MPL2510

PASSIVELY Q-SWITCHED DIODE-PUMPED SOLID-STATE LASER

TECHNICAL DESCRIPTION
&
USER'S MANUAL

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Preface

This manual contains information user needs to unpack, safely install and operate passively Q-switched picosecond laser model MPL2510.

The **Chapter 1 "Unpacking and Inspection"** briefly describes the unpacking procedure and lists the items you have received. The **Chapter 2 "Laser Safety"** is a very important part of this manual. Please read it carefully and follow the instructions provided within. The **Chapter 3 "Laser System Description"** contains a brief description of the laser head and controller. Laser specifications are given in the **Chapter 4 "Laser Specifications".** The **Chapter 5** describes the laser installation and controls, and then guide the user through its operation. The **Chapter 5** is a very important part of this manual. Please read it carefully and follow the instructions provided within. The last **Chapter "Warranty"** describes Warranty period.

Every effort has been made to ensure that the information in this manual is accurate. All information in this document is subject to change without notice. QS Lasers makes no representation or warranty, either expressed or implied, with respect to this document. In no event will QS Lasers be liable for any direct, indirect, special, incidental or consequential damages resulting from any defects in this documentation.

If you encounter any difficulty with the content or style of this manual, please let us know by sending a corresponding e-mail to **sales@qslasers.com**

Thank you for purchasing QS Lasers laser.

Chapter 1. Unpacking and Inspection

MPL2510-TH laser was thoroughly tested and carefully packed at QS Lasers in a defect free container. Upon receiving your laser, immediately inspect the outside of the package. If the container is seriously damaged, please unpack your device in the presence of the carrier representative.
Carefully inspect the laser as you unpack it. If any damage is evident, immediately notify the carrier and the QS Lasers's Sales Department at sales@qslasers.com
Please keep the shipping container, as it might be useful if you need to return the laser system for service at a later date.

Make sure that besides the Packing Slip the listed below components are present in your package.

1. Laser Head MPL2510, SN:N121
2. Laser Controller, SN:N1097
3. Laser Diode cable
4. Laser Control cable
5. USB 2.0 cable, 1pcs
6. Power supply cable
7. USB stick with written software and user's manual
8. Access Key
9. 50 Ohm Terminator

Fig. 1. Typical image of MPL2510 Laser system.

Chapter 2. Laser Safety

2.1 Safety Features and Compliance with Government Requirements

	**Danger!** **Laser Radiation**	MPL2510 is a **class 4** solid-state laser. Please carefully read this chapter and take all necessary precautions to prevent accidental exposure to both direct and reflected beams.

This laser is a fourth-class laser product according to radiation danger degree, and, by definition, relates to certain safety and fire hazards. The following features are incorporated into the laser to conform to several government requirements. The applicable United States Government requirements are contained in 21 CFR, chapter 1, subchapter J, administered by the Center for Devices and Radiological Health (CDRH). The European Community requirements for product safety are specified in the Low Voltage Directive (LVD) (published in73/23 EEC and amended in 93/68 EEC). The Low Voltage Directive requires that lasers comply with the EN-60825-1 (Radiation Safety of Laser Products) and IEC1010-1 (Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use).

The laser head is enclosed in a protective housing that prevents human access to radiation in excess of the limits of Class I radiation as specified in 21 CFR, subchapter J, Section 1040.10(f) (1) and Table 1-A/EN60825-1, clause 4.2 except for the output beam, which is Class IV.
The laser controls are positioned so that the operator is not exposed to laser emission while manipulating the controls (21 CFR, subchapter J, Section 1040.10(f) (7) /EN60825-1, clause 4.8).

2.2 Electromagnetic Compatibility

MPL2510 laser system complies with the European requirements for electromagnetic compatibility as defined in the Electromagnetic Compatibility Directive 89/336/EEC.
This laser system is intended for use in an ISM (Industrial, Scientific and Medical) Environment. Operation of this laser system in a different EMC environment may

require that the user take remedial action in addition to the normal installation and operation described in this manual to resolve potential electromagnetic compatibility problems. QS Lasers company makes no claims beyond those listed below concerning the compatibility of this laser system in EMC environment other than ISM environment.

2.3 Labeling

The laser housing and controller unit are hosting following labels:

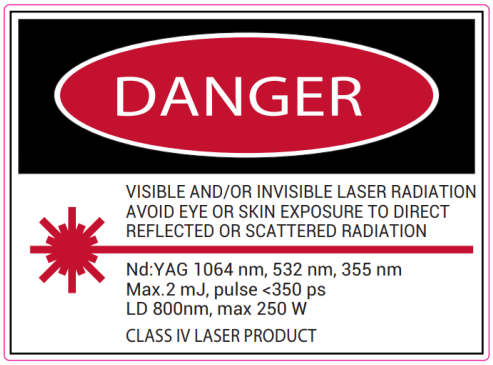
	CE Aperture Label
	CDRH Aperture label
	CE Warning label
	Laser model

Fig. 2. Typical labeling of MPL2510 laser system.

2.4 Precautions for the Safe Operation of Class IV Lasers

- Always have the power supply cover and the laser cover in place when the laser is connected to the line power.
- Always wear protective eyewear.
- Limit access to the laser to persons that are not familiar with the equipment. Keep the laser out of the hands of inexperienced or untrained personnel.
- When the laser is on and the output beam is not being terminated in an experiment or optics system, the beam should be blocked.
- **NEVER LOOK DIRECTLY INTO THE MAIN LASER BEAM, NEVER SIGHT DOWN A BEAM INTO ITS SOURCE.**
- Do not allow reflective objects to be placed in the laser beam. Laser light scattered from a reflective surface can be as damaging as the original beam. Even objects such as rings, watchbands, and metal pens or pencils can be hazardous.
- Attenuate laser power (use external attenuator) to a low level to minimize intensity of accidental stray reflections or refraction's when aligning a chain of optical components in the laser beam.
- Set up experiments so that the laser beam is NOT at eye level.
- Post warning signs and limit access to the laser area when the laser is in operation.
- **NEVER LEAVE THE LASER ON, OPENED AND UNATTENDED!**

2.5 CE Electrical Equipment Requirements

For information regarding the equipment needed to provide the electrical service listed under "Service Requirements" at the end of Chapter 4, please refer to specification EN-309, "Plug, Outlet and Socket Couplers for Industrial Uses," listed in the official *Journal of the European Communities*.

2.6 Environmental Specifications

The environmental conditions under which the laser system will function are listed below:

Indoor use only.

Altitude: up to 2000 m.

Temperatures: 20° C to 30° C.

Maximum relative humidity: 80% non-condensing for temperatures up to 25° C.

Mains supply voltage: do not exceed ± 10% of the nominal voltage stated in Chapter 4.

Chapter 3. Laser Description

3.1. Brief introduction to laser model MPL2510

Do not open the laser head cover! Laser is sealed.

Laser Head of the MPL2510 laser system includes an passively Q-switched, diode-pumped Nd:YAG laser operating at 1064 nm wavelength. Lasing at 1064 nm occurs in a two mirror cavity containing Nd:YAG active element and passive Q-switch made of Cr:YAG crystal. Latter is used for the resonator Q factor modulation which forces DPSS laser to operate in so called Q-switched mode and generate short optical pulses. Short laser cavity is fixed on thermo-stabilized and controlled baseplate which gives extremely stable output parameters performance. In this MPL2510 laser is one active output emitting 1064 nm wavelength (**Fig. 3**).

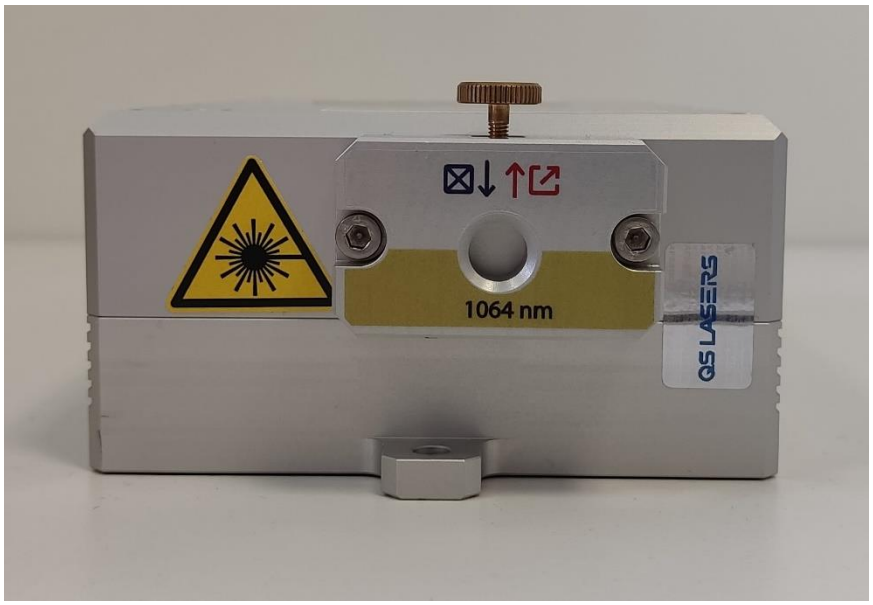


Fig. 3. Typical image of MPL2510 laser system.

Please refer to the drawings of the laser head (**Fig. 4**) to get familiar with placements of connectors, input/output ports and mounting holes of the laser head.

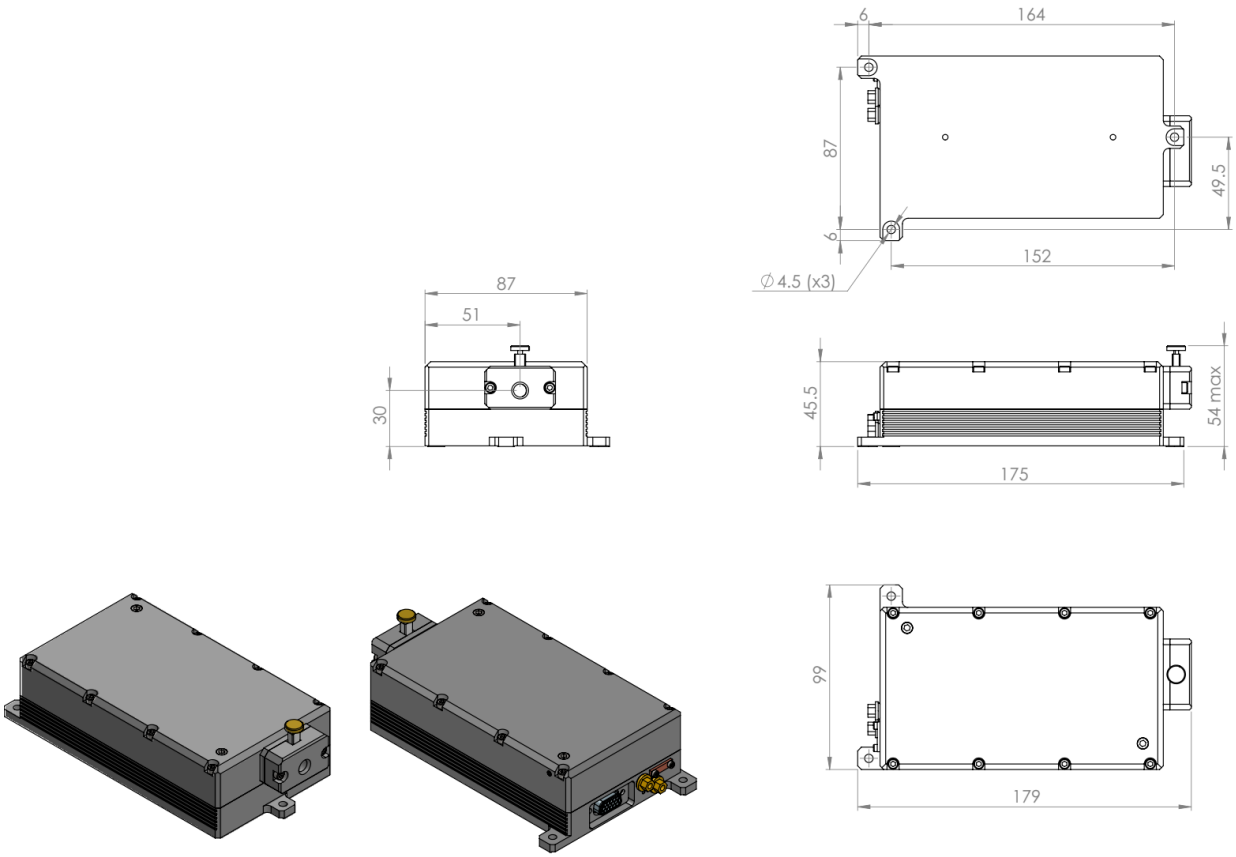


Fig. 4. Laser head external dimensions.

Please refer to the drawings of the laser controller (**Fig. 5**) to get familiar with placements of connectors, input/output ports and mounting holes of the laser controller.

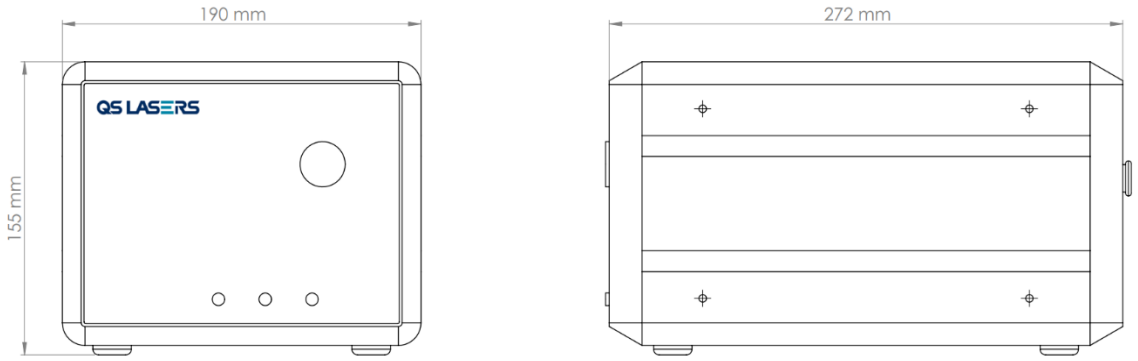


Fig. 5. Laser Controller external dimensions.

The laser controller is powered by 220 VAC mains adapter. The electrical interconnections of the laser modules are shown in **Fig. 6**.

The MPL2510 laser consists of two main parts (**Fig. 6**.):

- Laser Head
- Laser Controller

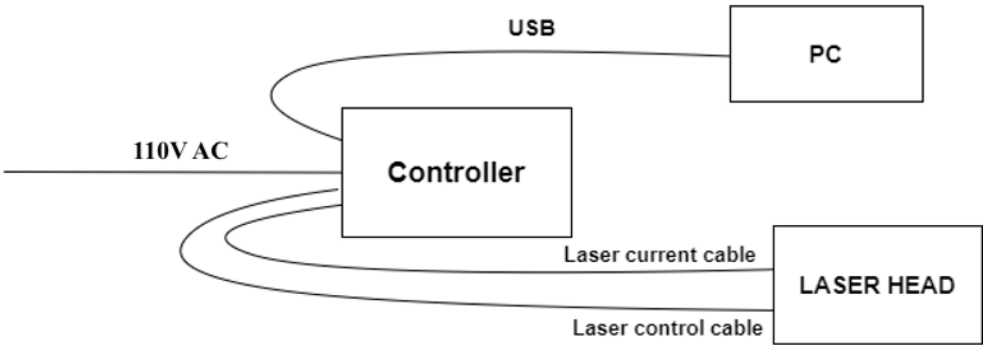


Fig. 6. Electrical interconnection of the system.

The laser control unit contains two drivers inside, so two LDX Control control program windows are required for laser control. The principles of laser control are explained in more detail in **Chapter 5.**

3.2. Description of Laser Controller

The laser controller consists of a control board that is a convenient device for operating the MPL2510 laser head.

Electronics of the control board comprises two basic parts:

- Laser diode driver (high current rate)
- Two TEC drivers

The laser controller allows the laser to be monitored and controlled via the USB interface. Please refer to the **Fig. 7** and corresponding tables to find out the placements of all connectors and indicators.

Fig. 7. Front panel of laser controller. **50 Ohm terminator must be connected to Monitor Photodiode connector.**

Fig. 8. Rear panel of laser controller.

Table 1. LASER CONTROLLER Front Panel Connectors and Indicators

Sign		Type/Name	Function	Note
POWER		Green LED	Indicates power ON	
LASER EMMISION		Amber LED	Indicates laser emission	
FAULT		Red LED	Indicates error in the laser controller	
TRIG IN		BNC receptacle/ LD TRIG IN	External triggering of pump Laser Diode	Input impedance is 10 kOhm TTL, Hi level 5V, Low level 0V, Pulse duration 1us.
TRIG OUT		BNC Receptacle/ TRIG OUT	Provides sync pulse to trigger user's device	Inactive in this Laser
MONITOR PHOTODIODE		BNC Receptacle/ MONITOR	Observation pump pulse of laser diode	
LASER ON	ON	Button/ LD Current	Allows to turn on/off Laser	
	OFF			
KEY	OFF	Access Key	Allows the only authorized person to operate the laser system	
	ON			
EMERGENCY STOP		Button	Pushing this button stops the laser controller, and the capacitor banks ground in less than 5 seconds. Pull the button out before restarting the system	

Table 2. LASER CONTROLLER Rear Panel Connectors and Indicators

Sign	Type/Name	Explanation	Note
MAINS 100-240 V AC	Inlet Male Power Socket	Power cord attachment	
LASER HEAD	D-SUB 5W5 female Connector	Laser Diode Connection	
LH CONTROL	D-SUB HD26 female Connector	Peltier, thermistors connection	
PC	USB type-B receptacle	Controller <-> PC Communication	
Fan		Provides continuous air flow from the LD driver	Avoid covering
Interlock	Interlock type	Can be used for external interlocking	

Chapter 4. Laser Specifications [1)]

Laser Specifications at 100 Hz are listed in the table below.

Parameter	**MPL2210-TH**
Wavelength [nm]	1064,
Pulse Energy [mJ] at 1064 nm	≥ 2
Pulse Width FWHM [ps]	≤ 450 ± 10% [2)]
Repetition Rate [Hz]	100 [3)]
Jitter RMS [µs]	~ 2 [4)]
Pulse Energy Stability at 355 nm RMS [%]	< 2 % [5)]
Beam profile	Close to Gaussian
Beam Diameter [mm]	~ 1.0 (at $1/e^2$ level) [6)]
Beam Divergence [mrad]	< 6 (full angle at $1/e^2$ level) [7)]
Operating Voltage [VAC]	100-240 VAC, single phase, 50-60 Hz
Power Consumption [W]	~40
Operating Temperature [°C]	20 – 30°C
Interfaces	USB, Trigger Out Signal (TTL Rising Edge)
Laser Head Dimensions (W×L×H) [mm]	99 × 179 × 54 mm
Laser Controller (W×L×H) [mm]	190 × 272 × 155 mm

1. *Due to continuous improvements all specifications are subject to change.*
2. *FWHM level at 1064 nm.*
3. *Factory-set pulse repetition rate is 100 Hz.*
4. *In respect to q-switch sync. signal in internal trigger mode, rising edge of TTL-sync. out signal. Internal trigger mode delivers TTL-sync. out signal.*
5. *Averaged from 30 second time interval in 5 series.*
6. *Beam diameter is measured 20 cm from laser output at $1/e^2$ level.*
7. *At 20cm from laser output.*

Chapter 5. Installation and Getting Started

Caution !	It is forbidden to operate the laser controller without proper grounding. The earth grounding can be performed through the power plug, or through the grounding bolt located at the rear panel of the controller. To avoid possible disruption of the laser diode, never touch the grounding bus before the grounding was performed.

5.1. Mounting Laser Head and Laser Controller

For proper operation, the laser head must be placed onto a flat horizontal surface. The Laser Controller should be placed onto a flat horizontal surface free of any foreign objects.

To prepare the laser head for using user should perform the following (step by step):

1. Place laser head onto a flat surface
2. Unscrew the shutter screws and remove it
3. Fasten the laser head to the base with screws
4. Check output window. If you see dust, please use compressed air to clean it. Do not open window, laser is hermetically sealed.
5. Put the shutter back on and tighten its screws.

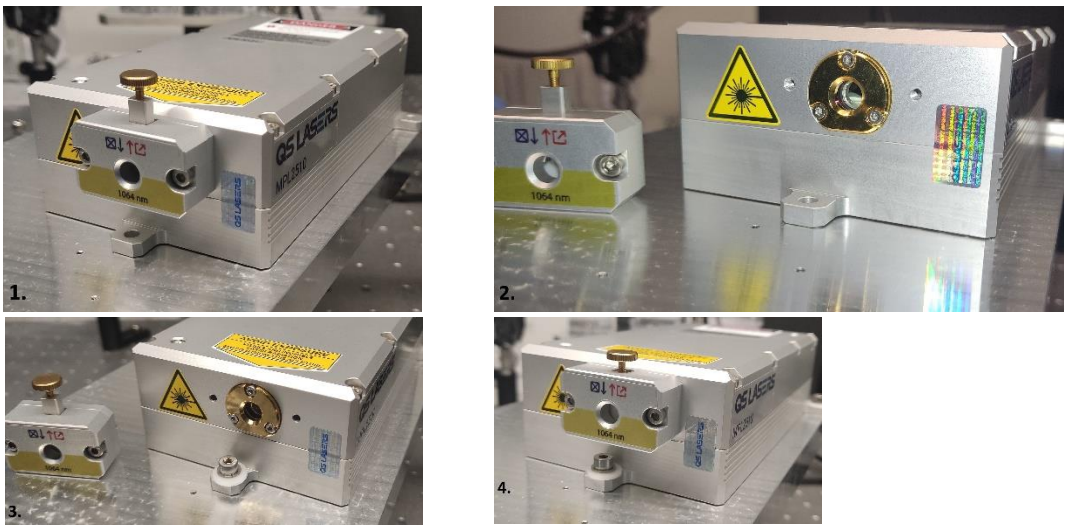


Fig. 9. Preparation of laser head for use.

5.2. Connecting Laser Head and Laser Controller

Caution	Never switch on the LASER ON button if the laser head is disconnected.

All operations outlined below should be performed in clean environment. **Please wear antistatic bracelet with the grounding to main laboratory ground when connecting Laser Head to the Laser Controller and power supply.**

To connect the laser head user should perform the following (step by step):

1. Check that both Laser Controller and Laser Head are placed properly.
2. Connect Laser Diode cable to as shown in **Fig. 10**.

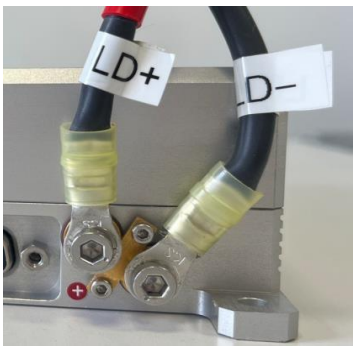


Fig. 10. Rear panel of laser head.

3. Connect Laser Controll cable to Laser Head and tighten the screws (**Fig. 11)**.

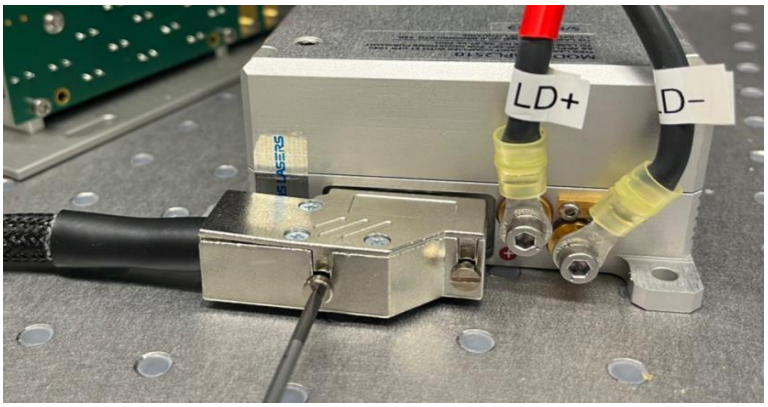


Fig. 11. Rear panel of laser head.

4. Connect Laser Diode cable to Laser Head connector of Laser Controller and tighten the screws. Please refer to **Fig. 12** Laser Head label.
5. Connect Laser Control cable to LH Control connector of Laser Controller and tighten the screws. Please refer to **Fig. 13** LH Controll label
6. Insert female plug of the power cord into male socket located at the rear panel of the Controller (please refer to **Fig. 8** sign 100 - 240 V AC.). Plug male connector of the power cord into the wall outlet (100 – 240 VAC).
7. Insert *Access Key* to the keyhole at the front panel of the controller (please refer to **Fig. 7**). Ensure the key is in the "**OFF"** position.

Fig. 12. Rear panel of laser controller with connected Laser Diode Cable.

Fig. 13. Rear panel of laser controller with connected Laser Controll and Laser Diode Cables.

8. Remove and fix shortening contacts of Laser diode as shown in the picture **(Fig 14)**. Please refer to **Fig. 15**.

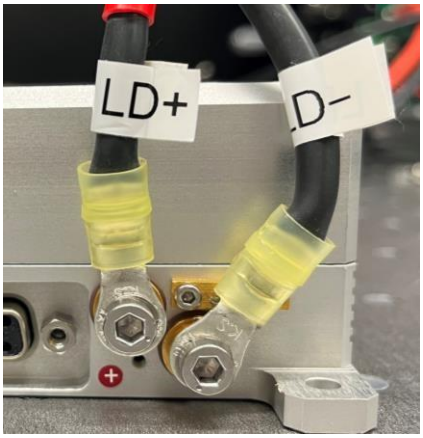


Fig. 14. Rear panel of laser head.

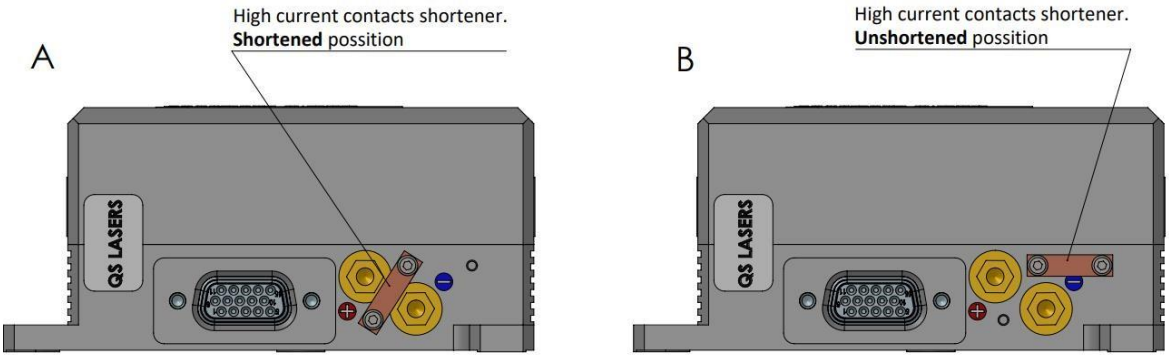


Fig. 15. High current contacts are shortened during transportation to avoid laser diode damage.

9. Double check if all connectors are fixed.

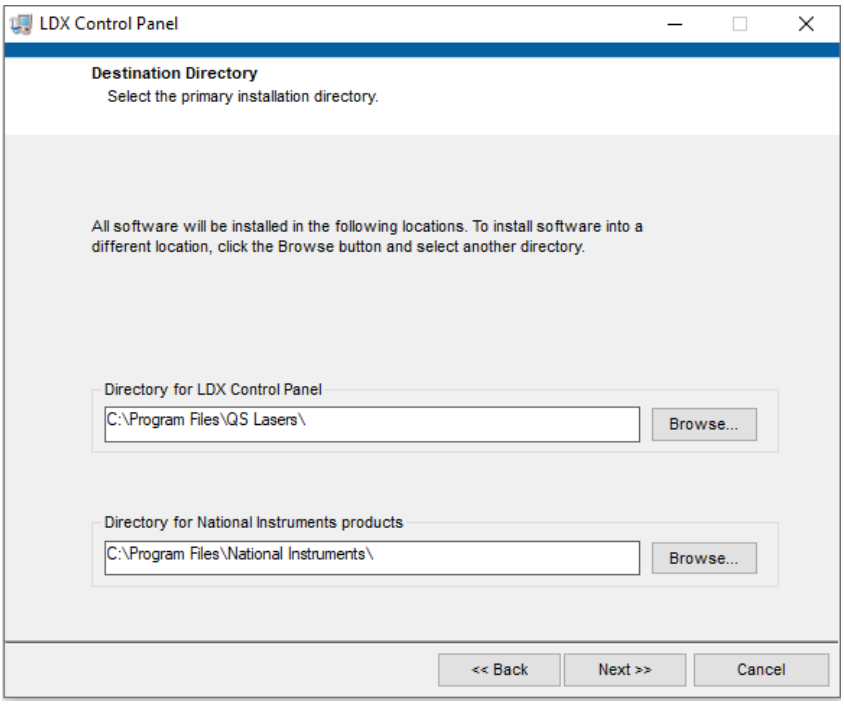
5.3. Connecting laser to PC

Connect Laser Controller to a PC with supplied USB 2.0 cables. Please refer to **Fig. 8** PC label. Install LDX software supplied in USB memory key.

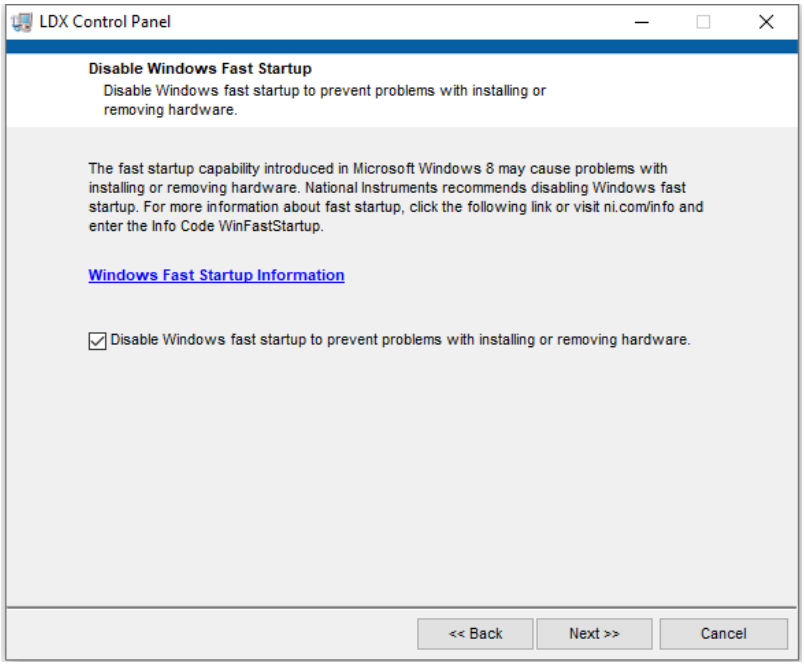
5.4. Installation of LDX software and VCP universal drivers

5.4.1. Installation of LDX software

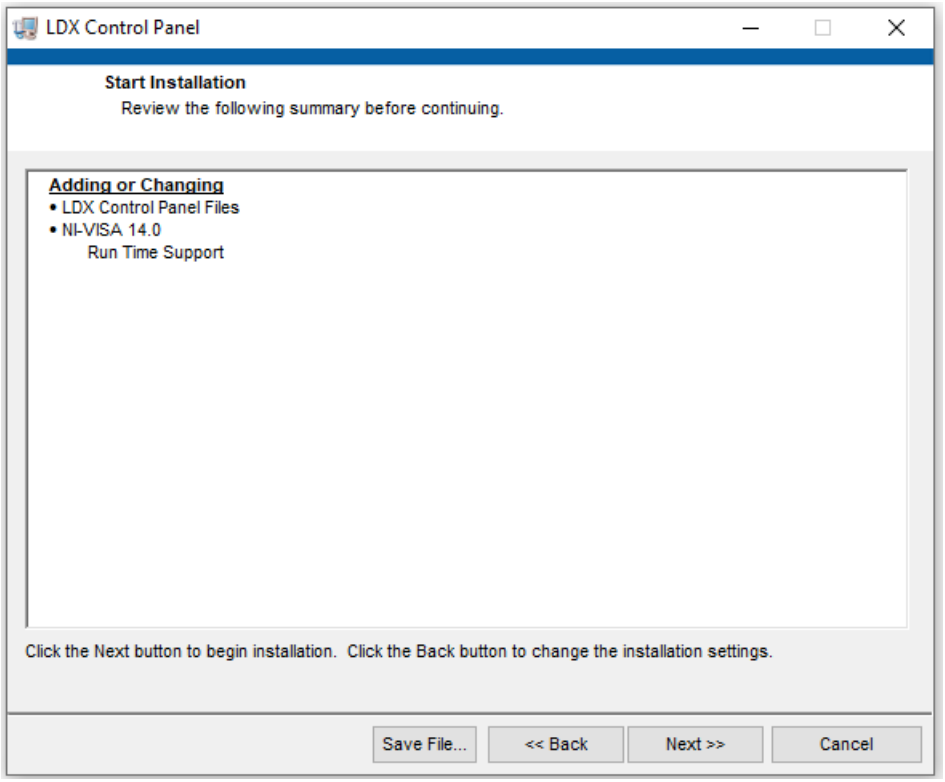
1. Install ***LDX-Control software*** *from USB stick.*
2. Unzip the ***LDX-Control_v.1.8.4_installer(x64)*** file and you will have a directory. containing the driver installer files.
3. Double click on **setup** file.
4. Click **Next**:



5. In next window click **Next**:



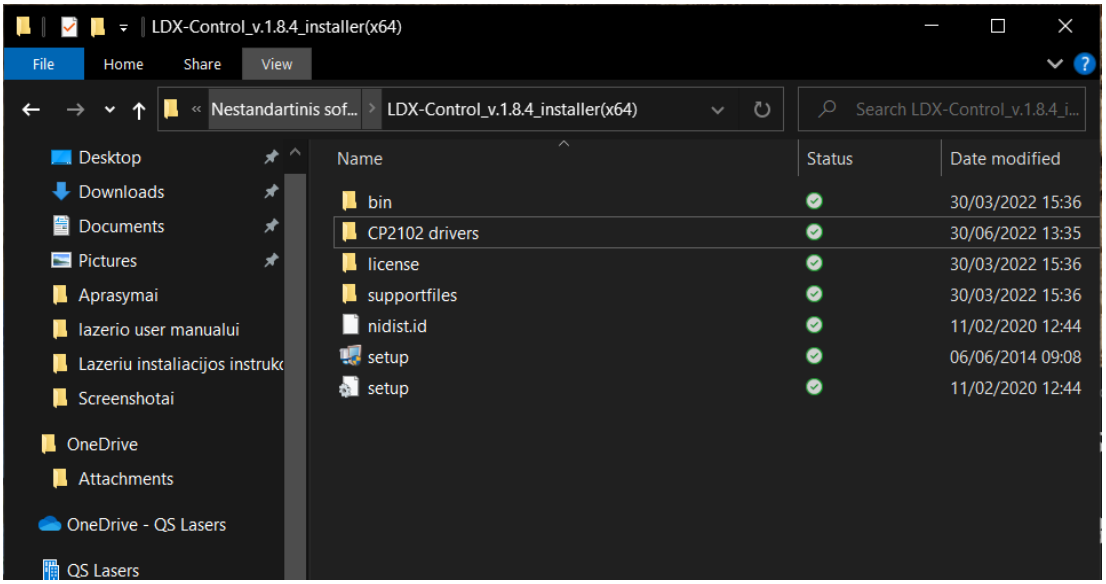
6. In next window click **Next:**



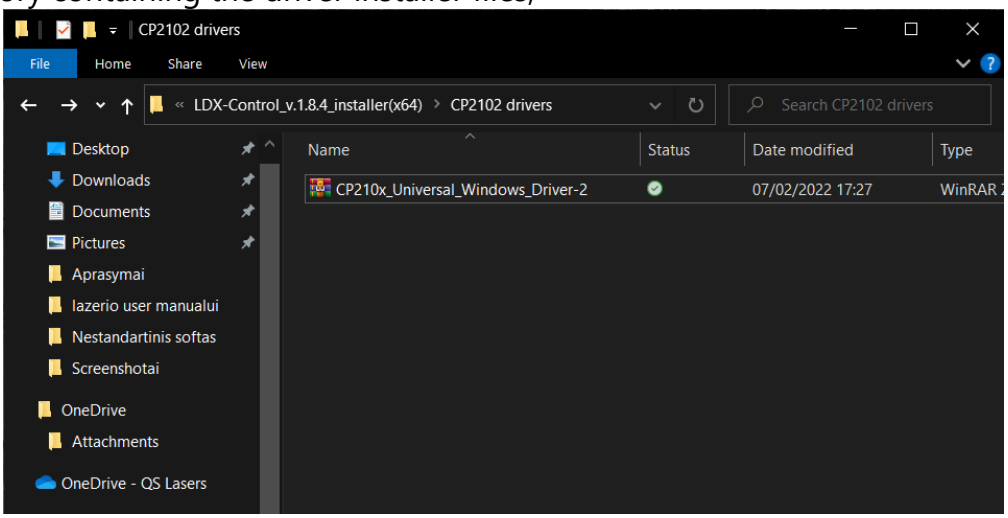
7. Click **Finish**.
8. Please restart your computer.
9. If you see the window with prompt that "***device cannot be established"*** it means that the additional drivers need to be installed. A COM Port (VCP) drivers, which are not included in Windows 10 and/ or Windows 11.

5.4.2. Installation of VCP universal drivers

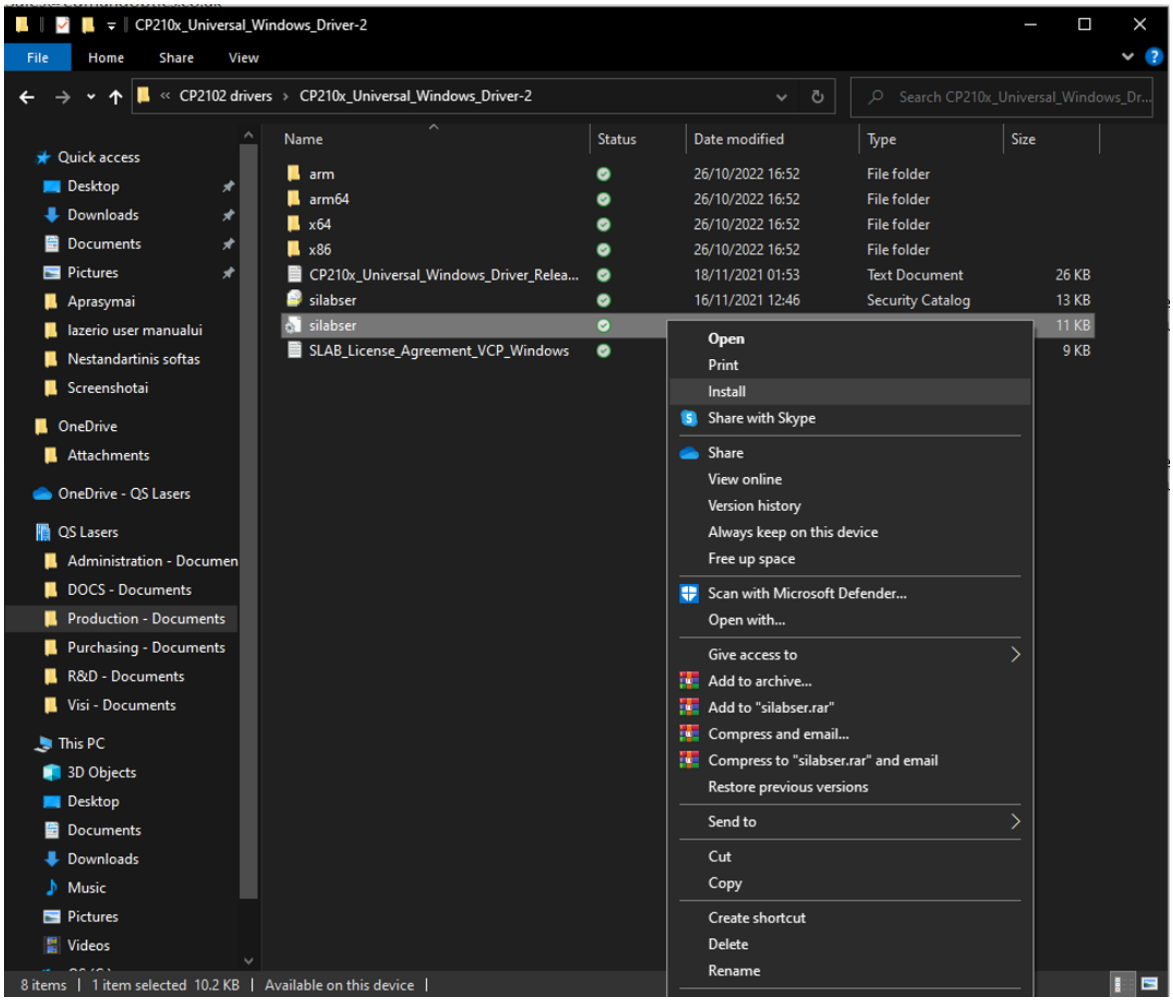
1. Double click on ***CP2102 driver*** folder.



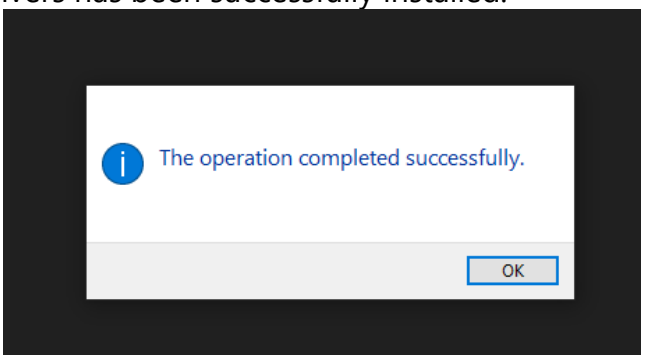
2. Unzip the ***CP210x_Universal_Windows_Driver-2.zip*** file and you will have a directory containing the driver installer files;



3. Using Windows File Explorer, locate the driver folder (that you previously unzipped).
4. Right click on the **silabser.inf** file and select **Install.**



5. Follow the instructions.
6. COM Port (VCP) drivers has been successfully installed.



5.5. Getting started

To switch on the laser system for the first time and a routine operation also user should perform the following operations:

Please note: *50 Ohm terminator must be connected to Monitor Photodiode connector of Laser Controller.*

1. Turn *Access Key* 90 degrees clockwise into "ON" position.
2. Power LED will start shining green.
3. Open LDX Control software. The LDX Control window for Laser Control will appear (S/N:1054, please refer to **Fig. 16,** Connect status label).

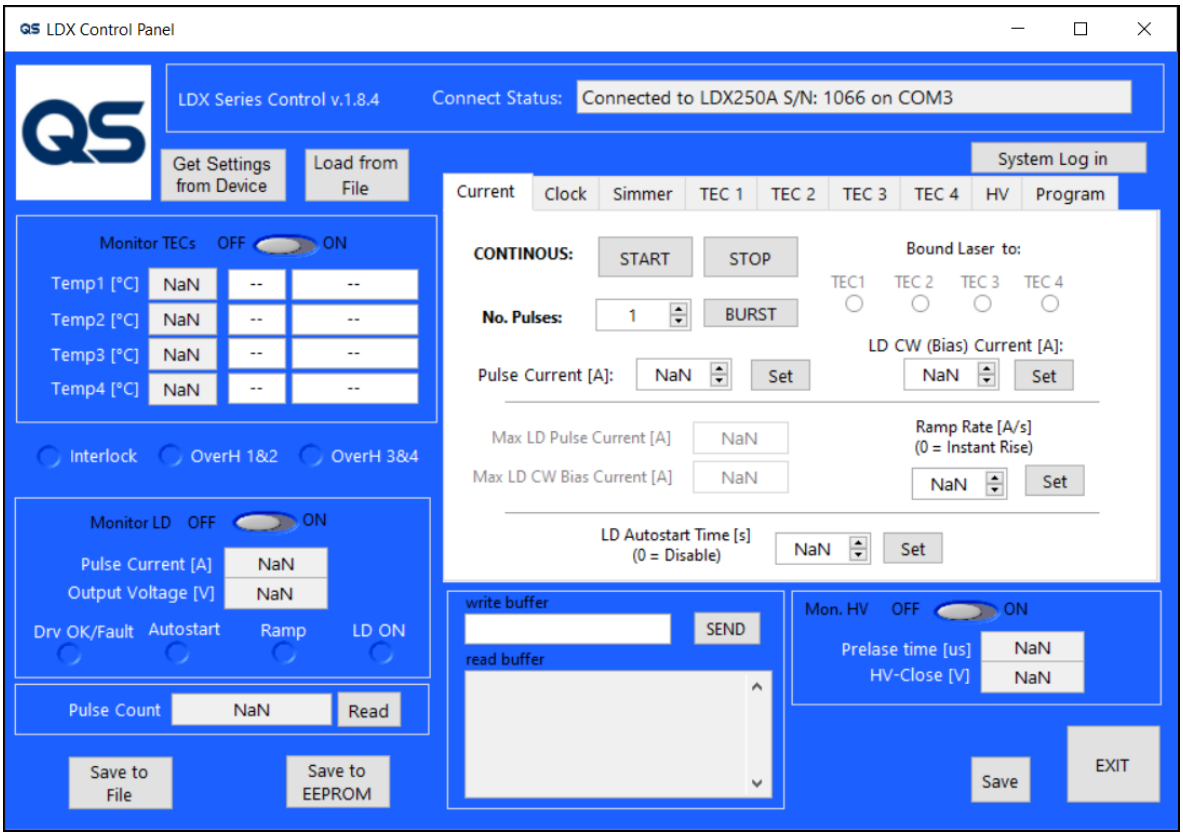


Fig. 16. LDX Control window for Laser Control.

4. Press "Get settings from device" in LDX Control window (**Fig. 17**).
5. Turn on "TEC's monitor" in LDX Control window (**Fig. 17**)..
6. Turn on "LD monitor" in LDX Control window (**Fig. 17**)..

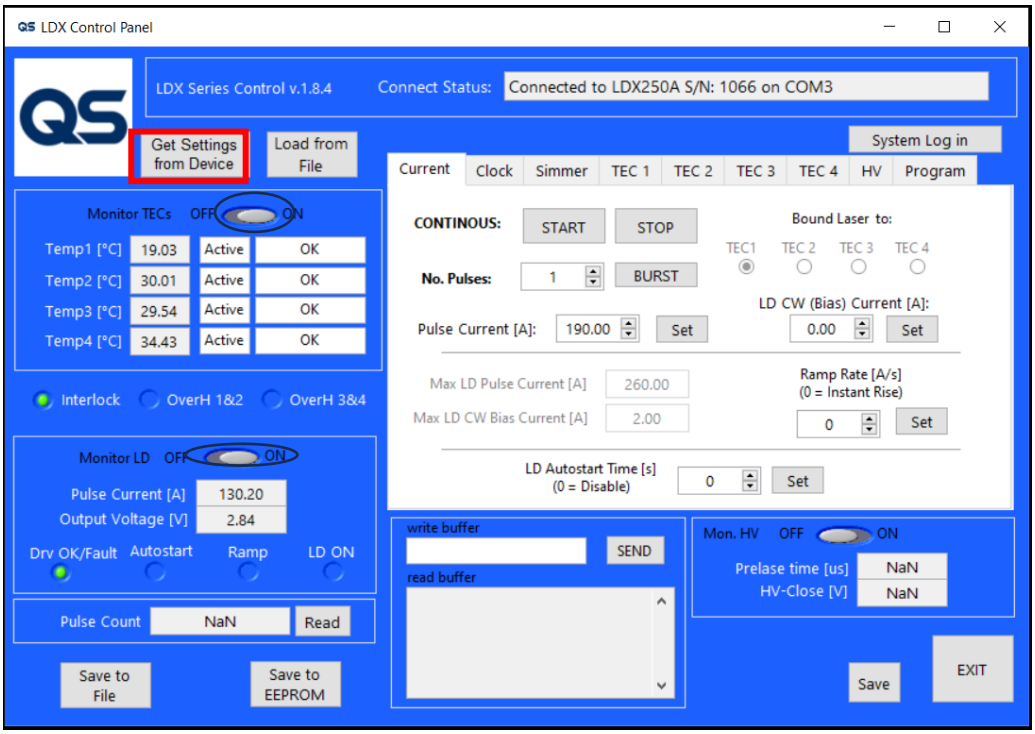


Fig. 17. LDX Control window for Laser.

7. When turning ON TEC and LD buttons read values will be seen on the screen. Please wait ~15 minutes time interval to warm-up laser. You will see that Pulse current is 132 A but laser do not generate pulses.
8. Please open the shutter with 1064 nm label.
9. Click the button "Start" in tab "Current" in LDX Control window.
10. Push "LASER ON" button that is located on the front panel of the Laser Controller (**Fig.7**). A Pulse Current changes from 132 A to 200 A (operational current).

Note. All settings of laser are optimized for 100 Hz operation on factory.

To switch off the laser system for a routine operation user should perform the following operations:

1. Push "LASER ON" button that is located on the front panel of the Laser Controller(**Fig.7**).
2. Click the button "Stop" in tab "Current" in LDX Control window.
3. Please close all the shutters.
4. Turn *Access Key* 90 degrees counterclockwise into "OFF" position
5. Exit from both LDX Control windows by clicking "Exit".

Chapter 6. Laser Control and Operation

6.1. Internal Triggering

The laser is set to operate on the internal triggering. The pulse repetition rate of the laser is set to 100 Hz.

In order to start lasing it is required to open shutter (label 1064 nm) and press the LASER ON button that is located on the front panel of the laser controller (please refer to **Fig. 7**). It is highly recommended to wait ~5 minutes afterwards for the energy to stabilize. It is important to know that it may be necessary to change the temperatures of the TECs in order to get the highest energy possible.

TEC temperatures that provide highest and most stable energies that were found are written down in the table in **Appendix 4. Factory settings**. Keep in mind that these temperature settings might be different in another environment and it may be necessary to tweak the temperatures of the TEC's:

Meanings of TEC'S in LDX Control window

- TEC1 is the temperature of the (Laser Diode) LD and it is highly likely it will not be required to change it at 100 Hz repetition rate.

- TEC2 is the temperature of the resonator, and it can be changed in 0.5 ˚C increments in order to find the temperature for the most stable energy regime. it is highly likely it will not be required to change it at 100 Hz repetition rate.

- TEC3 is the temperature of laser head. It is just as indicator.

- TEC4 is not active in this laser model.

Please refer to **Fig. 18** for how to change the temperature of the TECs.

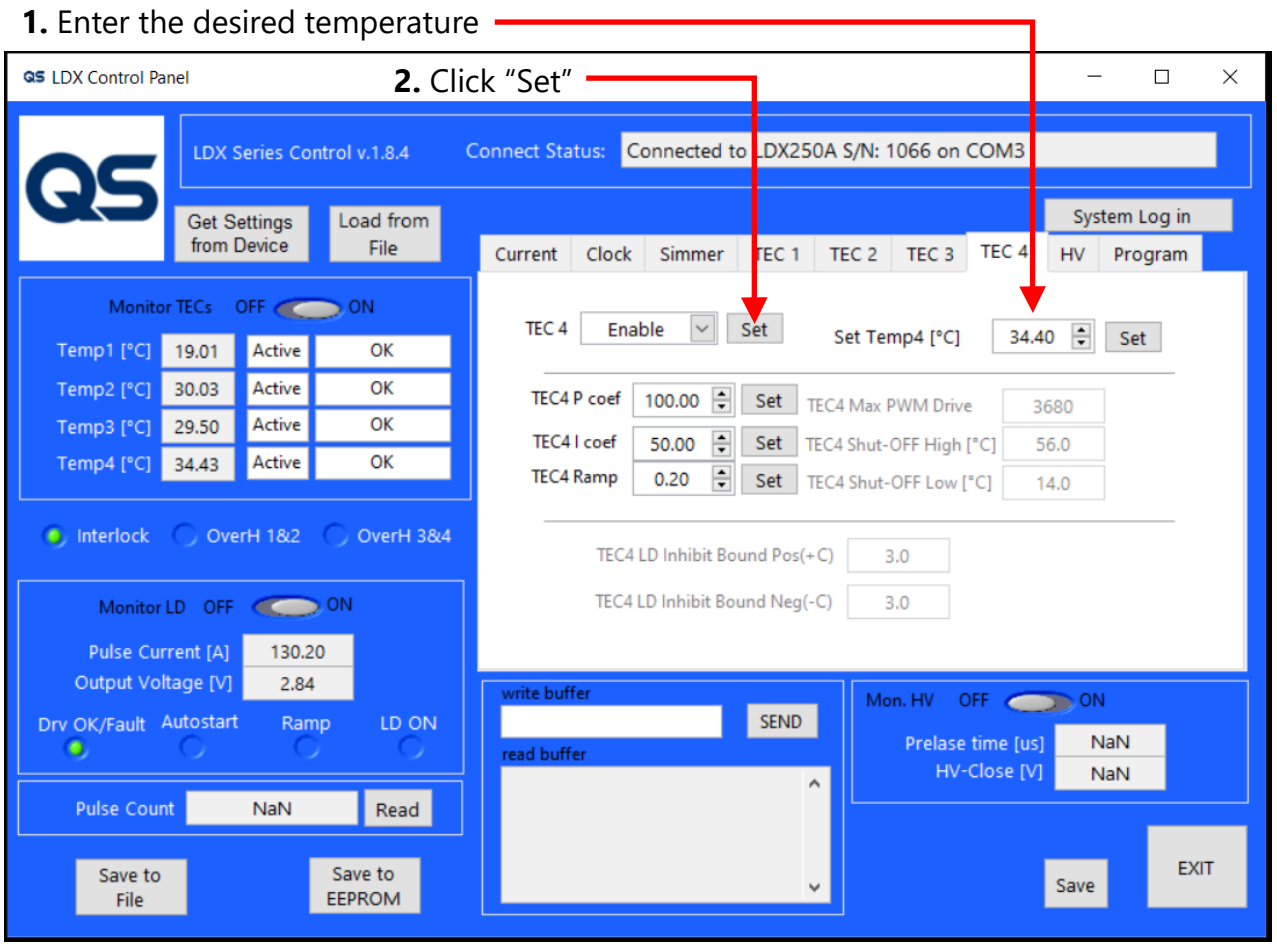


Fig. 18. Changing the temperature of a TEC.

***Note*: the exact values are shown for illustration purpose only. They are different from device to device.**

6.1.1 Changing pulse repetition rate

The pulse repetition rate of the laser is set to 100 Hz. In generally the repetition rate can be changed from 1 Hz to 100 Hz in this model lasers. Keep in mind that when changing repetition rate the energy of pulses can be change. To change the repetition rate from 1 Hz to 100 Hz in internal triggering mode, a user needs to use LDX Control window, S/N:1066, "LD Clock" tab. Please refer to **Fig. 19** for how to change the repetition rate. When repetition rate is selected, please click "SET" button.

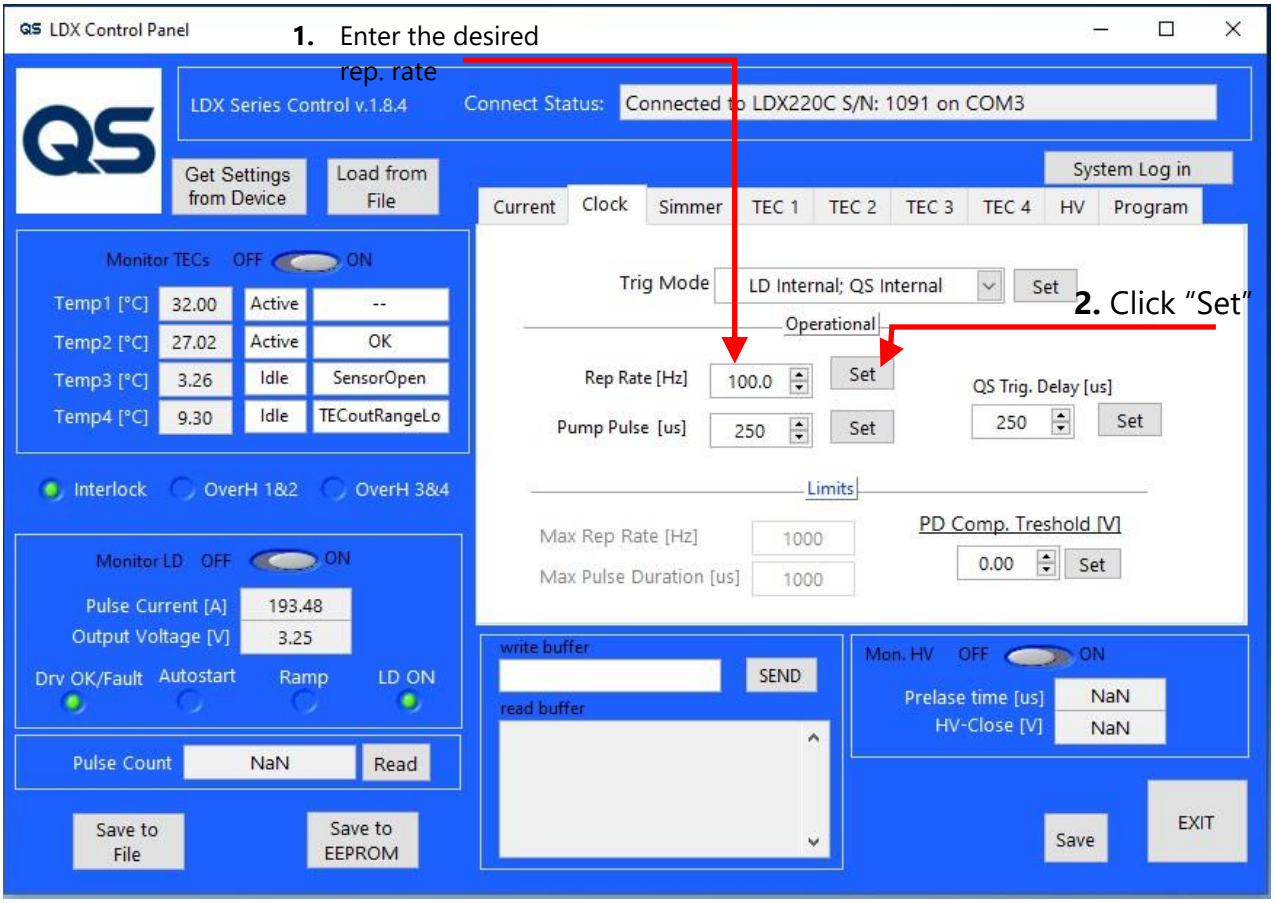


Fig. 19. Changing the repetition rate in internal triggering mode.

Please note that another laser settings should be changed if repetition rate was changed. The user should set appropriate TEC's temperatures, Pulse current and Simmer Pulse Current that provide highest and most stable energies that were found are written down in the table in **Appendix 3. Factory settings**

Meaning of Pulse Current in LDX Control window

The setting "Pulse current" is current of laser diode that pumps resonator and amplifier. It is highly likely it will not be required to change. If user notice that the laser sometimes stops generating or generates with an unstable repetition rate, the user can increase the Pulse Current in steps of 10 A until generation occurs, but not exceed 225 A. **However, the user must always inform the manufacturer about changing the Pulse Current.**

The procedure to change Pulse Current:

To change Pulse Current on the laser system user needs to use LDX Control window, , "Current" tab. Please refer to **Fig. 20** for how to change the Pulse Current. Appropriate values of Pulse Current are provided **Appendix 3. Factory settings.** The changing Pulse

Current is performed at the same manner as changing temperatures: entering appropriate value of pulse current and clicking button “set”.

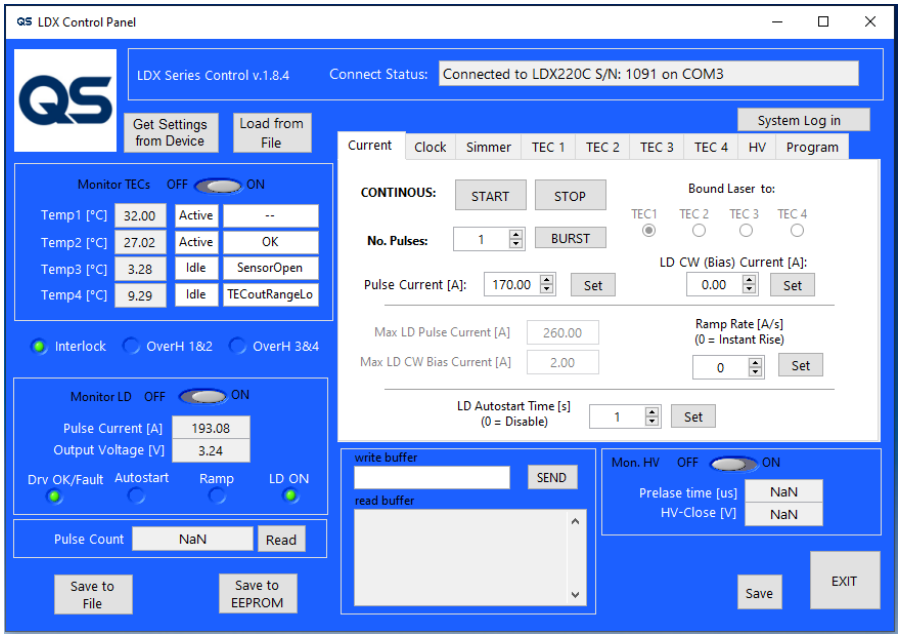


Fig. 20. Changing the Pulse Current in internal triggering mode.

Meaning of Simmer Pulse Current in LDX Control window

The setting “Simmer Pulse Current” is current of laser diode when Simmer regime is activated. The Simmer regime maintains a constant thermal load for crystals when laser is turned off for a short time. This allows to significantly reduce the unevenness of pulse energy when laser is turned on again. It is highly likely it will not be required to change. If user notice that the laser energy is not the same as before short pause of laser operation, user can optimize the Simmer Pulse current - it can be adjusted in steps of 5 A until energy of pulses keep the same level. **The user must always inform the manufacturer about changing the Pulse Current.** To change Simmer Pulse Current on the laser system user needs to use LDX Control window, “Current” tab. Please refer to **Fig. 21** for how to change the Simmer Pulse Current. Appropriate values of Simmer Pulse Current are provided **Appendix 3. Factory settings.**

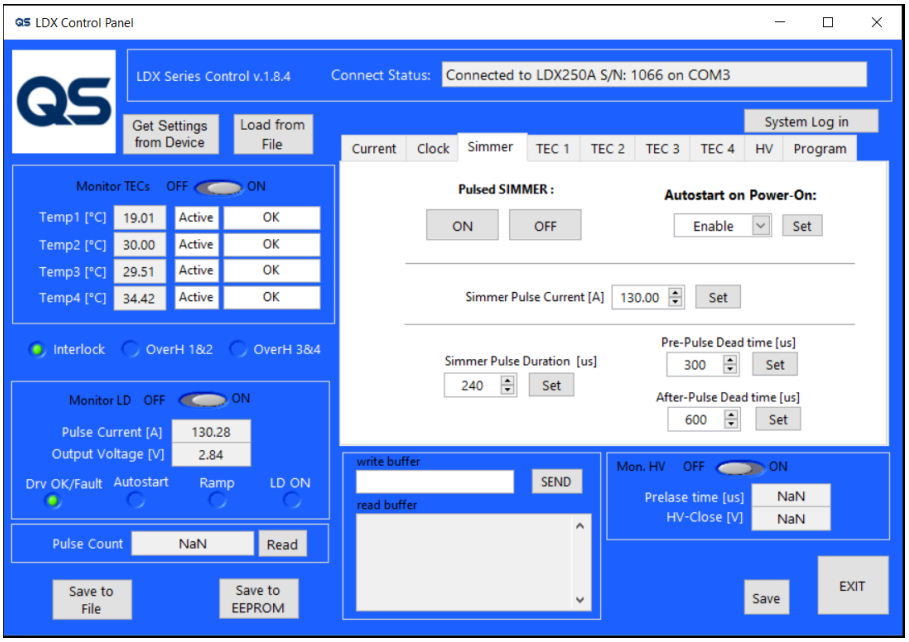


Fig. 21. Changing the Simmer Pulse Current in internal triggering mode.

Saving the set parameters

To save the set parameters for the next laser starting user should perform the following operations:

1. Stop Laser by pushing “LASER ON” button that is located on the front panel of the Laser Controller.
2. Click the button “Stop” in tab “Current” in LDX Control window.
3. Click the button “Save to EEPROM”.

The user can continue to operation with laser.

Please send your inquiries to sales@qslasers.com if you wish to change other parameters. Inquiries for permission code should contain the order number and the laser controller serial number.

6.2 External Triggering

Sequence of actions to change to external triggering

1. *Stop Laser by pushing "Stop" button in tab „Current"*
2. *Unpush „Laser ON" button in front panel of Laser Driver*
3. *Press „OFF" button in tab „Simmer"*
4. *Set „LD external" in tab „Clock".*
5. *Connect external trigerring source with „ TRIG IN" in front panel of Laser Driver*
6. *Run external trigerring source*
7. *Press „Laser ON" button in front panel of Laser Driver*
8. *Start Laser by pushing "Start" in tab „Current"*

Sequence of actions to change to internal triggering

1. *Stop Laser by pushing "Stop" button in tab „Current"*
2. *Stop external trigerring source*
3. *Unpush „Laser ON" button in front panel of Laser Driver*
4. *Set „LD internal" in tab „Clock".*
5. *Disconnect external trigerring source from „ TRIG IN" in front panel of Laser Driver*
6. *Press „ON" button in tab „Simmer"*
7. *Press „Laser ON" button in front panel of Laser Driver*
8. *Start Laser by pushing "Start" in tab „Current"*

Note:
Failing to set correct triggering pulse parameters might lead to damage of the laser. It is user responsibility to make sure that triggering pulse has parameters as specified in Table 3.

To change the laser operation regime from internal triggering mode to external user needs to use LDX Control window, “Clock” tab. In “Trig mode” field user shod choose external triggering. Please refer to **Fig. 22.**

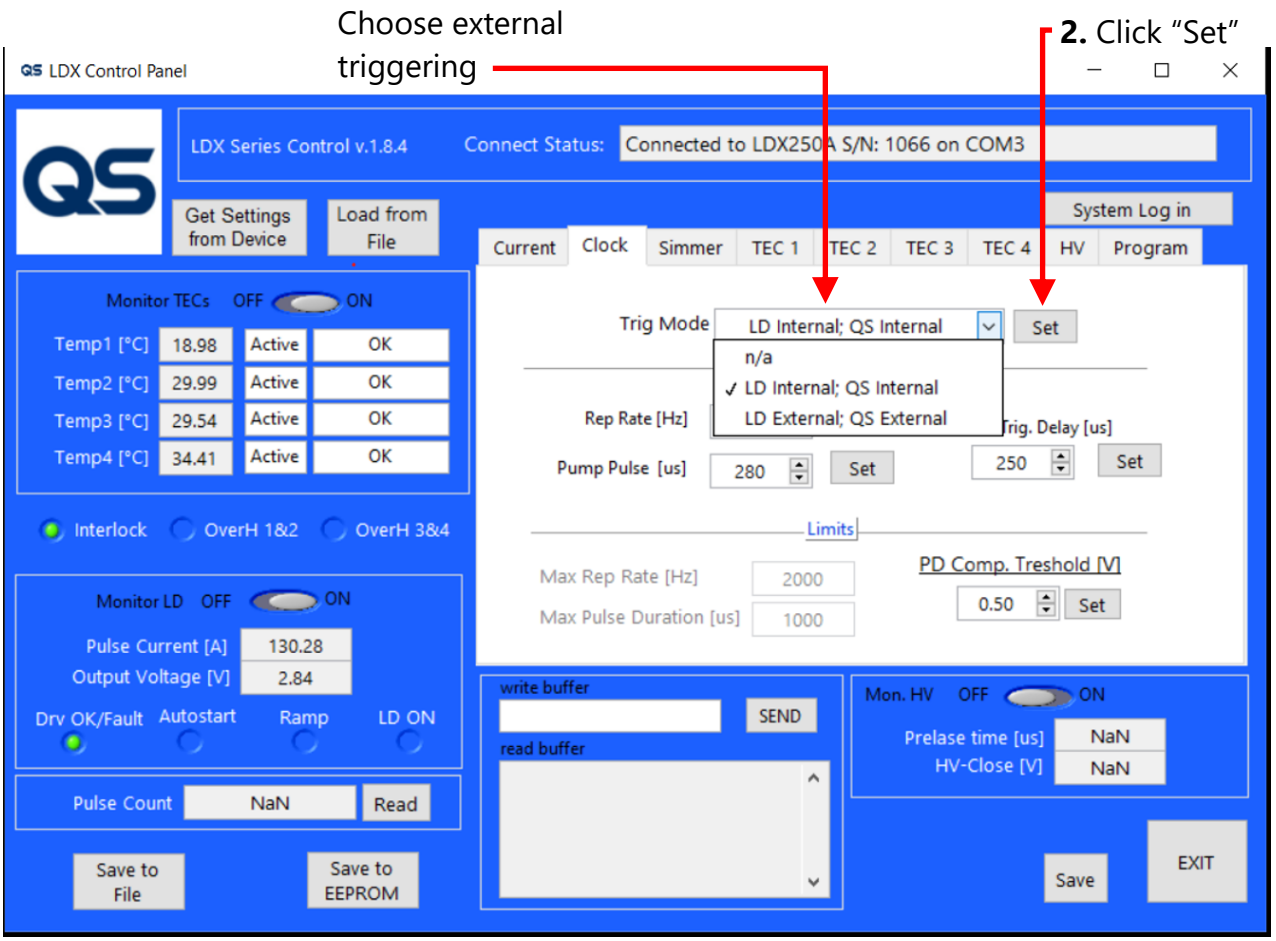


Fig. 22. Changing the triggering source.

Important:

Simmer feature is active only at internal triggering regime in this model.

The LASER CONTROLLER'S front panel settings and connections are listed in the table below:

Table 3. The LASER CONTROLLER front panel settings and connections

Name	**Position**	**Note**
Access Key	ON	
LD clock	External	Programmable
Monitor	Connected to Oscilloscope	Photodetector load 1 MOhm
LD TRIG IN	Connected to user's pump diode triggering device	Input impedance is 10 kOhm Hi level 5V, Low level 0V, Pulse duration 1us.

Warranty Statement

QS Lasers Ltd., further – QSL - warrants to the original purchaser that laser devices are free from defects in parts and workmanship. QSL will make any necessary repairs or replacement of parts to remedy any defect according to the conditions drawn up in the contract.

QS Lasers laser system MPL2510- is guaranteed to be free from defects in material and workmanship for a period of 12 months after delivery or for 10000 of operating hours (whichever occurs first). QSL does not assume liability from installation, labor and consequential damages.

The foregoing warranty does not cover equipment that is damaged by accident or improper use. QSL does not assume any liability if adaptations are made or accessories attached to the equipment that impair or alter the normal functioning of the equipment. The limited warranty and remedy contained in this paragraph are the only warranty and remedy pertaining to the equipment. QSL DISCLAIMS ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. *QSL* is *not* liable for any accidental, consequential or other damages or costs, lost profits or inconvenience occasioned by loss of the use of the equipment or labor expended by persons not so authorized by *QSL*.