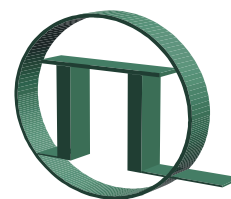


PDL 800-B



PICOQUANT
Unternehmen für optoelektronische
Forschung und Entwicklung

Picosecond Pulsed Diode Laser



User's Manual

Version 2.1

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Appendix:

Laser Delivery Reports and Test data

Glossary

FWHM (Full Width Half Maximum)

A quantity for the description of pulse or distribution widths, in which the full width of the curve shape is taken at a height of half of the maximum.

IRF (Instrument Response Function)

The instrument response function is ideally the response of the instrument to the input of a signal consisting of a Dirac delta function. All data measured with an instrument are the convolution of the actual input signal with its IRF.

LDH, LDH-C (Laser Diode Head)

Model numbers of the PicoQuant Laser heads:

LDH: without cooling

LDH-C: with thermoelectric cooler (TEC)

LED (Light Emitting Diode)

are used here in two different functions:

1. as a simple indicator light on the front panel
2. high power LEDs inside the →PLS light sources as the emitter of sub-nanosecond pulses

PLS (Pulsed Light Source)

Model Number of the LED based sub-nanosecond pulsed light sources for the PDL 800-B from PicoQuant

PMT (Photomultiplier Tube)

Photodetector with high sensitivity, dynamics and time resolution, commonly used for →TCSPC

NIM

The NIM standard (DOE/ER-0457), originally an acronym for Nuclear Instrumentation Methods, was established in 1964 for the nuclear and high energy physics communities. The goal of NIM was to promote a system that allows for the interchangeability of modules. Even today experimenters use NIM modules to assemble a system, which meets the specific requirements of their experiment. The NIM standard also specifies three sets of logic levels. In fast-negative logic, usually referred to as NIM logic, logic levels are defined by current ranges. Since the standard also requires 50 Ohms input/output impedances, these current ranges correspond to voltages of 0 V and -0.8 V for logic 0 and 1, respectively. Fast-negative logic circuitry can provide NIM signal with rise times of order 1 nsec

(Source : <http://www-esd.fnal.gov/esd/catalog/intro/intronim.htm>)

Peltier

The basic concept behind thermoelectric coolers (→TEC) is the Peltier effect, which was discovered in 1834. The Peltier effect occurs whenever current passes through the circuit of two dissimilar conductors; depending on the current direction, the junction of the two conductors will either absorb or release heat.

SPAD (Single Photon Avalanche Diode)

Semiconductor based photodetector with single photon sensitivity.

TCSPC (Time Correlated Single Photon Counting)

A light detection technique of high sensitivity, dynamics and time resolution that registers the arrival time of each single photon relative to a synchronisation signal from a repetitive pulsed light source. See our Tech Note on TCSPC for more details.

TEC (Thermoelectric Cooler)

Electrical cooling (or heating) device based on →Peltier elements.

1. System Description

The PDL 800-B is a pulsed diode laser driver unit featuring easy-to-use controls for both laser power level and pulse width (intensity) as well as the repetition frequency. Peak powers up to 1 Watt and pulses as short as 50 ps (FWHM) at repetition rates from single shot up to 80 MHz can be emitted, depending on the diode laser head in use.

The driver unit features a pulse generator that generates a low jitter clock signal at five user-selectable frequencies. The internal clock generator produces a master frequency of 40 MHz (standard, other frequencies available upon request, e.g. 80 MHz for red diode laser heads) that can be divided by a factor of 1, 2, 4, 8 or 16 to produce user-selectable frequencies of 40, 20, 10, 5 or 2.5 MHz. Alternatively, the laser pulses can be triggered by an external trigger input. This way the PDL 800-B can be synchronised with other instruments over the full frequency range. A permanently active sync output allows the PDL 800-B to trigger other devices such as TCSPC electronics. The power supply output can also provide supply voltages for external components such as PMTs or SPADs.

A simple change of the laser head allows a quick change of the wavelength. The laser heads are built in a Linos Microbench compatible housing and include collimating optics and can be optionally fitted with mono- or multi-mode optical fibres. The laser heads are also available with Peltier cooling.

The PDL 800-B driver is designed for operation with:

- LDH Series picosecond pulsed diode lasers
- LDH-C Series cooled picosecond pulsed diode lasers
- PLS Series sub-nanosecond pulsed LEDs

The laser heads contain a diode element and a power driver stage that features various adjustments and protection circuits. These parts are internally calibrated and then sealed after final inspection. Any tampering with these calibrations will void the guarantee.

The only user adjustable part of the laser head is the set-point for the thermoelectric (TE) cooler (LDH-C Series only). The temperature regulation is described in chapter 5.6.

2. Safety Instructions

To avoid hazardous radiation exposure, you should obey the following instructions:

1. Laser radiation can be emitted whenever the laser is powered and the green “STBY” (standby) LED (1) is illuminated. Never look directly into the laser beam. The laser head emits visible or invisible laser radiation from the collimator's aperture, shown below. The wavelength and maximum power that is emitted from your laser head model is indicated in the technical data sheet in the appendix of this manual and on the warning label on each laser head.

The warning label and an aperture label are located on the laser head, as shown below.

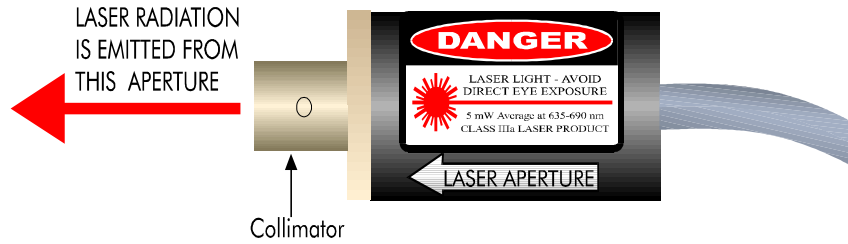


Figure 1. Model LDH laser head (not temperature controlled) - side view

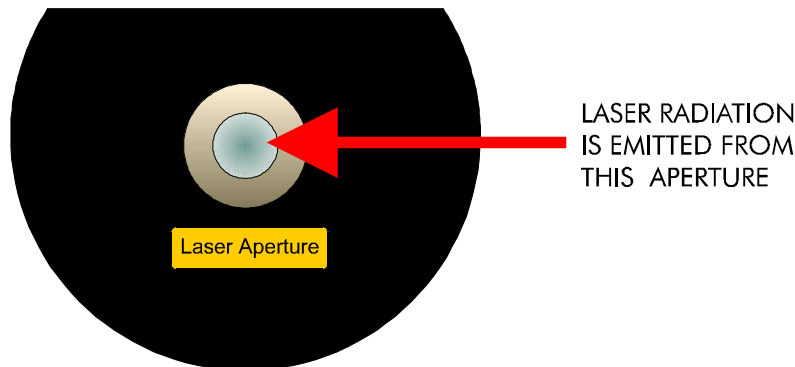


Figure 2. Model LDH-C laser head (temperature controlled)- front view

2. Always switch OFF the driving unit to remove or change the laser head or a fiber coupler.
3. Mount the laser head in your optical set-up in such a way that the laser light emitted from the collimator cannot cause any eye safety hazard. If a fibre output is installed, make sure that the fibre and the fibre coupler are mounted securely to the laser head. Mount the emitting end of the fibre in such a way that any exposure to the human eye is impossible.
4. Only use laser heads supplied by PicoQuant, or designated by PicoQuant as compatible, with the Laser Driver.
5. Never open the housing of the laser head or the driver unit. There is no need for maintenance beside visual inspection for damages and external cleaning. For safety reasons you should periodically (monthly) check the function of the emission indicators, the remote interlock and that no scattered radiation can leave the collimator (e.g. by missing screws).
6. **CAUTION - use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.**

3. User Interface - Operating Controls and Connections

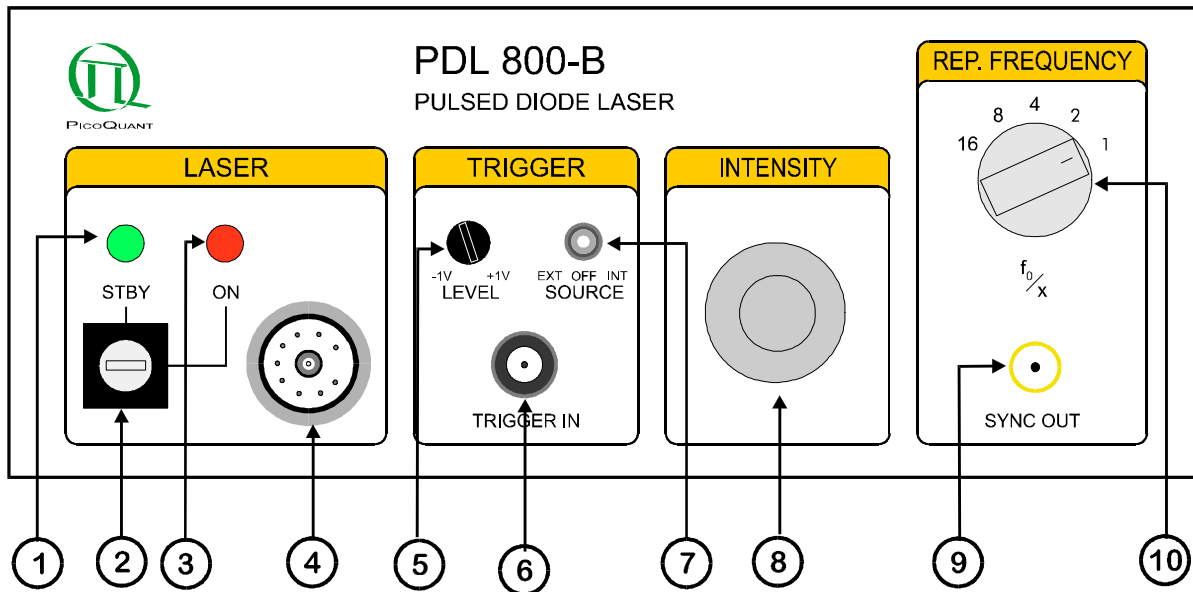


Figure 3. Front Panel

1. *Main Power indicator* - green “STBY” (standby) LED indicates that the PDL 800-B is ON and that laser radiation can be emitted.
2. *Key switch* (Laser power switch). Power to the laser can be locked OFF by turning the key to the “STBY” position and removing the key.
3. *Laser "ON" indicator* - red LED indicates that the laser is triggered.
4. *Laser output* (multi-pin connector)
5. *Trigger level threshold control*
6. *External trigger input*, (female BNC connector)
7. *Trigger source selector*
 - OFF - No laser pulses are triggered
 - INT - Laser is triggered by the internal oscillator
 - EXT - Laser is triggered by an external signal, provided that the Trigger level threshold (5) is correctly set
8. *Laser intensity control* - pulse shape (intensity and length) can be adjusted
9. *Synchronisation signal output* (SMA connector)
10. *Repetition frequency selector*: repetition frequency = the base frequency divided by the selector setting (illustration shows the setting for a 40 MHz repetition frequency = 40 MHz / 1)

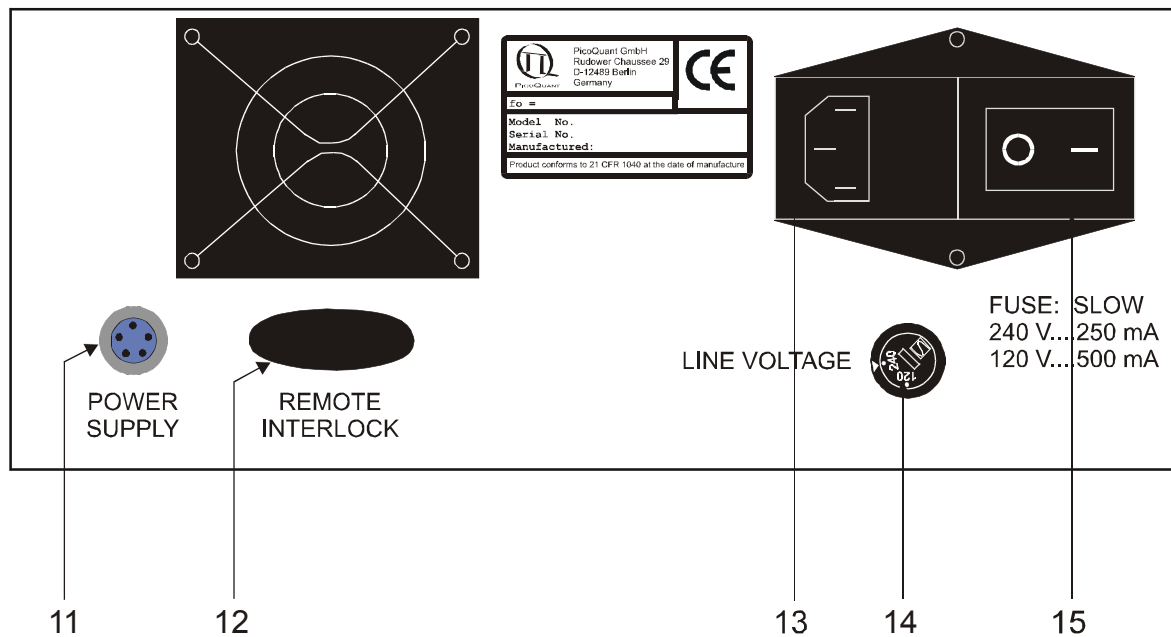


Figure 4. Back Panel

- 11. Power supply output for PicoQuant accessory modules
- 12. Remote interlock connector
- 13. Main power input socket with Fuse
- 14. Mains voltage selector 120 / 240 V
- 15. Main power ON / OFF switch

3.1 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 connector* (12) on the back panel is provided for this purpose. When the contacts are open the laser is then locked OFF.

Remove the bridge and connect your remote interlock (door) switch to the *remote interlock connector* (12). Standard banana plugs can be used for the connection. The loop resistance of the cabling plus the switch must be less than 10 Ohms. The voltage that is present on this connector is < 7 VDC.

4. Installation

Before making any connections, be sure that all of the following conditions are met:

- *Main power ON / OFF switch (15)* is in the OFF position.
- *Mains voltage selector (14)* is set to the correct voltage
- *Key switch (2)* is set to the "STBY" (standby) position.
- *Trigger source selector (7)* is in the OFF position
- *Laser intensity control (8)* is set to the lowest setting

4.1. Electrical Power and Signal Connections

- Connect the laser head to the *Laser head output connector (4)*.

Only use laser heads supplied by PicoQuant, or designated by PicoQuant as compatible, with the Laser Driver.

Only connect or disconnect a laser head when the driver unit is switched OFF.

- Connect (if necessary) the *remote interlock (12)* switch loop or use the installed short circuit bridge if no interlock is needed.
- If desired, connect an external trigger signal to the *External trigger input (6)*.
- If desired, connect the *Synchronisation output (9)* to an external device, e.g. the TimeHarp TCSPC board or an Oscilloscope.
- Plug in the mains power cable.

4.2. Heat Dissipation

Driver Unit:

Please ensure free air circulation and do not cover the cooling fan at the back panel.

Temperature Controlled Laser Heads (LDH-C Models):

The LDH-C series laser heads contain an active thermoelectric cooling mechanism. This produces, depending on the ambient temperature, a considerable amount of heat at the housing. A sufficient air circulation must be ensured to prevent overheating of the laser head.

Standard Laser Head (LDH Models)

The output power of laser heads without temperature stabilisation changes with the case temperature. They deliver better long term stability if they are operated in a temperature conducting mount.

If you own a high power, but not temperature controlled, laser head, an extra heat sink may be required. Otherwise the self-heating of the laser head would lead to a significant drop of the output power and also a shorter lifetime of the laser diode. It is mentioned in the test sheet of your laser head in the Appendix if a heat sink is mandatory. Placing the laser head into a metal bracket directly connected to a surface of some square centimetres is sufficient in most cases.

5. Operation

5.1 Power ON

- **Ensure that no one is looking into the aperture of the laser head.**
- Switch the *Main power switch (15)* to ON and the green “*STBY*” (*standby*) *LED (1)* will illuminate. If the *Key switch (2)* was in the “ON” position when the *Main power switch* was turned ON, then, for the first 10 seconds, the red *Laser “ON” LED (3)* will not illuminate and power will not be applied to the laser output.
- Turn the *Key switch (2)* to “ON”.
- Set the *trigger source selector (7)* to the appropriate position
 - OFF - No laser pulses are triggered
 - INT - Laser is triggered by the internal oscillator
 - EXT - Laser is triggered by an external signal, provided that the *Trigger level threshold (5)* is correctly set
- The red *Laser “ON” LED (3)* will illuminate and the laser head is powered, if:
 - 1 the *trigger source selector (7)* switch is in the “INT” or “EXT” position (if in the “EXT” position, the trigger source must be connected and the trigger level correctly set) and
 - 2 the *remote interlock (12)* loop is closed
- If needed, activate the external trigger source, $V_{pk} = \pm 5 \text{ V max.}$ and adjust the trigger level from -1 V to +1 V with the *Trigger level threshold control (5)*.
- Check the *Temperature Control Status LED* on the laser head (if so equipped), if it is:
 - “green” - the laser diode is within the correct operating temperature range
 - “red” - the laser diode temperature is too high and the laser head will automatically turn off
 - “off” - the laser diode has not yet reached the proper operating temperature

The temperature of the laser diode needs to reach a pre-set level for stable operation. Please refer to the specific instructions that were supplied with the laser head for proper adjustment of the temperature control.

- Adjust the Laser power level with the *laser intensity control (8)*.

If you cannot detect a laser beam, check the following:

- | | |
|---|---|
| <p>if the red <i>Laser “ON” LED (3)</i> is ON, check the:</p> <ul style="list-style-type: none"> - <i>Temperature Control LED</i> on the laser head - <i>Laser intensity control (8)</i> setting | <p>if the red <i>Laser “ON” LED (3)</i> is OFF, is the:</p> <ul style="list-style-type: none"> - <i>Key switch (2)</i> in the “ON” position ? - <i>Trigger source selector (7)</i> in the “INT” position? - Remote interlock contact closed ? |
|---|---|

5.2 Setting the Repetition Frequency

Set the repetition frequency for the output pulses with the *Repetition frequency selector (10)*.

Repetition frequency = the master frequency (f_o) of the driver divided by the selector setting

The master frequency (f_o) is 40 MHz for standard drivers (refer to the serial number label on the back panel of your driver for the master frequency). The following table lists the repetition frequencies that correspond to the selector settings for a driver with a master frequency of 40 MHz:

Selector Setting	Repetition Frequency, with $f_o = 40$ MHz
16	2.5 MHz
8	5.0 MHz
4	10.0 MHz
2	20.0 MHz
1	40.0 MHz

When the repetition frequency is changed, the brightness of the laser light will also change.

5.3 Changing the Pulse Intensity

The energy of the laser-pulses can be changed with the *Laser intensity control (8)*. At higher settings the pulses will not only be more intense, but also longer and a slight after-pulsing may occur.

Changing the repetition frequency may change the shape of the pulses. In some instances, these changes can be compensated for by adjusting the Laser intensity control (8), in order to retain the desired pulse form.

For long-term stable output power, allow the laser to warm-up for at least 20 minutes. This is especially important for temperature stabilised laser heads.

Some higher power laser heads may only operate in the upper range of the power region. Keep in mind that operation at higher power decreases the lifetime of the laser diode. 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 not be selected unless it is absolutely needed.

5.4 External Triggering of the Laser

The laser can also be triggered by an external signal source

- First, set the *Trigger source selector (7)* to the "OFF" position (No laser pulses are triggered when the switch is in the "OFF" position).
- Connect the trigger signal generator to the *External trigger input (6)*. The maximum limits for the trigger signal input voltage are from -5 V to +5 V. To prevent reflections, the output impedance of the signal source and coaxial connector must be exactly 50 Ohms.
- Set the *trigger source selector (7)* to the "EXT" position.
- Adjust the trigger level from -1 V to +1 V with the Trigger level threshold control (5). The trigger level may have to be "fine tuned" 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 triggering is not ideally locked. Readjusting the trigger level may help with weak input signals. The ringing of the signal source can lead to multiple pulses (consequently, the trigger level should not be set too close to zero).
- The laser pulses are triggered by the rising edge of the trigger signal.

5.5 Triggering other Devices with the Synchronisation Output Signal

The trigger signal also produces an NIM Standard signal (< -800 mV at 50 Ohms) at the *Synchronisation output (9)*. This provides the opportunity to synchronise other devices for time correlated measurements.

The sync out signal is always synchronised to the trigger source (i.e. INT or EXT depending on the setting of the *Trigger source selector*). No signal is present in the "OFF" position. If you only need the synchronisation signal without a laser (i.e. for installation and adjustment), switch off the laser at the key switch. The synchronisation signal will still be present.

For operation with the *TimeHarp 100®* Time Correlated Single Photon Counting board, an LTT100 pulse converter, available from PicoQuant, must be used.

5.6. Temperature Control (model LDH-C Laser Heads only)

The only user adjustable part of the laser head is the set-point for the thermoelectric (TE) cooler. Since the output power at a given potentiometer setting depends slightly on the temperature of the diode element, the set-point should only be changed if absolutely necessary, e.g. if the ambient temperature is too high.

The thermoelectric (TE) cooler maintains the temperature of the diode element and the collimating optics at a constant level. The factory pre-set value is approximately 20°C. Before first operating the diode laser, verify that the temperature control potentiometer is set correctly. The desired temperature can be set via the *Control Potentiometer* (see figure below) using a screwdriver.

The temperature level can be set from +15 to +25°C. The temperature should be chosen with respect to the ambient temperature and humidity conditions. The outer case acts as a heat sink. To prevent overheating, the temperature should not be set to the lowest value if the ambient temperature is higher than 30°C. Also, if the ambient humidity is high, water may condense on the collimator. Switch the laser OFF and look at the silver coloured collimator holder to determine if condensation is forming. **DO NOT look into the laser optics when the laser is ON!**

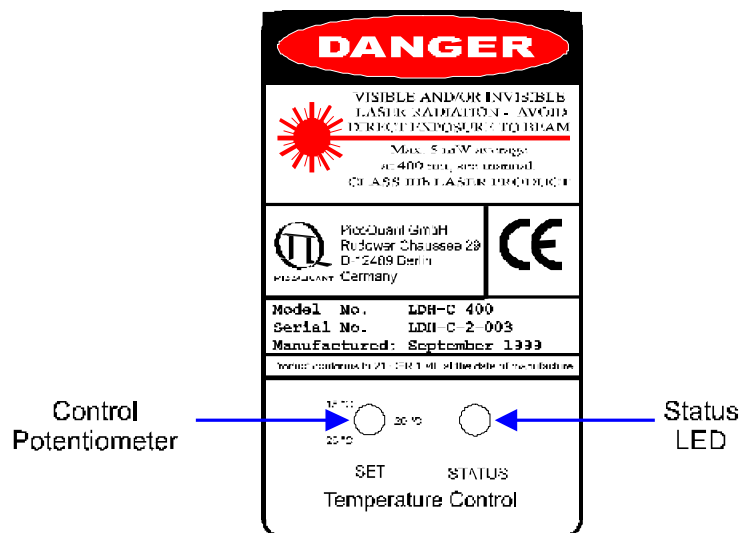


Figure 5 : Top View of an LDH-C Series Laser Head

The temperature of the diode element needs to reach the set-point temperature for stable operation. At start-up the *Status LED* may be "red" (if the diode element is initially >28 °C) or "OFF" (if the diode element is <28 °C but not yet at the set-point temperature). The laser is OFF when the LED is "red". Allow about 2 to 5 minutes after start-up, under normal conditions, for the TE cooler to reach the set-point temperature. The *Status LED* will change to "green" when the temperature has reached the set-point.

- ◆ Check the *Temperature Control Status LED* on the laser head, if it is:
 - green - the laser diode element is operating at the set-point temperature
 - red - the laser diode element temperature is too high and the laser will automatically shut OFF
 - OFF - the laser diode element has not yet reached the set-point temperature

Check the *status LED* periodically. If it is "red" the TE cooler is operating but not able to maintain the diode element temperature below 28 °C. In this case, switch the laser OFF and wait until the laser head has cooled down. Then, adjust the temperature set-point to a higher value, reduce the ambient temperature or increase the ventilation near the diode laser housing.

At higher operating temperatures the diode laser can provide approximately 10 % more output power, but the diode element lifetime will be much longer if operated at a lower temperature.

6. Application Tips

The PDL 800-B was designed for indoor laboratory use. The laser element, inside the laser head, is somewhat sensitive, i.e. overloads or stress may quickly damage it. Therefore, the laser head includes protection circuitry that may seem to hinder the user, but is absolutely essential for long-term reliable performance .

Remember to follow these basic operating rules :

- Ensure that no one is looking into the aperture of the laser head.
- Do not connect or disconnect the laser head from the base unit until the power has been switched OFF for at least 5 seconds.
- Do not connect the laser head to any driver other than the PDL 800-B, or designated by PicoQuant as compatible. If any other supply voltages or signals are connected to the laser head, the system can be damaged and / or uncontrolled laser radiation could result.
- The voltage at the external trigger input connector (8) should never exceed the range from -5 V to +5 V, otherwise the electronics may be damaged. To prevent reflections, the output impedance of the trigger signal source and the coaxial connector must be exactly 50 Ohms.
- There are no operator serviceable parts inside the laser heads or the driver unit. Repairs or recalibration should be left to qualified personnel authorized by PicoQuant GmbH. Especially do not try to remove the 4 screws at the front of the uncooled laser head! Doing this will easily damage the laser diode.
- An external signal should only be connected to / disconnected from the *External trigger input* (6) connector when the *Trigger source selector* (7) is in the "OFF" position and the *Key switch* (2) is in the "STBY" (standby) position. This will prevent "glitches" that might result in unwanted laser radiation.
- To ensure safer working conditions and to prolong the lifetime of the laser element, select a lower power setting (approx. 35% of full power). Full laser power should not be selected unless it is absolutely needed. This applies especially to the laser diodes in the ultraviolet to blue region, which still have a more limited lifetime (around 1000 operating hours). It is recommended to switch off these lasers at the trigger switch (7) or the key switch (2) whenever possible. The main power switch of the driver can be left on to maintain the stabilised temperature.

The pulse shape will be influenced by:

- Laser intensity setting - a higher intensity setting may produce:
 - Pulses with a higher amplitude and broader base. After-pulsing may also occur.
 - Peak shift to an earlier time (arrives sooner) in relation to the SYNC signal.
 - Peak shift of the emitted light to a shorter or longer wavelength (depending on the laser material).
- Repetition frequency - a higher repetition frequency may produce:
 - Pulses with a different shape or pulse width
 - Pulses with a lower peak power per individual pulse.
 - Pulses with lower energy per individual pulse.

In most cases, the energy of the individual pulses is not the same at each frequency setting, e.g. the energy at the 40 MHz setting is lower than at the 20 MHz setting. Changing the repetition frequency setting will not result in the same pulse energy until the setting is ≤ 10 MHz.

- Polarisation / orientation of the laser - rotating the laser head 90° may produce pulses with a different shape and a different intensity. This may also reduce the amount of background luminescence observed by the detector.

7. Support

The PDL 800-B has gone through extensive testing by PicoQuant and various users. It is now in its second generation and has become very stable and reliable. Nevertheless we will continually make improvements and incorporate these into upcoming versions.

In any case, we would like to offer you our complete support. Please do not hesitate to contact PicoQuant if you would like assistance with your system.

If you observe any errors or bugs, please try to find a reproducible error situation. E-mail a detailed description of the problem and relevant circumstances to photonics@pq.fta-berlin.de. Your feedback will help us to improve the product and documentation.

Of course we also appreciate good news: If you have obtained exciting results with one of our systems, we would also like to know!

8. Limited Warranty

The laser diode is excluded from the warranty since it is subject to natural degradation. However, PicoQuant does offer the following replacement credit for laser heads:

The laser diode will be replaced free of charge should it fail within the first two months after delivery. After the second month, we offer replacement at material cost during the warranty period. All shipping costs (including insurance, taxes, duties, etc.) are the responsibility of the customer.

9. Specifications - PDL 800-B Driver

Internal Oscillator

Type	crystal locked (up to 80 MHz max.)
Master frequency	40 MHz standard (see label on back panel) other frequencies available upon request
Repetition frequencies	40, 20, 10, 5 or 2.5 MHz (user-selectable)

External Trigger Input

Amplitude	-5 to +5 V _{PP} (maximum limits)
Trigger level (adjustable)	-1 to +1 V _{TH} (negative slope)
Pulse width	> 5 ns
Frequency range	10 Hz to 80 MHz
Delay	35 ± 5 ns (from trigger input to optical output), jitter < 40 ps
Impedance	50 Ohms (dynamic) / 500 Ohms (static)
Connector type	BNC (female)

Synchronisation Output

Amplitude	< -800 mV into 50 Ohms (NIM)
Pulse width	6 ns
Delay	12 ns (from falling edge to laser output), jitter < 20 ps
Impedance	50 Ohms
Connector type	SMA (female)

Remote Interlock

Voltage	< 7 VDC
Loop Resistance	10 Ohms max

Power Supply

Line voltage	220/240 or 110/120 VAC, 50/60 Hz (see label on back panel)
Power consumption	45 Watts max.
DC supply output	± 12 V / 100 mA or ± 5 V / 250 mA (for external modules)
Connector	6-pin DIN

Dimensions

Driver Unit	237 x 310 x 97 mm (w x d x h)
Laser heads	see next page



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Dimensions of the laser heads:

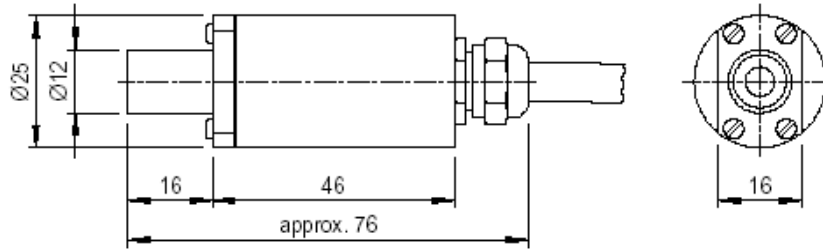
LDH model:

standard laser head
(without Peltier cooling)

all dimensions in mm

side view

front view



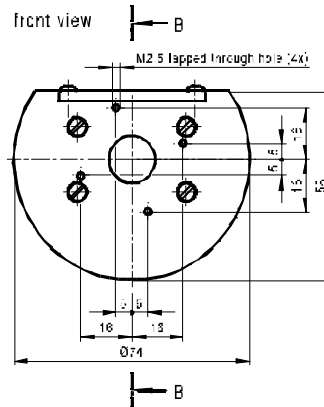
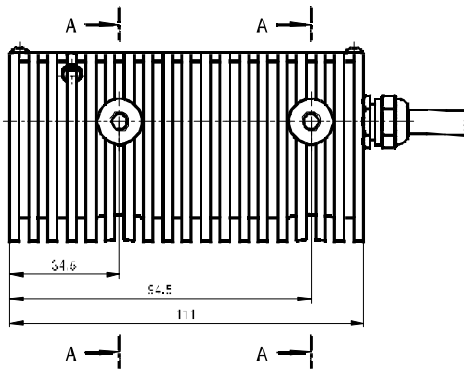
LDH-C model:

Peltier cooled laser head

all dimensions in mm

side view

front view



cross section B - B

cross section A - A

