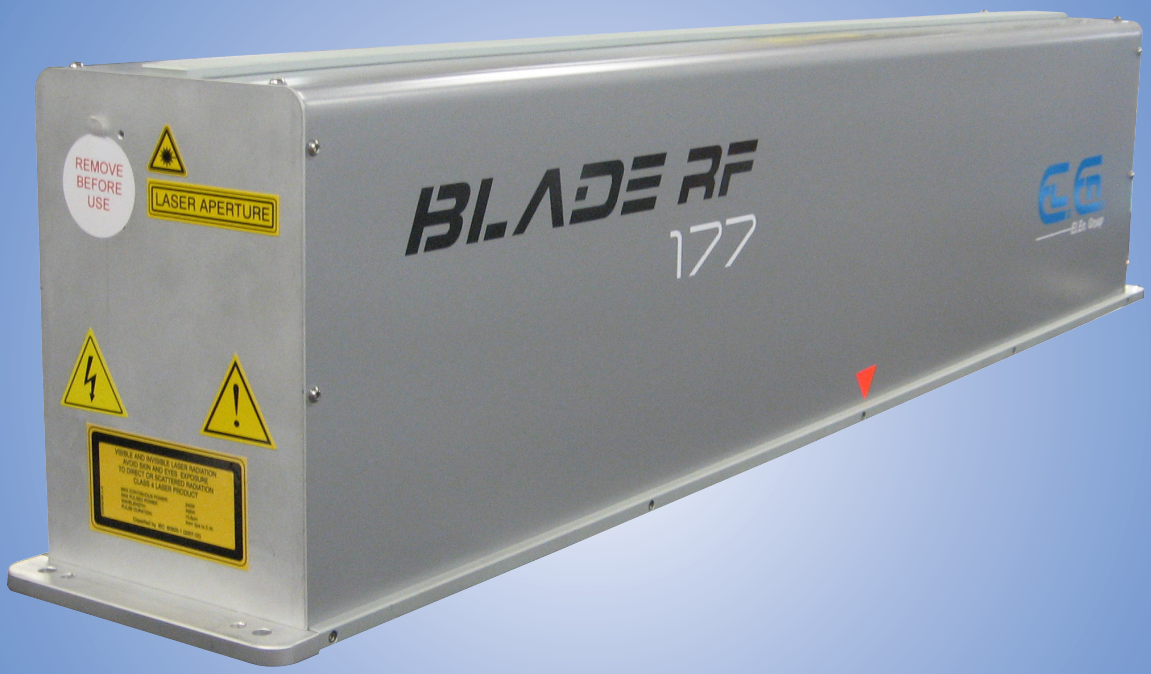
ELECTRONIC ENGINEERING

BLADE RF 177

Radio Frequency Excited CO_2 Laser



Assembly Instructions

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TABLE OF CONTENTS

INDEX OF FIGURES

INDEX OF TABLES

WARNINGS

The Blade RF 177 laser generates a CO_2 laser radiation with 10.6µm or 9.3µm wavelengths:

- Direct or reflected exposure to CO_2 laser radiations can damage permanently eyes and skin. The operators and anyone who is within Blade RF 177 laser operation area must wear protection glasses while the system is operating or if the cover structure of the laser source has been removed.

- Combustible materials may catch fire if exposed to laser radiations and cause fire or explosions.

- Only qualified staff may operate on the Blade RF 177 laser system.
  El.En. declines any responsibility for damage to persons or things caused by improper use of the system.

El.En. is considered responsible for safety, reliability and performance only if:

- the system is used in accordance with the instructions contained in this manual regarding both the usage modalities and the technical specifications;

- assembling, re-calibration, alterations, repairs and maintenance interventions are carried out by qualified staff authorised by El.En.;

- the electric system of the environment in which the system is installed complies with the IEC prescriptions and prescriptions in force locally.

El.En. commits to supply, upon written request, electric schemes, part list, calibration instructions and anything else necessary to the authorised maintenance staff relating only to the parts of the system that are considered unquestionably repairable by the same El.En..

ATTENTION!	**USE OF CONTROLS OR REGULATIONS OR EXECUTION OF PROCEDURES OTHER THAN THOSE SPECIFIED HEREIN COULD CAUSE DANGER OR UNCONTROLLED EXPOSURE TO LASER RADIATION.**
ATTENTION!	**DO NOT MODIFY THIS EQUIPMENT WITHOUT AUTHORIZATION OF EL.EN.**

Note: pictures in this manual are purely indicative and may be subject to changes.

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INTRODUCTION

The Blade RF 177 laser are is compact module; this characteristic makes its integration in specific systems for cutting, welding or thermal treatments simple and fast.

The Blade RF 177 includes the following models:
Blade RF 177 10.6µm model I05001
Blade RF 177G 9.3µm model I050A1

Different usages of the laser source from the ones specified in the Safety section of this manual are not allowed; El.En. is not liable for damages caused by improper use.

Control of received goods

On receipt of the Blade RF 177 laser sources inspect the shipping packaging and ensure that it has not been damaged during transport.

A damage indicator is present on the container.

If the indicator is red, the container has been handled improperly and the content could have been damaged. The transporter is liable for any damage due to transport. Quote what has been noticed on the Transport Document and inform the courier and El.En.

Remove the Blade RF 177 source from its packaging at the installation premises and check that all the material received is in keeping with what is quoted on the transport document.

Keep the wrapping and related packaging material that may be used if a shipping is necessary.

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1. SAFETY

All staff involved in the operations of installation, use and maintenance of the Blade RF 177 system must read carefully and fully understand all the instruction contained in this manual, paying special attention to the aspects relating to the safety.

In the event of any doubts or uncertainties, please do not hesitate to contact the manufacturer:

ELECTRONIC ENGINEERING

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Tel.055.8826807 - Fax 055.8832884

Staff responsible for operating, maintaining and installing the laser must have undergone appropriate training and must be informed in the above-mentioned operations, such as those specified in this section of the assembly instructions.

1.1. Laser use

Blade RF 177 laser sources are conceived for processing on materials, in an industrial context using infrared light.
Therefore the source should be part of the systems specific for processing such as systems for cutting, welding, thermal treatments and others in which they are incorporated. So, the use of laser sources is determined by the type of system in which it is incorporated.
Utilisation of the laser source for purposes other than those specified constitutes unauthorised use and, in such cases, El.En. cannot be held responsible for any potential damage which may be caused.

1.2. Reference regulations

Laser sources Blade RF 177 are manufactured in compliance with the following regulations:

- Directive 2006/42/EC (Machinery Directive)
- Directive 2004/108/EC (Electromagnetic compatibility)
- CEI EN 61000-6-2 Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments
- CEI EN 61000-6-4 Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments
- EN ISO 12100 Safety of machinery - General principles for design -- Risk assessment and risk reduction
- EN ISO 4414 Pneumatic fluid power - General rules and safety requirements for systems and their components
- EN 60825-1 Safety of laser products - Part 1: Equipment classification and requirements

Blade RF 177 laser sources are intended for incorporation as components in laser processing system. As supplied by El.En., Blade RF 177 laser sources do not meet the requirements of the standard EN 60825-1 without additional safeguards.
This type of product, which is usable only after the integration into a more complex system (and not usable as supplied by the manufacturer), is not subject to fully satisfy the standard, since the final laser processing system will itself be subject to the requirements of the standard.
Consequently, the buyer of this type of product, that incorporate it in a laser processing system to use it as end-user or to sold it to another end-user, is solely responsible for the assurance that laser processing system complies with the standard EN 60825-1.
Note that when a Blade RF 177 laser source is integrated into another system, the entire final machinery installation must be in accordance with the standards EN 60204 and EN 12100 "Safety of machinery", ISO/IEC 11553-1, the 2006/42/EC "Machinery Directive", and every other applicable standards and that the liability for these enforcements are ascribed to the manufacturer of the final integrated system.

The residual risks in the partly completed machinery are related to the following articles of the 2006/42/EC "Machinery Directive": 1.1.3, 1.2.1, 1.2.2, 1.2.3, 1.2.4.1, 1.2.4.2, 1.2.4.3, 1.2.6, 1.3.3, 1.3.4, 1.5.1, 1.5.3, 1.5.5, 1.5.6, 1.5.7, 1.5.12, 1.5.13, 1.6.1, 1.6.2, 1.6.3, 1.7.1.2.

1.3. Residual risks

1.3.1. Residual risks in accordance with EN 60825-1

Table 1 lists the requirements of the standard EN 60825-1, for the Blade RF 177 laser, that the final installer has to satisfy; prescriptions must be implemented to assure the compliance of the final system with the standard. For a complete analisys, please refer to the last version of the standard.

Table 1 - Residual risks in accordance with EN 60825-1

EN 60825-1 Article	Requirements	Prescription
4.2.1	Protection shields	The optic path of the laser beam must be shielded from the laser aperture to the application target.
4.2.2	Use of tools for the removal of the shields' wraps.	All the shields external to the source must be removed only using tools.
4.3.1	Safety interlock	A safety interlock must be provided by the system integrator for access panel of laser beam protective housing and working area.
4.3.2	Safety interlock override mechanism	If a safety interlock override mechanism is provided on destination machine, it must comply this point of EN 60825-1, e.g.: 1) A safe operation procedure with override mechanism installed must be available. 2) The system cannot be operated in standard mode with override mechanism installed. 3) The mechanism must be indicated by appropriate labels. 4) A acoustic or visual warning device must indicate the condition of safety interlock override activated. The visual warning must be seen wearing safety glasses.
4.4	Remote interlock connector	A remote interlock connector must be installed on the destination machine. The control signal of the Blade RF 177 laser cannot be used for this safety function.
4.5	Manual reset	To install on the destination machine to enable the resumption of laser emission after interruption caused by remote interlock connector for an interruption longer than 5s of electrical mains power.
4.6	Key control	A key control must be installed on destination machine to comply this point of EN 60825-1.
4.7.2	Acoustic/visual warning fail safe or with redundancy	An acoustic or visual warning device fail-safe or with redundancy must be installed on destinations machine to comply this point of EN 60825-1.
4.7.3	Warning device for every remote (>2m) opening	If destination machine is designed to operate remote opening a related warning device must be provided to comply this point of EN 60825-1.
4.7.4	Warning device for multiaperture laser system	If destination machine is designed to operate on multi aperture optical path a warning device must be provided at each aperture to comply this point of EN 60825-1.
4.8	Beam stop or attenuator	A beam stop or attenuator must be provided on destination machine to reduce accessible radiation levels. If shutter or attenuators are intended as safety devices an appropriate performance level must be considered.

Table continues in next page

EN 60825-1 Article	Requirements	Prescription
4.9	Controls	The integrator is responsible for ensuring the proper positioning on the control panel so that commands and adjustments are carried out without exposure to hazardous radiation.
4.14.1	Non-optic risks	See EN 60204-1
4.14.2	Collateral radiation	The laser source metallic chassis can shield from any emission except the infrared laser beam. If the process involving infrared radiation can produce harmful radiation, the designer must provide shielding for those secondary emissions.

The Blade RF 177 laser sources supply a high laser emission power and are therefore classified as class 4 sources. Their use implies potential risks referred to the following areas:

- **Exposure risks to direct o scattered laser emission**
- **Fire risk**
- **Generation of smoke or vapors resulting from to the laser processing**
- **Risks due to ejected objects**
- **Ignition of explosive atmosphere**

It is intended that despite the design provisions and accordance with the reference norm that the manufacture has observed for the safety issues, only an appropriate use of the system and correct compliance with the safety regulations on behalf of the users can guarantee a performance in full safety.

Therefore it is recommended to:

- **Verify that all the operators have received correct information on the safety aspects**;
- **Restrict the operation area of the laser system and allow access only to those who are qualified to operate with the system**;
- **Indicate the potential risks checking the visibility of safety signs and warnings present on the laser source and replacing them or adding others if necessary**;
- **Verify that the following are not present in the laser source area**:
  - **objects that reflect the laser light (**note that some materials, although appearing dark at daylight, may be good reflector for the infrared radiation at 10.6µm/9.3µm as produced by Blade RF 177 laser sources);
  - **materials, either solid, liquid or gas, that flame easily when struck by laser emissions**.

1.3.2. Risk of exposure to laser emission

The Blade RF 177 sources belong to the class 4 and emit a high power beam of infrared light, wavelength 10.6µm/9.3µm, which proves dangerous, both direct or scattered radiation can cause serious and permanent lesions to the eyes and can also cause serious burns to the human body.

ATTENTION! **LASER EMISSION FROM THIS SOURCE IS NOT VISIBLE TO THE HUMAN EYE.**

The impact with laser emission proves to be dangerous, not only in case of direct exposure, but also in case of exposure to the scattered light.

ATTENTION! **AVOID EXPOSURE TO DIRECT OR DIFFUSE RADIATION.**

Many surfaces which appear as not very reflective or even as opaque to the naked eye can generate dangerous reflections or diffusions. One example is the surface of silked or sanded metallic objects, which act as reflectors in the presence of infrared rays.

1.3.3. Precautions to follow

- During laser source working, do not allow access to the laser action area according to safety measures of EN 60825-1.
- During maintenance intervention, allow access to the laser action area only to operating staff.
- Avoid all possible accidental exposures both direct and secondary, that are via reflection or diffusions.
- All the staff present in the laser action area must wear special protection glasses with lateral protections and complying with the safety measures prescribed by the EN207 and EN208 standards. According to EN207 standard, safety goggles must have the characteristics indicated in paragraph "7.1. Technical characteristics" on page 44.

ATTENTION! **SAFETY GOGGLES ARE NOT SUFFICIENT TO PROTECT FROM DIRECT NOR FOCALIZED EXPOSURE TO LASER EMISSION. THEY PROTECT THE OPERATOR JUST FOR THE TIME NEEDED FOR THE HUMAN NORMAL REACTION TO MOVE AWAY AND AVOID EXPOSURE TO THE LASER EMISSION.**

- Optical path must be enclosed within a closed path, up to the point of utilisation. Material and dimensions of the enclosure must take into account the laser beam power.
- If doubts persist on the effective optic path do not allow the laser beam to be delivered.
- Once working parameters have been set, the operator has not to operate in any way on the laser source while functioning.

1.3.4. Fire risk

Many materials, when exposed to the emission of CO_2 lasers, 10.6µm or 9.3µm wavelength, are strongly absorbent and can rapidly increase their temperatures, reaching easily the flame point. This leads to risk of both fire and explosions.

- Avoid keeping inflammable or explosive materials in the laser action area.
- Do not use the source in potentially explosive atmosphere.
- Avoid the exposure of inflammable or explosive materials to direct or diffused laser emission.
- Guarantee the presence of, and easy access to, fire extinction devices (extinguishers).

1.3.5. Danger of noxious smoke or fumes

During laser processing, that is anyway a thermal processing, the vaporization temperatures of many materials can be reached. Chemical bindings can be broken on other materials, like plastic, causing the emission of dangerous or toxic smoke. In particular, as an example, it is reminded that the PVC cut generates hydrochloric acid which is extremely dangerous.

- Do not process materials of which there is no perfect knowledge of properties and reaction to temperature.
- Always consult the supplier of the processed materials or the relative technical manuals before proceeding with the laser processing.
- The user must install protective screens, systems of ventilation and extractor systems for smoke and fumes produced by the laser processing. Smoke extractors must be in compliance with the requirements provided by EN 11553-1.

1.3.6. Electric precautions

The laser source Blade RF 177 requires 48V_{DC} supply. Every internal electric part must be considered dangerous. When the laser source is on, high voltage parts are present inside.

ATTENTION!

ONLY MAINTENANCE PERSONNEL TRAINED AND AUTHORISED BY EL.EN. CAN OPERATE ON THE BLADE RF 177 LASER SOURCE.
DO NOT REMOVE THE COVERAGE NOR ALTER THE CLOSING SCREWS IN ANY WAY.

1.3.7. Precaution during optics handling

The laser source, and any eventual system of beam delivery and focalization, are equipped with optics generally made up of a support of silicon, of copper, of zinc selenide or gallium arsenide, upon which a number of thin layers of dielectric materials are deposited to obtain the desired characteristics.
In normal working conditions these components do not constitute any risk. In the case of breakage they can, however, prove to be dangerous, and must therefore be handled using protective rubber gloves, and taking care not to inhale the dust. The damaged optics should be carefully wrapped up, that is in such a way that they cannot accidentally fall out of the packaging, and disposed according local regulations in force.

1.3.8. Danger of ultraviolet emission

During the laser welding process a plasma of metallic vapours is created emitting ultraviolet light. This emission, invisible to naked eye, can damage eyes and skin seriously.

- Wear appropriate protective clothing and use adequate optical screens, as well as protective glasses.

1.4. Labels

Safety labels applied on the laser source are indicated hereafter.

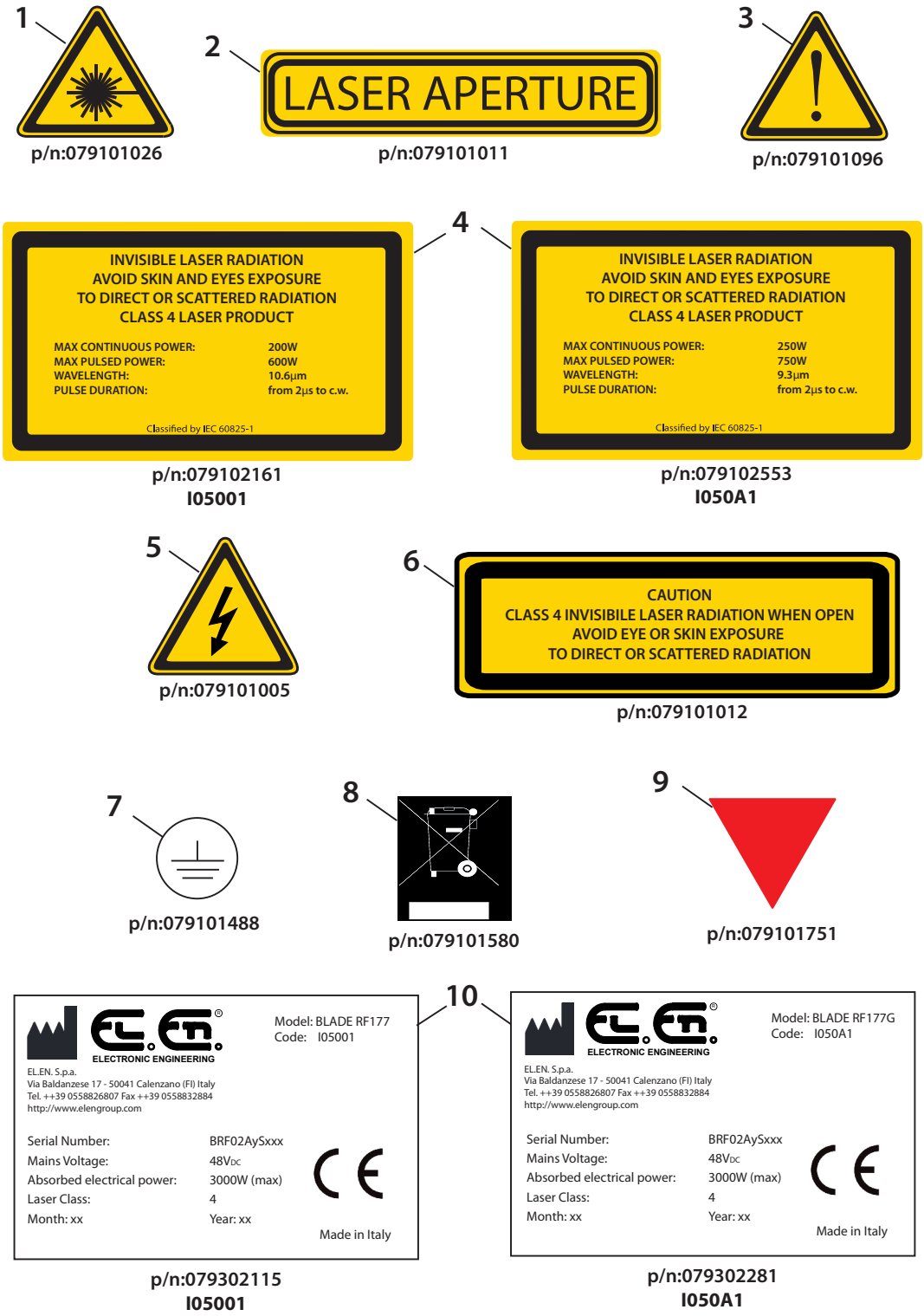

Fig.1 - Safety labels

Table 2 - Meaning of the safety labels applied to the system

Labels in Fig. 1	Meaning
1	Danger: Laser radiation
2	This label is placed near the laser beam output: never look at this opening and never expose any part of the body.
3	Generic Warning: Read the assembly instructions before using the system
4	Label containing warnings for the operator on the use of the system and specific to the system.
5	Danger: High Voltage
6	Label containing warnings for the operator on the use of the system:
7	Protection earth connection point.
8	Warning on the system disposal (Directive 2002/96/EC).
9	This label is the reference mark for system transportation - see par. “3.1. Moving/Transporting the source” on page 25 -.
10	Identification data for Blade RF 177 laser sources.

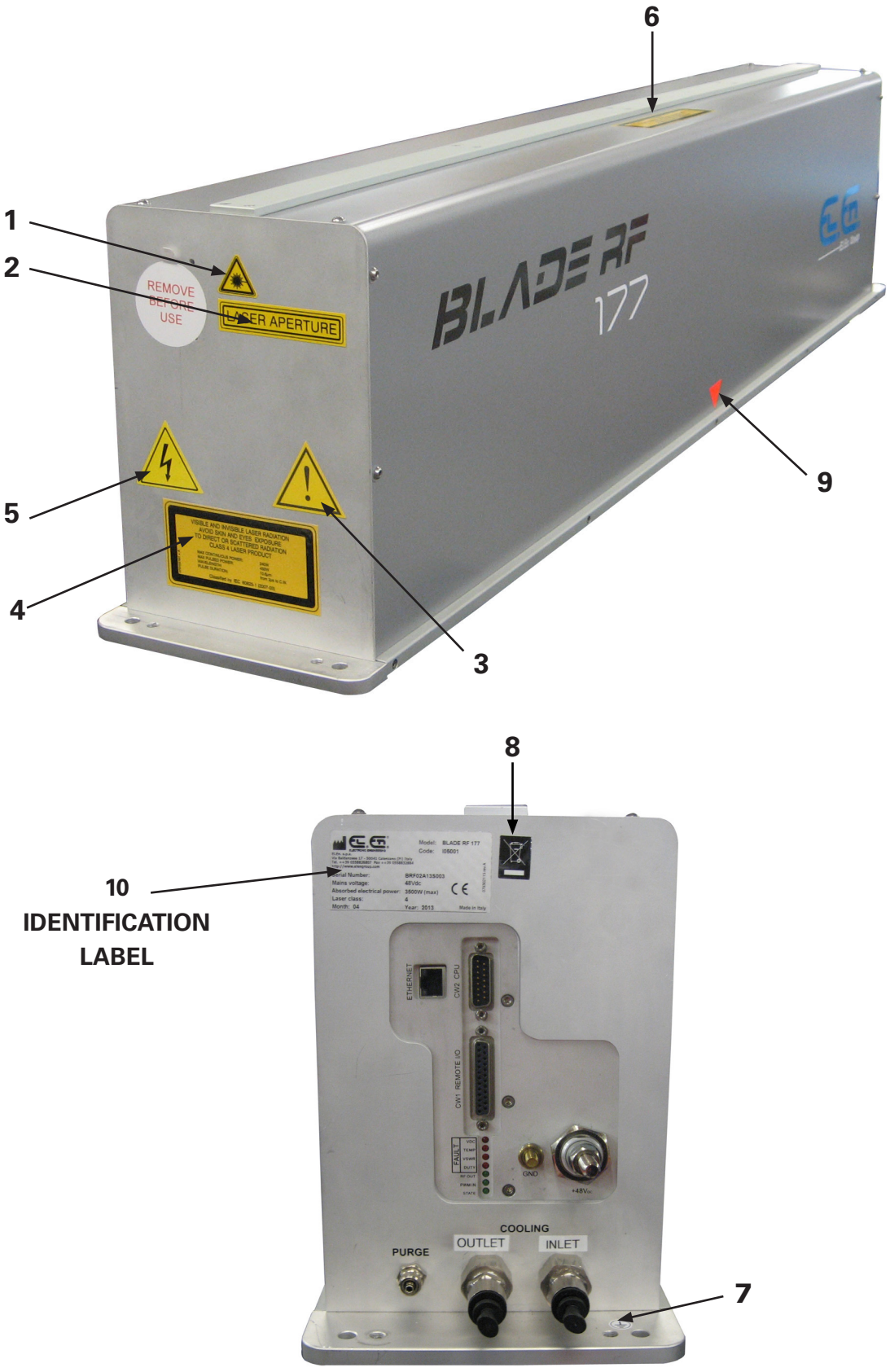

Fig.2 - Position of the safety labels

2. DESCRIPTION

Blade RF 177 laser is a compact module. The sealed laser source guarantees continuous operation, without interruption caused by external gas mix exchange.
As shown in Fig.3, the laser beam output is on the front plate; the connectors and joints for electrical and hydraulic connections necessary for the laser functioning are on the rear plate - Fig.4.

Fig.3 - Front view of the laser source

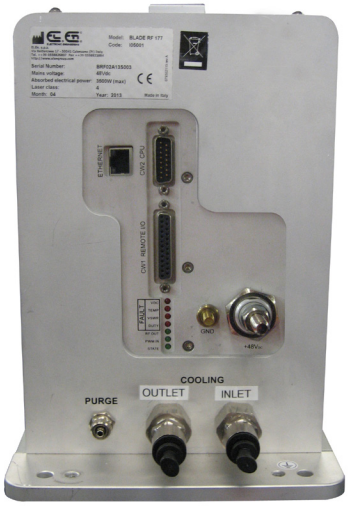

Fig.4 - Rear view of the laser source

Inside the structure are placed the functional sub-assembly of the system; a functional diagram of the laser is reported in Fig.6 and includes:

- Laser resonator (coolant cooled)
- Beam shaping Optic System
- RF Supply (coolant cooled)
- CPU control board with display

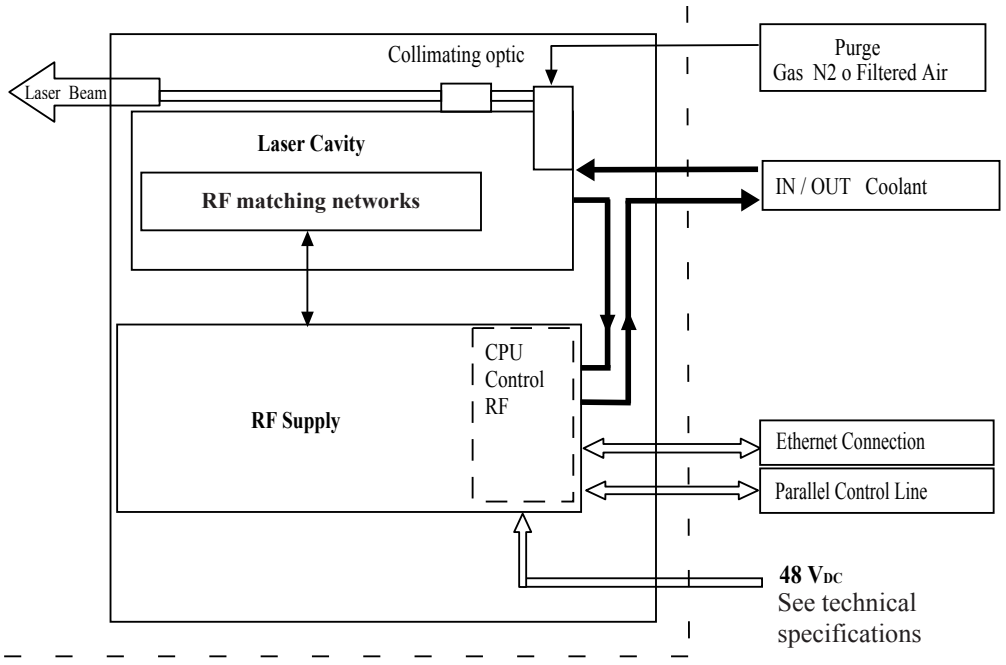

Fig.5 - Blocks system

As shown in the block diagram the Blade RF 177 laser functioning requires the following supplies and controls:

- DC Power Supply 48VDC;
- Coolant;
- Connection to the control system;
- Filtered Air or nitrogen for the pressurization of the laser beam optic path.

The laser source Blade RF 177 does not require connections to external laser gas bottles.
See section "3. INSTALLATION" on page 25 and "7. TECHNICAL SPECIFICATIONS" on page 43.

2.1. The laser resonator

The laser resonator is made of aluminium blocks; the main of this block constitutes the support structure inside which are the electrodes for the radiofrequency excitation of the active medium.
These blocks are a sealed container with only the active medium inside (gas mix) and the laser resonator optics.

The laser resonator is cooled through adequate canalization to guarantee the optimal cooling of the active medium and the stability of the laser resonator.

2.2. Beam shaping optic system

The optic system is mechanically supported by the laser resonator structure to obtain an excellent dimensional stability among all the optic elements that make it up. In this way even the necessary stability of the laser beam tracking is guaranteed.
The beam is obtained by means of opportune resonator optics placed inside the sealed container and by other optics that determine its characteristics.
The latter are integrated externally to the laser resonator in an optic path anchored to the same resonator; it is pressurized with nitrogen or clean air in order to guarantee that the cleanness of the optics is maintained.

Note that at the end of the optic path is NOT placed a shutter group.

2.3. Radio frequency power supply (RFPS)

As indicated in the block scheme of Fig.5, the supply is a sub-assembly of the laser source. It converts 48V_{DC} input voltage in a radio-frequency signal (RF) that, after correct amplification, is sent to the laser resonator electrodes to excite the gas mix and trigger the laser action.
The connection to the laser resonator is made with coaxial cables towards matching networks, directly integrated on the resonator.
RF power supply includes a control CPU dedicated to the management of the supply itself. This CPU manages all the system functions interfacing with the Blade RF 177 laser source and, by means of the "CW1 REMOTE I/O" connector, with the external control systems.
LEDs on the power supply front panel allow the operator to verify the status of the system.

RFPS is coolant-cooled like the laser resonator.

2.4. Cooling system

The Blade RF 177 laser source needs coolant cooling for the disposal of electric power absorbed and not transformed into laser power.
The cooling system, shown in Fig.6, cools the laser source main components that are represented by the two aluminium electrodes and by the RF supply.

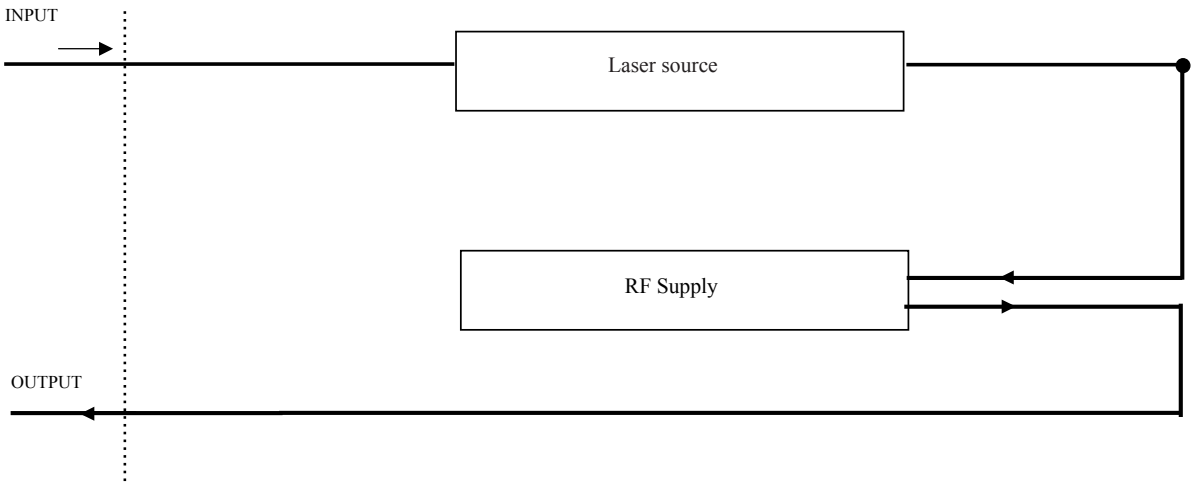

Fig.6 - Cooling circuit

The incoming coolant supplies the cooling system of the laser source; then it supplies the RFPS input. The connections to the circuit (INPUT/OUTPUT) are placed on the rear side of the laser source (see Fig.4 and cfr. "3.4. Coolant requirements" on page 27).

3. INSTALLATION

3.1. Moving/Transporting the source

To move the Blade RF 177 source, use the red triangle labels on the laser cover (one on each side, see Fig.2 on page 20) as reference: this label marks the centre of mass position along the major axis of the laser source.

For the Blade RF 177 source the centre of mass is located at the distance of 520mm from the system front side (the one with laser output).

Put the two forks of the fork truck at the same distance respect to the point marked by the labels in order to lift the laser from the bottom and move it.

3.2. Assembling the source

During the installation of the laser source it will be necessary to follow instructions indicated below in order to guarantee correct operation and maintenance feasibility of the system:

- The Blade RF 177 source requires four clamping points. Use the four holes on the plate base. For the inserting of the laser refer to "7.2. Source dimensions" on page 45, where the bulk dimensions are indicated with other information useful for assembling.
- Be sure that the laser source location is vibration-free.
- In order to assure "beam pointing stability", avoid relative movements between the laser source and the optical parts of the beam delivery system.
- The laser source unit must be properly located in order to allow the access to all the removable panels of the enclosure for periodical maintenance and service. Please consider the minimum clearance required for service access as indicated in paragraph "7.2. Source dimensions" on page 45.

3.3. Connections

The supply connections are all located on the rear side of the system.
Proceed as follows - please refer to Fig.7 - :

- Connect the two coolant connectors **(A)** with appropriate tubes (diameter 12/10mm) - see par. "3.4. Coolant requirements" on page 27 -;
- Connect the connector **(B)** for the pressurization of the optic path (tube's diameter 6/4mm) - see par. "3.5. Optic path pressurization and environmental requirements" on page 28 -;
- Connect 48V_{DC} power supply and ground reference connectors **(C)** - see par. "3.6. Electric supply" on page 29;
- Connect 25 Pin type D parallel male connector **(D)** to control the source - see par. "3.7. Control connection" on page 30 -, and Ethernet connector **(E** opcional**)** - see par. "4.4 TCP/IP communication protocol" on page 37.

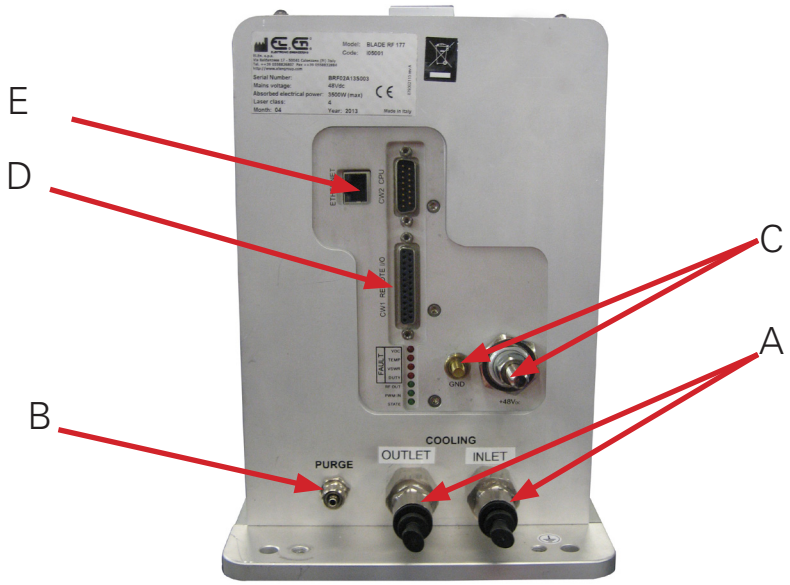

Fig.7 - Supply connections

ATTENTION! **MAKE SURE THAT ALL THE NECESSARY SUPPLIES COMPLY WITH THE SPECIFICATIONS DESCRIBED IN THIS SECTION AND IN THE SECTION "7. TECHNICAL SPECIFICATIONS" ON PAGE 43.**

ATTENTION! **ALL CONNECTIONS MUST BE PROTECTED FROM MECHANICAL DAMAGE CAUSED BY INVOLUNTARY SHOCK AND SHOULD NOT BE EXPOSED TO OPERATORS PASSAGE PATHS.**

3.4. Coolant requirements

Blade RF 177 laser source requires a minimum flow of coolant to a closed circuit supplied with an external "chiller".
The "chiller" must be able to guarantee the required stability of the coolant temperature with the thermal load generated by the Blade RF 177 laser source: see the following table.

Table 3 - Cooling circuit requirements

Requirement	Value
Heat load	3.5kW
Coolant set point temperature range	(20±0.5)°C
Inlet coolant pressure	4Bar
Coolant differential pressure (between the input and output lines at laser source plug)	≥1.6Bar at 7l/min
Inlet coolant temperature stability	±1°C/min
Dynamic coolant flow rate	(7.0±0.5)l/min
Residual particulate dimensions	<200µm
Humidity	Absence of condensation at inlet coolant temperature.

ATTENTION!

INSERT A PARTICULATE FILTER (200µm) TO PROTECT THE INTERNAL COOLING CIRCUIT AND PIPING.
THE FILTER SHOULD BE AS CLOSE AS POSSIBLE TO THE LASER SOURCE INLET.

The cooling fluid must have the following composition:

- **60-70% demineralized water with hardness <10 French degree, electrical conductivity <50µs/cm at 25°C;**
- **40-30% Dowcal 200 (stabilized propylene glycol);**
- **150mg/kg (150ppm) Lab Algicide[1] if the propylene glycol concentration is lower than 40% and part of the duct is made by plastic material transparent to visible light and/or UV.**

ATTENTION!

THE BLADE RF 177 LASER SOURCE REQUIRES COOLANT STABILITY WITH GRADIENTS THAT DO NOT EXCEED 1°C PER MINUTE TO GUARANTEE SPECIFIED PERFORMANCES.

1 Lab Algicide contact: Polyscience P.O. Box 48313 Niles IL 60648 (data subject to change without notice).

The connection to the closed circuit cooling system must be made using the two 12/10mm quick connectors present on the rear panel of the source, respecting the "WATER INPUT" and "WATER OUTPUT" indications.

ATTENTION! **THE USER HAS TO PROVIDE THE WATER CIRCUIT OF THE FINAL SYSTEM WITH A HYDRAULIC CIRCUIT BREAKER.**

Once the connection operations have been completed, verify that there are no leaks in the circuit. Open the cooling water increasing the input pressure slowly, verifying that the maximum value is in accordance with the value reported on Table 3.

ATTENTION! **THE BLADE RF 177 SOURCE COOLING CIRCUIT IS PURGED BY PURE DOWCAL200 FLOWING AND COMPRESSES AIR DRYING BEFORE SHIPMENT. THIS PROCEDURE IS PROVIDED TO AVOID FREEZING OF COOLANT RESIDUALS INSIDE THE CIRCUIT DUE TO EXPOSITION TO EXTREME TEMPERATURE CONDITIONS.**
IF A NEXT SHIPMENT IS SUPPOSED TO EXPOSE THE SOURCE TO SEVERE ENVIRONMENTAL CONDITIONS, REPEAT THE PURGING PROCEDURE.

3.5. Optic path pressurization and environmental requirements

The pressurization of the optic path within the source reduces the risk of contamination of the optics. The required characteristics are reported in Table 4; the environmental functioning and storage requirements are included in the same table.

ATTENTION! **THE USER HAS TO PROVIDE THE OPTIC PATH PRESSURIZATION CIRCUIT OF THE FINAL SYSTEM WITH A CIRCUIT BREAKER AND A PRESSURE REGULATOR.**

Table 4 - Environmental usage characteristics

Characteristics	**Value**
Optic path pressurization	Nitrogen (2÷3l/min 99,95% purity) Pmax =0,5Bar OR Compressed air (clean, dry, oil free, filtered at 0,1µm, dew-point <-40°C). Use only a neutral plastic 6mm-ext/4mm-int connection tube.
Operating temperature	From 5°C to 35°C (in case of temperature below 10°C, make flow the coolant for 15minutes before turning on the source).
Storage temperature	From 5°C to 50°C
Altitude	<3000m
Humidity	Absence of condensation at inlet water temperature

3.6. Electric supply

The Blade RF 177 laser source must be supplied using the "Power Line" connectors on the source rear panel: one "Power Line 48V" connector (M8 screw) and one ground reference;

Follow electrical specification indicated in paragraph "7.1. Technical characteristics" on page 44.

ATTENTION! **ENSURE THAT THE CHASSIS IS PROPERLY PROTECTED FROM EXPOSURES TO DANGEROUS VOLTAGES AND ALWAYS MAINTAINS THE GROUND REFERENCE.**

The laser system does not include the AC/DC supply. If necessary, refer to El.En. to receive indications on the commercial supply models usable to supply the Blade RF 177 laser source.
Ensure that the size of the supply cable fits the length of the wire in compliance with the supply specifications.
During the connection of the cables, insert a suitable protective cup of 48V_{DC} connector.

ATTENTION! **ENSURE THAT THE SUPPLY IS OFF BEFORE CONNECTING TO THE BLADE RF 177 SOURCE.**

ATTENTION! **PROVIDE SUITABLE PROTECTIONS FROM OVERCURRENTS (E.G. FUSES) ON THE SUPPLY LINE.**

ATTENTION! **ENSURE THAT THE SUPPLY LINE IS STABLE IN ORDER TO GUARANTEE THE PERFORMANCES SPECIFIED IN THIS MANUAL.**

ATTENTION! **POWER SUPPLY (48V_{DC}) INTERRUPTION DETERMINES THE STOP OF OPERATION. THE USER HAS TO PROVIDE THE FINAL SYSTEM WITH AN APPROPRIATE CIRCUIT WITH CONTACTOR TO CORRECTLY MANAGE POWER SUPPLY RESTORING.**

ATTENTION! **DO NOT REVERSE POLARITY WHEN CONNECTING THE AC/DC POWER SUPPLY. REVERSED DC POLARITY MAY DAMAGE THE SYSTEM IRREPARABLY.**

3.7. Control connection

ATTENTION!

THE BLADE RF 177 SOURCES ARE PROVIDED ONLY WITH FUNCTIONAL CONTROL SIGNALS.
THE USER HAS TO PROVIDE THE FINAL SYSTEM WITH AN APPROPRIATE CONSOLE WITH CONTROL AND EMERGENCY DEVICES, IN COMPLIANCE WITH REFERENCE STANDARDS.
ENSURE THAT THIS CONSOLE IS EQUIPPED WITH PROTECTED BUTTONS SO THAT ANY UNINTENTIONAL ACTIVATION IS PREVENTED.

All control connections to Blade RF 177 laser system are made through the "CW1 - REMOTE I/O" connector on the RF power supply's front panel. The two other connectors, CW2 and CW3, must be left diconnected.

ATTENTION!

DO NOT CONNECT NOR DISCONNECT THE CONTROL WIRES WHEN THE SYSTEM IS SUPPLIED.

- **"CONTROL" Connector**

It is necessary to use the functions on this female connector 25 Pin (type D) to control the source.
This connector allows to manage laser power enabling, modulation functions, alarm functions and the state of some elements as indicated on Table 5. Also a +15V (200mA max) output is available in this connector for possible external services.

Table 5 - Pin function parallel control connector

Pin Function "CW1 REMOTE I/O" (female connector 25 pin)		
Pin	**Function**	**Description**
1(+) e 14(-)	PWM_MOD	Digital optoinsulated input (0-5V) for the control of the laser power modulation. The laser is switched on bringing the pin 1 to a high level (3,5-5V) compared to pin 14, and switched off at a lower level (0-1V) between pin 1 and 14. The command circuit of this line must be able to supply the required voltages on a typical 400Ω load. The parameters of the modulating signal must comply with the operating limits reported in fig.17: pulse duration between 2ms e 1000ms, maximum duty cycle 50%, maximum modulation frequency 50kHz. The modulation control does not have effects until the system is not ready to emit laser power ("Ready" mode, see below).

Pin Function "CW1 REMOTE I/O" (female connector 25 pin)		
Pin	**Function**	**Description**
2(+) e 7(-)	ENABLE	Digital optoinsulated input (0-24V) for the enabling of laser power modulation. The ENABLE signal is activated bringing the pin 2 to a high level (13-24V) compared to pin 7, and deactivated with a low level (0-1V) between pin 2 and 7. The control circuit of this line must be able to supply the required voltages on a typical load of 2kΩ. The laser system is enabled in correspondence of a transition from deactive to active of the ENABLE signal. The enabling of the system implies the activation of internal procedures for the ignition of the source main discharge. These operations could require a varying time that is anyhow below 60 seconds. The end of the procedure is signalled by the passing to the "Ready" mode, indicated on the LCD display and by the activation of the "READY" line (see below). In case of alarm during functioning, it is necessary to deactivate the ENABLE signal for at least 1 second to reset the alarm.
15(+) e 20(-)	AUX_IN	Digital optoinsulated input (0-24V) not-used at the moment. Do not connect pin 15 and 20.
5(C) e 21(E)	READY	Digital optoinsulated output (NPN, C=collector, E= emitter) for the indication of the "Ready" mode. The system "Ready" mode is indicated by driving the optoinsulated transistor in conduction state. The absorbed current must be limited externally to 100mA. If the system is not in the "Ready" mode, the output transistor is interdicted. The voltage between pin 5 (collector) and pin 21 (emitter) must be between 0 and 24V. The "Ready" mode is reached after the activation of the ENABLE control, and it indicates that the source is ready to receive modulation controls (PWM_MOD) to emit laser power. Following an alarm, the source exits automatically from the "Ready" mode.
3(C) e 9(E)	ALARM	Digital optoinsulated output (NPN, C=collector, E= emitter) to indicate the "Alarm" mode. One or more alarms detected by the system are indicated by driving the optoinsulated transistor in conduction state. The absorbed current must be limited externally to 100mA. If there are no alarms, the output transistor is interdicted. The voltage between pin 3 (collector) and pin 9 (emitter) must be between 0 and 24V. If one or more alarms are detected the ALARM line is activated and the laser system is protected. In this case it is necessary to remove the alarm conditions and deactivate the ENABLE command to reset the alarm.

Pin Function "CW1 REMOTE I/O" (female connector 25 pin)		
Pin	**Function**	**Description**
4(C) e 10(E)	TEMP_ALARM	Digital optoinsulated output (NPN, C=collector, E= emitter) for the indication of the temperature alarm (the one measured on RF power supply's active component, TALARM=65°C). The temperature alarm is indicated by driving the optoinsulated transistor in conduction state. The absorbed current must be limited externally to 100mA. If temperature is lower than the maximum allowed value, the output transistor is interdicted. The voltage between pin 4 (collector) and pin 10 (emitter) must be between 0 and 24V. If temperature alarm is detected the ALARM line is activated to indicate that the RF power supply is interdicted until the alarm reset (TRESET=45°C).
16(C) e 22(E)	VSWR_ALARM	Digital optoinsulated output (NPN, C=collector, E= emitter) for the indication of the VSWR alarm (mismatching between RF power supply and laser source). The VSWR alarm is indicated by driving the optoinsulated transistor in conduction state. The absorbed current must be limi-ted externally to 100mA. If VSWR alarm is not detected, the output transistor is interdicted. The voltage between pin 16 (collector) and pin 22 (emitter) must be between 0 and 24V. If VSWR alarm is detected the VSWR_ALARM line is activated and the RF supply output power is limited. If the fault persists, after 5s the ALARM line is activated and the RF supply is interdicted. In this case it is necessary to disable the ENABLE line in order to reset the alarm condition. NOTE: VSWR alarm can be detected only with pulse duration greater than 200ms or duty cycle greater than 15% (approximately).
17(C) e 23(E)	DUTY_LIMIT	Digital optoinsulated output (NPN, C=collector, E= emitter) for the indication of duty cycle/pulse duration overflow. The DUTY_LIMIT signal is indicated by driving the optoinsula-ted transistor in conduction state. The absorbed current must be limited externally to 100mA. If modulation parameters are correct, the output transistor is interdicted. The voltage between pin 17 (collector) and pin 23 (emitter) must be between 0 and 24V. If a duty cycle and/or pulse duration overflow are detected, the DUTY_LIMIT line is activated and the RF supply output power is interdicted. Once modulation parameters are again within limits, the laser output complies again with the external modulation signal. If only DUTY_LIMIT line is enabled, alarm line is not activated.
18	+15V	Service supply 15V±5%, referred to GND. Maximum current 200mA. If the service supply is used provide suitable overload protection (e.g. fusible).

Pin Function "CW1 REMOTE I/O" (female connector 25 pin)		
Pin	**Function**	**Description**
8, 11, 12, 24	GND	Reference ground for service supply and serial connection (pin18). These pins are also connected to the negative terminal of the main DC and to the metallic structure of the RF power supply.
13, 25,6,19	N.C.	Pins not used; do not connect these pins.

3.7.1. Laser beam output

The laser beam aperture is positioned on the front part of the laser system Blade RF 177 . The laser aperture is protected with a removable label as illustrated in the particular of Fig.8.
The aperture is provided with a perforated flange that can be used to fit light structures of the laser beam optic path out of the source. - see par. "7.2. Source dimensions" on page 45 for dimensions -.

ATTENTION! **REMOVE THE PROTECTIVE LABEL BEFORE SWITCHING ON THE LASER SOURCE.**

The mechanical characteristics of the flange do not allow stressing it with static or dynamic loads.

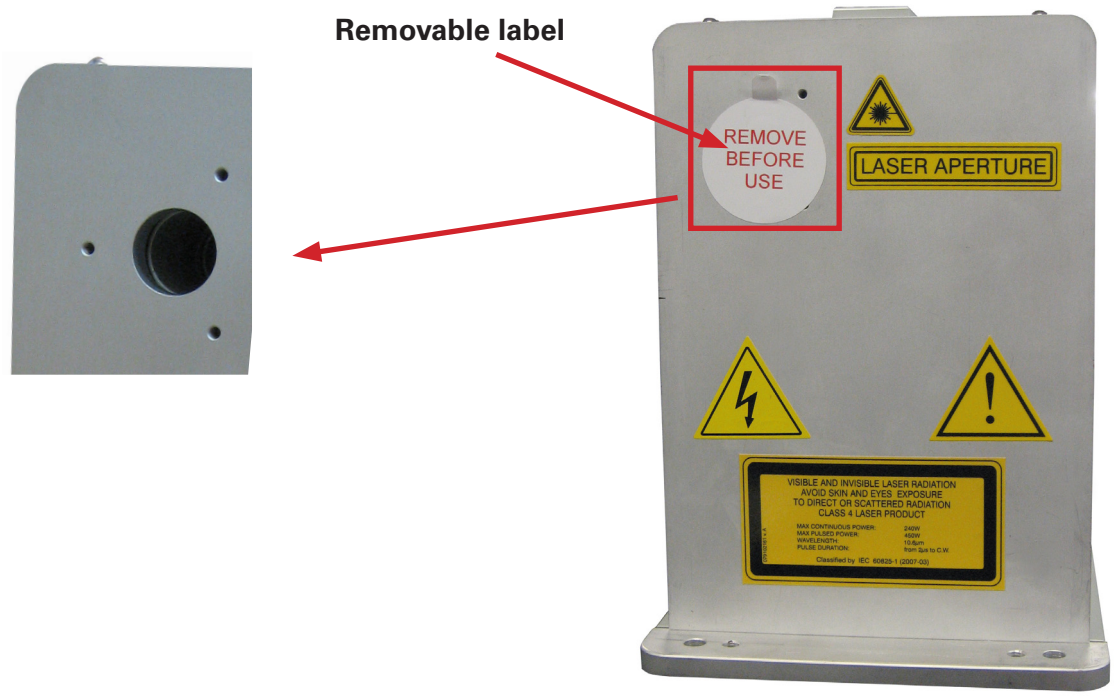

Fig.8 - Particular of the removable label and interface flange

4. LASER OPERATION

4.1. System start up

Before turning the Blade RF 177 source on carry out the following checks and operations:

- if the source is not integrated as components in a laser processing system, position a power gauge or a dump with suitable characteristics on the propagation line and enclosure the optical path from laser to beam dump;
- start up the cooling system;
- apply the 48VDC power supply ensuring that all the input lines are deactivated (PWM_MOD, ENABLE, SHUTTER_OPEN e RESET).

All output lines and all power supply's LEDs are activated for 250ms and then deactivated (this function allows to control the correct functioning of indicators).
If no allarms are detected, Blade RF 177 laser source enters in "Stand-by" mode and can be activated using "ENABLE" and "PWM" commands (within operational limits).

4.2. Source activation

If the system is in "Stand-by" mode, laser source can be activated.
First of all activate "ENABLE" command on the "CW1" connector (transition from low to high level) - cfr. Table 5 -. This action starts the gas mix internal pre-ionization automatic procedure that has a variable duration that is anyhow below 1min.
The source control system provides automatically to ignite the discharge in the gas, laser active medium, and its maintenance, so that the power emission is controlled by the modulation signal promptly.
The procedures carried out for this purpose provide to keeping the discharge on with such a power level that does not allow laser emission (pre-ionization level).
The laser source is ready to operate only at the end of this phase - "Ready" mode - and it is possible to enable the laser power emission with the desired modulation using the PWM_MOD line.

ATTENTION!	**AFTER "ENABLE" ACTIVATION AND ALSO WHEN THE SOURCE IS IN THE "READY" MODE, THE DISCHARGE IS ALWAYS ON AND READY TO EMIT POWER, INDEPENDENTLY FROM THE EXTERNAL MODULATION (A DELAY, MAX. 60S, CAN BE OCCURRED BETWEEN THE DISCHARGE TURNING ON AND THE ACTIVATION OF "READY" MODE).**

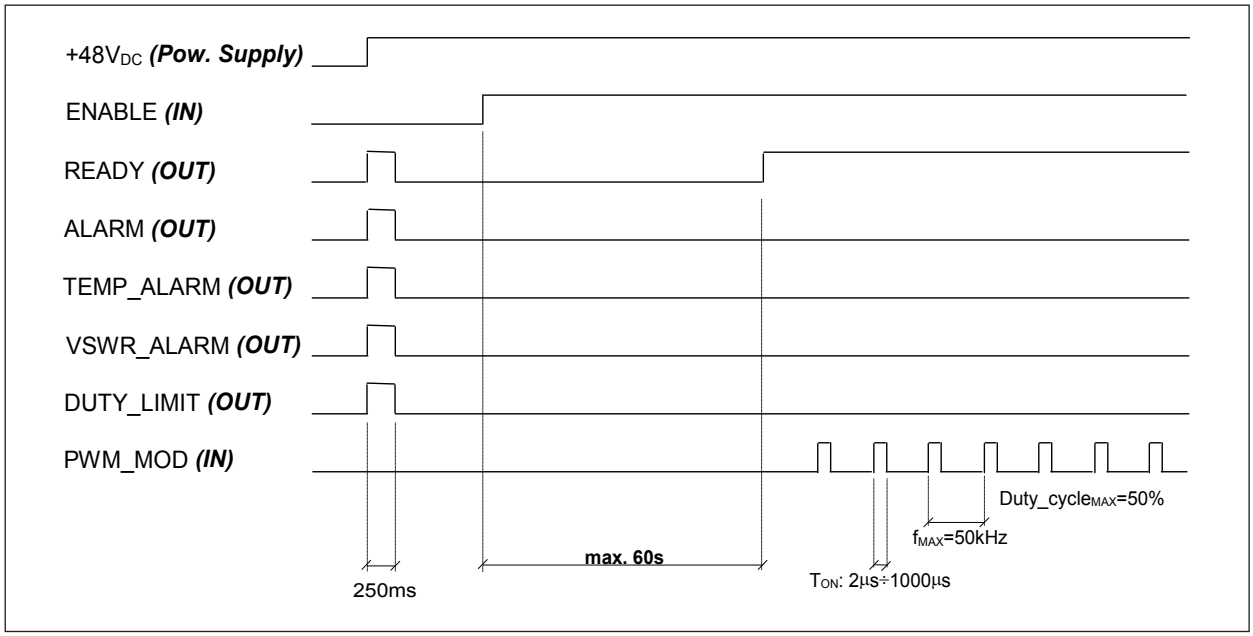

Fig.9 - Sequence of activation. High lev.=line enabled; Low lev.=line disabled

4.3. Light emitting indicators (LED)

On the RF power supply front plate, 7 LEDs allow to control functioning or alarm state of the laser source - see Fig.14-.

The LEDs and their functioning are listed below:

- **STATE**: indicates the state of Blade RF 177 control system.

In particular:

  – if the system is in "Stand-by" mode (ENABLE line deactivated), this led flashs continuously;
  – if the "ENABLE" command is activated, during gas ignition procedure, this led blinks quickly;
  – if the system is in "Ready" mode (READY line activated), this led blinks slowly;
  – if an alarm is detected, this led is constantly turned on.

- **PWM IN**: if this led is turned on, it indicates that there is a modulation signal on PWM_MOD line.

- **RF_OUT**: if this led is turned on, it indicates that RF power supply is emitting RF power. If power supply generates VSWR alarm (ALARM and VSWR lines activated) and the RF power is not sufficient, this led blinks quickly (see 6 on page 41).

- **DUTY**: if this led is turned on, it indicates "Duty Cycle" alarm.

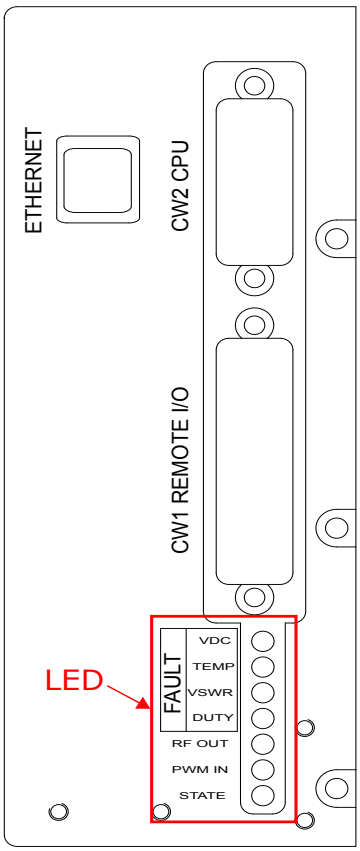

Fig.10 - LEDs on the rear panel

- **VSWR**: if this led is turned on, it indicates “VSWR” alarm.

- **TEMP**: if this led is turned on, it indicates “Temperature” alarm.

- **VDC**: if this led is turned on, it indicates “Voltage supply” alarm.

In case of alarm during functioning, proceed as follows:
- deactivate all the input lines,
- remove the conditions that have caused the alarm,
- deactivate the ENABLE line for at least 1s,
- verify that the ALARM signal deactivates.

See "6. ALARMS AND TROUBLESHOOTING" on page 41.

4.4. TCP/IP communication protocol

The ETHERNET connector - (E) in Fig.7 – allows to establish a connection between an external control unit and the RF source to verify the status of the source itself.
The communication is through a TCP/IP protocol: the IpAddress of the Laser Source is 192.168.1.100 and the port used is 10001.
Upon request, El.En. may provide a software solution for the management of the source parameters that can simply be used with a regular computer. Contact your El.En. agent for more information.

The verification protocol is structured as follows:
- the RF source acts as the com slave so it always waits for one byte – command/control code (1 byte) from the remote control unit;
- once a byte code is received, the laser control unit sends back a 3 byte-answer whose first byte is the echo of the command itself and the other two bytes contain the requested information.

This function is enabled only if the system is not in “Ready” mode, otherwise commands connector are ignored.

The control codes available to the remote unit to verify the system mode are reported in Tab.6

Table 6 - Control Codes

Code	Request	Response		
		Byte 1	Byte 2	Byte 3
0x00	Revision code for S/W and RF supply configuration	0x00	Revision code for S/W (hexadecimal notation)	bit 7 not used bit 6 not used bit 5 not used bit 4 not used bit 3 SW MODE (MSB) bit 2 SW MODE (LSB) bit 1 BIAS LEVEL (MSB) bit 0 BIAS LEVEL (LSB)
0x01	Alarm list (see Table 7 on page 41)	0x01	bit 7 not used bit 6 not used bit 5 not used bit 4 DUTY CYCLE bit 3 ENABLE_ON bit 2 VSWR bit 1 TENSIONE ALIM.+48V bit 0 TEMPERATURA	bit 7 Reserved bit 6 VSWR_LOW_RF_POW bit 5 not used bit 4 not used bit 3 not used bit 2 not used bit 1 not used bit 0 not used
0x02	Measurement of voltage supply (48VDC)	0x02	A	B
			Voltage supply VDC = (A*256 + B)/18.315 V	
0x03	Measurement of RF supply internal temperature.	0x03	A	B
			Temperature = 96.854°C - 0.107*(A*256 + B)°C	
0x04	Measurement of RF direct voltage.	0x04	A	B
			Direct voltage RF = (A*256 + B) relative value	
0x05	Measurement of RF reflected voltage.	0x05	A	B
			Reflected voltage RF = (A*256 + B) relative value	

4.5. Source switching off

To switch the source off it is advisable to deactivate the controls according to the following procedure:

- disable PWM_MOD;
- disable ENABLE;
- disable the supply 48VDC.

ATTENTION! **IT IS NOT RECOMMENDED TO DISABLE THE 48VDC POWER SUPPLY BEFORE TURNING OFF THE 'ENABLE' COMMAND.**

5. MAINTENANCE

ATTENTION!

EL.EN. ASSUMES NO RESPONSIBILITY IN CASE OF DAMAGE TO PEOPLE OR OBJECTS CAUSED BY ALTERATIONS, BAD CONDITIONS OR POOR MAINTENANCE OF THE SYSTEM OR DERIVING FROM THE NON-OBSERVANCE OF THE INSTRUCTIONS INCLUDED IN THIS MANUAL.

5.1. Maintenance generalities

The Blade RF 177 sources do not require particular maintenance interventions in addition to the cooling circuit verification.

IMPORTANT:
IT IS ABSOLUTELY FORBIDDEN TO REMOVE THE SOURCE COVERAGE

For further information concerning the installation of the source contact the manufacturer:
EL.EN. S.p.A.
Via Baldanzese, 17 - 50041 - Calenzano - Firenze - ITALY
Tel.055.8826807 - Fax 055.8832884

5.2. Cooling circuit

Once a year, resume cooling circuit with fresh coolant compliant to specifications on paragraph "3.4. Coolant requirements" on page 27.

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6. ALARMS AND TROUBLESHOOTING

6.1. Alarms description

In case of alarm the RF source is immediately deactivated and the ENABLE e PW-MOD remote controls are disabled.

Table 7 - Alarms list and description

Allarm	Description	LED	Suggestions
Duty cycle	During normal functioning (that is source in "Ready" mode and emission controlled by PWM modulation), the activation of the DUTY_LIMIT line indicates that parameters of PWM_MOD signal are not correct (TON>1ms or Duty_cycle>50%) so the PWM modulation line is automatically inhibited (no laser emission). Once modulation parameters are again within limits, the laser output complies again with the external modulation signal after ~100ms. Note that the source remains in "Ready" mode.	DUTY	Verify that modulation parameters (PWM_MOD) are within operating limits.
VSWR	VSWR_ALARM line indicates a mismatching between RF power supply and laser source. This alarm can occur after a long period that the source is not in use. If VSWR alarm is detected (only during laser emission) the VSWR_ALARM line is activated and the RF supply output power is limited. If the fault persists, after 5s the ALARM line is activated and the RF supply is interdicted.	VSWR	- Verify that the RF cable is correctly connected. - When ALARM line is activated, verify that RF-OUT led is off. - Verify that voltage supply is 48V ±1V. - Disable the ENABLE line for at least 1s in order to reset the alarm condition. Contact the El.En. technical assistance if the problem persists.
Temperature	Temperature of RF power supply's active component is constantly detected. TEMP_ALARM and ALARM lines are both activated if temperature is greater than 65°C. RF power supply is interdicted.	TEMP	- Disable the ENABLE line for at least 1s and wait until temperature reaches a value lower than 45°C. - Verify that cooling system characteristics comply with values in Tab.5.

Allarm	Description	LED	Suggestions
Supply voltage	If supply voltage is out of range 48V±1V, the ALARM line is activated and the RF power supply is interdicted.	VDC	- Disable the ENABLE line for at least 1s in order to reset the alarm condition. - Verify that voltage supply is within operating range also during functioning.
ENABLE activated at the start-up	When RF supply is feeded with 48VDC, the ENABLE line must not be activated otherwise ALARM line is activated.		Disable the ENABLE line for at least 1s in order to reset the alarm condition. Do not feed the system if ENABLE line is already activated.
Commands via serial connector are ignored.	Even if the command (hexadecimal code) via serial is correctly sent, the system doesn't answer as described in Table 6 on page 38.		- Make sure that the system is NOT in "Ready" mode.
The system does not enter in "Ready" mode.	Even if ENABLE line is activated the system does not enter in "Ready" mode.		- Verify that STATE led blinks quickly after that ENABLE line is activated, that is the system is in "Stand-by" mode. - Verify that control's cable is correctly connected.

7. TECHNICAL SPECIFICATIONS

The functional characteristics of Blade RF 177 laser sources are listed in the following tables in terms of performances and features of the generated laser beam, warranty operative limits and electric supply.

Fig.11 on page 45 reports the bulk dimensions with the relative information for Blade RF 177 source integration in systems for laser processing.

7.1. Technical characteristics

Table 8 - Technical characteristics of Blade RF 177

	VALUE	
TYPE	**I05001 MODEL**	**I050A1 MODEL**
Laser power and wavelength		
Wavelength	10.6µm ± 0.4µm	9.3µm ± 0.2µm
Laser class	4	4
Average Outlet Power[1]	≥150W	≥170W
Effective power peak[2]	600W	700W
Power stability (long-term)[3]	±5%	±5%
Input modulation signal		
Pulse frequency	≤100kHz	≤100kHz
Pulse width range	from 2µs to 1000µs	from 2µs to 1000µs
Maximum duty cycle	50%	50%
Beam quality		
Beam size diameter (at exit)	(9.5 ± 0.5)mm	(9.5 ± 0.5)mm
Beam divergence r 86% (complete angle)	(3.0 ± 0.3)mrad	(3.0 ± 0.3)mrad
Beam ellipticity	1.15:1	1.15:1
Output mode	M^2<1.15	M^2<1.15
Beam point stability[4]	<0.3mrad	<0.3mrad
Optical pulse rise and fall time	<50µs	<50µs
Polarization	Linear (perpendicular to fixing plate)	Linear (perpendicular to fixing plate)
Nominal Ocular Hazard Distance (NOHD)	236m	267m
Safety eyewear required	OD≥4 @ 10.6µm Plastic or glass filter: DLB5 ILB4	OD≥4 @ 9.3µm Plastic or glass filter: DLB5 ILB4
Mechanical characteristics		
Weight	37.5kg	37.5kg
Dimensions (DxWxH)	1200mm x 190mm x 264.6mm	1200mm x 190mm x 264.6mm
Electric characteristics		
Input Voltage and Current (DC)	(48±1)VDC, 60A max	(48±1)VDC, 60A max
Peak Current	100A for a maximum of 3ms	100A for a maximum of 3ms

[1] Typical value with a frequency of 25Hz and 50% duty cycle. Power reduction of 1% for °C with water cooling temperature above 25°C.

[2] Typical value at 1kHz and 10% duty cycle.

[3] With constant frequency and duty cycle and constant water cooling temperature (20.0±0.5)°C after 1h from the ignition and 10min of warm up.

[4] After 10min of warm up

7.2. Source dimensions

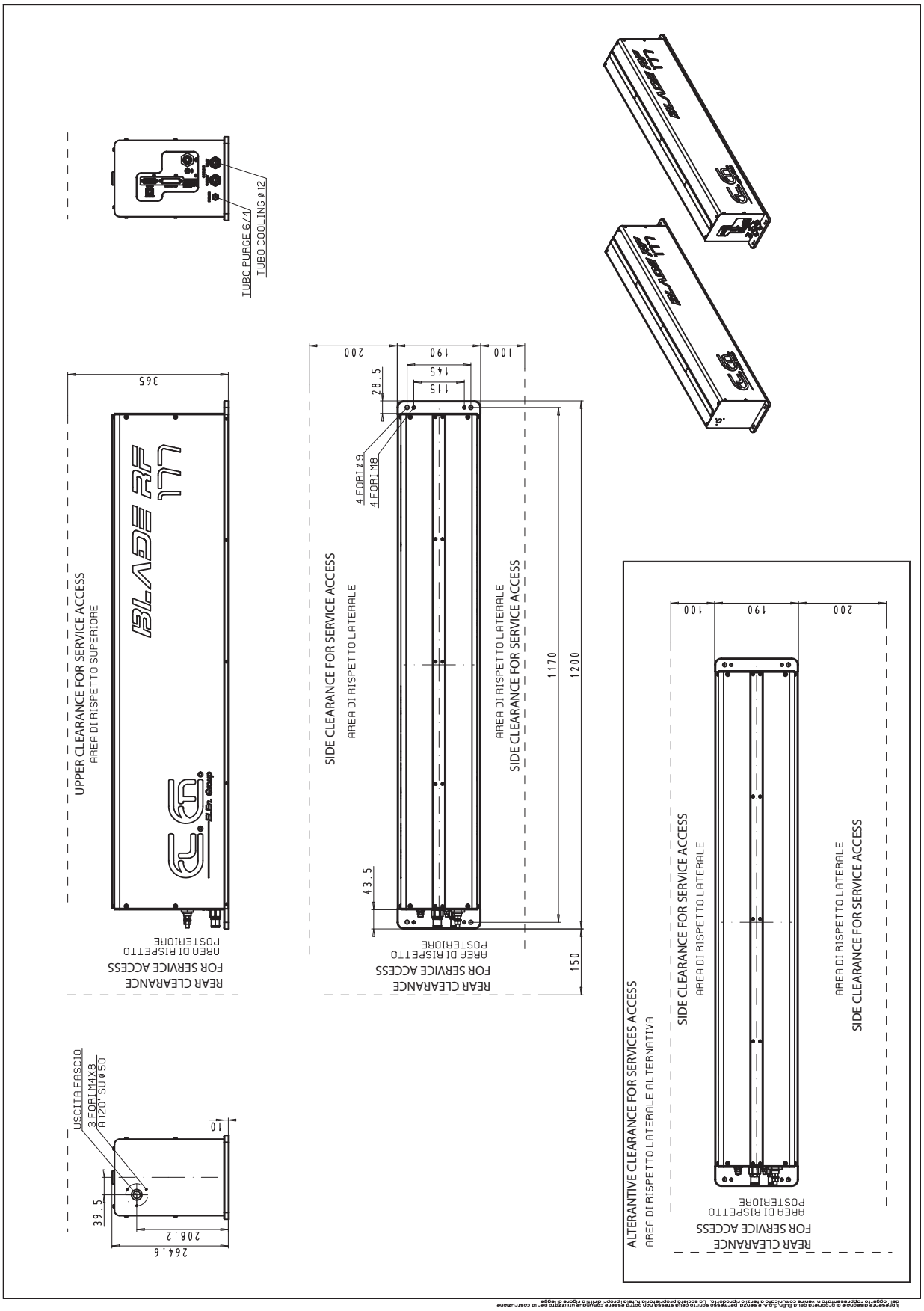


Fig.11 - Blade RF 177 laser source (dimensions in mm)

7.3. Operating limits

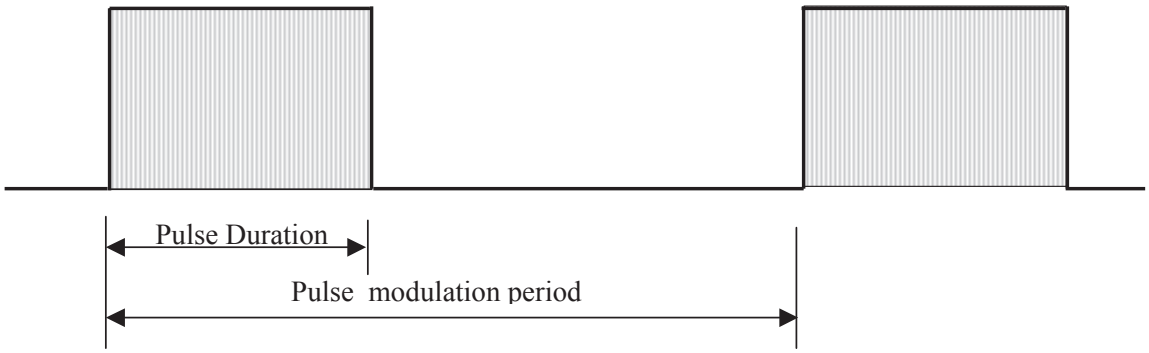
The Blade RF 177 source can operate with various pulse shape that allow to control the generated laser power.
The parameters that can be controlled by the operator through the PWM control are:

- Pulse modulation frequency (impulse period);
- Pulse duration.

Varying these parameters the result is the control of the following characteristics of generated laser beam:

- Average power;
- Pulse peak power;
- Pulse duration.

The control dynamics is very wide-ranging obtaining application performances typical of this type of sources.
The detail of modulation pulse typical shape is showed in Fig.12; in the same figure the definition of Duty Cycle is also reported that represents the percentage of the pulse period during which the supply is on.



$$\text{Duty Cycle} = \frac{\text{Pulse duration}}{\text{Pulse Period}} \times 100\ \% \qquad \text{Pulse Frequency} = \frac{1}{\text{Pulse Period}}$$

Fig.12 - Modulation pulse typical shape

Anyhow, note that the shape of generated laser pulse, corresponding to a modulation pulse, is different from the latter (rise and falling time) depending on the active medium response time. Typically, the rise time of laser pulse is 30-50µs with a slightly lower falling time. A typical laser pulse shape generated by a modulation pulse of 300µs is showed in Fig.13.

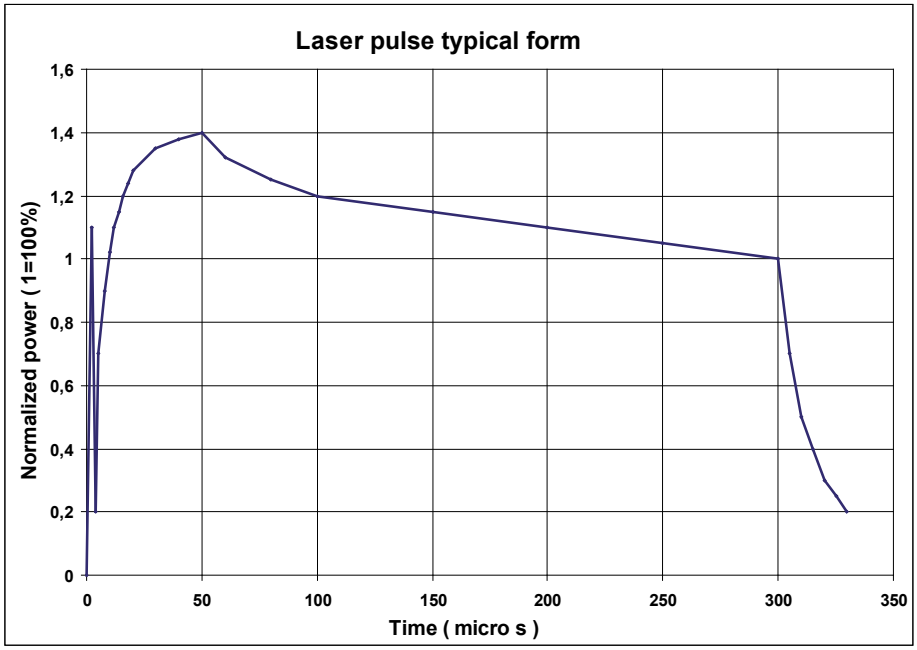


Fig.13 - Laser pulse typical shape

The operating limits of Blade RF 177 laser source in terms of modulation frequency, pulse duration and Duty Cycle are showed in Fig.14.
Operating within these limits, the laser source Blade RF 177 guarantees performances reported in the technical specifications on paragraph "Technical characteristics" on page 44.

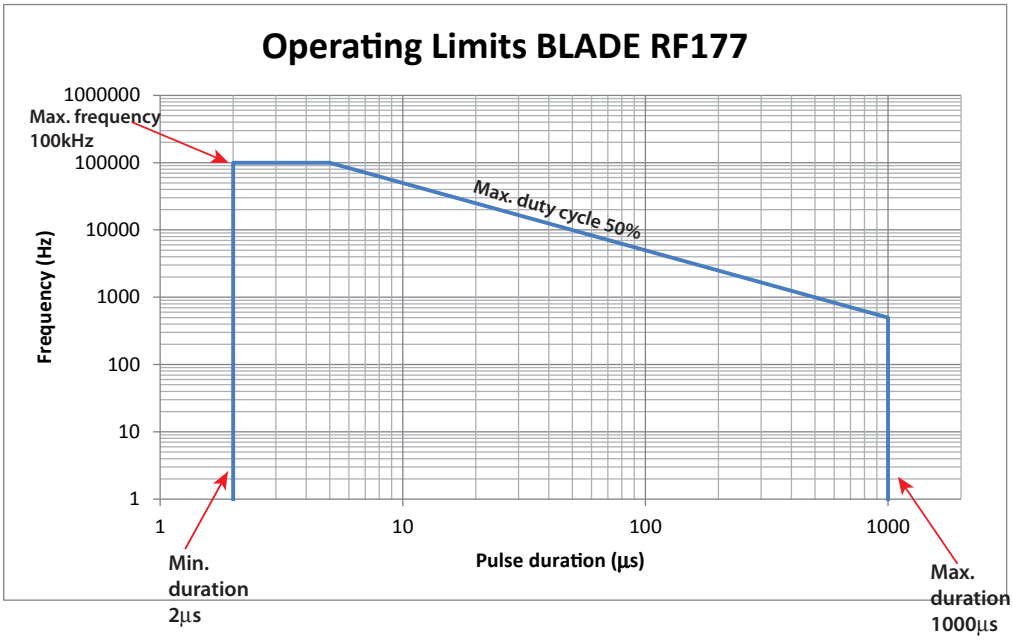


Fig.14 - Operating limits

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