LIGHT CONVERSION

CARBIDE

CB3 - 80W
Femtosecond Laser System

USER MANUAL

Date: 25 October, 2023
Code: CB3-D-MAN-FM-14

WWW.LIGHTCON.COM

PREFACE

This manual contains user information for safe installation, operation and maintenance of the CARBIDE laser system.

NOTICE ***The latest version of all product manuals is always available online at www.lightcon.com. User registration is required to access the download section.***

Read this manual carefully before operating the laser system for the first time. Special attention must be paid to the "SAFETY PRECAUTIONS" chapter, which describes hazards associated with the system and precautions that must be taken to operate the laser safely.

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

Thank you for using Light Conversion products.

Support Needs

If you have any technical questions or problems, please contact our authorized representatives or Light Conversion directly:

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Legal information

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Abbreviations

- CPA - Chirped pulse amplification
- CW - Continuous wave
- HV - High voltage
- LD - Laser diode
- LDD - Pump laser diodes driver
- ML - Mode-locking
- OSC - Oscillator
- SC - Stretcher compressor
- PD - Photodiode
- PP - Pulse picker
- PSU - Power supply unit
- RA - Regenerative amplifier
- TEM - Timing electronics module
- SELV - Safety Extra Low voltage

WARRANTY STATEMENT

Light Conversion warrants that the supplied system is free from defects in parts and workmanship. Light Conversion will make any necessary repairs or replacement of parts to remedy any defect according to the conditions drawn in this statement.

The warranty period for the delivered system is detailed in the purchase contract. Extended warranty can be purchased together with the product or at a later date at least a month before the expiration of the present warranty period. Warranty terms for some internal components may differ from those for the entire system. The warranty period starts after the final acceptance report is approved or one month after delivery, whichever occurs first.

Sealed design Light Conversion products (lasers, industrial harmonics generators etc), have limited on-field engineer access to the internal components. Repair works requiring access to the internal components shall be carried out in a clean room at Light Conversion service centers. If such repairs become necessary, the system or its components shall be sent to an authorized service center for repairs. Shipping expenses from customer's facility to the authorized service center shall be covered by the customer. Repairs and return shipment expenses (excluding custom duties if applicable) shall be covered by Light Conversion.

Light Conversion products without sealed cavities (many Optical Parametric Amplifiers and other scientific products) in most cases are serviced in the field.

This warranty does not cover equipment or parts damaged by accident, improper use (including, without limitation, incorrect voltages, power surges, fires, operation in an improper environment, natural disasters or other situations out of the control of Light Conversion), failure to operate in accordance with instructions provided in the User's Manuals, including specific safety and operational warnings contained therein, cosmetic damage sustained in use, and damage caused by unauthorized modifications of any equipment which impair or alter its normal functioning.

The limited warranty and remedy contained in this statement are the only warranty and remedy pertaining to the equipment. Light Conversion disclaims all other warranties, expressed or implied, including any warranty of merchantability or fitness for a particular purpose. No oral information or advice given by Light Conversion, its dealers, its distributors, agents, officers, or employees shall create a warranty or in any way increase the scope of this warranty (the scope of the warranty may be increased only in writing and only by Light Conversion Sales or Service manager).

Shall the system require minimal repair or maintenance which can be performed by the customer himself, customer is entitled to perform such a repair only after explicit Light Conversion approval.

In the event of return shipping of the product to Light Conversion for maintenance, repairs or any other reason, it is the customer's responsibility to properly pack the product. Responsibility for any damages or cosmetic wear caused by improper packaging of the product will fall upon the customer. Contact Light Conversion for product packaging requirements.

All information in this document is subject to change without notice. In no event will Light Conversion be liable for any direct or indirect damages resulting from any defects in this documentation. Always consult with Light Conversion if you have any doubts regarding any information written in this manual prior to taking action.

INTRODUCTION

This document is directed towards anyone who works with the CARBIDE laser system or performs maintenance tasks. The structure of this document is linear in such a way, how the user should be introduced to the laser system. The document begins with essential safety precautions and warnings, followed with a general laser system overview, system installation and ends with instructions on daily device operation with both the User App and the Service App. At the end of this document you will also find an appendix containing various additional but non-essential information.

Throughout this document there are reference to various type of personnel, definition and requirements for each type of personnel are listed below:

- **Qualified personnel** are considered individuals, who on account of their professional training, knowledge and experience, as well as their knowledge of the relevant statutory provisions, can make a correct assessment of work assigned to them and identify possible dangers. They must be familiar with the CARBIDE laser structure, principles of operation, laser and electrical safety precautions.
- **Instructed personnel** are considered individuals, who have been instructed and educated (if necessary) on the work assigned to them, as well as on the potential dangers arising from inappropriate conduct. Individuals with knowledge about required protective devices and protective measures.
- **Service personnel** are considered individuals from Light Conversion or its authorized representatives, who are specifically trained on this type of laser, with specialist knowledge and experience with the structure of the device and its optical and electrical layouts.

NOTICE ***All pictures shown are for illustration purpose only. Actual product may vary due to product enhancement.***

SAFETY SIGNAL WORDS AND SIGNS

The following safety signal words and safety signs are used throughout this manual:

Table 1. Safety signal words and safety signs used in this manual

Safety sign	Signal word	Description
	DANGER	Indicates a hazardous situation that, if not avoided, will result in death or serious injury.
	WARNING	Indicates a hazardous situation that, if not avoided, could result in death or serious injury.
	CAUTION	Indicates a hazardous situation that, if not avoided, could result in minor or moderate injury.
	**NOTICE**	Indicates information considered important, but not hazard-related (e.g. relating to property damage).
		Indicates danger of exposure to hazardous laser radiation.
		Indicates danger of electrical hazard to personal safety.
		Indicates fire hazard.
		Indicates toxic materials released because of laser material processing or as by-product of the laser process.

1 SAFETY PRECAUTIONS

This section should be carefully reviewed prior to operating the CARBIDE laser. Safety precautions contained herein and throughout the manual must be carefully followed to ensure that all personnel who operate the laser are protected from accidental exposure to laser radiation and high voltage.

	**WARNING**	***The laser system was designed for indoor use only. Usage of the laser system outdoors poses potential optical, electrical, chemical and fire hazards.***

1.1 Safety Hazards

Optical Hazards

CARBIDE is a Class 4 laser product that poses safety hazards if not used properly. Produced direct or scattered laser radiation can cause permanent eye damage and possible blindness, skin injuries. Beams can be powerful enough to burn skin, clothes, or ignite fire and can also damage light sensitive optical equipment such as video cameras, photodiodes, etc.

CARBIDE emits invisible and visible femtosecond pulses with an average power up to several watts. Direct viewing of the laser output beam or even specular reflection from polished or diffuse surfaces can cause instantaneous and permanent eye damage and/or possible blindness.

	**WARNING**	***Avoid viewing the laser beam and specular reflections. Always wear protective eyewear when aligning and operating the CARBIDE laser. Ensure your protective glasses cover all wavelengths emitted by the laser.***
	**WARNING**	***Ensure that the emission status indicator is clearly visible both to the naked eye and through the filters of your protective eyewear. If necessary install additional emission indicators in accordance with IEC 60825-1.***
	**WARNING**	***Areas in which the maximum permissible ocular exposure is exceeded must be protected by screens. All access panels and doors must be secured by means of interlock switches connected to the power supply unit.***

All CARBIDE Laser users are advised to follow the precautions below:

1. Always wear protective eyewear. Choose protective eyewear appropriate to the intensity and wavelength of the radiation, as well as environmental conditions of use and required visual functions.
2. Never look directly into the laser beam or at any scattered laser light from any reflective (or partially reflective) surface.
3. Avoid wearing watches, jewelry and other objects that may reflect or scatter the laser beam.
4. Set up the laser system in such a way, that the laser beam paths are located well below eye level.
5. Use energy absorbing targets and shields to block the beam and/or prevent unnecessary beam reflections or scatter.
6. Avoid blocking the output beam or its reflection with any part of your body. The intensity of the beam can cause skin burns or ignite clothing.

7. Maintain a high ambient light level in the laser operating area. This keeps the eye's pupils constricted and can reduce the possibility of eye damage in case of an accident.
8. Extreme caution must be exercised when using volatile solvents near laser.
9. Limit laser access to qualified personnel only, who have received appropriate safety laser trainings and are aware of the dangers involved.
10. Use the laser in a closed room. Laser light remains collimated over long distances and therefore presents a potential hazard if not confined.
11. Post warning signs near the laser operation area.

Electrical Hazards

Hazardous voltages are present in the PSU. Do not disassemble or otherwise modify the PSU.

1. Never remove the access covers of the power supply or the laser electro-optical units unless the power supply is switched off and disconnected from the mains. Voltages present on these components present a safety hazard, which could result in personal injury or death.
2. Do not connect or disconnect any cables while the power supply is turned on.
3. Never work on electrical equipment unless there is another person present who is familiar with the operation and hazards of the equipment and is competent to administer first aid.
4. After disconnecting the main power, wait at least one minute for the capacitors to discharge before touching any electrical equipment.

	**WARNING**	***To avoid the risk of electrical shock, this equipment may only be connected to an electrical source equipped with protective earth.***
	**CAUTION**	***If laser is plugged to the wall socket, clearances must be kept allowing easy and fast access to the plug in case of emergency.***

Chemical Hazards

Exposure to dust and gases released during laser material processing.

	**WARNING**	***A suitable extraction system must be connected if laser is used to process materials.***

Explosion and Fire Hazards

The laser beam can ignite substances in its path even at some distance.

	**DANGER**	***Risk of fire and explosion! Due to the energy and power density of the laser beam there is risk of fire and explosion. Never install the laser-system in locations exposed to fire and explosion hazards.***

Mechanical hazards

The CARBIDE laser system along with other components overall may weight up to 37 kg. It must be transported, unpacked and dismantled respectively. Some parts and boxes may have sharp edges while disassembling them.

	**NOTICE**	***The laser system may be installed and dismantled by authorized technicians who must be aware of the dangers involved. Use safety shoes while handling heavy pieces of equipment. Use safety gloves where indicated by the signs.***

1.2 Safety Related Controls

The laser is enclosed in a protective housing that prevents human access to radiation in excess of the limits of Class 1 radiation. Several engineering controls have been implemented to ensure the safe use of the laser and are listed in the table below and shown in the figure after the table.

Table 2. CARBIDE laser safety related controls

Safety related controls	Description
Safety shutter	The CARBIDE laser has an integrated Safety Shutter, that is used to open/close the laser output apertures. Safety Shutter diagnostics controller constantly monitors shutter operation and activates error outputs in case of detecting failure. Safety Shutter diagnostics controller is a functional safety device which fulfills performance level d requirements according to EN 13849-1. Note: CARBIDE laser must be completely powered off to recover from shutter error condition. Device that switches off the laser is not a part of the laser and must be provided separately. If performance reliability level d is required for the complete system, device for switching off the laser must be at least PL= d. Refer to the electrical safety section at the end of this document for more details.
Shutter key	The shutter key is used to enable/disable the Safety Shutter. If the key is turned to a position where the Safety Shutter is enabled, the Safety Shutter can be controlled by software and/or external inputs signals. Refer to electrical safety section at the end of this document for information on controlling shutter externally.

Table 2. CARBIDE laser safety related controls

Safety related controls	Description
Remote interlock	The Safety Shutter has an integrated remote interlock function in compliance with IEC 60825-1. The interlock circuit can be installed by the user to prevent access to areas where ocular exposure exceeds the maximum permissible levels, specified in the International Laser Safety Standard IEC 60825-1. Interlock switches must be installed on all access panels and doors. Once the interlock circuit is open the Safety-Shutter is closed. No laser radiation is emitted! Interlock circuit must be restored and the Interlock Reset pins must be closed to restore laser operation. Note: Remote Interlock lines of CARBIDE shipped from the factory are bypassed in XB3 connector. It is user's responsibility to install interlocking switches and connect them to the laser. Refer to the electrical safety section at the end of this document for information on how to connect the Remote Interlock lines.
Laser emission indicator	LED, active when current of the laser pump modules is activated.
Shutter status indicator	LED, active when Safety Shutter is open.

 **WARNING**	Even when the Safety-Shutter is closed there is hazardous laser radiation present inside the laser enclosure. Removal of the laser enclosure or any works inside the laser enclosure must only be carried out by Qualified or Service Personnel.
 **WARNING**	Any modification or use of the CARBIDE laser which changes, disables or overrides the function of these safety related controls invalidates the Class 4 certification of the laser described in this manual.

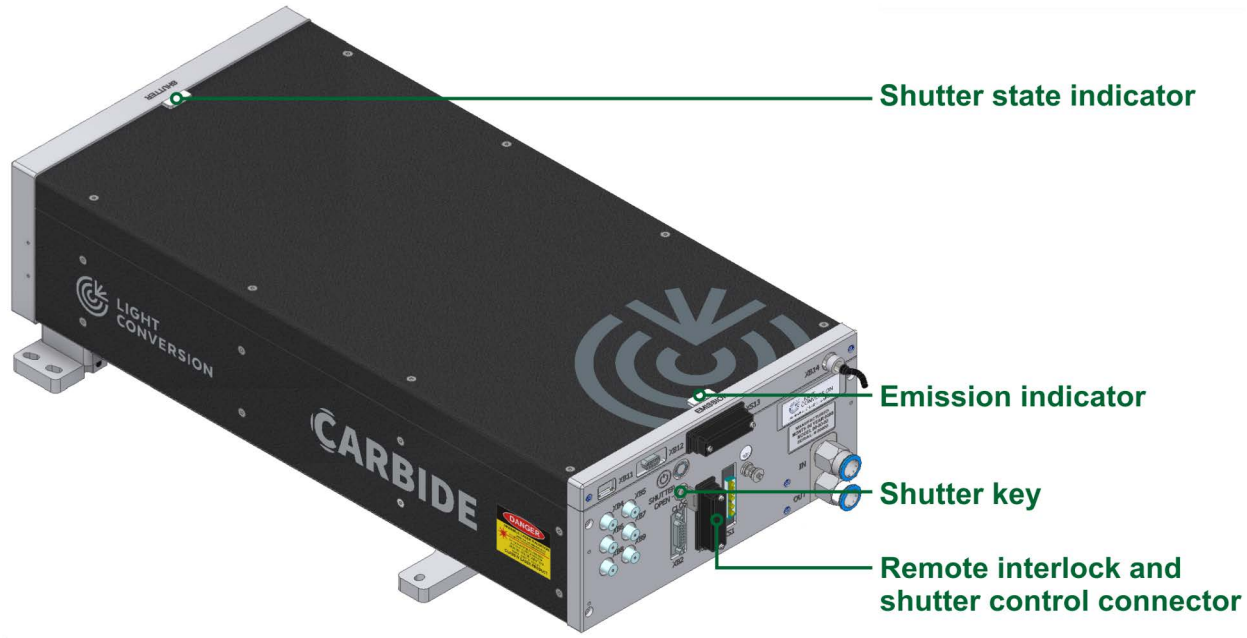
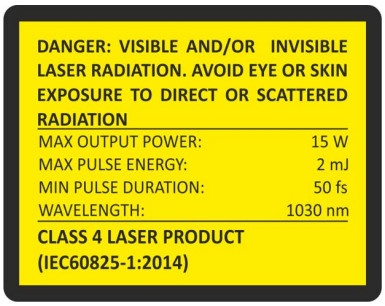
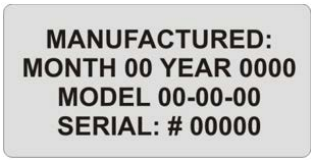


Figure 1. Location of the CARBIDE laser shutter key, interlock connectors, emission and shutter state indicators

1.3 Warning and Informational Labels

System areas with potential risks are marked with the prescribed warning and information labels on the relevant spots. Description and location of these labels is presented in the table and figures below.

Table 3. Description of CARBIDE labels

No.	Label	Location and description
1		**Warning label** is located on the side of the CARBIDE housing. Depending on the model, the label shows max pulse energy, max average output power, pulse duration and wavelength.
2		**Grounding contact label** is located on the back of the CARBIDE housing, near the grounding contact.
3		**Manufacturer identification label** is located on the back of the CARBIDE housing.
4		**Product identification label** is located on the back of the CARBIDE housing.
5		**Aperture label** is located next to the beam output aperture of CARBIDE laser system. Depending on the device model actual emitted pulse energy and duration are stated on this label.
6		**Aperture label** is located next to the beam output aperture.
7		**High voltage warning label** is located on the housings of devices in which high voltage is used (not displayed in present figures).
8		**Power supply product identification label** is located on the power supply.

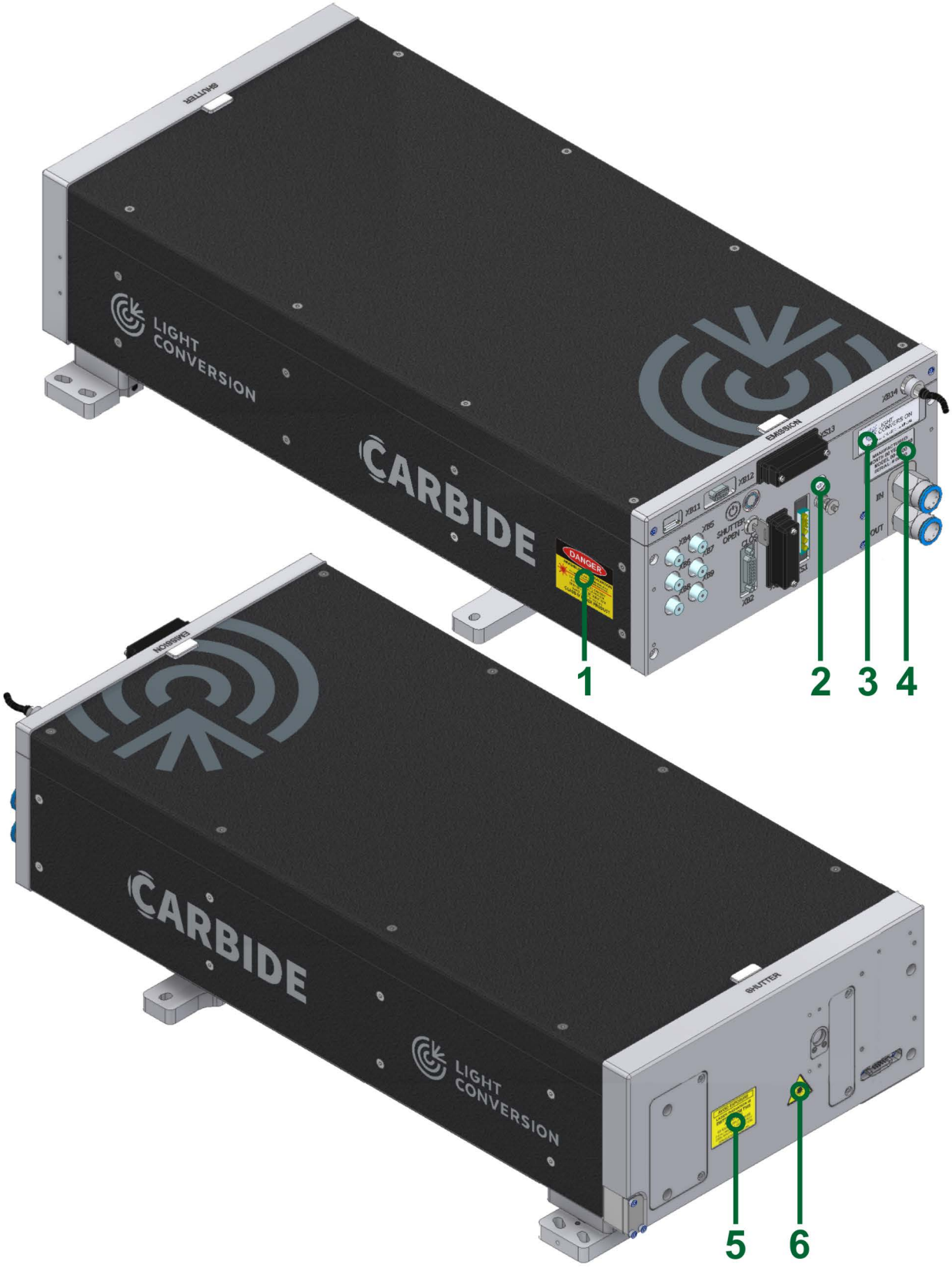


Figure 2. Label locations on the CARBIDE laser head

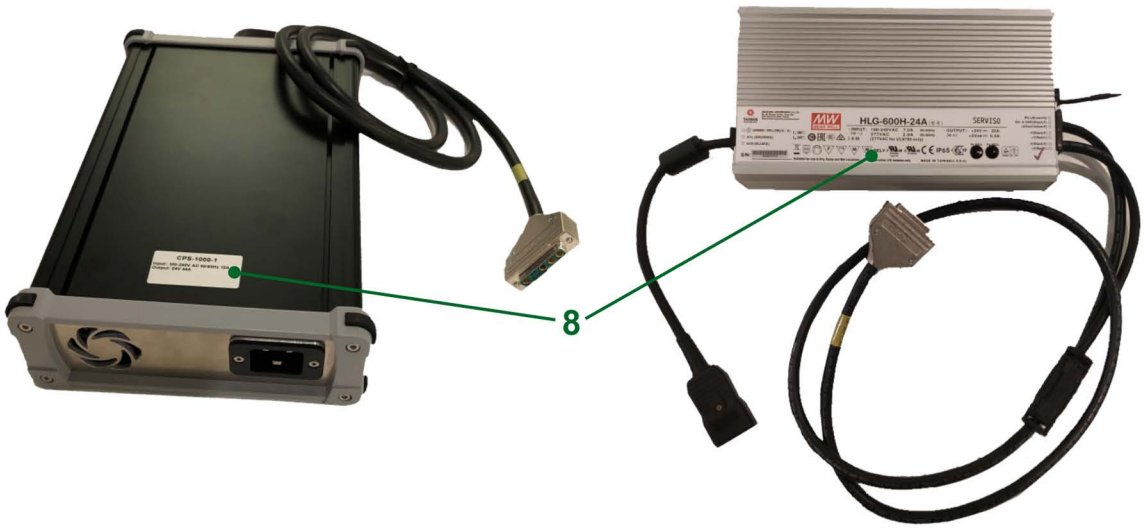


Figure 3. Label locations on the power supply

1.4 Integration of the Laser

The laser system is designed and constructed in accordance with essential health and safety requirements. Additional external safety controls can be installed, such as the external interlock switches or the emergency stop switch. **It is the integrators responsibility to install these additional safety controls.**

If the laser system is integrated into another system, it must not begin operations within the European Community until the finalized system has been declared in conformity with all the applicable EC Directives.

The manufacturer shall not be responsible or liable, directly or indirectly, for any damage or loss, caused or alleged to be caused by systems, containing the laser system as one of the components of a different system.

WARNING

When integrating the laser system, keep in mind the possibility of laser beam reflections from external components. Avoid collimated and especially diverging reflections from external optics or surfaces towards the laser head as this may damage internal optics comprising the laser. For example, reflections from negative lenses (often used in beam expanders) with non-optimized coating. Back-reflections of even 1% of the laser beam may cause irreplaceable damage to the optics.

1.5 Disposal

	**NOTICE**	***The laser system may only be dismantled by authorized technicians who must be aware of the dangers involved.***
	**NOTICE**	***Make sure that any government, district or local authority regulations regarding the disposal of environmentally dangerous substances are observed.***

Technical personnel must comply with the following:

- The safety instructions provided in the operating manual.
- Suitable protective clothing must be worn (protective gloves, safety shoes, goggles, etc.).
- The electrical energy supplies must be disconnected and secured against being switched on again in accordance with relevant accident prevention regulations.

1.5.1 Dismantling the System

Dismantle the laser-system in the following order:

1. Switch off the laser-system.
2. Switch off the power supply.
3. Unplug the power cable.
4. If a chiller is used in the laser system, remove all the water from laser head cooling system and chiller.
5. Dismantle the laser-system into modules using the appropriate tools.
6. Disassemble the dismantled modules into their component parts.

1.5.2 Disposal

Dispose of the components in a suitable manner, observing any legal and company regulations for:

- Metals
- Glass
- Plastics
- Cables
- Packaging
- Packaging materials
- Batteries
- Electrical appliances
- Electronic components
- Transport media (pallets, etc.)

	**WARNING**	***Pockels cell drivers contains BeO ceramics (see "LIST OF HAZARDOUS MATERIALS USED IN PRODUCT" attached at the end of this document). It is prohibited to perform grinding, sanding, polishing, crushing, abrading or any other form of machining without adequate safety precautions. This information must be passed to any personnel or organization responsible for recycling of the Pockels cell drivers.***

2 ELECTRICAL AND PHYSICAL SPECIFICATIONS

Table 4. Electrical characteristics

CARBIDE Laser	PSU input voltage: Frequency: Max. PSU input current: Max. Laser Power consumption:	100 - 240 VAC 50/60 Hz 7 A / 11 A (at 100 VAC) (for 1 MHz / 2 MHz laser) 600 W / 1000 W (for 1 MHz / 2 MHz laser)

Table 5. Environmental characteristics

*Operating temperature**	15 - 30 °C
*Environmental temperature**	Non-condensing relative to the operating temperature and surrounding humidity
*Relative humidity**	0-80 % (non-condensing)
*Storage temperature**	5 - 40 °C
*Storage relative humidity**	<80% (non-condensing)
Altitude	Up to 2000 m

NOTICE

Both the temperature and relative humidity should be kept at optimal levels to prevent condensation on the laser parts.

Table 6. Physical characteristics

Weight of the laser head	37 kg
Weight of the power supply unit	4 kg
Dimensions of the laser head	630,5 L x 350 W x 174 H mm
Dimensions of the laser head (modified to accommodate an optical parametric amplifier)	630,5 L x 350 W x 188 H mm
Dimensions of the power supply	280 L x 144 W x 49 H mm (< 40W PSU) 320 L x 200 W 75 H mm (> 40W PSU)
Weight of chiller (approximate)	32 kg or 48 kg (see accompanying chiller documentation)

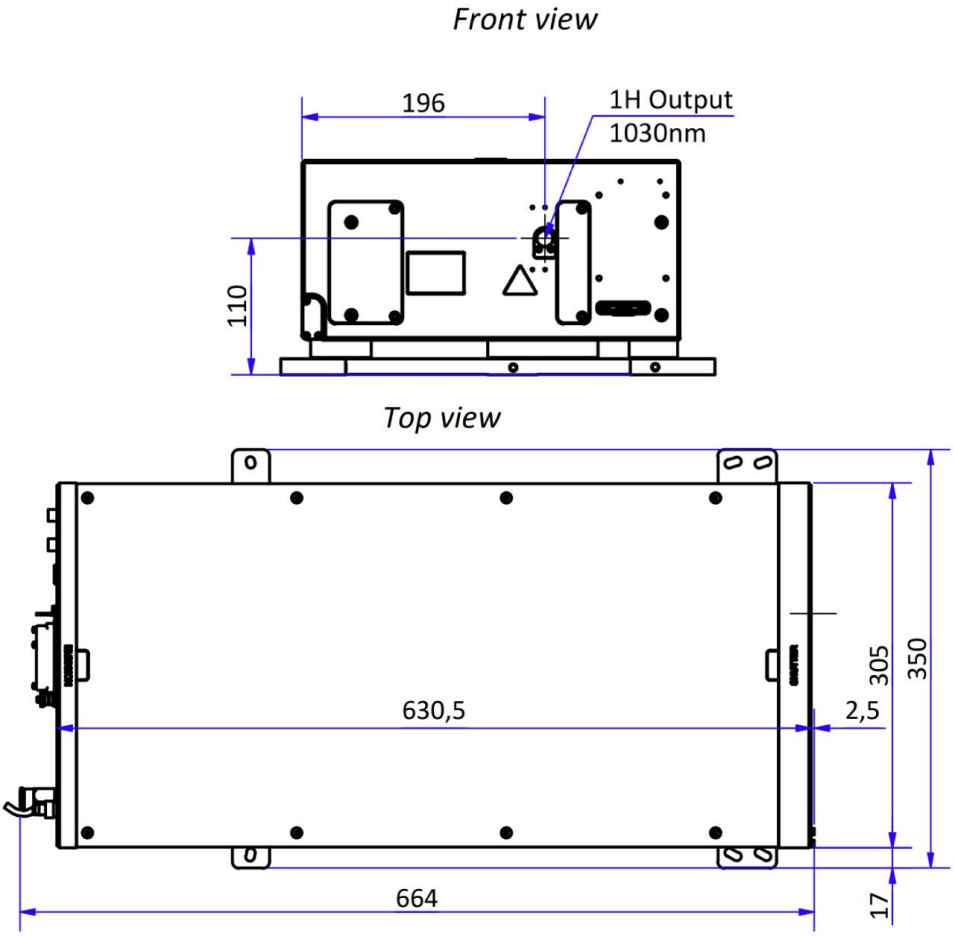


Figure 4. CARBIDE laser dimensions

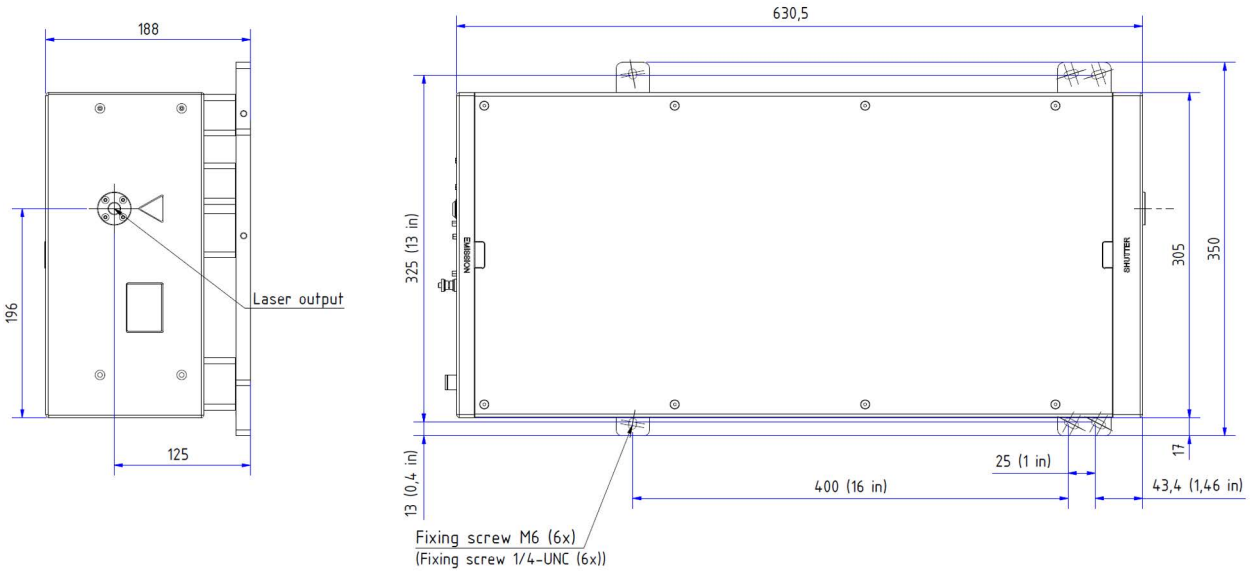


Figure 5. Dimensions of a CARBIDE laser, modified to accommodate an optical parametric amplifier

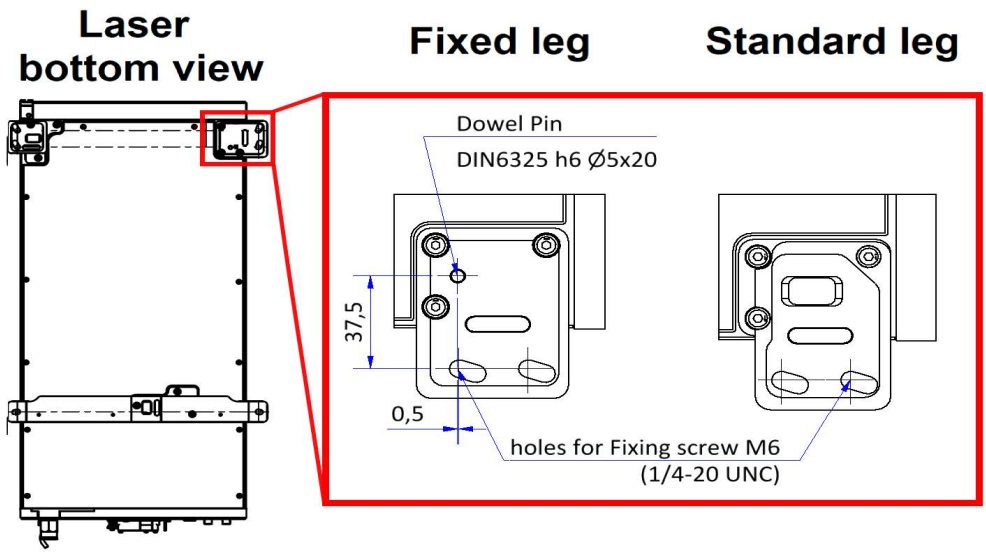


Figure 6. Dimensions of a CARBIDE laser's standard mounting leg and a fixed mounting leg, which replaces the front-left leg for vertical installation (shown in bottom view)

2.1 Output specifications

Table 7. Output specifications for CARBIDE laser

Output	Parameter	Specification
Fundamental output	**Central wavelength**	1030 nm ± 10 nm
	Average output power	Depends on laser specifications*
	Maximum pulse energy	Depends on laser specifications*
	Typical pulse duration	Depends on laser specifications*
	Spatial mode	TEM_{00}, M^2<1.2
	Polarization	Vertical
	Stability of pulse energy, STD	< 0.5%

*Refer to the factory test certificate of the supplied laser.

2.2 Data Interface Specifications

Table 8. Default data interface specifications

LAN interface	*IP address*	192.168.240.10
	Subnet mask	255.255.255.0
	Gateway	192.168.240.1

3 LASER SYSTEM DESCRIPTION

CARBIDE is a high repetition rate femtosecond laser system based on a chirped pulse amplification (CPA) technique, which uses directly diode-pumped Yb:KGW (ytterbium-doped potassium gadolinium tungstate) as active medium. The CARBIDE laser head comprises of a Kerr lens mode-locked Oscillator (OSC), Regenerative Amplifier (RA) and Stretcher-Compressor (S-C) units. The full system incorporates a desktop-type power supply. Additional components like the automated harmonics module are also available.

The entire body of the CARBIDE laser is maintained at constant temperature, leading to high performance stability, barely affected by the operating environment.

Laser operation is automatically controlled by driving electronics. Operating parameters can be adjusted via PC, which is linked to the laser via LAN interface. Dedicated control software and a library of commands are supplied with the laser.

Oscillator (OSC), regenerative amplifier (RA) and stretcher-compressor (S-C) comprise a monolithic laser head. The laser head is divided into three main sections. The S-C section is located on top of the CARBIDE. The OSC and RA cavity sections are located at the bottom side of the head. Laser control electronics and the Pockels cells are located in the rear part of the laser.

3.1 Oscillator

The oscillator (OSC) employs a cavity with active medium end pumped by high brightness laser diode module. Generation of a high repetition rate femtosecond pulse train is ensured by Kerr lens mode-locking. Oscillator operation is controlled automatically by internal firmware of the laser.

3.2 Stretcher-Compressor

Stretcher of the CARBIDE is designed to produce a temporal pulse stretching. Output of the stretcher is seeded into the RA for amplification and subsequent compression. By changing the compressor length, it is possible to tune the output pulse duration from the minimum value, typically ~270 fs (laser model dependent), to a maximum one of about 10 ps. In the standard CARBIDE system pulse duration can be changed from the minimum to the maximum in just a few seconds

3.3 Regenerative Amplifier

A Pockels cell within the amplifier cavity is used to both inject the seed into the RA and to eject the amplified pulse toward the pulse picker. The second Pockels cell is used as a pulse picker. It controls the RA output repetition rate and is adjustable from 2 MHz to ~100 kHz (minimum frequency may vary from laser to laser).

3.4 Electrical Connections

CARBIDE electrical connectors are presented in the picture below.

NOTICE ***All the connectors labelled XB are type female, while the XS are type male.***

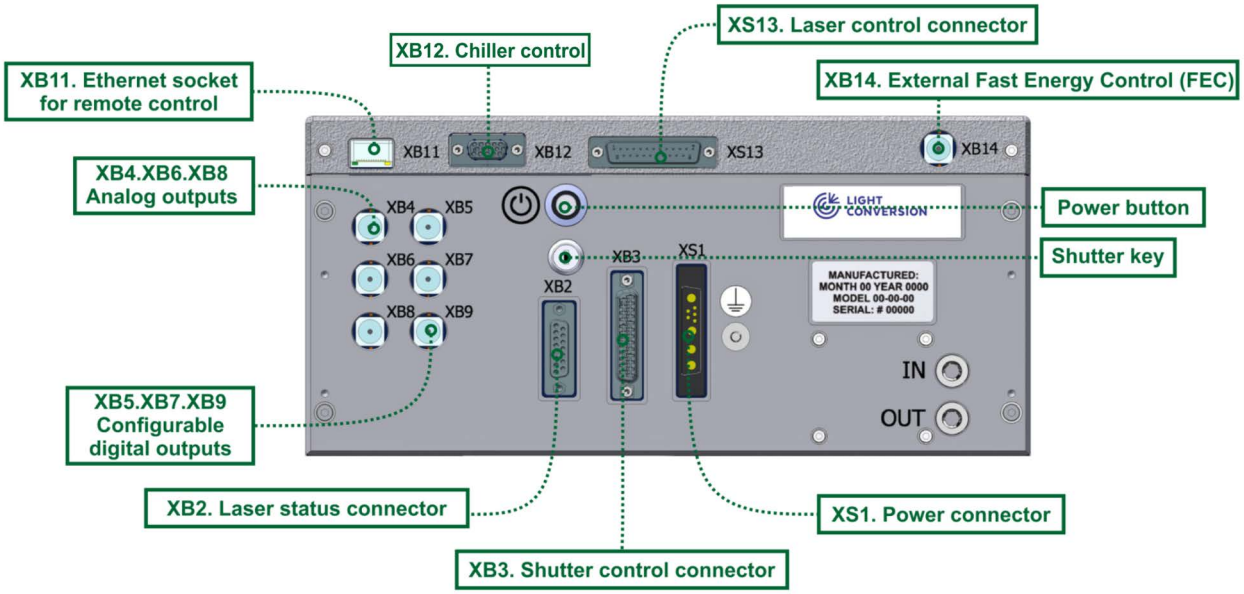


Figure 7. CARBIDE electrical connectors

3.4.1 BNC connectors (XB4, XB5, XB6, XB7, XB8, XB9)

XB5, XB7 and XB9 connectors are configured using the Service App.

Table 9. Description of the BNC connector

Pin	Output name	Signal type	Direction	Description
XB4	OSC_OUT	Analog	OUT	Oscillator pulse train photodiode output signal
XB5	DIGITAL_OUT_1	+3.3V 50 ohm. SINGLE END TERMINATION*	OUT	Configurable digital output
XB6	AUX_OUT	Analog	OUT	*Reserved, do not connect.*
XB7	DIGITAL_OUT_2	+3.3V 50 ohm. SINGLE END TERMINATION*	OUT	Configurable digital output
XB8	LASER_OUT	Analog	OUT	Laser output photodiode signal
XB9	DIGITAL_OUT_3	+3.3V 50 ohm. SINGLE END TERMINATION*	OUT	Configurable digital output

*In the event of reading these digital signals on a oscilloscope, the oscilloscope input impedance must be set to 1 M ohm.

3.4.2 Shutter Control Connector (XB3)

XB3 connector can be used to control and monitor shutter status externally. Connector type: D-SUB 25 female. Connector pinout is presented in the table below.

Table 10. XB3 shutter control connector pinout

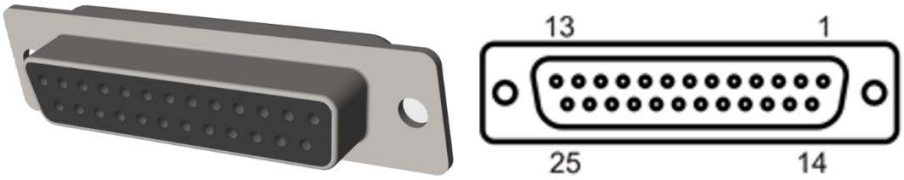
PIN	Name	Signal Type	Dir	Description
				
Type: D-SUB 25 female				
1-3	GND	Ground	-	-
4	SHUTTER_STATUS_ CLOSED	24V	OUT	High level if shutter is closed (20mA max)
5	GND	Ground	-	-
6	SHUTTER_CTRL_2_ WIRES_OUT_NTRL	0V	OUT	Neutral output for shutter control with a double switch. This pin must be connected to SHUTTER _CTRL_2_WIRES_IN_NTRL (XB3.7) to open the shutter
7	SHUTTER _CTRL_2_ WIRES_IN_NTRL	0V	IN	Neutral input for shutter control with a double switch. This pin must be connected to SHUTTER _CTRL_2_WIRES_OUT_NTRL (XB3.6) to open the shutter
8	REMOTE_INTERLOCK_ OUT_NEG	Current loop	OUT	Negative output of isolated power supply for remote interlock circuit
9	REMOTE_ INTERLOCK_ IN_NEG	Current loop	IN	Negative input of the remote interlock circuit. This pin must be connected to REMOTE_INTERLOCK_ OUT_NEG to keep the interlock deactivated. Disruption of this circuit activates the remote interlock and closes the shutter
10-11	GND	Ground	-	-
12	E_STOP_B_1	Passive	-	Shutter emergency stop status line. This pin is connected to pin E_STOP_B_2 (XB3.13) when shutter electronics are functioning normally (500mA fused)
13	E_STOP_B_2	Passive	-	Shutter emergency stop status line. This pin is connected to pin E_STOP_B_1 (XB3.12) when shutter electronics are functioning normally (500mA fused)
14	GND	Ground	-	-
15	SHUTTER_CTRL_ 1_WIRE	24V	IN	Input for shutter control with a single switch. This output must be connected to GND to open the shutter

Table 10. XB3 shutter control connector pinout

PIN	Name	Signal Type	Dir	Description
16	SHUTTER_STATUS_ ERROR	24V	OUT	High level if a shutter error is detected (20mA max)
17	SHUTTER_STATUS_ OPEN	24V	OUT	High level if shutter is open (20mA max)
18	SHUTTER _CTRL_2_ WIRES_OUT_POS	24V	OUT	+24V output (500mA max) for shutter control with a double switch. This pin must be connected to SHUTTER _CTRL_2_WIRES_IN_POS (XB3.19) to open the shutter
19	SHUTTER _CTRL_2_ WIRES_IN_POS	24V	IN	+24V input for shutter control with a double switch. This pin must be connected to SHUTTER _CTRL_2_WIRES_OUT_POS (XB3.18) to open the shutter
20	REMOTE_INTERLOCK_ OUT_POS	Current loop	OUT	Positive output of isolated power supply for the remote interlock circuit
21	REMOTE_ INTERLOCK_ IN_POS	Current loop	IN	Positive input for the remote interlock circuit. This pin must be connected to REMOTE_INTERLOCK_OUT_POS (XB3.20) to keep the interlock deactivated. Disruption of this circuit activates the remote interlock and closes the shutter
22	GND	Ground	-	-
23	REMOTE_INTERLOCK_ RESET	TTL	IN	Active level (low) resets the remote interlock circuit (Connection between XB3.20 and XB3.21). Input has internal pull-up. **Warning. Do not connect 24V to this input!**
24	E_STOP_A_1	Passive	-	Shutter emergency stop status line. This pin is connected to pin E_STOP_A_2 (XB3.25) when shutter electronics are functioning normally (500mA fused)
25	E_STOP_A_2	Passive	-	Shutter emergency stop status line. This pin is connected to pin E_STOP_A_1 (XB3.24) when shutter electronics are functioning normally (500mA fused)

3.4.3 Laser Control Connector (XS13)

XS13 connector can be used to control the laser operation externally or to obtain status signals. Connector type: Type: D-SUB 25 male. Connector pins description is presented in the table below.

Table 11. XS13 laser control connector pinout

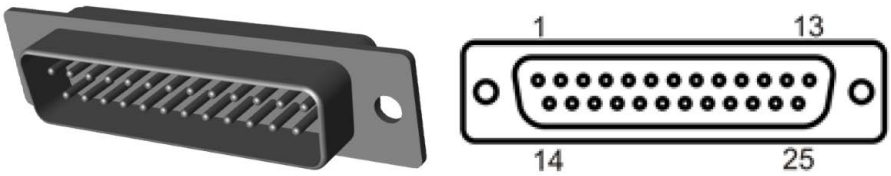
PIN	Name	Signal Type	Dir	Description
				
Type: D-SUB 25 male				
1-7	GND	Ground	-	-
8	FAST_OFF_ CL_IN	Current loop	IN	Signal must connect to pin FAST_OFF_CL_OUT (XS13.20) for normal laser operation. Disruption of this circuit stops the OSC and RA. Laser operation can be restored after circuit closure
9	GND	Ground	-	-
10	EXT_1	TTL	IN	Configurable extra input. Input has internal pull-up. 3.3V nominal, 5V tolerable
11	EXT_2	TTL	IN	Configurable extra input. Input has internal pull-up. 3.3V nominal, 5V tolerable
12	GND	Ground	-	-
13	5V_OUT	+5V	OUT	5V DC output (300 mA max).
14	SYNC_IN	TTL	IN	Input of an external clock for laser synchronization. High level pulse duration must be between 100 ns and 500 ns. Signal frequency must be stable within the laser operating frequency range. Laser operating frequency range is specified in the factory test certificate. Input has internal pull-up. 3.3V nominal, 5V tolerable.
15	PP_ DIV_DIS	TTL	IN	Active level (low) disables the PP divider (divider is set to 1). Input has internal pull-up. 3.3V nominal, 5V tolerable
16	PP_EN	TTL	IN	Active level (high) enables the PP. Trigger active level can be configured (high <-> low) in the User App -> External Control section. Input has internal pull-up. 3.3V nominal, 5V tolerable.
17	RA_RDY	TTL	OUT	High level if RA is enabled and operational (pulse picker and AOM states do not affect this output). 3.3V, 25mA maximum
18	SYNC_OUT	TTL	OUT	Output of the laser synchronization signal, which is triggered by the internal laser OSC or SYNC_IN. In the case of an external clock the pulse duration is the same as the input pulse duration. If SYNC_IN is < 500ns then SYNC OUT is extended to ~500 ns. In the case of internal clock SYNC_OUT is ~500 ns. 3.3V, 25mA maximum
19	SYSTEM_ STATUS	TTL	OUT	High level if system is functioning normally, low level if failures are detected. 3.3V, 25mA maximum

Table 11. XS13 laser control connector pinout

PIN	Name	Signal Type	Dir	Description
20	FAST_OFF_CL_OUT	Current loop	OUT	Must connect to pin FAST_OFF_CL_IN (XS13.8) for normal laser operation. Disruption of this circuit stops the OSC and RA. Laser operation can be restored after circuit closure
21	FAST_OFF	TTL	IN	Active level (high) must be present to keep the laser running. Disconnection of the high level signal stops the OSC and RA. Laser operation can be restored after complete laser reboot
22	SHUTTER_STATUS_OPEN_TTL	TTL	OUT	High level if shutter is open. 5V, 25mA maximum. (While shutter is in transition (maximum transition time 200ms), it is possible that the state will be open and closed at the same time)
23	SHUTTER_STATUS_CLOSED_TTL	TTL	OUT	High level if shutter is closed. 5V, 25mA maximum. (While shutter is in transition (maximum transition time 200ms), it is possible that the state will be open and closed at the same time)
24	VAC_CTRL	Analog (0-5V)	IN	Analog signal to control the output pulse energy. Load 1kOhm. (Used only if laser is equipped with Integrated attenuator, AOM, or CBM02/CBM04 harmonics modules).
25	SHUTTER_CTRL_TTL	TTL	IN	Active level (high) enables the shutter. 3.3V nominal, 5V tolerable

3.4.4 Laser Status Connector (XB2)

XB2 connector may be used to control external equipment. Connector type: D-SUB 15 female. Connector pins description is presented in the table below.

Table 12. XB2 laser status connector pinout

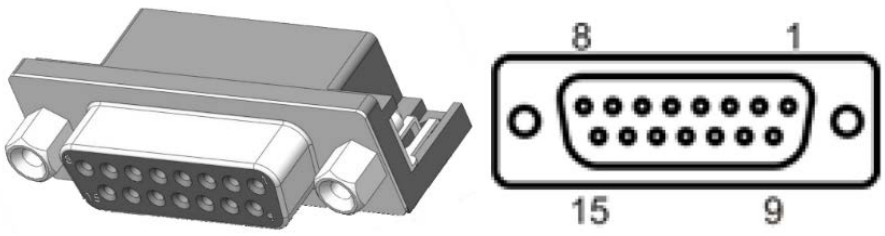
PIN	Name	Signal Type	Dir	Description
				
Type: D-SUB 15 female				
1	24V_OUT	POWER	OUT	Persistent 24V max 1000mA output (bridged with pins 2 and 4)
2	24V_OUT	POWER	OUT	Persistent 24V max 1000mA output (bridged with pins 1 and 4)
3	STATUS_1*	0V	OUT	Configurable pull-down switch (1000mA max)
4	24V_OUT	POWER	OUT	Persistent 24V max 1000mA output (bridged with pins 1 and 2)
5	STATUS_2*	0V	OUT	Configurable pull-down switch (1000mA max)
6	GND	Ground	-	-

Table 12. XB2 laser status connector pinout

PIN	Name	Signal Type	Dir	Description
7-9	RELAY_1*	Passive	-	Passive programmable relay switch. Pin 8 (common) is connected to Pin 9 (NC) when no configured trigger signal is present. When a configured trigger signal is present, Pin 8 (common) is shorted to Pin 7 (NO). This relay can be used to start/stop the chiller on some systems (50mA max)
10-12	RELAY_2*	Passive	-	Passive programmable relay switch. Pin 11 (common) is connected to Pin 12(NC) when no configured trigger signal is present. When a configured trigger signal is present, Pin 11 (common) is shorted to Pin 10(NO) (50mA max)
13-15	RELAY_3*	Passive	-	Passive programmable relay switch. Pin 14 (common) is connected to Pin 15(NC) when no configured trigger signal is present. When a configured trigger signal is present, Pin 14(common) is shorted to Pin 13(NO) (50mA max)

*Pins are configurable via Laser Service App (refer to the Daily Operations section).

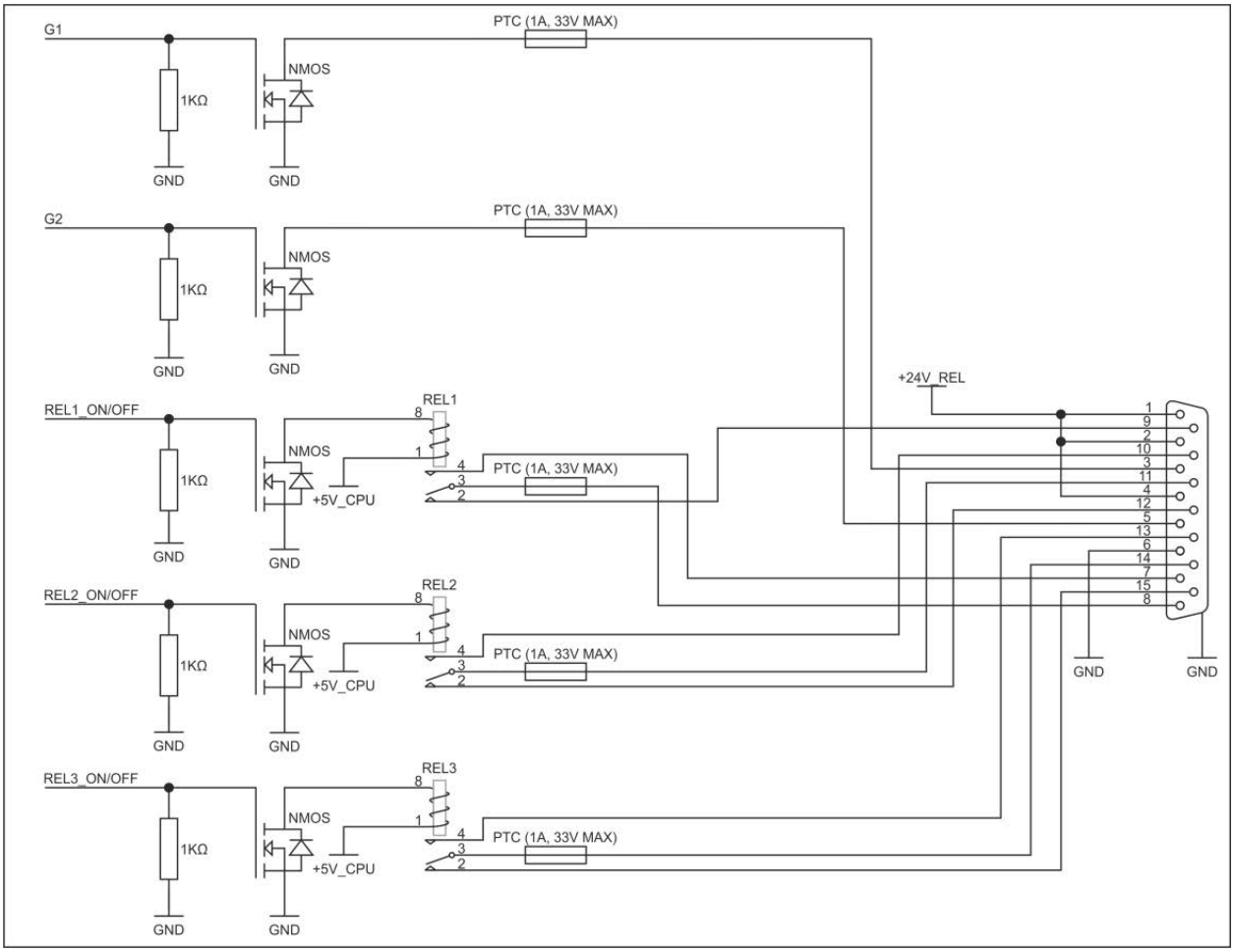
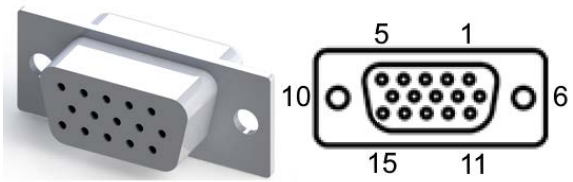


Figure 8. XB2 laser status connector electrical schematic

3.4.5 Chiller connector (Toradex)(XB12)

XB12 Chiller connector is used to connect chillers to Toradex based lasers. This connection allows chiller remote start functionality, chiller temperature control, and various data exchange. Connector type: D-SUB 15 HD female. Connector pins description is presented in the table below. A reference to the previous XB12 connector is present in the chiller connection appendix.

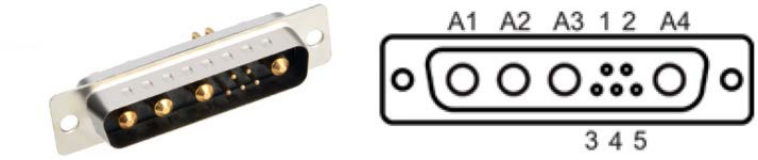
Table 13. XB12 Chiller connector (Toradex)

PIN	Name	Signal Type	Dir	Description
				
Type: D-SUB 15 High Density female				
1-15	Reserved	-	-	All pins are reserved for Chiller control

3.4.6 Power Connector (XS1)

XS1 connector provides 24V DC power for the laser. Connector pins description is presented in the table below.

Table 14. XS1 power connector pinout

PIN	Name	Signal Type	Dir	Description
				
Type: D-SUB 9w4 male				
A1	POWER_IN_GND	GND	-	-
A2	POWER_IN	POWER	IN	Laser power input (+24V max 42A)
A3	POWER_IN_STANDBY	POWER	IN	Power input for laser control electronics (+24V max 4.2A)
A4	POWER_IN_STANDY_GND	GND	-	-
1-4	Reserved	-	-	-

3.4.7 External Fast Energy Control (FEC) analog input XB14

The XB14 analogue control connector can be used for high speed external energy control (energy of individual pulses in the pulse train can be controlled). The control source can be selected via the CARBIDE User app, advanced section.

Table 15. XB14 analog input description

Pin	Name	Signal type	Direction	Description
XB14	FEC	Analog	IN	Analog signal for fast external energy control (0-10V). Output power response latency <10 µs. Modulation speed <10 µs. Full scale individual pulse amplitude control

3.4.8 Bypass Plugs

To operate laser without additional equipment CARBIDE is provided with two bypass plugs.

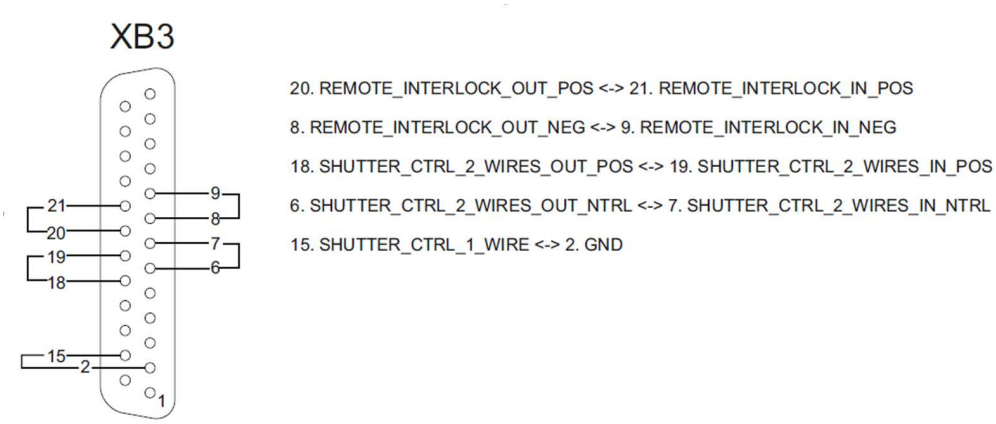


Figure 9. XB3 connector bypass plug wiring

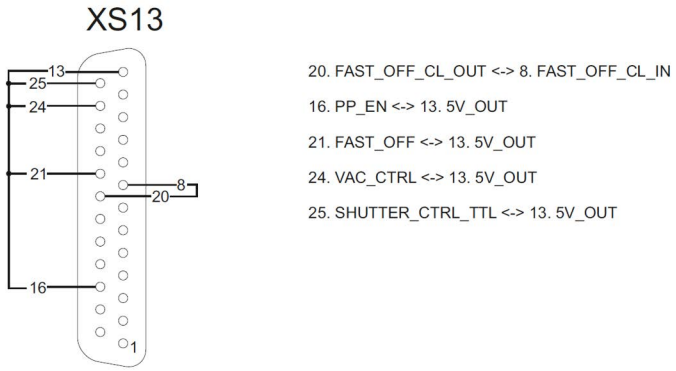


Figure 10. XS13 connector bypass plug wiring

3.5 Power On/Off Button

There is only one button on CARBIDE rear panel, but it can activate different functions depending on laser state and push duration.

Table 16. Power on/off button functions

Current Laser state	LED on button state	User action	System reaction
Laser Off	Continuously off	Press, hold and release button after 2-5 seconds	Laser will turn on and transition to the operational preset. Last executed preset is applied. By default the shutter is closed.
Laser On	Continuously on	Press, hold and release button after 2-5 seconds	Laser will start the turning off procedure. LED will be blinking slowly until the procedure is complete
		Press, hold and release button after 5-10 seconds	Laser will switch off immediately (Emergency Off), LED starts blinking rapidly after holding the power button pressed for 5 seconds, this indicates that Emergency Off will be executed on button release. If button is held pressed longer than 10 seconds, no system reaction will be initiated

4 INSTALLATION

4.1 Unpacking

	NOTICE	***The CARBIDE laser was packed with great care, and its container was inspected prior to shipment. If any major damage was noticed at the time of receipt (holes in the container, water leak, crushing, etc.), please notify the carrier and manufacturer.***
	NOTICE	***If the laser was transported in cold weather conditions, keep it in transportation boxes for at least 6 hours at room temperature to prevent possible water condensation on sensitive components of the laser after opening. The laser head is hermetically sealed.***
	NOTICE	***It is recommended that you wait for a Light Conversion representative to unpack your system. You should not attempt to install the laser by yourself without prior agreement from Light Conversion. Any unauthorized action may result in a warranty void charge for the repair of any damage.***
	NOTICE	***CARBIDE laser head weights 37 kg. Unpacking and installation of the laser system should be done by at least two people to avoid any mechanical or personal damage!***
	NOTICE	***The Power Supply may only be connected/disconnected to/from the laser only while it is disconnected from the mains! Disconnecting or connecting the power supply while it is connected to the mains may damage the laser control boards.***
	NOTICE	***Some chiller models have an internal transformer set for an input voltage of 230 V prior to delivery. Please check the voltage in your environment and reconnect an appropriate internal transformer plug. See the accompanying chiller documentation for more information.***

1. Carefully open the transportation boxes without damaging them. Transportation boxes might be necessary for future transportation. The latest example of the laser head transportation box is equipped with holding mechanisms that tightly close the lid of the transportation box without any screws. Raise the collapsible handle of each lock and loosen the grip until the gripping claw can be moved away from the lid. Once all gripping claws are removed, lift the lid to uncover the laser (see Figure below). Transportation boxes may vary depending on the equipment (some will be closed with simple screws or Allen (hex socket) screws).

Figure 11. Handling of a transportation box

2. Unpack the transportation boxes, and remove all external components: humidity absorbers, cables, manuals, and factory test certificates. Take all contents out of the top layer and remove the packing material.

Figure 12. Transportation box contents

NOTICE

The contents of the transportation boxes may vary depending on the laser model, modification or any other special-order alterations. The contents and their placement provided earlier are intended as an example only and do not guarantee the presence of these items in your shipment.

Please check the "Assembly List", which is normally packed with the laser head, for a full list of all contents of your shipment (see figure below). If some components are missing based on your "Assembly list", please contact Light Conversion.

LIGHT CONVERSION	ASSEMBLY LIST	C19232
		P4-F2 v.2
Product	CARBIDE	Page 1 of 2
Assembled by	Remigijus Sirutis	2019-12-20

Box #1

ITEM	DESCRIPTION		QUANTITY	NOTES
1.	CARBIDE laser head CB3-40-0400-10-S S/N: C19232		1	
2.	CARBIDE factory test certificate		1	
3.	CARBIDE User's Manual	CB3-D-MAN-FM-05	1	
4.	CARBIDE power supply S/N: RB86033430		1	
5.	C19<->USA/Japan (NEMA 5-15 Type B), 125V 15A, MC30-250		1	
6.	C13<->USA/Japan (NEMA 5-15 Type B), 125V 10A, MC31-250		1	
7.	LAN cable		1	
8.	Key for shutter control		1	
9.	USB flash drive with software		1	
10.	Control laptop with software S/N: PF1NR9L4		1	
11.	Fixing screws for laser head M6x25 (metric and imperial)		6+6	
12.	XB3 terminator with interlock connectors	XB3-RI	1	
13.	XS13 terminator with selected laser control connectors	XS13-A-BNC	1	

Box #2

ITEM	DESCRIPTION		QUANTITY	NOTES
1.	Chiller SMC, Type HECR008-A5-P, water-to-air S/N: XW-0768		1	*115 V*
2.	Wheels for chiller		4	
3.	Spare filter for chiller		1+1	
4.	Manual of chiller		1	
5.	Water tubes 15 m		2	
6.	Watering can for chiller		1	
7.	Chiller control cable, P67-1500, + WC66-50, + Null modem adapter		1	
8.	Chiller controller E-PB-02-830-01, S/N: 0075		1	
9.	Water distributor	PM-01-508-220	1	
10.	Water distributor	PM-03-813-200	1	
11.	Fixing screws for water distributor (metric and imperial M6x35)		1+1	
12.	Water tubes 1 m		2	

Figure 13. Assembly list example

3. Remove the laser head from the transportation box. It is very important to lift the laser by holding it by the sides! Never by the front or back!

Figure 14. Removing the laser head from the transportation box

4. Place the laser head on the optical table (or onto other machinery in which it will reside) and fix it using appropriate screws (M6X20-25 mm, the screws should be provided along with the laser). For certain CARBIDE laser models, you might need to remove the external covers or fan filters to access the fixing legs.

	NOTICE	***Avoid harsh mechanical impacts when placing the laser head on the optical table. Be careful while placing the laser head in the correct position.***
	NOTICE	***Cylindrical bearings in the mounting legs have some backlash in the axial direction. When fixing the laser head to a base-plate, it is necessary to check that the position of the bearing is not up to the edge. This may cause mechanical deformations in the housing of the RA.***

5. Remove all aperture protection stickers, even from apertures that you do not intend to use.

Figure 15. Aperture protection sticker

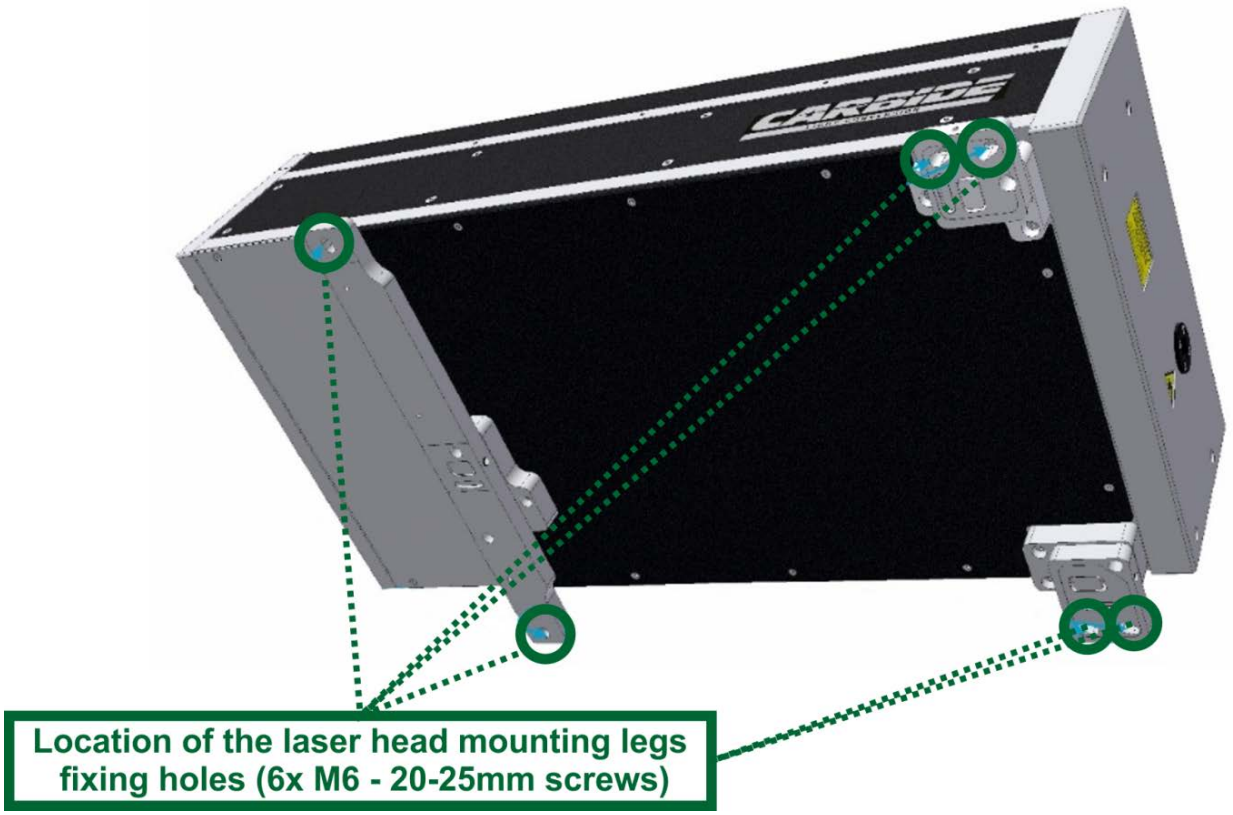


Figure 16. Bottom view of the CARBIDE laser head - location of all the mounting legs

6. Put the shutter key into the shutter lock. A shutter key prevents accidental activation of the laser emission and ensures that only authorized personnel can activate the laser output.

Figure 17. Location of the CARBIDE laser's shutter lock

4.2 Software setup

The CARBIDE software can be found on the USB memory card shipped with this manual (see Figure below) (or attached to the factory test certificate), or it can be downloaded from the Light Conversion website (www.lightcon.com; registration is required to access the downloads section).

Figure 18. Device control software USB memory card

	NOTICE	***The control software is updated often; therefore, screenshots may not exactly match the current version. They should be used as a general reference only.***
	NOTICE	***The Power Supply may only be connected/disconnected to/from the laser only while it is disconnected from the mains! Disconnecting or connecting the power supply while it is connected to the mains may damage the laser control boards.***

Two applications are used to control the CARBIDE: CARBIDE User App and Laser Service App. The CARBIDE User App is designed and updated for daily laser use. The main control window provides an intuitive interface for efficient management of laser parameters.

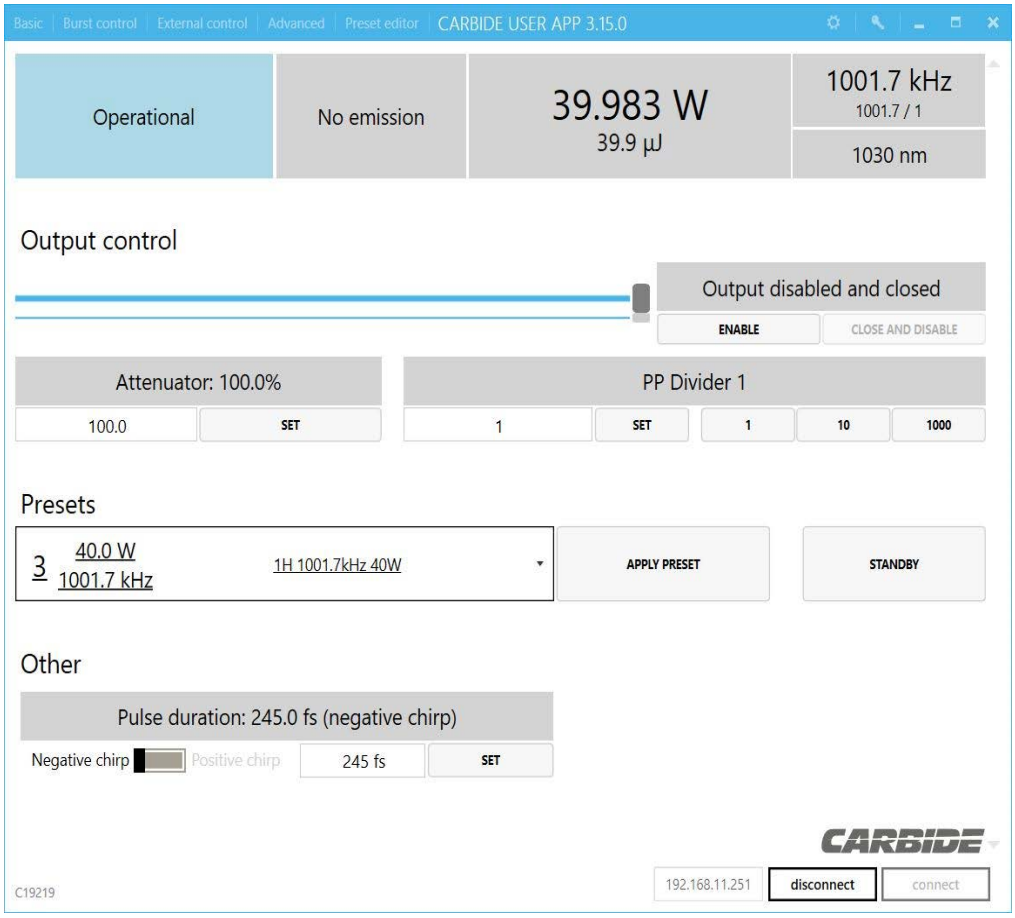


Figure 19. CARBIDE User App - main control window

The Laser Service App is dedicated to troubleshooting issues with the laser, and it is mainly used by Light Conversion engineers.

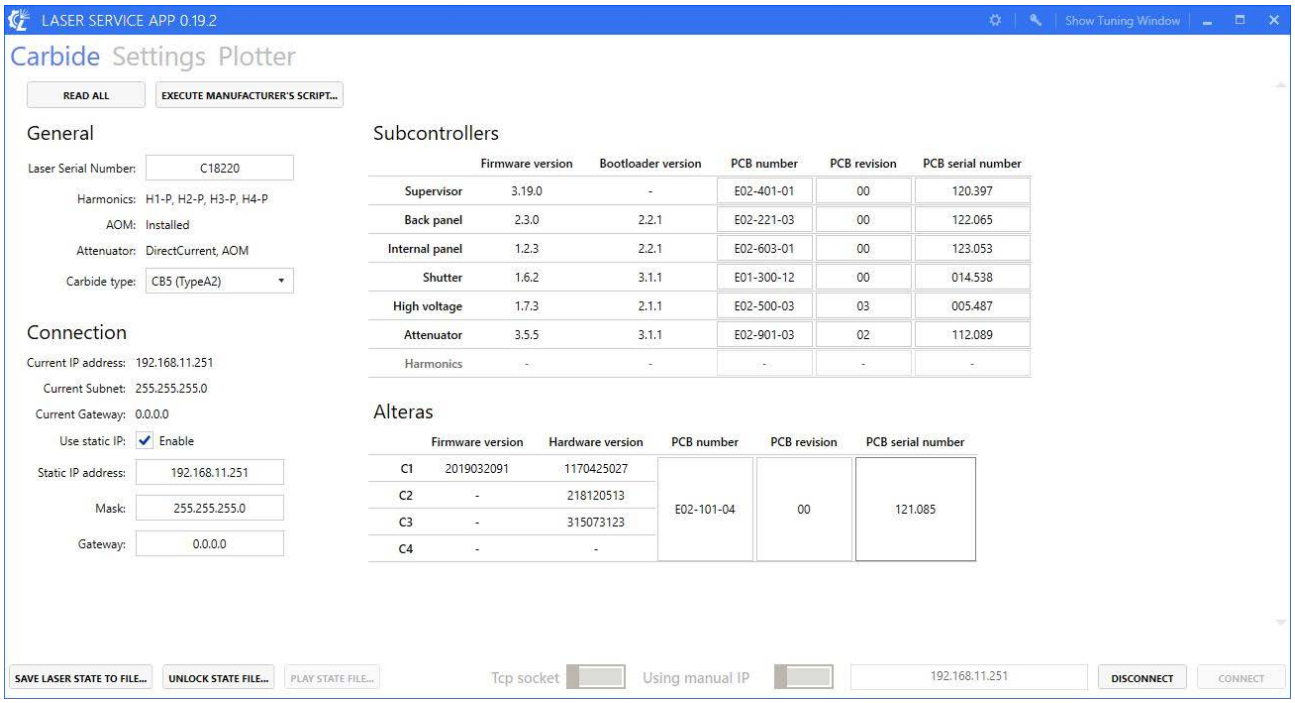


Figure 20. Laser Service App main control window

The newest versions of CARBIDE User App and Laser Service App can be downloaded from Light Conversion web site (www.lightcon.com). User registration is required to access downloads.

4.2.1 Installing software for your laser

After saving the setup tool to your device, open it and follow the instructions in the window. Pick the installation folder, shortcut folder, and confirm your settings to finish the setup.

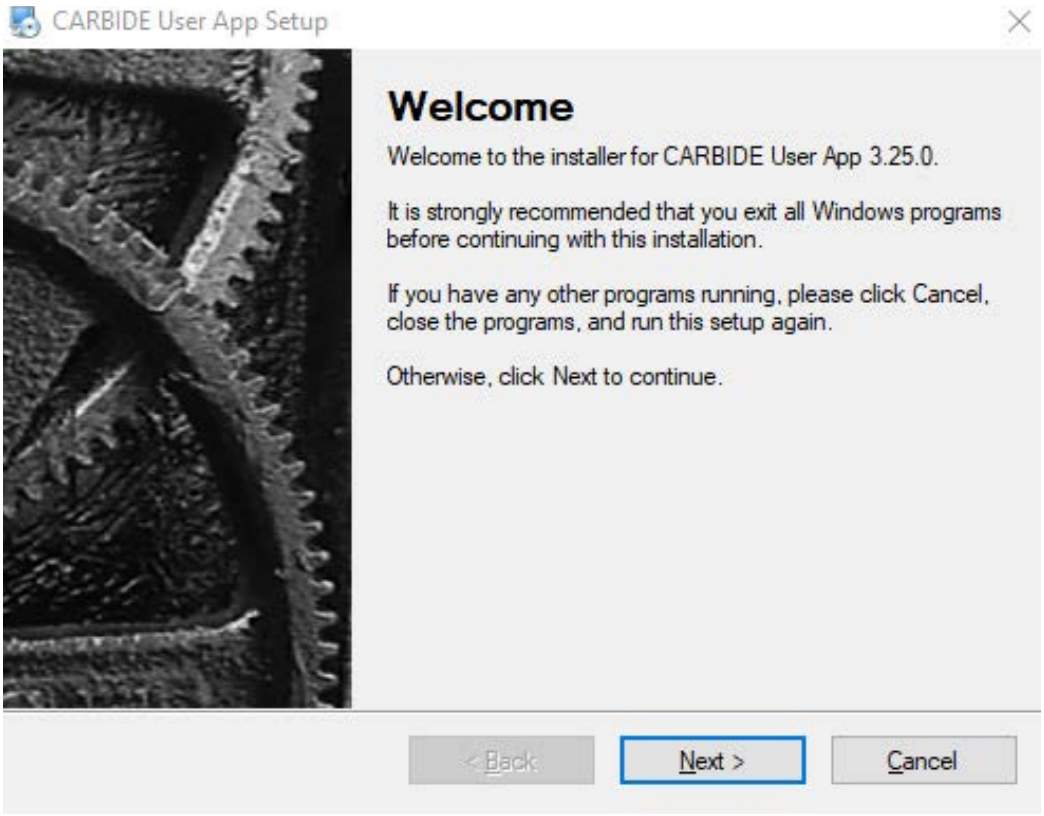


Figure 21. CARBIDE User App installation tool

NOTICE

CARBIDE control software can be installed on any PC with Windows 7 or newer operating systems. If required, the .NET framework will be installed automatically.

4.2.2 Locating the IP Addresses of your Laser

Practically there are two categories of CARBIDE IP addresses:

1. Undefined - in which case the CARBIDE laser uses the default IP address “192.168.240.10”. In this case, there are no additional indicators of the IP address used.
2. Defined - in which case the CARBIDE laser uses the standard defined IP addresses:
    a. 192.168.240.10
    b. 192.168.11.251
    c. 192.168.244.10
    d. 10.1.251.1
    e. 10.1.251.2

If the IP address of the CARBIDE laser is defined, there will be an IP address sticker present on the rear side of the laser, above the Ethernet connector port.

Figure 22. Location of the IP address sticker on the CARBIDE laser

NOTICE ***This IP address will be used both in the User App and the Service App to connect to the laser.***

4.2.3 Setting the Correct IP Addresses

Depending on the laser system configuration, the computer can be supplied together with the laser and will contain pre-installed and preconfigured software. If the computer is not part of the supplied system, then additional steps are necessary to complete the set-up process.

The CARBIDE laser by default is shipped with a static IP address, it can be either one of the defined addresses mentioned earlier, or the standard undefined one: 192.168.240.10.

Once you are sure about the IP address of your laser, you will need to set a correct static IP address on the computer's side. Usually, setting the “PC IP address” to the “Laser IP address + 1” works fine. Below is a table of suggested IP address pairs.

Table 17. List of IP address configuration pairs

Static Laser IP address	Static Computer IP address
192.168.240.10	192.168.240.11
192.168.11.251	192.168.11.252
192.168.244.10	192.168.244.11
10.1.251.1	10.1.251.2
10.1.251.2	10.1.251.3

1. Go to “Control panel” -> “Network and Internet” -> “Network Connections”. Click the Ethernet connection that is used to control CARBIDE, and click “Properties” in the window that pops up:

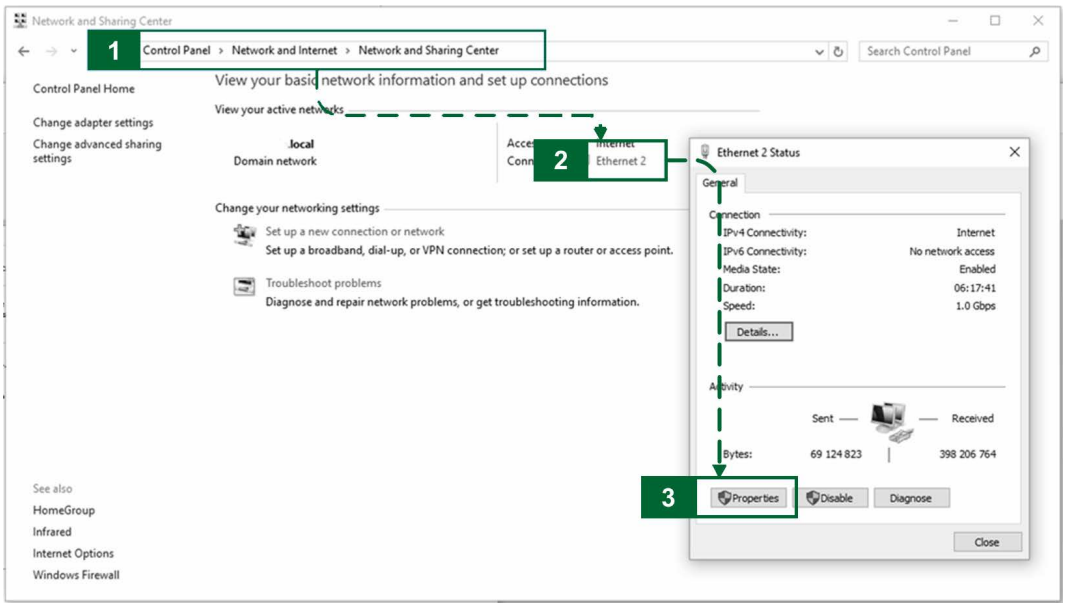


Figure 23. Accessing the computer network settings

2. Double-click “Internet Protocol Version 4 (TCP/IPv4)” and set the interface IP Address corresponding to your laser:

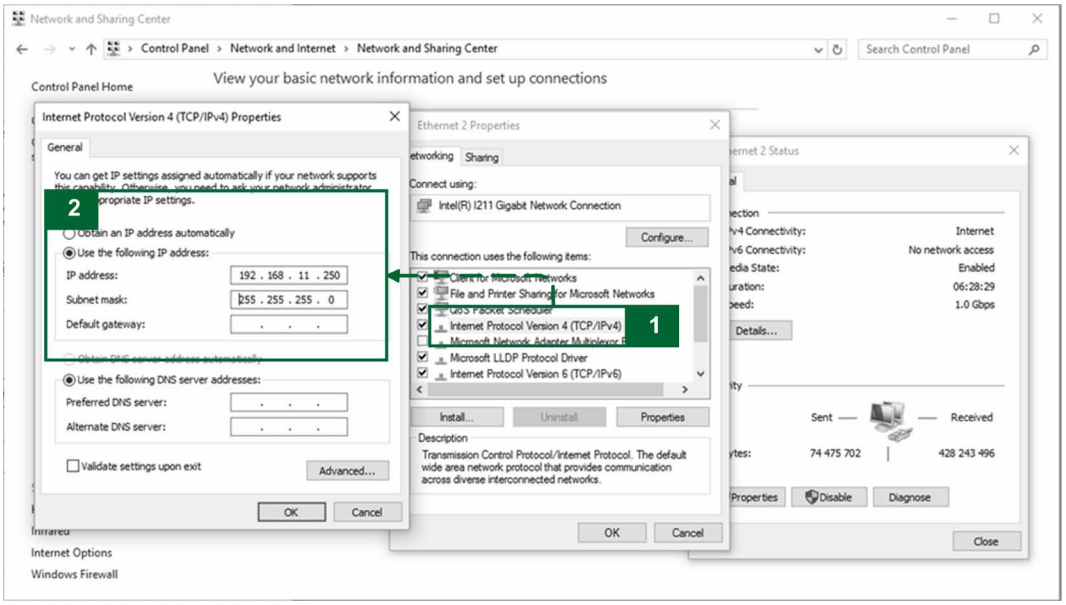


Figure 24. Setting the correct static IP address

3. Press OK on all windows. You should now be able to connect to the CARBIDE laser.

NOTICE

The CARBIDE laser can be configured to use a dynamic IP address; thus, it can be connected to a local network. Even though this connection method is possible, we recommend using a peer-to-peer Ethernet connection with a static IP address.

4.3 Cable connections

The laser is shipped with already connected XB3 and XS13 bypass connectors. If necessary, connect other external control or status indication connectors. Next, follow these steps:

1. Connect the water tubes from the laser head to the chiller. Check the color coding on both the tubes and water connectors. Double-check the water flow direction, refer to the direction markings and color coding (RED = outlet = hot returning water. Blue = inlet = cold water headed towards the laser).

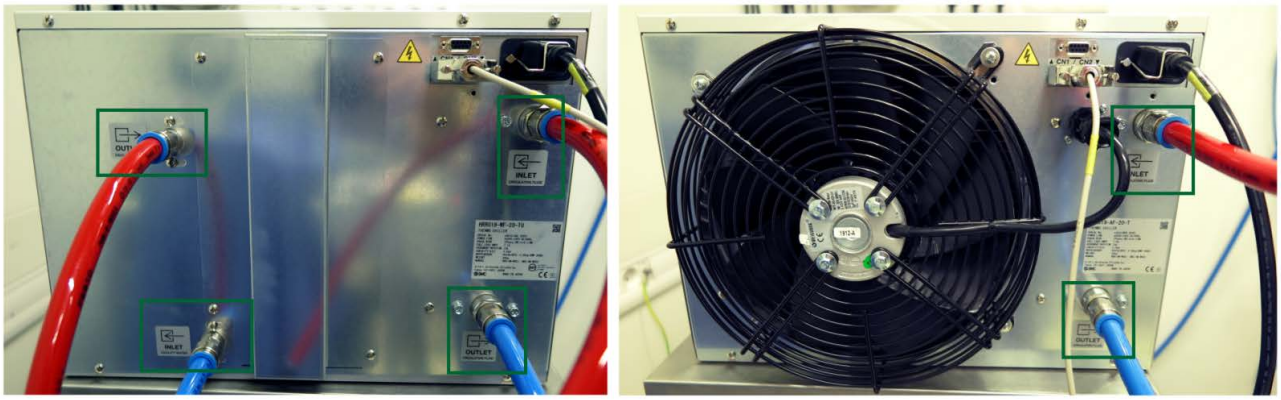


Figure 25. Coolant tube color coding and inlet / outlet marking examples

Figure 26. Coolant connectors color coding examples

NOTICE

Default 16 mm push-in connectors are used for the water tube connections.

Different non-standard push-in connector sizes or different connector types may be present depending on the order and provided specifications, in which case, refer to the Order Information Sheet.

2. Plug in the Ethernet cable. Make sure the power supply is disconnected from the mains! Connect the power cable from the power supply to the laser head, then plug in the power supply to the mains. The laser microcomputer will start booting up, which will take about 2 minutes. During the bootup procedure, BNC connections on the back of the laser will be slowly blinking. Connection to the laser could be established after the bootup procedure is finished. **Do not turn on the laser yet!**

4.3.1 XB3-RI adapter for remote interlock connection (optional)

The XB3-RI adapter is shipped with every CARBIDE laser and is intended to simplify the use of the remote interlock. By default, a terminator plug is installed on the XB3 connector. The terminator plug can be replaced with this adapter, since it connects all the necessary pins required for normal laser operation (same as the terminator) as well as provide two wire lines for the remote interlock switch (RI+ & RI-) and remote interlock reset switch (RIR & GND).

An example of the adapter, as well as its wiring diagram are provided below. The pinout for this adapter is the same as the one described for the XB3 connector in the electronic connections section.

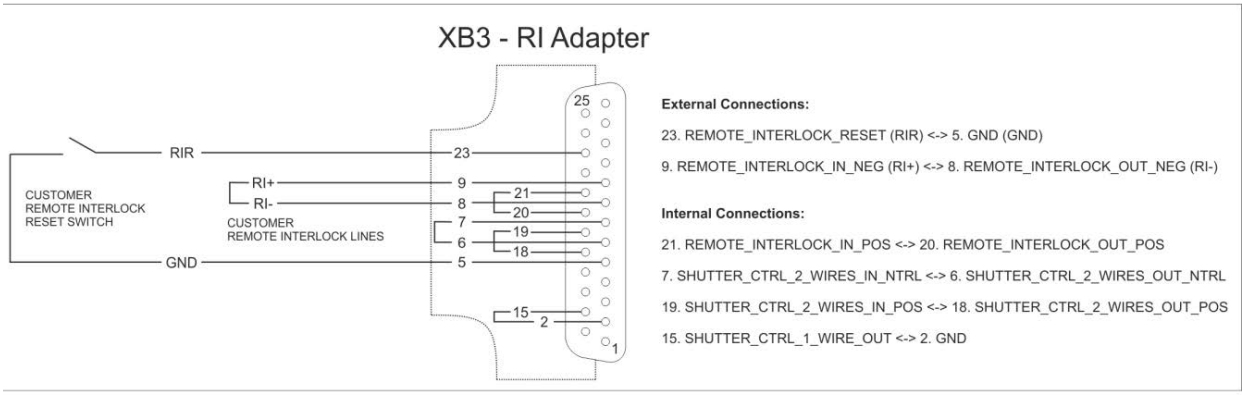


Figure 27. XB3 - RI Adapter image and wiring diagram

NOTICE ***The Pin numeration marked in the image above is displayed from the inner side of the adapter or the face side of the XB3 connector on the laser.***

4.3.2 XS13-A-BNC adapter for partial remote control (optional)

The XS13-A-BNC adapter is shipped with every CARBIDE laser and is intended to partially simplify the remote control of the laser. By default, a terminator plug is installed on the XS13 connector. The terminator plug can be replaced with this adapter, since it connects all the necessary pins required for normal laser operation (same as the terminator) as well as provide three BNC wires which can be used for partial external control. The following BNC wires are available on this adapter:

- PP - is connected to pin XS13.16 - Active level (low) enables the PP and AOM (if installed). Input has internal pull-up. 3.3V nominal, 5V tolerable.
- AV - is connected to pin XS13.24 - Analog signal to control the voltage amplitude (Load 1kOhm). (Unused if the laser is not equipped with a motorized attenuator or an AOM).
- RA - is connected to pin XS13.14 - Input of an external clock for laser synchronization. High level pulse duration must be between 100 ns and 500 ns. Signal frequency must be stable in range from 60kHz to 1000kHz. Input has internal pull-up. 3.3V nominal, 5V tolerable.

	**NOTICE**	***The pin numbers mentioned previously correlate to the pinout of the XS13 connector, described in the electrical connections section.***
	**NOTICE**	***The BNC adapter is universal for all CARBIDE lasers, thus some wires are actually not used on certain laser models.***

Figure 28. XS13-A-BNC adapter

4.4 Chiller integration

1. Connect the chiller to the laser. There are two chiller connection methods: **Toradex and GHI,** that depend on the laser's microcomputer. Toradex is the current connection standard. GHI is outdated, but connection details are still present in the **manual's appendix**.

Figure 29. Identifying the operating microcomputer based on XB12 connector

2. The chiller is controlled via the XB12 socket. The **SMC** chiller is connected directly to the laser via an RS-232 type socket (DB9 connector marked as "CN2") from the chiller to socket **XB12** (DB15 HD on the laser). An LC-provided DB9->DB15HD cable is used for this connection. No other special adapters are needed.

Figure 30. SMC chiller to laser connection

	**WARNING**	***The chiller is only compatible with a mains voltage of 200-230 V AC, 1-phase (50/60 Hz) input.***
	**NOTICE**	***The direction of the cooling water flow is important for correct system operation. Connect the hoses correctly to their corresponding connectors. Incorrect coolant flow may cause unstable laser operation.***
	**NOTICE**	***The chiller should be placed in such a way so that the warm air exhaust from the chiller rear panel does not vent into the PSU, or vice versa.***

3. **Optional**. Depending on the chiller model and the order specifics, screw-on wheels might be available for installation on the chiller. For this example, a "SMC" manufactured chiller is used:

a. In the chiller transportation box, locate a set of 4 wheels. The wheels are attached to a “L” form bracket. Four hex type screws should be present along with the wheels.

Figure 31. SMC Chiller attachable legs

b. The wheels must be placed and fastened using the supplied screws to the side of the chiller. For this modification, standard chiller outer chassis fixation holes are used. Remove the screws marked on the figure below from both sides of the chiller.

Figure 32. SMC Chiller chassis fixation holes for the attachable legs modification

c. Place the wheels with the “L” shaped bracket directed towards the chiller. This placement direction is very important for the structural integrity of the wheels. Fasten the wheels with the provided hex screws (not the ones removed from the chassis).

Figure 33. SMC Chiller - view of the attached wheel to the chassis

4. Connect the power supply cable to the mains and turn on the chiller. The chiller is set to start based on a laser command. Once the system is running, it is mandatory to check the coolant level, as it may decline. For the **SMC** chiller, remove the filling cap and fill the chiller with steam distilled or reverse osmosis water. Check the chiller manufacturer user manual for more information.

Figure 34. Coolant filling and coolant level locations for the SMC chillers

	**NOTICE**	***The user must not operate the chiller without coolant. The coolant level must be checked regularly and maintained to an appropriate level. Use only steam-distilled or reverse osmosis water.***
	**NOTICE**	***Do not use deionized water, as it corrodes the internal components of the system.***

5. If you decide to use a different chiller, make sure to set the cooling water temperature as defined in the "Factory test certificate". Adjust the bypass value of the chiller to reach the water flow value given in the "Factory test certificate" (typical flow rate is 4–6 l/min). Consult the chiller manual for instructions on adjusting the flow rate and operating temperature.

	**NOTICE**	***The laser already comes with a chiller that is preset to the factory settings, as defined in the "Factory test certificate".***

4.5 System Deployment

To power up your system for the first time, follow these steps:

1. Fill the chiller with steam distilled or reverse osmosis water. Consult with the chiller manufacturer before using any water additive. There is a possibility of some air remaining trapped inside the laser or the chiller.

	**NOTICE**	***The manufacturer does not recommend using any special water additives to prevent corrosion and/or growth of algae. Check the chiller user manual for more information.***

2. Open the Carbide User App.
3. Go to the "Advanced" section located on the top menu.

4. At the bottom, there is a segment dedicated to the chiller's settings. Click "TURN ON" to start your chiller.

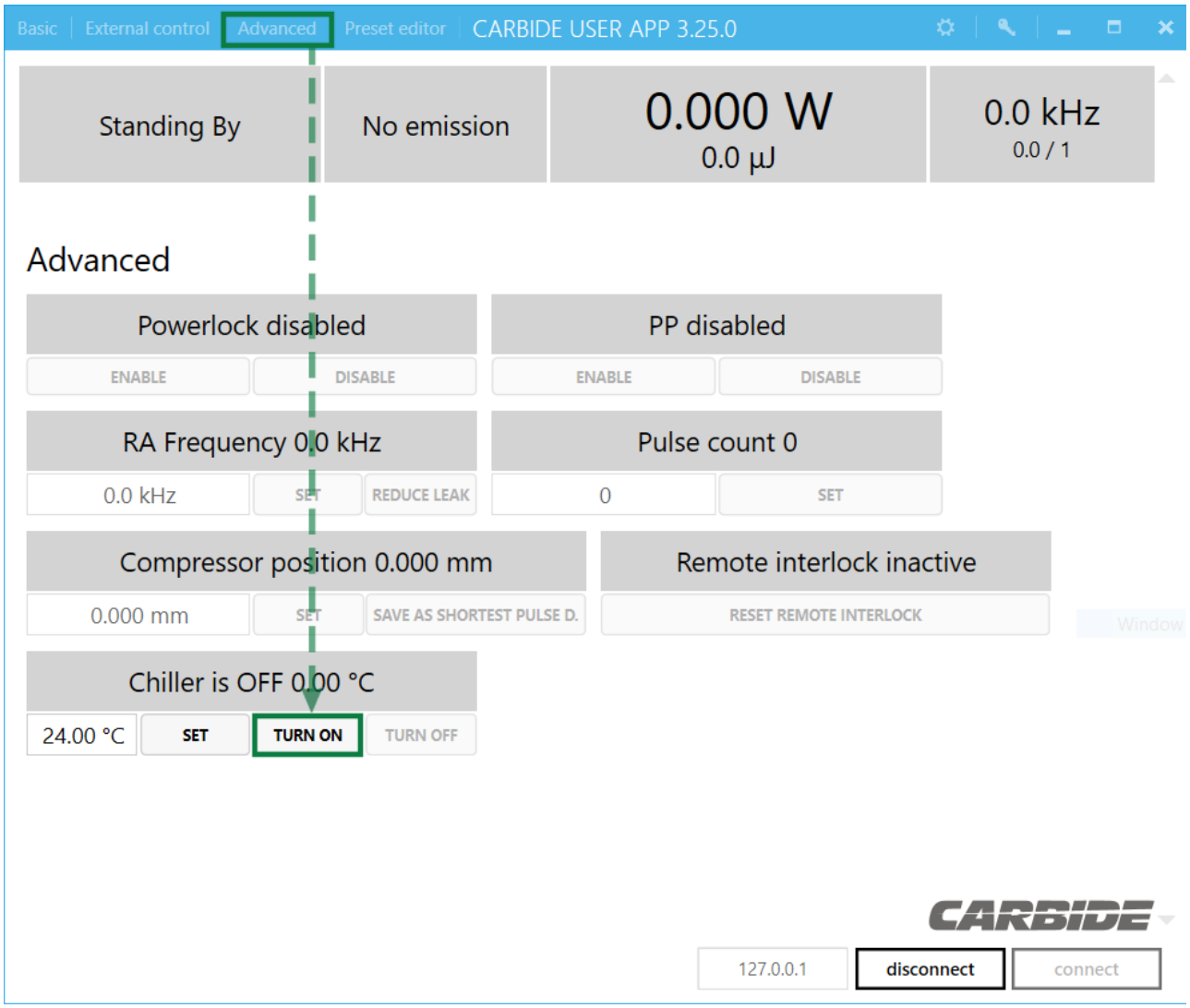


Figure 35. Chiller activation button in the Carbide User App

5. While starting the system for the first time, cooling water fills the laser cooling system; therefore chiller will most likely run out of water and stop. Turn off the chiller and refill the cooler with steam distilled or reverse osmosis water. Make sure the coolant level is between the minimum and maximum mark. Turn on the chiller. If the chiller works as intended, you can proceed with laser deployment.

NOTICE ***Once the system is running, it is mandatory to check the coolant level, as it may decline.***

Optional. You can also start your chiller by applying a preset in the Carbide User App:

1. Fill the chiller with steam distilled or reverse osmosis water.
2. Start the CARBIDE User App and press "*Connect*" in the lower right corner of the main control window.

3. Select a preset which you want to execute from the preset drop-down menu and click "*Apply preset*".

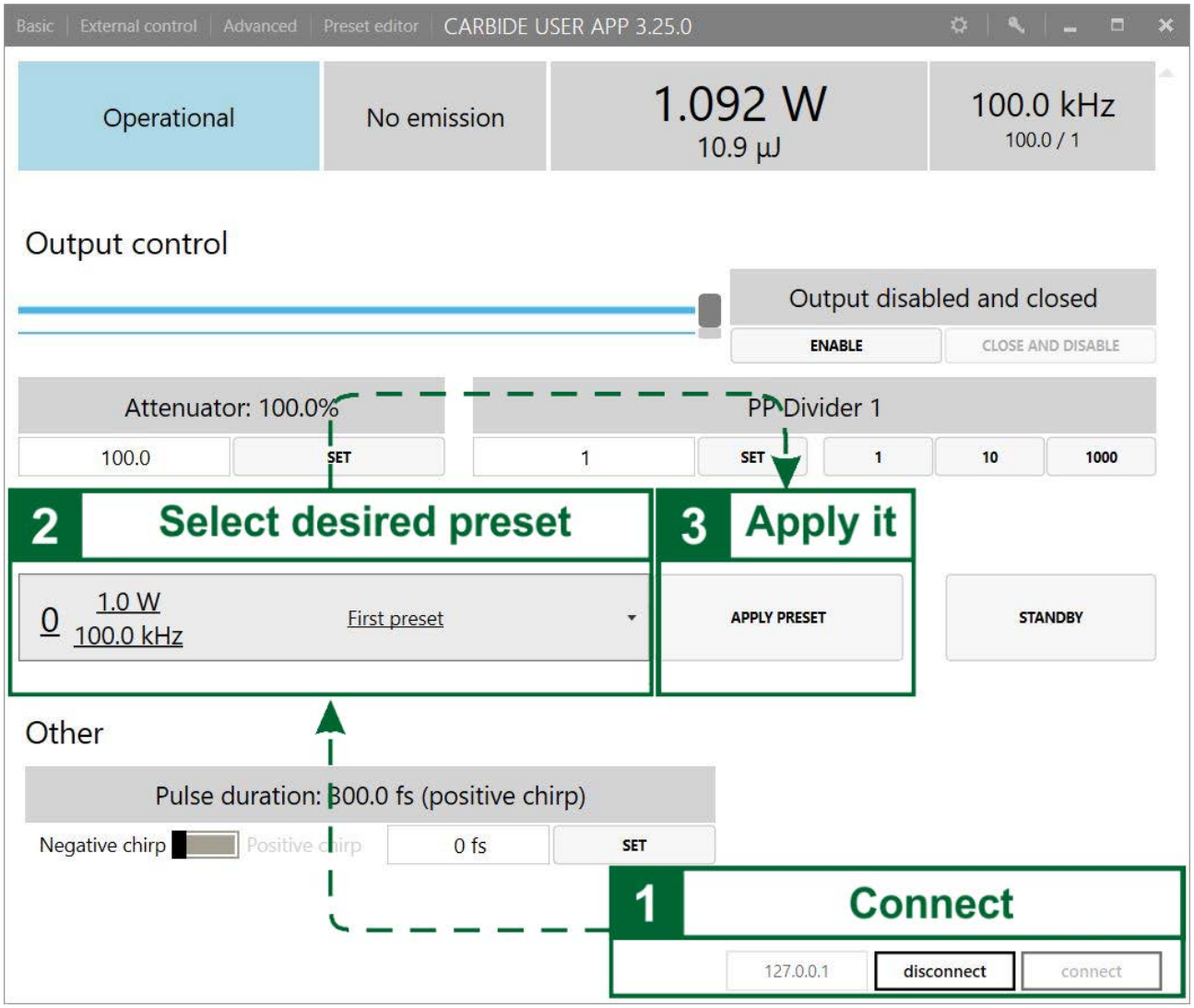


Figure 36. CARBIDE User App - preset application procedure

4. The preset causes the chiller and laser to begin operation at the same time. However, the chiller fills the laser cooling system, but it will most likely run out of water and stop. Instead of starting, the laser will go into a failure state (error E0616 – chiller sensor low water level). To fix that, put the system into standby mode and refill its water supply up to the specified range.

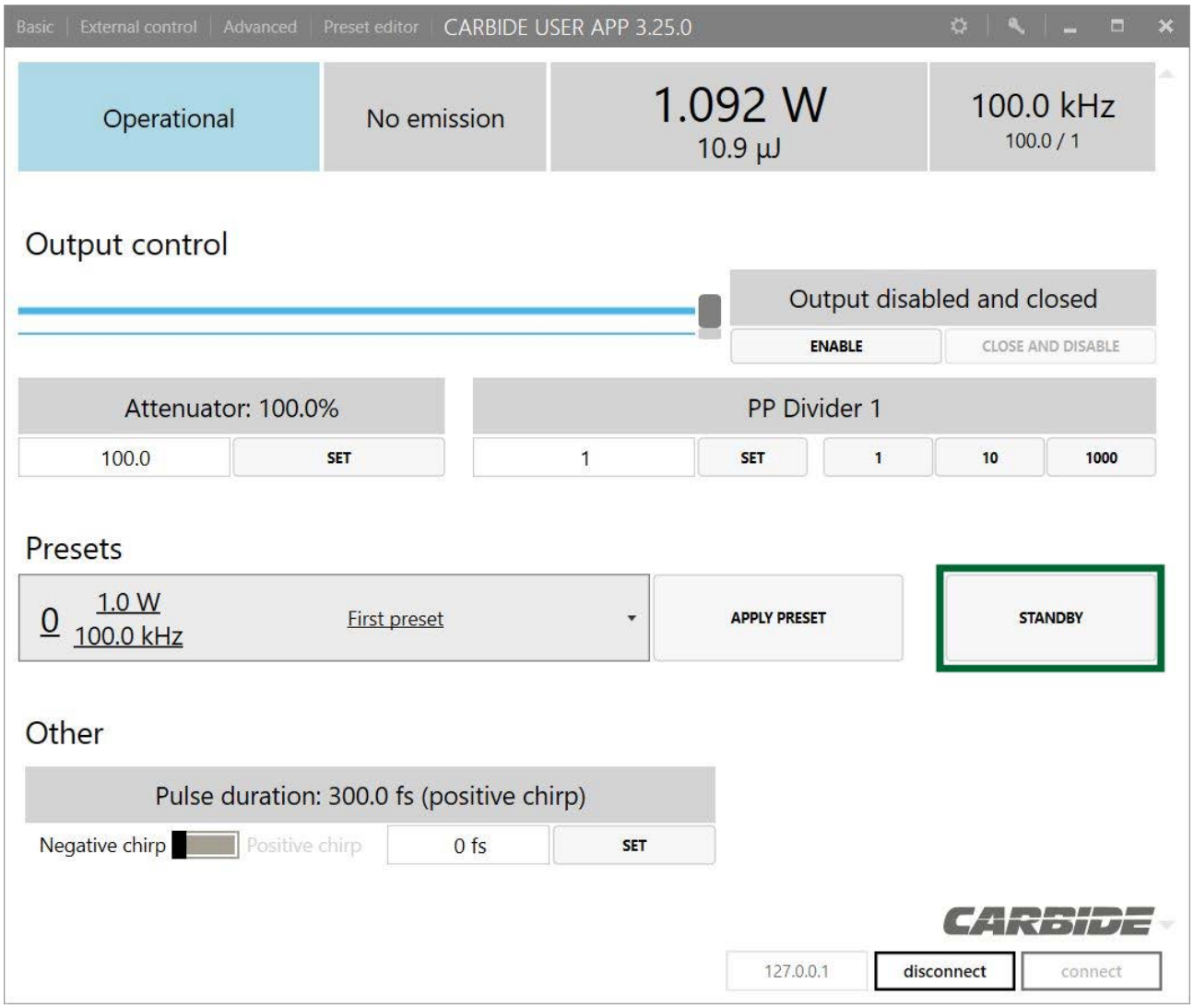


Figure 37. CARBIDE User App - preset application procedure

5. Repeat steps 2–3 to apply the preset and start your system.

5 DAILY OPERATION

5.1 Start-Up

The most convenient to power up the laser is to use the CARBIDE User App:

1. Start the CARBIDE User App and press "*Connect*" in the lower right corner of the main control window.
2. Select a preset which you want to execute from the preset drop-down menu and click "*Apply preset*".
3. Wait for the laser to start-up.
4. To activate laser output, turn the shutter key to open position and press "Enable" in the CARBIDE User App.

WARNING

This step enables laser emission. Always wear protective eyewear when aligning and operating the CARBIDE laser. Ensure your protective glasses cover all wavelengths emitted by the laser.

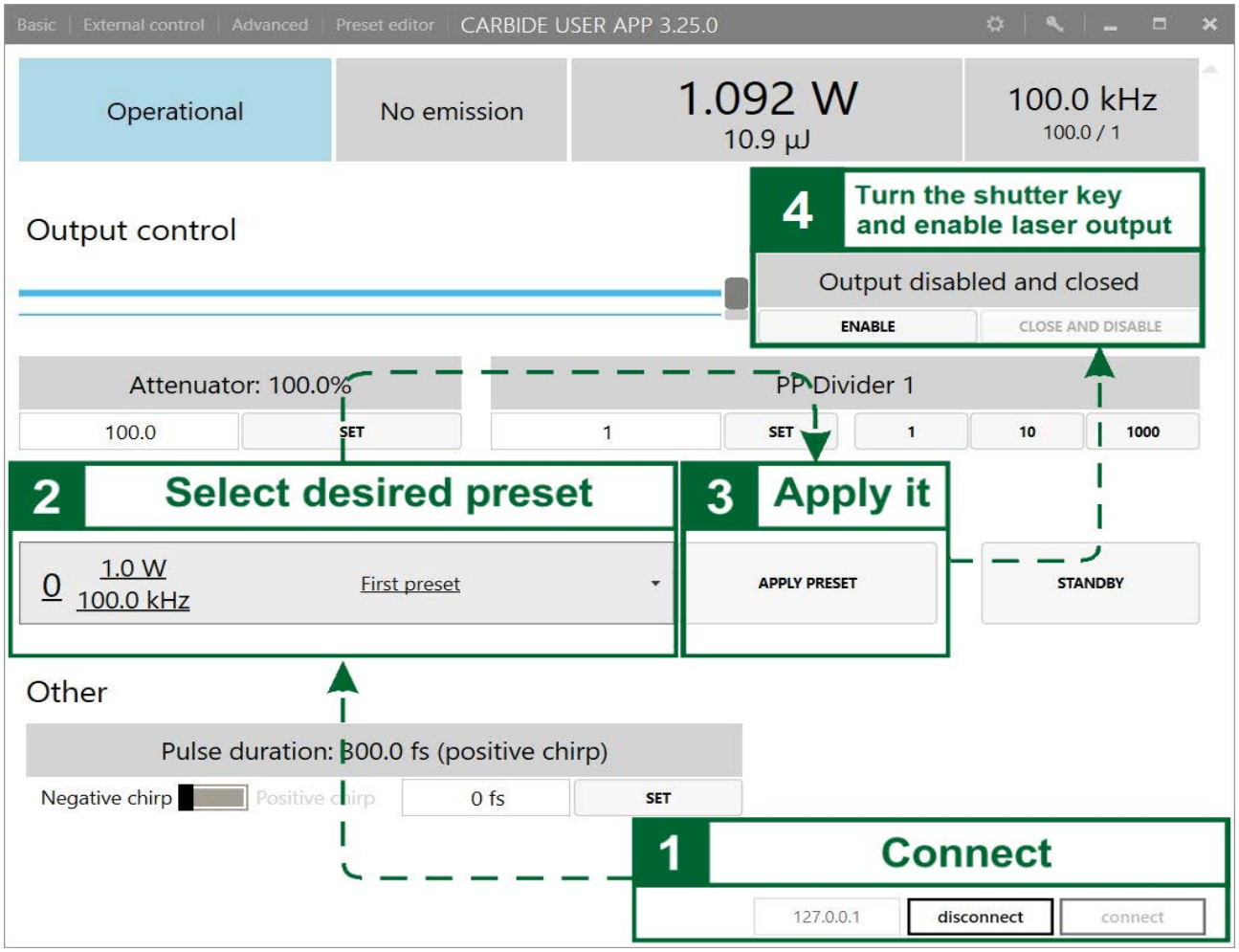


Figure 38. CARBIDE User App - laser initialization procedure

Alternatively, you can initiate start procedure by holding power button for at least 2 seconds. Depending on the actual situation, after around 2-6 minutes the CARBIDE laser should be ready for operations.

NOTICE

Starting the laser with a power button will apply the last configured preset.

NOTICE

Holding power button for at least 2 seconds when CARBIDE is already powered on will initiate shutdown procedure.

5.2 Shut-Down

Table 18. Comparison of the Shut-Down procedure via manual method vs using the app

Procedure	Action
Turning off the laser by using the CARBIDE User app	Press the "Standby" button in the CARBIDE User app
Turning off the laser by using the Power ON/OFF button	Press and hold the Power ON/OFF button for 2-5 seconds on the laser rear panel.

NOTICE

Switching off may take up to a minute, due to gradual decrease of currents and voltages. Disrupting power before complete shutdown procedure may damage the laser. It is only safe to unplug CARBIDE once it is in "Standby" state.

5.3 State Machine

CARBIDE Supervisor (integrated laser control computer) implements a strictly defined state machine. Eight states are possible, all of which are described in the table and figure below.

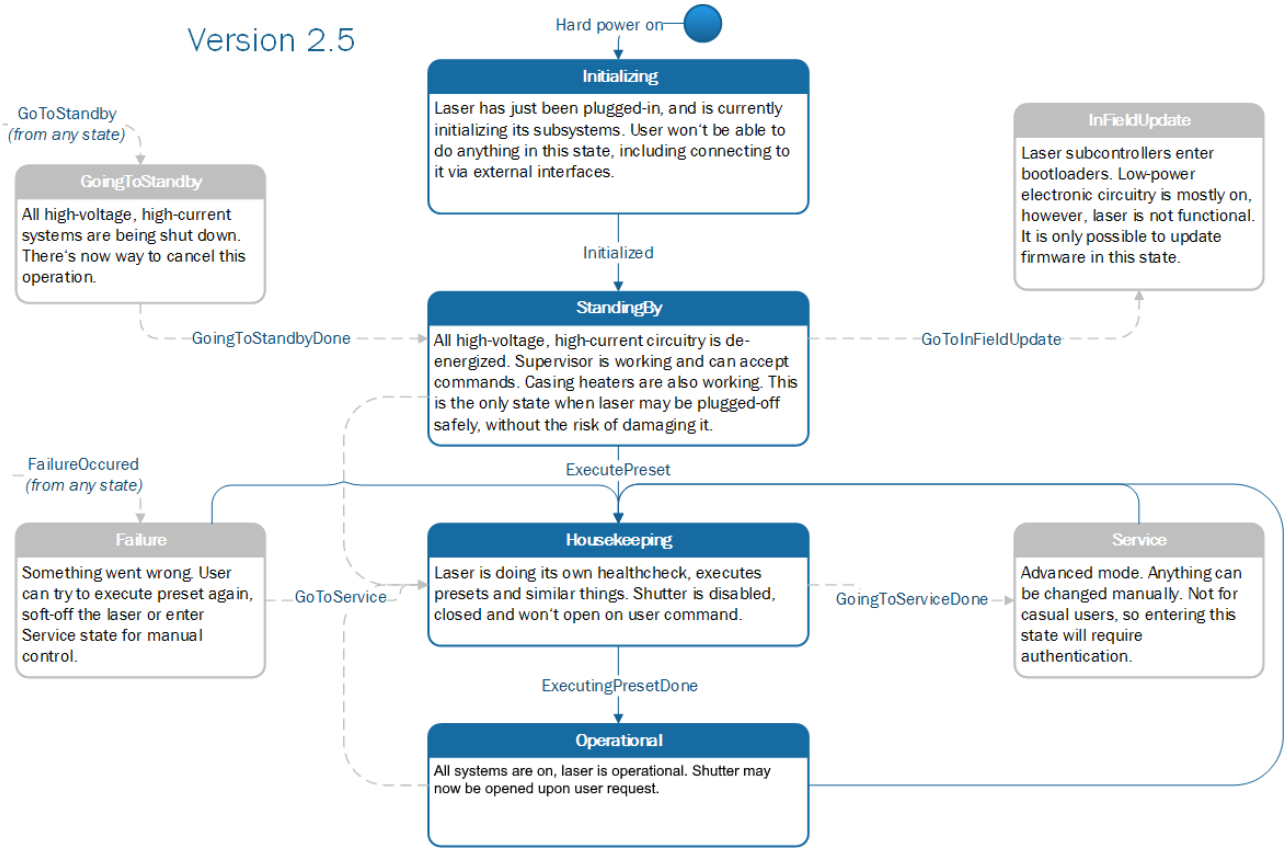


Figure 39. CARBIDE Supervisor state machine

Table 19. Description of the CARBIDE Supervisor state machine states

State	Description
Initializing	Laser has just been plugged-in and is currently initializing its subsystems. User won't be able to do anything in this state, including connecting to it via external interfaces. It is a temporal state; it will eventually change to either "StandingBy" or "Failure"
StandingBy	Laser controller is operational and accepts commands from LAN interface. Heaters are operational and laser body temperature is stabilized. All other units (pump drivers, cooling circuits and high voltage supply) are switched off
Housekeeping	Laser is doing its own health check, executing presets, etc. Shutter is disabled, closed and will not open on user command
Operational	All systems are on, the laser is operational. Shutter may now be opened upon user request
GoingToStandby	All high-voltage, high-current systems are being shut down. There is no way to cancel this operation and user commands will be ignored
InFIeldUpdate	Laser sub controllers enter bootloaders. Low-power electronic circuitry is mostly on; however, the laser is not functional. It is only possible to update firmware in this state

Table 19. Description of the CARBIDE Supervisor state machine states

State	Description
Service	Advanced mode for service engineers, authentication required
Failure	Failure in laser operation has occurred. It is only possible to soft-off the laser or enter Service state to try recovering manually

5.4 Burst Control (Optional feature)

NOTICE ***The burst control feature is optional and is available only on burst ready lasers.***

The Burst control tab allows the user to control the Burst settings of the laser. Depending on the laser model, it can operate at either a single pulse or both single and burst pulse modes. Depending on the configuration, the burst packets consists of several pulse groups, while each group consists of several sub-pulses. The distance in between the burst packet groups is called a **nanosecond burst, N.** The distance in between the sub-pulses in the group is called a **picosecond burst, P.**

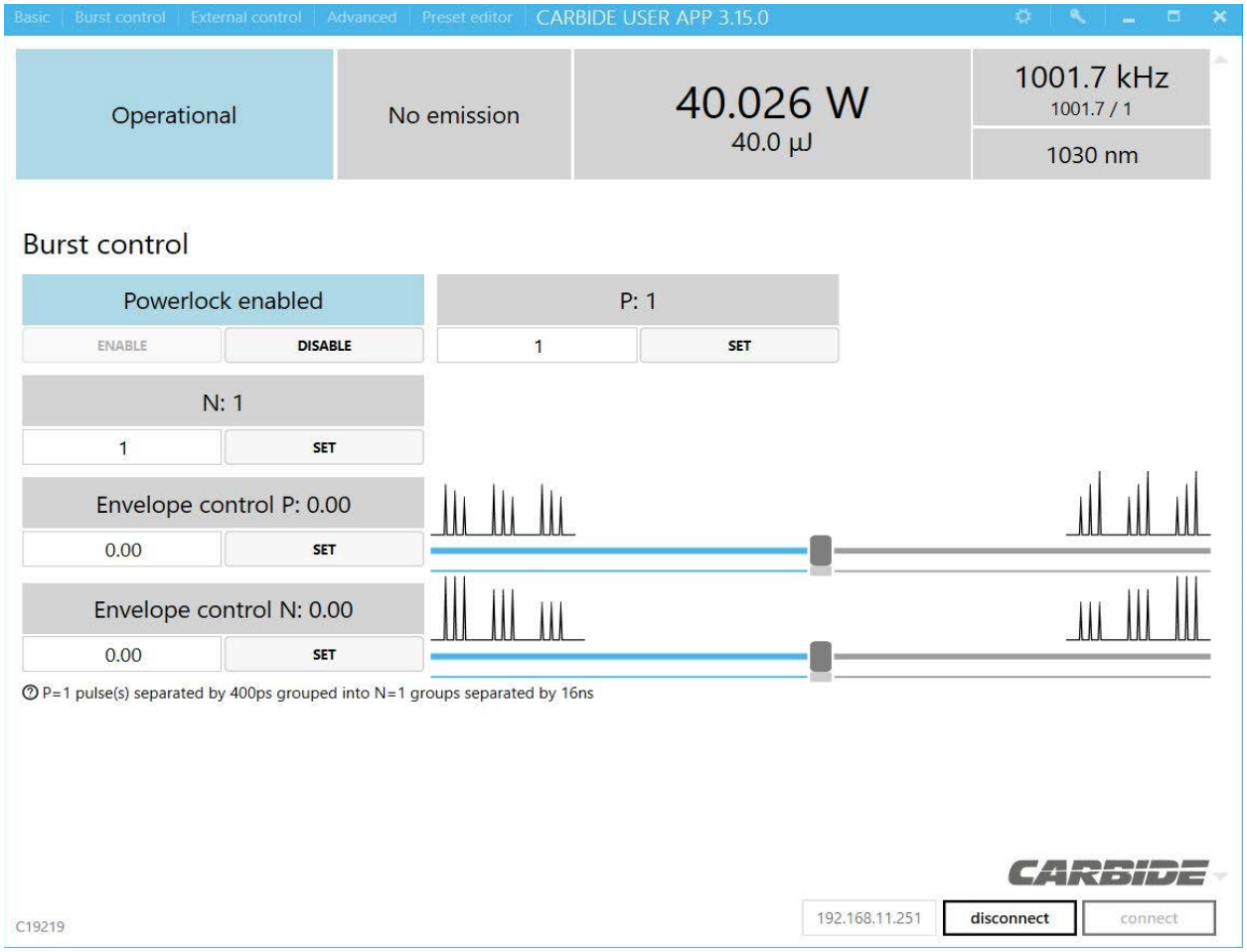


Figure 40. Burst control section of the CARBIDE User App

The image below illustrates the difference between the single pulse mode and burst pulse mode. In the single pulse mode, the RA amplifier amplifies one single pulse at some repetition rate, i.e. 50 kHz. In burst pulse mode, the output consists of several picosecond burst packets (on the example below, three packets are shown) each separated by an equal time period between each packet,(i.e, separated by 16 ns), each packet can contain a number of sub pulses (on the example below, six sub pulses are shown) which are also separated by an equal time period between each pulse (i.e, 440 ps). This nanosecond burst has the same repetition rate as the single pulse mode, 50 kHz.

Available burst mode settings:

- N - Number of pulse groups in a packet (Actual number depends on laser specifications, refer to the factory test certificate).
- P - number of pulses in a group (Actual number depends on laser specifications, refer to the factory test certificate).
- Envelope control N and P - a slider which allows to control the burst pulse amplitude shape. The user application displays a preview of how the amplitude shape changes.

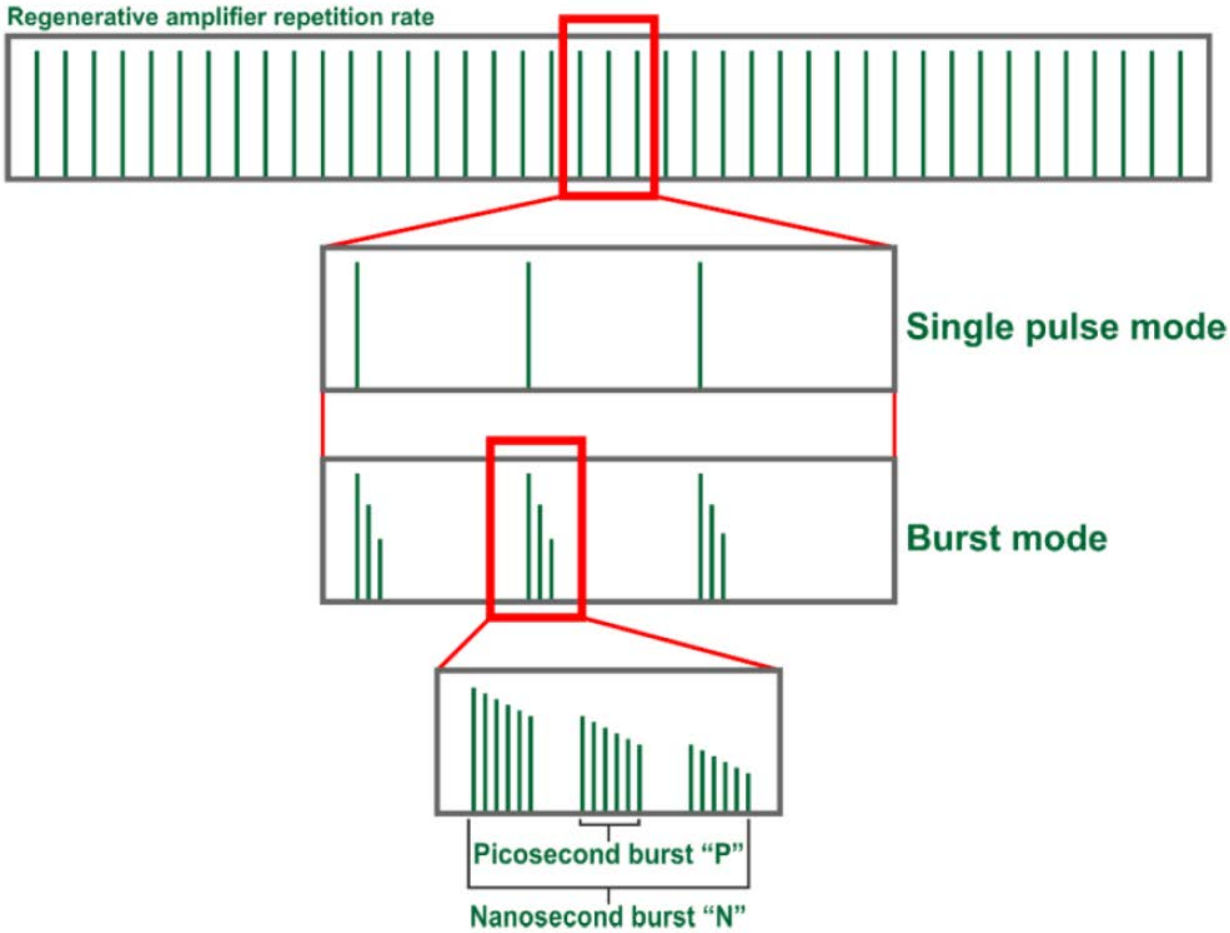


Figure 41. Detailed structure of the difference between a single pulse and a burst pulse

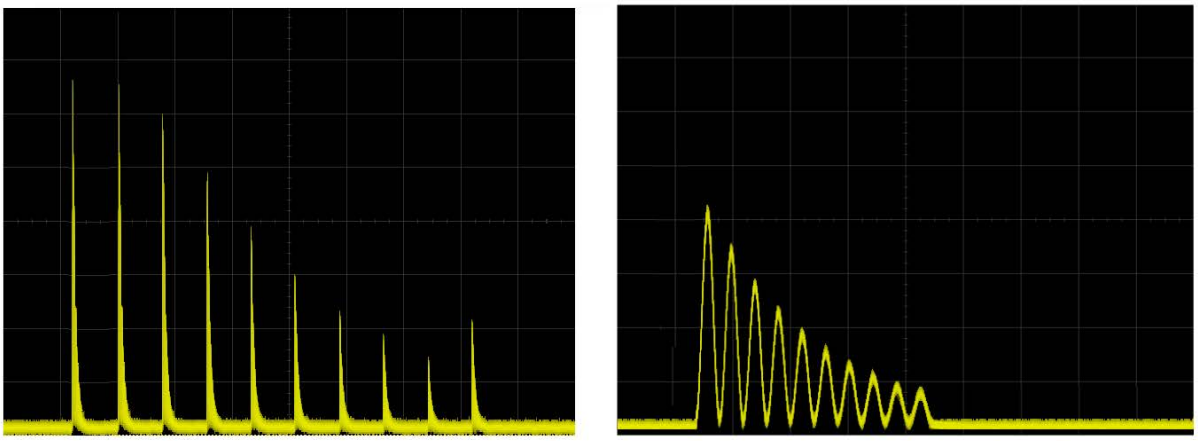


Figure 42. Burst mode oscillogram readings for various burst packet structure

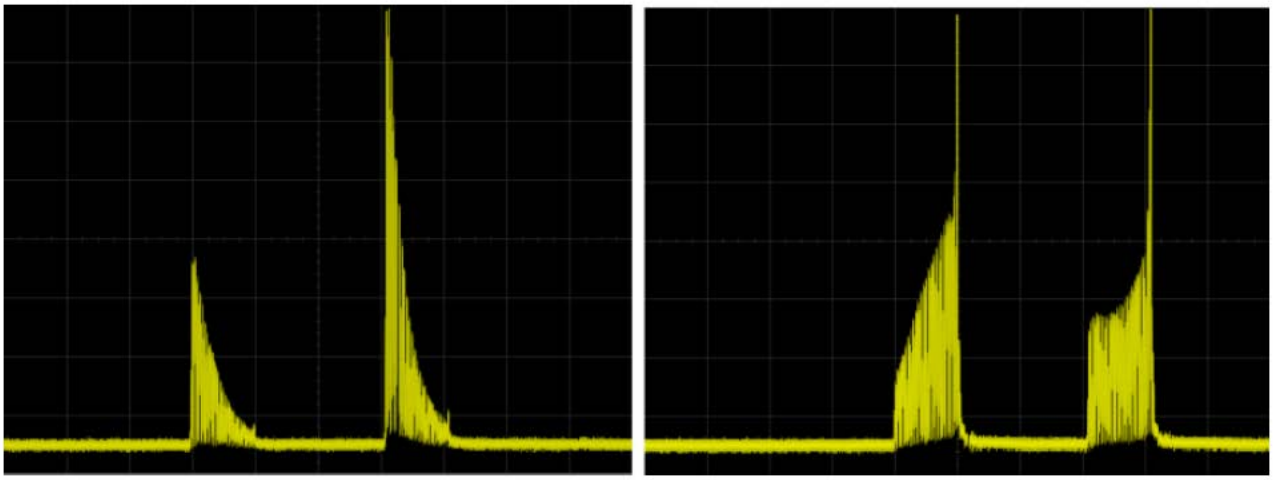


Figure 43. Burst mode oscillogram readings for various envelope shapes

5.5 Laser Nanosecond Mode

CARBIDE-CB3 laser can be switched to emit 16 - 160 ns pulses instead of the fs output. This is useful in some setups where a combination of fs and ns pulses from a single laser source is required.

Average power and pulse energy in nanosecond (NS) mode is limited to ~85-90% of the maximum laser power in femtosecond mode. This option is available only for the fundamental wavelength. Laser beam position, direction, intensity, polarization, and stability in nanosecond mode remain unchanged. To switch to NS mode, follow these steps:

1. On the CARBIDE User App Click on “Preset editor” in the top menu.
2. In the “Advanced settings” section, locate the NS mode function.
3. Click on the window to open the drop-down menu and select “Enabled”.

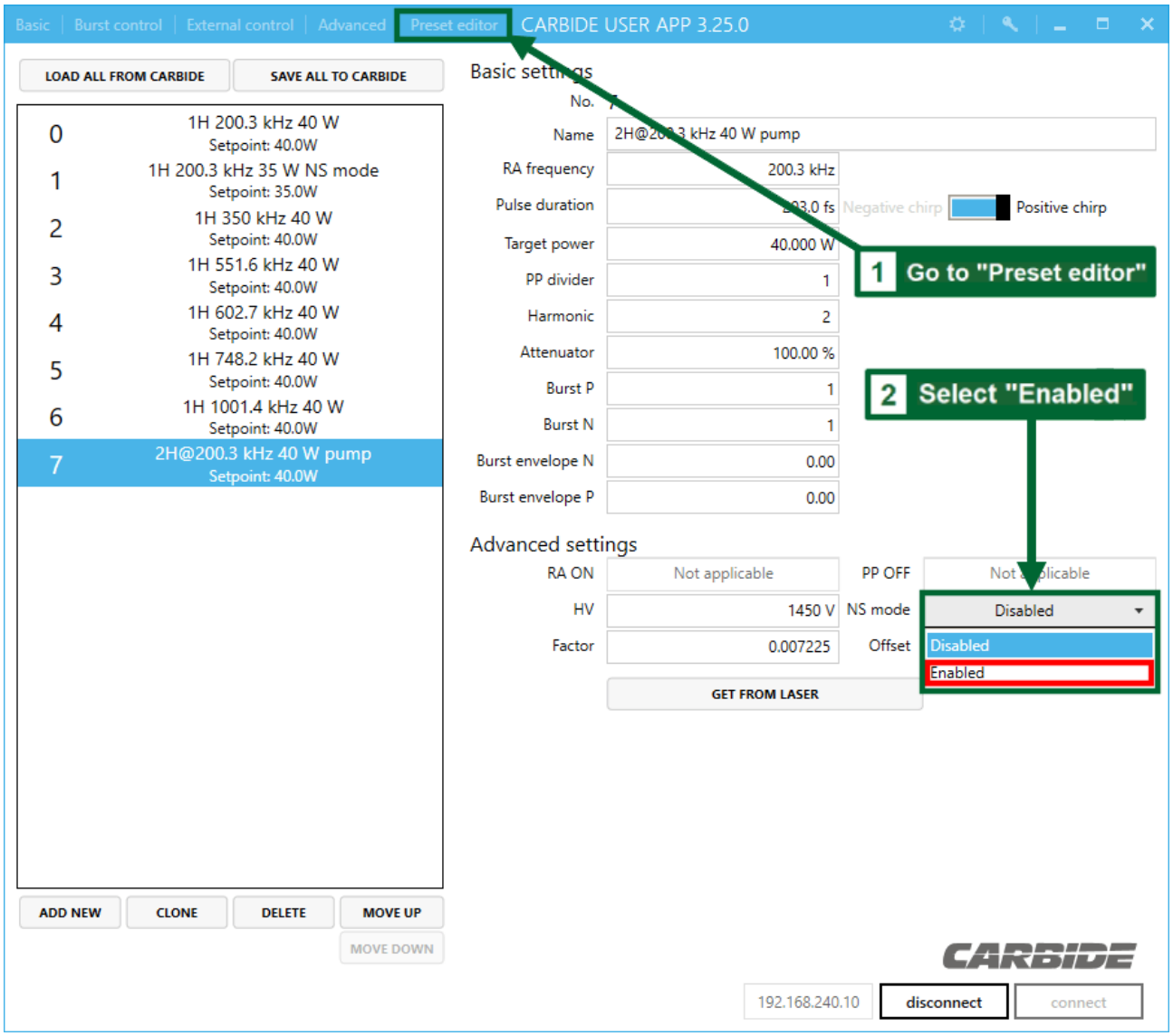


Figure 44. CARBIDE User app - Enabling laser's Nanosecond mode

5.5.1 Adjusting Nanosecond Pulse Duration

NOTICE ***This feature is only available for lasers with BiBurst function.***

Nanosecond pulse duration can be adjusted from 16 to 160 ns in 16 ns steps (Pulse duration = N*16). This is performed within the 'Basic' section of the CARBIDE User App:

1. Select "Basic" in the top menu of your app.
2. In the "Other" section, locate the function to control the pulse duration multiplier – N.
3. Press "+" and "-" symbols to increase or decrease the multiplier's value.
4. Click "Set" to finalize your changes.

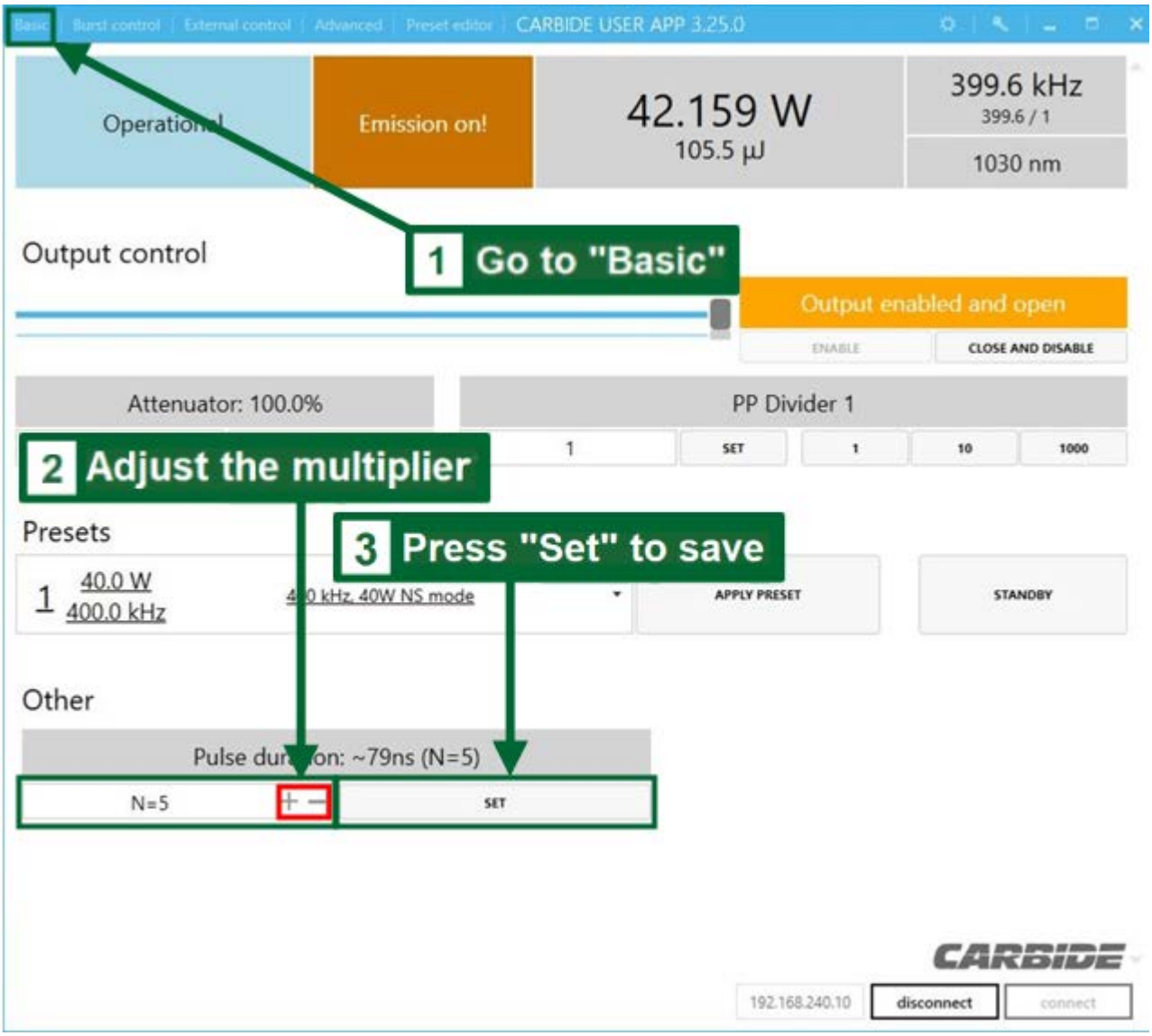


Figure 45. CARBIDE User App - Adjusting nanosecond pulse duration

Figure 46. Display of the adjusted nanosecond pulse on the oscilloscope (N=5)

5.5.2 Adjusting Nanosecond pulse shape slope

NOTICE ***This feature is only available for lasers with BiBurst function.***

Slope of nanosecond pulse shape is adjustable with N Burst Envelope control via the CARBIDE User App:

1. Select “Burst control” in the top menu of your app.
2. Change the Envelope control parameter N. There are two methods to change this setting:

   Method 1: Enter the N parameter from-1 to 1 and press “Set”.

   Method 2: Adjust the slider until the N parameter matches your desired value.

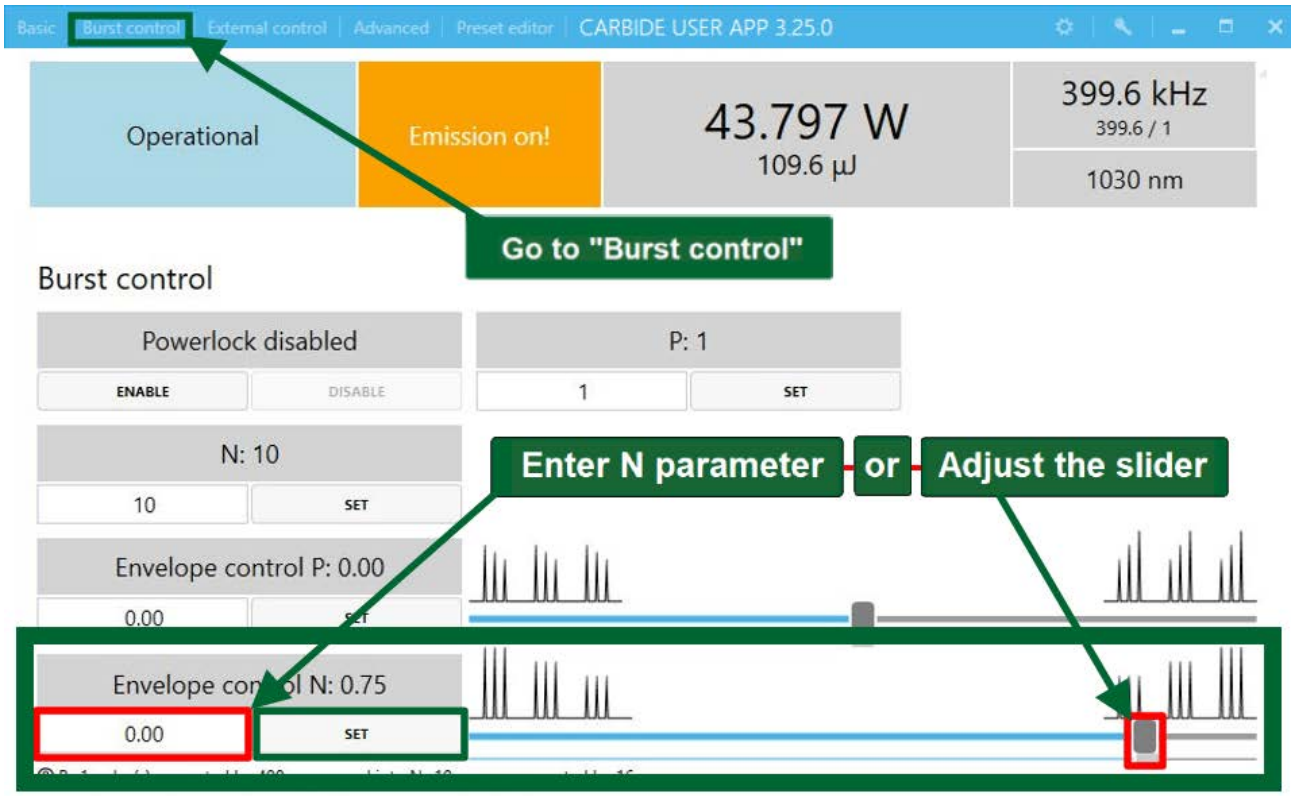


Figure 47. CARBIDE User App - Adjusting nanosecond pulse shape slope via User App

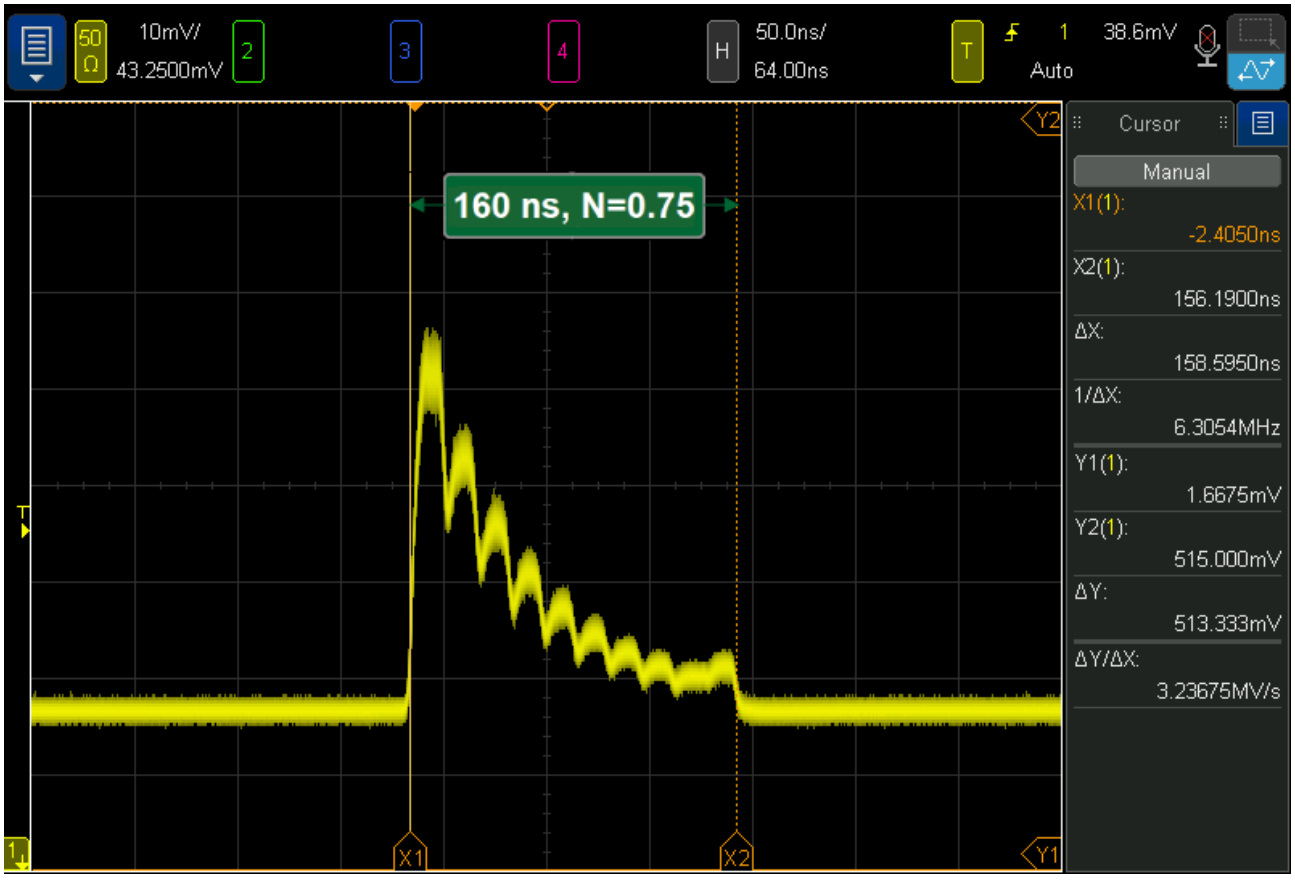


Figure 48. Display of the adjusted nanosecond pulse shape slope on the oscilloscope (N=0.75)

5.6 External Control

Carbide external control is made possible by manipulating the analogue signal inputs at the XS13 connectors in the back of the laser. To activate external control, the laser must be configured appropriately via software (External control tab in the User app). The laser ships with a XS13 terminator included which is needs to be modified, or a new one prepared to allow external laser control.

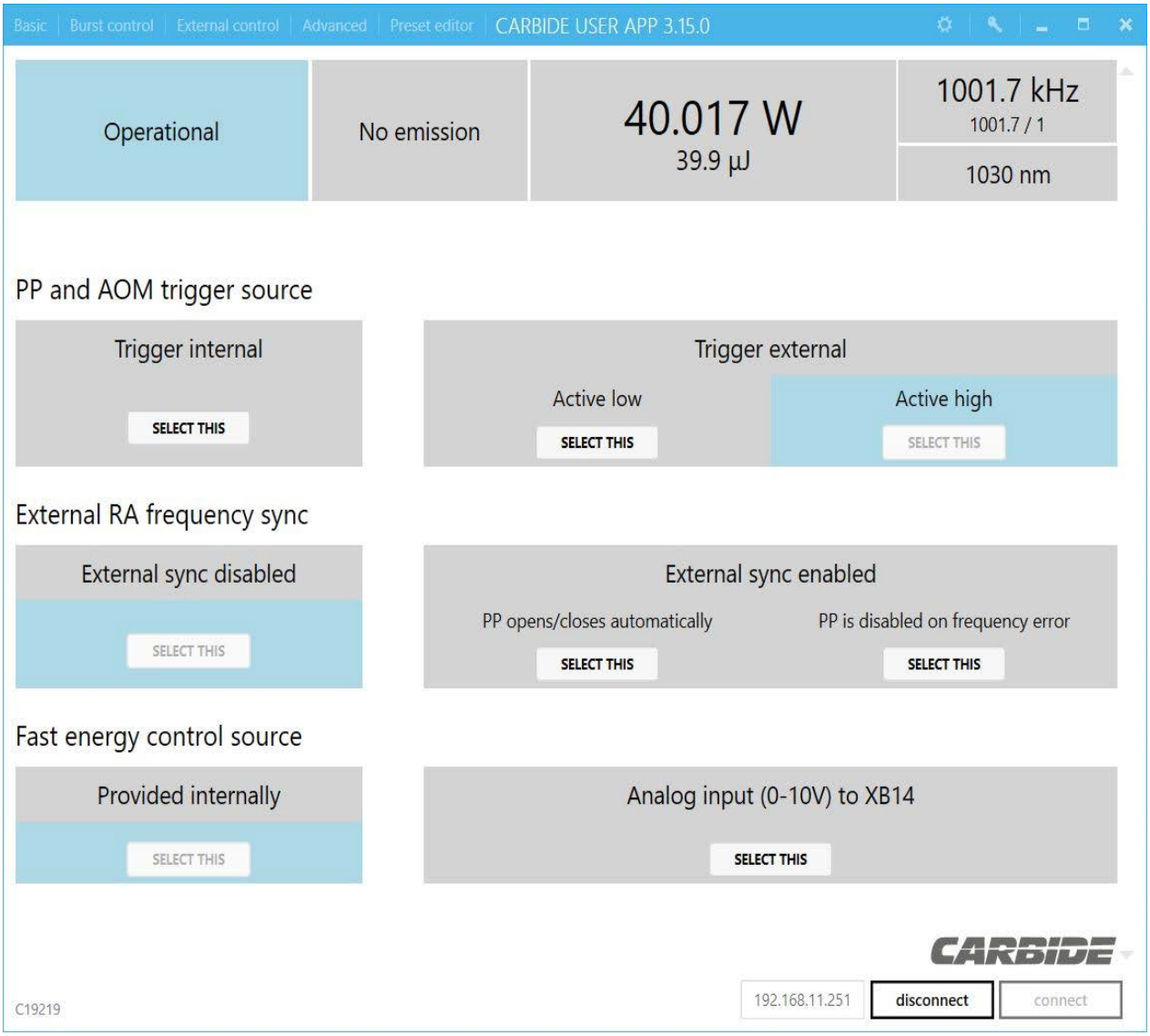


Figure 49. CARBIDE User app - "External Control" section

5.6.1 Triggering the Pulse Picker Externally

To trigger the pulse picker externally TTL signal (0V low and 3.3V high level) must be supplied to pin 16 at the XS13 connector. If provided laser terminator XS13 is used, pin16 must be unsolder from pin 21, pin 24, pin 25 and pin 13, and used separately. External PP control will start working if "Trigger external", "Active low" or "Active high" is selected in the "PP trigger source". Depending on supplied external signal, the Pulse Picker will remain in CLOSED and OPEN state as long as an external signal is supplied to pin 16. Due to security reasons, it is always recommended to use "Active low" triggering logic. If the signal from pin 16 is detached (cable unplugged), this would result in a closed PP (due to integrated pull-up inside).

5.6.2 Controlling Power With External Analog Signal (Optional)

Analog signal (0-5V) can be supplied to Pin24 of the XS13 connector to control the output pulse energy of the laser. Applicable only to lasers which are equipped with Integrated attenuator, AOM or CBM02/CBM04 harmonics modules. Energy response is not linearized while controlled via Analog signal.

5.6.3 Using SYNC IN ("External sync" Option)

It is possible to lock the RA frequency to an external frequency source. To implement this, TTL signal (0V low and 3.3V high level) must be supplied to pin 14 at the XS13 connector. Signal width must be between 200- 500 ns in duration (active level high). The laser automatically detects the externally supplied signal. Once the laser has started at this repetition rate, the frequency must remain confined within 0-20% limit, otherwise the RA will resume working at the frequency it was started at (it would not react to external input signal anymore). If "PP open/closes automatically" option is selected, PP will close automatically when this happens and will get reopened again if appropriate external SYNC IN signal is registered. If "PP closes on frequency error" is selected when the SYNC IN frequency is out of range, PP will always remain closed unless reopened manually.

5.6.4 Controlling the Shutter

To control the laser shutter externally, TTL signal (0V low and 3.3V high level, 5V tolerable) must be supplied to pin 25 of XS13 connector (shutter open on High level). If the original laser terminator XS13 is used, pin 25 must be unsoldered from pin 21, pin 24, pin 16, pin 13 and used separately. No software configuration is required to control the shutter directly over pin 25. Please refer to the appendix "CARBIDE Electrical circuits related to personal safety for more extensive documentation on shutter control and E-stop.

5.6.5 Fast Energy Control (FEC)

The fast energy control can be executed internally (default method) via the output control slider in the basic window of the CARBIDE User app, or it can be controlled externally. External control is executed via the XB14 connector, by sending an analog signal within the voltage range of 0-10V. The received voltage directly correlates to the set output power. To use this external control method, it is necessary to select this option in the "External control" window "Analog input (0-10V) to XB14".

5.6.6 Advanced Section

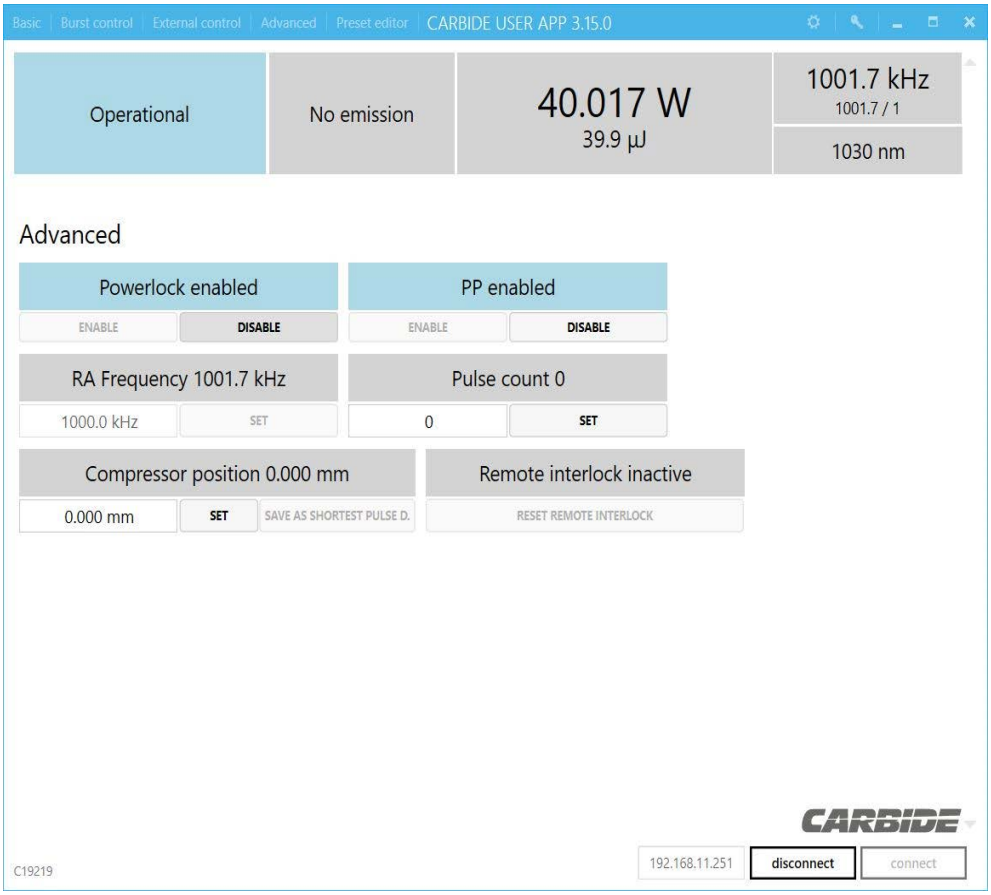


Figure 50. CARBIDE User app - advanced section

5.6.7 Power-Lock

When power-Lock is enabled, the current feedback loop is activated to maintain constant output power out of the laser. It is always recommended to use Power-Lock to increase long term power stability of the laser. It is enabled by default after execution of a preset. If laser settings need to be tweaked manually, it is recommended to switch the power-lock off while doing that.

5.6.8 Adjust Compressor Position

This section covers movement of the compressor motor to another location. It can be used to calibrate pulse duration when the measured shortest pulse duration differs from the laser software indication. To perform pulse duration calibration follow these steps:

1. Go to "*Advanced*" window.

2. Click on the key icon in the top-right corner to open the authorization prompt.

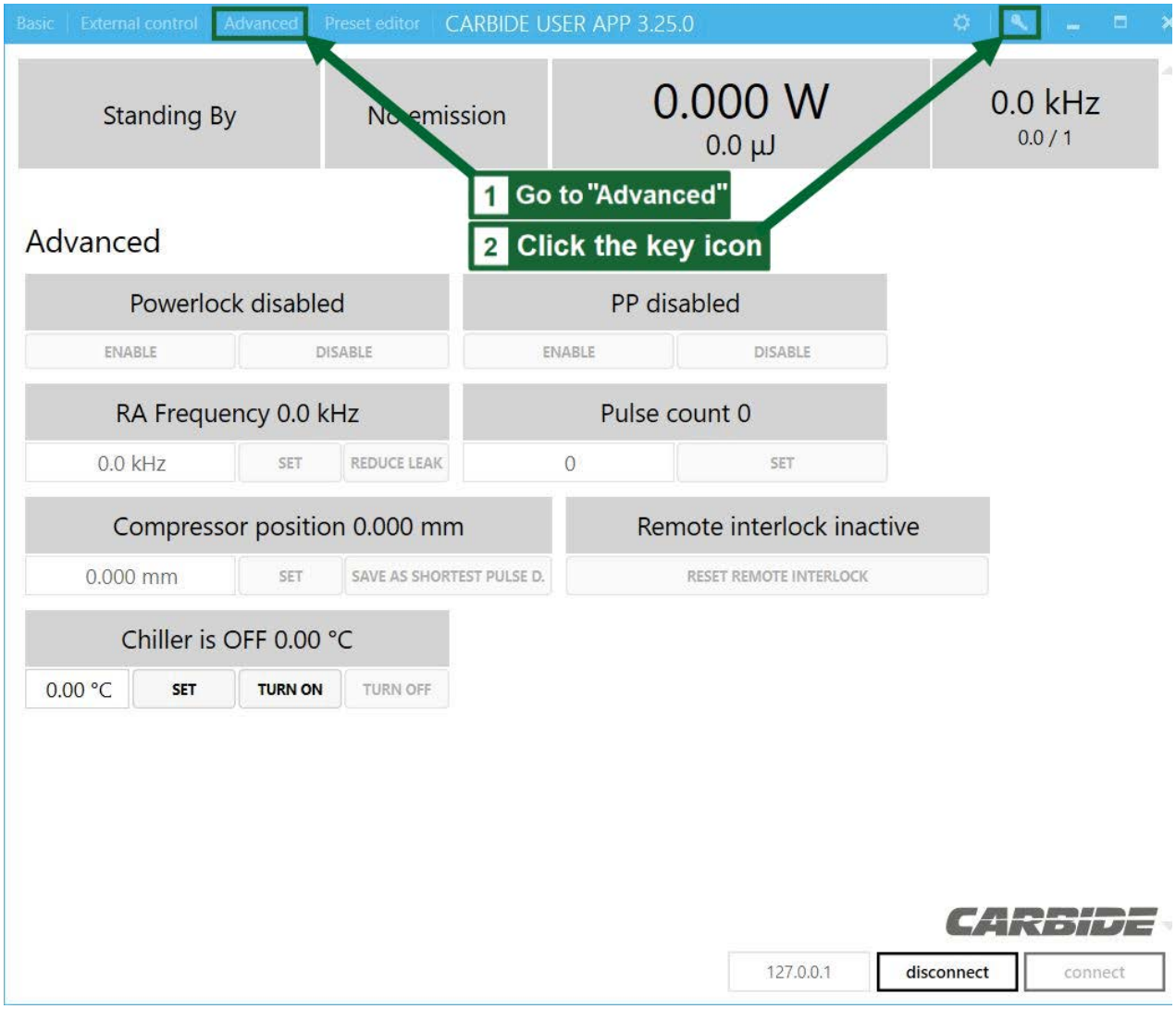


Figure 51. Accessing technician authorization in the Carbide User APP

3. Enter the technician password – 5172.

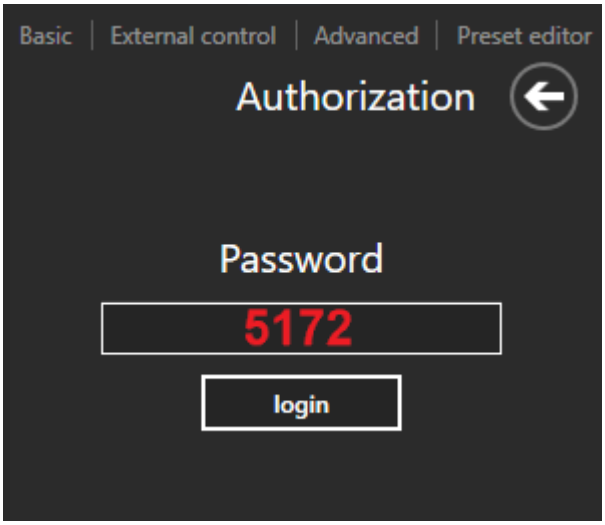


Figure 52. Technician authorization prompt

4. Adjust the compressor position in 0.01mm increments, moving both to the negative and positive sides, while measuring the actual pulse duration with an external measurement device. Try to identify the shortest pulse duration.
5. When shortest possible pulse duration is measured, press "Save as shortest pulse d." button.

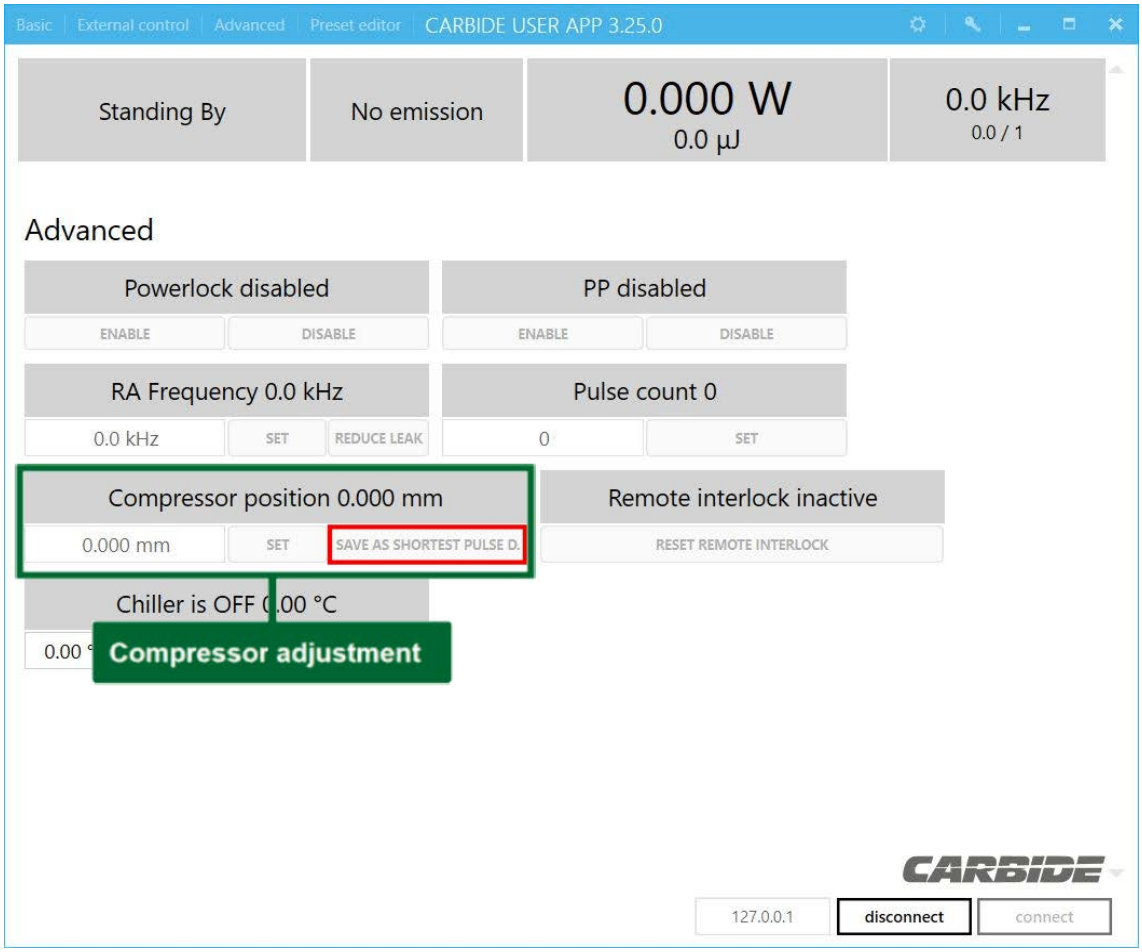


Figure 53. Adjusting the Compressor position

5.6.9 Pulse Count

If 0 is selected, all the pulses generated inside RA will be emitted from the laser once Pulse Picker is opened. If another integer number is selected, only the selected number of pulses will be emitted from the laser and the PP will be closed automatically. This feature is useful if an exact number of pulses are required to be emitted from the laser.

5.7 Forbidden frequencies

To ensure fast switching while maintaining relatively high pulse energies electro-optical modulators (Pockels cells) are used for pulse manipulation inside the laser. The laser has one physical Pockels cell, that acts as both RA and PP. It is known that at specific frequencies which match the acoustic vibration harmonics of the Pockels cell crystal, the Pockels cell exhibits polarization contrast deterioration. Frequency ranges at which the contrast is reduced are measured during the laser testing and are software-locked. If a user selects a frequency which matches the resonant frequency, a closest possible safe frequency is set instead automat-

ically. These frequencies are unique to each laser and are listed individually for each laser in the Factory Test Certificate.

5.8 Presets

A “Preset” is a set of most important parameters (frequency, target power, timings, calibration factors, etc.) that Supervisor changes automatically in required order (that is, “executes” or “applies” a preset). Some of them are created by the manufacturer, others may be created by user. At any time, you can edit the preset values using CARBIDE User App (see figure below).

CARBIDE presets list is created in the factory during manufacturing of the laser. If user requires additional modes of operation, additional presets can be created, the preset creation process is described in the next section.

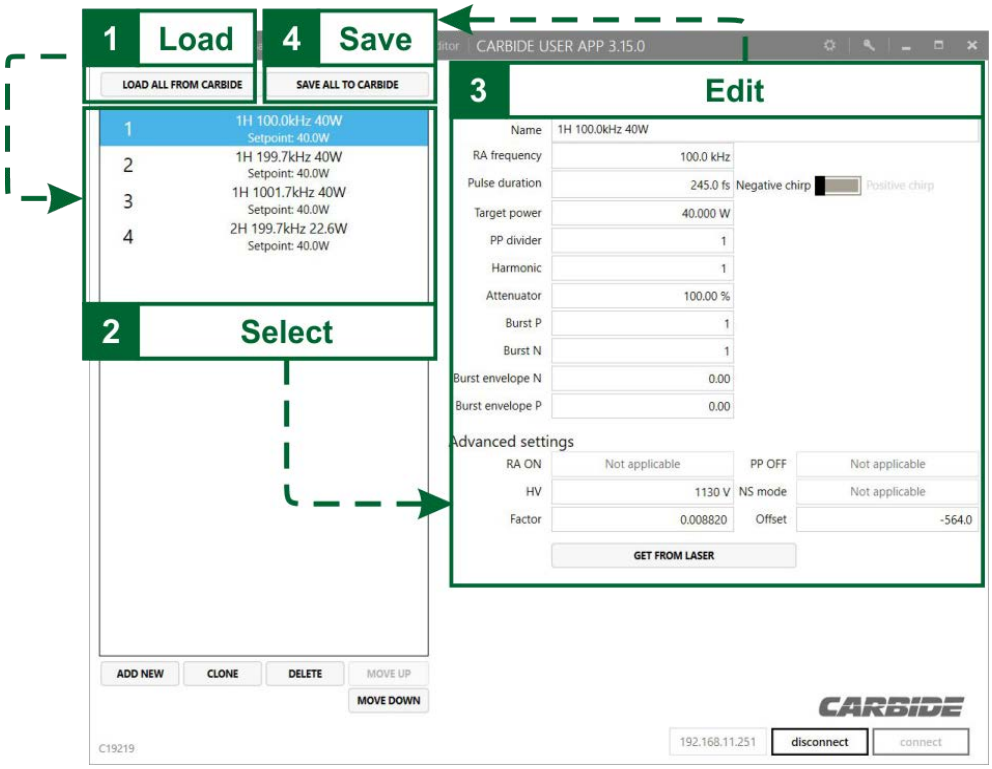


Figure 54. CARBIDE User app - presets section

5.9 New preset creation

To create a new preset, it is recommended to follow these steps:

1. Power up and connect to the laser.
2. In the CARBIDE user app - basic tab, select an existing preset with the frequency closest to the one you are planning to set.
3. Apply the selected preset and wait until the laser enters “Operational” state.
4. Go to the advanced tab of the user app and disable the “Powerlock”.
5. Change the RA frequency to the one you require.
6. Wait around 10-15 minutes for the laser temperatures to stabilize and adjust to the newly set frequency.

7. Go to the “Preset editor” tab and click “ADD NEW” to create a new preset, then click “GET FROM LASER”.
8. Save the preset to the laser by clicking the “SAVE ALL TO CARBIDE” button.
9. Apply the newly created preset.
10. Compare the output power between the internal (P_{int}) and external (P_{ext}) power meters. If the readings are not equal, slightly adjust the initial Factor (F_{init}) value. For the new Factory value calculation, use the following formula : $F_{new} = (F_{init} * P_{ext})/P_{int}$.
11. After adjusting the Factor, save the preset, apply it and compare the power again.
12. Repeat steps 10-11 until the internal and external power meter readings match.

5.10 Warning and Errors

Supervisor continuously monitors laser for some special conditions signifying a *warning* or an *error*.

Warnings are non-critical for laser operation, but performance may not be optimal or begin degrading. For example, due to incorrect environmental conditions or a malfunctioning chiller the “Oscillator temperature is out of range”, while it is not yet critical, it will cause the laser performance to degrade and possibly cause instabilities in its operation.

Errors signify a critical situation when laser performance is affected severely. For example, RA pumping bar unit stops working resulting in massive drop of the output power or no power at all. Some errors may be cleared after executing a preset again. Others will persist, and the cause should be checked.

The list of warnings and errors is predefined. Description of these warnings and errors can be found in the troubleshooting section.

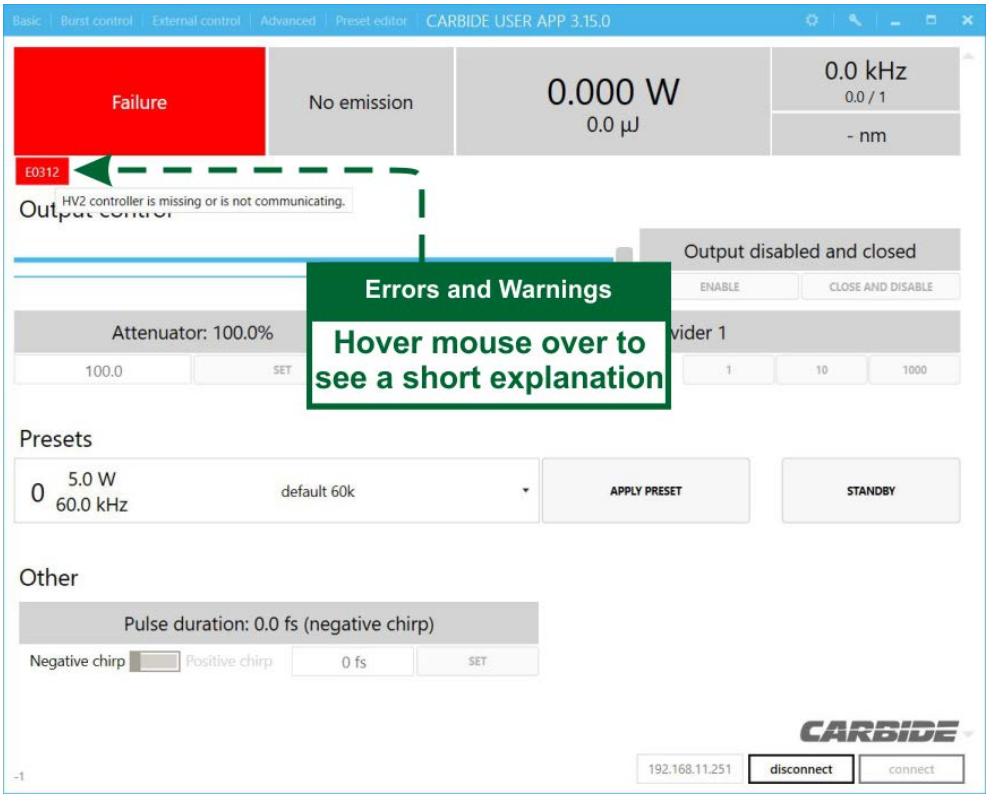


Figure 55. CARBIDE User app - location of the errors and warnings notifications

5.11 Configuring the XBx output signals

The XB2 connector, as well as the XB BNC connectors are equipped with several programmable pins (see laser system description section).The configuration of these pins is achieved via the laser service app. The configuration settings are written to the supervisor of the laser, which means that the laser must be powered (power supply plugged in to the mains and connected to the laser) during this procedure. To configure a XBx pin, follow these steps:

1. Start the laser service app and connect to the laser.
2. At the top right corner, select “Show Tuning Window”.
3. Select the “XBx” tab.
4. You will be presented with a menu with all of the configurable XBx pins. The top section of this menu displays the current configuration for each available configurable XBx pins and allows setting the new configuration. Notice that only the pins and connectors shown in the top panel can be configured. If the XB2 pins are not shown, you may need to upgrade your firmware. Setting a signal for a pin is straight forward. Decide which pin you want to configure, then in that row, simply select a signal for that pin from the drop-down list and click “Set”.

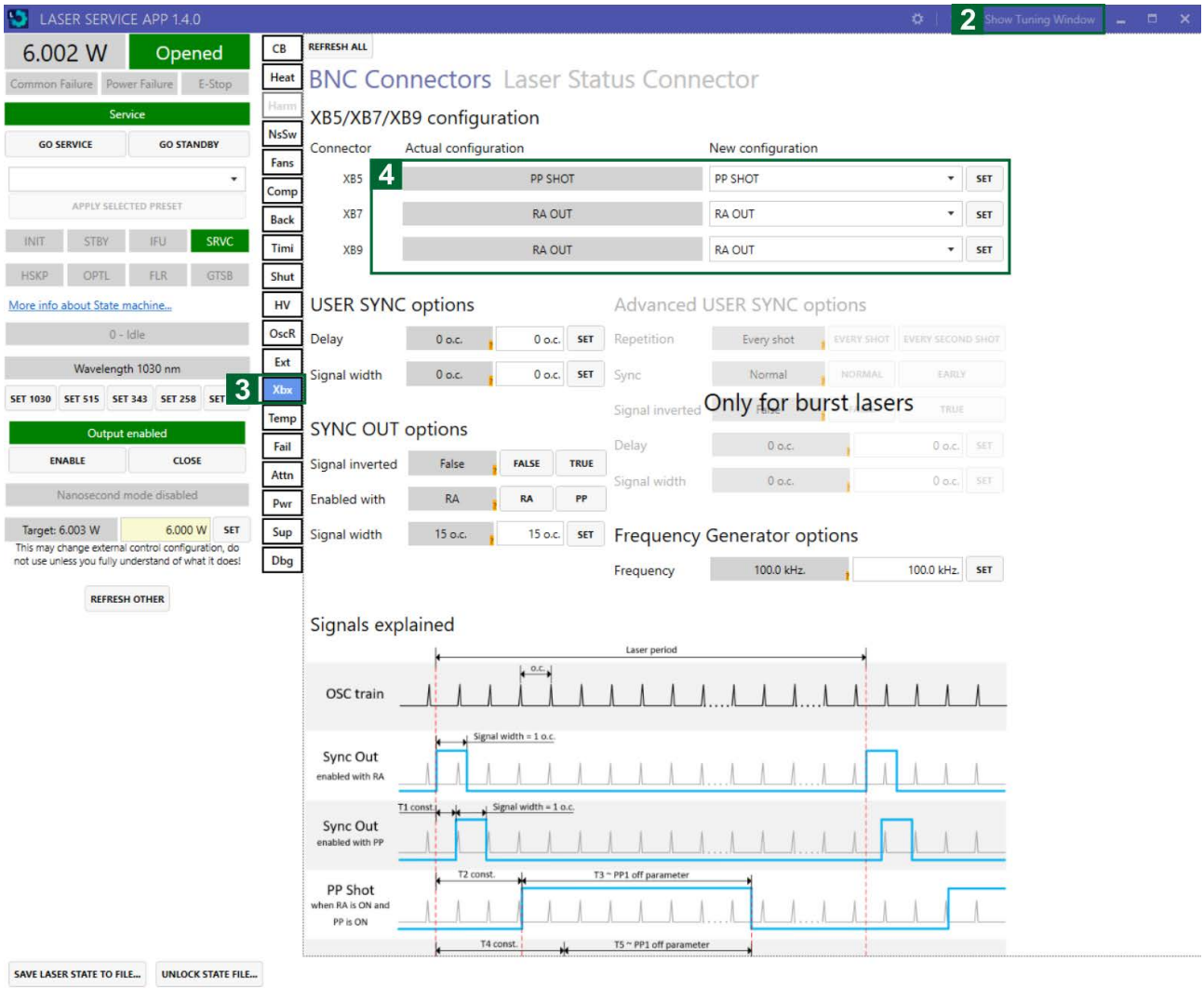


Figure 56. Laser Service app - Configuring the XBx output signals

NOTICE	***The configurable output signals on the XB2 connector are only available from supervisor version 3.2 and back panel firmware version 2.3. If your firmware versions are outdated, contact Light Conversion representatives for instructions on how to perform the firmware update.***
NOTICE	***The default signal duration is approximately 12 ns. Some signals can be prolonged in steps relative to the of the oscillator period, which is typically ~15 ns or ~ 13 ns.***

Table 20. List of possible configurable XB2 signals

Signal	Description
Always OFF	Constant signal off state
Always ON	Constant signal on (active) state
Laser in Service state	Active when laser is in service mode
Laser in IFU state	Active when laser is in a state for firmware update
Laser in StandingBy state	Active when laser is in standby mode
Laser in GoingToStandby state	Active when laser is going to standby mode
Laser in Failure state	Active when laser has a failure
Laser in Housekeeping state	Active when laser is turning on or a preset is applied
Laser in Operational state	Active when laser is in operational mode. At this state the laser is ready to operate
First harmonic	Active when fundamental (1030nm) harmonic is selected
Second harmonic	Active when second (514nm) harmonic is selected
Third harmonic	Active when third (343nm) harmonic is selected
Fourth harmonic	Active when fourth (257nm) harmonic is selected
Any error active	Active when laser has an error
Any warning active	Active when laser has a warning
EStop active	Active when E-stop (emergency stop) circuit is disrupted
Remote interlock active	Active when remote interlock circuit is disrupted
Chiller control	Active when signal to turn on the chiller is activated
PP enabled	Active when pulse picker is open
Shutter open	Active when shutter is open
Main power is on	Active when main power is on. Main power enables LDD and HV drivers. This condition is enough for laser light to be generated within the hardware

NOTICE	***The list provided describes a generalized list of signals, each XB configurable PIN has a set of signals which can be configured on it. Thus some of the listed signals will not be available on some of the XB connectors.***

5.12 Changing laser IP address

The CARBIDE laser's IP address can be changed to resolve IP conflicts or adapt to network changes. To change your laser IP, follow these steps:

1. Open the CARBIDE User App.
2. Go to the Settings section by clicking the gear icon in the top right corner.
3. Click “Open control panel page”

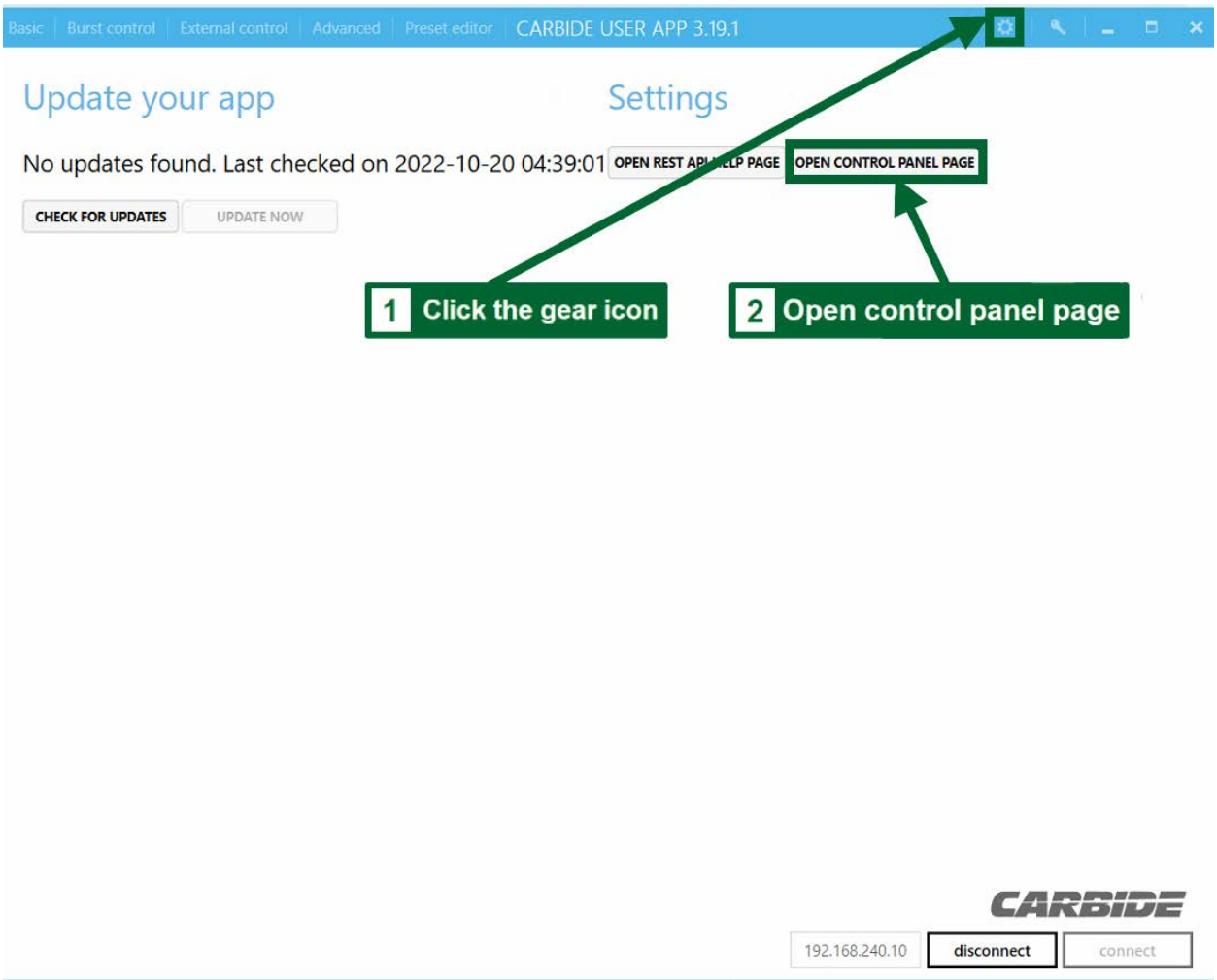


Figure 57. CARBIDE User App - Accessing the control panel page

4. On the menu bar, go to “System Control”

5. In the network tab, enter your new IP address and click “Save”

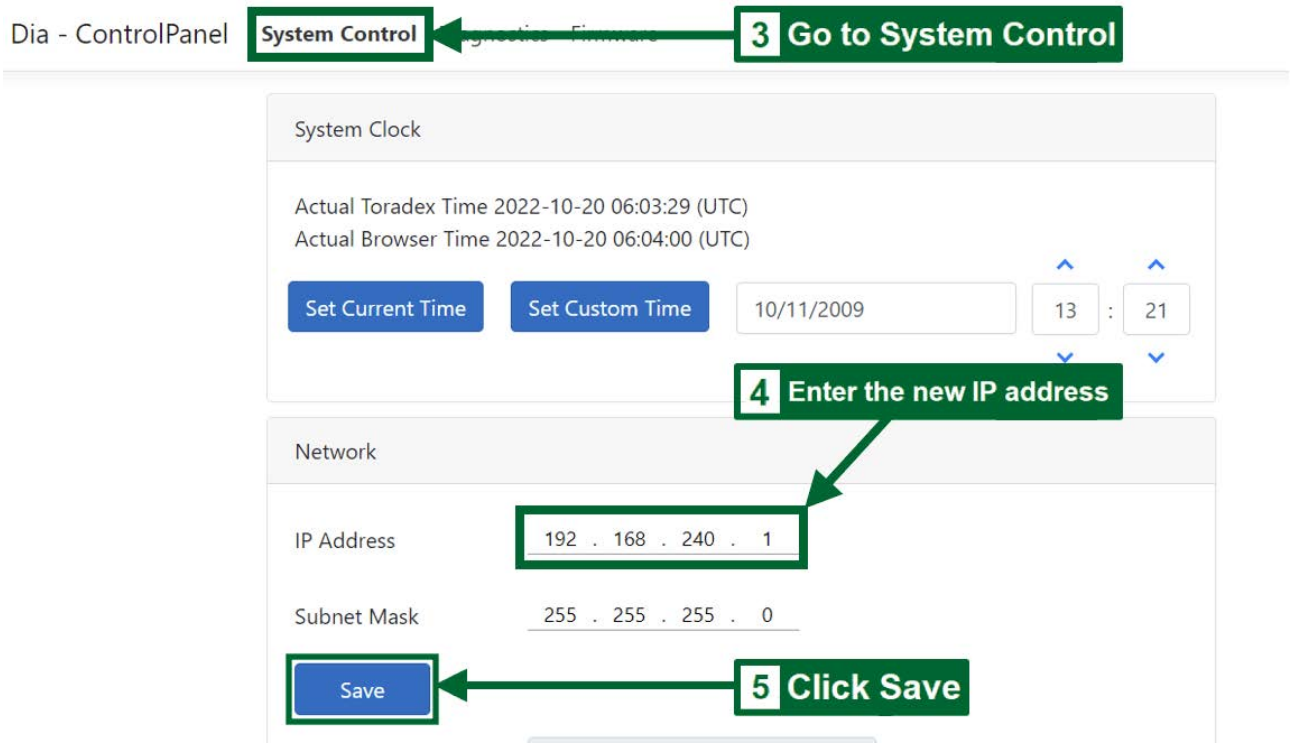


Figure 58. Control panel page - Changing laser’s IP address

6. Enter the technician's password – 5172, and click confirm to finalize your changes.

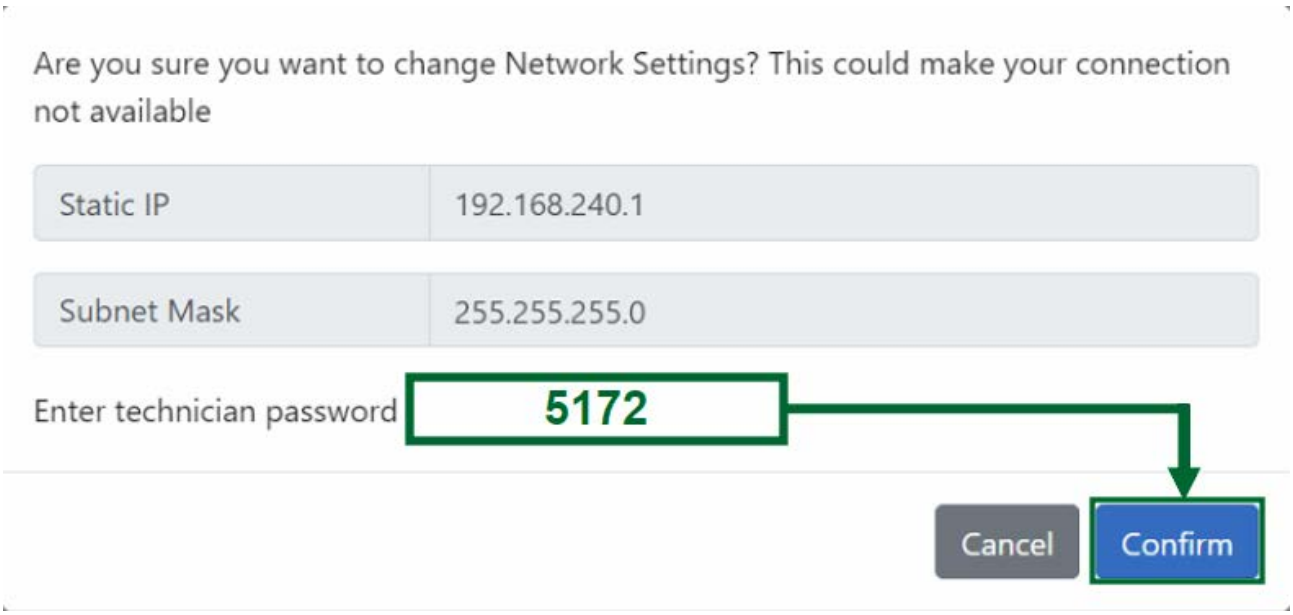


Figure 59. Control panel page - Entering the technician’s password

7. After changing the laser’s IP address, make sure that the address of your computer is still in the same subnetwork, defined by the third digit of your IP. In the example, the laser’s subnetwork is 240; therefore both the computer and the laser have to be in the same subnetwork.

NOTICE ***For more information on changing your computer’s IP, please refer to section 4.1.3 – Setting the Correct IP Addresses.***

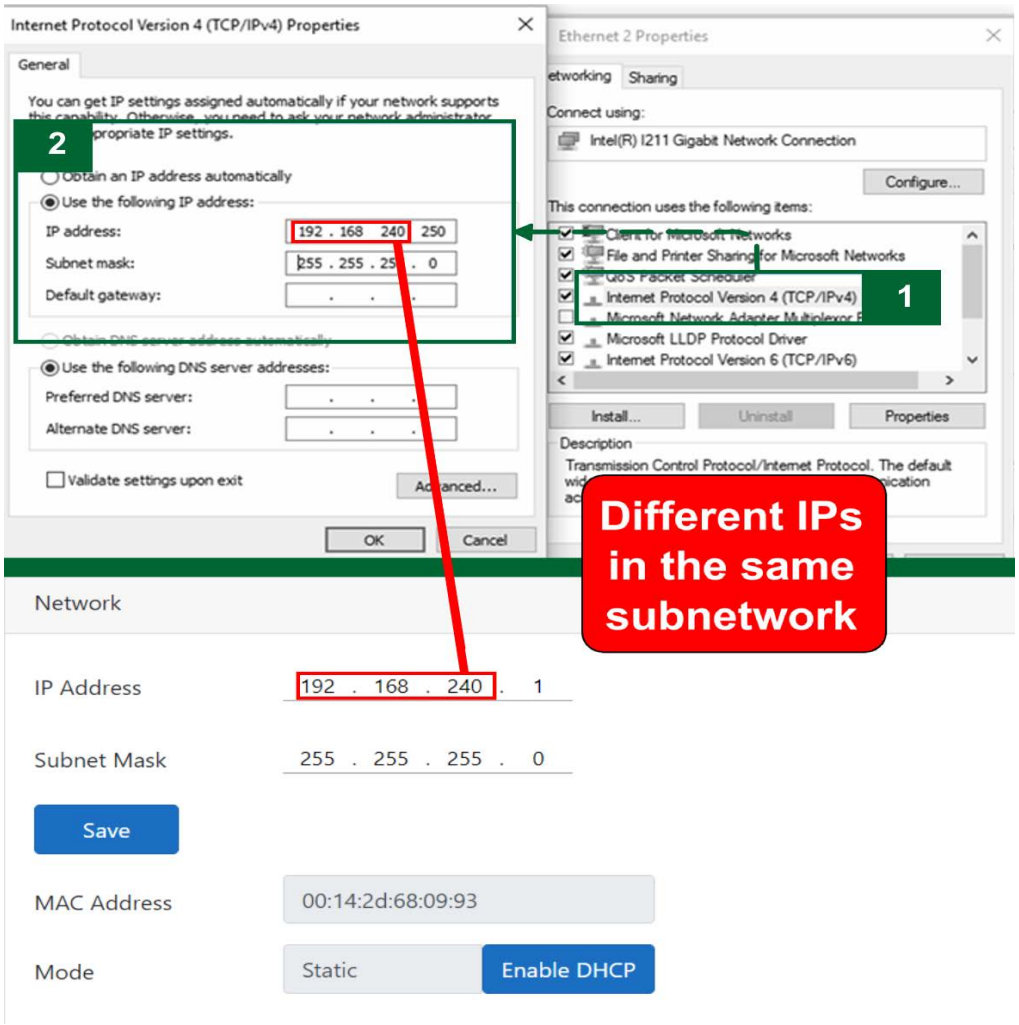


Figure 60. Setting matching subnetworks for laser and computer IP addresses

5.13 Laser control via REST

The CARBIDE laser supports control via REST requests. The REST API is an integrated part of the laser, and control via REST is enabled as long as power is supplied to the laser electronics, see XS1 connector - pin A3. A general description of the REST control and available endpoints can be accessed via the CARBIDE User App:

1. Press the gear button in the top right corner of the CARBIDE User App.

2. Click “OPEN REST API HELP PAGE”.

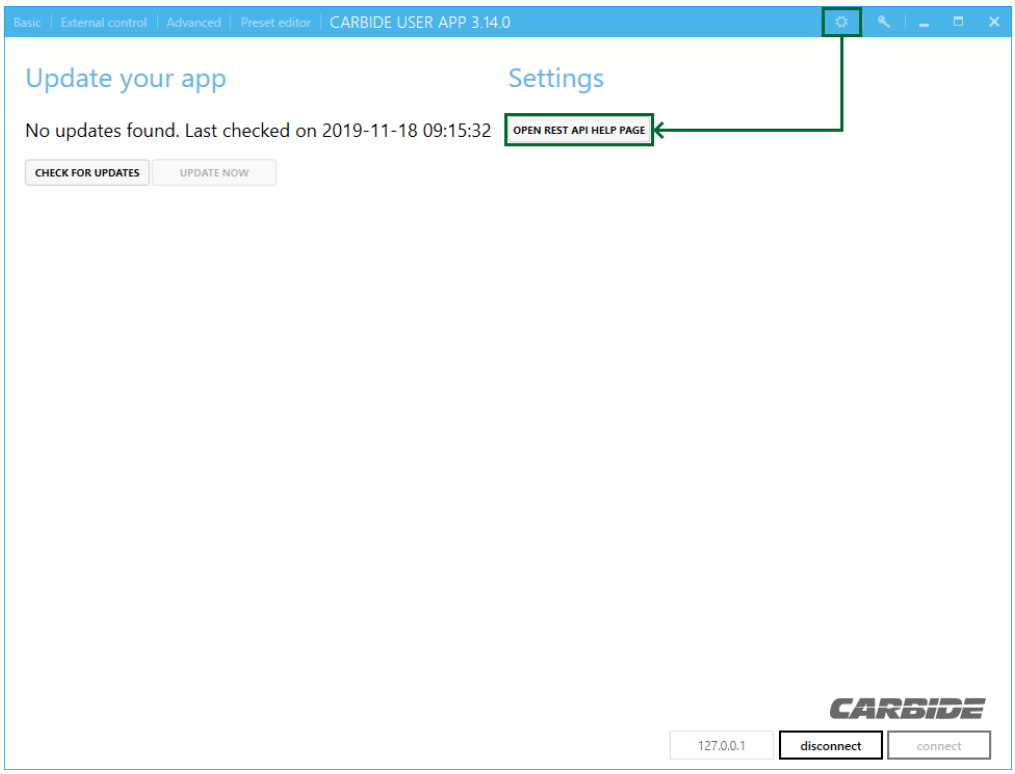


Figure 61. CARBIDE User App - accessing the REST help page

NOTICE ***Advanced developers information is available at www.lightcon.com . Registration and login is required.***

6 MAINTENANCE

6.1 Chiller Maintenance

Each CARBIDE laser system is aligned and optimized for a defined cooling water temperature, the number is given in the *"Factory test certificate"* provided with each laser. Operation at a different water temperature can cause misalignment or poor performance of the system.

NOTICE

It is important to prevent water condensation on cooled laser components in a high humidity and high temperature environment. Use a psychometric chart to calculate a dew point in your environment. Do not use laser if there is a risk of water condensation. Consult manufacturer for optimal regime of laser operation at high humidity conditions.

It is important to prevent formation of algae in the cooling system water. The presence of algae in the cooling system can lead to the formation of blockages in critical places, causing overheating of the laser crystal, softening of water tubes and possibly flooding and damaging the laser. To prevent algae formation, it is important to change the cooling water periodically.

NOTICE

The user must not operate the chiller without coolant. The coolant level must be checked regularly and maintained at an appropriate level

NOTICE

Use only steam-distilled or reverse osmosis water.

The coolant filter must be replaced along with every coolant change. The water filter of the cooling system is situated on the rear panel of the chiller (depending on the chiller model). The laser cooling system must be rinsed with clean water twice during the coolant replacement. Remove the filter and wash it carefully when changing the coolant.

NOTICE

Coolant and filter change periods may vary, depending on the chiller manufacturer. For accurate and additional maintenance (not listed in this document) please refer to the chiller manufacturer manual supplied with the chiller.

6.2 Maintenance Schedule and Spare Parts List

Table 21. Maintenance schedule

Component	Action	Periodicity
Chiller coolant water level	Check and refill if necessary	1 day
Chiller coolant water	Replace	6 months*
Chiller coolant water filter	Replace	6 months*

Table 22. Maintenance spare parts list

Component	Part description	Part no.
Chiller coolant water	Steam-distilled or reverse osmosis water, 4-8 L	
Chiller water filter	Primary circuit (coolant water): 25 µm	S-PG10325
	Secondary circuit (industrial water)**: 50 µm	S-PG10414

* Actual periods may vary depending on the chiller model, refer to the chiller manual for accurate maintenance information.

**For water-to-water chiller models.

NOTICE

Actual maintenance periods may vary depending on the chiller manufacturer and model. Maintenance periods and part numbers provided are generalized. For more accurate information, please refer to the supplied chiller user's manual.

7 TROUBLESHOOTING

7.1 Introduction

This section is dedicated to identifying various issues that may arise during normal laser operation. The majority of issues arise from incorrect usage, bad settings or laser parameters drifting beyond the set thresholds. Since most of the standard issues are known, internal health checks constantly run diagnostics and inform the user of possible issues in a form of Warning and Error messages. The list for all currently existing Errors and Warnings is provided in the sections below.

Besides standard issues, there are cases when help from LC support engineers is necessary. Technical support and diagnostics are performed via the Laser Service App. The LSA is available for download at lighcon.com (registration required).

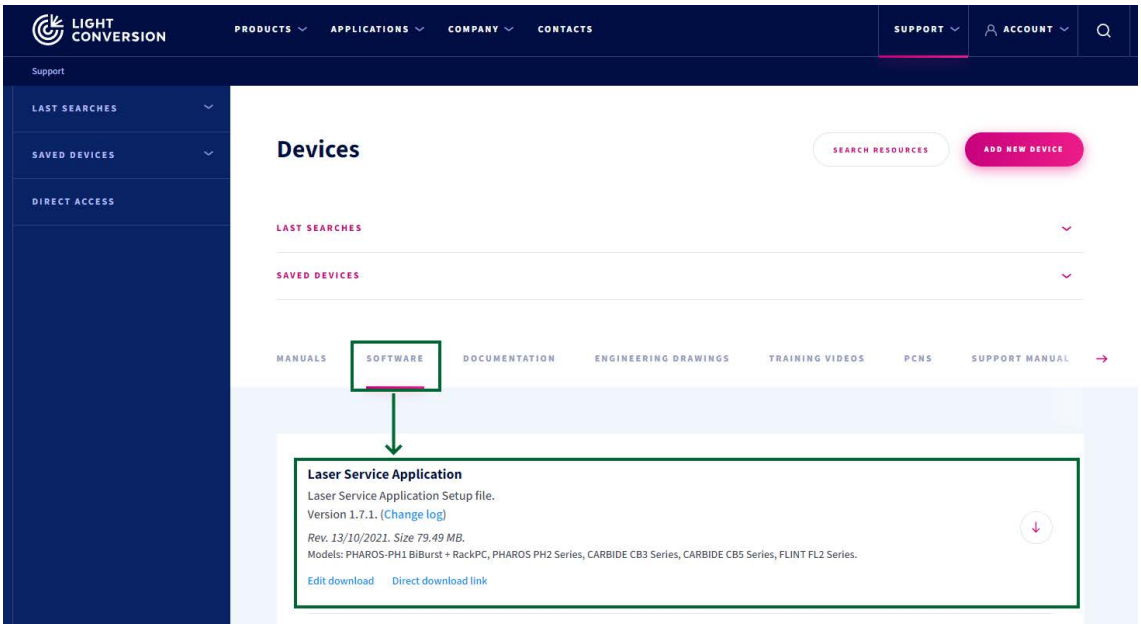


Figure 62. Laser Service App download location at lightcon.com

7.1.1 LSA - Saving the laser state file

The laser state file is one of the main diagnostics tools used by service engineers, thus it is often requested from our clients. To save a laser state file:

1. Start the Laser Service App.
2. In the bottom right corner, select your laser model, enter the IP address of the laser and click connect.

3. Once connected, in the top left corner, click the CARBIDE section, then click “READ ALL”.

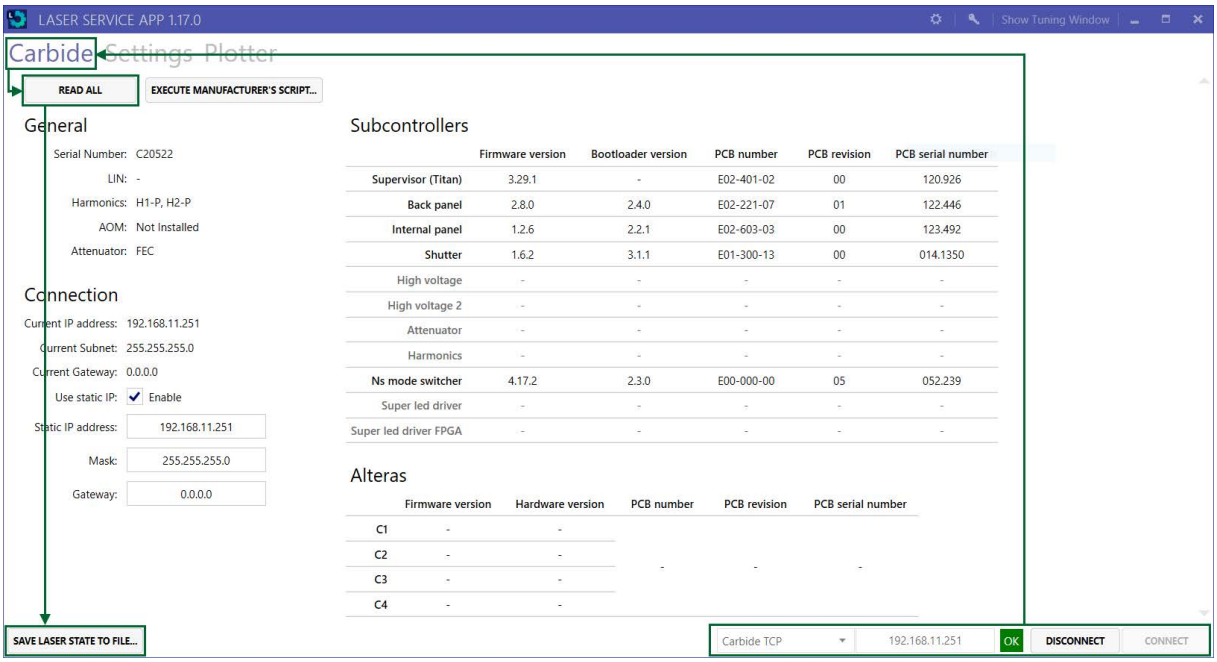


Figure 63. Laser Service App - saving the laser state file

4. In the bottom left corner, click the “SAVE LASER STATE TO FILE..” button and pick a directory where to save the file.
5. Send the state file along with your support request.

7.2 Errors and Warnings

Both warnings and errors are numbered incrementally and grouped into functional groups. Location of warnings and error messages is shown in the previous Warnings and Errors section.

Table 23. CARBIDE error and warning groups

Functional group	Range
Software	0100-0199
Safety	0200-0299
Hardware	0300-0399
Power supply	0400-0499
Pumping	0500-0599
Cooling	0600-0699
Timing	0700-0799
Heating	0800-0899
Stretcher / compressor	0900-0999
Operational	1000-1099

7.2.1 Software errors and warnings

Table 24. Software errors and warnings

Code	Type	Description
E0100	Error	Altera firmware version is too old
W0101	Warning	Old low-level preset detected

7.2.2 Safety errors and warnings

Table 25. Safety errors and warnings

Code	Type	Description
E0200	Error	ESTOP. Full power cycle is required
W0201	Warning	Remote interlock is active. Shutter is closed, disabled and will not open until remote interlock is reset
E0202	Error	Can't close output
E0203	Error	Can’t enable output
W0204	Warning	Fast off is active
W0205	Warning	Slow off is active
E0206	Error	Laser stopped because remote interlock is active

7.2.3 Hardware errors and warnings

Table 26. Hardware errors and warnings

Code	Type	Description
E0300	Error	Altera board is missing or is not communicating
E0301	Error	Rear panel controller is missing or is not communicating
E0302	Error	Back panel controller is missing or is not communicating
E0303	Error	HV controller is missing or is not communicating
E0304	Error	FAN controller is missing or is not communicating
E0305	Error	Internal panel controller is missing or is not communicating
E0306	Error	Heater controller is missing or is not communicating
E0307	Error	HV controller can't reach voltage setpoint
E0308	Error	HV2 controller can't reach voltage setpoint
E0309	Error	Detected HV is incompatible with this laser
E0310	Error	Detected HV2 is incompatible with this laser
E0311	Error	Detected TEM firmware/hardware is incompatible with this laser
E0312	Error	HV2 controller is missing or is not communicating
E0313	Error	LPHV controller is missing or is not communicating
E0314	Error	LPHV2 controller is missing or is not communicating
E0315	Error	LPHV controller can’t reach voltage setpoint
E0316	Error	LPHV2 controller can’t reach voltage setpoint
E0317	Error	Nanosecond mode switcher is missing or is not communicating

7.2.4 Power supply errors and warnings

Table 27. Power supply errors and warnings

Code	Type	Description
E0400	Error	Input rail voltage (non-switched) is too low
W0401	Warning	Undervoltage detected (main, non-switched 24V)
W0402	Warning	Overvoltage detected (main, non-switched 24V)
W0403	Warning	Undervoltage detected (bars, switched 24V)
W0404	Warning	Overvoltage detected (bars, switched 24V)
W0405	Warning	Back panel problems detected

7.2.5 Pumping errors and warnings

Table 28. Pumping errors and warnings

Code	Type	Description
E0500	Error	Oscillator bar doesn't work properly
E0501	Error	RA bar(s) doesn't work properly
W0502	Warning	Oscillator humidity is out of range
W0503	Warning	Oscillator temperature is out of range
W0504	Warning	Oscillator is in continuous wave mode
E0505	Error	Oscillator is in continuous wave mode
W0506	Warning	RA temperature is out of range

7.2.6 Cooling errors and warnings

Table 29. Cooling errors and warnings

Code	Type	Description
W0600	Warning	Cooling fan(s) doesn't work properly
W0601	Warning	Cooling sensor(s) doesn't work properly
W0602	Warning	Peltier cooling sensor doesn't work properly
W0603	Warning	Peltier cooling device doesn't work properly
E0604	Error	Laser cooling system doesn't work properly (overheat)
E0605	Error	AOM overheated
W0606	Warning	Heatsink temperature is close to cutoff level
E0607	Error	Heatsink temperature is too high
W0608	Warning	AOM temperature is close to cutoff level
E0609	Error	Bar cannot reach temperature setpoint
W0610	Warning	Chiller doesn't work properly
W0611	Warning	Chiller sensor water temperature too low
E0612	Error	Chiller sensor water temperature too low
W0613	Warning	Chiller sensor water temperature too high
E0614	Error	Chiller sensor water temperature too high
W0615	Warning	Chiller sensor low water level

Table 29. Cooling errors and warnings

Code	Type	Description
E0616	Error	Chiller sensor low water level
W0617	Warning	Chiller sensor low water flow rate
E0618	Error	Chiller sensor low water flow rate
W0619	Warning	Chiller sensor other problems warning
E0620	Error	Chiller sensor other problems warning
W0621	Warning	Chiller communication lost
E0622	Error	Chiller communication lost
W0623	Warning	Chiller water temperature out of range
E0624	Error	Chiller water temperature out of range
W0625	Warning	Chiller water flow rate out of range
E0626	Error	Chiller water flow rate out of range
E0627	Error	Bars critical temperature reached

7.2.7 Timing errors and warnings

Table 30. Timing errors and warnings

Code	Type	Description
W0700	Warning	Timing parameters are out of range
W0701	Warning	External frequency is out of range
W0702	Warning	Requested burst P parameter exceeds limit, maximum possible P number is set
W0703	Warning	Requested burst N parameter exceeds limit, maximum possible N number is set

7.2.8 Heating errors and warnings

Table 31. Heating errors and warnings

Code	Type	Description
W0800	Warning	Heating element doesn't work properly
W0801	Warning	Heating sensor doesn't work properly

7.2.9 Stretcher-Compressor errors and warnings

Table 32. Stretcher-Compressor errors and warnings

Code	Type	Description
W0901	Warning	Compressor cannot reach target position
W0902	Warning	Current compressor position is not calibrated. Pulse duration is unknown
E0903	Error	Compressor humidity is too high
E0904	Error	Compressor limit switches don’t work properly

7.2.10 Safety errors and warnings

Table 33. Safety errors and warnings

Code	Type	Description
E1000	Error	RA stopped unexpectedly
E1001	Error	RA power-lock failed
E1002	Error	Main power cannot be enabled
E1003	Error	HV cannot be enabled
E1004	Error	OSC LDD cannot be enabled
E1005	Error	RA LDD cannot be enabled
E1006	Error	RA cannot be enabled
E1007	Error	PP cannot be enabled
E1008	Error	OSC limits finding procedure timeout
E1009	Error	Altera failed to start the laser. Consider using newer low-level preset
E1010	Error	HV2 cannot be enabled
E1011	Error	Failed applying burst parameters
E1012	Error	LPHV can not be enabled
E1013	Error	LPHV2 can not be enabled
E1014	Error	Oscillator start failed
E1015	Error	FEC is not responding
E1016	Error	LPHV stopped unexpectedly
E1017	Error	LPHV2 stopped unexpectedly
E1018	Error	Switching ns mode failed
E1019	Error	PP trigger source is unknown
E1020	Error	Invalid preset
W1021	Warning	Maximum harmonics pump energy exceeded

7.3 Known issues

7.3.1 Laser unresponsive to external communication via direct commands or via control applications

Problem description: In some cases the laser may become unresponsive, this is characterized by unresponsiveness to commands from the control applications such as the User App or the Service App, as well as direct communications via REST or similar methods. The laser will also stop broadcasting status information, such as states, output power, etc.

Solution: The laser must be powered down completely:

1. Press and hold the power button on the rear side of the laser for 2-5 seconds.
2. Disconnect the 24V AC/DC supply from the mains AC.
3. Wait around 30-60 seconds, then reconnect the power supply back into the mains.

8 APPENDIX 1. CARBIDE electrical circuits related to personal safety

Table 34. Applicable safety standards

Applicable standards	EN 60825-1
	ISO 12100
	EN 13849-1

8.1 Safety Shutter

Table 35. Safety shutter models

Safety shutter models	E01-300-10 / E02-310-05
	E01-300-11 / E02-310-05
	E01-300-12 / E02-310-05

8.1.1 Parameters

Table 36. Safety shutter parameters in accordance to EN 13849-1

Mean Time to Failure (MTTF)	607052 hours (69 years), or 1647 failures per 10^9 hours
Mean Time to Dangerous Failure ($MTTF_d$)	1236903 hours (141 years), or 808 failures per 10^9 hours
Performance level	**d**
Diagnostic Coverage	90.6%
Common Cause Failure	65
Service time	20 years
Designated architecture category	3
Process safety response time	<450 ms
Shutter gate close time	<100 ms
Maximal operational frequency	3 Hz

NOTICE

To comply with performance level d requirements, an additional switching unit must be used with the laser system. The purpose of this switch is to switch the laser off in the event of a shutter failure.

8.1.2 Safety Shutter Block Diagram

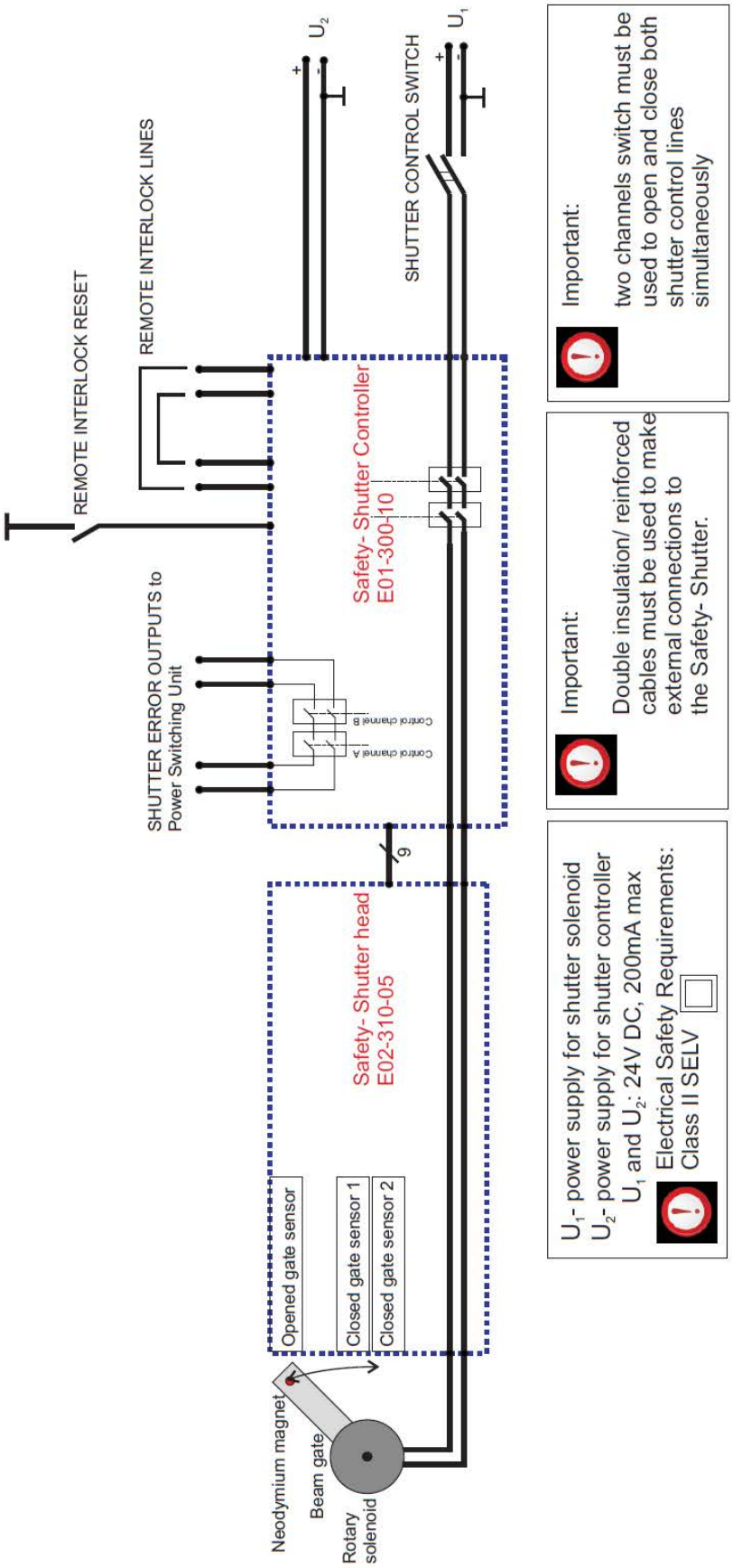


Figure 64. Safety shutter block diagram

Notes:

- Shutter control by means of operating and closing the shutter gate via “SHUTTER CONTROL SWITCH” or from the control software is the intended function of the system.
- Safety-shutter controller monitors if this function is performed properly and disrupts the “SHUTTER ERROR OUTPUTS” in the event of a detected failure.
- An additional emergency stop circuit is necessary to disrupt the laser power in the event of a shutter malfunction. Shutter functionality can be restored only by a cycle of completely powering off and then powering on the shutter controller.
- Activation (disruption) of the remote interlock circuit is considered an “abnormal” state and thus require a manual reset, performed via the “REMOTE INTERLOCK RESET” switch or from the control software to restore the shutter functionality.

8.1.3 Block Diagram for the personnel Safety System

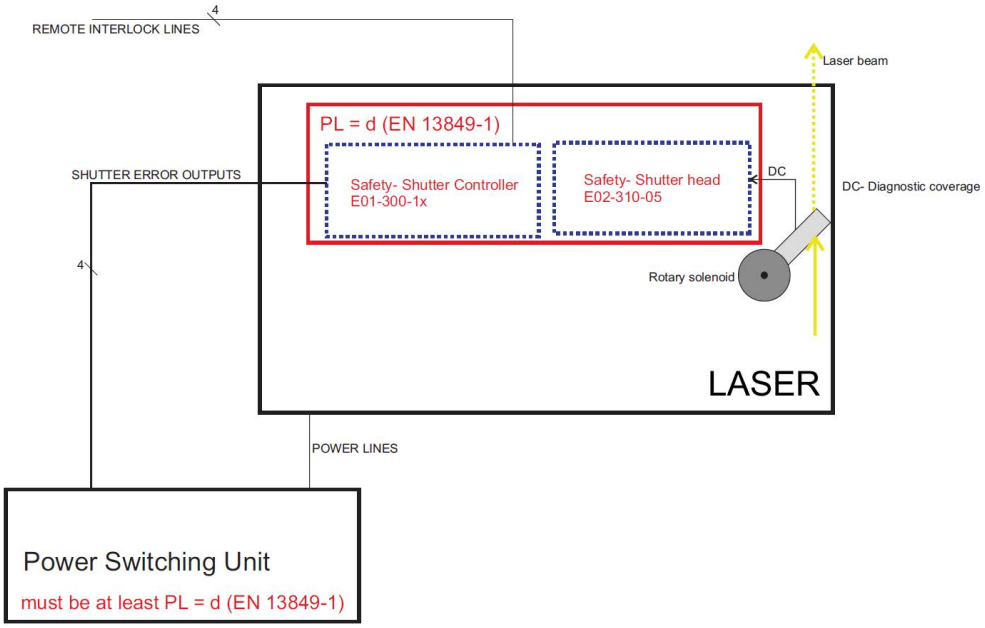


Figure 65. Safety shutter block diagram for personnel safety system

Notes:

- The function of the Power Switching Unit is to switch off the laser power (emergency stop) in the event of shutter failure.
- The Power Switching Unit is not a part of the laser system and must be provided by the integrator of the laser system.

8.1.4 Shutter Control Circuits

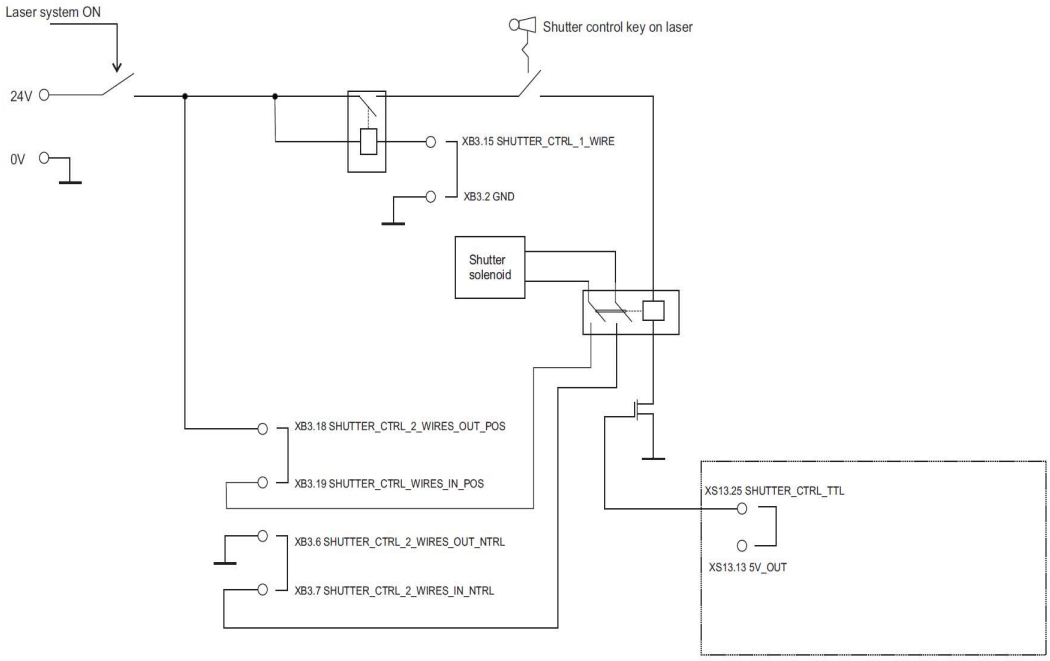


Figure 66. Shutter control circuits diagram

8.1.5 Options for Control

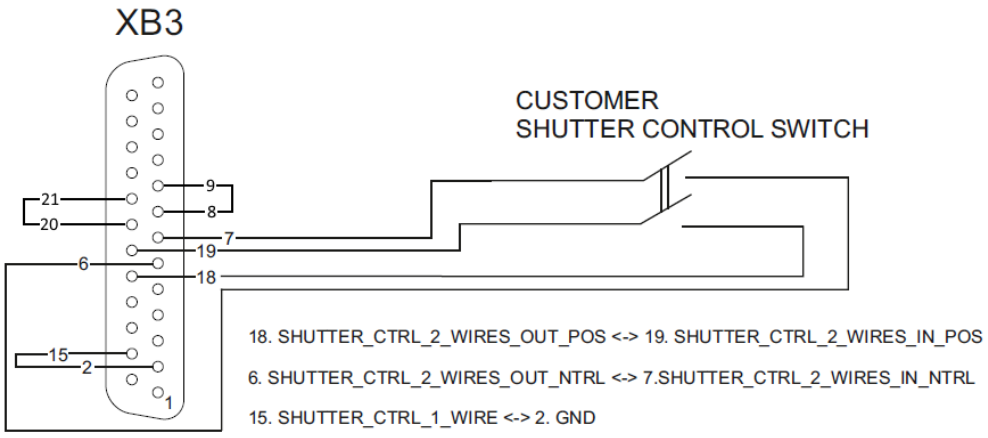


Figure 67. 2 Wire shutter control mode (mandatory to fulfill the requirements for performance level d)

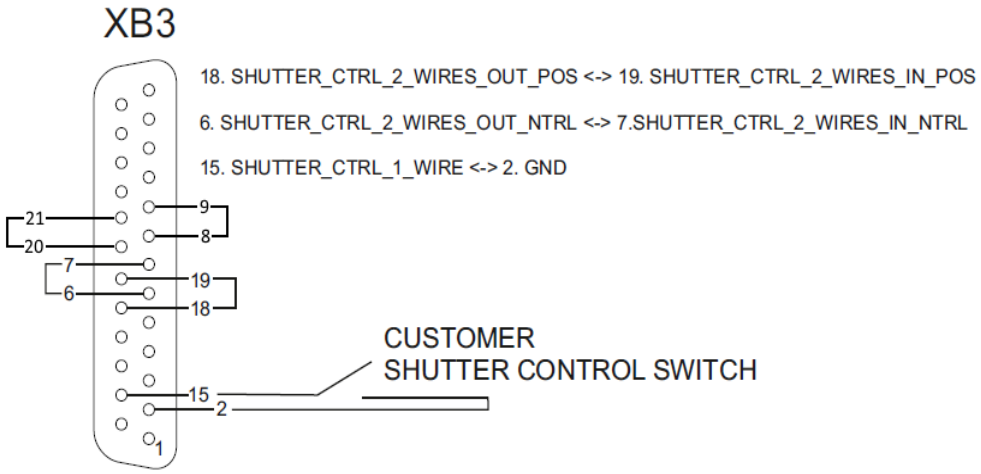


Figure 68. 1 Wire shutter control mode

8.1.6 Remote Interlock Circuit in Compliance with EN 60825-1

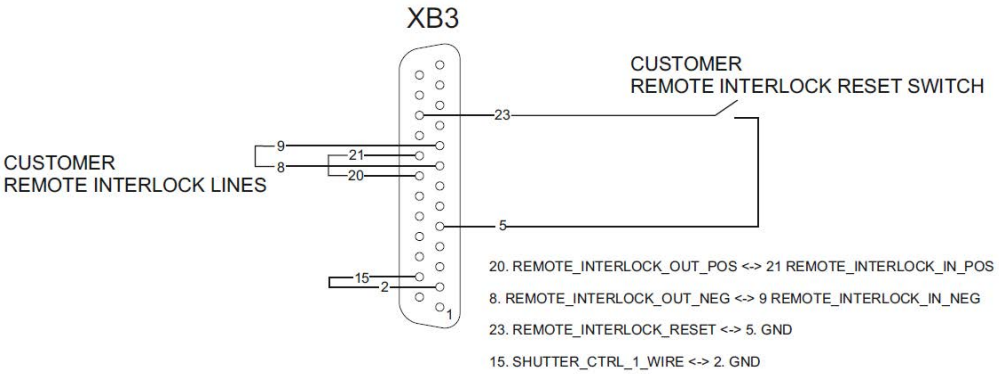


Figure 69. Remote Interlock Circuit in compliance with EN 60825-1

8.1.7 Recommended Emergency Stop Circuit

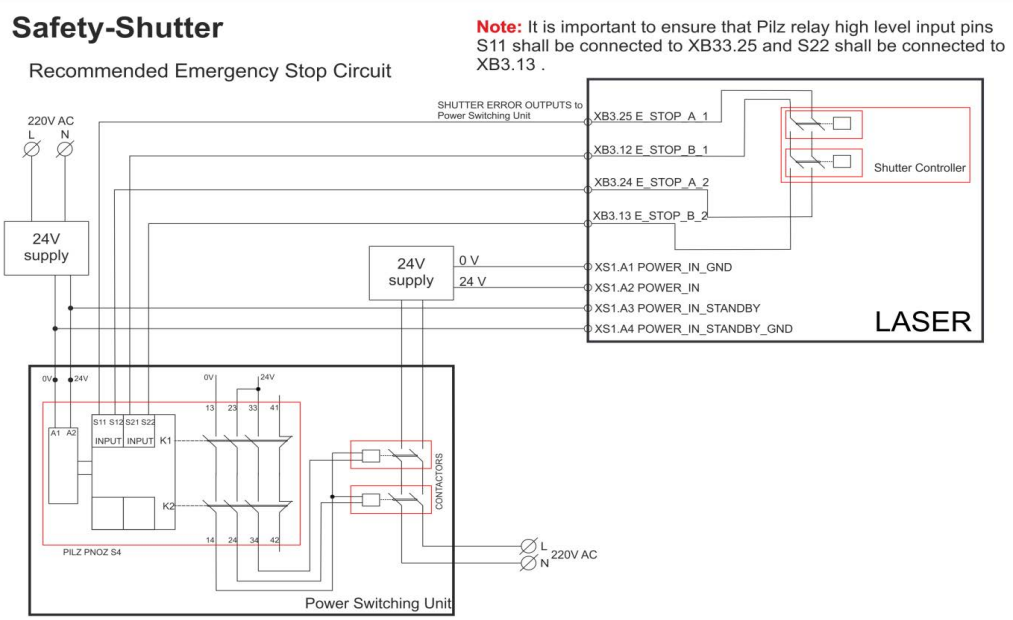


Figure 70. Recommended Emergency Stop Circuit diagram

Note:

- It is important to ensure that the Pilz relay high level input pin S11 is connected to XB3.25 and pin S22 is connected to XB3.13

8.1.8 Laser Emission and Laser Shutter indicators

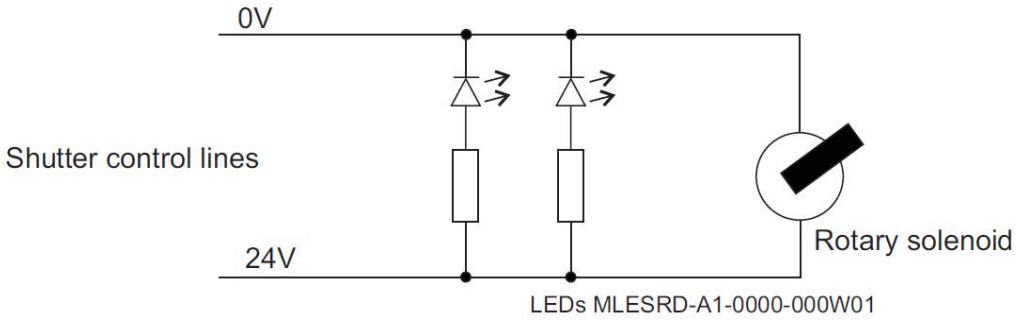


Figure 71. Connection diagram for the laser shutter indicator

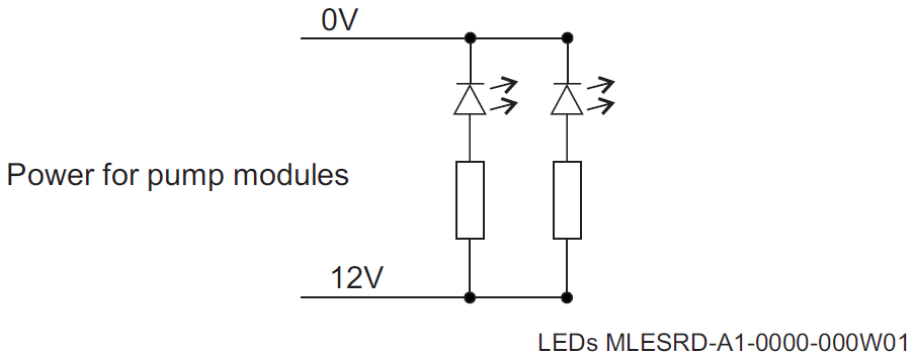


Figure 72. Connection diagram for the laser emission indicator

8.2 Other Safety Circuits

8.2.1 Fast Laser Stop Circuits

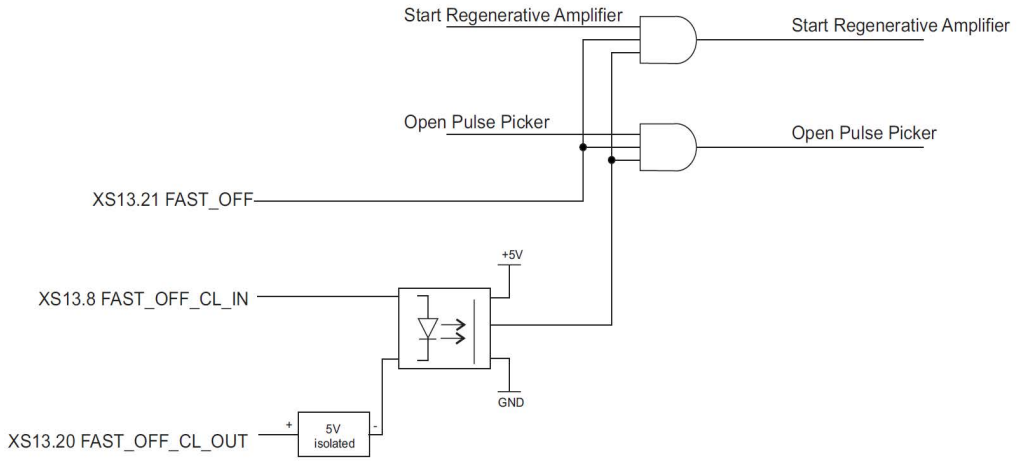


Figure 73. Fast-loop stop circuit diagrams

Notes:

- The FAST_OFF is an effective safety precaution method, but due to its complexity, we cannot provide certified fail-safe reliability certification for this feature.
- The Fast Laser Stop circuits disables the laser emission on the next laser pulse. This function is utilized using simple hardware components (no Firmware or Software components are used).
- FAST_OFF trigger speed is at 10-150 ns, while in comparison, E-STOP reaction speed is <200 ms.
- After the FAST_OFF circuitry is activated, a subsequent software command follows which closes the shutter (shutter is closed when emission is already terminated by the E-STOP).
- The emission indicator does not indicate if FAST_OFF was triggered.
- FAST_OFF is a level-based signal.
- FAST_OFF_CL is a current loop signal.
- The Fast Laser Stop state is puts the system into a lock-down, which can be removed only after a full system reboot.

8.2.2 Using System Interlock with Shutter Control Electronics via FAST_OFF_CL <-> shutter control electronics

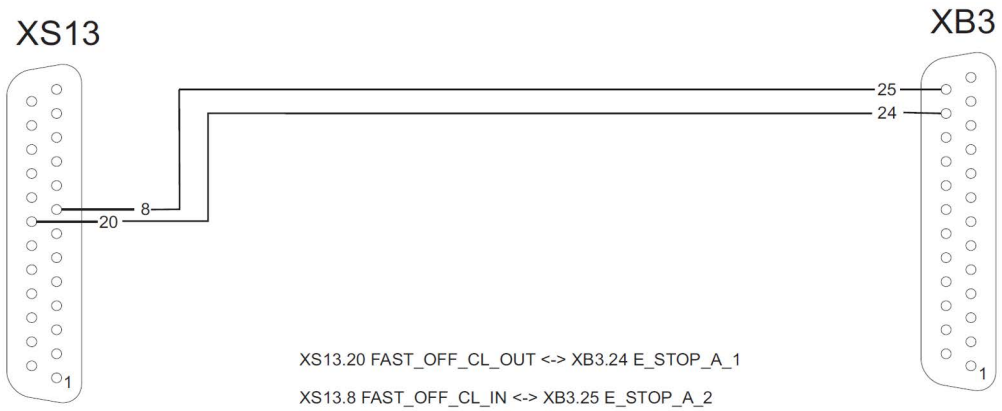


Figure 74. System interlock connection to shutter control electronics diagram

9 APPENDIX 2. Chiller connection for GHI based lasers

9.1 Introduction

Before approximately 2022 Q3, chillers were only semi-integrated into the entire laser control system. Until then they used a specific RS-232 connection and communication method which was limited in its capabilities. The new connection method requires that the laser is equipped with a Toradex computer, otherwise you cannot use the new connection. This section is present for special cases when the old chiller connection and communication method is necessary.

9.2 SMC chiller connection

The SMC chiller is controlled via the XB2 socket. The **SMC** chiller is connected to the laser via DB15 type socket (Marked as "CN2") from the chiller to socket XB2 on the laser. Please note that the SMC chiller must be connected by using the communication cable provided by Light Conversion. Note that the communication cable connectors are marked to which equipment that side should be connected.

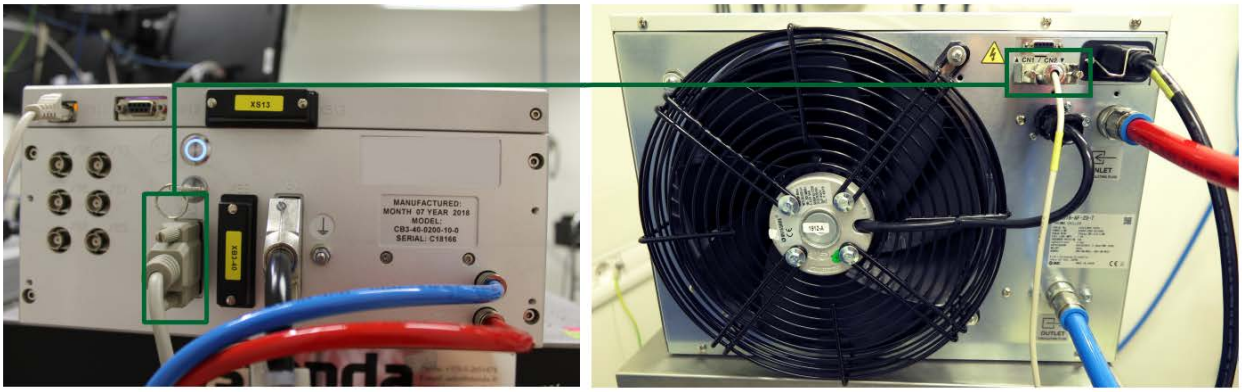


Figure 75. SMC chiller connection to the CARBIDE laser

9.3 Serial Control Connector (XB12 type DB9)

XB12 serial remote-control connector can be used to control the laser over a serial connection. Connector type: D-SUB 9 female. Connector pins description is presented in the table below.

Table 37. XB12 Serial remote-control pinout

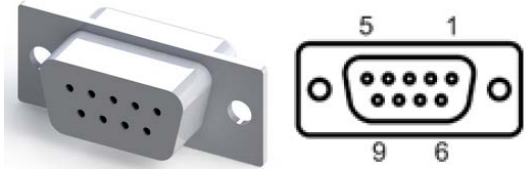
PIN	Name	Signal Type	Dir	Description
				
Type: D-SUB 9 female				
1	NC	-	-	Not connected

Table 37. XB12 Serial remote-control pinout

PIN	Name	Signal Type	Dir	Description
2	RS-485-A/ RS-232-TX	Logic	IN/OUT	Programmable dual purpose pin. RS-485 A pin and RS-232 TX pin
3	RS-485-B/ RS-232-RX	Logic	IN/OUT	Programmable dual purpose pin. RS-485 B pin and RS-232 RX pin
4	-	-	-	Shorted to pin 6 (Null Modem)
5	ISO-GND	GND		Isolated ground reference of RS-232 and RS-485
6	-	-	-	Shorted to pin 4 (Null Modem)
7	-	-	-	Shorted to pin 8(Null Modem)

BeO Material Data Safety Sheet

MATERIAL DATA SAFETY SHEET

SECTION I IDENTIFICATION

Beryllium Oxide Sintered Ceramic
Product Name: BERLOX®
Common Name & Synonyms: Beryllia
Chemical Name: BERYLLIUM OXIDE (BeO)
Chemical Family Beryllium Compound

24 Hour Emergency Assistance
Call Chemtrec at 800-424-9300

Customer Service
American Beryllia Inc
16 First Avenue
Haskell NJ 07420
Phone 973-248-808
Fax 973-248-8013
Website www.AmericanBeryllia.com

Hazard Rating		
Least 0	Slight 1	Health 2
Moderate 2	High 3	Fire 0
Extreme 4		Reactivity 0

SECTION II HAZARDOUS INGREDIENTS

CONSTITUENTS	C.A.S. NO.	PERCENTAGE
BERYLLIUM OXIDE	1304-56-9	99.5%

SECTION III OCCUPATIONAL STANDARDS (BERYLLIUM)

*All Concentrations Are In Milligrams Per Cubic Meter Of Air

	OSHA*			ACGIH*	
Substance	**PEL**	**CEILING**	**PEAK**	**TLV**	**TLV-STEL**
BERYLLIUM Niosh rtecs# DS 4025000	0.002	0.005	0.025	0.002	0.01

ACGIH: =American Conference of Governmental Industrial Hygienists
OSHA =Occupational Safety and Health Administration
PEL =Eight Hour Average Permissible Exposure Limit
CEILING =Not To be Exceeded Except For Peak Limit
PEAK =30 Minute Maximum Duration Concentration Above Ceiling Limit (OSHA)
TLV =Eight Hour Average Threshold Limit Value (ACGIH)
TLV-STEL =15 Minute Short Term Exposure Limit (ACGIH)
CAS =Chemical Abstract Service
NIOSH =National Institute for Occupational Safety and Health
RTECS =Registry of Toxic Effects of Chemical Substances

The American Conference of Governmental Industrial Hygienists (ACGIH) recommends occupational standards for all listed substances. The ACGIH defines a threshold limit value standard as follows:

Threshold Limit Values refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. Because of wide variation in individual susceptibility, however, a small percentage may be of workers may experience discomfort from some substances at concentrations at or below the threshold limit; a smaller percentage may be affected more seriously by aggravation of a preexisting condition or by development of an occupational illness. Individuals may also be hyper susceptible or otherwise unusually responsive to some industrial chemicals because of genetic factors, age, personal habits (smoking, alcohol, or other drugs), medication, or previous exposures. Such workers may not be adequately protected adverse health effects from certain chemicals at concentrations at or below the threshold limits.

SECTION IV PHYSICAL & CHEMICAL PROPERTIES

Boiling Point (F): N/A
Evaporation Rate: N/A
Freezing Point: N/A
Odor: None
PH: N/A
Physical State: Solid
Color: White to Off-White
Density: 2.85 gm/cc
Radioactivity: N/A
Solubility: Insoluble in water
Vapor Density: N/A (Air = 1
Vapor Pressure: N/A (mm/Hg)
Melting Point(C): 2547
% Volatiles by Volume: N/A
Molecular Weight: 25.01

SECTION V STABILITY & REACTIVITY

General reactivity: This material will not further decompose upon heating
Incompatibility (Materials to avoid): N/A
Hazardous Decomposition: None under normal use products.
Hazardous Polymerization: Will not occur
Flash Point: N/A
Flammable Limits: LEL N/A UEL N/A
Conditions and Materials to Avoid: Volatile Beryllium Hydroxide can be formed when firing solid Beryllium Oxide parts at high temperature (over 1200°C) and in moist atmospheres.

SECTION VI HEALTH HAZARDS

Potential Health Effects
Although this material is supplied in a clean, solid state, exposure can occur during subsequent operations involving any form of machining, grinding, sanding, polishing, crushing, or abrading. Operations requiring chemical cleaning, heat treating, melting, brazing, metalization, or laser cutting can also generate respiratable particulates*
*Particulate refers to any dust, fame, mist or fragment.

Inhalation:
Particulates containing Beryllium can cause irritation to the nose, throat, lungs, and mucous membranes. Inhaling beryllium containing particulates may cause chronic Beryllium Disease, a serious chronic lung disease with cough, chest pain, shortness of breath, weight loss, weakness, fatigue and possibly fatal. Chronic Beryllium Disease may be related to genetic factors in which hypersensitivity or allergic condition cause inflamed lung tissues and fibrosis (scarring).

Ingestion:
Ingestion can occur from contaminated hand, clothing, food or drink contact. The effects of Beryllium ingestion are unknown.

Skin:
Skin contact with Beryllium may cause an allergic response with redness, itching, and pain in some sensitive individuals. Particles lodged under the skin or in open wounds may reduce may induce infections, skin lesions, and sensitization.

Eyes:
Eye exposure to airborne particulates or contaminated hands or clothing may cause irritation or mechanical injury.

Carcinogenic References:
Beryllium Oxide: The International Agency for Research on Cancer (IARC) lists beryllium as a Group 1- Known human Carcinogen. The National Toxicology Program (NTP) lists beryllium s reasonably anticipated to be a human carcinogen. The ACGIH lists beryllium as an A1- Confirmed Human Carcinogen.
The above determinations are based on intense exposure to beryllium, pre 1950 to workers involved in the refining, machining, and production of beryllium metal.

SECTION VII FIRST AID

Inhalation: Remove from source of exposure to fresh air. Perform artificial respiration if breathing has stopped and obtain medical help.

Ingestion: Find solid beryllium oxide ceramics are indigestible. Induce vomiting if necessary as directed by medical personnel.

Eyes: Immediately flash eyes with plenty of water for 15-20 minutes. Obtain medical attention.

Skin: Use standard first aid procedures to clean, disinfect, and cover all wounds to avoid infections and contamination before continuing work. Obtain medical attention for wounds that result in material implanted or lodge under the skin.

SECTION VIII EMPLOYEE PROTECTION

Respiratory Protection: NIOSH approved high efficiency cartridge or supplied air mask is required if Beryllium in air concentrations exceeds OSHA standards.

Eye Protection: None required except as related to normal operations.

Protective Gloves: None normally required except where skin abrasions or cuts may occur during handling.

Other Protective Equipment: Personnel performing operations where there are exposures to dust, mists, or fumes should be provided full-body protective clothing.

Ventilation: Provide adequate local exhaust ventilation when performing operations such as machining, grinding, laser trimming, sand blasting, chemical etching, etc. where respirable dusts, mists, or fumes are generated. Powdered materials must be stored in sealed containers; transfers must be made in ventilated hoods. Operations generating airborne material must be sampled to determine exposure level. Medical surveillance should be conducted for employees where warranted by exposure date. Concentrations of suspended Beryllia in liquid coolants used for machinery should be kept low to avoid particulate matter from becoming airborne.

SECTION IX SPECIAL PRECAUTIONS

Precautions for Handling and Storing: Store in closed containers. Handling solid Beryllium Oxide ceramics is harmless so long as they are kept dust-free. Avoid any operations which would create respirable dusts or mists.

Spill or Leakage Precautions: Clean any loose material using wet cleaning or properly equipped vacuum cleaner supplied with Hepa filters. Personnel involved in cleanup should wear proper respirator and protective clothing.

SECTION X SPECIAL PRECAUTIONS

EPA Emission Standard (As Beryllium) - National Emission Standard for Beryllium (40 CFR 61, Subpart C)
0.01 Micrograms per cubic meter (30 day average) Ambient Air Standard
10 Grams /24 Hrs. Total Site Emission Limit
EPA Wastewater Regulations - Regulations are pending contact local and state governments for applicable standards.

NOTE: State and Local Regulations may vary

D.O.T. REGULATIONS- None for shipment of BeO Ceramic high fired material. Inner package warning label denoting beryllium product as shown below.

BERYLLIA CERAMIC
DANGER-INHALATION OF DUST OR FUMES MAY CAUSE SERIOUS CHRONIC LUNG DISEASE
POTENTIAL CANCER HAZARD BASED PRINCIPALLY ON ANIMAL TESTS
This product contains beryllium and may contain nickel. Overexposure to beryllium by inhalation may cause berylliosis, a serious chronic lung disease. Hazard Communication Regulations of the Occupational Safety & Health Administration require that caution labels for materials listed as potential carcinogens in either the International Agency for Cancer Research Monograph Series or the National Toxicology Program Annual Report on Carcinogens must contain a cancer warning. Beryllium and nickel have so listed.

* If processing produces dust or fumes, use only with exhaust ventilation or other controls designed to meet OSHA standards.
* Solid for manufacturing purposes only.
See Material Safety Data Sheets on file with your employer for further details concerning OSHA standards and precautionary measures.

SECTION XI WASTE DISPOSAL METHOD

Because of its value Beryllium Oxide scrap is normally recycled. In cases where economics do not justify the segregation of Beryllium Oxide scrap for resale, solid material may be landfilled. Because of the potential inhalation hazard of handling this material as a discarded powder (such as baghouse fines) we recommend it be: 1) Sealed in two plastic bags, 2) placed within a DOT container approved for Poison B compounds, 3) label the outer container with the appropriate DOT Hazard Warning Labels, and 4) Ship to an approved hazardous waste disposal site.

Solid wastes must be managed and disposed of, in accordance with federal, state and local requirements. This material is not classified a hazardous waste under federal law.

MARCH 1986/REV JUNE 1986

Declaration of Conformity

Manufacturer	Light Conversion, UAB Telephone: +370 5 2491830 FAX: +370 5 2698723 Email: company@lightcon.com Internet: http://www.lightcon.com Address: Keramikų str. 2B, LT-10233 Vilnius, Lithuania
Product	Femtosecond laser system “CARBIDE” (models CB3-xxx) With optional harmonics modules (models CBM03-xx)

The manufacturer declares that the above products and manufacturing environment satisfy the requirements of following applicable Directives and Regulations:

- 2014/30/EU Electromagnetic compatibility Directive
- 2014/35/EU Low voltage Directive
- 1907/2006 REACH Regulation
- EU 2015/863 RoHS 3Directive
- 2006/42/EC Machinery Directive
- 89/391/EEC Workplace Health and Safety Framework Directive
- 2009/104/EC Directive concerning the minimum safety and health requirements for the use of work equipment by workers at work

Compliance was demonstrated for the following specifications:

EN 55011:2016 EN 55011:2016/A1:2017	Industrial, scientific and medical equipment - Radio-frequency disturbances characteristics: Conducted disturbance at the AC mains terminals.
EN 55032:2015 EN 55032:2015/AC:2016-07	Electromagnetic compatibility of multimedia equipment - Emission Requirements: Conducted emission from wired network ports.
EN 55011:2016 EN 55011:2016/A1:2017	Industrial, scientific and medical equipment - Radio-frequency disturbances characteristics: Radiated disturbance (only Class A)
EN 61000-3-2:2014	Harmonic current emission
EN 61000-6-2:2005 EN 61000-6-2:2005/AC:2005 EN 61000-4-2:2009	Electrostatic discharge immunity test
EN 61000-6-2:2005 EN 61000-6-2:2005/AC:2005 EN 61000-4-3:2006 EN 61000-4-3:2006/A1:2008	Radiated RF electromagnetic field immunity test

EN 61000-4-3:2006/A2:2010	
EN 61000-6-2:2005 EN 61000-6-2:2005/AC:2005 EN 61000-4-4:2012	Electrical fast transients/burst immunity test (AC mains power and IO signal/control ports)
EN 61000-6-2:2005 EN 61000-6-2:2005/AC:2005 EN 61000-4-5:2014	Surges immunity test
EN 61000-6-2:2005 EN 61000-6-2:2005/AC:2005 EN 61000-4-6:2014	Electrical fast transients/burst immunity test (AC mains power and IO signal/control ports)
EN 61000-6-2:2005 EN 61000-6-2:2005/AC:2005 EN 61000-4-11:2004/A1:2017 EN 61000-4-11:2006/A1:2008	Voltage dips and short interruptions immunity test
EN 61010-1:2011	Safety requirements for electrical equipment for measurement, control and laboratory use. Part 1: General requirements
IEC 60825-1+A1+A2:2014	Safety of laser products-Part 1: Equipment classification and requirements

Signature: 

Printed Name: Darius Mikalauskas

Title: Quality Manager

Date: 2020-03-04 Vilnius

Document is managed in document control system, Code: CB3-D-DCL-02, Id: 1878

Declaration of Conformity to EU RoHS

Manufacturer

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Email: company@lightcon.com
Internet: http://www.lightcon.com
Address: Keramikų str. 2B, LT-10233 Vilnius, Lithuania

The manufacturer declares under sole responsibility that the products

Femto-second laser systems "***CARBIDE***" models "**CB3**-xxx"

are in compliance with Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 as amended by (EU) 2015/863 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (also known as "RoHS 3"). Products listed in this declaration do not contain the substances listed in the table below in concentrations greater than the listed maximum value.

Substance	Maximum limit (ppm)
Lead (Pb)	1000
Cadmium (Cd)	100
Mercury (Hg)	1000
Hexavalent Chromium (Cr^{6+})	1000
Poly Brominated Biphenyls (PBB)	1000
Poly Brominated Diphenyl ethers (PBDE)	1000
Bis (2-Ethylhexyl) phthalate (DEHP)	1000
Benzyl butyl phthalate (BBP)	1000
Dibutyl phthalate (DBP)	1000
Diisobutyl phthalate (DIBP)	1000

Vilnius, 2020-02-25

Darius Mikalauskas, Quality Manager

List of Hazardous Materials Used in Product

Manufacturer

Light Conversion, UAB
Telephone: +370 5 2491830
FAX: +370 5 2698723
Email: company@lightcon.com
Internet: http://www.lightcon.com
Address: Keramikų str. 2B, LT-10233 Vilnius, Lithuania

The manufacturer declares under sole responsibility that the products

Femto-second laser systems "***CARBIDE***" and "***CARBIDE-alpha***"

to the best of our knowledge, contain these hazardous materials:

Material	Quantity	Area in use
BeO ceramics	< 3 grams	Pockels Cell drivers

Vilnius, 2019-02-11

Darius Mikalauskas, Quality Manager

Laser classification

Manufacturer	Light Conversion, UAB Telephone: +370 5 2491830 Email: company@lightcon.com Internet: http://www.lightcon.com Address: Keramikų str. 2B, LT-10233 Vilnius, Lithuania
Product	Femtosecond laser systems "**CARBIDE**" Models CB3-xxx

The manufacturer declares that the above products are classified as Class 4 laser based on EN 60825-1:2014, clause 5. Laser beam parameters are defined by:

- Maximal average output power < 80W
- Maximal pulse energy < 800uJ
- Output wavelengths:
  - 1030 nm ± 5 nm
  - 515 nm ± 3 nm
  - 343 nm ± 2 nm
  - 257 nm ± 1nm

Vilnius, 2021-05-26

Darius Mikalauskas, Quality Manager

Document is managed in document control system, Code: CBx-D-DCL-03, Id: 377

Declaration of Conformity

Manufacturer

Light Conversion, UAB
Telephone: +370 5 2491830
FAX: +370 5 2698723
Email: company@lightcon.com
Internet: http://www.lightcon.com
Address: Keramikų str. 2B, LT-10233 Vilnius, Lithuania

The manufacturer declares that the Safety - Shutter controllers used in femtosecond laser systems ***PHAROS***, ***CARBIDE***, ***CARBIDE-alpha*** meet requirements of performance level **d** as defined by EN 13849-1:2008 (reference "Technical report of the Type testing of the Laser System Interlock Safety Shutter", Report no.LV86359T, 2014-12-23, TÜV SÜD Rail GmbH, Embedded Systems, Barthstraße 16, D-80339 München).

Safety function	***Activation of emergency stop signal on shutter failure***			
Type of safety function	***Monitoring of safety-related parameters***			
Reliability parameters				
Laser models	**Safety Shutter version (controller version / Sensors board version)**			
PHAROS models PH1, PH2	E01-300-10/ E01-310-05	E01-300-11/ E01-310-05	E01-300-12/ E01-310-05	E01-300-13/ E01-310-05
CARBIDE models CB1, CB3, CB4, CB5	E01-300-10/ E01-310-05	E01-300-11/ E01-310-05	E01-300-12/ E01-310-05	E01-300-13/ E01-310-05
$MTTF_d$ (Mean time to failure dangerous):	141 years			
MTTF (Mean time to failure):	69 years	65 years		
DC_{avg} (Diagnostic Coverage)	91%			
CCF (Common Cause Failure)	65			
Performance level in accordance with EN 13849-1: 2008	**d**			

Vilnius, 2020-05-29

Darius Mikalauskas, Quality Manager

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