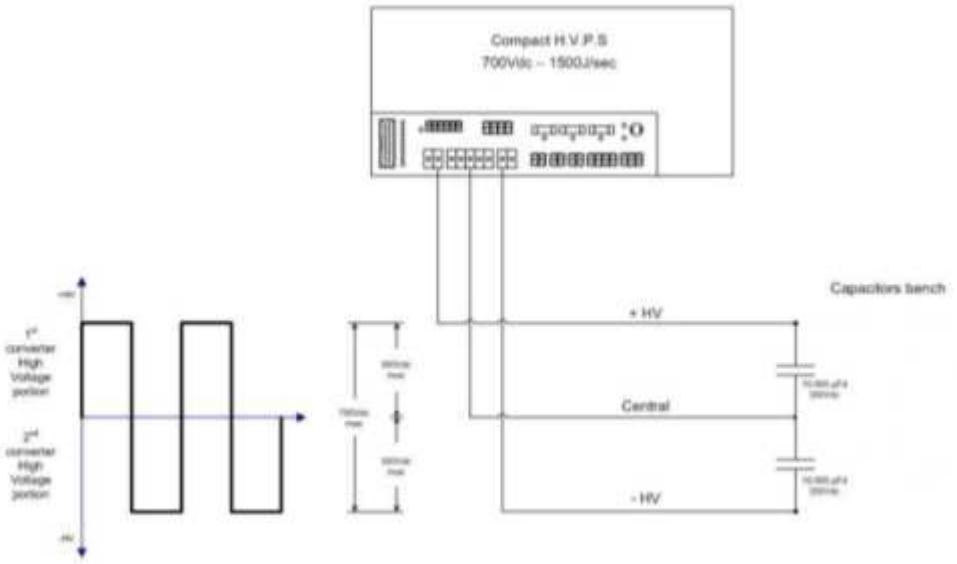
Only after a correct simmering procedure, the H.V.P.S. provides to charge the capacitor bank through the *Charging* section. A low voltage analog signal (DAC, from 0 to 4.7Vdc), comes from microcontroller board and, according to the output energy request, is used to set the appropriate H.V.P.S. output voltage during the laser operation. When enabled by signal ENACC (digital, active low), the power supply charges the capacitor bank. When the capacitor bank is completely charged, according to what is requested by software, the *Charging* section release the end of charge signal (FCC, digital, active low) to the microcontroller board.
From this moment the *Discharging* section takes control of operations and, once the system is moved into Ready mode, it will provide a discharging sequence of the stored energy into the flashlamp.

The H.V.P.S. uses switching technology to supply high voltage. A high frequency square wave-formed voltage is internally produced by a chopping inverter, then an output transformer provides to step it up to the required values. It has an internal architecture that includes two different charging converters, each one of those is used to process half portion of the square wave created by inverter, one for positive and one for negative.

The output configuration of H.V.P.S includes:

- + HV – positive High Voltage output
- Central – central point output
- - HV – negative High Voltage output

This structure allows connecting the capacitor bank wired in series, using the connection point between two capacitors as a central point of H.V.P.S output, keeping the balanced load on charging converters.



Capacitor connections to HVPS

The maximum H.V.P.S output voltage is 700Vdc and the charge rate is approximately 1500J/s. The output current has an initial peak at approximately 600 A. The module will charge 10.000µF within 0.95sec.

All input/output connections are concentrated on the front side of H.V.P.S. as well as some status LEDs.
The LEDs indicate operating conditions of the device and allow also a simple diagnostic.

The H.V.P.S. exchanges with microcontroller certain command/status signals that are processed by the software.

Principal signals are:

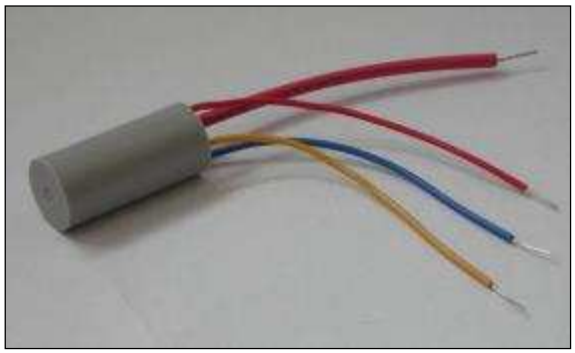
- ENAL1, Enable Lamp 1 Ignition
- ENACC, Enable Capacitor Bank charger
- LAMP1ON, Lamp 1 simmered
- DAC, Capacitor Bench charging voltage
- PULSE1, Flashlamp pulse trigger

6.3.3 *Capacitors bank*

The **capacitor bank** is the energy storage part of the system. It is composed of two capacitors 10.000µf-350Vdc rated, wired in series to suit HVPS max voltage capability. Total capacity becomes therefore 5mF-700Vdc.

The capacitor bank is located on the left side of the system, in the power electronics area. Wiring between capacitor bench and H.V.P.S. is shown in the previous section.

6.3.4 *Trigger transformer*



Trigger transformer

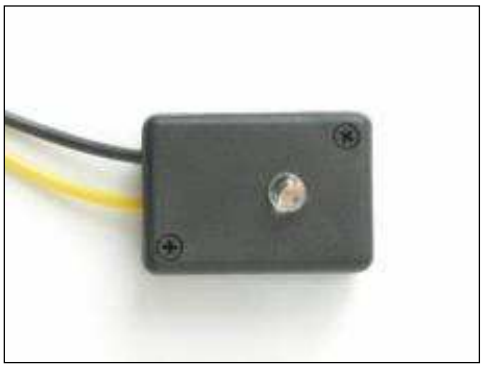
The trigger transformer steps up the trigger pulse, generated by H.V.P.S., from an initial pulse of around 1µs and voltage of 200V to the final voltage of 20.000V on the laser head.

Its location is normally under the laser head, beneath the optical deck and it is wired to H.V.P.S. through a Molex connector.

The connections are as follows:

- **Primary coil** Blue – trigger output from H.V.P.S.
  Yellow – trigger ground output from H.V.P.S.
- **Secondary coil** Red (silicon wire) – trigger HV output to laser head
  Red – ground

6.3.5 *Capacitor charge sniffer*

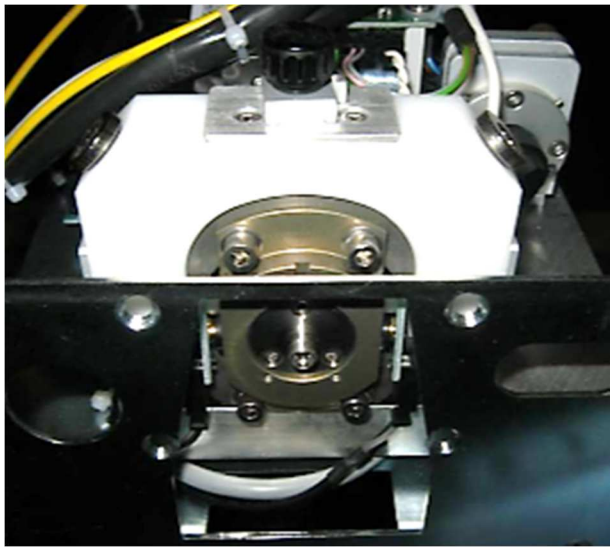


The capacitor charge sniffer is a safety part which provides engineers indications about residual charge of the bank and located in the power electronics area. It contains a circuit that sniffs charge on the bank and a LED that blinks with a frequency directly proportional to the residual charge.
The higher is the residual charge on the capacitor bank, the faster is the LED's blinking.

As safety feature it is recommended to wait until the red LED is completely off, before operating with capacitor bank and H.V.P.S.

6.4 **Sensors**

6.4.1 *Fiber sense interlock*



The fiber sense interlock is directly mounted on the optical fiber receptacle. It is composed of a transmitter (photodiode) and a receiver (phototransistor). Basically the transmitter emits some light that is captured by the receiver.

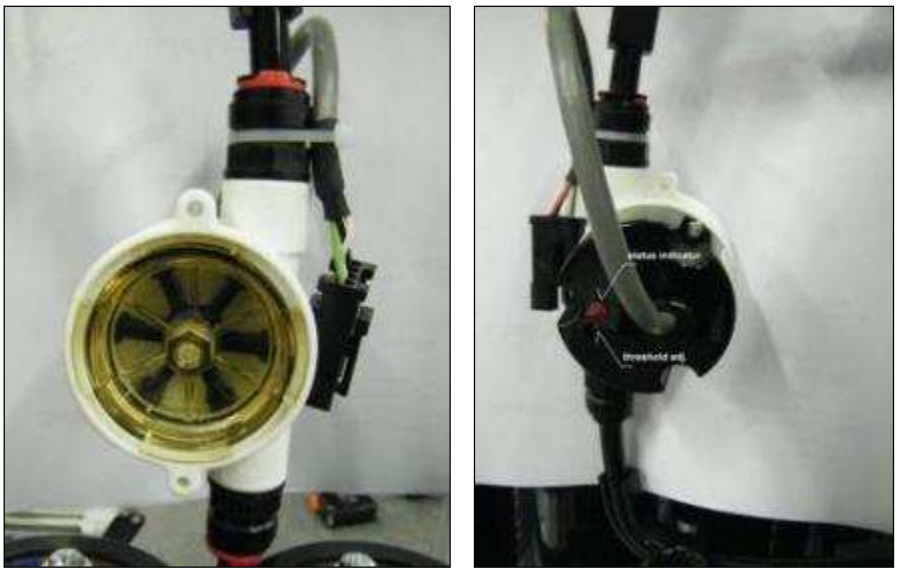
Once an optical fiber is inserted, this light beam is interrupted and a “fiber in” signal is sent to microcontroller. The fiber sense interlock assembly is normally setup at the Factory in order to provide “fiber in” signal ONLY when the optical fiber is correctly inserted into receptacle.

6.4.2 *Thermo switch*

When the water temperature increases over 60°C the thermo switch opens a contact giving a signal acquired by the microprocessor which displays the “Over temperature” error message.
The switch closes the contact at 45 °C. The tolerance for the opening temperature is ±3 °C, while ±5 °C is the tolerance for the closing temperature.

6.4.3 *Flow switch*

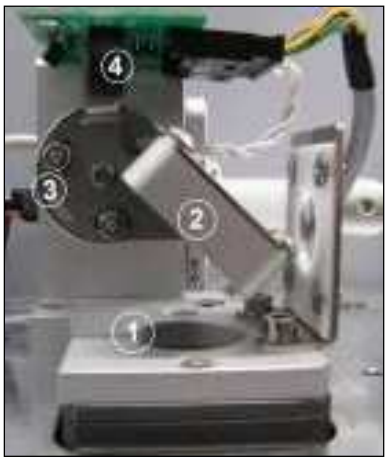
The flow switch prevents laser to run if the water flow rate is not enough, for the sake of safe laser operation. A low flow rate implies a poor cooling of the laser rod, flashlamp and pump cavity which in turn results into a very poor laser performance or in a permanent damage of the pump cavity assembly.



The flow switch is shown in the figure above: front view (left hand side) and in rear view (right hand side). In the rear part of the flow switch a red LED blinks when the flow rate is higher than the appropriate threshold value. This is set up at the factory by adjusting the threshold screw which is close to the LED. This threshold MUST NOT be changed unless agreed differently with the technical personnel of manufacturer. When the water is flowing, rotating blades are visible in the front part of the device but their motion cannot provide the real perception of the flow rate. Therefore, check of the flow must be done by looking at the LED only. The signals from the flow switch are routed to the interface board and then to the microprocessor which displays an error message whenever flow rate is lower than the threshold.

6.4.4 *Shutter optical fork*

The optical fork is shown as item **4** in the following shutter assembly:



An optical switch (optical fork), included into a small board mounted on the top of the shutter assembly, is used to sense the position of the shutter flag. When the shutter is closed (mirror reflects the beam into the sink) the sensor

does not detects infrared light from the led side of the optical switch. When the shutter is energized and moved out of the beam path, the signal passes from phototransistor to sensor.

The firmware returns an alarm if the shutter flag is detected in wrong position during operations, e.g. if it is opened when the footswitch is not being pressed.

6.5 Maintenance Procedures

6.5.1 *Energy meter calibration*

The calibration of the photodiode is required every time when there is a difference between the energy value measured by a power meter (before the fiber launch assembly) and the one visualized on display. To calibrate the photodiode please follow the next steps:

1. Enter the system in Service Mode;
2. **Disable energy adjust: MENU → SERVICE**
3. Set the energy at a middle level;
4. Release the adjusting screw (on top of photodiode assembly) by unscrewing the fixing grain
5. Measure the energy of the laser before the launch into the fiber (see the procedure explained for the cavity alignment);
6. Compare this value to the one shown on display;
7. By adjusting the screw correct the energy value visualized on display;
8. Proceed until the two values (measured and visualized) are equal;
9. Tight the fixing grain;
10. Control the correspondence between these two values at different energy values (if the correspondence is lost, repeat the procedure from point 5 and be more accurate until the target is achieved);
11. Select the energy measure mode in the setting parameters;
12. Verify that the program works as it is expected (if not, repeat the procedure).

Warning:
The photodiode calibration is a critical procedure. If it is done in a wrong way it can compromise the operating condition of the laser device. Because of the photodiode calibration indirectly affects the Energy Calibration, it must be performed with extreme attention.

Having a wrong calibration, the software receives wrong information about the real laser beam energy. In this condition the Microprocessor will compare a wrong energy value coming from the photodiode with the one set on the display by the user and it will start adjusting the output charging voltage based on the wrong information. The result will be a discrepancy between the visualized energy value and the real value.

6.5.2 *Compact H.V.P.S. replacement*

For this procedure please refer to the HVPS layout, (see Appendices) for connections and pinout.
The compact H.V.P.S. is fixed on a C-shaped plate with two screws on top. The retaining plate itself is fixed on laser chassis with four screws on its corners, as indicated by arrows on the following figure.

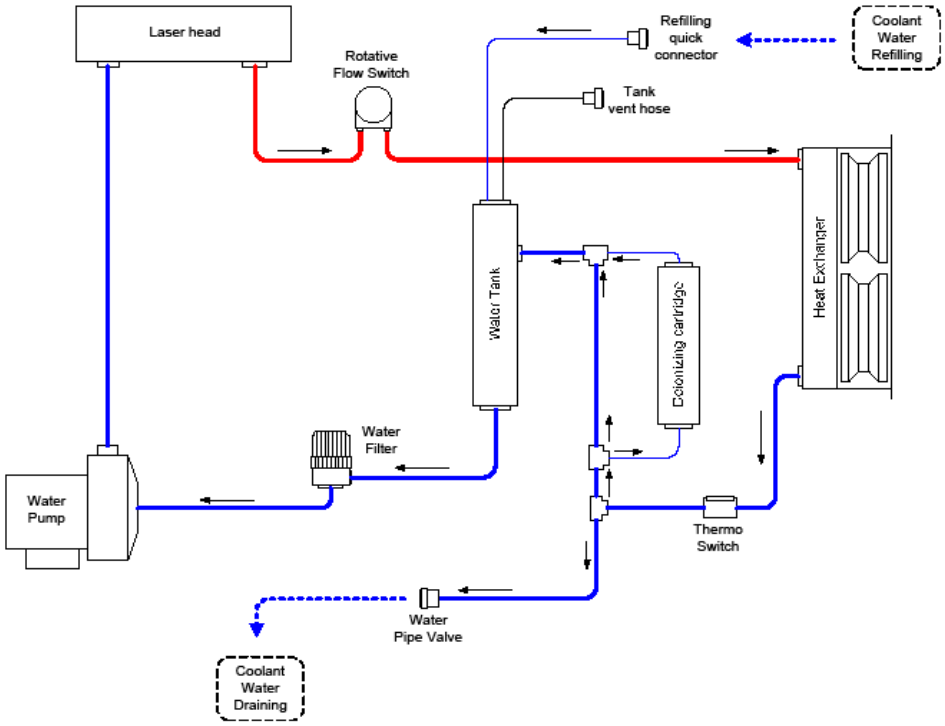
To replace the compact H.V.P.S., please follow the next steps:

1. Disconnect power cord from the system
2. Remove left side panel
3. Be sure that Capacitor Charge Sniffer is not blinking
4. Unplug the flat cable from JM1
5. Unplug all Molex connectors from H.V.P.S., from JM2 to JM8
6. Take note of HV wire positions from pins 14 to 22 and then disconnect all wires
7. Remove the Capacitor Charge Sniffer assembly from laser chassis
8. Unscrew the four screws that hold C-shaped bracket in place
9. Gently slide H.V.P.S. and C-shaped assembly out
10. Replace H.V.P.S., by releasing it from the two screws that keep it fixed on the bracket, with a new one
11. Plug back HV wires, taking special care not to exchange central point connection
12. Plug back all other connectors, taking care that they will be well inserted
13. Turn on the system and, selecting a low energy, run the laser in the User Mode checking if any alarm appears on display

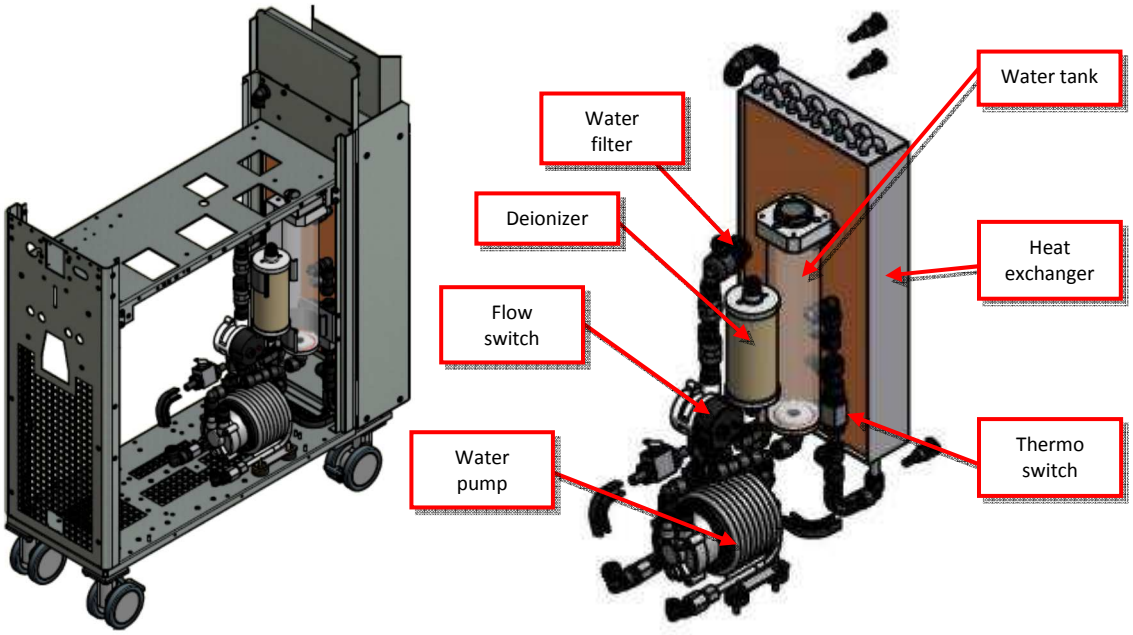
7 COOLING SYSTEM

7.1 Cooling System overview and Block Diagram

The cooling system block diagram is given below:



The cooling circuit is located in the lower part of the structure as shown in the figures below:



The water filling of the cooling circuit is carried out on the rear side of the laser, by opening the rear panel door (see Section 3.4.2).

7.2 Cooling System components

7.2.1 *Water pump*

The water pump is a brushless, low voltage, high efficiency pump. The input voltage is 24 V and its operation is controlled by the driving electronic board into the pump.

7.2.2 *Water filter*

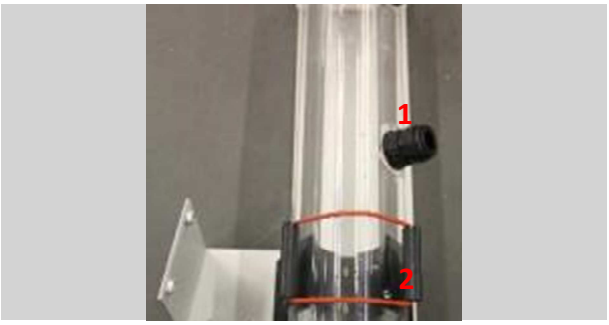
The water filter assembly is mounted in the cooling loop. In the figure below its subparts are shown. The filter size is a standard of 100 mesh.
In the standard maintenance procedure, when the cooling loop has to be cleaned, this filter (which is metallic), after being removed from its housing, can be washed, following the appropriate procedure.

7.2.3 *Deionizer (deionizing cartridge)*

The deionizer is shown below. This filter is placed in parallel to the main stream and only a small flow goes through it. It reduces and also keeps low the conductivity of the water. Typically, after a few hours of operation, the conductivity of the water stabilizes at about 1 µS.

7.2.4 *Water tank*

The water tank has four connections with the rest of the cooling loop:



1. Filling inlet
2. Flow inlet (coming from the heat exchanger)
3. Flow outlet to the water filter and pump

The transparent water tank allows quickly checking of the water level and purity status of the water. This can be examined also when the side panels are mounted looking through the inspection window placed on the right panel.

3

7.2.5 *Heat exchanger*

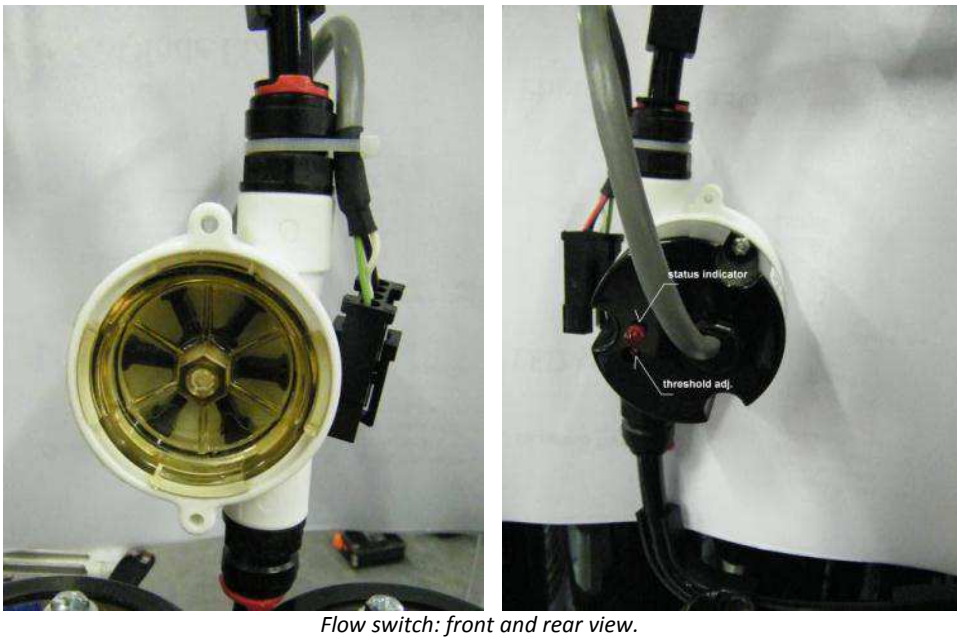
The water-to-air heat exchanger is shown below. Fans are turned on as soon as the system is switched on. There are no fans switched on and off by the firmware.

The water cooling is provided only by fans and heat exchangers, hence the water temperature depends on the desired power of the laser and the room temperature. Typically when laser is operated at maximum power level, temperature of the water getting out the pump cavity is about 14 °C higher than the room temperature. For a safe operation of the laser, the room temperature must not exceed 25 °C.

7.2.6 *Flow switch*

The flow switch prevents laser to run if the water flow rate is not enough for safe operation of the laser itself. A low flow rate implies a poor cooling of laser rod, flash lamp and pump cavity which in turn results into a very poor laser performance or in a permanent damage of the pump cavity assembly.
The flow switch is shown below. In the rear view, a red LED lights when the flow rate is higher than an appropriate threshold value. This is set at the factory by adjusting the threshold screw which is close the LED. This threshold MUST NOT be changed unless agreed with technical personnel from the Manufacturer.

When the water is flowing rotating blades are visible in the front part of the device but their motion cannot provide the real perception of the flow rate. Therefore check of the flow must be done looking at the LED only.
The signals from the flow switch are routed to the interface board and then to the microprocessor which displays an error message whenever flow rate is lower than threshold.



Flow switch: front and rear view.

7.2.7 *Thermo switch*

When the water temperature increases over 60°C, the thermo switch opens a contact giving a signal acquired by the microprocessor which displays the “Over temperature” error message. Switch closes the contact at 45 °C. Tolerance on opening temperature is ±3 °C, while ±5 °C is tolerance on the closing temperature.

It is positioned at the output of the heat exchanger and before the water tank.

7.3 Cooling System Standard Maintenance Procedures

The cooling system needs a few periodic maintenance procedures:

1. draining and replacement of the cooling water;
2. cleaning of the water filter and cooling loop
3. refilling of water
4. replacement of filters

Besides those, some other interventions are needed but not on periodic basis:

1. water draining for shipment, storage or cooling loop repairing
2. water filling (e.g. after shipment and during installation)
3. replacement of failed components

7.3.1 *Draining and replacement of the cooling water*

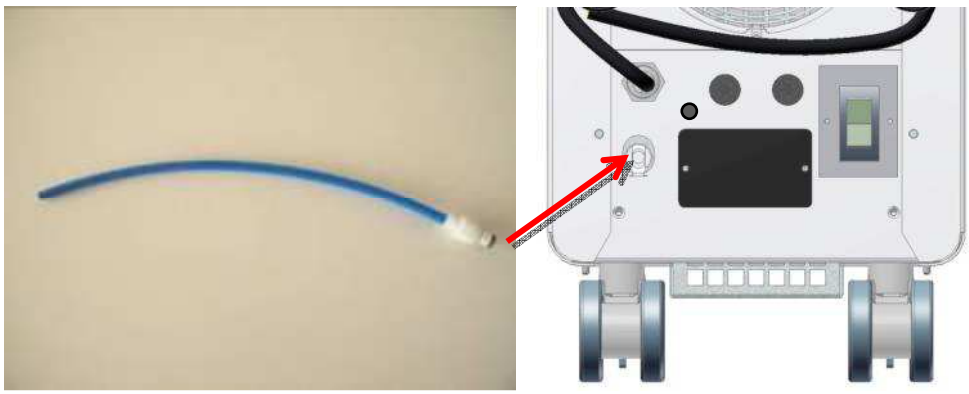
For efficient laser operation, cooling water must be kept pure and clean as much as possible. Dirty water limits the efficiency of the laser, resulting in a lower output power. Pollution of the water can be due to different causes like bacteria and algae proliferation (due to contamination from surrounding environment) or diffusion into the cooling loop of particles and tiny material fragments due to damage of laser components and sub-parts coming from any failure condition.

Periodic check of the water condition must be done every 2 or 3 months of operation, looking at the water through the inspection window placed on the right panel or, more efficiently, after removing the right side panel looking directly at the transparent water tank (see fig 7.9). Water check is mandatory in case of any failure of components included in the cooling loop (e.g. in case of laser rod or flashlamp cracking) or if the laser has not been used since a long time without removing the cooling water.

If the water tank is dirty it is quite easy to see:

- if water is not clear anymore,
- if some particles are moving inside the tank when the pump is switched On and Off
- if the water tank wall is dingy.

Anyway, a periodic replacement of the cooling water is recommended, mainly after the flashlamp replacement.
In all these cases, dirty water must be drained from the cooling system, which has to be cleaned, then the system must be filled with new, clear de-mineralized water.
Draining can be easily accomplished by plugging a pipe, equipped with fast connector on its end, into the draining port in the rear panel of the device (see arrow):



7.3.2 *Cleaning of the cooling system*

After draining the cooling loop, it must be washed and cleaned for removing any organic or inorganic pollutant. The cleaning must be done by using clear water added with sodium hypochlorite: 5 cm^3 of sodium hypochlorite for domestic use (which is a 5% solution) must be added to each litre of water used for cleaning. This solution must flow in the cooling loop for 2 hours, without the water filter.

The water filter must be very carefully washed and cleaned (removing any material inside and being sure that mesh is not partially occluded or dingy) or, better, replaced with a new one, otherwise when mounted again inside the cooling loop, it would contaminate the system again. Refer to Section XX for replacing the water filter.

After 2 hours, water added with sodium hypochlorite must be removed (in the same way as before) and the cooling loop must be carefully washed with clean, de-mineralized water. Finally, remove the washing water and re-fill the system with new de-mineralized or distilled water for the laser operation.

Warning: *Avoid to wash the cooling loop with tap water, use de-mineralized or distilled water only.*

7.3.3 *Water filling*

Water filling must be accomplished by using the special bottle shown below:

Warning: *Be sure that the bottle is clean. Do not use it for removing the dirty water. Do not let any water inside and keep it dry when it is not used.*

If not clean and dry, the bottle can contaminate pure water.

For the refilling procedure, connect the bottle to the filling hose, then turn it upside down and press its cap: water will flow into the water tank. Look at the rising level inside the water tank and stop with filling when the water is close to the top of the tank, or when looking through the inspection window on the right side panel, when water level is at the top of the window (see also Section 3.4.3).

7.3.4 *Replacement of the Cooling System Components*

Apart from the cooling water, the only parts which can be easily replaced are the **water filter**, the **deionizing cartridge** and the **flow switch** (but its failure is very infrequent).
Other cooling system components like pump or heat exchanger very seldom break and under specific conditions (e.g., heat exchanger can break if water is let inside the cooling system and environmental temperature goes under 0 °C) but their replacement can be done only in the factory.

Water filter:
The water filter must be replaced when it cannot be cleaned anymore or it is damaged by fragments which are flowing in the loop after a failure.
Opening of the filter housing can be done by hands by unscrewing the lower cap. This must be done after all the water has been completely removed from the cooling system.

Deionizer:
The deionizer (deionizing cartridge) must be replaced when its color has changed from the original one (a new deionizer is brown). As for the water filter, deionizer must be removed after the cooling loop has been emptied. The blue pipes connected to the cartridge can be easily removed by simply pressing back the locking ring of the fast fitting, while pulling the blue pipe.

Flow switch:
The flow switch can be easily replaced because pipes are connected with fast fittings and electrical wiring is made through an electrical connector. The flow switch failure is very infrequent and it must be assessed with the support of the Service Department of ROCAMED. In case of replacement, the switching threshold must be set in the correct way, following detailed instructions supplied by the Service Dept. of ROCAMED.

 **Warning:** *Do not attempt to set the flow-switch threshold without phone assistance of Service Department of ROCAMED.*

7.3.5 *Water draining for Shipment and Storage purpose*

When the laser system has to be shipped or stored, it is possible that it must withstand low temperature, especially if shipped in cold regions and/or during winter time. In case of air freight shipment, flight conditions can be very changing and temperature can be easily lower than 0 °C.
For these reasons cooling water must be always removed before any shipment; for the same reason, the laser system coming from the factory is always drained before shipping.
If the laser system is stored or shipped without removing the water, when the environment temperature goes below 0 °C, the water freezes, and ice breaks cooling components, mainly the heat exchanger and pump cavity.

 **Warning:** *Do not ship or store the laser system with cooling water inside.*

8 TROUBLESHOOTING

8.1 Troubleshooting table

Trouble	Possible cause	Solution
The device can not start up	• Power line not connected • Main line breaker is off • Emergency push button is pressed down	• Check line cord breaker • Pull up the emergency push button
Footswitch Error	• Footswitch disconnected • Defective Footswitch	• Connect the footswitch • Check if footswitch must be replaced
Water Flow Error	• Not enough water • Water filter occluded • Water tube twisted • Water leakage	• Fill water reservoir • Check water filter • Check water tubes • Look for any water leakage
Water Temperature Error	• Room temperature too high or air inlet/outlet not free	• Check cooling circulation and fans • Assure that a correct distance from the rear panel to the wall exists • Check water pump
Flashlamp error	• Flashlamp is exhausted or broken • Power supply	• Check power supply • Exchange the flashlamp
Simmering Error	• Simmering breakage • Flashlamp broken • Trigger transformed failed	• Check the compact power supply • Check the flashlamp • Check trigger transformer
OverVoltage, Temp Error	• Problem in power electronics	• Check the compact power supply
External Interlock Error	• Interlock not well connected or not connected at all	• Check the connection of the Interlock
Shutter Error	• Incorrect shutter position	• Change the shutter or its electronic board
Energy Warning: high or low energy	• Fluctuation of the energy • Incorrect energy	• Check the photodidode reading • Check the optics and laser head
No correspondence between displayed energy and application effects	• Damage of the fiber	• Exchange the fiber

See also the "Alarms and Warnings" Section 4.6, Table 4.1.

In case the device must be sent back to the company fill the **RMA request** and send it to the **ROCAMED Service Department**.

8.2 Alarm descriptions

The possible failures can be in optical, electronic or cooling system. If an alarm has been shown on touch screen it will help the service engineer/technician to focus his attention on a particular part of the system.
If no alarms have been displayed, then the laser system should be opened and checked.

In the next Sections, some common failures are listed.

Warning: *When an electrical adjustment is required:*

- *switch OFF the system*
- *put on the protective gloves*
- *wait at least 5 minutes for the discharge of the capacitor bench*
- *remove the Lexan protection only when it is strictly required*

8.2.1 *Lamp alarm*

The flashlamp is OFF. This could be caused by certain factors:

- The flashlamp is broken: exchange the flashlamp with a new one
- Simmering is not working: check LED L7 (see Appendices)
- The high voltage is not coming from the Compact Power Supply: check on the Compact Power Supply the output voltage by removing the connector and measuring the High Voltage (by High Voltage Probe) on the PINS connected to the capacitor bank (see Chapter 6 and Appendices for electrical schemes and connectors pin-out) If there isn't the right voltage value, substitute the Compact Power Supply.

8.2.2 *Flow alarm*

The flow rate is below the threshold. The red LED on the flow switch should be OFF. Find out why the flow rate is so low and control the status of the water filter. It is possible that a dirty filter reduces the flow rate. If so, please clean the filter.

8.2.3 *Temp alarm*

The temperature is too high. This could happen for the following reasons:

- Lacking of the cooling water: verify the water level and add water if necessary
- See if the cooling fans are rotating or the rear side of the system is too close to the wall of the room obstructing the right heat exchange with the reservoir
- Be sure that the room temperature is not too high

8.2.4 *Shutter alarm*

The Shutter is not in the right position according to the command sent by the Microprocessor. Verify if there are certain mechanical malfunctions or if the electronic board of the shutter is not working appropriately. Depending on malfunction, change either the shutter or the electronic board.

8.2.5 *Low Energy*

Usually the problem is in low energy out from the optical fiber: this cannot be indicated by any error message but it can be found by measuring the fiber output power.
Anyway in this case:

- first the fiber should be checked for any damage
- if the fiber is undamaged, inspect the optics and open the laser head. Verify the fiber alignment and the optical performances.

9 CUSTOMER SERVICE

9.1 Manufacturer warranty and responsibility

The Manufacturer will disclaim any responsibility about a misuse of the system.

The Manufacturer shall not be held responsible for any damage or failure deriving from a wrong use of the device.

A correct use consists in:

- following the instructions described in this manual
- following a proper maintenance program for the system.
- complying with national and international safety standards.

The Rocamed MH01 system is warranted against any defects in material and workmanship for a period of one (1) full year from its delivery.
Repairs necessary as a result of natural disasters, accidents, electrical system faults, negligence, improper use or misuse of the appliance or servicing or repairs carried out by persons not authorized by Manufacturer are not covered by warranty.
Manufacturer staff must be allowed free access to the appliance.
Any repairs which cannot be carried out on site will be effected in our labs.

Warranty and responsibility of the Manufacturer will also expire for any of these reasons:

- Use of the device not conforming to the procedures and instructions reported in the user manual.
- Incorrect installation and maintenance.
- Use of the faulty safety system, not correctly installed or damaged.
- Unfulfilling of the instruction of this manual concerning: transportation, storage, installation, and maintenance.
- Arbitrary alteration of the device.
- Incorrect reparations.
- Accident caused by external element.

In no case the customer can be entitled to claim compensation for any damage resulting from the machine being out of operation.
On demand, the manufacturer will provide all technical information including electrical drawings, components list and suggested applications protocols.

9.2 Repair and modifications of the device

- Only authorized service personnel can execute repairing and maintenance.
- It is recommended to follows the standard maintenance program.
- It is recommended to replace all the damaged components.
- Use only original spare parts.
- Constructive modifications are not permitted.

9.3 Service department contacts

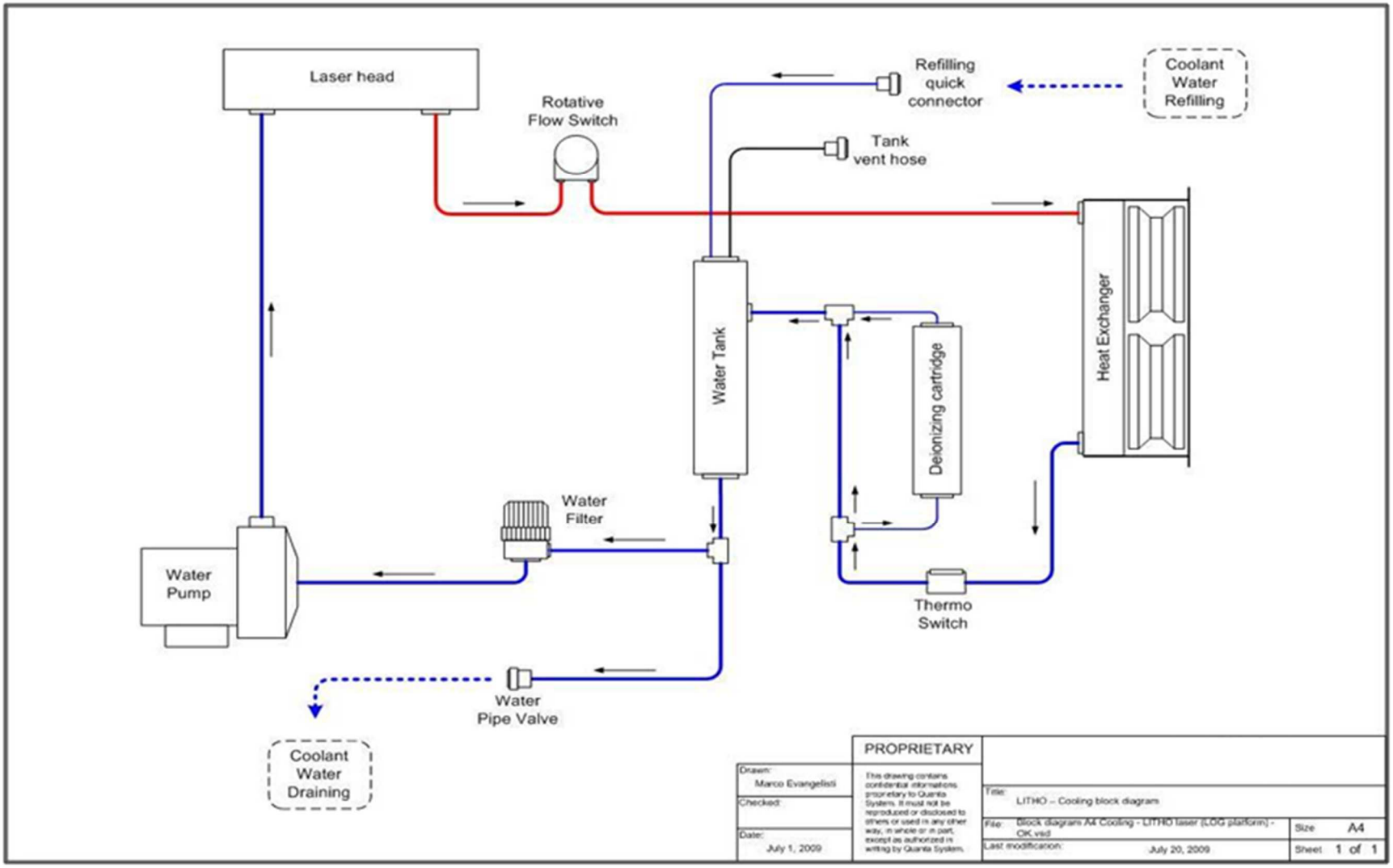
ROCAMED offers its customers resolve problems through e-mail and telephone contact, in addition to training courses for clients in ROCAMED, repairs and maintenance.
Please contact the Service Department of ROCAMED through the contacts listed below. Please keep to hand the serial number of your device.

ROCAMED

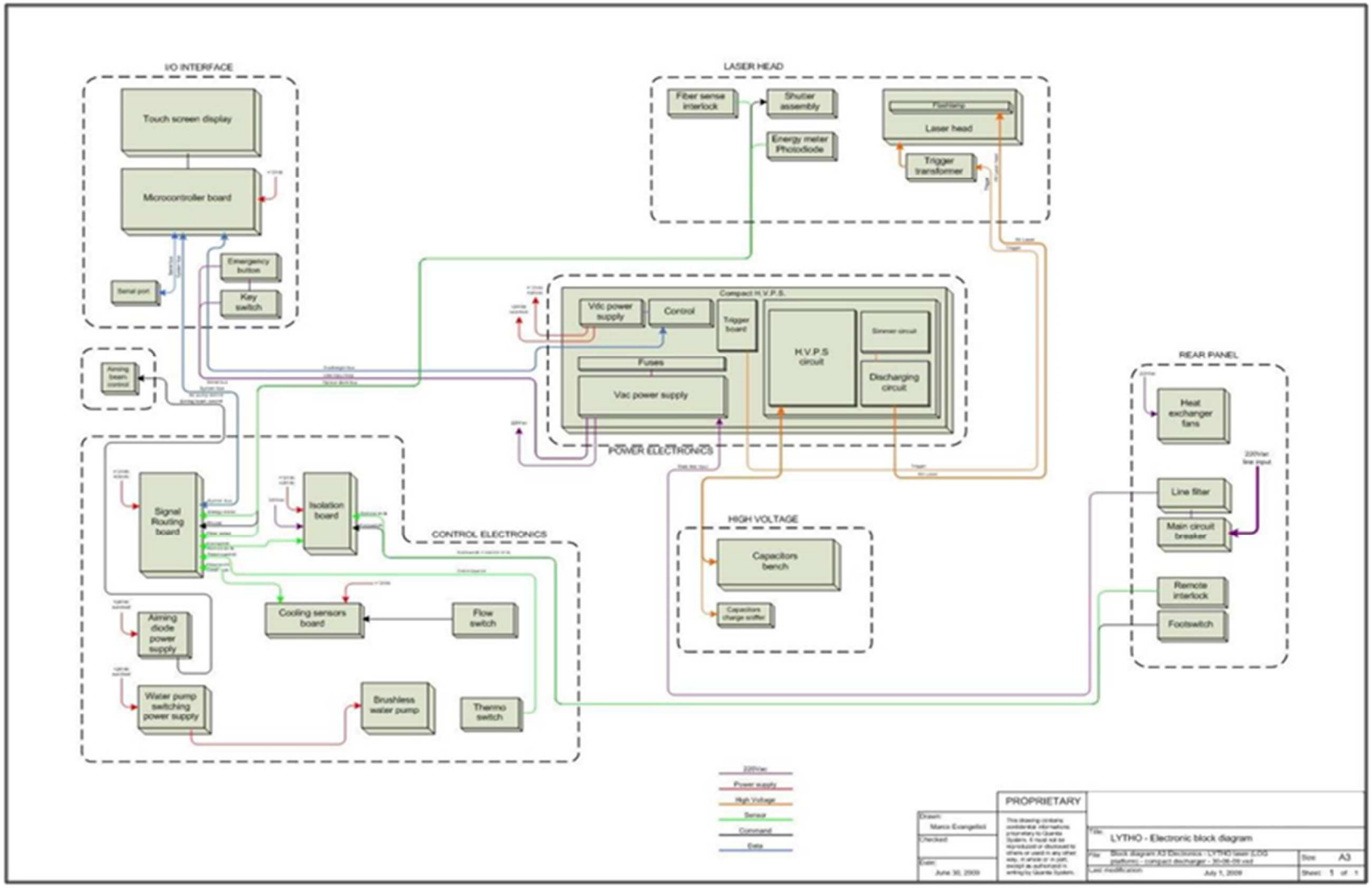
9, avenue Albert II
MC 98000 Monaco
E-mail: info@rocamed.eu
Phone: +377 97 98 42 32

ANNEX I

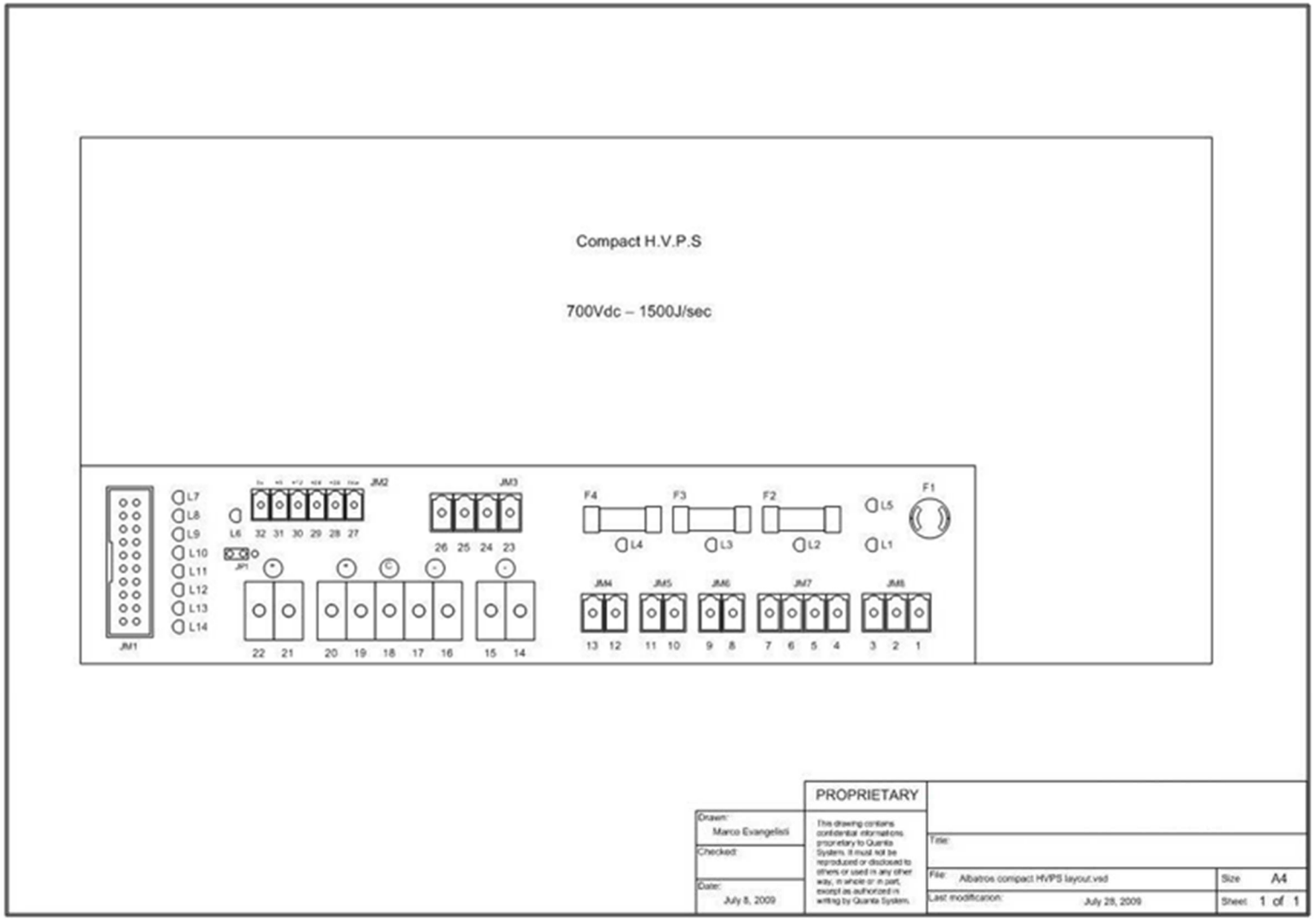
Block Diagrams and Schematics



Cooling system block diagram



Electronic system block diagram



Compact H.V.P.S. layout

Signal	JM1 Pinout		Signal
Ground	1	2	Ground
input (0V=enable lamp 1 ignition) ENAL1	3	4	Ground
input (0V=enable lamp 2 ignition)ENAL2	5	6	DAC analog input (4,7Vdc=max Vcap)
output (0V=lamp 1 lit) LAMPON1	7	8	+5Vdc
output (0V=lamp 1 or lamp 2 lit) LAMPON	9	10	OVCC output (0V=overvoltage)
output (0V=lamp 2 lit) LAMPON2	11	12	OTCC output (0V=overtemperature)
input (0V=enable AC aux voltage) ENAAUX	13	14	FCC output (0V=end of charge)
input (0V=enable AC power voltage) ENAPOT	15	16	VCC analog output (4,7Vdc=max Vcap)
input (0V=enable cap charger) ENACC	17	18	+12Vdc
input (input IGBT pulse) PULSE1	19	20	PULSE0 (input IGBT pulse ground)

Led	Colour	Description	Section
1	Green	Main Line Input presence (JM8)	AC Input
2	Green	Internal Service Line presence	Services
3	Green	Main Power Out presence (JM5-JM6)	
4	Green	Aux Power Out presence (JM4)	
5	Red	Main Line Input overvoltage	AC Input
6	Green	Low Voltages presence (JM2)	Low Voltage
7	Green	Flashlamp 1 simmer ON	High Voltage
8	Green	Flashlamp 2 simmer ON	
9	Green	Pulse request	
10	Yellow	EOC End of charge capacitors bench	
11	Yellow	Capacitors Bench Voltage presence	
12	Red	HVPS overtemperature	
13	Red	HVPS overvoltage	
14	Red	Flashlamp shortcircuit	

Fuse	Rated	Protection	Section
1	16A	Main Line Input presence	AC Input
2	2A	Internal Line presence	Services
3	5A	Main Power Out presence	Services
4	2A	Aux Power Out presence	Low voltage

Connector	Pinout	Description	Section	Signal
JM8	1	Main Line Input PE	AC Input	230Vac
	2	Main Line Input N		
	3	Main Line Input L		
JM7	4	Keyswitch-Emergency button loop Out N	Main switch	230Vac
	5	Keyswitch-Emergency button loop Out L		
	6	Keyswitch-Emergency button loop In N		
	7	Keyswitch-Emergency button loop In L		
JM6	8	Main Power Out N	Services	230Vac
	9	Main Power Out L		
JM5	10	Main Power Out N	Services	230Vac
	11	Main Power Out L		
JM4	12	Aux Power Out N	Services	230Vac
	13	Aux Power Out L		
HV	14	Lamp 1 Lamp 2 HV -	High Voltage	from 0Vdc to 700Vdc
	15	Lamp 1 Lamp 2 HV -		
	16	Capacitors bench HV -		
	17	Capacitors bench HV -		
	18	Capacitors bench central point		
	19	Capacitors bench HV +		
	20	Capacitors bench HV +		
	21	Lamp 1 Lamp 2 HV +		
	22	Lamp 1 Lamp 2 HV +		
JM3	23	Trigger Ground	Trigger	200Vdc pulse
	24	Trigger Ground		
	25	Trigger Pulse Lamp 1		
	26	Trigger Pulse Lamp 2		
JM2	27	0Vdc switched	Low voltage power supply	0Vdc switched
	28	+24Vdc		+24Vdc
	29	+24Vdc		+24Vdc
	30	+12Vdc		+12Vdc
	31	+5Vdc		+5Vdc
	32	Ground		Ground

PROPRIETARY

Drawn: Marco Evangelisti
Checked:
Date: July 9, 2009

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Title: Compact HVPS - connectors leds and fuses
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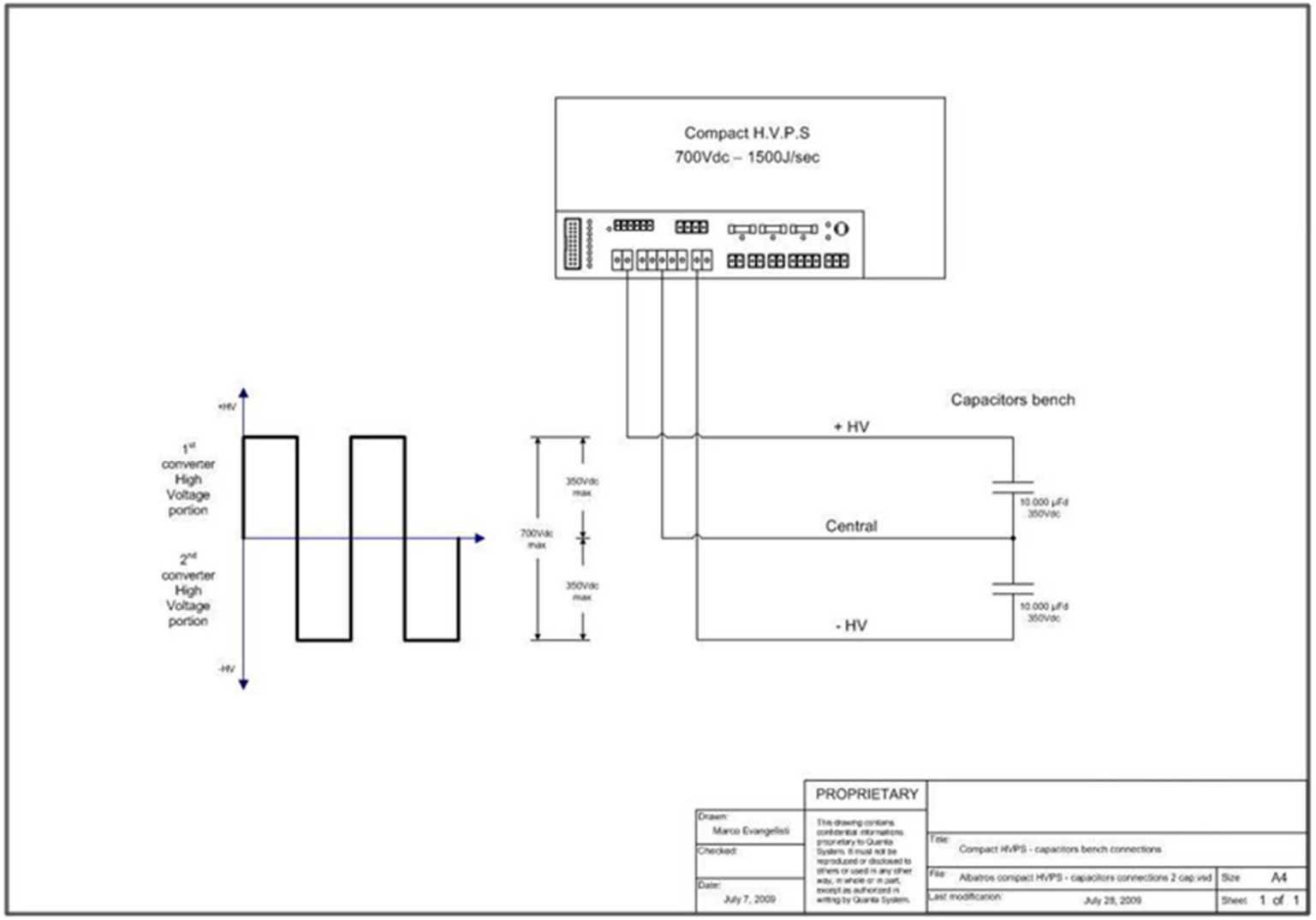
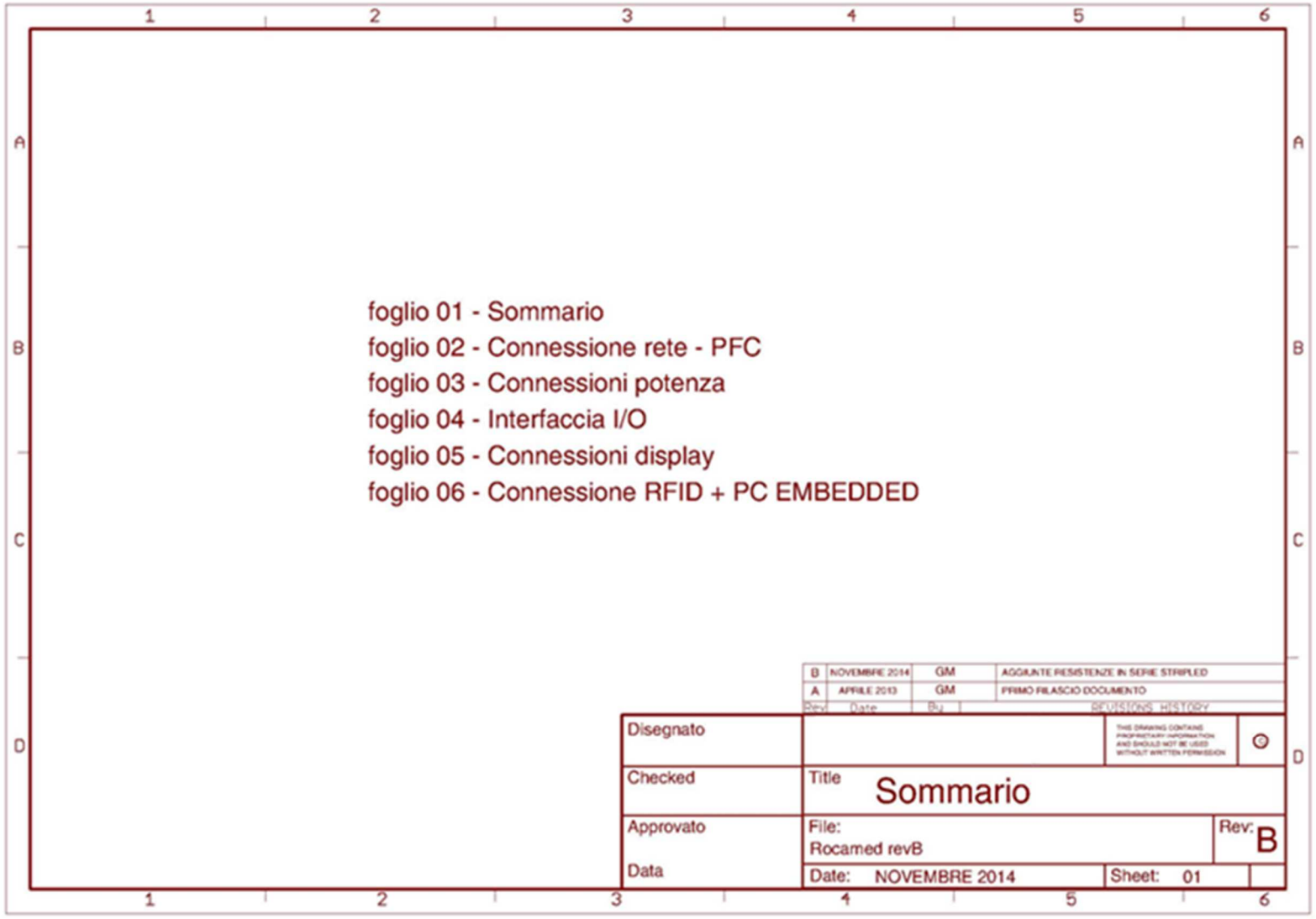
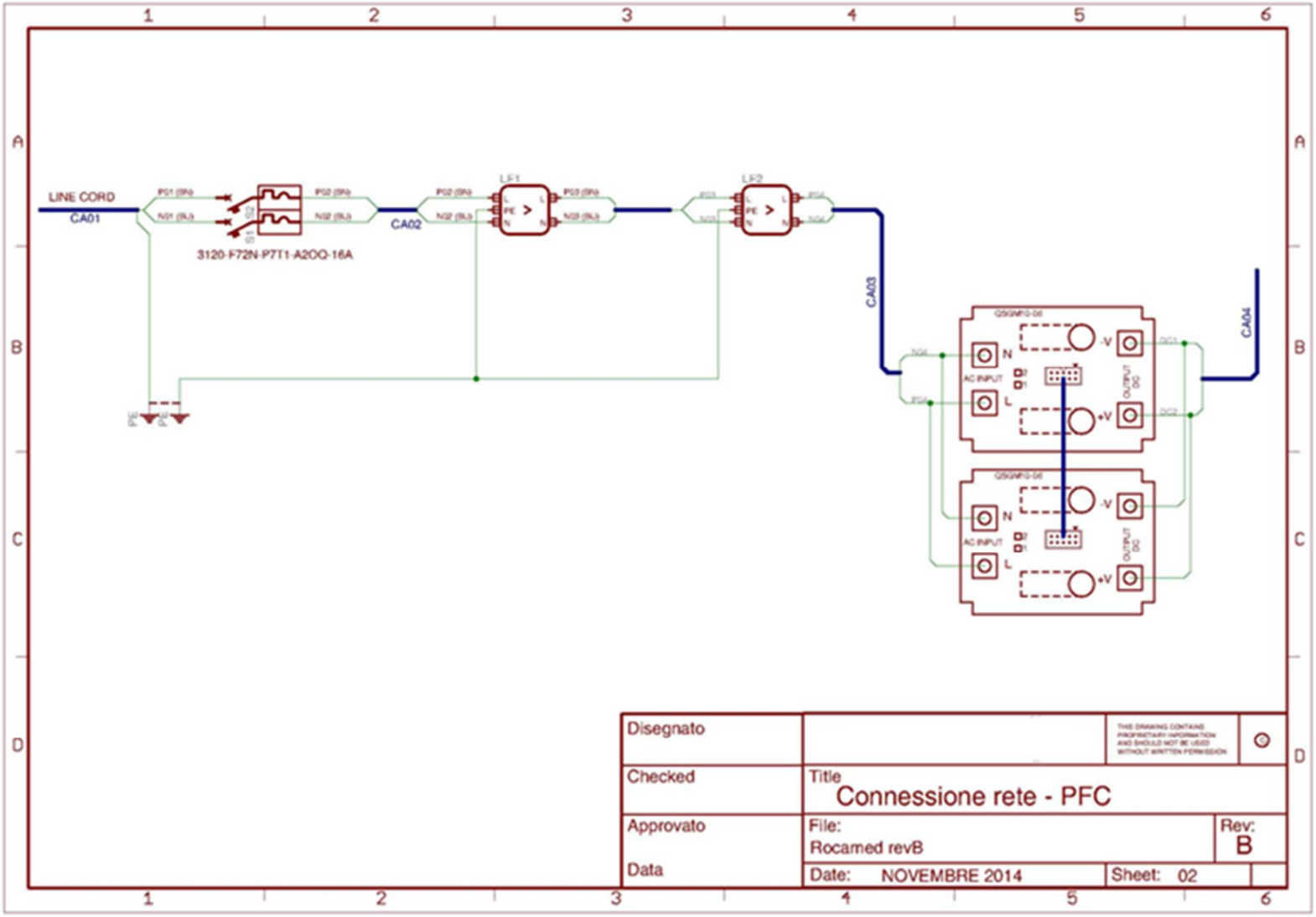
Size: A4
Last modification: July 23, 2009
Sheet: 1 of 1

Compact H.V.P.S connectors pinout, leds and fuses



H.V.P.S. - Capacitors bench connection


foglio 01 - Sommario
foglio 02 - Connessione rete - PFC
foglio 03 - Connessioni potenza
foglio 04 - Interfaccia I/O
foglio 05 - Connessioni display
foglio 06 - Connessione RFID + PC EMBEDDED
B NOVEMBRE 2014 GM AGGIUNTE RESISTENZE IN SERIE STRIPLED
A APRILE 2013 GM PRIMO RILASCIO DOCUMENTO
Rev Date By REVISIONS HISTORY
Disegnato
Checked
Approvato
Data
Title
Sommario
File:
Rocamed revB
Rev: B
Date: NOVEMBRE 2014
Sheet: 01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LF1
LF2
CA03
CA04
AC INPUT
OUTPUT DC
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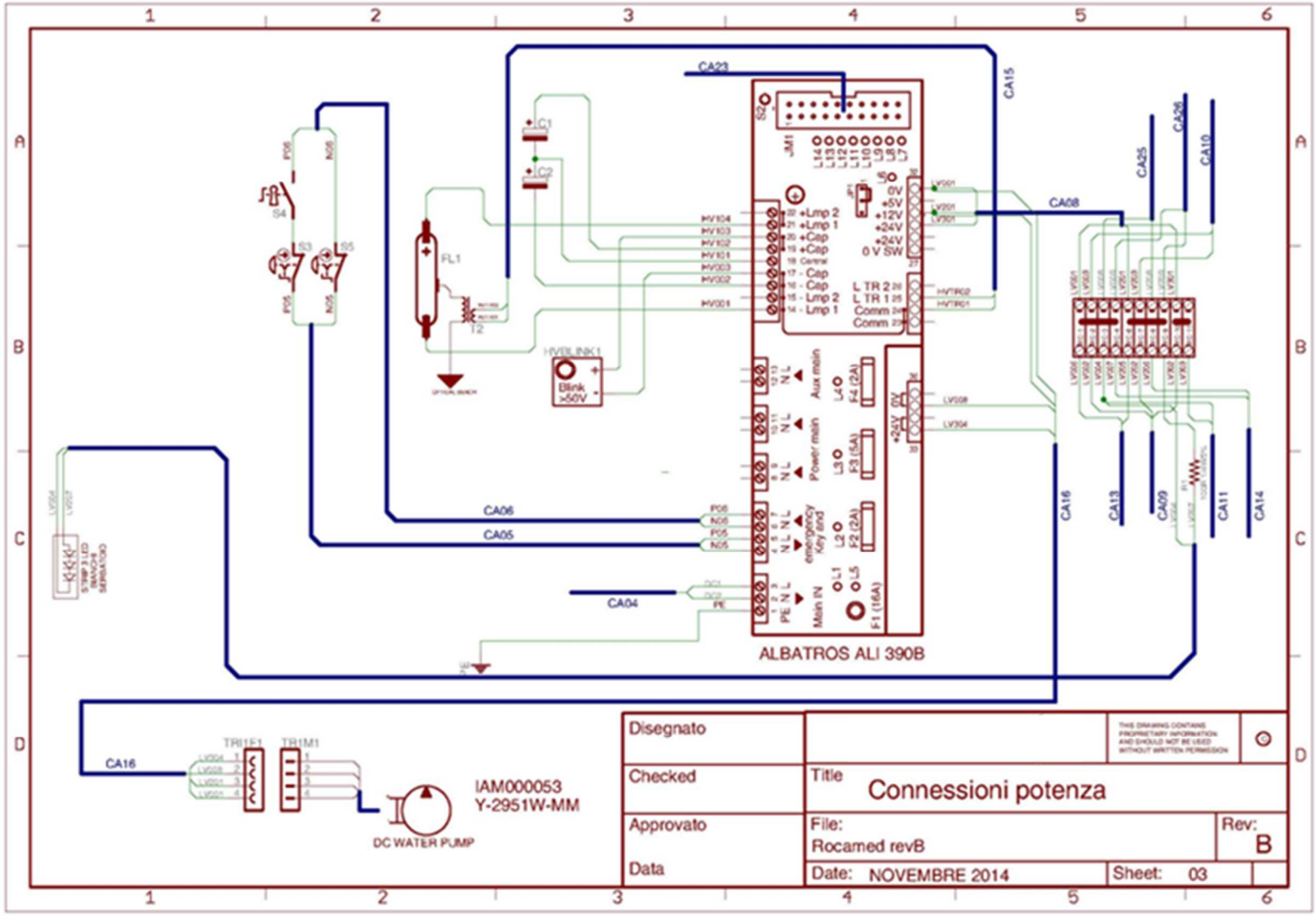
Rev:
B
Date: NOVEMBRE 2014
Sheet: 02


CA23
CA15
CA08
CA25
CA26
CA10
CA06
CA05
CA04
CA16
CA13
CA09
CA11
CA14
ALBATROS ALI 390B
IAM000053
Y-2951W-MM
DC WATER PUMP
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Approvato
Data
Title
Connessioni potenza
File:
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Rev:
B
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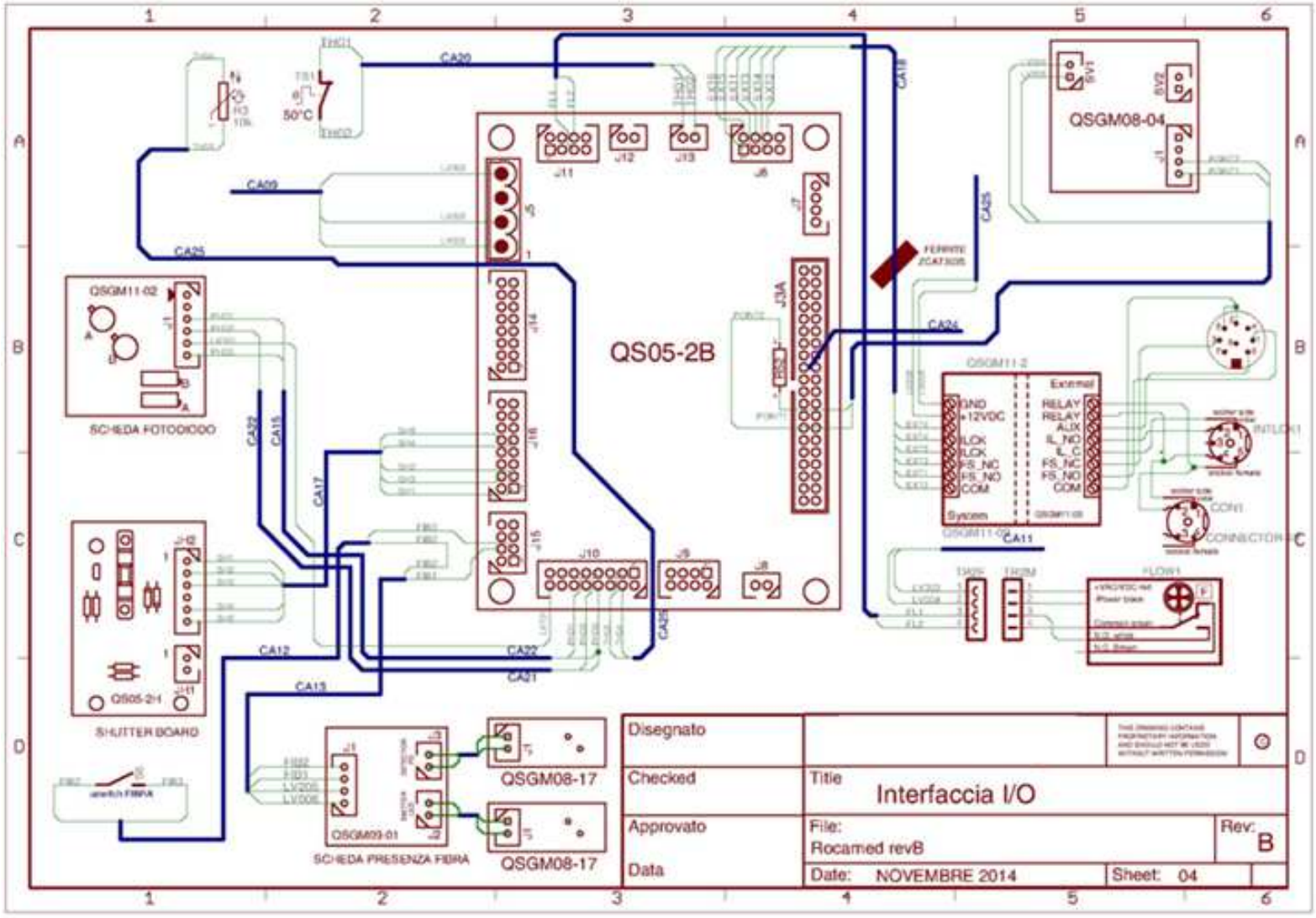
QS05-2B
QSGM08-04
QSGM11-02
SCHEDA FOTODIODO
QS05-2/1
SHUTTER BOARD
QSGM09-01
SCHEDA PRESENZA FIBRA
QSGM08-17
QSGM08-17
CA20
CA09
CA25
CA22
CA15
CA17
CA12
CA13
CA22
CA21
CA18
CA25
CA26
CA11
FERRITE ZCAT3035
50°C
Disegnato
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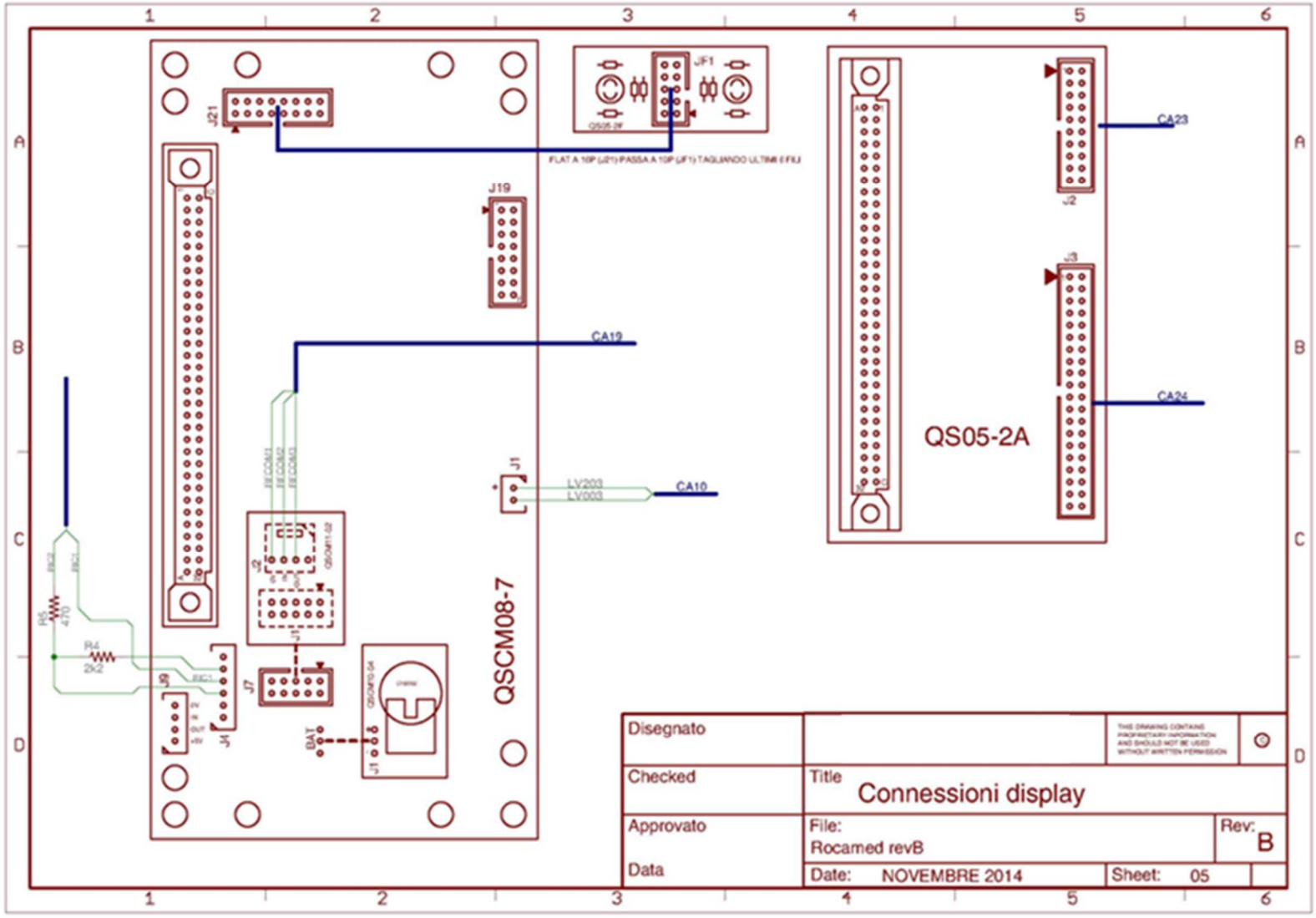
Approvato
Data
Titie
Interfaccia I/O
File:
Rocamed revB
Rev:
B
Date: NOVEMBRE 2014
Sheet: 04


QSCM08-7
QS05-2A
J21
J19
JF1
J1
J2
J3
J4
J7
J9
CA19
CA10
CA23
CA24
LV200
LV000
BAT
Disegnato
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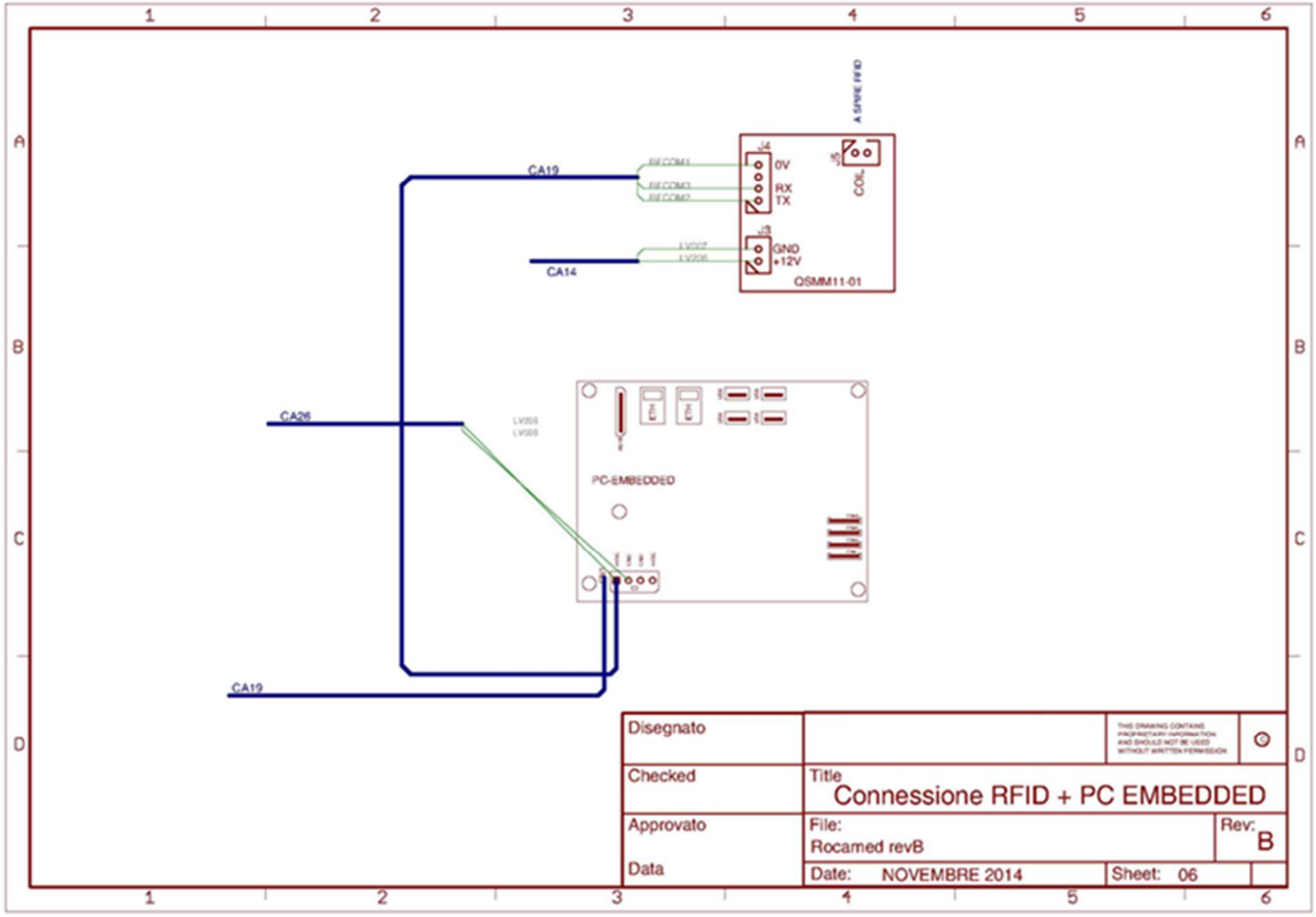
Approvato
Data
Title
Connessioni display
File:
Rocamed revB
Rev:
B
Date: NOVEMBRE 2014
Sheet: 05

X


CA19
CA14
CA26
CA19
0V
RX
TX
GND
+12V
QSMM11-01
PC-EMBEDDED
Disegnato
Checked
Approvato
Data
Title
Connessione RFID + PC EMBEDDED
File:
Rocamed revB
Rev:
B
Date: NOVEMBRE 2014
Sheet: 06

ANNEX II

Spare Parts List