

## Laser module with cooling block and driver **LUxxxxDyyy, LU-CB2-TEC and DS11-LA18V08 driver**



Figure 1: Image of the driver unit (left) and the Laser module mounted into the cooling block (right).

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### Short description:

This document describes how to put the LUXXXXDYYY LASER MODULE WITH LU-CB2-TEC AND DS11-LA18V08 DRIVER into operation. Special care must be taken to ensure that during handling and operation of diode laser proper ESD/EOS practices are followed, and that the optical fiber pigtail is suitable protected from physical and thermal damage.

Lumics GmbH shall not be liable for errors in this manual or damages in connection with the use of this material. The information contained in this manual is subject to change without prior notice.

Read this operating instruction manual carefully before putting the LUXXXXDYYY LASER MODULE WITH LU-CB2-TEC AND DS11-LA18V08 DRIVER into operation.

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## 1. Preface

### 1.1 Laser Safety

The LUXXXXDYYY LASER MODULE WITH LU-CB2-TEC AND DS11-LA18V08 DRIVER system is a Laser CLASS 4 product.

Avoid any eye or skin exposure to direct or scattered radiation light emitted from the optical fiber output of the LUXXXXDYYY LASER MODULE.

Always use protective eyewear during operation of the laser. For guidance please consult user standards such as ANSI, ACGIH, or OSHA. Never open the protective housing of this laser.

The LUXXXXDYYY LASER MODULE WITH LU-CB2-TEC AND DS11-LA18V08 DRIVER is an OEM product for incorporation into other equipments and is only to be used as component. Lumics customer is responsible for CDRH (center for devices and radiological health) certification of all systems sold with this product.

Do not open the diode laser system. All the service and maintenance work should be performed by Lumics employees only.

### 1.2 Optical Safety

The diode laser system is a source of intense light having characteristics that are very different from the light emitted from conventional light sources. Therefore, before attempting to operate the laser, the user must be aware of these characteristics of laser light and the proper safety precautions. The energy level of the laser beam is high enough to cause serious injury to the eye and skin, with for example probable loss of vision if the beam were to pass directly or indirectly into the eye. When the laser beam is collimated, the energy in the beam remains high and dangerous even at great distances from the laser.

### 1.3 Electrical Safety

The DS11-LA18V08 includes a power supply. The voltage involved and the current available have the potential to cause fatal electric shock. Do not switch on the unconnected power supply.

### 1.4 Safety Recommendations for using the Laser

Review the following safety precautions before operating the laser system:

**NEVER LEAVE THE LASER ON, OPEN, AND UNATTENDED!**

1. Never open the laser cover.
2. Remove the power supply when not operating the diode laser.
3. Do not allow untrained and not experienced personnel to handle the laser.
4. When the laser is on, and the output beam is not being terminated during an experiment or optics system, the beam should be blocked.

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5. NEVER LOOK DIRECTLY INTO THE MAIN LASER BEAM
6. Remove the power supply when inspection or cleaning the fiber connector
7. Always avoid placing reflective objects in the laser beam. Laser light scattered from a reflective surface can be as damaging as the original beam.
8. Post warning signs when laser is in operation, limit access to the laser area.

## 1.5      Warranty

Lumics warrants the **LUXXXDYXX LASER MODULE WITH LU-CB2-TEC AND DS11-LA18V08 DRIVER** to be free from defects in material and workmanship for 12 months from the date of shipment if not agreed differently and confirmed by Lumics to the customer. If any item of the laser fails during the warranty period specified above, return the item freight prepaid to Lumics. Lumics will, at its option, repair or replace the defective item and return it freight prepaid to your facility. Any attempt by the user to repair any **LUXXXDYXX LASER MODULE WITH LU-CB2-TEC AND DS11-LA18V08 DRIVER** during the above warranty will void the warranty.

After the expiration of the warranty period, Lumics will repair the item on a time and material cost basis, provided the defective item is returned to Lumics.

Please follow the Lumics return policy stated in our home page: <http://www.lumics.com/RMA.382.0.html>  
Or contact Lumics during regular business hours.

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Tel. +49 30 678 0676-0  
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[www.lumics.com](http://www.lumics.com)

## 1.6      Disposal

- The packing materials can be recycled.
- Laser driver, laser module and cooling block: Disconnect them from their power supply.
- Laser driver, laser module and cooling block may not be treated as household waste. Instead, make sure that the devices are disposed according to your local rules for waste disposal for electrical/electronic devices (e.g. a collection point for the recycling of electrical/electronic equipment).



## 2. Installation

### 2.1 Mounting to heat sink, electrical wiring, and optical fiber output

The diode laser LUXXXDYXX LASER MODULE WITH LU-CB2-TEC AND DS11-LA18V08 DRIVER is very sensitive to over-current and static discharge. Operate it only in an environment with appropriate grounding and antistatic precautions. See the figures 2, 3 and 4 for illustration of the mechanical mounting, the electrical wiring and the optical fiber connection described in this section.

If you have just received the LUXXXDYXX LASER MODULE WITH LU-CB2-TEC AND DS11-LA18V08 DRIVER diode laser please wait at least 3-4 hours at room temperature, before operating the device. This is simply to balance any temperature variations which might have occurred during transportation.



Figure 2 (a): Mounting the LUxxxxDyyy onto the cooling block.

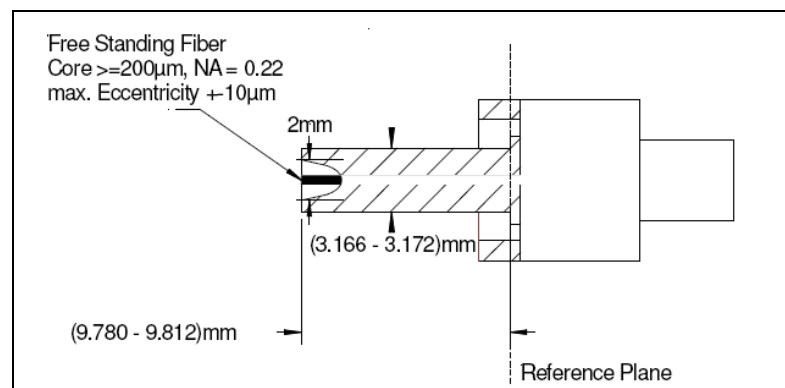
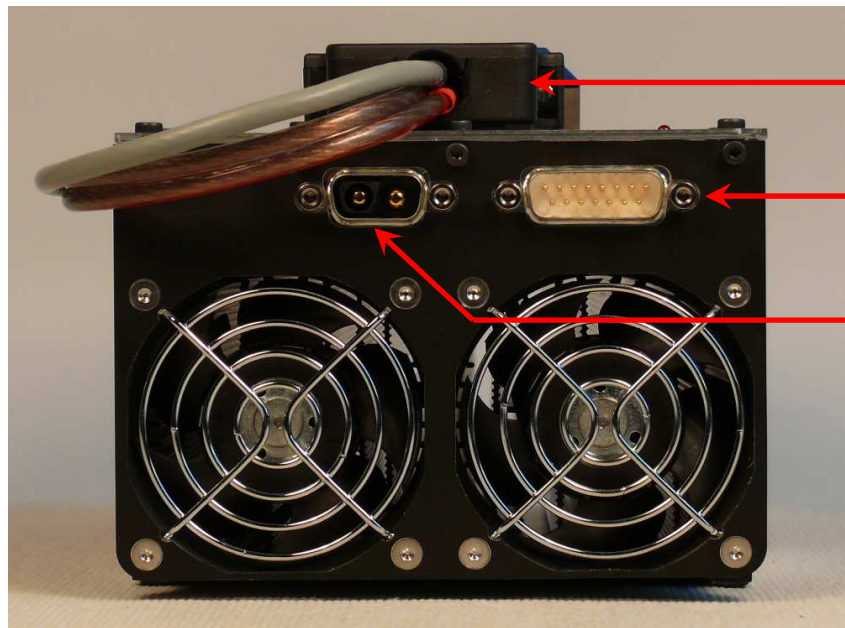


Figure 2 (b): SMA connector



Connector for LuOcean Mini  
(LUxxxxDyyy laser module)

Support connector on cooling block  
(internally wired to LuOcean Mini  
connector) \*

Laser connector  
(internally wired to LuOcean Mini  
connector) \*

\*: only when ordered option  
„Open System - Assembly & Test“

Connector	Pin No.	Signal abbr.	function
Support connector	1	FSUP	Fiber Sensor Supply +12..13V **
Support connector	2	FIN	Fiber Sensor Signal **
Support connector	3	SENINP	Temperature Sensor Input (NTC), bridge to pin 11 **
Support connector	4	LED+	“Laser On” LED (+)
Support connector	5	PL+	Pilot Laser (+) **
Support connector	6	PDV	Monitor diode voltage (+) **
Support connector	7; 8	PEL+	Peltier element (+)
Support connector	11	SENSUP	Temperature Sensor Supply (NTC), bridge to pin 3 **
Support connector	12	GND	Common Ground
Support connector	13	1..24V	1..24V Supply for Fans
Support connector	14; 15	PEL-	Peltier element (-)
Laser connector	A1	LDA+	Laser Anode
Laser connector	A2	LDC-	Laser Cathode
Connector of LuOcean Mini	1		Fiber Sensor Signal 1
Connector of LuOcean Mini	2		Fiber Sensor Signal 2 *
Connector of LuOcean Mini	3		Fiber Sensor / Monitor Diode 12V
Connector of LuOcean Mini	4		Fiber Sensor (GND) LM35 (GND) Monitor Diode (GND)
Connector of LuOcean Mini	5		LM35 Signal (NTC *)
Connector of LuOcean Mini	6		Monitor Diode Signal 2 *
Connector of LuOcean Mini	7		Monitor Diode Signal 1
Connector of LuOcean Mini	8		Pilot Laser (GND)
Connector of LuOcean Mini	9		LM35 5V (NTC *)
Connector of LuOcean Mini	10		Pilot Laser 3V

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Connector of LuOcean Mini	A1		Laser Diode (+)
Connector of LuOcean Mini	A2		Laser Diode (-)
Connector of LuOcean Mini	A3		N. C.

\* = optional

\*\* = has to be wired up to the LUxxxxDyyy laser module if no „Open System - Assembly &amp; Test“ is ordered

Figure 2 (c): Pin-out for the connector on the cooling block.

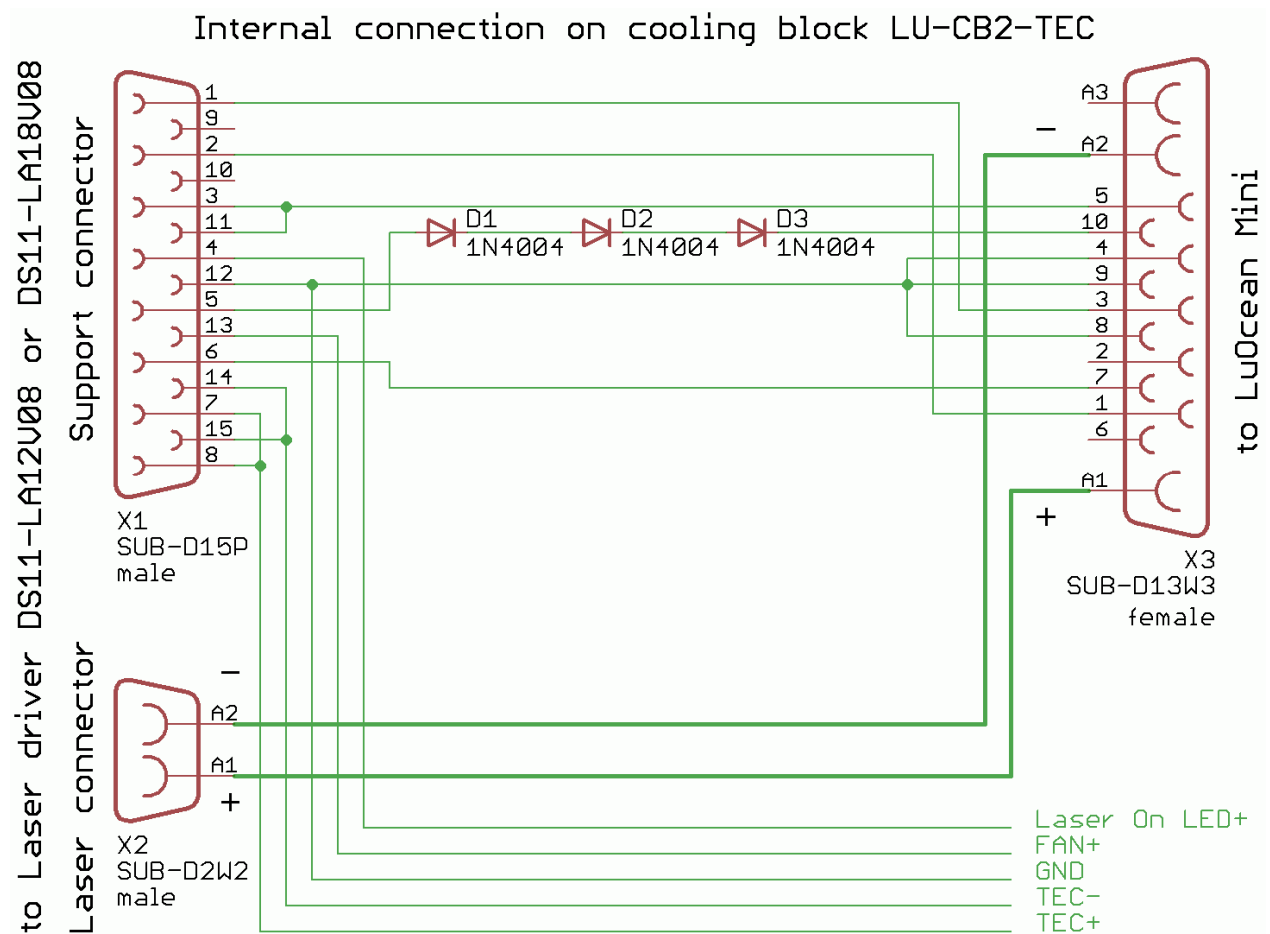


Figure 2 (d): Internal connection on cooling block LU-CB2-TEC when using Lumics Laser driver DS11-LA12V08 or DS11-LA18V08



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Perform the following steps for installation:

Mount the LUxxxxDyyy laser module onto the heat sink (see figure 2(a)):

This procedure is not needed if the cooling block is delivered with the laser module already mounted.

- a) Put the diode laser onto the mounting block and tighten the enclosed 4 mounting screws with spring washer. Use dynamometric screwdriver with 0.9Nm. Thermal pads or heat sink compound may be used to assure good thermal conductivity.

Optical output SMA fiber connector (see figure 2(b)):

- b) The LUxxxxDyyy laser module could be operated with different types of output fiber cables with SMA905 connector (see Figure 2(b)). High power SMA connector with free standing fiber is only necessary for optical output power of more than 40W. Optical fiber is a multi mode fiber with 105, 200, 400 or 600µm core diameter (depending on exact product type, see data sheet) and numerical aperture 0.22. The fiber centricity should be better than  $\pm 10\mu\text{m}$  ( $\pm 5\mu\text{m}$  for the 105µm fiber option).

Use a fiber microscope to inspect the facet of the optical fiber before connecting it to the laser. Make sure that the facet of the output fiber is absolutely clean and free of particles, grease or any other contamination. Use a clean-room compatible tissue, put some Isopropyl alcohol onto it and carefully clean the facet of the fiber facet or connector facet, or use special fiber cleaning tools. For more details see section 3.3.

The connector is now ready to be mounted into customer's optical head.

It is recommended to adjust the fiber ferrule to maximum power, especially in case of 105µm core and if the fiber has poor centricity. In order to perform an adjustment set the laser power at approximately 1-5W. Rotate the connector and then fix it when the maximum is reached. In case of a 105µm fiber option the pre adjustment is very important.

The fiber cable connector may become hot during operation due to scattered light. Refer to a cable manufacture for a maximal allowed operation temperature of the cable. Under normal conditions the connector must be able to dissipate about 2-4% of output power.

Do not bend a fiber with a radius smaller than minimum allowed bending radius for corresponding core diameter, (refer table 1 in attachment).

## **! Important note**

Never use an optical fiber with smaller core diameter or numerical aperture than it is specified.



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## Electrical connections:

- c) Wire-up the LUxxxxDyyy laser module according to the pin-out of its connector with the cooling block or your specific laser driver, in case you have ordered the cooling block without the laser diode driver. The pin-out of this connector is shown in Figure 2 (c) above.
- If you have ordered and received laser module, laser driver and cooling block without the option “Open System - Assembly & Test”, you should manufacture the electrical connection between LUxxxxDyyy laser module and cooling block according the schematics in Figure 2 (d) and two connection cables between Laser driver and cooling block (1x 2W2 Laser connection 1:1, 1x DSUB 15pole Support connection 1:1).
- Use following cross sections:  $2.5\text{mm}^2$  or more for laser connection and  $0.34\text{mm}^2$  or more for support connection.
- Note, that the three diodes 1N4004 in Figure 2 (d) are necessary to reduce the supply voltage for the red pilot from 5V delivered from the laser driver to 3V.

- d) If you have ordered and received the LuOcean Mini together with Lumics laser driver and cooling block with option “Open System - Assembly & Test”, you may proceed as follows:

Connect the enclosed cables on the cooling block to the corresponding connector on the back side of the laser diode driver (1x 2W2 Laser connection 1:1, 1x DSUB 15pole Support connection 1:1). The LuOcean Mini is pre-mounted onto the cooling block and electrically connected.

The last step is to connect the power cable to the power connector on the back side of the laser diode driver and plug into the 100V – 240V power line.

## Notes:

Figure 2 (e) shows how the temperature sensor (usually an NTC) is connected to the laser driver. Note that the bridge between SENSUP (Pin 11) and SENINP (Pin 3) is necessary for operation. This bridge should be realized on cooling block LU-CB2-TEC.

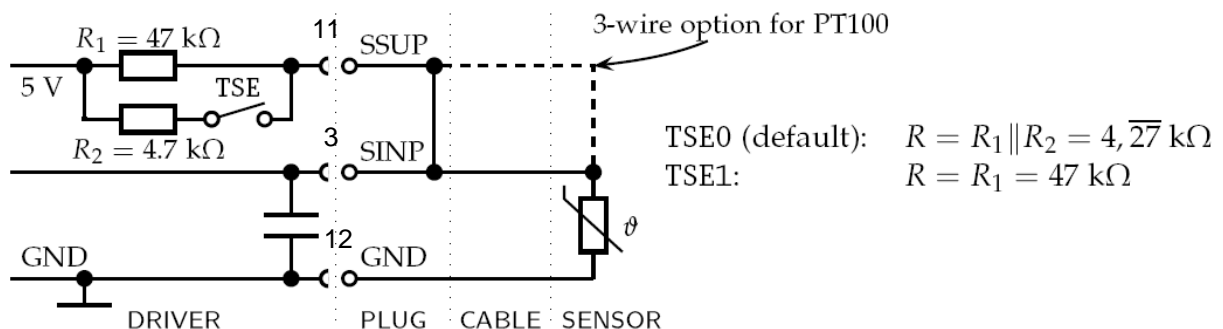


Figure 2 (e): Electrical connection of temperature sensor

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## 2.2 Replacement of the protection window (optional)

The Laser Module is optionally equipped with a replaceable protection window in the fiber output connector. Perform the following steps to replace the window. The replacement should be performed in a clean and dry environment. Any dust and moisture must be avoided.

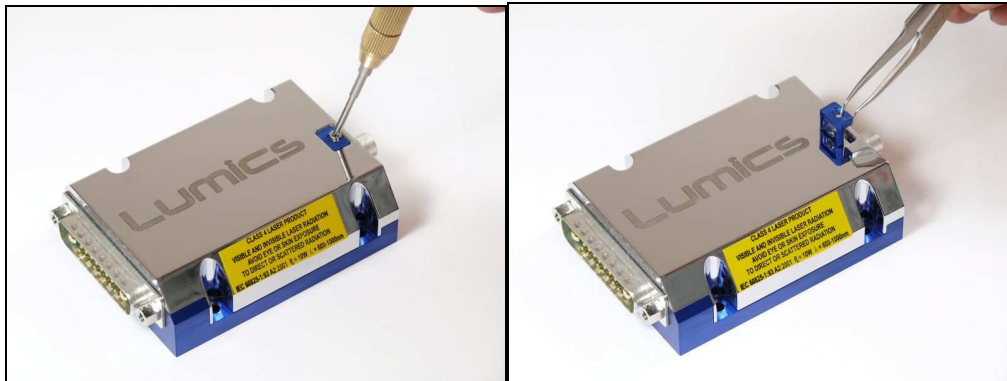


Figure 2 (f): Demonstration how to remove the protection window

1. Order the protection window from Lumics.
2. Turn the operating current to zero prior to window replacement. Ensure that there is no electrical current applied to the laser and to the signal connector. In case of uncertainty it is recommended to remove the signal connector.
3. Open the screw on top of the laser module which is close to the fiber output connector using a cross slot screw driver (see left part of Figure 2 (f))
4. Carefully pull out the window carrier by using an angled tweezer (see right part of Figure 2 (f))
5. Replace the window carrier with the window and put the new window back into the opening as show in the right part of Figure 2 (f).
6. Tighten the mounting screw as shown on the left part of Figure 2 (f).

Now the Diode laser is again ready for operation.

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### 3. Operation

Read the safety precautions information to fiber handling in section 3.2 and 3.3 carefully before putting the Diode Laser System into operation. You may also read the manual of the DS11-LA18V08.

#### Warning:

Make sure that the facet of the output fiber is absolutely clean and free of particles, grease or any other contamination. Use a clean-room compatible tissue, put some Isopropyl alcohol onto it and carefully clean the facet of the fiber facet or connector facet, or use special fiber cleaning tools. For more details see section 3.3.

Strong back reflection, could be absorbed on the facet of the laser diode and may result in overheating with possible damage of the laser. The optical system must be designed to reduce harmful back reflection.


#### 3.1 Putting the laser diode into operation


Perform the following steps in order to put the diode laser into operation. See the general Lumics Laser driver user manual in addition to this manual for further details about operating.

#### **! Important note**


If you have ordered and received the laser driver firmware with unlocked parameters and limits (for experiences users), please set-up all limits to a safe value according to the data sheet of your specific laser module. For this, please have a look at the general Lumics laser driver manual which is delivered separately, chapter Laser Control / Preparations.

- a) Turn the key switch at the back side of the power supply to the “on” position to start the driver.
- b) Ensure the interlock connector bridge (3.5mm jack) and the optical fiber is connected. Both are necessary to enable the interlock function.
- c) **TEC (option):**  
Adjust the TEC temperature now.

1) Move the cursor onto the upper right position marked as: “” and press ENTER repeatedly until you reach the TEC menu shown in Fig 5 below.

2) Move the cursor to position TT and insert the selected laser operating temperature value (typically 25°C) using the UP and DOWN keypads. Use the  key to change the position within the number and to enter the value.

Make sure, that the temperature does not exceed the Laser Operating temperature stated in the data sheet for the diode laser system. It should be within 15 to 35°C.

3) Move the cursor onto the LTon/off position marked as “[]” and press ENTER. Now the TEC controller is switched on, and the laser diode heat sink temperature adjusted at TT should be reached within a few seconds. The actual heat sink temperature is displayed at TA. The TCA / TVA values indicate the current and voltage applied to the TEC in order to reach the adjusted temperature.

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Now, you can change the heat sink temperature by moving the cursor onto the TT position and repeat step 2) in order to adjust another operating current value.  
Make sure, that the adjusted temperature is reached and stabilized before starting the diode laser.

**Notes:**

- The TEC driver may not be able to adjust the pre-set temperature value if the ambient temperature is above 35°C. Therefore, it is important to ensure an ambient laboratory temperature below 35°C for the diode laser system.
- The TEC values in newer displays are represented without without leading 'L'. As TEC command the leading 'L' is still necessary.

d) **Start the Diode Laser:**

- 1) Move the cursor onto the upper right position marked as: "▶" and press ENTER until you reach the 1<sup>st</sup> menu shown in Fig. 3.
- 2) Move the cursor to position LCT where the line is "—" displayed, and insert the selected laser diode operating current value using the UP and DOWN keypads. Make sure, that the output current does not exceed the Laser Operating current stated in the Test Data Sheet provided for each individual laser module.

**! Important note**

It is recommended to adjust the fiber ferrule to maximum power, especially in case of 105µm core and if the fiber has poor centricity. In order to perform an adjustment set the laser power at approximately 1-5W. Rotate the connector and then fix it when the maximum is reached. In case of a 105µm fiber option the pre adjustment is very important.

- 3) Move the cursor to the Lon/off position "[ ]" and press ENTER. Now the Diode Laser should be on, and the power corresponding to the adjusted current should be emitted from the output fiber. The actual (mean) laser current will be displayed on the top of the screen.  
Now, you can change the output power by moving again onto the LCT position and repeat step 2) in order to adjust another operating current value.

Now the laser module is in full operation.

4) Switching the Laser off:

Move the cursor to the Lon/off position "[ ]" and press ENTER. Now the Diode Laser should be off, and the power will ramp down.

5) Switch on/off the red pilot beam:

Move the cursor onto the upper right position marked as: "▶" and press ENTER repeatedly until you reach the 4<sup>th</sup> menu (see Fig 6 below)  
Move the cursor onto the pilot laser on/off position marked as "[ ]" and press ENTER to switch the Pilot laser on or off.

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6) Switching the TEC controller off:

Move the cursor to the LTon/off position “[\_]” in the menu shown in Fig. 5, and press ENTER. Now the TEC should be off, and the power will ramp down.






See the general Lumics Laser driver manual in addition to this manual for further functions.

Comments:

This cooling block operates with air cooling. Temperature stabilization within 20 to 35°C may have to be implemented by using the internal NTC temperature sensor reading in the driver display.

- Whenever power supply is switched on or off, ALWAYS ensure, that the current is turned to 0 and the key switch is turned off prior to switching the power supply on or off. Uncontrolled on/off switching may cause spikes and result in fatal device damage. This applies also for the red pilot laser.
- Do not operate the laser without or with insufficient cooling, or high temperature environment.
- The temperature reading from the thermistor in the laser module and the outside temperature during operation must be below 35°C
- Do not allow the temperature of the diode laser exceed 35°C, during any short time of operation.
- Do not operate the laser unit in dusty or moist environment.
- To avoid possible contamination do not leave the fiber connector without protective cap.
- The temperature control of the laser requires a period of stabilization. Only 5 minutes after stabilization of the temperature readout the laser can be operated.

**Description of driver Keypads:**

- |   |   |
|---|---|
|  UP          | • increases the digit under the cursor  |
|  DOWN        | • decreases the digit under the cursor  |
|  LEFT        | • moves to the previous input field   |
|  RIGHT       | • moves to the next input field   |
|  OK or Enter | • starts input field actions / toggles checkboxes / enters changed value<br>/ pressing it twice on unchanged digits moves the cursor position |

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## Description of Display Menus and Functions:

In the following you find a description of the menus on the driver display which let you control the device. Figures of menus use the following legend:

—	Input field for numeric values
....	Output field for numeric values
[ ]	Input field check box
[.]	Output field check box
->	Input field action
▶	next menu

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The menus are shown in Figure 3, 4, 5 and 6. The abbreviations have the following meanings:

LCA	Laser current actual
LCT	Laser current target
LVA	Laser voltage actual
LTA	Laser temperature actual (internal heat sink temperature: NTC)
LON/OFF	Laser On / Off – use this feature to turn the laser on and off
ILOCK	Interlock feature
LTCL	Laser temperature current limit
GX On Start	External device control on startup, setting it causes the driver to switch to external mode after 5 seconds
GDefaults	Sets global defaults
GXControl	External device control over RS232
Pilot Laser	Activates the pilot laser if laser is on
GF	External fan voltage
GFD	Default external fan voltage
LCL	Laser current limit
LVC	Laser voltage compliance
LVA	Laser voltage actual
LTM	Laser Temp Max
LMAX	Laser Modulation analog external
LMDX	Laser modulation digital external
LMDI	Laser Modulation Digital Internal
PC	pulse count
GE	error code
LMWU	Laser Modulation Pulse Width in $\mu$ s
LMWM	Laser Modulation Pulse Width in ms
LMPU	Laser Modulation Pulse length in $\mu$ s
LMPM	Laser Modulation Pulse length in ms
LG	Laser Gate

TEC commands, see Laser Temperature menu Fig 5:

LTC	temperature controller stop/run (on/off)
LTA	actual temperature
LTT	temperature target (adjust)
LTLU	upper temperature limit
LTLL	lower temperature limit
LTCA	actual TEC current
LTCL	current TEC limit
xtVA	actual TEC voltage
k (LTCCk)	PID parameter: gain factor
n (LTCCn)	PID parameter: reset time
V (LTCCV)	PID parameter: rate time

Note, that in newer displays the TEC value may appear without the leading 'L'.



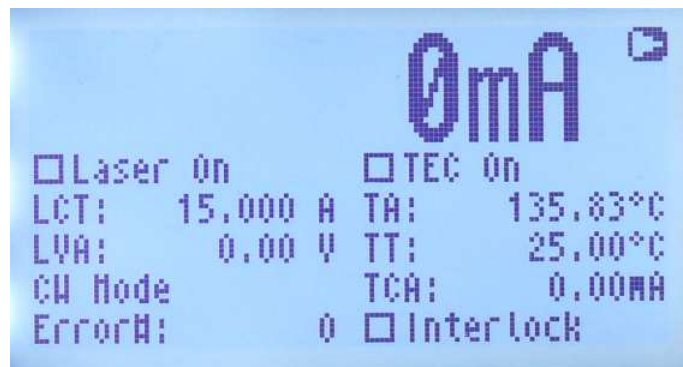


Figure 3: Start menu (1<sup>st</sup> level) of the diode laser. It appears after driver turn-on.

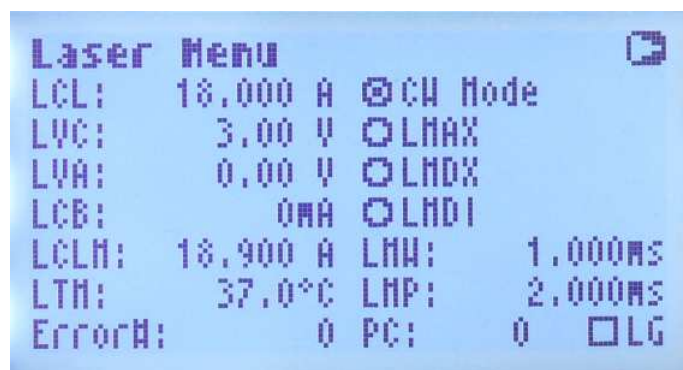


Figure 4: Control menu (2<sup>nd</sup> menu) for display of limit settings, and pulsed operation setting.



Figure 5: Laser Temperature Menu (3<sup>rd</sup> menu) for TEC control.

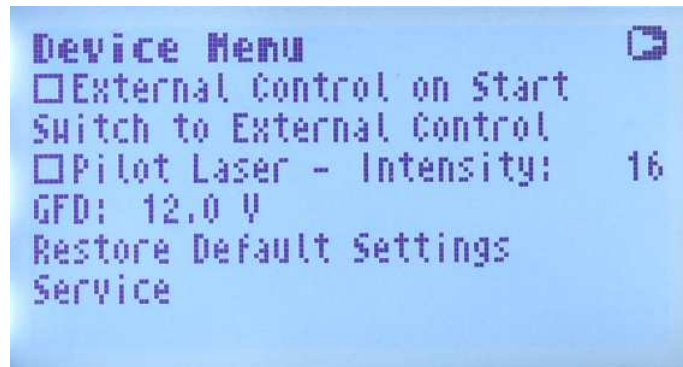


Figure 6: Device Menu (4<sup>th</sup> menu) for pilot laser on/off or for switching to external remote control

### 3.2 Warning / Laser Safety

1. The LUXXXDY YY LASER MODULE WITH LU-CB2-TEC AND DS11-LA18V08 DRIVER diode laser emits very high optical output power and therefore can cause serious damage.
2. The LUXXXDY YY LASER MODULE WITH LU-CB2-TEC AND DS11-LA18V08 DRIVER should only be operated by personnel experienced or trained in high power laser system operation and safety measures.
3. Do not allow access to the diode laser to personnel who are inexperienced or untrained.
4. The laser beam must always be blocked when the diode laser is in operation with the output not being terminated in an experiment or optics system.
5. Never look directly into the laser beam.
6. Always avoid looking down along the laser beam towards the direction where the source of the laser light is.
7. Do not allow reflective objects to be placed in or close to the laser beam. Laser light scattered from a reflective surface can be just as dangerous as the original beam. Even objects such as rings, watches and metal pens or pencils can be hazardous.
8. Attenuate the laser power to a low level in order to minimize intensity if accidental stray reflections during the alignment of optical components in the laser beam.
9. Do not set up Laser experiments with the laser beam close to the eye level.
10. Use eye protection.
11. Post warning signs and limit access to the laser area when the laser is in operation.
12. Never leave the diode Laser unattended when it is in operation.

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**General Note:**

**During installation, operation, maintenance or service of the diode laser – ALWAYS avoid unnecessary exposure to laser light or collateral in excess of the accessible emission limits listed in Performance Standards for Laser Products, such as 21CFR 1040.10 (d).**

For further information see the following laser safety information sources:

Deutsche Elektrotechnische Kommission im DIN und VDE (DKE)  
Stresemannallee 15; D- 60 596 Frankfurt am Main; [www.dke.de](http://www.dke.de)

CEN Central Secretariat  
36, rue de Stassart; B-1050 Brussels; Fax: + 32 2 550 08 19  
E-mail: [infodesk@cenorm.be](mailto:infodesk@cenorm.be)

Union Technique de l'Electricite (UTE)  
33, Av. General Lectrec – BP 23; F- 92262 Fontenay-aux-Roses Cedex; [www.ute-fr.com](http://www.ute-fr.com)

Director (HFX-400), Division of compliance  
Bureau of Radiological Health  
5600 Fishers Lane; Rockville, MD 20857; (Regulations and Requirements)

Laser Institute of America  
400 Executive Park Drive; Cincinnati, OH 45241; (Safety Guide)  
American National Standard Institute, Inc.  
1430 Broadway; New-York, NY 10018; (Safety Guide)

### **3.3      Fiber Connector Handling**

Dust, grease and other contaminations of the fiber facet cause light absorption and local overheating. In some cases it can cause a fiber degradation making a laser operation impossible. Operate laser only with clean fiber facet.

- Avoid dusty environment.
- Do not touch the fiber front facet and not allow it contacts with other surfaces.
- Periodically control the fiber and connector facet and clean if necessary.
- Do not expose the fiber to temperature higher than 80°C during storage or operation.
- Do not pull the fiber.
- Do not bend a fiber with a radius smaller than minimum allowed bending radius for corresponding core diameter, (refer table 1 in attachment).
- Avoid strong back reflection targeting the connector.

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Use a clean-room compatible tissue, put some Isopropyl alcohol onto it and carefully clean the facet of the fiber facet or connector facet, or use special fiber cleaning tools. Perform cleaning only with power supply switched off!

***Important.*** Usual SMA 905 fiber connector has a special high power design where a fiber tip do not have a physical contact with a ferrule, therefore do not apply much force by cleaning, it can brake the fiber tip.

**Remark:**

There are many materials commercially available for fiber optic cleaning. Some are marketed specifically for the fiber optic industry. Isopropyl alcohol is the most commonly used one. Isopropyl alcohol will loosen particular contaminants and allows to remove oil or grease from the fiber. It is used on swabs and wipes, by directly spraying, in soaking tubs, and in ultrasonic cleaners.

Adhesive type cleaners are used to remove particle contamination. It is important to select an adhesive in-line with the particular application so that the adhesive itself does not create a new source of contamination or damage to the fiber.

Generally: In case of any failure you may contact us for service.

Lumics GmbH

Carl-Scheele-Str. 16

12489 Berlin, Germany

Tel. +49 30 678 0676-0 / Fax +49 30 678 0676-26 / [www.lumics.com](http://www.lumics.com)

## 4. Attachments

Table 1. Minimum bend radius vs. fiber core diameter.

Fiber core diameter, $\mu\text{m}$	Bending radius, mm	Bending radius, inch
105	40	1.6
200	85	3.3
400	145	5.7
600	200	7.9
800	265	10.4
1000	330	13.0