Taiko PDL M1

High-End Picosecond Diode Laser Driver

PicoQuant

User Manual

Document version 2.3.0

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1. General safety information

CAUTION! Before using this device, make sure that you have read and understood the content of this user manual. Store this documentation in a safe and easily accessible place for future reference.

Incorrect handling of this product may result in personal injury or physical damage. The manufacturer assumes no responsibility and cannot be held liable for any injury / damages resulting from operating the device outside of the normal usage defined in this manual.

1.1. Warning Symbols and Conventions

The following symbols and conventions will be used throughout this manual. Please take time to familiarize yourself with their meaning before proceeding.

	The **general safety alert symbol** is used to alert you to hazards that may lead to personal injury or physical damage. Follow all associated safety instructions to avoid possible injury or death.
	A **high voltage warning symbol** is used to indicate the presence of un-insulated, dangerous voltage inside the enclosure. Note that this voltage may be sufficient to constitute a risk of shock.
	The **laser radiation warning symbol** alerts you that the device can generate laser radiation. Follow all applicable laser safety instructions to avoid injury or damages.
	The device's susceptibility to electrostatic discharge (ESD) is indicated by the **ESD warning symbol**. Ensure that you follow proper ESD protection rules to avoid damaging the device.
CAUTION!	Make sure to follow any instructions prefaced with "**CAUTION!**" to avoid personal injury or damaging the device.
WARNING!	The "**WARNING!**" label prefaces any instructions that have to be followed to avoid sever injury or death.
NOTICE	Important tips and information for device operation that do not include a risk of injury or damage are prefaced with the "***NOTICE***" label.
	This symbol indicates that an earth terminal needs to be connected to the ground (to avoid risks of electrical shock).

1.2. Electrical Safety Instructions

WARNING! To avoid electric shock, the power cord's protective grounding conductor must be connected to the ground.

This devices contains no user serviceable components. Do not remove covers! Servicing of internal components is restricted to qualified personnel.

Disconnect the power cord from the electrical outlet before performing any maintenance.

1.3. Laser Safety Instructions

WARNING! Visible and invisible laser radiation

Diode laser heads from the LDH-I Series are available at different wavelengths and intensities. Some laser heads can emit infrared light. Infrared light is not visible to the eye! **Some laser modules can emit laser light of up to class 4 / IV.** Please refer to the labels affixed to the laser head for information on classification.

Lasers can be hazardous and have unique safety requirements. Permanent eye injury and blindness is possible if lasers are used incorrectly. Pay close attention to each safety REMARK and WARNING statement in the user manual. Read all instructions carefully BEFORE operating this device.

The Taiko laser driver and laser diode heads of the LDH-I Series are manufactured according to the International Laser Safety Standard IEC 60825-1:2014 and comply with the US law 21 CFR §1040.10 and §1040.11.

Required Laser Safety Measures

Please observe the laser safety measures for class 3B / IIIB, 3R / IIIR or class 4 / IV (depending on laser head) lasers in accordance with applicable national and federal regulations. The owner / operator is responsible for observing the laser safety regulations.

What does the owner / operator have to observe?

- The owner / operator of this product is responsible for proper and safe operation and for following all applicable safety regulations.
- The owner / operator is fully liable for all consequences resulting from the use of the laser for any purposes other than those listed in the operating manual. The laser may be operated only by persons who have been instructed in the use of this laser and the potential hazards of laser radiation.
- The owner / operator is responsible for performing and monitoring suitable safety measures (according to IEC/EN 60825-1 and the corresponding national regulations).
- The owner / operator is also responsible for naming a laser safety officer or a laser protection adviser (according to the standard IEC/EN 60825-1: "Safety of laser products, Part 1: Classification of systems, requirements and user guidelines" and the respective national regulations).

The following security instructions must be followed at all times.

General Safety Instructions for Operation

- Never look directly into a laser beam or a reflection of the laser beam. Avoid all contact with the laser beam.
- Do not introduce any reflective objects into the laser beam path.
- Every person involved with the installation and operation of this device has to:

- Be qualified
- Follow the instructions of this manual

- As it is impossible to anticipate every potential hazard, please be careful and apply common sense when operating the *Taiko PDL M1* laser driver and its associated diode laser heads. Observe all safety precautions relevant to class 3B / IIIB, class 3R / IIIR or class 4 / IV lasers, respectively.
- Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.
- For safety reasons, you should periodically check (on a monthly basis) the function of the emission indicators, remote interlock, and key switch on the laser driver, as well as verify that no scattered radiation can escape the collimator (e.g., by missing screws).
- **Do not open the device** under any circumstances! There are no user serviceable parts inside.

1.4. Safety Labels on the Laser Device

The safety labels are affixed to the laser head housings, with an arrow pointing towards the laser emission aperture (see Fig. 1 for some examples). The label states the laser product classification, certification, power, and wavelength range relevant for the classification. LDH-I laser head have currently either a cylindrical or cuboid shape.

1.4.1. Cylindrical Laser Heads

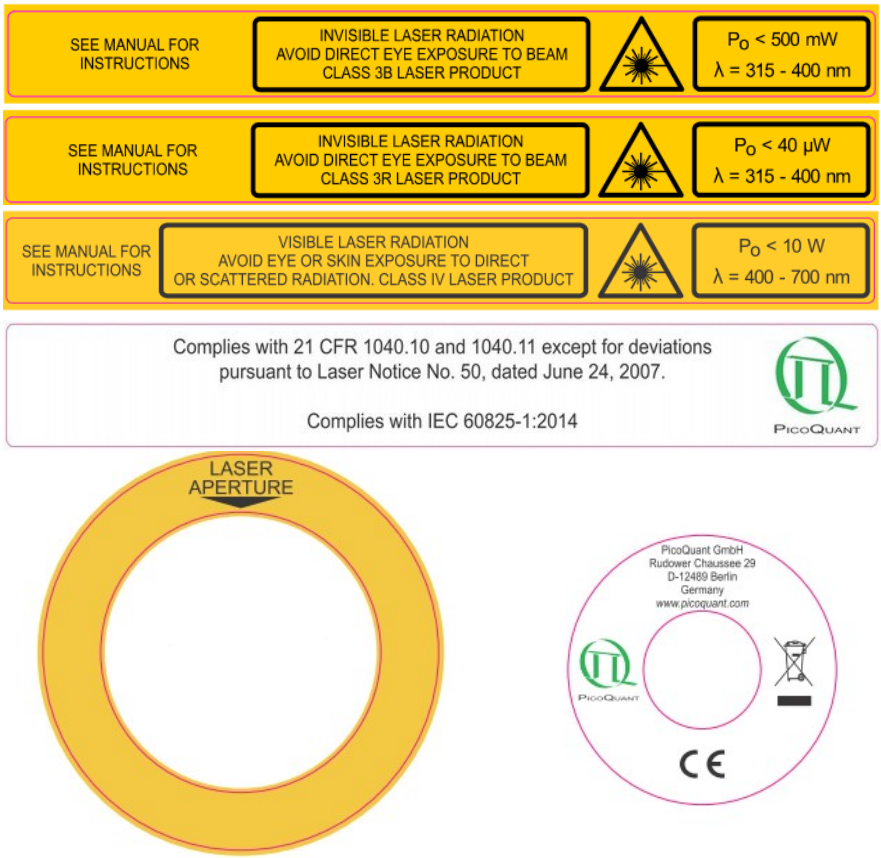


Fig. 1: Example of laser warning, certification, laser classification, and laser aperture indication labels on cylindrical laser heads of the LDH-I Series.

Fig. 2, Fig. 3, and Fig. 4 show different views of the laser head under different perspectives in order to show the position of the respective labels.

Fig. 2: Cylindrical Taiko Laser Head LDH-I - top view

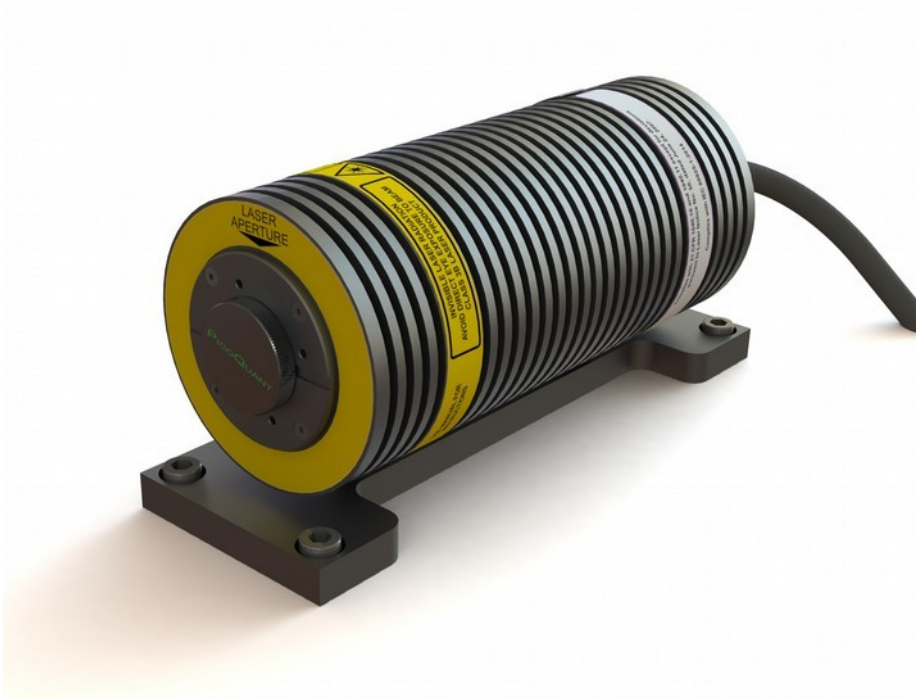


Fig. 3: Cylindrical Taiko Laser Head LDH-I - front view

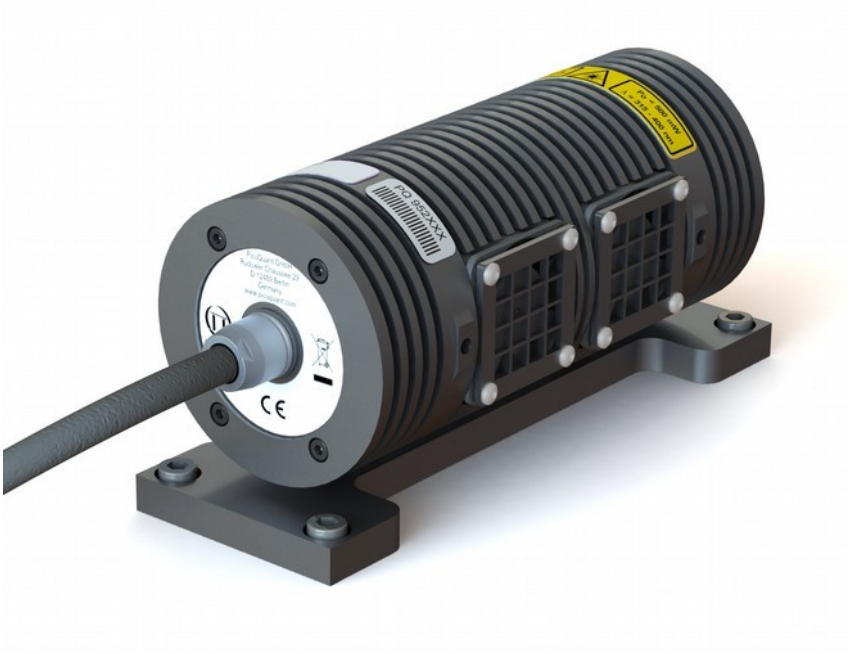


Fig. 4: Cylindrical Taiko Laser Head LDH-I - rear view

Please refer to the *laser delivery report* in the Appendix for information on the central emission wavelength, maximum achievable optical output power, and pulse shape of the delivered LDH-I laser head.

1.4.2. Cuboid Laser Heads

Fig. 5 shows an example of laser warning, certification, laser class, and aperture indication label that can be found on a cuboid laser head of the LDH-I Series. The label location on the laser head can be seen in Fig. 6.

Please refer to the *laser delivery report* in the Appendix for information on the central emission wavelength, maximum achievable optical output power, and pulse shape of the delivered LDH-I laser head.

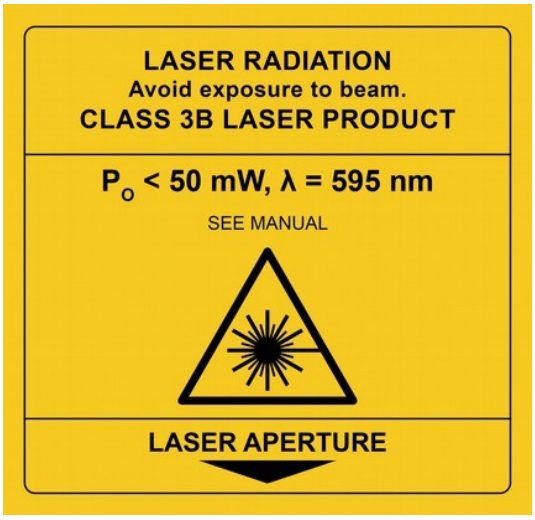


Fig. 5: Example of laser warning, certification, laser classification, and laser aperture indication labels on cuboid laser heads of the LDH-I Series.

Fig. 6: Cuboid Taiko laser head - side view.

1.5. Remote Interlock Connector and Manual Reset

A hardware lock as well as a remote interlock connector are part of the *Taiko PDL M1 laser driver*. Removing the connector or breaking the interlock circuit will immediately deactivate the power supply of the laser.

The remote interlock connectors (banana plug and LEMO) are located on the back panel as shown in Fig. 7.

In order to meet laser safety regulations, you may need to install a remote interlock, e.g., a door switch, to deactivate the power to the laser when the door to the laser area is opened.

Note that there is no indication of the status of the interlock at the local user interface.

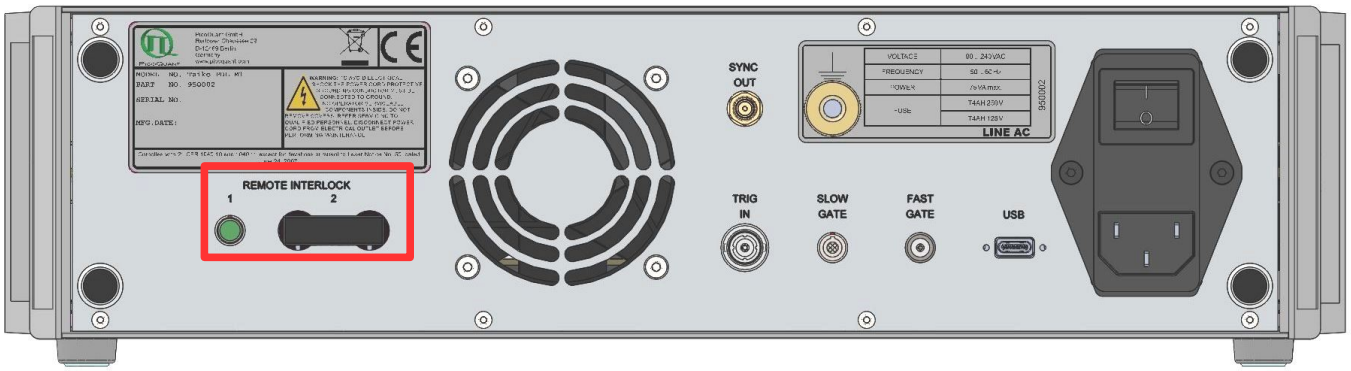


Fig. 7: Location of the remote interlock connectors on the Taikos back panel (highlighted by the red box).

CAUTION! **The laser driver is delivered with 2 bridging plugs. A green LEMO plug, which bridges pins 2 and 3 of Remote Interlock 1 and a banana plug, which bridges the Remote Interlock 2. Using both bridging plugs at once is NOT intended for everyday use of the laser driver as they cannot act as a functional remote interlock circuit, since they have no capability to react to e.g., a door switch.**

Pin assignment for the interlock

The interlock is a 4 pin LEMO EGG.00.304.CLL female connector as shown in Fig. 8. In order to activate laser emission, **pins 2 and 3** need to be bridged using a suitable adapter. Do **not** apply any voltage.

Fig. 8: Interlock LEMO connector

Important Note:

Please note that when a class 4/IV rated LDH-I laser head is connected to the Taiko, laser output will be internally blocked if one of the following events occur:

- Power interruption during the operation of the *Taiko PDL M1* laser driver. Laser emission will **not** resume once power is restored.
- Interruption of the remote interlock circuit.
- Laser key switch is **not** in the *STBY* position when the mains power switch is switched to the *ON* position.

Once the hardware lock of the system has been triggered, the *ON* LED will **permanently blink**, even when the laser key switch is in the *ON* position.

To unlock the system, a **manual reset** is needed. The **manual reset** is done by turning the laser key switch back into the *STBY* position. Laser emission can then be reactivated by turning the laser key switch into the ON position.

NOTICE **The internal lock and need for a manual reset do not apply while the Taiko is operated with LDH-I laser heads rated up to class 3B / IIIB or 3R / IIIR.**

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

2. Introduction

The introduction of the Taiko laser driver marks the beginning of a new generation of smart picosecond diode lasers. The Taiko is a universal laser driver that can operate and monitor any laser head from the LDH-I Series. The focal points of its design are flexibility and ease-of-use, making it accessible not only for experts but also novice laser users. For example, changing the emission wavelength is as simple as plugging in a different laser head and the Taiko will automatically recognize its operation parameters.

Take full control

The Taiko smart driver interfaces with laser heads from the LDH-I Series to read out and display various operational parameters. These include central and current emission wavelength, laser head temperature, repetition rate, as well as an estimation of the current output intensity.

Every LDH-I head is calibrated during manufacturing with regards to its intensity / output power curve and temperature dependent wavelength shift. The Taiko is thus able to provide an indication of current output power and central wavelength during operation.

Setting of the output power can be done either by relative percentage values of intensity or by absolute calibrated values of optical power (mW, W). Due to its extended high power capability, the Taiko can drive an even wider range of laser heads, including our latest generation of high power, multi mode diodes.

Flexible pulse patterns

The Taiko laser driver supports internal repetition rates ranging from single shot (1 Hz) to up to 100 MHz. In addition to constant repetition rates, it can also generate user-defined burst sequences consisting of an arbitrary amount of pulses with freely selectable burst periods.

Power setting

Each Taiko head from the LDH-I Series can be operated in two different power setting modes: *linear* or *max. power*, except the following laser heads: LDH-IB-530-T, LDH-IB-560-T, and LDH-IB-595-T. These only support linear mode. Switching between these modes is done by simply selecting the desired mode of operation from either the local or remote GUI and requires no system restart or other adjustments.

In *linear mode*, each laser head is calibrated in terms of average optical power, meaning that for a given setting of laser intensity and repetition rate, a corresponding calibrated mW value of average optical power can be read from the local display and /or through the software interface. More importantly, both pulse energy and pulse shape are guaranteed to remain constant over the entire range of repetition rates when operating in this mode.

The *max. power* mode allows reaching higher optical output powers than in *linear* mode. The exact amount of extra power that can be achieved depends both on connected laser head as well as repetition rate at which it is operated. Note that when a laser head is operated at an optical output level above the linear mode maximum, the pulse shape will always be broadened.

Displaying wavelength shifts

The central wavelength of each compatible laser head is calibrated as a function of the operation temperature and the shifted values can be obtained from the local display or through the software interface.

Choice of user interface

The Taiko laser driver can be controlled either locally through an intuitive menu-driven system on the Taiko color LCD display or remotely on a PC via USB connection.

3. Installation and Quick Start

The number labels used in this chapter refer to the hardware elements shown in Figs. 11 and 12. Before making any connections, be sure that all of the following conditions are met:

- *Mains power switch* (L) on the back panel is in the *OFF* position.
- *Laser key switch* (B) on the front panel is set to the *STBY* position.

3.1. Operating Site

The product is for indoor use only at an altitude of up to 2000 m above sea level. The device position shall ensure access to all manual control components including the mains power switch.

Driver Unit

Please ensure free air circulation around the unit for heat dissipation and do not cover the cooling fan at the back panel.

Temperature Controlled Laser Heads (LDH-I models)

The LDH-I series laser heads contain an active thermoelectric cooling system. Depending on the ambient temperature, this can produce a considerable amount of heat at the housing.

Sufficient air circulation must be ensured to prevent overheating of the laser head. If possible, mount the laser head on little posts as shown in fig. 9 to allow air convection around the whole surface. Mounting material as shown here is available from PicoQuant as an accessory.

Fig. 9: LDH-I laser head mounted on posts, allowing for air convection.

3.2. Electrical and Signal Connections

3.2.1. Connecting the Laser Head to the Laser Driver

Changing or connecting a laser head to the *laser head output connector* is a straightforward task, but a few points have to be taken into account. Following the step-by-step guide given here is strongly recommended.

WARNING! Ensure that the laser head is firmly attached to its base plate or optical bench and that the beam aperture or optical fiber exit is oriented so that they do not pose an eye hazard BEFORE turning the laser on.

Connecting a laser head from the LDH-I Series

- Laser heads from this series can be connected via a single cable, which is plugged into the *laser output* port of the Taiko PDL M1 (A).

- The LDH-I laser heads support hot plugging. They can be connected / disconnected without having to shut down the Taiko PDL M1.

3.2.2. Other Signal Connections (back panel)

- Connect (if necessary) the "*REMOTE INTERLOCK*" (F) to a switch loop (see below) or use the provided short circuit bridge if no remote interlock is needed.
- Should you wish to use an external trigger signal, connect it to the "TRIG IN" (H) port.
- Connect any desired external devices (e.g., a TimeHarp or PicoHarp TCSPC unit or an oscilloscope) to be synchronized to the "*SYNC OUT*" connector (G).
- Plug in the power cable (L).

Remote Interlock Connector

In order to meet laser safety regulations, you may need to install a remote interlock, e.g., a door switch, to deactivate power to the laser when the door to the laser area is opened. The *REMOTE INTERLOCK* connectors are provided for this purpose. When the contacts are open the power supply of the laser is then disabled.

Remove the bridge of the connector you intend to use and connect your remote interlock (door) switch to the *REMOTE INTERLOCK* connector. Standard Lemo 00.304 or banana plugs can be used for the connection. The loop resistance of the cabling plus switch must be less than 10 Ohms. The voltage that is present on this connector is < 16 VDC.

3.3. Continuous Wave Operation

The Taiko PDL M1 allows operating the laser heads from the LDH-I Series in continuous wave (cw) mode. This mode can be activated either from the drivers local interface or from the (optional) Windows based software GUI. Please refer to sections 5.1 Local User Interface or 5.2 Remote User Interface (PC Software) for detailed instructions on changing the laser operation modes.

Note that significantly higher optical output powers will be produced in cw compared to pulsed mode, especially when the laser is operated at low repetition rates. In this operation mode, the optical output power can be adjusted in the same way as in pulsed mode through the local interface or from the Windows based software GUI.

When switching from pulsed to CW operation, the Sync Output of the Taiko will keep running at the formerly set repetition rate.

3.4. Fiber Coupling

Depending on their emission wavelength, the optical output of laser heads from the LDH-I Series can be fiber coupled. The heads can be equipped with either single-mode (SM), multi-mode (MM) or polarization maintaining (PM) fibers. If applicable, the fiber type for each specific laser head is indicated in the individual Laser Delivery Report in the Appendix.

CAUTION!	**Please do not remove the optical fiber from the coupling optics as the adjustment of the coupling will be lost! Re-adjustment is a demanding task and requires an experienced operator.**

3.5. Polarization

The laser beam which is emitted from the collimated output is linearly polarized. The polarization extinction ratio for diode lasers is typically about 20 dB or 100 : 1. The polarization plane of the laser output is indicated by a small label on the back of the laser head. Note that the polarization might be different for different types of laser heads.

3.6. Triggering Other Devices with the Synchronization Signal

Each laser pulse also generates a NIM standard signal (< -800 mV at 50 Ohms) at the s*ynchronization output* ("*SYNC OUT*") port (G). This provides the opportunity to synchronize the laser with multiple light sources or other devices for time correlated measurements. The sync out signal is always synchronized to the trigger source (i.e. INT or EXT depending on the setting of the t*rigger source selector*).

If you only need the synchronization signal without laser pulses (i.e. for installation and adjustment), switch off the laser with the *laser key switch*. The synchronization signal will still be present, running according to the settings.

In cw mode, a synchronization signal according to the settings of the "*INT*" mode is applied to the "*SYNC OUT*" port. In burst mode, only the first laser pulse of a burst sequence generates a synchronization pulse.

3.7. Gating

For special applications such as in scanning devices, the Taiko PDL M1 features two gating functions which allow suppressing laser emission by an external signal.

Both gating functions can be enabled and disabled from the local or remote interface. If a gating function is disabled, then connecting the corresponding gating signal will have no effect on the driver. Note that the Taiko PDL M1 can use both types of gating at the same time.

Fast Gate

The *Fast Gate* function affects the triggering mechanism. If the Taiko is gated off, both laser emission and Sync Out signal will be deactivated.

The *Fast Gate* is effective whether the Taiko is being triggered from the internal oscillators or running in CW mode.

Two *Fast Gate* configurations can be chosen:

- 50 Ohm / ground: the laser is OFF => connect a high active TTL signal (5V into 50 Ohm) to gate the laser on. This termination prevents reflections on the transmission line.
- 10 kOhm / High (5 V): the laser is ON => connect a low active TTL signal (ground) to gate the laser off. This termination can be used for weak sources.

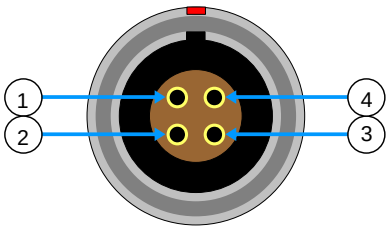
The Fast Gate function can perform transition within nanoseconds; assuming a precise timing, it can switch between two laser pulses even at high repetition rates.

Slow Gate

The *Slow Gate* function affects both laser emission and Sync Out signal of the device.

The *Slow Gate* is effective whether the Taiko is being triggered from the internal oscillators or running in CW mode.

There is only one *Slow Gate* configuration with 500 Ohm impedance:



Pin #	***Function***
1	Anode
2	Cathode
3	Ground
4	+5 Volts

Fig. 10: Pin assignment of the SLOW GATE input port.

The Slow Gate input is isolated by an opto-coupler and a voltage of 5 V between pin 1 and pin 2 of the connector must be fed into the input to unblock the Slow Gate.

Alternatively you can use an external generator delivering 5 V signal into 500 Ohm (ca 10 mA).

The Slow Gate is a rather slow modulation and may not switch between two laser pulses at high repetition rates..

3.8. Software Installation

Before installing and using the Taiko PDL M1, please make sure to have

1. a solid base onto which the Taiko PDL M1 can be placed (e. g. an optical table)
2. a computer to install and run the operation software. The computer needs to have a free USB port as well as a Windows operating system.

Place the Taiko PDL M1 on its dedicated place, insert the power cord and connect the Taiko PDL M1 to the host computer using the delivered USB cable.

NOTICE	**The Taiko PDL M1 should not be turned on before the control software is installed on the host computer.**

The control software for your Taiko PDL M1 needs to be set-up by an installer and is supplied on the CD along with your device. Installing the software is straightforward and performed by a step-by-step installation wizard. To install the software:

1. Insert the CD into the host computer.
2. Launch the program: `PDLM_Drv_Setup.exe`

NOTICE	**The installer may contain a newer firmware version for the Taiko. Please refer to section 3.9 for addition information.**

3. Follow the instructions on the screen:
   - Accept the License agreement and click *Next* when requested.
   - Define the destination folder for the installation of the software and which launcher icon(s) that should be generated.
   - Click *Next* to validate your choices and then the *Install* button to start the installation.
4. Click *Next* to start the installation of the drivers.
   - It is possible that a *Windows Safety Warning* window pops up. In that case confirm the installation when requested in order to continue with the installation.
5. Click *Next* when requested to complete the installation.
6. Click *Finish* to close the Installation wizard.

Once the software is installed, the Taiko PDL M1 can be turned on (see chapter 3.10 Quick Start Guide). When the laser is turned on for the first time, Windows will detect a new device and install the necessary device drivers.

3.9. Firmware updates

Both the firmware (local GUI) and control software for Windows-based PCs can be updated to provide general improvements as well as new features. Please refer to the release notes included with the update installer packages for information on the specific changes an update includes. It is strongly recommended to update to the latest firmware and software versions, as older ones will no longer be maintained.

WARNING!	**Please note that there is no way for the end user to revert to a previous firmware version. Downgrading the Taiko PDL M1's firmware requires returning the device for a factory overhaul.**

The update process for the Taiko PDL M1 is straightforward for the end user: An update occurs in several steps: First, the software for the control software for Windows based PCs is updated, then the new firmware is copied to the Taiko PDL M1 and flashed, and finally the USB device driver is updated.

NOTICE

If a version mismatch exists between the Taiko PDL M1 firmware and the USB device driver, the laser driver might either not be recognized by the host PC (i.e. no connection possible) or the some of the panels in the windows control software might show up empty.

To resolve such an issue, please ensure that the USB device driver version on the host PC matches the laser driver's firmware (e.g., for firmware version 2.x or higher, the USB driver service name should be WINUSB and not PQUSB or PQUSB64).

Firmware version number can be seen in the *About* panel of the local GUI.

Follow the steps outlined below to perform a firmware update:

1. Download the desired firmware update installer package from the PicoQuant website
2. Copy the installer on to the PC that is connected to the Taiko PDL M1, if necessary.

CAUTION! Do not power off the Taiko PDL M1 or connected PC during the entire update process!

3. Make sure that the Taiko PDL M1 is connected to the PC via the USB cable.
4. Turn the laser key switch (B) to the *STBY* position. Note that attaching an LDH-I Series laser head is **not** required for the update process.
5. Switch the *mains power switch* (L) on the back of the Taiko PDL M1 to *ON.*
6. Run the update installer by double clicking on the executable file you downloaded.
7. Follow the on screen instruction:
   - Accept the License agreement and click *Next* to start the update process.
   - Select the folder where the control software GUI should be installed and click *Next*.
   - Choose the additional components to be installed and click *Next*.
   - Select the launcher icon(s) that should be generated and click *Next* and then *Install* to start the installation of the control software GUI.
   - Once this step has successfully concluded, the installer will check the firmware versions of all connected Taiko PDL M1 and display a pop-up window listing the number of devices in need of a firmware update. Note that the installer will only update a firmware with an older version number (i.e. it will never overwrite a current or newer version).
   - Click on *Yes* to update the firmware of all connected devices or select *No* to abort the update process. Note that after selecting No, the installer will also undo the control software GUI update done before (i.e. the software will be rolled back to the previous version).

NOTICE

After updating the firmware, these Taiko PDL M1 laser drivers will no longer run with older software versions. The remote control GUI, firmware, and USB device driver versions need to be matched to each other to ensure proper operation.

PicoQuant strongly recommends performing the update, as older versions will no longer be maintained.

   - After clicking on Yes, the installer copies the firmware file to the device(s), automatically performs integrity checks, and the flashes the firmware(s)
   - Once the flashing is done, a window summarizing the performed updates is displayed. Click on *Next* to continue.
   - In this step, the new USB device driver will be installed. Click *Next* when prompted to proceed along the update process.
     - It is possible that a *Windows Safety Warning* window pops up. In that case confirm the installation when requested in order to proceed.
   - At the end of this step, the installer will display an installation report. Click *Next* to proceed.

- The update process is now completed. All updated Taiko PDL M1 should now be powered off and then on again before they can be used with the control software.
  - Depending on the operating system version, it may take a while until Windows recognizes the updated Taiko PDL M1 laser drivers.

8. Click *Finish* to close the Installation wizard.

3.10. Quick Start Guide

3.10.1. Powering up the Taiko PDL M1

1. Turn the *laser key switch* (B) to the *STBY* position.
2. Ensure that all laser safety instructions as outlined in chapter 1.3 Laser Safety Instructions are observed.
3. Switch the *mains power switch* (L) on the back of the Taiko PDL M1 to *ON* and the *white LED in the power button* (E) will light up.

WARNING! **If a Laser Class 4/IV (or equivalent) laser head is connected to the driver and the *laser key switch* is left in the *ON* position during power up, then the hardware lock will be triggered. A manual reset is required to resume lasing. Please refer to section 1.5, page 8.**

NOTICE **If a Laser Class 3/III (or lower) laser head is connected to the Taiko and the laser key switch is left in the ON position during power up, then laser output will be locked off for 5 seconds. After this time span, the laser head will start emitting according to the current settings.**

4. Select the desired trigger source through either the local interface or windows software:
   - Internal: the Taiko will use its internal oscillator to trigger the laser pulses
   - External: laser will be triggered by an external signal; provided that the trigger level threshold is set correctly
   - Continuous wave: select this mode to run the laser head in cw mode (only for selected LDH-I models)
5. If the laser head is triggered by the internal oscillator, set the desired repetition rate in either local or remote interface.
6. Turn the laser key switch (B) to "***ON***".
7. The LED *ON* (B) will light up in white and the buzzer will generate a short, audible beep.
8. Adjust the laser power level either through the local interface (menu item Intensity) or through the windows GUI.
9. Open the laser output shutter (O) if using a cuboid laser head.

If you cannot detect any laser emission, check the following:

<table>
<tr><td colspan="4">Is the white “laser on” indicator LED (B) on?</td></tr>
<tr><td>Yes</td><td colspan="3">No</td></tr>
<tr><td rowspan="2">Has the Slow Gate switched off? (see section 3.7)
If no Slow Gate is used, it must be configured as disabled (see point 7.5 Gating in section 5.1.4)</td><td colspan="3">Selected trigger source?</td></tr>
<tr><td>CW</td><td>INT</td><td>EXT</td></tr>
<tr><td rowspan="2">Is the “INTENSITY” setting high enough?

A laser head will only start emitting light when operated above the lasing threshold. Increase the intensity setting accordingly (when using a laser head with calibration curve, an estimation of the output power will be shown on the LCD)</td><td rowspan="2"></td><td rowspan="2">Is the selected frequency above an internally set limit (see section 3.10.2)? Check rear panel for a note.</td><td>Is the trigger level set correctly?</td></tr>
<tr><td>Does the triggering signal meet the specifications of pulse width and amplitude? See section 3.10.4</td></tr>
<tr><td rowspan="2">Is the shutter (O) in position open if a cuboid laser head is used?</td><td></td><td colspan="2">Has the Fast Gate switched off? (see section 3.7)
A short circuit on the “Gate” connector (J) switches off the laser.</td></tr>
<tr><td colspan="3">Is the laser key switch (2) in the “ON” position?</td></tr>
<tr><td></td><td colspan="3">Is the remote interlock loop closed? See section 1.5</td></tr>
</table>

3.10.2. Setting the Repetition Frequency

The repetition frequency (or rate) of the internal trigger signal can be chosen in the range from single shot (1 Hz) up to 100 MHz (upper repetition rate limit depends on the individual laser head). Repetition frequency can be easily set through either the local interface or remotely with the Windows software (see chapter 5 Software Description).

When the repetition frequency is changed, the average power of the laser will also change. As the pulse energy is constant for a wide range of repetition frequencies the average power typically doubles or halves respectively when doubling or halving the repetition rate.

Note that for repetition frequencies above 20 MHz, saturation effects can occur causing a slight drop in pulse energy and consequently lower average optical output power than expected.

3.10.3. Changing the Pulse Intensity

The energy of the laser pulses can be adjusted through the intensity menu item of the local interface or remotely through the laser driver software. In order to reach stable optical output power, allow the laser to warm-up for at least 20 minutes.

Note that most of the LDH-I laser head can be operated in two different power modes: *linear* or *max. power*. Switching between these modes is done by simply selecting the desired mode of operation from either the local (see section 5.1.4) or remote GUI (see section 5.2.4.2) and requires no system restart or other adjustments.

In *linear mode*, each laser head is calibrated in terms of average optical power, meaning that for a given setting of laser intensity and repetition rate, a corresponding calibrated mW value of average optical power can be read from the local display and /or through the software interface.

The *max. power* mode allows achieving higher optical output powers than in *linear* mode. The exact amount of extra power that can be reached depends both on the connected laser head as well as the repetition rate at which it is operated. Refer to the calibration power curves in Appendix 10.4 (Laser Delivery Report) to get an overview of the achievable power gains for the connected laser head.

Note that in *max. power* mode, the laser head will behave as in *linear* mode when operated at power settings at or below the limit for linear range.

At higher optical output settings, the pulses will not only be more intense but also longer and slight after-pulsing may occur. When operating above the linear mode power limit, changing the repetition frequency may also change the pulse shape. In some instances, these changes can be compensated for by adjusting the intensity setting, in order to retain the desired pulse form.

Some higher power laser heads may only operate in the upper range of the intensity setting. Keep in mind that running a laser diode at high power levels will decrease its lifetime. To ensure safer working conditions and to prolong the lifetime of the laser element, select a power setting that is as low as possible for your needs. Full laser power should only be selected if absolutely needed.

3.10.4. External Laser Triggering

The laser can also be triggered by an external signal source at any frequency.

1. First, set the laser key switch (B) to the *STBY* position.
2. Connect the trigger signal generator to the "***TRIG IN***" port (H). The maximum limits for the trigger signal input voltage are -5 and +5 V. To prevent reflections, the output impedance of the signal source as well as the characteristic impedance of the cable and coaxial connectors must be exactly 50 Ohms.
3. In either the local or remote interface, set the trigger source to "***Ext Rising***" or "***Ext Falling***"
4. Adjust the trigger level between -1 to +1 V in the appropriate sub-menu (see chapter 5). The trigger level may have to be optimized in order to achieve the shortest possible pulse width. If the pulses are significantly broader than with internal triggering or if there are multiple pulses, the external trigger signal is not ideally locked. Readjusting the trigger level may help with weak input signals. Ringing of the signal source can lead to multiple pulses. Consequently, the trigger level should not be set too close to zero.

Trigger signal recommendations

Special care has to be paid to the quality of the triggering signal. To maintain the picosecond pulse to pulse stability, the signal source itself must have the appropriate quality. A good trigger signal has steep slopes (of a few nanoseconds) with low noise and stable periodicity.

Although the trigger input is designed to be quite sensitive, the best results are achieved with amplitudes between 1 and 2 V and pulse widths greater than 5 ns.

When using TTL signals, an attenuator of 10 dB may deliver better results. As per specifications, the low level of a TTL signal may be as high as 0.8 V, which is already very close to the highest settable trigger level.

4. Hardware Description

4.1. Front Panel

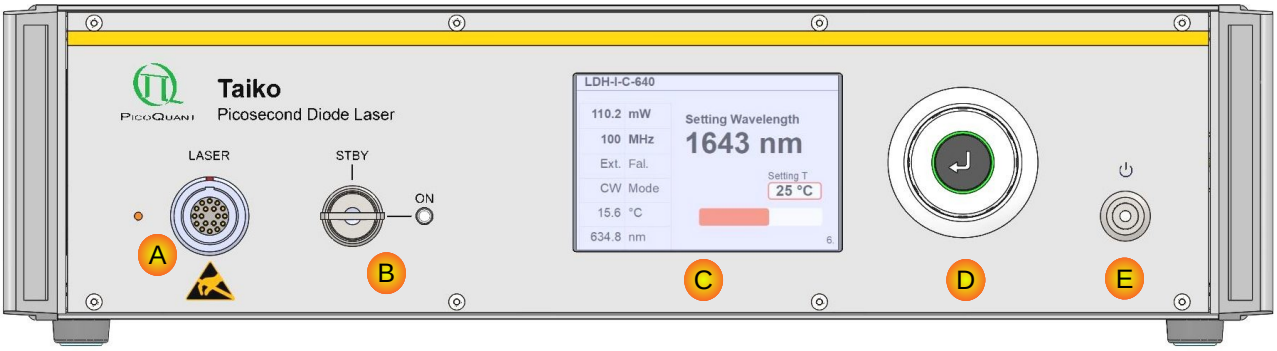


Fig. 11: Front panel of the Taiko PDL M1.

A *Laser output port* for connecting an LDH-I Series pulsed diode laser head (multi-pin connector).

B *Laser key switch, laser emission indicator and buzzer*: Turning the key to the ON position activates the laser. Power to the laser can be locked off by turning the key to the *STBY* position and removing the key. The white LED indicates that the Taiko PDL M1 is ON and that laser radiation is being emitted. When the laser emission indicator lights up, a buzzer generates a short, audible beep.

C Color *LCD display* used by the local control interface. All relevant laser information and settings are displayed here.

D *One button control*: this push-turn dial is used for local control of the Taiko PDL M1. Press the button to access the interface menu. Turning the dial clock-wise or counter clock-wise allows selecting different sub-menus and to adjust parameters. Refer to section 5.1 Local User Interface for more information.

E *Power button and laser emission warning indicator*: Pressing this button switches the Taiko PDL M1's power state from off to on (and vice versa). The white LED indicates that the Taiko PDL M1 is powered and that laser radiation can be emitted

4.2. Back Panel

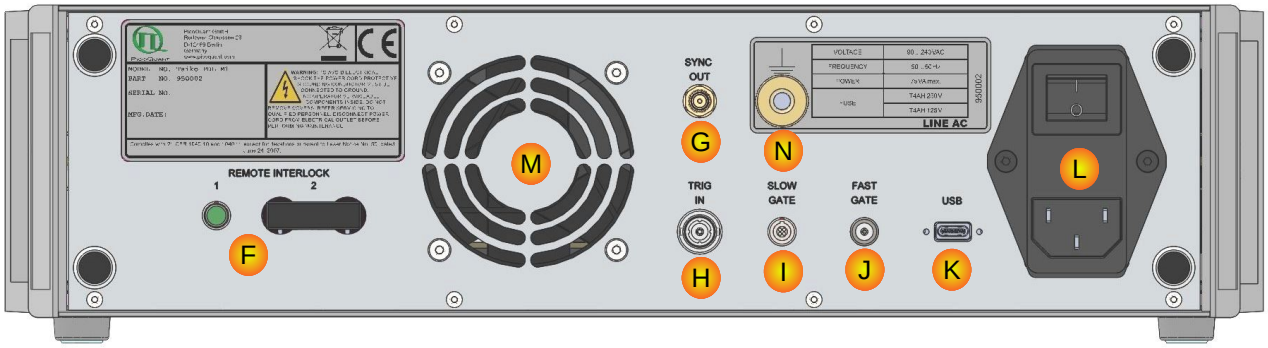


Fig. 12: Back panel of the Taiko PDL M1.

F REMOTE INTERLOCK: two interlock connectors (LEMO and Banana) connected in series are provided on the back panel to connect a remote interlock system. See also Chapter 1.5 Remote Interlock Connector and Manual Reset.

G SYNC OUT: if desired, an external device such as a TCSPC device from PicoQuant (TimeHarp 260, PicoHarp 300, HydraHarp 400) or an oscilloscope can be connected via SMA plug.

H TRIG IN: connect an optional external trigger source via the BNC connector to the Taiko PDL M1, if desired.

I SLOW GATE: laser output can be disabled by supplying gating inputs in signals with TTL shape. Refer to section 3.7 Slow Gate for additional information.

J FAST GATE: fast gating of the laser signal can be achieved by supplying TTL signals at this LEMO connector. Refer to section 3.7 Fast Gate for further information.

K USB port: you can optionally connect the Taiko PDL M1 to a PC via a USB cable for remote control. See also section 5.2 Remote User Interface (PC Software) for a description of the Windows software GUI.

L Main voltage input socket with fuse (bottom) and mains power switch (top).

M Fan opening: Do not cover up this opening and make sure that sufficient space is left between the Taiko PDL M1 and any obstacle.

N Ground connector

4.3. Cuboid Laser Heads

The cuboid laser heads are equipped with a manually controlled laser output shutter (see Fig. 6 O) which is operated by pulling / pushing the handle up / down. The shutter is **closed** (laser emission is mechanically blocked) when the handle is in the **lower position** (away from the laser aperture label) and **open** (laser emission is not mechanically blocked) when the handle is in the **upper position** (towards the laser aperture label).

WARNING! Laser light can be emitted from the aperture when the shutter is open. Ensure that all applicable laser safety measures are observed before opening the mechanical shutter.

4.4. Buzzer

When the laser radiation is switched on the laser emission indicator (B) lights up. Additionally, a buzzer generates a short, audible beep.

5. Software Description

The Taiko PDL M1 can be controlled through the local push-dial interface (see section 5.1) or the remote windows GUI (see section 5.2). Note that both interface types can be used either in **exclusive mode** (i.e. only one of them can actively control the driver) or in **cooperative mode** (i.e. both interfaces are synchronized and can be used interchangeably to adjust parameters).

NOTICE **If some of the options and settings described in this section are not displayed by the local GUI of your Taiko PDL M1, then a firmware update might be needed. Refer to section 3.9 Firmware updates for step-by-step instructions.**

5.1. Local User Interface

The local interface for the Taiko PDL M1 is menu based and uses a single push dial for navigation and setting of parameters. The main menu (see fig. 13) is accessed by simply pressing once on the push dial (D).

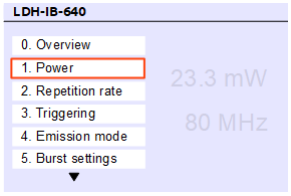


Fig. 13: The local interface main menu.

Sub-menus are accessed by scrolling the red focus box to the desired entry using clock-wise or counter clockwise turns of the dial. Black arrows on the top or bottom of the list indicate that more entries can be accessed by scrolling up or down.

Note: turning the dial clock-wise will move the red box down, while moving upwards is done by turning the dial counter clock-wise.

The menus do not “warp around”: once the last menu entry is reached, moving down once more will not move you away from that entry. The same is true also for the top most entry.

Once the desired entry is highlighted, press the push dial once. Set the desired values or options using the dial and confirm you choices by pressing the dial. Exiting a sub-menu is done by pressing once more on the push dial or waiting. The menu will also close automatically after a certain time elapses without any user interaction (default value: 10 sec; can be adjusted by the user).

5.1.1. Warning Icon

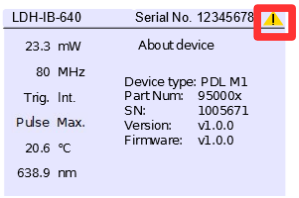


Fig. 14: Screen with warning icon in the upper right corner.

A warning icon (yellow triangle with exclamation mark) will be shown in the upper right corner of the display if one of the following events occur:

- incompatible laser head connected to the Taiko PDL M1
- incompatible Taiko PDL M1 firmware
- internal hardware error (either laser driver or head)
- temperature outside of allowed operational range
- External input frequency exceeds operational range of laser diode head
- other severe issues

In such a case, laser emission will be automatically interrupted for safety reasons. Please connect the Taiko PDL M1 to a Windows PC (via USB) and start the remote interface software to obtain a description of the actual error.

5.1.2. Information Icon

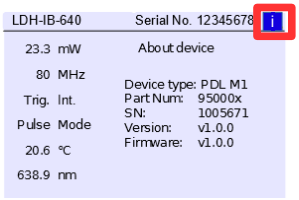


Fig. 15: Screen with information icon in the upper right corner

An information icon (blue rectangle with white letter “i”) will be shown in the upper right corner of the displayif the laser is operated in pulsed mode and current diode temperature is different from calibration temperature setting.

Since the optical power calibration is done for a setting of 25°C, the actually emitted optical power may differ from the displayed value at other temperatures. Note that this inaccuracy will increase at larger temperature differences.

5.1.3. Calibration Expired Icon

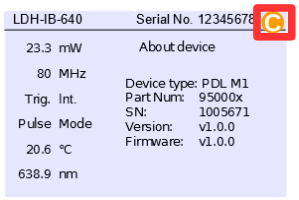


Fig. 16: Screen with calibration expired icon in the upper right corner

A calibration expired icon (orange circle with white “C” letter) will be shown in the upper right corner of the display once a laser head has exceeded a threshold in operating hours (laser diode dependent). Beyond this threshold, the calibrated power values can no longer be guaranteed. The deviation between the true value of emitted optical power and the displayed mW value might now lie above +/-10%.

When this happens, you can still use the laser head with an expired calibration. However, it is recommended to send the laser head back to PicoQuant for check-up and re-calibration (including repairs if needed). To do so, please contact support@picoquant.com to get a RMA number.

Should you ever see the calibration expired icon, we would kindly ask you to send the support info file for the laser head (see section 5.2.1 and Fig. 40) to support@picoquant.com.

If you send in your laser head for check-up / repair / re-calibration, PicoQuant will test the laser head and will offer the following actions:

a) If the laser diode is still working optimally: only a re-calibration would be needed
b) If the laser diode has started to degrade: exchange the laser diode and perform a re-calibration

5.1.4. Menu Structure

0. Overview

Selecting this menu entry will return the user to the overview screen where all of the lasers relevant operational parameters are displayed. The local interface will also return to this screen after a certain time has elapsed without user interaction.

1. Power

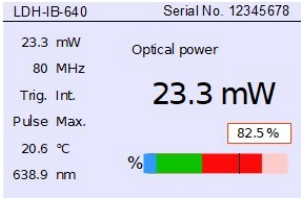


Fig. 17: Power setting screen.

This menu entry allows adjusting the optical output power for the connected laser head. Increase the setting by turning the dial clock-wise and decrease by turning counter clock-wise. Changes can be done in 0.1% steps and the percentage bar will update accordingly. The current optical output power is indicated in mW or µW under the heading “***Optical power***”.

Note: the increment size is dependent on the rotation speed of the dial. Spinning the dial quickly will lead to a faster increase of the value. Turn the dial slowly to make fine adjustments

The displayed calibrated power value corresponds to the average power value of the collimated free beam output. For fiber coupled laser heads, the average power at the fiber output is lower and depends on the coupling efficiency. The typical coupling efficiency is 40% into single mode fibers and polar. maintaining fiber, 80% coupling efficiency into multi-mode fibers.

The Taiko PDL M1 will automatically compensate for thermal drifts in optical power output to ensure that the users desired power level is maintained at all times.

When the connected laser head is running in ***linear*** or ***max. power mode***, the color of the percentage bar will change depending on the power setting as follows:

- Blue: the laser operates below the lasing threshold and behaves like an LED. Note that for some high powered laser heads, such a situation may not occur.
- Green: the laser head runs in the ***narrow pulse*** mode, providing short pulses with optimal pulse shape.
- Red: this color indicates that the laser head is now operating in the ***broad pulse*** mode, which generates pulses with higher power but also with pulse broadening and/or worse pulse shape. Note that the broad pulse mode may not be available for specific low-power laser heads.

When operating in ***max. power mode***, a black line will be displayed somewhere on the percentage bar. This line indicates the maximum optical output power achievable in *linear mode*. The bit to the right of the line represents the additional optical output power available in *max. power mode*. The exact amount of extra optical output power available depends on both the laser head type and repetition rate. Please refer to the calibration curves in the Laser Delivery Report of the specific laser head.

When *max. power mode* is active, the stepping for optical power setting may become coarser due to the increased power range.

Note that when the power setting is located to the left of the black line, the laser head will behave similarly to *linear mode*. However, only the intensity setting will be kept constant during a change in repetition rate (but not the pulse energy). For example, when switching from 10 to 100 MHz at low intensities, the power will not change by a factor of ten, as would be the case in *linear mode*.

Also, when operating at optical power settings above the *linear mode* maximum, pulses will be broadened and no guarantee can be made about maintaining pulse shape or pulse energy at various repetition rates.

2. Repetition rate

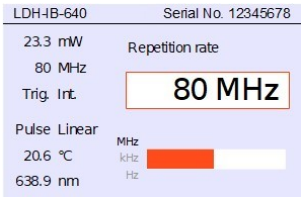


Fig. 18: Repetition rate setting screen.

On this screen, you can adjust the repetition rate (requires laser head to be operated in pulsed mode). Turn the dial clock-wise to increase the rate and reduce it by turning counter clock-wise. The displayed value and orange status bar will update accordingly.

Note that changes in the Hz and kHz ranges occur on a logarithmic scale, while changes will be linear in the MHz range.

3. Triggering

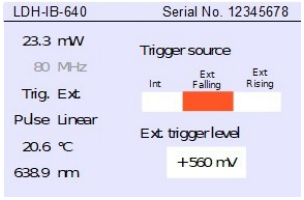


Fig. 19: Trigger source selection screen.

The trigger source can be switched on this screen from internal (***Int***) to external (***Ext Falling*** or ***Ext Rising***) by turning the dial. The orange box below the source list will move to the appropriate entry.

When the trigger source is set to internal, the "***Ext. trigger level***" setting box will not be displayed as setting a value would not be relevant.

If the selected source is ***Ext Falling*** or ***Ext Rising***, the "***Ext. trigger level***" setting box can be access by pressing the dial once. The desired signal level can be adjusted by turning the dial (only values between -1 and +1 V are accepted).

4. Emission mode

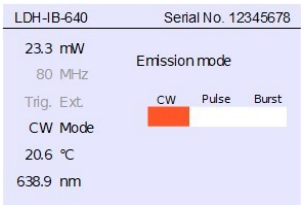


Fig. 20: Emission mode setting screen.

The selection bar on this screen allows choosing the emission operation mode for the connected laser head. The orange selection box can be moved between the modes ***CW*** (continuous wave), ***Pulse*** or ***Burst*** by turning the dial.

Note that if CW mode is selected, the repetition rate and trigger source lines in the information bar will be grayed out, as these are not applicable in this case.

5. Burst settings

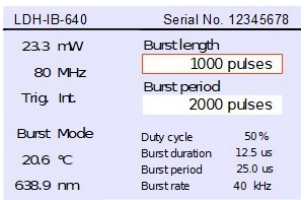


Fig. 21: Screen for burst settings.

This screen is used for setting up burst pattern. The first option field "***Burst length***" allows specifying the numbers of pulses that will be present in the burst. The value is set by turning the dial: clock-wise for increasing the value and counter clock-wise to decrease it. Note that the increments are dynamic (either 1 or 10 pulses).

Once the desired number of pulses is set, press the dial to access the "***Burst period***" option field. The default value is equal to 2 x the "***Burst length***" setting and can be adjusted by turning the dial (clock-wise increases; counter clock-wise decreases). Note that the value changes in integer multiples of the "**Burst length**" value.

The lower right part of the screen displays information about ***duty cycle*** (percentage of time spent emitting pulsed light), ***burst duration*** (how long one burst lasts), ***burst period*** (time between the start of two bursts), and ***burst rate*** (number of bursts per second). These values are derived from the laser settings and are updated dynamically.

6. °C / wavelength

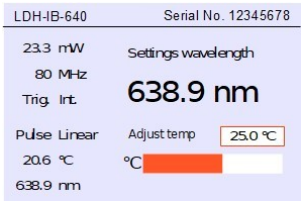


Fig. 22: Temperature setting screen.

Use this screen to set the target temperature and thus central wavelength of the laser head by turning the dial (clock-wise to increase and counter clock-wise to decrease). The "***Adjust temp***" display box and the "***°C***" bar will be updated simultaneously. The current laser head temperature is displayed in the left hand display panel. Upper and lower limits for the set-point temperature limits will depend on connected laser head type. They will be automatically read out and enforced by the Taiko PDL M1. Please note that the cooling system might not be able to reach and maintain low temperatures in very hot environments. Note that wavelength tuning is not available when using tapered laser heads (such as the LDH-IB-530-T, LDH-IB-560-T, and LDH-IB-595-T).

If the connected laser head comes with the appropriate calibration data, the expected central wavelength for the desired temperature is displayed under both the "***Settings wavelength***" heading and in the left hand information panel.

Note: if no calibration data is available or the head does not support wavelength calibration, then only the nominal central wavelength will be displayed.

7. Device settings

This series of sub-menus allow saving and loading of presets, setting gating options, and configuring the local GUI of the Taiko PDL M1.

7.0. Back

Selecting this sub-menu entry and pressing the dial will send you back to the main menu.

7.1. Load presets

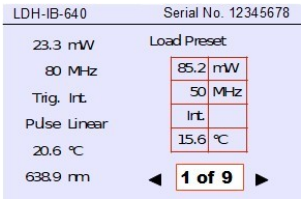


Fig. 23: Load preset screen.

The Taiko can store up to 9 presets for future use. Each preset stores the settings for output intensity, operation mode, repetition rate and burst pattern (if applicable), trigger source, and temperature. Saved presets can be loaded from this screen. Scroll through presets 1 to 9 by turning the dial.

The current slot number and its stored parameters are displayed on screen when scrolling. Note that the display will show a red "***Empty***" label instead if no preset has been saved into that slot.

Some settings in the stored presets can be specific to a laser head. If some of these do are not applicable to the currently connected head, then a label "**Incompatible**" will be displayed and the preset cannot be loaded.

To load a saved preset, select the desired slot and then press on the dial.

7.2. Save presets

Use this screen to store the current settings for output intensity, operation mode, repetition rate (if applicable), trigger source, and temperature in one of nine available preset slots. Start by selecting the desired preset slot by turning the dial to scroll through them. The display will show either a red "***Assigned***" or a green "***Empty***" label, depending on whether a slot is already in use or not.

Once you have selected the desired preset slot, pressing on the dial will bring up the save preset dialogue. Switch between the "***Yes***" and "***No***" option by turning the dial and then pressing it.

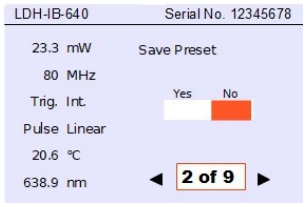


Fig. 24: Save preset confirmation screen.

Note: using an assigned slot will overwrite any data stored in it.

7.3. Delete presets

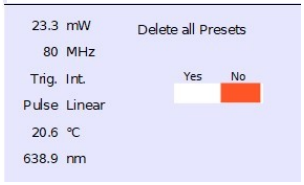


Fig. 25: Delete all presets confirmation dialogue.

This screen allows deleting all saved presets in one go. Select "***Yes***" or "***No***" by turning the dial and confirm it by pressing the dial. Please note that data stored in **all** slots will be deleted when choosing "***Yes***".

7.4. Pulse power dynamics

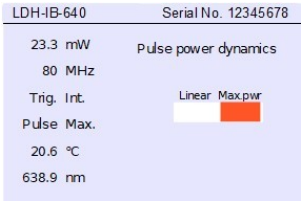


Fig. 26: Selection options for pulse power dynamics

On this screen, the power dynamics mode can be switched from ***linear*** to ***max. power*** mode by turning the dial and confirming the choice by pressing the dial.

In *linear mode*, each laser head is calibrated in terms of average optical power, meaning that for a given setting of laser intensity and repetition rate, a corresponding calibrated mW value of average optical power can be read from the local display and /or through the software interface.

The *max. power* mode allows reaching higher optical output powers than in *linear* mode. The exact amount of extra power that can be achieved depends both on connected laser head as well as repetition rate at which it is operated. Note that the max. power mode is not available when using tapered laser heads (such as the LDH-IB-530-T, LDH-IB-560-T, and LDH-IB-595-T). In that case, the whole sub menu will be disabled.

7.5. Gating

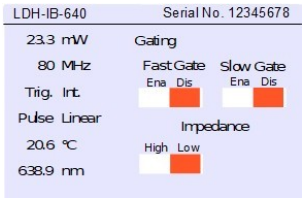


Fig. 27: Selection screen for gating options.

Gating type (fast or slow) as well as impedance for the gating signal can be set from this screen. Turning the dial flips the currently active switch from enable (***Ena***) to disable (***Dis***) or from "***High***" to "***Low***", respectively.

Press the dial to move from one switch to the next. The order in which the switches are accessed are: "***Fast Gate***", "***Impedance***" and finally "***Slow Gate***". Note that both *Fast* and *Slow Gate* can be active at the same time and that the Impedance setting is related to the *Fast Gate* only.

Refer to section 3.7 "Gating" for detailed information on gating behavior.

7.6. Laser head fan

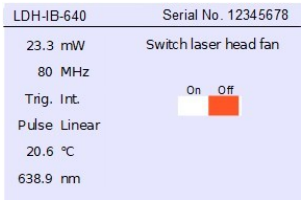


Fig. 28: Setting screen for laser head fan.

This screen allows toggling the laser head fan on or off for some models. Turning the dial flips the state of the switch. Please keep in mind that the additional cooling from the fan might be necessary to maintain temperature under some conditions (i.e. when operating at very high room temperatures). The default value for this setting is therefore 'On'.

7.7. Coarse rep rate

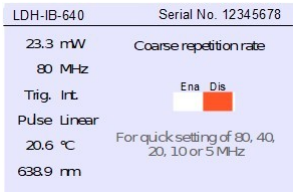


Fig. 29: Setting screen for coarse repetition rate option.

Enabling the coarse repetition rate setting on this screen will restrict choices when above 2 MHz to 5, 10, 20, 40, 80, and 100 MHz. For repetition rates up to 2 MHz, the quasi-logarithmics scale (1-2-5) is retained. The state of the switch is flipped from enabled (***Ena***) to disabled (***Dis***) by turning the dial.

7.8. Lag time

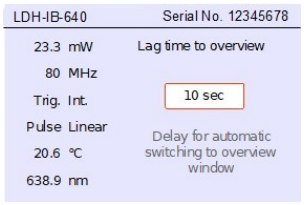


Fig. 30: Lag time setting screen.

This settings screen is used to configure the delay required for the interface menu to return to the overview screen. Turn the dial clockwise to increase the value and counter clock-wise to decrease it. Default value is 10 seconds without user interaction.

7.9. Color scheme

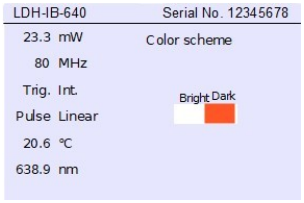


Fig. 31: Color scheme selection screen.

The toggle switch on this screen allows changing from the (default) bright to the dark color scheme for the local interface. The switch is operated by turning the dial.

7.10. Display on/off

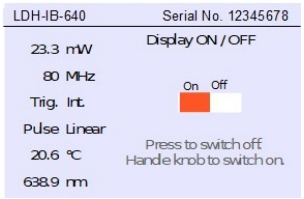


Fig. 32: Display settings screen.

This setting screen allows turning the local LCD display on or off. Select the desired option and press on the dial to confirm your choice. The display can be reactivated by pressing the dial when the Taiko PDL M1 is on.

7.11. About

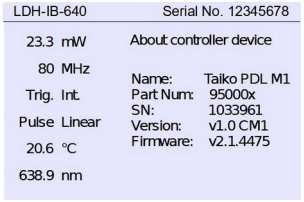


Fig. 33: Information screen "About".

By accessing this menu option, the Taiko PDL M1 will display various information on the driver and connected laser head. Namely: the device type, part and serial numbers, the control module type CM as well as hardware and firmware versions.

Note that these information are important when communicating with PicoQuant's support team.

5.2. Remote User Interface (PC Software)

The remote interface GUI is available in three different **color schemes:** PicoQuant bright, PicoQuant dark, and a standard Windows scheme. The latter can be customized using the standard Windows control panel. The color scheme is applied by the command line parameter "`/style=<scheme>`" where the placeholder `<scheme>` could be one of the legal values "`dark`", "`bright`" or "`windows`".

The dark scheme is intended for light sensitive set-ups and experiments such as photon counting and single molecule sensitive spectroscopy set-ups, where ambient light perturbation should be minimized as far as possible.

During the installation setup of the software, the installer can optionally generate separate desktop as well as quick launch icons for the respective bright and dark schemes (see section 3.8). In the interest of ergonomics, all relevant active controls (button, edit box, etc.) change color when the mouse pointer hovers above them. An overview of the GUI with all control elements is shown in Fig. 34.

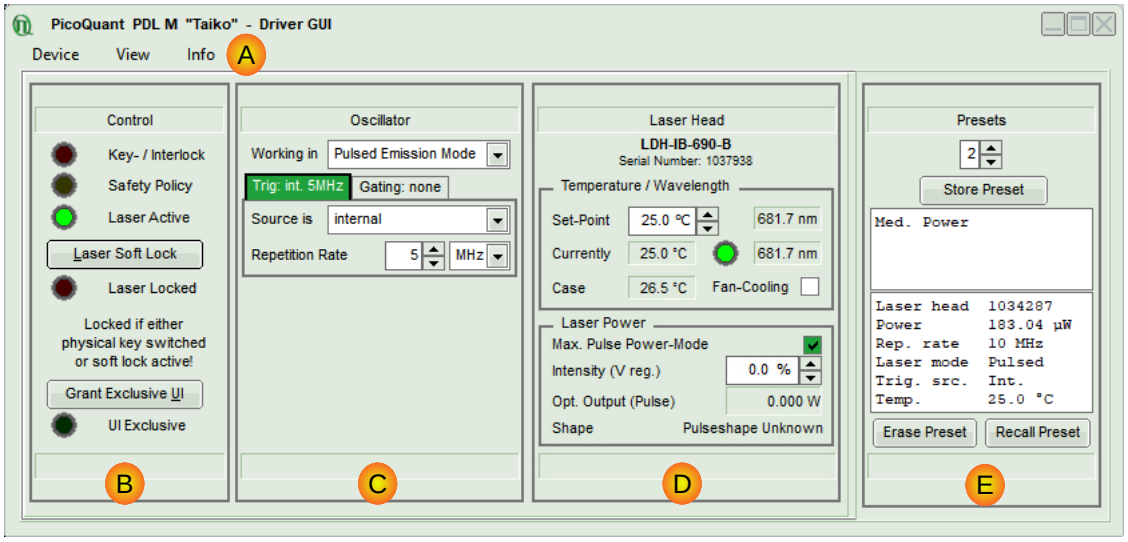


Fig. 34: The Taiko PDL M1 Windows remote interface.

NOTICE	**If some of the options and settings described in this section are not displayed by the control software of your Taiko PDL M1, then a firmware update might be needed. Refer to section 3.9 Firmware updates for step-by-step instructions.**

5.2.1. Main Menu A

The menu bar at the top of the window has three entries: ***Device***, ***View***, and ***Info***. The Device entry allows connecting or disconnecting the Taiko PDL M1. It also allows restoring the USB connection to a device should it be lost during operation for any reason.

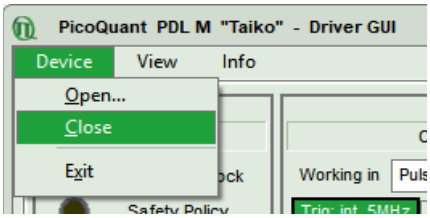


Fig. 35: The Device menu entry.

Selecting the ***Open...*** entry will start a scan for supported devices connected to the PC. A modal dialogue with an *OK* and *Cancel* button presents a list box with the currently connected devices (Fig. 36). When opening the list box, all detected devices are listed by their serial number. The currently selected device is marked with an asterisk "*".

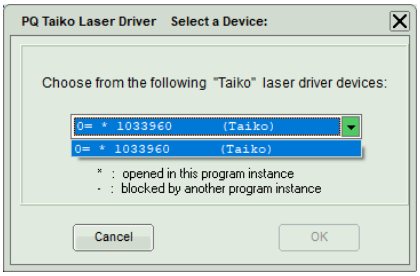


Fig. 36: Select device.

Cancel Back to the main window without any changes.

OK Change to the newly selected device. Note that this might lead to changes in the GUI, if a device of different type or configuration is selected.

The ***Close*** menu item allows disconnecting the currently active laser driver, while the ***Exit*** option will close the remote GUI software.

The ***View*** entry allows changing the currently used theme (via ***Theme*** sub-menu), selecting the units in which temperatures are displayed (°C, °F, K) via the ***Temperature Unit*** entry, or display all logged information (via the ***Log Window*** entry).

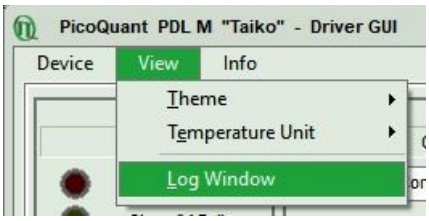


Fig. 37: The View menu entry.

If the remote GUI software was started with the command line switch "/ErrorLog", an additional menu entry will be displayed: ***HW-Error Log*** (see Fig. 38). Selecting it opens a window containing a list of errors that were sent by the Taiko hardware. Note that this list is purely of informational interest. The list might come in handy in some support requests to help our technical personnel understanding the error situation (see also section 7.2.3).

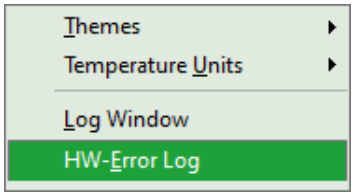


Fig. 38: Additional entry in the View menu when the remote GUI with the "/ErrorLog" command line switch.

Furthermore, most of the "errors" listed are non problematic and result from normal, intended behavior. As an example, Fig. 39 shows the list of error codes generated after successfully hot-plugging a laser head. Note that none of these error codes indicate a failure or other problem.

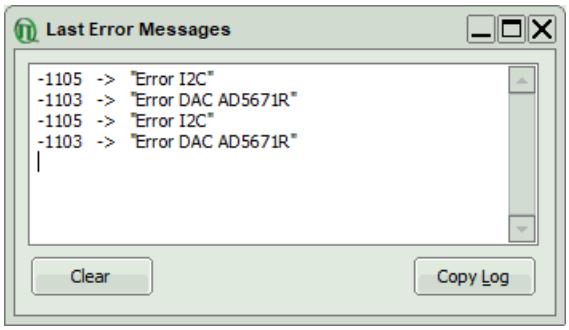


Fig. 39: Error messages generated by hot-plugging a laser head.

Clicking the ***Info*** entry will bring up extended information about the device, including software and firmware versions, serial numbers, operating hours, etc. These information are required for every support request. The easiest way to save them is to press the button labeled *Copy Support Infos* (see fig. 40), and paste it into a text editor like NotePad before saving the information as a plain text file. It is also possible to search for possible software updates by clicking on the button labeled *Check for Updates* (Fig. 40). If an update is available, a download link to the latest version will be provided.

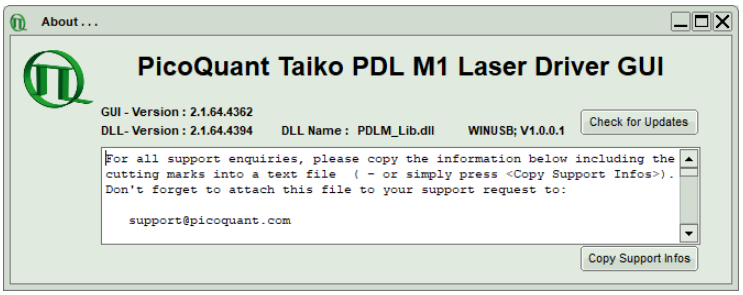


Fig. 40: The “About” window includes extended information about the status of the device

5.2.2. Control pane B

The Taiko PDL M1 can be locked (no emission of laser light) and unlocked (laser light is emitted) not only through the hardware key switch on the front panel, but also via the GUI by clicking on the button labeled *Laser Soft Lock* / *Laser Soft Unlock*, which is located in the controller frame on the left side of the software window.

The *Laser Unlocked* state is recognizable in the software by the *Laser Locked* indicator turning dark red (see Fig. 41), the Taiko’s *Laser Active* indicator turning light green and the white LED ON at the front panel will be turned on.

The *Laser Locked* state is recognizable in the software by the *Laser Locked* indicator turning bright red. The button text could be either ***Laser Soft Lock*** in case the system was hard locked by key or remote interlock circuit (see Fig. 41, right), or ***Laser Soft Unlock*** (see Fig. 41, left) in case the system was soft locked. In this case, the white LED ON will be turned off.

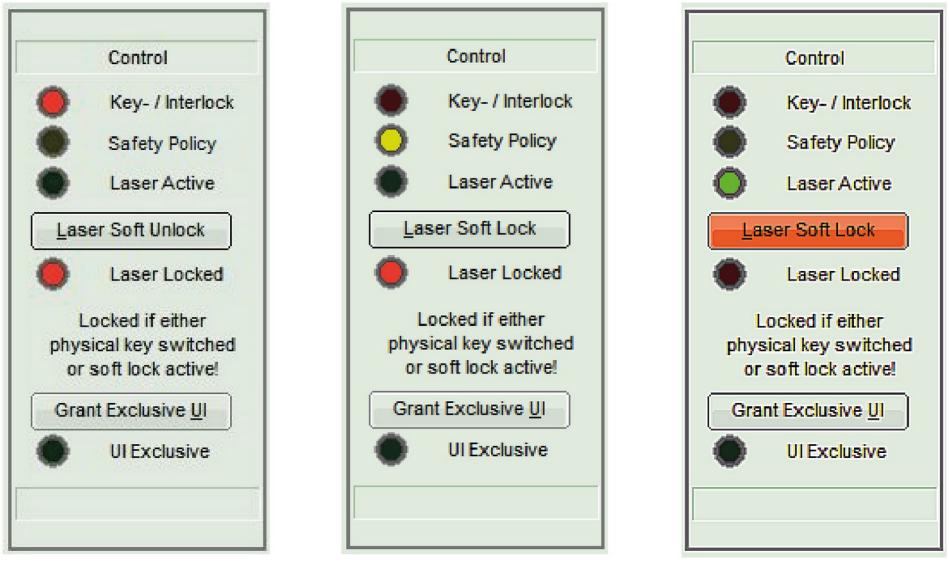


Fig. 41: Laser lock status: both key and soft locked (left), laser locked for safety reasons (middle), and unlocked laser (right).

A “***Safety Policy***” indicator will light up in yellow if laser emission has been automatically interrupted by the Taiko PDL M1. If a laser of class 3 / III (or lower) is connected to the driver and the driver is powered on while the laser key switch is in the ON position. In this case, laser emission will be blocked off for 5 seconds and the yellow “***Safety Policy***” indicator will be lit up in yellow during that time.

In order to comply with Laser Class 4 / IV regulations, the Taiko PDL M1 also features a hardware lock that can be triggered under several conditions (see section 1.5, page 8), which will require a manual reset before laser emission can be resumed. This tripped hardware lock will also be indicated in the remote GUI by the lit up yellow "***Safety Policy***" indicator. The hardware lock can only be released by turning the laser key switch first to the *STBY* position and then to the ON position.

The remote GUI can be used to control the Taiko PDL M1 either exclusively or in tandem with the local push-dial interface (cooperative mode). Switching of the user interface mode is accomplished by clicking on the button at the bottom of the ***Control*** pane.

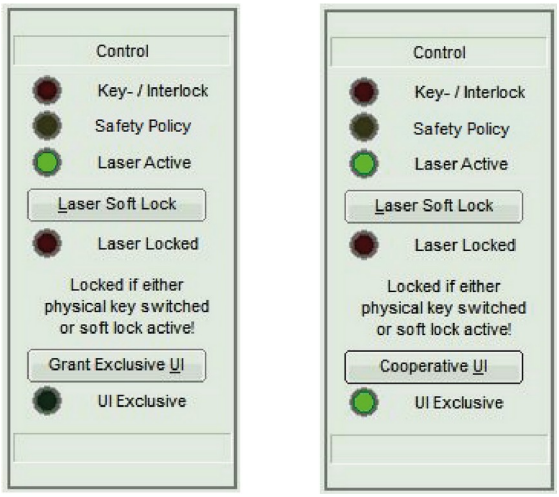


Fig. 42: Cooperative and exclusive user interface.

Note that the button label will change depending on the current interface mode (i.e. "Grant exclusive UI" when in cooperative mode or "Cooperative UI" when in exclusive mode). When running in exclusive mode, the indicator light "UI Exclusive" will be lit up. On the Taiko laser driver, the UI Exclusive state claimed by any software on the PC is indicated by turning off the dial's green illumination. Switching back to Cooperative Mode will turn the green illumination of the dial back on.

5.2.3. Oscillator pane C

The layout of the oscillator pane changes depending on the selected operating mode for the laser head. To select the desired operating mode, open the drop down menu labeled "***Working in***" and choose from **Continuous Wave Mode**, **Pulsed Mode**, or **Burst Mode**. The options displayed in the drop down menu will depend on the type of connected laser head.

Continuous wave mode

When the connected laser head operated in **Continuous Wave Mode**, the Oscillator pane provides a tab with ***Gating*** options. The ***Gating*** tab has two check boxes for selecting ***Fast Gate*** or ***Slow Gate***, as well as radio buttons to choose the impedance for the fast gate (either 10 kΩ or 50 Ω). Note that both gate types can be active at the same time (as shown in Fig. 43).

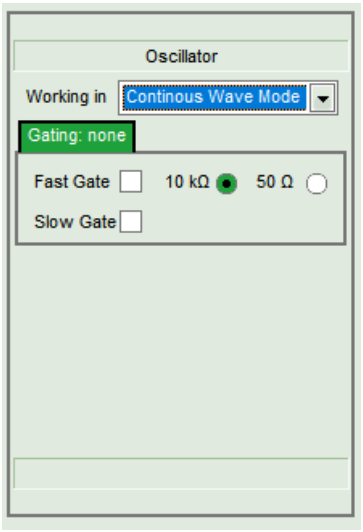


Fig. 43: Gating options in cw mode.

Pulsed emission mode

Selecting the "***Pulsed Emission Mode***" adds a section with two tabs to the oscillator pane, that allow setting trigger and gating options. The tabs display a summary of the current settings and the active one is highlighted in green.

The ***Trig.*** tab provides a drop down menu for selecting the trigger signal source: either the internal low-jitter quartz clock or trigger on rising or falling edge of an external source. When the "***internal***" source is selected, an additional spin-edit box and drop down menu become available. Enter the desired repetition rate value into the spin-box and select the unit (MHz, kHZ, or Hz) from the drop down menu. Selecting "***external, falling edge***" or "***external, rising edge***" will provide the user with a spin-edit box for setting the signal level (in V; range: -1.000 to +1.000).

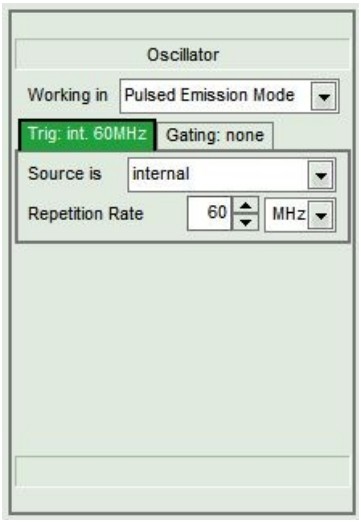


Fig. 45: Internal trigger source.

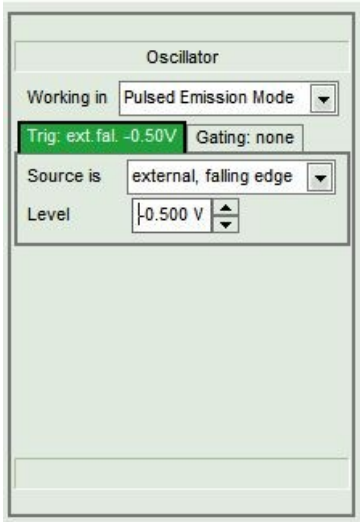


Fig. 44: External trigger source.

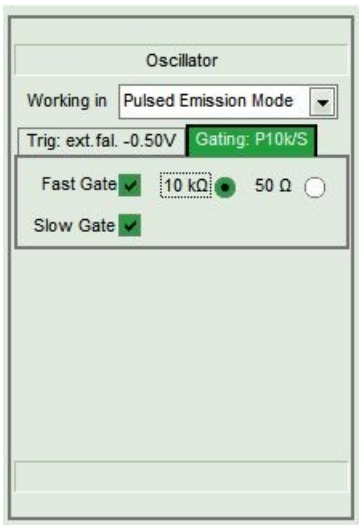


Fig. 46: Gating options.

The ***Gating*** tab has two check boxes for selecting ***Fast Gate*** or ***Slow Gate***, as well as radio buttons to choose the impedance for the fast gate (either 10 kΩ or 50 Ω). Note that both gate types can be active at the same time (as shown in Fig. 46).

Burst emission mode

After selecting the "***Burst Emission Mode***", the oscillator pane will display a field for setting up the desired burst pattern (entitled "Burst Data"), along with the section for setting the gating options. The gating options work in the same way as described in "***Pulsed emission mode***". As the Burst Emission Mode can only be used with an internal trigger, the trigger option is set to internal by default.

The "***Burst Data***" section features two spin-edit boxes for setting the periodicity ("***Period***") and "***Burst Length***". Both values are expressed as pulses (pls). The "***Period***" setting refers to the number of trigger pulses that will elapse between the start of two consecutive bursts. "***Burst Length***" represents the number of laser light pulses to be emitted in each burst.

Note that the value for "***Period***" has to be strictly larger than the one for "***Burst Length***". Invalid entries will be highlighted in red and settings will not be applied until valid inputs are provided.

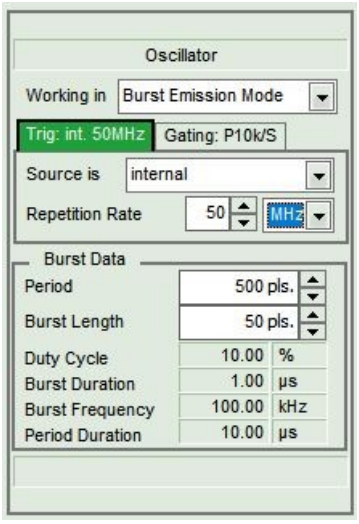


Fig. 47: Burst emission mode (internal triggering.

The values of the four entries "***Duty Cycle***" (percentage of time spent emitting light), "***Burst Duration***" (how long one burst lasts), "***Burst Frequency***" (number of bursts per second), and "***Period Duration***" (time between the start of two bursts) are derived from the repetition rate, burst length and period settings. These values are calculated automatically and the display is updated dynamically.

5.2.4. Laser Head pane D

At the top of the Laser Head pane, the designation and serial number of the currently connected laser head is displayed. This information is automatically updated every time a new head is connected.

5.2.4.1. Temperature / Wavelength

The "***Temperature / Wavelength***" section provides a spin-edit box for setting the laser head target temperature ("***Set-Point***") as well as a check box for enabling or disabling the cooling fan (may not be available for some laser heads). Note that wavelength tuning is not available when using tapered laser heads (such as the LDH-IB-530-T, LDH-IB-560-T, and LDH-IB-595-T). Upper and lower limits for the set-point temperature limits will depend on connected laser head type. They will be automatically read out and enforced by the Taiko PDL M1. Current laser head temperature is displayed in the "***Currently***" information box. An indicator light next to it changes color depending on the difference between current and set-point values: red (current higher than set-point), green (current and set-point are matched), blue (current lower than set-point). Depending on the environmental conditions, the peltier cooler might not be able to reach or hold the set-point temperature.

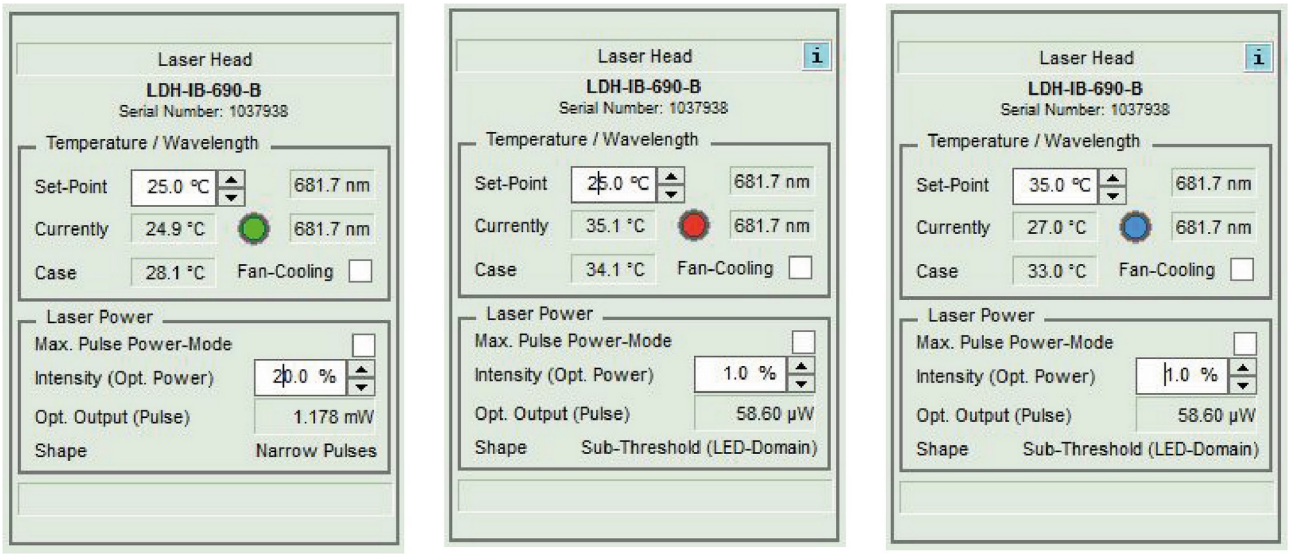


Fig. 48: Laser head pane with laser diode at set-point temperature (right), with laser diode above set-point temperature (middle), and with laser diode below set-point temperature.

The two information boxes in far right column indicate the nominal central wavelength at 25 °C (top box) and the expected wavelength at the set-point temperature (lower box). Please note that if the connected laser head does not come with temperature shift calibration data, only the nominal wavelength will be displayed.

5.2.4.2. Laser Power

The check box called **Max. Pulse Power-Mode** allows switching the laser head operation mode from ***linear*** to ***max. power*** and back. Note that the **Max. Pulse Power-Mode** is not available when using tapered laser heads (such as the LDH-IB-530-T, LDH-IB-560-T, and LDH-IB-595-T). Therefore only the linear mode is available and no checkbox appears. Note that ticking or un-ticking the box will always set the currently selected Intensity percentage to zero. This is due to the fact that in both modes, the achievable maximum optical power can be quite different while the intensity setting still goes from 0 to 100 %.

In ***linear mode***, each laser head is calibrated in terms of average optical power, meaning that for a given setting of laser intensity and repetition rate, a corresponding calibrated mW value of average optical power can be read from the local display and /or through the software interface. More importantly, both pulse energy and pulse shape are guaranteed to remain constant over the entire range of repetition rates when operating in this mode.

The ***max. power mode*** allows reaching higher optical output powers than in *linear mode*. The exact amount of extra power that can be achieved depends both on connected laser head as well as the repetition rate at which it is operated.

Note that when operating at optical power settings above the *linear mode* maximum, pulses will be broadened and no guarantee can be made about maintaining pulse shape or pulse energy at various repetition rates. When running at or below the *linear mode* maximum, only the intensity setting will be kept constant during a change in repetition rate (but not the pulse energy. For example, when switching from 10 to 100 MHz at low intensities, the power will not change by a factor of ten, as would be the case in *linear mode*.

The spin-edit box in this section allows setting the lasers optical output power in steps of 0.1% of the maximum power. The Taiko PDL M1 will automatically compensate for thermal drifts in optical power output to ensure that the users desired power level is maintained at all times.

When operating in ***linear mode***, the diode in the laser head may operate in one of three different emission modes depending on the power setting: **sub-threshold** (no lasing, only spontaneous emission), **narrow pulses** (temporal pulse width corresponds to specification), **broad pulses** (high power settings lead to a temporal broadening of the pulses). The regime that the laser is currently operating in is indicated at the bottom of the panel, next to the heading "***Shape***".

Current optical output power is shown in the "***Opt. Output***" information box in units of µW or mW.

Fig. 49: Laser pulse shape indicator: sub-threshold (left), narrow (middle), and broad pulses (right).

CAUTION! **When laser emission is locked (either through the key switch, interlock, soft- or hardware lock) the value in the Intensity spin-edit box will be set to zero. All changes to this value will be rejected until laser emission has been restored. Note that the Intensity setting will then be restored its last known value.**

5.2.4.3. Warning labels

Several warning icons may appear in the top right corner of the Laser Head pane, which are similar to those shown in the local interface. Note that they can be clicked to open a message providing more information.

Warning icon

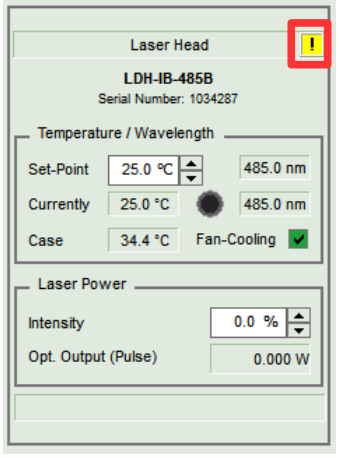


Fig. 50: Warning Icon.

A yellow square with exclamation mark will be shown in the upper right corner of the display if one of the following events occur:

- incompatible laser head connected to the Taiko PDL M1
- incompatible Taiko PDL M1 firmware
- internal hardware error (either laser driver or head)
- temperature outside of allowed operational range
- External input frequency exceeds operational range of laser diode head
- Demo mode has expired (this will also be displayed as a text string next to the serial number of the laser head.
- other severe issues

In such a case, laser emission will be automatically interrupted for safety reasons. Check the error messages in the GUI for additional information.

Information icon

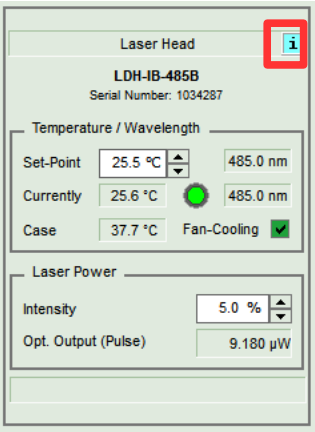


Fig. 51: Screen with information icon in the upper right corner

An information icon (blue rectangle with the lower case letter “i”) will be shown in the upper right corner of the display if the laser is operated in pulsed mode and current diode temperature is different from temperature setting.

Since the optical power calibration is done for a setting of 25°C, the actually emitted optical power may differ from the displayed value at other temperatures. Note that this inaccuracy will increase at larger temperature differences.

Calibration expired warning

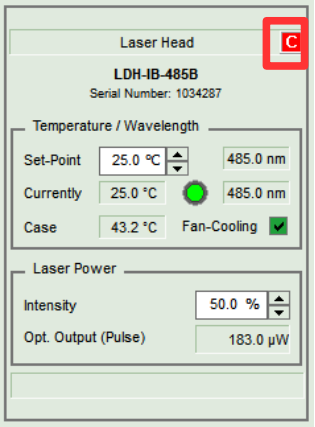


Fig. 52: Screen with calibration expired icon in the upper right corner

A calibration expired icon (red square with white “C” letter) will be shown in the upper right corner of the display once a laser head has exceeded a threshold in operating hours (laser diode dependent). Beyond this threshold, the calibrated power values can no longer be guaranteed. The deviation between the true value of emitted optical power and the displayed mW value might now lie above +/-10%.

When this happens, you can still use the laser head with an expired calibration. However, it is recommended to send the laser head back to PicoQuant for check-up and re-calibration (including repairs if needed). To do so, please contact support@picoquant.com to get a RMA number.

Should you ever see the calibration expired icon, we would kindly ask you to send the support info file for the laser head (see section 5.2.1 and Fig. 40) to support@picoquant.com.

If you send in your laser head for check-up / repair / re-calibration, PicoQuant will test the laser head and will offer the following actions:

a) If the laser diode is still working optimally: only a re-calibration would be needed
b) If the laser diode has started to degrade: exchange the laser diode and perform a re-calibration

5.2.5. Presets pane E

Up to 9 presets can be stored for future use. Each preset stores the settings for output intensity, operation mode, repetition rate and burst pattern (if applicable), trigger source, set-point temperature along with user-defined comments. The current slot number is shown in the spin-edit box above the text fields with stored comment and data.

NOTICE	The laser head's serial number is always stored with the presets. When restoring the preset, the Taiko will check whether the stored serial number matches that of the currently connected laser head. This is done to ensure that the stored values can be safely used.

To save a preset, choose the desired slot number and press the "***Store Preset***" button. Note that doing so with a preset slot containing any data will overwrite its data. Loading a saved preset is done by selecting the desired slot and then clicking on the "***Recall Preset***" button. The currently selected preset can be deleted by clicking on the "***Erase Preset***" button.

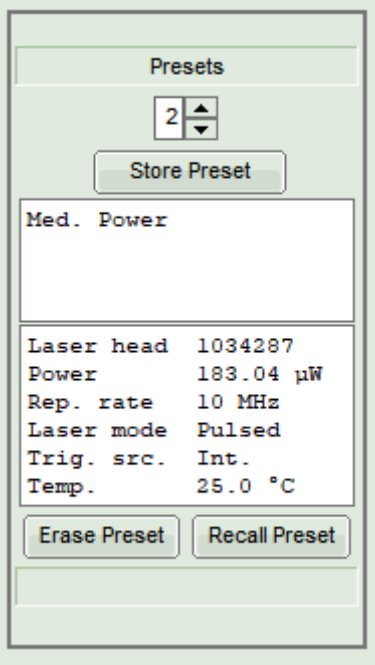


Fig. 53: Preset pane.

6. Technical Data / Specifications

Internal Oscillator

Type..... crystal locked
Operation mode..... pulsed, burst, or continuous wave (cw)
Repetition frequency range..... 1 Hz to 1 MHz in 1, 2, 5 steps
..... 1 to 100 MHz in 1 MHz steps

Synchronization Output

Amplitude..... < -800 mV into 50 Ohms (NIM)
Pulse width..... 5 ns
Delay..... sync output (falling edge) to laser output: typ. 10 ns, jitter < 20 ps
Input impedance..... 50 Ohms
Connector..... SMA socket (female)

External Trigger input

Input voltage range..... -5 to +5 V (TTL compatible)
Trigger level (adjustable)..... -1 to +1 V
Required pulse width..... > 5 ns
Delay..... trigger input to optical output: typ. 16 ns, jitter < 40 ps
..... trigger input to sync output: typ. 6 ns
Frequency range..... single shot to 90 MHz
Input impedance..... 50 Ohms
Connector..... BNC socket (female)

Gating Inputs

Fast gate..... **pulsed or burst mode**: transition time typically 10 ns
..... **CW mode**: rise time typ. 5-10 µs (from 0% to 80-90% of maximum cw
..... emission power, wavelength dependent)
.....user selectable input impedance: 10 kOhms with pull-up or 50 Ohms
.....with pull-down
Connector type..... 1-pin LEMO socket – 00.250 series
..... Example of connector: FFA.00.250.NTA
Slow gate..... transition time < 1 ms
Connector type..... 4-pin LEMO socket – 00.304 series
..... Example of connector: FGG.00.304.CLA

Remote Interlock

Voltage..... < 16 V (DC)
Loop resistance..... 10 Ohms maximum
Remote Interlock connectors..... Lemo 00.304 and banana socket

Computer

PC interface..... USB 2.0 (USB Type C socket)
Operating System..... Windows™ 10

Power Supply

Line voltage..... 220 / 240 or 110 / 120 V (AC), 50 / 60 Hz
Power consumption..... 140 W maximum
Fuse..... 4 AT / 110~240 V

Main Device

Base unit..... 355 x 311 x 95 mm (w x l x h)
Weight..... 3.5 kg

Operation Environment

Temperature range..... 10 to 40 °C
Rel. humidity..... < 80 %

Retraction of Old Devices

Waste electrical products must not be disposed of with household waste. This equipment should be taken to your local recycling center for safe treatment.
WEEE–Reg.–No. DE 96457402

7. Support

7.1. Returning Products for Repair

Should you encounter serious problems that require sending the device in for inspection / repair, please contact us first at: support@picoquant.com and request an RMA number before shipping the device. Observe precautions against static discharge under all circumstances during handling, packaging and shipping. Use original or equally protective packaging material. Inappropriate packaging voids any warranty.

7.2. Troubleshooting

7.2.1. Checklist – No Laser Emission

<table>
<tr><td colspan="4">Is the white “laser on” indicator LED (B) on?</td></tr>
<tr><td>Yes</td><td colspan="3">No</td></tr>
<tr><td rowspan="2">Has the Slow Gate switched off? (see section 3.7)
If no Slow Gate is used, it must be configured as disabled (see point 7.5 Gating in section 5.1.4)</td><td colspan="3">Selected trigger source?</td></tr>
<tr><td>CW</td><td>INT</td><td>EXT</td></tr>
<tr><td rowspan="2">Is the “INTENSITY” setting high enough?

A laser head will only start emitting light when operated above the lasing threshold. Increase the intensity setting accordingly (when using a laser head with calibration curve, an estimation of the output power will be shown on the LCD)</td><td rowspan="2"></td><td rowspan="2">Is the selected frequency above an internally set limit (see section 3.10.2)? Check rear panel for a note.</td><td>Is the trigger level set correctly?</td></tr>
<tr><td>Does the triggering signal meet the specifications of pulse width and amplitude? See section 3.10.4</td></tr>
<tr><td>Is the shutter (O) in position open if a cuboid laser head is used?</td><td colspan="3">Has the Fast Gate switched off? (see section 3.7)
A short circuit on the “Fast Gate” connector (J) switches off the laser.</td></tr>
<tr><td rowspan="2"></td><td colspan="3">Is the laser key switch (2) in the “ON” position?</td></tr>
<tr><td colspan="3">Is the remote interlock loop closed? See section 1.5</td></tr>
</table>

7.2.2. Taiko PDL M1 is not Recognized by Host PC

This issue occurs when connecting the firmware version of a Taiko PDL M1 does not match the version of the corresponding USB device driver installed on the host PC. Another issue that might occur in such a case is that the remote can connect to the Taiko PDL M1 but some of the GUI controls are missing.

To resolve such an issue, please update the USB device driver on the host PC to match the laser driver’s firmware (e.g., for firmware version 2.x or higher, the USB driver service name should be WINUSB and not PQUSB or PQUSB64).

You can check the firmware version number in the ***About*** panel of the local GUI.

7.2.3. Displaying Hardware Errors

If needed, the PC remote control software can be configured to display hardware errors. To enable this mode, append the command line parameter “`/ErrorLog`” to the desktop shortcut and restart the program. To view any logged hardware errors, select the new option HW-***Error Log*** from the ***View*** menu (see also section 5.2.1).

Error messages are continuously added to the list. Click on the *Clear* button to clear the currently displayed list. To save the current list, click on the *Copy Log* button and then append it right to the end of your Service Request text file.

This log is useful for diagnosing hardware issues of the Taiko PDL M1 and might be requested by support. Note that some entries are due to events and will either not impede the proper function of the Taiko PDL M1 or are trivial to fix (e.g., if no laser head is connected).

7.2.4. Audible beep

An audible beep does not indicate an error. Instead, the audible beep occurs when the laser radiation has been switched on.

8. Legal Terms

8.1. Copyright

8.2. Trademarks

Other products and corporate names appearing in this manual may or may not be registered trademarks or subject to copyrights of their respective owners. PicoQuant GmbH claims no rights to any such trademarks. They are used here only for the purposes of identification or explanation and to the owner's benefit, without intent to infringe.

9. Further Reading

9.1. PicoQuant Bibliography

PicoQuant maintains a database of publications mentioning PicoQuant devices. It can be found at our website www.picoquant.com/scientific/references. It is a valuable source if you would like to know which laboratories are using PicoQuant products or how broad the field of various applications is.

9.2. Download of Technical Notes / Application Notes

PicoQuant, along with our customers, continuously writes and publishes short documents about techniques, methods and applications that are possible with our hardware or software. The download section can be found at www.picoquant.com/scientific/technical-and-application-notes

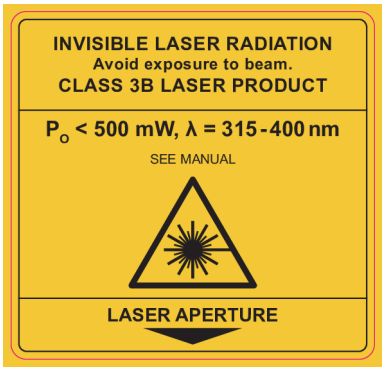
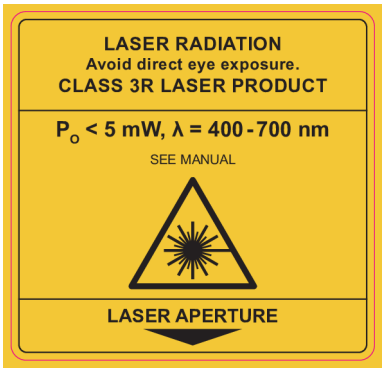
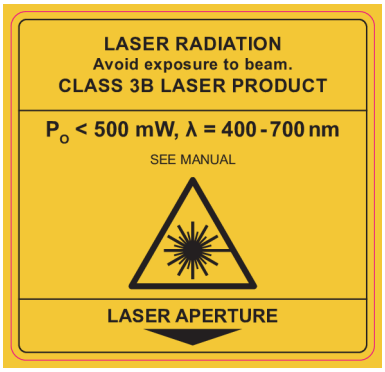
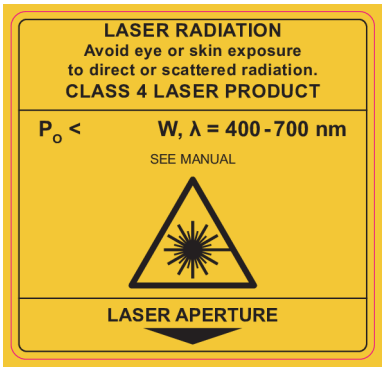
10. Appendix

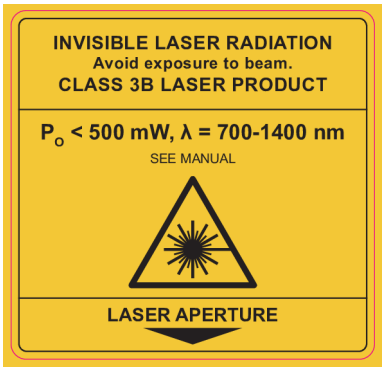
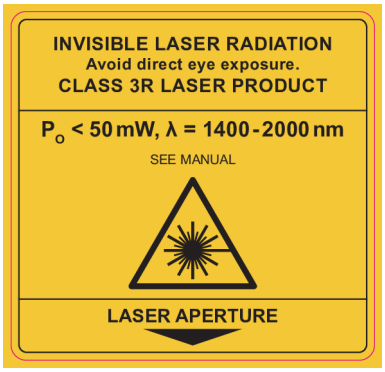
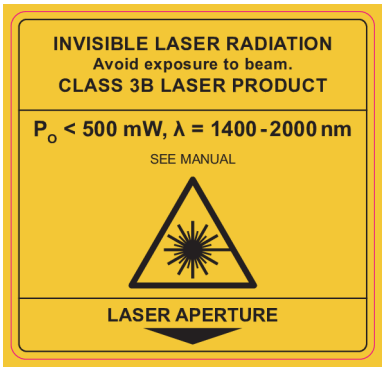
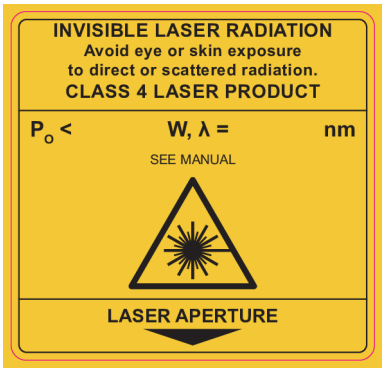
10.1. Abbreviations

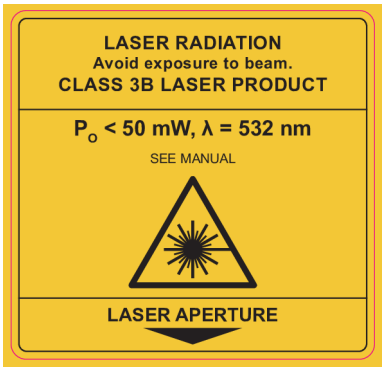
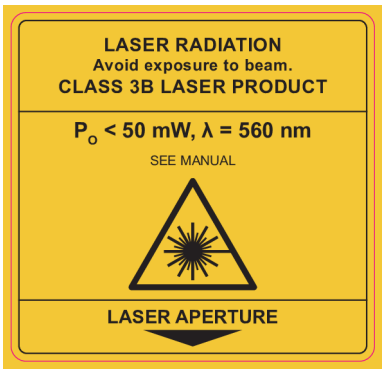
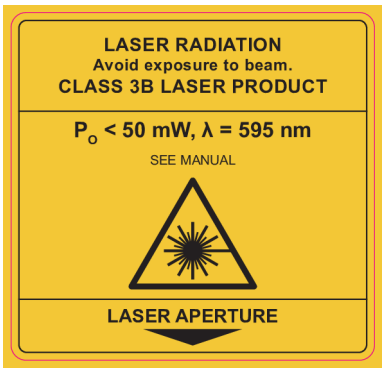
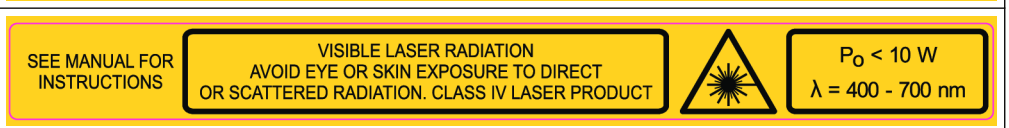
FWHM	**Full Width at Half Maximum**
LDH	**Laser Diode Head**
IRF	**Instrument Response Function**
LED	**Light Emitting Diode**
PMT	**Photomultiplier Tube**
NIM	**Nuclear Instrumentation Methods**
TTL	**Transistor to Transistor Logic**
SMA	**Sub-Miniature version A (connector type)**
TE	**Thermoelectric (cooler)**
SM	**Single Mode (fiber type)**
MM	**Multi-Mode (fiber type)**
PM	**Polarization Maintaining (fiber type)**
RMA	**Return Mechandise Authorization**
WEEE	**Waste Electrical and Electronic Equipment**
SPAD	**Single Photon Avalanche Diode**
cw	**Continuous wave**

10.2. Overview of Laser Warning Labels by Model Type

The table in this section provides an overview of laser warning labels by model type. Note that this list ist not exhaustive and encompasses Taiko PDL M1 compatible laser heads available at the time this manual was released.

Model type	Warning label on the laser head
LDH-IB Series (Cuboid Laser Heads)	
315-400 nm **P_O < 500 mW**	
400-700 nm **P_O < 5 mW**	
400-700 nm **P_O < 500 mW**	
400-700 nm **blank W**	

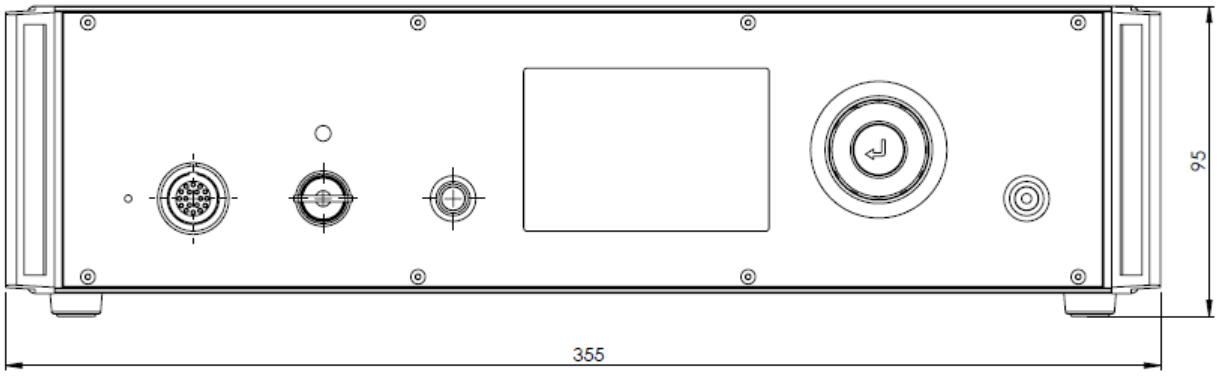
Model type	Warning label on the laser head
700-1400 nm **P_O < 500 mW**	
1400-2000 nm **P_O < 50 mW**	
1400-2000 nm **P_O < 500 mW**	
blank nm **blank W**	
LDH-IB-T Series (Cuboid Laser Heads)	

Model type	Warning label on the laser head
532 nm **P_O < 50 mW**	
560 nm **P_O < 50 mW**	
595 nm **P_O < 50 mW**	
LDH-IB Series (Cylindrical Laser Heads)	
315-400 nm **P_O < 40 µW**	
315-400 nm **P_O < 500 mW**	
400-700 nm **P_O < 5 mW**	
400-700 nm **P_O < 500 mW**	
400-700 nm **P_O < 10 W**	

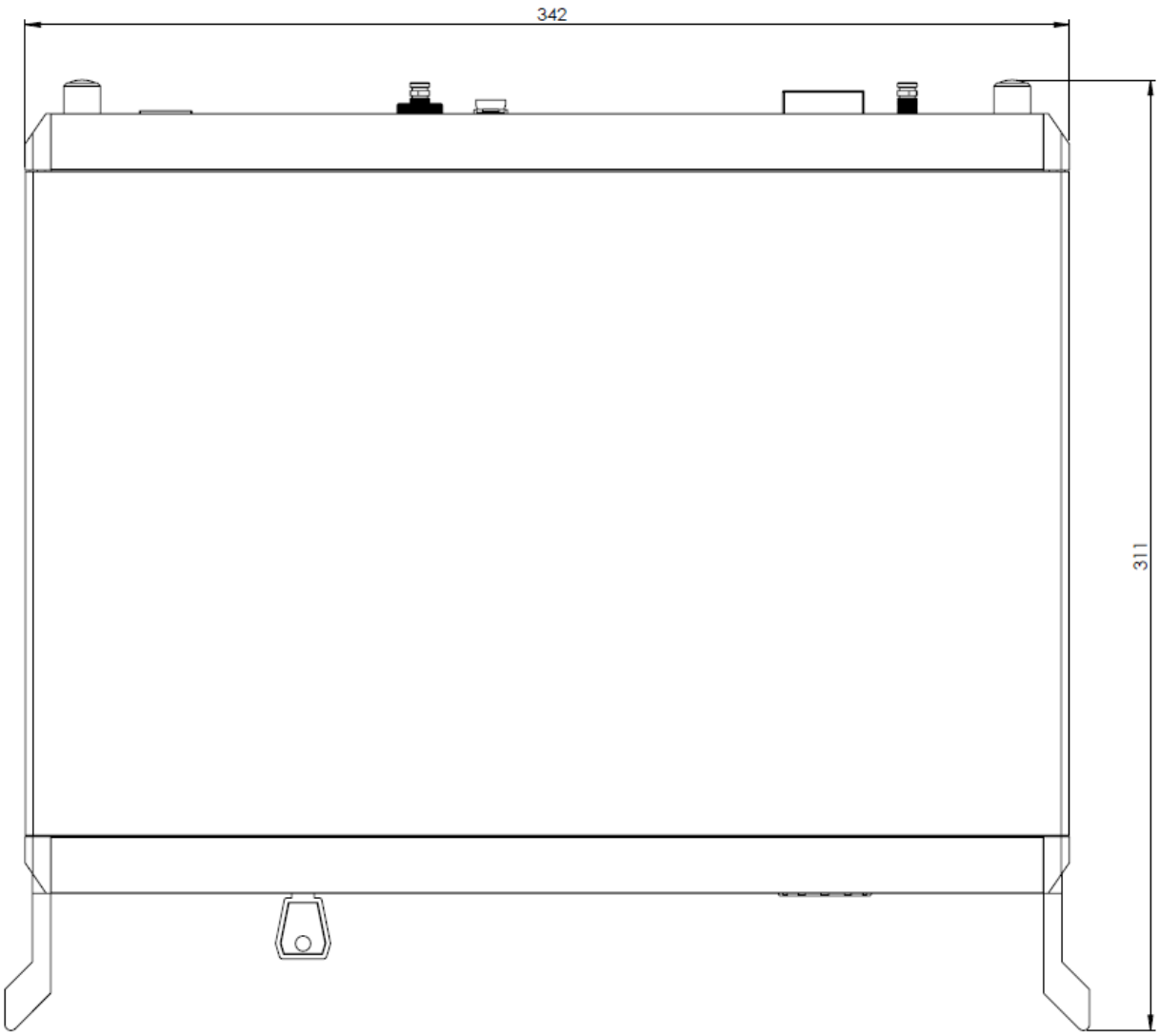
Model type	Warning label on the laser head
700-1400 nm blank mW	
700-1400 nm P_O < 500 mW	
1400-2000 nm P_O < 50 mW	
1400-2000 nm P_O < 500 mW	
blank nm blank mW	

10.3. Dimensions of the Taiko PDL M1 and LDH-I Laser Heads

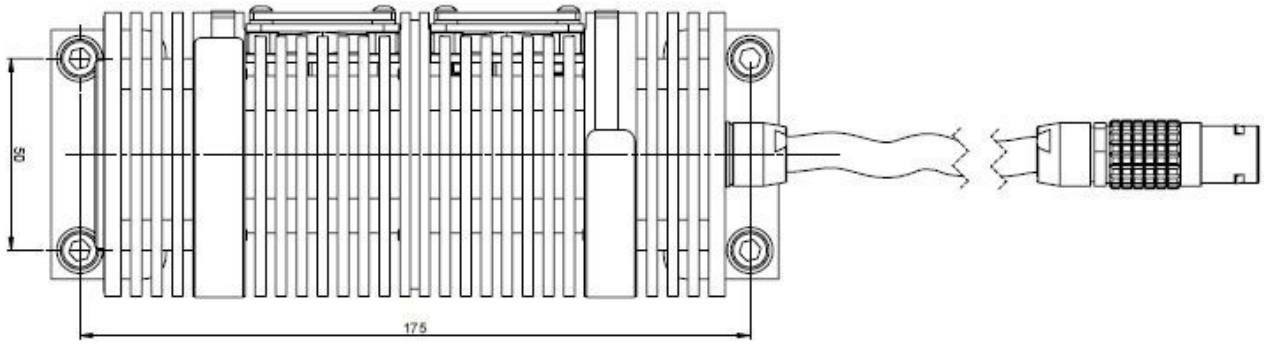
Taiko PDL M1 – Front View



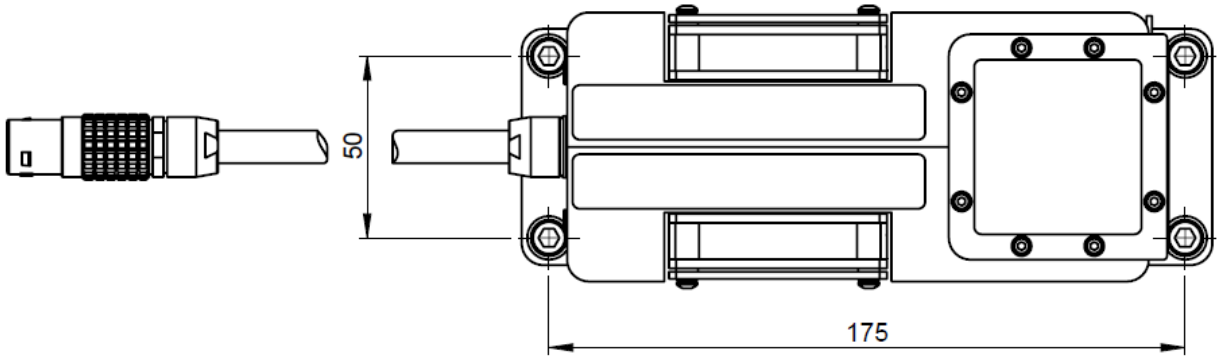
Taiko PDL M1 – Top View



Cylindrical LDH-I Laser Head – Top View



Cuboid LDH-I Laser Head – Side View



10.4. Laser Delivery Report

The delivery report of your lasers, including all final production test results for pulse shape, optical power, and line width is attached to this user manual. A PDF copy can be provided on request.

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