



## Compact Laser Diode Controller

# CLD101x Operation Manual



2018

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We aim to develop and produce the best solution for your application in the field of optical measurement technique. To help us to live up to your expectations and constantly improve our products we need your ideas and suggestions. Therefore, please let us know about possible criticism or ideas. We and our international partners are looking forward to hearing from you.

*Thorlabs GmbH*

**Warning**

Sections marked by this symbol explain dangers that might result in personal injury or death. Always read the associated information carefully, before performing the indicated procedure.

**Attention**

Paragraphs preceded by this symbol explain hazards that could damage the instrument and the connected equipment or may cause loss of data.

**Note**

This manual also contains "NOTES" and "HINTS" written in this form.

Please read this advice carefully!

# 1 General Information

The CLD101x is a compact laser diode and temperature controller with a USB 2.0 interface for driving laser diodes up to 1.5 A (CLD1015) or 1.0 A (CLD1010LP and CLD1011LP) laser current and 3.0 A TEC current.

Special highlights of the CLD101x Compact Laser Diode and Temperature Controllers are:

- CLD1015 operates DFB lasers type 1 (pump lasers) and type 2 (DFB type lasers) in butterfly package
- CLD1010LP operates Thorlabs LP pigtailed laser diodes with pin codes A, D, E, and G
- CLD1011LP operates Thorlabs LP pigtailed laser diodes with pin codes B, C, and H
- Photodiode (monitor diode) current feedback
- Laser diode operation can be operated in constant current as well as in constant power mode
- CC mode with modulation up to 250 kHz (CLD1015) and up to 300 kHz (CLD1010LP / CLD1011LP)
- External modulation input, RF BIAS input on CLD1010LP and CLD1011LP
- Interlock for automatic switch off by an external emergency switch or by a cable interruption
- Temperature controller with excellent temperature stability
- Temperature window for laser protection
- A wide variety of protection features safeguard the laser diode and the TEC element from damage.
- Touch panel for easy operation
- USB interface for remote operation supporting the USBTMC protocol
- SCPI compliant command set
- VXIppn Instrument Drivers for various programming environments including NI-LabVIEW™, NI-LabWindows™/CVI and MS-Visual Studio

## 1.1 Safety

### Attention

The safety of any system incorporating the equipment is the responsibility of the assembler of the system.

All statements regarding safety of operation and technical data in this instruction manual will only apply when the unit is operated correctly as it was designed for.

The CLD101x must not be operated in explosion endangered environments!

Do not obstruct the air ventilation slots in the housing!

Do not remove covers!

Do not open the cabinet. There are no parts serviceable by the operator inside!

This precision device is only serviceable if properly packed into the complete original packaging including the plastic foam sleeves. If necessary, ask for replacement packaging.

Refer servicing to qualified personnel!

Only with written consent from Thorlabs may changes to single components be made or components not supplied by Thorlabs be used.

Follow the common recommendations for handling of ESD sensitive devices when installing a laser diode to the CLD101x .

**Attention**

Prior to applying power to the CLD101x , make sure that the protective conductor of the 3 conductor mains power cord is correctly connected to the protective earth ground contact of the socket outlet! Improper grounding can cause electric shock resulting in damage to your health or even death!

To avoid risk of fire, only the appropriate fuses for the corresponding line voltage must be used.

All modules must only be operated with duly shielded connection cables.

**Attention**

The following statement applies to the products covered in this manual, unless otherwise specified herein. The statement for other products will appear in the accompanying documentation.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules and meets all requirements of the Canadian Interference-Causing Equipment Standard ICES-003 for digital apparatus. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Users that change or modify the product described in this manual in a way not expressly approved by Thorlabs (party responsible for compliance) could void the user's authority to operate the equipment.

Thorlabs is not responsible for any radio television interference caused by modifications of this equipment or the substitution or attachment of connecting cables and equipment other than those specified by Thorlabs. The correction of interference caused by such unauthorized modification, substitution or attachment will be the responsibility of the user.

The use of shielded I/O cables is required when connecting this equipment to any and all optional peripheral or host devices. Failure to do so may violate FCC and ICES rules.

**Attention**

Mobile telephones, cellular phones or other radio transmitters are not to be used within the range of three meters of this unit since the electromagnetic field intensity may then exceed the maximum allowed disturbance values according to EN 61326-1.

This product has been tested and found to comply with the limits according to EN 61326-1 for using connection cables shorter than 3 meters (9.8 feet).

**Warning**

Laser emission is dangerous to human eye. Do not stare into the emitting aperture, wear protective glasses and observe the safety instructions supplied with the laser diode.

## 1.2 Ordering Codes and Accessories

CLD1015	Compact Laser Diode Controller with mount for Type1 and Type2 14-pin butterfly laser diodes.
CLD1010LP	Compact Laser Diode Controller with mount for Thorlabs LP pigtailed laser diodes, pin codes A, D, E, and G
CLD1011LP	Compact Laser Diode Controller with mount for Thorlabs LP pigtailed laser diodes, pin codes B, C, and H

For included in delivery parts please see section [Parts List](#)<sup>7</sup>. Please see also the Thorlabs website for services, spare parts and available accessories.

## 1.3 Requirements

These are the requirements to a PC dedicated to remotely control the CLD101x .

### 1.3.1 Hardware Requirements

CPU: 1 GHz or higher  
RAM: 256 MB  
Hard disc with at least 100 MB free storage space  
USB 2.0 port  
USB cable according the USB 2.0 specification

### 1.3.2 Software Requirements

The CLD101x software is compatible with the following operating systems:

- Windows ® XP (32-bit) SP3
- Windows ® Vista (32-bit, 64-bit)
- Windows ® 7 (32-bit, 64-bit)
- Windows ® 8 (32-bit, 64-bit)
- Windows ® 10 (32-bit, 64-bit)

For operation of the CLD101x , also an NI-VISA™ (version 5.3 or higher) is required. The NI-VISA™ engine is included with the Thorlabs CLD101x Installation CD, that is delivered with the CLD101x , but can also be downloaded from the National Instruments website [www.ni.com/visa](http://www.ni.com/visa).

## 2 Operation

### 2.1 Parts List

Inspect the shipping container for damage.

If the shipping container seems to be damaged, keep it until you have inspected the contents and you have inspected the CLD101x mechanically and electrically.

Verify that you have received the following items within the package:

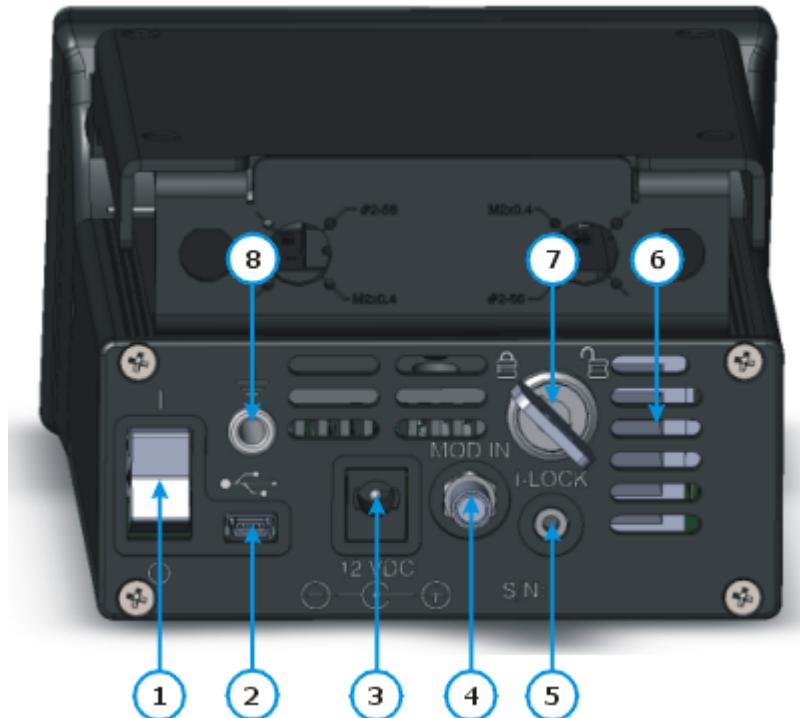
- 1 CLD1010LP / CLD1011LP / CLD1015 driver
- 1 Compact wide range power supply (AC 100...240 V to DC 12 V / 3.75 A)
- 1 Power Cord
- 1 USB 2.0 A to Mini B cable, 1.5 meters
- 1 Allen wrench 1.5 mm
- 1 Allen wrench 2.0 mm (CLD1015 only)
- 5 Screws M2 x 5 mm for fixing the Laser Diode (CLD1015 only)
- 1 Set of auxiliary mounting accessories
- 1 Quick Reference

### 2.2 Operating Elements

#### Front panel

The compact laser driver CLD101x has a touch-sensitive LCD front panel. The controls are intuitive, for detailed explanations please see subsequent chapters.

#### Rear panel



- 1 Power switch
- 2 USB 2.0 Interface
- 3 DC supply input
- 4 Modulation input (SMA)
- 5 Interlock connector
- 6 Ventilation slots
- 7 Locking Key
- 8 Ground jack

## 2.3 Safety and Protection Features

The CLD101x incorporates a number of safety and protection features in order to prevent damages to the laser diode and to protect the user.

### Key lock switch

The key switch disables the laser current output. This feature complies with the CDRH (Center for Devices and Radiological Health) requirements and prevents an unauthorized usage of the laser driver.

### Interlock

The interlock function provides several protection functions simultaneously.

- Safety lock to prevent unintentional use
- An external emergency switch may be connected
- To connect your external automatic protection equipment, e.g. for temperature monitoring

The laser can only be operated with the interlock input shortened. Please refer to section [Laser Protection](#)<sup>23</sup> for details.

### Softstart

The soft start function protects the laser diode against undesired peaks during the laser switch-on process.

### Laser current limit (hardware limit)

The maximum laser current can be adjusted by the laser current limit, that can be set in the [Laser Driver Setup](#)<sup>22</sup> menu.

### Open circuit detection for the laser diode

If the connection to the laser is interrupted even for a short time during operation, an immediate emergency switch off occurs.

### Electronic short-circuit switch for the laser diode

With the laser driver output switched off, an electronic switch will short the laser diode so that no voltage is applied to the laser contacts.

### Temperature window protection of the laser diode

This feature protects the laser diode from unwanted operating temperatures in combination with the integrated TEC controller: Defining a temperature window around the laser temperature set point, the laser can be paused or permanently switched off, if the actual temperature is outside of that window.

Please see [TEC Driver setup](#)<sup>25</sup> and [Laser Protection](#)<sup>22</sup> sections for details

### Over-temperature protection

The CLD101x has an automatic over-temperature protection. If the allowed internal operating temperature should be exceeded, the outputs will be switched off. After a temperature drop of about 10 °C, the outputs of the CLD101x can be switched on again.

### Defined states after switch-on

When turning on the CLD101x with the main switch, the laser and TEC output are by default switched off. The setup allows to switch on the [LD](#)<sup>22</sup> and/or [TEC](#)<sup>25</sup> output when starting the device.

## Line failure monitoring

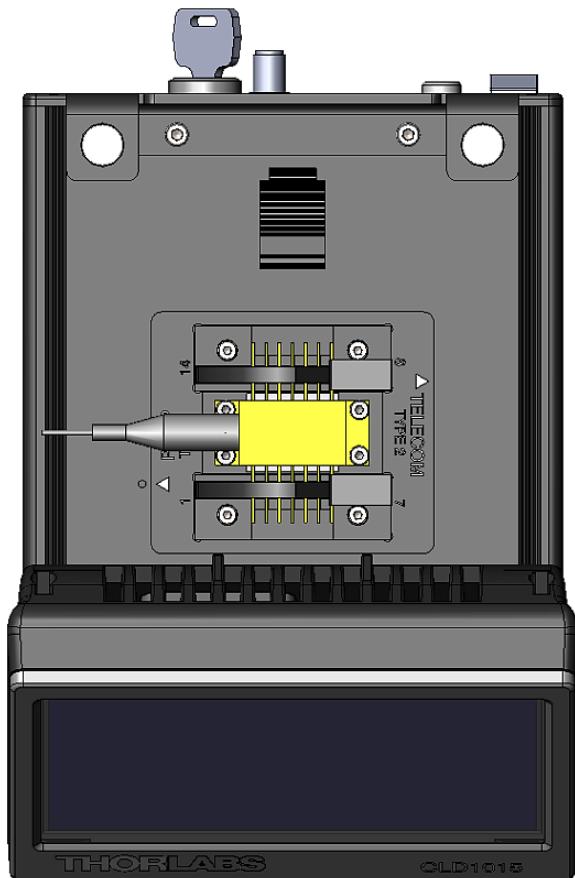
In case of line failure / line interruption the CLD101x will restart anew as if it has been turned on with default power-on settings.

## 2.4 Getting Started

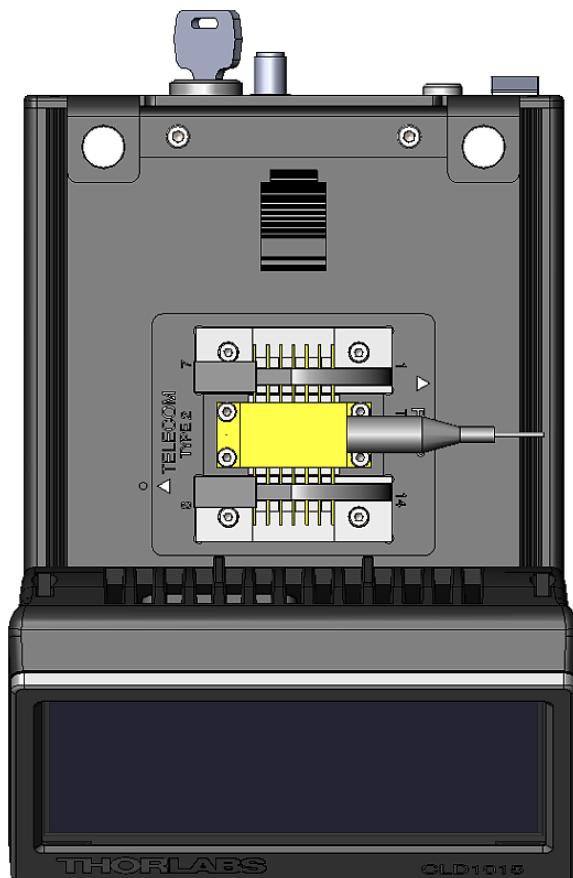
### Warning

A laser diode is extremely sensitive to electrostatic discharges. Take care for ESD protection during installation of the laser. Connect the ESD protection ground of your workplace and wrist strap to the [GND jack \(8\) on the rear panel](#)<sup>[7]</sup> of the CLD101x. Improper ESD grounding may lead to damage of the laser diode!

### 2.4.1 Installing "Butterfly" Laser Diodes to CLD1015



CLD1015 with installed BFY1 type pump laser



CLD1015 with installed BFY2 type telecomm laser

1. Verify the pinout of the laser diode to be installed. CLD1015 supports the two standard pin styles of 14 pin butterfly laser diodes (see [Standard BFY Pinouts](#)<sup>[75]</sup>). The actual pinout of the laser can be found in its data sheet.

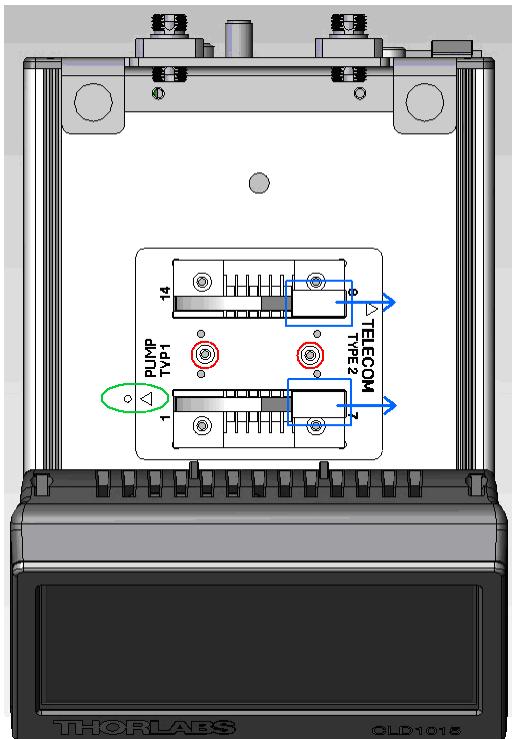
2. Remove the 2 screws, fixing the laser mount to the CLD1015 (marked red), using the attached 2.0 mm Allen wrench.

3. Remove the laser mount and install it according to the type of pinout - the arrow for the package type should line up with the round marker (see green marking). The picture shows the installation of the laser mount for a standard pump laser.

4. Fix the laser mount to the enclosure. Open the ZIF ("Zero Insertion Force") socket clamps by pressing down the lids and sliding the release levers into the shown direction (marked blue).

5. Install the laser diode into the ZIF socket:

- Make sure, the laser pin numbering matches with the imprint on the laser socket. Please refer to the laser diode's data sheet for location of pin #1.
- Insert the laser into the mount in such way, that the pins fit easily into the slots of the ZIF socket.
- For laser diodes with high heat load use the delivered thermal conductive pad to improve thermal contact between laser and heat sink.
- Fix the laser diode to the laser mount using the attached 4 screws M2 x 5 and the 1.5 mm Allen wrench. In order to ensure the best thermal contact between the bottom plate of the laser diode (hot side of the laser's TEC) and the surface of the laser mount, it is recommended to use thermal compound - particularly in case of a high laser power.
- Close the clamps of the ZIF socket.



## 2.4.2 Installing LP Pigtalled Laser Diodes to CLD101xLP

The CLD1010LP is designed for mounting Thorlabs LP Series pigtailed laser diodes (laser anode grounded - AG) and supports pin styles (codes) A, D, E, and G, while CLD1011LP (laser cathode grounded - CG) supports pin styles (codes) B, C, H. The installation of the pigtailed laser diode requires a number of mandatory steps, explained in the following.

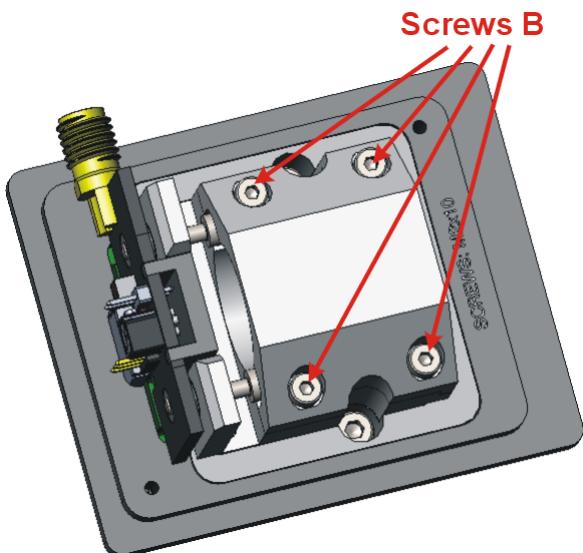
- Find the laser diode's pin code from the specifications.

- Disassemble the laser mount:

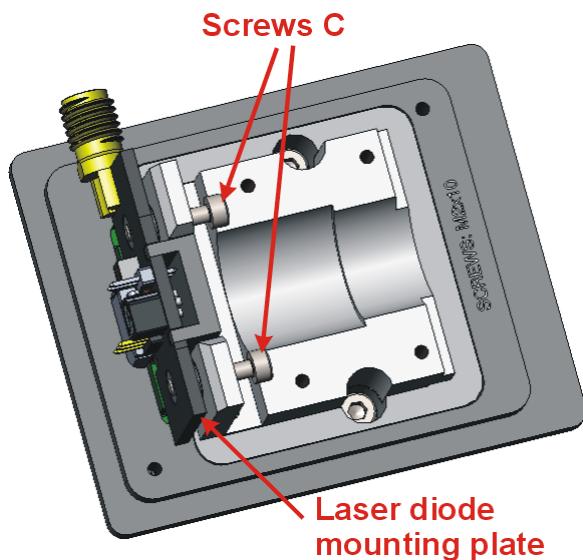
1. Remove the 2 screws "A" from the protection cover:



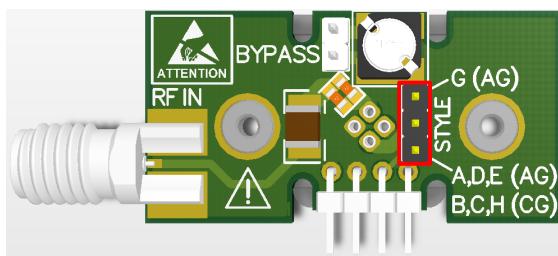
2. Remove the 4 screws "B", that fix the upper cooler shell, and remove the upper shell:



3. Remove the 2 screws "C" fixing the laser mounting plate to the cooler and pull out the mounting plate from the connector:



4. Set the STYLE jumper on the mounting plate (PCB) according to the pin code:

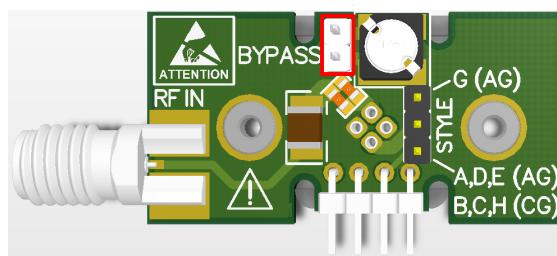


- ⇒ **CLD1010LP**: for pin codes A, D, E set the jumper to the lower 2 pins
- ⇒ **CLD1010LP**: for pin code G, set the jumper to the upper 2 pins
- ⇒ **CLD1011LP**: for pin codes B, C, H set the jumper to the lower 2 pins

*STYLE jumper location on the laser mounting PCB*

5. The BYPASS jumper should be set only, if the laser is modulated via the [CLD101xLP modulation input \(4\)](#) and the internal noise reduction filter is switched off. Please see also the following table:

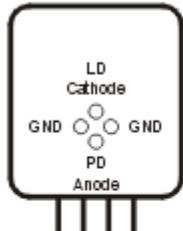
Operation Mode	Noise Reduction Filter	Bypass Jumper
Low noise, no modulation	ON	no
RF Modulation via RF IN (BIAS-T)	ON	no
Modulation via CLD101xLP	OFF	set



*BYPASS jumper location on the laser mounting PCB*

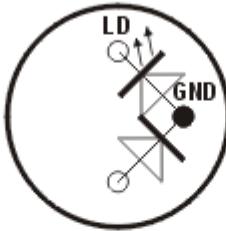
6. Insert the laser diode into the socket on the opposite to the jumpers side of the mounting plate according to the pin code as shown in the figure below:

**Socket Pin Diagram**  
set by Jumper **STYLE**

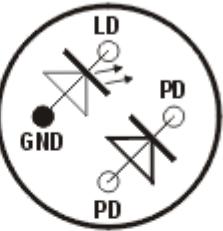


STYLE - A,D,E

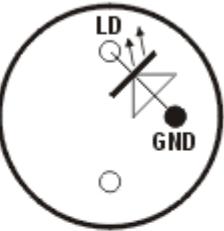
**Laser Diode Pin Diagrams - Bottom View**  
(Bold dots indicate case connection)



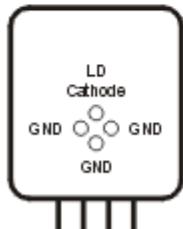
Pin Code A



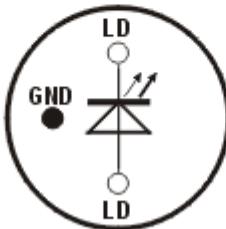
Pin Code D



Pin Code E



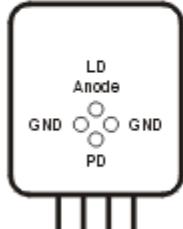
STYLE - G



Pin Code G

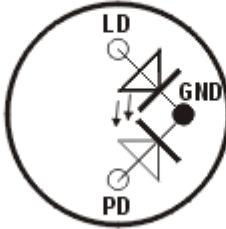
*Pin Styles CLD1010LP (Laser Diode - Anode Grounded)*

**Socket Pin Diagram**  
set by Jumper **STYLE**

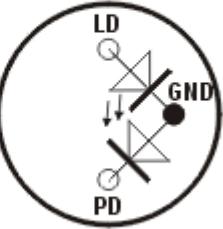


STYLE - B,C,H

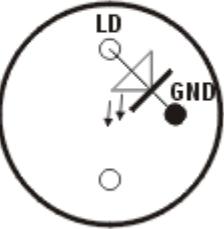
**Laser Diode Pin Diagrams - Bottom View**  
(Bold dots indicate case connection)



Pin Code B



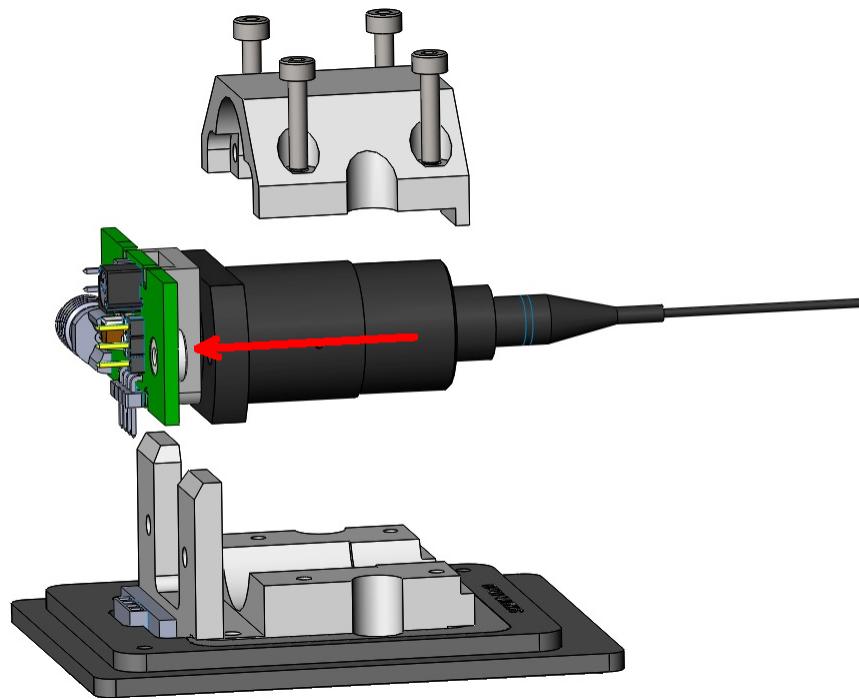
Pin Code C



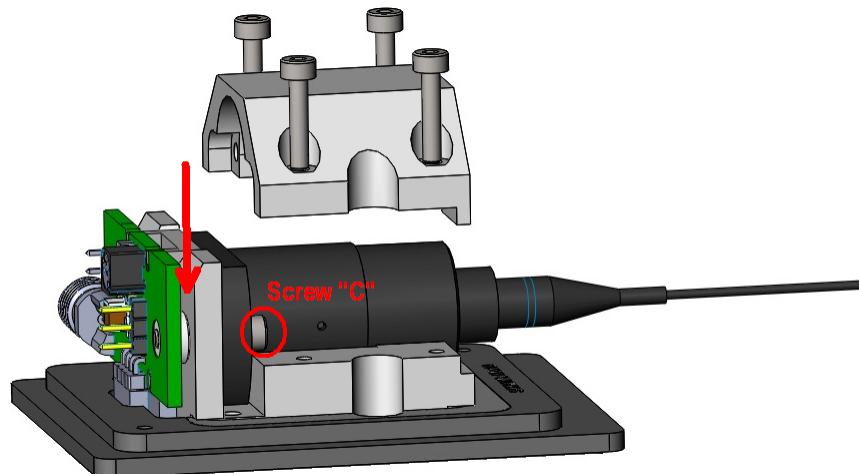
Pin Code H

*Pin Styles CLD1011LP (Laser Diode - Cathode Grounded)*

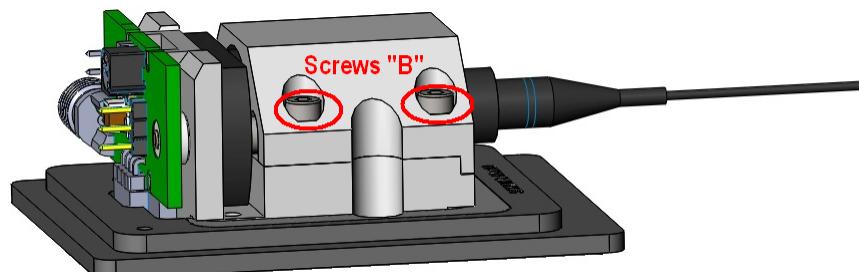
Insert the pigtailed laser diode and make sure, that the orientation matches exactly with the pin code:



7. Insert the adapter PCB with installed laser diode into the connector and fix it using the 2 screws "C":



8. Install upper cooler shell and fix it using the 4 screws "B":



9. Attach the protection cover and fix it using the 2 screws "A".

## RF Modulation via SMA RF input

The CLD1010LP / CLD1011LP laser mount has an RF input for modulating the laser with an external RF source from 200 kHz to beyond 1 GHz. This is a  $50\ \Omega$  input that is AC-coupled directly to the laser through the Bias-T network. To calculate the desired RF power to modulate the laser, determine the amount of modulating current needed from the laser manufacturer's data sheets and use the following calculations:

$$\text{RF voltage} = \text{LD modulating current} \times 50\ \Omega$$

It is strongly recommended that you start off conservatively by a factor of 10 below the calculated modulating voltage and slowly bring the RF power up until the desired depth of modulation is reached. Use the CLD1010LP / CLD1011LP to establish the DC operating point of the laser.

### Warning

The RF input is directly coupled to the laser. Any excessive transients or noise will be coupled into the laser and may cause the laser to be overdriven. Also, the laser can be easily overdriven if excessive RF power is applied to this input. Use the RF modulation input with care to avoid damaging your laser.

### 2.4.3 Preparation

1. Check if the interlock jumper or an external emergency switch is installed to the [LOCK connector \(5\)](#)<sup>7</sup>, see section [Interlock](#)<sup>23</sup> for details.
2. Insert the key into the [lock \(7\)](#)<sup>7</sup>. For normal operation turn the key clockwise, this way enabling the laser current output. In this position, the key cannot be removed.
3. Connect the power supply to the [DC input \(3\)](#)<sup>7</sup> and switch the CLD101x on (1).
4. The CLD101x turns on and the boot screen appears for abt. 3 seconds. It displays basic information.



CLD101x Boot Screen

During the boot process, a variety of hardware and software self tests are carried out. If any of these test failed, an appropriate error message will be displayed in above screen. Please note this error message and contact Thorlabs Tech Support.

5. Then the standard ("HOME") operation panel is displayed.

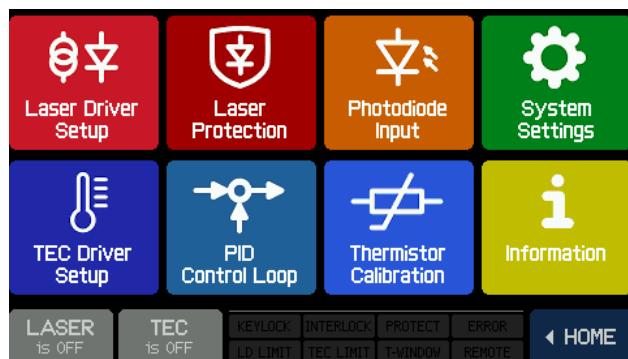


CLD101x Standard Operation Panel

If the Laser Current output is locked, **KEYLOCK** lites up, if the interlock is open - **INTERLOCK**.

## 2.5 Operating Instruction

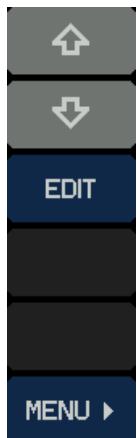
Prior to switching on the TEC and Laser output, configure the CLD101x according to your laser diode specification. The following sections explain these settings in detail. All setting menus are available via the **MENU ▶** button in the lower right corner of the panel:



### General Operations:

#### Menu sidebar

- select menu topic up
- select menu topic down
- edit menu topic (change value)  
(alternatively, push the highlighted topic a 2nd time)
- exit and return to Main Menu



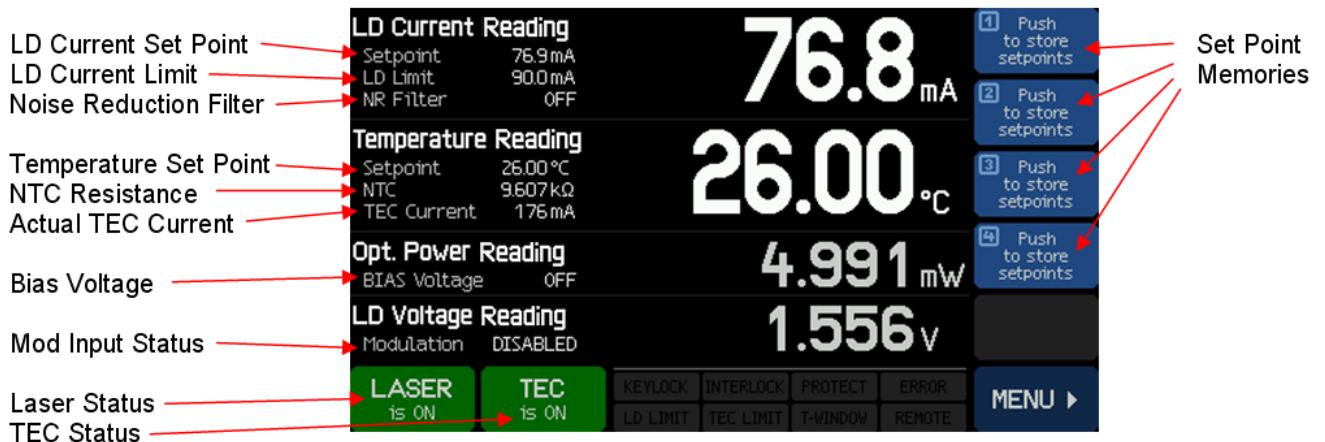
#### Edit sidebar

- increase value
- decrease value
- shift cursor left
- shift cursor right
- save changes and return to previous menu
- don't save changes and return to previous menu

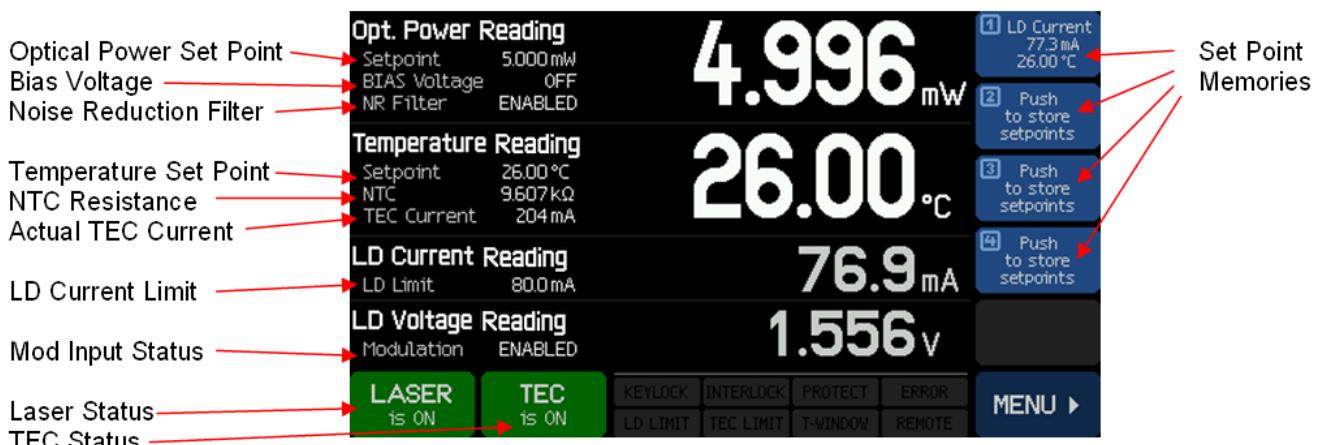


The operation via the touch panel is simple and intuitive. In the center of the display, the actual readings are displayed. The main parameters are shown in large characters this way providing a good visibility even from some distance.

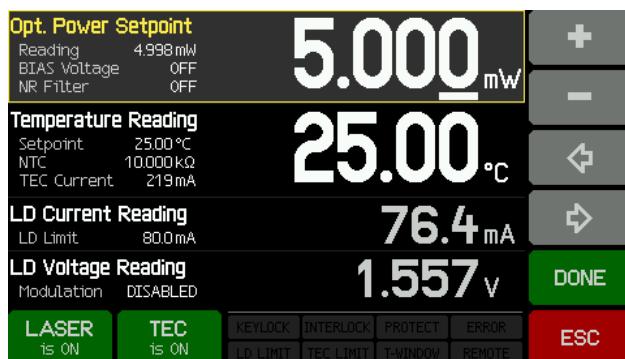
The appearance depends on the selected [laser operation mode](#)<sup>[22]</sup> (CC or CP).



Main operation panel (HOME) in CC mode



Main operation panel (HOME) in CP mode



The set points can easily be changed - touch the desired parameter or value and the display changes from read-out to set point values. Modify the set point as described in [General Operations](#)<sup>[18]</sup>, then save the settings (button DONE). The ESC button returns the display to read-out values without saving changes.

Touching a not editable parameter results in an appropriate warning message in the display.

## 2.5.1 Set Point Memories

Up to 4 set points (optical power or laser current and temperature) can be stored. Simply touch and hold for about 3 sec a set point memory icon. A beep, accompanied by the message "Set points stored" confirms saving.

### Note

In case the memory is not empty, the data will be overwritten!

A set point can be retrieved by short touch of the icon, settings immediately take place. If the memory data are related to a different operating mode, the laser must be switched off before the CLD101x can load the set point. If the laser is on, an appropriate warning message appears.

Set point memories can be cleared only at once from the **Clear Memories** button in [Information](#)<sup>29</sup> panel.

## 2.5.2 Main Panel Status Messages

<b>KEYLOCK</b>	LD current output is locked	Turn locking key (7) <sup>7</sup> on the rear panel to "enable" position
<b>INTERLOCK</b>	Interlock circuit is open	Close interlock circuit, e.g. by installing the jumper (5) <sup>7</sup>
<b>PROTECT</b> <b>PROTECT</b>	<a href="#">Laser Protection</a> <sup>22</sup> active	Laser switched off or paused due to exceeding the given temperature window. Make sure the TEC controller is ON.
<b>LD LIMIT</b>	<a href="#">Laser Current Limit</a> <sup>22</sup> reached	The laser current set value reached the limit.
<b>TEC LIMIT</b>	<a href="#">TEC Current Limit</a> <sup>25</sup> reached	May appear for a short time after switching the TEC on.
<b>T-WINDOW</b>	Actual temperature exceeded <a href="#">window</a> <sup>22</sup> .	Switch on TEC.
<b>REMOTE</b>	Device is in Remote Mode	
<b>ERROR</b>	An error in remote mode occurred. There are errors in the instrument's error queue. Use the 'SYSTem:ERRor' <a href="#">SCPI command</a> <sup>48</sup> to read out the error queue.	

### 2.5.3 Main Panel Error Messages

Error messages are displayed for abt. 7 sec. as text pop-ups in the lower part of the display instead of the status message boxes. Typical error messages are:

**The instrument is overheated.**

The temperature inside the enclosure exceeded the max. allowed value. Switch off the instrument and let it cool down.

**Outputs switched off. Mount failure detected.**

A failure in the laser mount was detected. TEC and laser current are switched off. Check the [laser connections](#)<sup>[10]</sup> and proper fixing of the laser mount. If the error persist, please contact Thorlabs.

**Laser output can't switch on while interlock is open.**

The [interlock circuit](#)<sup>[23]</sup> was found interrupted when trying to switch on the laser current. Check the [interlock connector \(5\)](#)<sup>[7]</sup> for properly installed jumper or, if applicable, the external interlock circuit.

**Laser output can't switch on while key switch is in locked position.**

Insert the [key \(7\)](#)<sup>[7]</sup> and turn it to the UNLOCK position.

**Laser output switched off. Voltage protection was tripped.**

Possible reasons are a interruption of the laser current (connection of the laser) or a too high forward voltage of the installed laser. The forward voltage of the installed laser must not exceed the specified "[Compliance Voltage](#)<sup>[68]</sup>" of your CLD101x .

**Laser output switched off due to temperature protection.**

The laser temperature exceeded the given [temperature window](#)<sup>[23]</sup>. Possible reasons are:

- TEC settings: If the TEC current is at its limit as well, increase the limit. Check the set temperature.
- Temperature window is set too small.
- Insufficient thermal contact between the the laser cabinet and the laser mount, see [Installing "Butterfly" Laser Diodes to CLD1015](#)<sup>[10]</sup> or [Installing LP Pigtailed Laser Diodes to CLD101xLP](#)<sup>[12]</sup>.

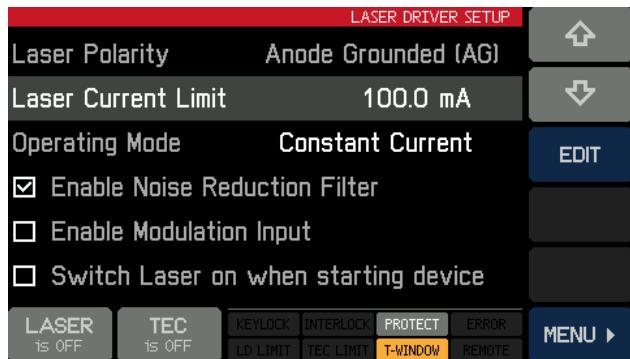
**TEC output switched off. Voltage protection was tripped.**

Possible reasons are a interruption of the TEC current (connection of the laser) or a too high forward voltage of the TEC element (CLD1015). The voltage across the TEC element must not exceed the specified compliance voltage of the TEC current output (4.7 V).

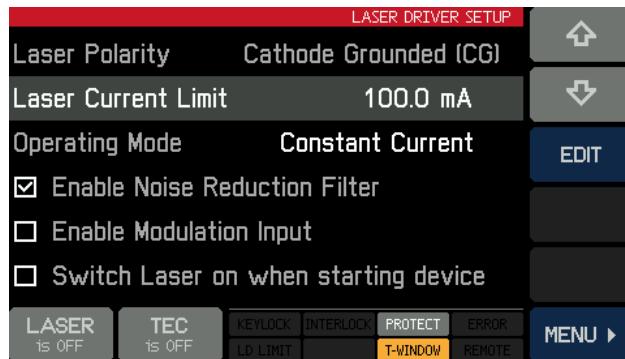
**Output switched off due to a temperature sensor failure.**

In order to prevent damage to the laser as a result of overheating, the CLD101x switches off if the temperature sensor fails.

## 2.5.4 Laser Driver Setup



Laser Driver Setup - CLD1010LP and CLD1015



Laser Driver Setup - CLD1011LP

Use the arrow buttons to select a parameter, then push EDIT button, or push the selected topic a second time.

- **Laser Current Limit:** Set the current limit to prevent damage of the laser diode.
- **Operating mode:** Select Constant Current or Constant Power mode. For details, please see the [Appendix](#)<sup>77</sup>.
- **Noise reduction filter:** Enabling this filter reduces the output current noise by a factor of ~ 2. Along with that, the modulation bandwidth reduces to 7.5 kHz, see [Specifications](#)<sup>68</sup>. The filter can be enabled / disabled only with the laser switched off.
- **Enable Modulation Input:** Checking this box, the signal applied to the SMA connector (4) on the [rear panel](#)<sup>71</sup> modulates the laser.
- **Switch Laser on when starting device:** Default setting is "Laser OFF" when starting the CLD101x . If required, the laser switched-on state can be changed.

## 2.5.5 Laser Protection



Use the arrow buttons to select a parameter, then push EDIT button, or push the selected topic a second time.



• **Temperature protection:** Select the required action in case the laser temperature exceeds the desired operating temperature range ("Temperature window"). The temperature window is centered to the laser Temperature Set Point. Available actions are:

1. None
2. Pause - the laser current is switched off and automatically switches on again, when the temperature is back within the given range. The return of the laser to operation can be delayed additionally (see *Protection Reset Delay* below).

3. Switch off - the laser current is switched off, when the temperature window is exceeded. After the temperature returns to the allowed range, the laser can be switched on manually only.

- **Protection Reset Delay:** The return to operation can be delayed for up to 600 sec.

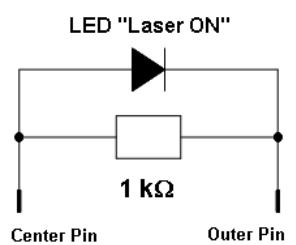
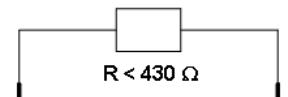
- **Temperature Window:** Defines the allowed operating temperature range to  $(T_{set} \pm T_{win}/2)$ .

## Interlock

Another safety feature is the hardware interlock, accessible via the [I-LOCK connector \(5\)](#)<sup>7</sup> on the rear panel. By default, a short circuit jumper is installed to the jack.

The interlock interface represents a current source (~16 mA when laser is switched on), where the voltage across the external circuit is observed. As soon as this voltage rises above a certain threshold (~ 2.5 V), the external circuit is considered "open" and the laser current output is disabled.

Instead of the jumper, an external emergency switch (opener) can be connected to the interlock, as well as an external circuit (total resistance < 430 Ω) or by a LED (anode to center pin, cathode to outer pin, connect in parallel resistor R=1 k ) alerting that the laser is switched on.



### Note

Do not use blue LED due to their high forward voltage.

## 2.5.6 Photodiode Input

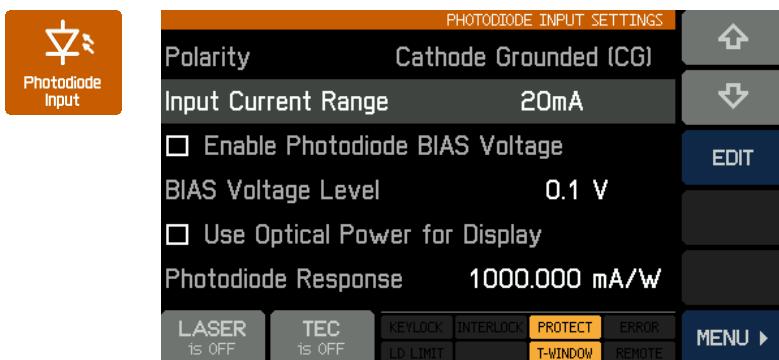


Photo Diode Input settings - CLD1015 and CLD1010LP

Use the arrow buttons to select a parameter, then push EDIT button, or push the selected topic a second time.

- **Input Current Range:** There are two ranges - max. 2mA (LOW) and max. 20mA (HIGH). Push EDIT button, then select the required measurement range.

- **Photodiode BIAS:** If the photodiode needs to be biased, enable the bias voltage by either clicking to the text or by pushing the

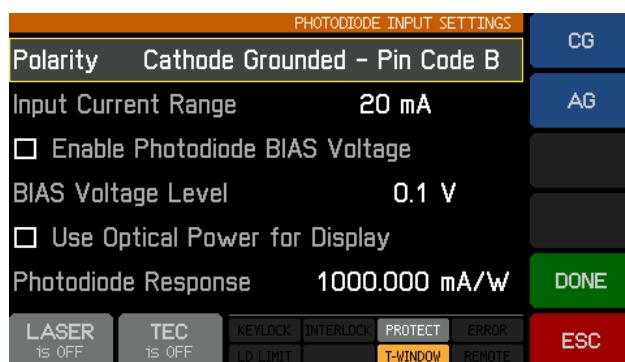
EDIT button (toggle function). The **BIAS Voltage Level** can be set between 0.1 and 6.0V - select the topic and push EDIT.

- Use Optical Power for Display:** Instead of the measured PD current, it can be converted into optical power of the laser diode. For this purpose, the **Photodiode Response** must be set properly. The responsivity of the photodiode can be calculated from the individual specifications (individual data sheet) of the laser diode - usually, the manufacturer states the photodiode current at nominal optical power. Please note the unit - mA/W - the photo current must be stated in mA, the optical power in W. An alternative way to determine the PD response is to measure the current and in the same time the optical power out of the laser, using an optical power meter. PD response can be set between 0.010 and 10000.000 mA/W.

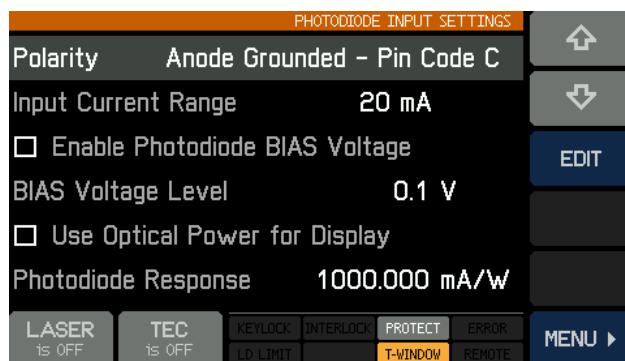
Example: The photo current is specified to 485 µA at 5.00 mW optical power. The response is calculated to

$$R = \frac{0.485\text{mA}}{0.005\text{W}} = 97\text{mA/W}$$

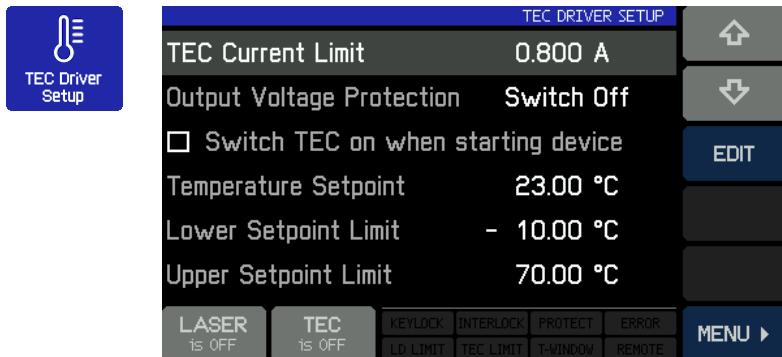
- Photo Diode Polarity (CLD1011LP only):** The CLD1011LP allows to change the photodiode polarity. Select the **Polarity** parameter using the arrows, then push EDIT button, or push the **Polarity** topic a second time:



- Select the desired polarity according to the [pin code](#)<sup>[14]</sup> of your laser using the **CG** or **AG** button. Press **DONE** to confirm change.



## 2.5.7 TEC Driver Setup



Use the arrow buttons to select a parameter, then push EDIT button, or push the selected topic a second time.

- **TEC Current Limit:** The TEC current limit must not exceed the specified max. rating of the laser diode. If the temperature set point is close to environmental temperature, a reduced TEC current limit may be helpful to decrease the temperature settling time (reduce number of overshoots during settling time). The max. TEC current limit of the CLD101x is 3.0 A.

- **Output Voltage Protection:** If the TEC current is interrupted (TEC open), the output voltage exceeds the TEC compliance voltage and the TEC output is switched off (default setting). The same may happen if a TEC with a high resistance is driven by a high current - in such cases the TEC output voltage protection can be switched off: Choose EDIT to select between "Switch off" and "None".
- **Switch TEC on when starting device:** By default, the TEC is switched off. If required, the TEC can be switched on at power up. Check the appropriate box if required.
- **Temperature Set Point:** Edit this value to set the target temperature to the desired value. In certain cases (e.g. DFB laser diodes) it is recommended to set this value to the reference temperature as stated in the individual test report of the laser.
- **Lower / Upper Set Point Limits:** To avoid unwanted operating temperatures of the laser, the set point interval can be limited. The absolute limits depend on the thermistor parameters and are given by the measurement limits of the CLD101x .

## 2.5.8 PID Control Loop



The temperature controller in the CLD101x is using a digital proportional-integral-derivative controller (PID controller) to correct the difference between a measured temperature and a desired temperature set point. The temperature can be adjusted accordingly by calculating and then outputting a corrective current.

The PID controller calculation (algorithm) involves three separate parameters; the Proportional, the Integral and Derivative values. The Proportional value determines the reaction to the current temperature error, the Integral value determines the reaction based on the sum of recent temperature errors, and the Derivative value determines the reaction based on the rate at which the temperature error has been changing. The weighted sum of these three terms is used to adjust the temperature via the current supply of a cooling/heating element (Thermo-Electric Cooler (TEC), aka Peltier Element).

By tuning the three constants in the PID controller algorithm, the control loop properties can be optimized in order to get a maximal stable temperature as close as possible to the target temperature and with a minimum settling time.

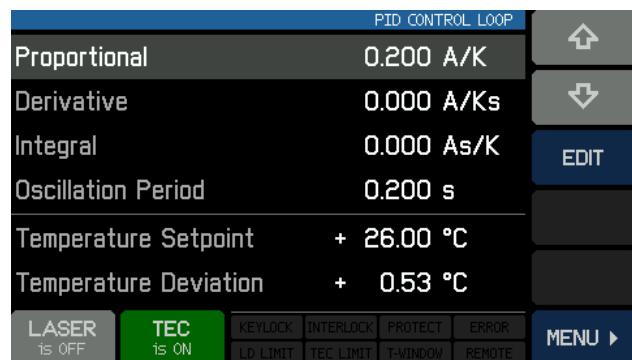
Every constant (P, I, D) can be set to zero to disable it. For example, by setting the Derivative value to zero, the PID controller will operate as PI controller. This may be useful in an noisy environment since derivative action is very sensitive to measurement noise.

On the other hand, the absence of an integral value may prevent the system from reaching its target temperature and is not recommended. A short PID Tutorial can be found in [appendix](#)<sup>[78]</sup>.

Use the arrow buttons to select a parameter, then push EDIT button, or push the selected topic a second time.

Below the PID optimizing procedure is described in detail.

1. Set the Temperature Set Point to the required temperature.
2. Set the P share to a very low value (e.g. 0.2) and the D and I shares to minimum (0) in the PID control loop settings menu. Set the Oscillation Period to Minimum (0.2 s).
3. Switch on the TEC output. Watch the course of the actual measured temperature.



### Note

If temperature oscillates continuously, or even builds up to increasing amplitude, switch the TEC output off immediately. Further decrease the Proportional parameter before switching the TEC output on again.

### Proportional (P) share:

Repeatedly increase and decrease the temperature set point for about (1...2)°C around the desired target temperature. Watch the settling behavior of the actual measured temperature.

Increase the P share gradually. By increasing P share, the settling time will decrease. Too high values will increase the amplitude and number of overshoots. This may lead to an unstable system (continuous oscillation or even increasing amplitude), which should be avoided. The P parameter is set optimally if the oscillation is notably damped - the actual temperature approaches the set point with each overshoot having about half the amplitude of the previous overshoot. Due to the disabled Integral constant, a temperature deviation may remain. Please evaluate the time span between the maximum temperature of the positive overshoot and the minimum temperature of the following negative overshoot (i.e., half a period); doubling this value will be approximately equal to the full period of a continuous, undamped oscillation.



## Oscillation period:

The oscillation period value corresponds to the resonance frequency of the temperature control setup. The value entered here impacts the control cycle period of the digital PID control, which is determined as one-hundredth of the oscillation period. Enter the time span which has been observed in the previous section during adjustment of the P parameter.

PID CONTROL LOOP	
Proportional	2.000 A/K
Derivative	0.000 A/Ks
Integral	0.000 As/K
Oscillation Period	0.500 s
Temperature Setpoint	+ 26.00 °C
Temperature Deviation	+ 0.04 °C
<b>DONE</b>	
LASER is OFF	TEC is ON
KEYLOCK LD LIMIT	INTERLOCK TEC LIMIT
PROTECT T-WINDOW	ERROR REMOTE
<b>ESC</b>	

## Derivative (D) share:

PID CONTROL LOOP	
Proportional	2.000 A/K
Derivative	0.100 A/Ks
Integral	0.000 As/K
Oscillation Period	0.500 s
Temperature Setpoint	+ 24.00 °C
Temperature Deviation	+ 0.06 °C
<b>DONE</b>	
LASER is OFF	TEC is ON
KEYLOCK LD LIMIT	INTERLOCK TEC LIMIT
PROTECT T-WINDOW	ERROR REMOTE
<b>ESC</b>	

a temperature deviation may remain.

Change temperature set points for 1...2°C repeatedly around your desired target temperature while observing the settling behavior of the actual temperature. Increase the D share gradually. By increasing D share, the amplitudes and number of overshoots at first decrease to a minimum, after that with increase of D share the overshoot effects increase. The D share is set to an optimum, if the actual temperature settles at a value close to the temperature set point after a minimum of overshoots. Due to the disabled Integral constant,

## Integral (I) share:

PID CONTROL LOOP	
Proportional	2.100 A/K
Derivative	0.100 A/Ks
Integral	0.700 As/K
Oscillation Period	0.200 s
Temperature Setpoint	+ 26.00 °C
Temperature Deviation	+ 0.00 °C
<b>DONE</b>	
LASER is ON	TEC is ON
KEYLOCK LD LIMIT	INTERLOCK TEC LIMIT
PROTECT T-WINDOW	ERROR REMOTE
<b>ESC</b>	

Change temperature set points for 1...2°C repeatedly around your desired target temperature while observing the settling behavior of the actual temperature. Increase the I share gradually. By increasing I share, the temperature settling will accelerate and the residual error decreases, too high I share increases the amplitude and number of overshoots or will even make the system unstable. The I parameter is set correctly when the actual temperature reaches the set temperature in a minimum time with a minimum of overshoots

and no residual error.

The following table summarizes the effects of increasing the P, D and I share:

Parameter	Rise Time	Overshoots	Settling Time	Residual Error
Increase P share	decrease	increase	small change	decrease
Increase D share	small decrease	decrease	decrease	none
Increase I share	decrease	increase	increase	eliminate

## PID Control Loop Default Settings

Depending on the CLD101x type, the following factory settings of the PID control loop are applied:

Parameter	CLD1015	CLD1010LP CLD1011LP
P share	1.0 A/K	8.0 A/K
D share	0.0 A/Ks	3.7 A/Ks
I share	0.1 As/K	3.2 As/K
Oscillation Period	1.0 sec	2.0 sec

### 2.5.9 Thermistor Calibration

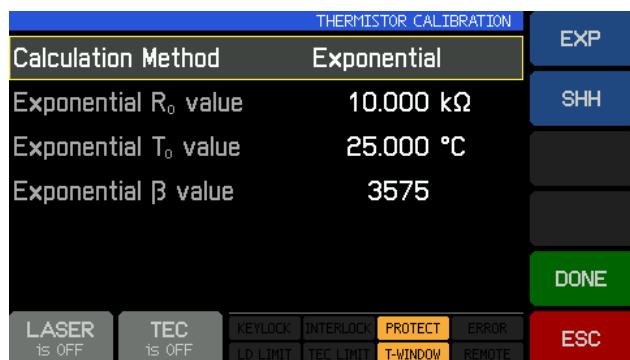


The CLD101x is designed to use the built-in into the laser diode thermistor for temperature sensing. Therefore, the resistance is measured and from this, the temperature can be calculated. There are two commonly used approximations - Steinhart-Hart and exponential method (see [appendix](#)<sup>[81]</sup>). Select the desired calculation method, and push EDIT (or directly click to the Calculation Method line.).

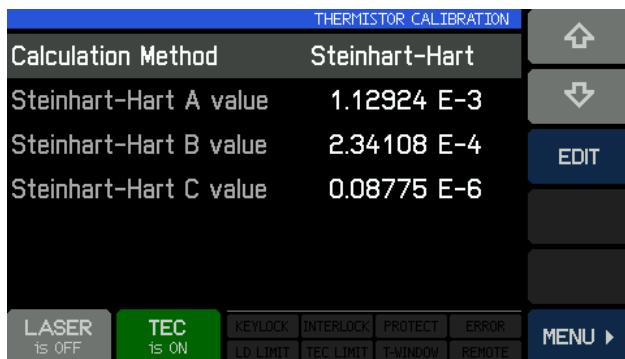
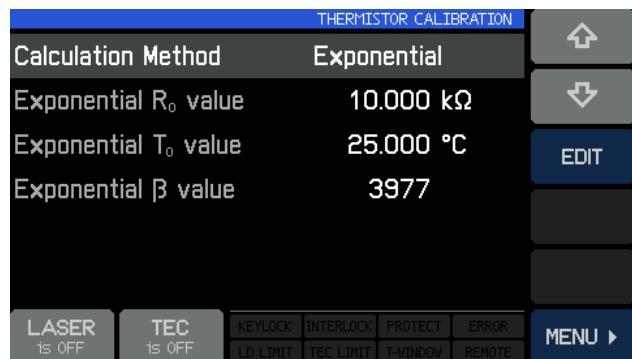
#### Note

Calculation Method and thermistor parameters can be changed only if the TEC controller is switched off!

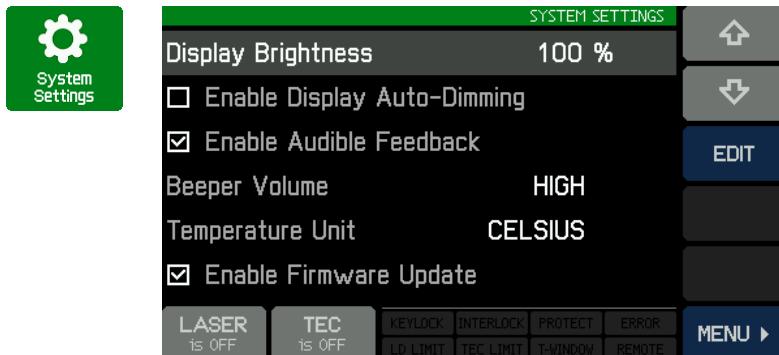
Select the desired calculation method, then push DONE. Further the thermistor constants can be changed - use the arrow buttons to select a parameter, then push EDIT button, or push the selected topic a second time.



For each approximation method, typical values are given by default. Change these parameters only, if reliable data for the given thermistor are available.



## 2.5.10 System Settings



Use the arrow buttons to select a parameter, then push EDIT button, or push the selected topic a second time.

- **Display Brightness** can be set between 20% and 100%
- **Auto Dimming**: When enabled, after 30 sec the display ceases and reactivates with a touch to the panel.
- **Audible feedback**: A click sound confirming touch panel operation.

- **Beep Volume**: Volume of the alert sound.
- **Temperature Unit**: The temperature can be displayed in °C, °F and K (Kelvin).
- **Enable Firmware Update**: If enabled, the CLD101x responds as a DFU device to an external control PC (see [Firmware Upgrade](#)<sup>60</sup>), else the CLD101x is recognized as a USB Test and Measurement Device.

## 2.5.11 Information



This screen gives information about the device.

There are buttons to start a touch panel calibration and to clear the [set point memories](#)<sup>20</sup>.

## 2.5.12 External Modulation

To generate in Constant Current Mode a time dependent laser diode injection current "ILD" or in Constant Power Mode a time dependent photodiode current "IPD", these current settings can be modulated via an independent ground-symmetric modulation input "[MOD IN](#)"<sup>71</sup>. Its input resistance is >10 kΩ.

The relation between the externally applied modulation voltage and the resulting laser (photodiode) current is described by the modulation coefficient **m**. The modulation coefficient is equal for all models:

Constant Current mode: **m** = 150 mA / V

Constant Power mode - photo current range 2 mA: **m** = 200 µA / V

Constant Power mode - photo current range 20 mA: **m** = 2 mA / V

"ILD" and "IPD" are calculated as:

$$\text{ILD} = \text{ILD SET} + \text{UMOD} * \text{m} \quad (\text{in constant current mode})$$

or       $\text{IPD} = \text{IPD SET} + \text{UMOD} * \text{m} \quad (\text{in constant power mode})$

with:

- $I_{LD\ MAX}$ : Maximum laser current (1.5 A for CLD1015; 1.0 A for CLD1010LP(CLD1011LP))  
 $I_{PD\ MAX}$ : Maximum photodiode current (2 mA / 20 mA depending on the selected [PD current range](#)<sup>[23]</sup>)  
 $I_{LD\ SET}$  or  $I_{PD\ SET}$ : Set values (see [Operating Instruction](#)<sup>[19]</sup>)  
 $U_{MOD}$ : voltage at input "MOD IN" (4)

Start operation in constant current or constant power mode and adjust the desired set value.

Connect the modulation source to the jack "MOD IN" (4). Avoid ground loops when connecting the function generator.

The laser diode current " $I_{LD}$ " can be monitored in the main panel.

If the injection current " $I_{LD}$ " reaches the current limit " $I_{LIM}$ " in operation, the status message **LD LIMIT** lights up and the laser current is limited to the value of the current limit " $I_{LIM}$ ". In this case, ripple and noise do no longer correspond to the specifications for normal operation. However the set maximum current " $I_{LIM}$ " cannot be exceeded.

### 3 Remote Operation

The CLD101x provides a USB 2.0 Full Speed link according to the USB 2.0 specification, the USBTMC specification and the USBTMC USB488 specification. It allows sending commands from a host computer to the instrument. The connection to the PC is accomplished by a USB cable with a 'A' type connector at the PC side and a 'Mini B' connector on the instrument side.

Thorlabs provides an VXIpnnp Instrument Driver and a NI VISA engine, the same as for Thorlabs 4000 Series. An individual remote control software (GUI) for the CLD101x is not available.

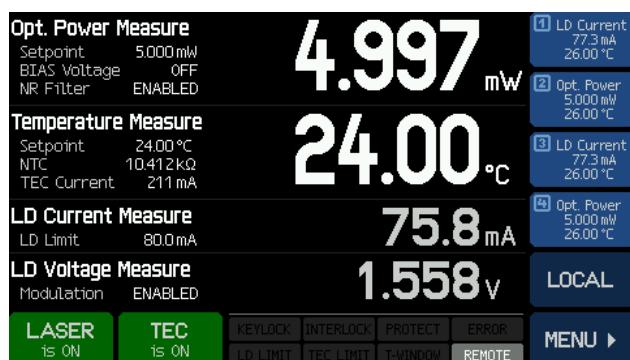
Prior to connect the CLD101x first time, make sure that the required software is [installed](#)<sup>[32]</sup>.

When connecting the instrument to the PC the first time, on Windows systems the "New Hardware Found" wizard will be displayed.

Third party data logging, data acquisition and data analysis software (e.g. MATLAB, NI LabVIEW Signal Express, Agilent VEE) can easily be connected via the instrument's USB interface.

For basic instrument communication the *Thorlabs Instrument Communicator*<sup>[35]</sup> Software can be used. It is included with the CD coming with the CLD101x . Please see also the [Write your Own Application](#)<sup>[40]</sup> section for a detailed description of the instrument's command set.

When receiving a command, the CLD101x will enter remote mode:



Remote Mode panel

Operated remotely, the touch panel control is disabled in order to avoid accidental entries and settings conflicts. This also includes the LASER and TEC on/off buttons.

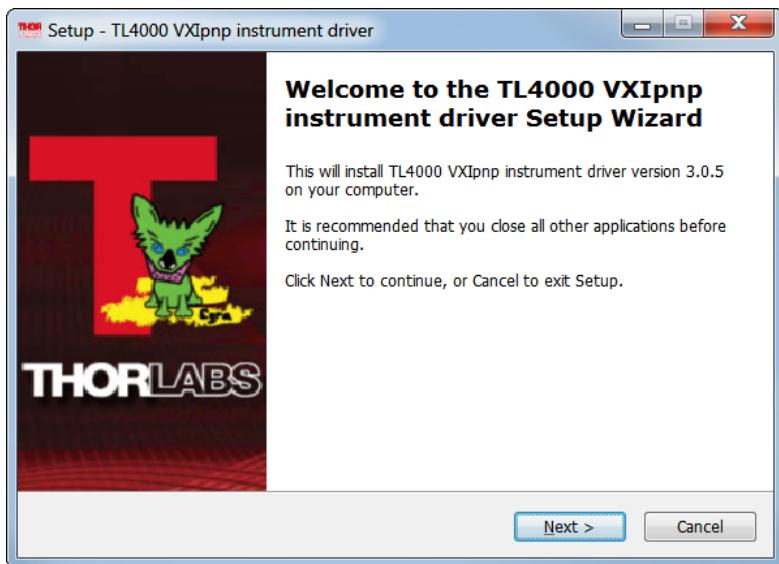
The LOCAL button returns the device to local operation mode.

### 3.1 Installing Driver Software

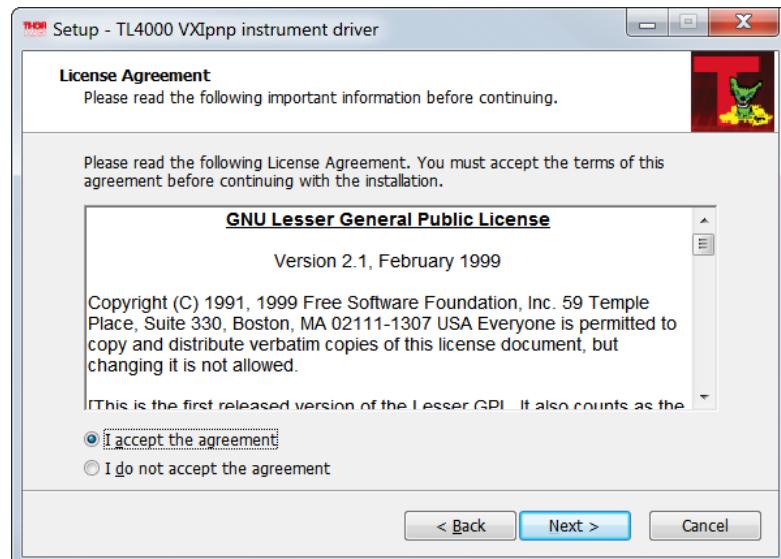
Insert the CD coming with the CLD101x .



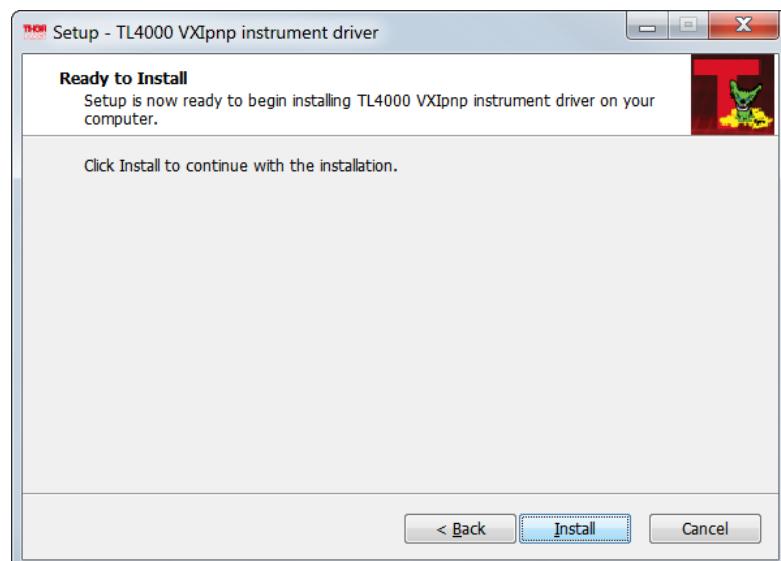
The Instrument Driver installer checks the computer for the installed Windows version and verifies, if a LabView installation is present. According to the results, the necessary components will be installed.



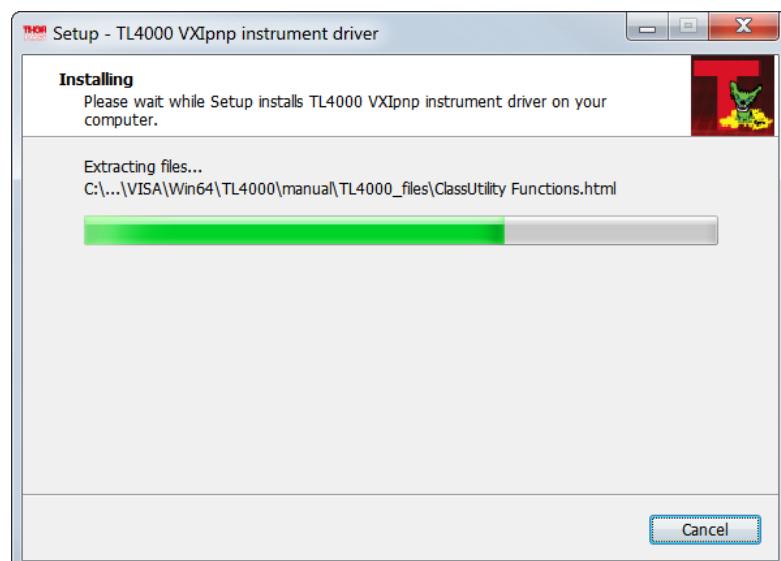
Click 'Next >>' to continue. The installer verifies if a NI-VISA engine is installed already. If not, it will install the included NI-VISA, otherwise only the required drivers will be installed.

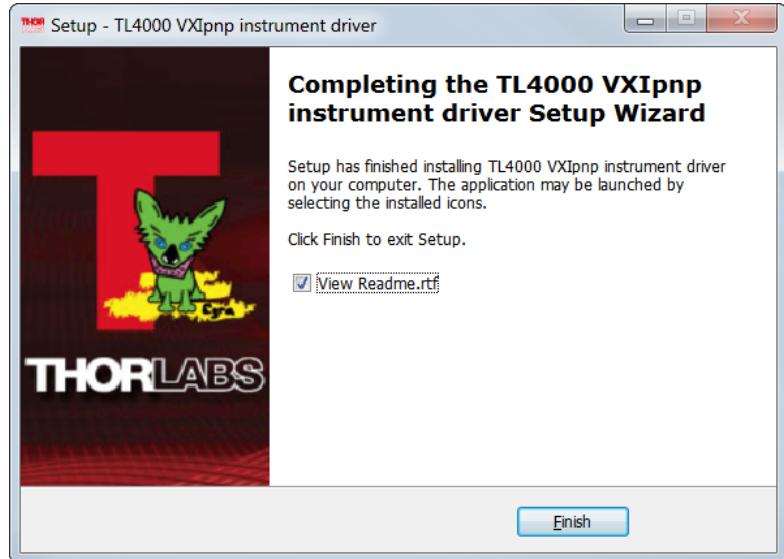


Select "I accept..." if you do so, then click 'Next >' to continue.



Click 'Install' to continue.





Click 'Finish' to continue. In case NI components were installed or updated, you may be requested to restart the computer.



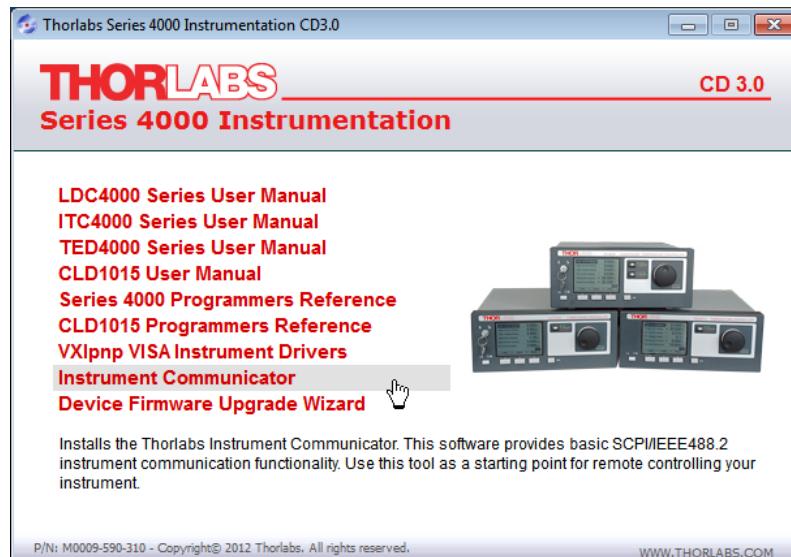
### Note

In this case, a proper operation is possible only after restart!

## 3.2 Instrument Communicator

The Thorlabs Instrument Communicator is a simple tool for basic communication (based on the common [IEEE488.2 commands](#)<sup>[47]</sup>) with the CLD101x . It is included with the delivered CD.

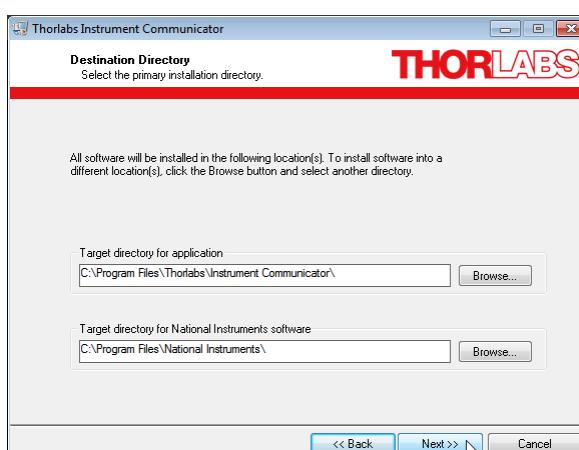
### Installing Instrument Communicator



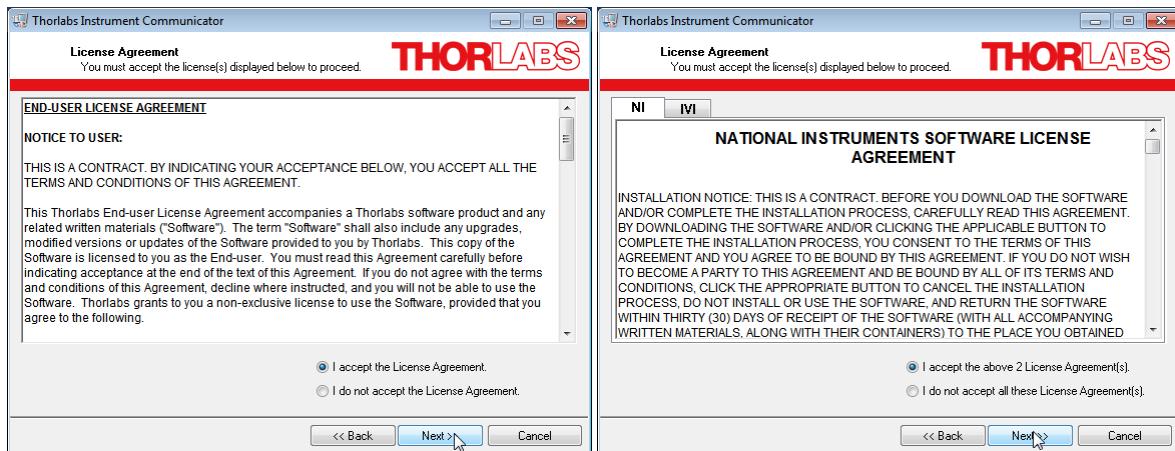
Insert the CD into the drive. Select "Instrument Communicator"



Click 'Next>>' to continue.



Click 'Next>>' to continue.



Select "I accept..." if you do so, then click 'Next>>' to continue.



Click 'Next>>' to continue. You may be prompted to restart your computer.

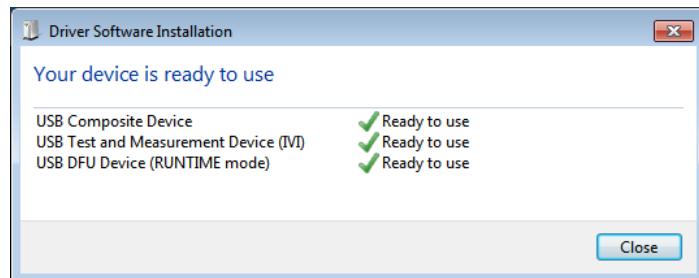


### Note

In this case, a proper operation is possible only after restart!

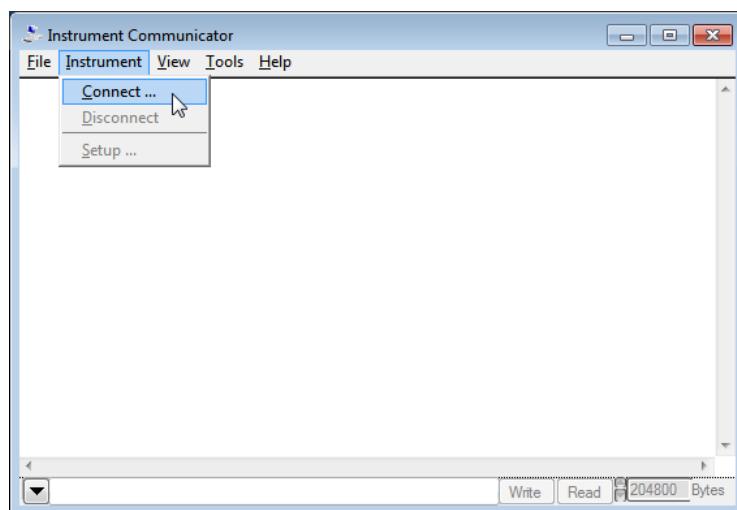
## Connecting the CLD101x

Switch on the CLD101x and connect it to a free USB port of the computer. The instrument is recognized by the operating system and the appropriate drive software is being installed:

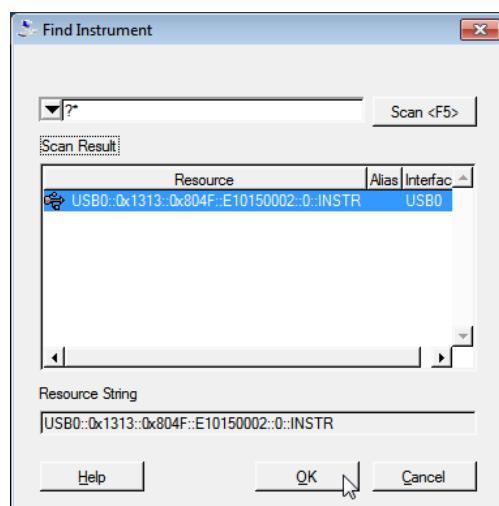


## Starting the Instrument Communicator

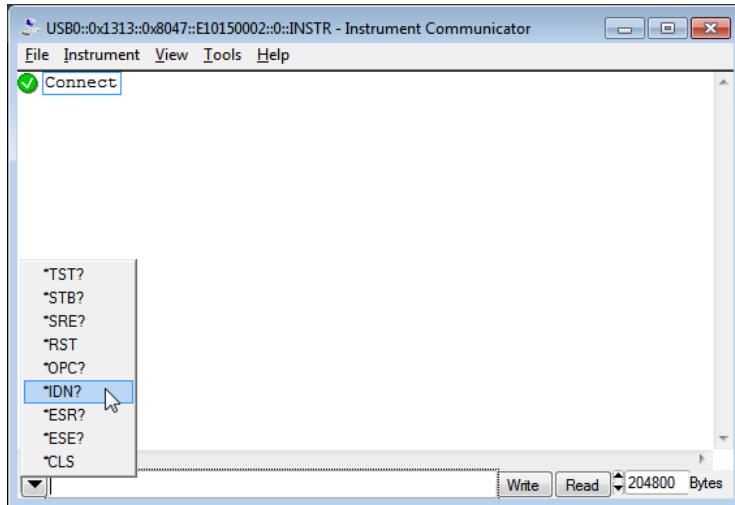
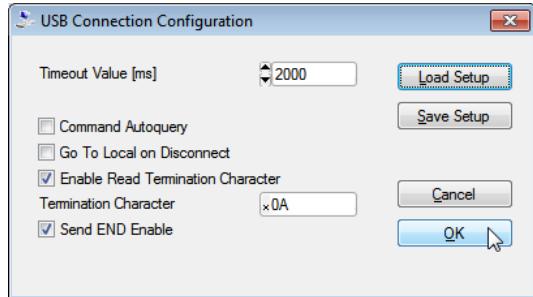
Select from Windows button 'All Programs' -> Thorlabs -> Instrument Communicator -> Instrument Communicator. The GUI opens.



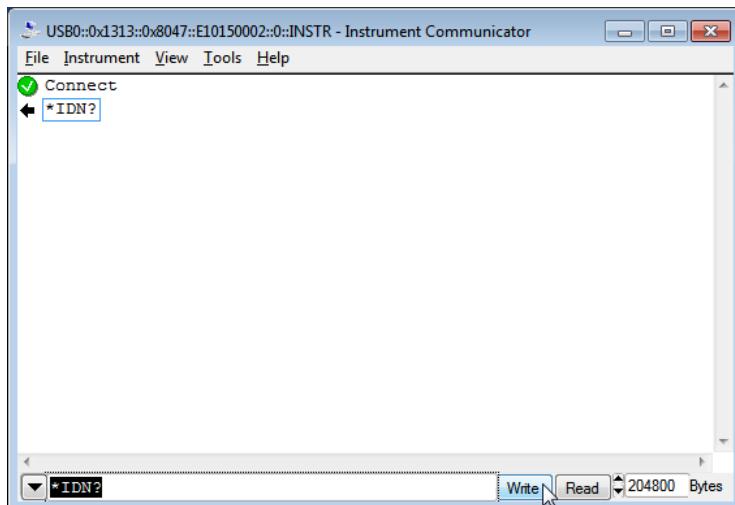
Select 'Connect...'



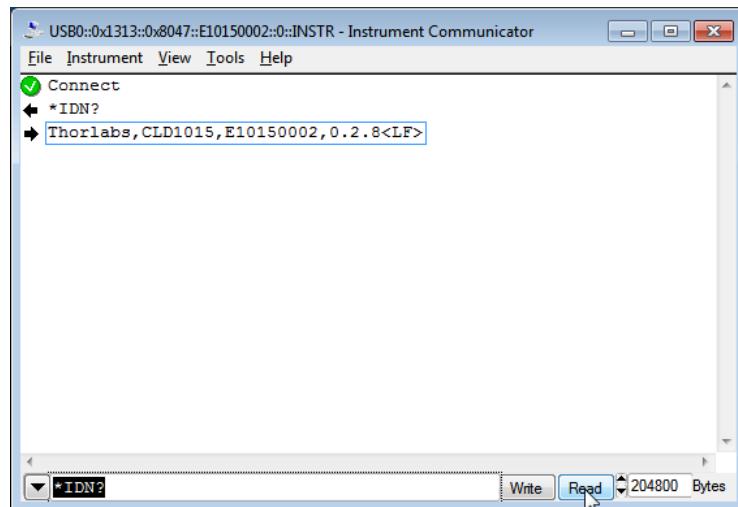
A list of available instruments appears. Select the CLD101x (can be recognized by serial number), then click 'OK'. The next screen allows to configure the USB connection and command line terminators. Click 'OK' to connect.



Enter a IEEE488.2 command (see [list of supported commands](#)<sup>47</sup>), alternatively a command can be selected from the drop down list. Click the 'Write' button.



The Instrument communicator lists the sent command in the log panel.



Click 'read' to see the response from the connected device. In above example, the \*IDN? command retrieves the identification information, which is being returned in the format "[manufacturer], [device name], [serial number], [firmware version]"

## 4 Write Your Own Application

In order to write your own application, you need a specific instrument driver and some tools for use in different programming environments. The driver and tools are being installed to your computer during software installation and cannot be found on the installation CD.

In this section the location of drivers and files, required for programming in different environments, are given for installation under Windows XP (32 bit), Windows VISTA (32 and 64 bit) and Windows 7 (32 and 64 bit) Windows 8 (32 and 64 bit), Windows 10 (32 and 64 bit). These drivers and samples are the same as used for Thorlabs 4000 Series.

In order to fully support 64 bit LabView version, the installation offers two installer versions:

- for Win XP - SP2+, Windows VISTA (32 bit) and Windows 7 (32 bit), Windows 8 (32 bit), Windows 10 (32 bit): Install "TL4000 VXlpnp Instrument Driver (32 bit)"
- for Windows VISTA (64 bit), Windows 7 (64 bit), Windows 8 (64 bit), and Windows 10 (64 bit): Install "TL4000 VXlpnp Instrument Driver (64 bit)"

In the table below you will find a summary of what files you need for particular programming environments.

Programming environment	Necessary files
<b>C, C++, CVI</b>	*.h (header file) *.lib (static library)
<b>C#</b>	.net wrapper dll
<b>Visual Studio</b>	*.h (header file) *.lib (static library) or .net wrapper dll
<b>LabView</b>	*.fp (function panel) and VXlpnp Instrument Driver Beside that, LabVIEW driver vi's are provided with the *.llb container file

### Note

All above environments require also the VXlpnp Instrument Driver dll !

In the next sections the locations of above files are described in detail.

## 4.1 32 bit Version

### Note

According to the VPP6 (Rev6.1) Standard the installation of the 32 bit VXIpnnp driver includes both the WINNT and GWINNT frameworks.

### VXIpnnp Instrument driver:

```
C:\Program Files\IVI Foundation\VISA\WinNT\Bin\TL4000_32.dll
```

### Note

This instrument driver is required for all development environments!

### Source file

```
C:\Program Files\IVI Foundation\VISA\WinNT\TL4000\TL4000.c
```

### Header file

```
C:\Program Files\IVI Foundation\VISA\WinNT\include\TL4000.h
```

### Static Library

```
C:\Program Files\IVI Foundation\VISA\WinNT\lib\msc\TL4000_32.lib
```

### Function Panel

```
C:\Program Files\IVI Foundation\VISA\WinNT\TL4000\TL4000.fp
```

### Online Help for VXIpnnp Instrument driver:

```
C:\Program Files\IVI Foundation\VISA\WinNT\TL4000\Manual
```

### NI LabVIEW driver

The LabVIEW Driver is a 32 bit driver and compatible with 32bit NI-LabVIEW versions 8.5 and higher only.

```
C:\Program Files\National Instruments\LabVIEW
xxxx\Instr.lib\TL4000...
...\TL4000.llb
```

(LabVIEW container file with driver vi's and an example. "LabVIEW xxxx" stands for actual LabVIEW installation folder.)

### .net wrapper dll

```
C:\Program Files\Microsoft.NET\Primary Interop Assemblies...
...\Thorlabs.TL4000.dll
C:\Program Files\IVI Foundation\VISA\VisaCom\...
...\Primary Interop Assemblies\Thorlabs.TL4000.dll
```

## Example for NI LabWindows/CVI (C)

### Project file (NI-LabWindows<sup>TM</sup>/CVI 2010):

```
C:\Program Files\IVI Foundation\VISA\WinNT\TL4000\Samples\CVI\...
...sample.prj
```

**Source file:**

```
C:\Program Files\IVI Foundation\VISA\WinNT\TL4000\Samples\CVI\...
...sample.c
```

**Executable sample demo:**

```
C:\Program Files\IVI Foundation\VISA\WinNT\TL4000\Samples\CVI\...
...sample.exe
```

**Example for MS Visual Studio (C++)**

**Solution file:**

```
C:\Program Files\IVI Foundation\visa\WinNT\TL4000\Samples\...
...MS_VCpp\Sample.sln
```

**Project file:**

```
C:\Program Files\IVI Foundation\visa\WinNT\TL4000\Samples\...
...MS_VCpp\Sample\Sample.vcproj
```

**Executable sample demo:**

```
C:\Program Files\IVI Foundation\visa\WinNT\TL4000\Samples\...
...MS_VCpp\Release\Sample.exe
```

**MS Visual Studio, .NET (C#)**

**Solution file:**

```
C:\Program Files\IVI Foundation\visa\WinNT\TL4000\Samples\...
...\\MS.NET_CS\Thorlabs.TL4000Test.sln
```

**Project file:**

```
C:\Program Files\IVI Foundation\visa\WinNT\TL4000\Samples\...
...\\MS.NET_CS\\TL4000Test\\Thorlabs.TL4000Test.csproj
```

**Executable sample demo:**

```
C:\Program Files\IVI Foundation\visa\WinNT\TL4000\Samples\...
...\\MS.NET_CS\\TL4000Test\\bin\\Release\\TL4000Test.exe
```

(Select the correct type and device mode, e.g., TMC or DFU, and enter serial number, then connect)

**Example for LabView**

```
C:\Program Files\\National Instruments\\LabVIEW
xxxx\\Instr.lib\\TL4000...
...\\TL4000.llb
```

(LabVIEW container file with driver vi's and an example. "LabVIEW xxxx" stands for actual LabVIEW installation folder.)

## 4.2 64 bit Version

### Note

According to the VPP6 (Rev6.1) Standard the installation of the 64 bit VXIpnP driver includes the WINNT, WIN64, GWINNT and GWIN64 frameworks. That means, that the 64 bit driver includes the 32 bit driver as well.

In case of a 64 bit operating system, 64bit drivers and applications are installed to

`"C:\Program Files"`

while the 32 bit files - to

`"C:\Program Files (x86)"`

Below are listed both installation locations, so far applicable.

### VXIpnP Instrument driver:

```
C:\Program Files (x86)\ivi foundation\visa\WinNT\Bin\TL4000_32.dll
C:\Program Files\IVI Foundation\VISA\Win64\Bin\TL4000_32.dll
C:\Program Files\IVI Foundation\VISA\Win64\Bin\TL4000_64.dll
```

### Note

This instrument driver is required for all development environments!

### Source file

```
C:\Program Files (x86)\ivi foundation\visa\WinNT\TL4000\TL4000.c
C:\Program Files\IVI Foundation\VISA\Win64\TL4000\TL4000.c
```

### Header file

```
C:\Program Files\IVI Foundation\VISA\Win64\TL4000\TL4000.h
C:\Program Files (x86)\ivi foundation\visa\WinNT\TL4000\TL4000.h
```

### Static Library

```
C:\Program Files (x86)\ivi
foundation\visa\WinNT\lib\msc\TL4000_32.lib
C:\Program Files\IVI
Foundation\VISA\Win64\lib\msc\TL4000_32.lib
C:\Program Files\IVI
Foundation\VISA\Win64\Lib_x64\msc\TL4000_64.lib
```

### Function Panel

```
C:\Program Files (x86)\ivi foundation\visa\WinNT\TL4000\TL4000.fp
C:\Program Files\IVI Foundation\VISA\Win64\TL4000\TL4000.fp
```

### Online Help for VXIpnP Instrument driver:

```
C:\Program Files\IVI Foundation\VISA\WinNT\TL4000\Manual
```

### NI LabVIEW driver

The LabVIEW Driver supports 32bit and 64bit NI-LabVIEW2009 and higher.

```
C:\Program Files\National Instruments\LabVIEW
xxxx\Instr.lib\TL4000...
...\TL4000.llb
```

(LabVIEW container file with driver vi's and an example. "LabVIEW xxxx" stands for actual LabVIEW installation folder.)

**.net wrapper dll**

```
C:\Program Files (x86)\Microsoft.NET\Primary Interop Assemblies...
...Thorlabs.TL4000.dll

C:\Program Files (x86)\ivi foundation\visa\VisaCom\...
...Primary Interop Assemblies\Thorlabs.TL4000.dll
```

**Example for NI LabWindows/CVI (C)**

**Project file (NI-LabWindows™/CVI 2010):**

```
C:\Program Files\IVI Foundation\VISA\Win64\TL4000\Samples\CVI\...
...sample.prj
```

**Source file:**

```
C:\Program Files\IVI Foundation\VISA\Win64\TL4000\Samples\CVI\...
...sample.c
```

**Executable sample demo:**

```
C:\Program Files\IVI Foundation\VISA\Win64\TL4000\Samples\CVI\...
...sample.exe
```

**Example for MS Visual Studio (C++)**

**Solution file:**

```
C:\Program Files\IVI Foundation\VISA\Win64\TL4000\Samples\...
...MS_VCpp\Sample.sln
```

**Project file:**

```
C:\Program Files\IVI Foundation\VISA\Win64\TL4000\Samples\...
...MS_VCpp\Sample\Sample.vcproj
```

**Executable sample demo:**

```
C:\Program Files\IVI Foundation\VISA\Win64\TL4000\Samples\...
...MS_VCpp\Release\Sample.exe
```

**MS Visual Studio, .NET (C#)**

**Solution file:**

```
C:\Program Files\IVI Foundation\VISA\Win64\TL4000\Samples...
...MS.NET_CS\Thorlabs.TL4000Test.sln
```

**Project file:**

```
C:\Program Files\IVI Foundation\VISA\Win64\TL4000\Samples...
...MS.NET_CS\TL4000Test\Thorlabs.TL4000Test.csproj
```

**Executable sample demo:**

C:\Program Files\IVI Foundation\VISA\Win64\TL4000\Samples...

...\\MS.NET\_CS\TL4000Test\bin\Release\TL4000Test.exe

(Select the correct type and device mode, e.g., TMC or DFU, and enter serial number, then connect)

**Example for LabView**

C:\Program Files\National Instruments\LabVIEW  
xxxx\Instr.lib\TL4000...

...\\TL4000.llb

(LabVIEW container file with driver vi's and an example. "LabVIEW xxxx" stands for actual LabVIEW installation folder.)

## 4.3 Command Reference

### 4.3.1 IEEE488.2 Common Commands

Common commands are device commands that are common to all devices according to the IEEE488.2 standard. These commands are designed and defined by this standard. Most of the commands are described in detail in this section. The following common commands associated with the status structure are covered in the “Status Structure” section: \*CLS, \*ESE, \*ESE?, \*ESR?, \*SRE,

#### Command summary

Mnemonic	Name	Description
*CLS	Clear status	Clears all event registers and Error Queue
*ESE <NRf>	Event enable command	Sets the Standard Event Enable Register
*ESE?	Event enable query	Returns the Standard Event Enable Register
*ESR?	Event status register query	Returns and clear the Standard Event Register
*IDN?	Identification query	Returns the unit's identification string
*OPC	Operation complete command	Sets the Operation Complete bit in the Standard Event Register
*OPC?	Operation complete query	Places a “1” into the output queue when all device operations have been completed
*RST	Reset command	Returns the unit to the *RST default condition
*SRE <NRf>	Service request enable command	Sets the Service Request Enable Register
*SRE?	Service request enable query	Returns the Service Request Enable Register
*STB?	Status byte query	Returns the Status Byte Register
*TST?	Self-test query	Performs the unit's self-test and returns the result.
*WAI	Wait-to-continue command	Waits until all previous commands are executed

#### Command reference

##### 1. \*IDN? – identification query - read identification code

The identification code includes the manufacturer, model code, serial number, and firmware revision levels and is sent in the following format: Thorlabs, MMM, SSS, X.X.X, where

- MMM            is the model code
- SSS            is the serial number
- X.X.X        is the instrument firmware revision level

##### 2. \*OPC – operation complete - set OPC bit

##### 3. \*OPC? – operation complete query – places a “1” in output queue

When \*OPC is sent, the OPC bit in the Standard Event Register will set after all pending command operations are complete. When \*OPC? is sent, an ASCII “1” is placed in the Output Queue after all pending command operations are complete.

Typically, either one of these commands is sent after the INITiate command. The INITiate command is used to take the instrument out of idle in order to perform measurements. While operating within the trigger model layers, many sent commands will not execute. After all programmed operations are completed, the instrument returns to the idle state at which time all pending commands (including \*OPC and/or \*OPC?) are executed. After the last pending command is executed, the OPC bit and/or an ASCII “1” is placed in the Output Queue.

##### 4. \*RST – reset – return instrument to defaults

When the \*RST command is sent, the instrument performs the following operations:

- Returns the instrument to default conditions
- Cancels all pending commands.
- Cancels response to any previously received \*OPC and \*OPC? commands.

## 5. \*TST? – self-test query – run self test and read result

Use this query command to perform the instrument self-test routine. The command places the coded result in the Output Queue. A returned value of zero (0) indicates that the test passed, other values indicate that the test failed.

## 6. \*WAI – wait-to-continue – wait until previous commands are completed

The \*WAI command is a no operation command for the instrument and thus, does not need to be used. It is there for conformance to IEEE488.2.

### 4.3.2 SCPI Command Reference

#### SYSTem subsystem commands

Command	Description	SCPI
<b>SYSTem</b>	Path to SYSTem subsystem.	✓
:BEEPer		✓
[ :IMMEDIATE ]	Issues an audible signal	✓
:STATE {ON 1 OFF 0}	Activates/deactivates the beeper	✓
:STATE?	Returns the state of the beeper	✓
:VOLUME <value>	Sets the beeper volume	✓
:VOLUME?	Returns the beeper volume	✓
:ERRor		✓
[ :NEXT]?	Returns the latest error code and message	✓
:MOUNT		
[ :TYPE]?	Returns the mount type (<NR1>,description)	
:VERSION?	Returns level of SCPI standard (1999.0)	✓

#### DISPlay subsystem commands

Command	Description	SCPI
<b>DISPlay</b>	Path to DISPlay subsystem.	✓
:BRIGHTness <value>	Sets the display brightness	✓
:BRIGHTness?	Returns the display brightness value	✓
:CALibration[:TOUCH] [:INITiate]	Initiates Touchscreen calibration	
:FADEout		
[ :STATE] {ON 1 OFF 0}	Activates/deactivates automatic dimming	
[ :STATE]?	Returns the state of automatic dimming	

## STATus subsystem commands

Command	Description	SCPI
<b>STATus</b>		<input checked="" type="checkbox"/>
:MEASurement	Path to control measurement event registers	<input checked="" type="checkbox"/>
[:EVENT]?	Returns the event register	<input checked="" type="checkbox"/>
:CONDITION?	Returns the condition register	<input checked="" type="checkbox"/>
:PTRansition <value>	Sets the positive transition filter	<input checked="" type="checkbox"/>
:PTRansition?	Returns the positive transition filter	<input checked="" type="checkbox"/>
:NTRansition <value>	Sets the negative transition filter	<input checked="" type="checkbox"/>
:NTRansition?	Returns the negative transition filter	<input checked="" type="checkbox"/>
:ENABLE <value>	Sets the enable register	<input checked="" type="checkbox"/>
:ENABLE?	Returns the enable register	<input checked="" type="checkbox"/>
:OPERation	Path to control operation event registers	<input checked="" type="checkbox"/>
[:EVENT]?	Returns the event register	<input checked="" type="checkbox"/>
:CONDITION?	Returns the condition register	<input checked="" type="checkbox"/>
:PTRansition <value>	Sets the positive transition filter	<input checked="" type="checkbox"/>
:PTRansition?	Returns the positive transition filter	<input checked="" type="checkbox"/>
:NTRansition <value>	Sets the negative transition filter	<input checked="" type="checkbox"/>
:NTRansition?	Returns the negative transition filter	<input checked="" type="checkbox"/>
:ENABLE <value>	Sets the enable register	<input checked="" type="checkbox"/>
:ENABLE?	Returns the enable register	<input checked="" type="checkbox"/>
:QUESTIONable	Path to control questionable event registers	<input checked="" type="checkbox"/>
[:EVENT]?	Returns the event register	<input checked="" type="checkbox"/>
:CONDITION?	Returns the condition register	<input checked="" type="checkbox"/>
:PTRansition <value>	Sets the positive transition filter	<input checked="" type="checkbox"/>
:PTRansition?	Returns the positive transition filter	<input checked="" type="checkbox"/>
:NTRansition <value>	Sets the negative transition filter	<input checked="" type="checkbox"/>
:NTRansition?	Returns the negative transition filter	<input checked="" type="checkbox"/>
:ENABLE <value>	Sets the enable register	<input checked="" type="checkbox"/>
:ENABLE?	Returns the enable register	<input checked="" type="checkbox"/>
:AUXiliary	Path to control auxiliary event registers	<input checked="" type="checkbox"/>
[:EVENT]?	Returns the event register	<input checked="" type="checkbox"/>
:CONDITION?	Returns the condition register	<input checked="" type="checkbox"/>
:PTRansition <value>	Sets the positive transition filter	<input checked="" type="checkbox"/>
:PTRansition?	Returns the positive transition filter	<input checked="" type="checkbox"/>
:NTRansition <value>	Sets the negative transition filter	<input checked="" type="checkbox"/>
:NTRansition?	Returns the negative transition filter	<input checked="" type="checkbox"/>
:ENABLE <value>	Sets the enable register	<input checked="" type="checkbox"/>
:ENABLE?	Returns the enable register	<input checked="" type="checkbox"/>
:PRESet	Return status registers to default states.	<input checked="" type="checkbox"/>

## LD output subsystem commands

Command	Description	SCPI
<b>OUTPut[1]</b>	<b>Path to LD output</b>	<input checked="" type="checkbox"/>
[:STATE] {ON 1 OFF 0}	Enables (ON) or disables (OFF) LD output	<input checked="" type="checkbox"/>
[:STATE]?	Returns output state	<input checked="" type="checkbox"/>
:PON		
[:STATE] {ON 1 OFF 0}	Sets the power-on LD output state	<input checked="" type="checkbox"/>
[:STATE]?	Returns power-on LD output state setting	<input checked="" type="checkbox"/>
:CONDITION?	Returns the output condition (query only, 1 0)	
<b>:FILTer[:LPASS]</b>	<b>Path to LD output protection</b>	<input checked="" type="checkbox"/>
[:STATE] {ON 1 OFF 0}	Enables/disables LD output low pass filter	<input checked="" type="checkbox"/>
[:STATE]?	Returns output filter state	<input checked="" type="checkbox"/>
<b>:PROTection</b>	<b>Path to LD output protection</b>	<input checked="" type="checkbox"/>
:INTLock[:TRIPPed]?	Returns interlock circuit protection tripped	
:KEYLOCK[:TRIPPed]?	Returns key lock protection tripped	
:OTEMperature[:TRIPPed]?	Returns over temperature protection tripped	
:CONNECTION[:TRIPPed]?	Returns connection failure protection tripped	
<b>:TEMPerature</b>		
:MODE {OFF PROTection ENABLE}	Sets temperature protection mode	
:MODE?	Returns temperature protection mode	
{:TRIPPed}?	Returns protection tripped	
<b>:POLarity?</b>	Returns the LD polarity (AG(CG) (FW>1.8)	

## PD input subsystem commands

Command	Description	SCPI
<b>INPut[1]</b>	<b>Path to photodiode input</b>	<input checked="" type="checkbox"/>
:POLarity {AG CG}	Sets PD polarity (FW>1.8, CLD1011LP only)	
:POLarity?	Returns the PD polarity (AG/CG) (FW>1.8)	
<b>:BIAS</b>	<b>Path to PD BIAsing</b>	<input checked="" type="checkbox"/>
[:STATE] {ON 1 OFF 0}	Enables (ON) or disables (OFF) BIAS	<input checked="" type="checkbox"/>
[:STATE]?	Returns BIAS state	<input checked="" type="checkbox"/>
<b>:VOLTage</b>	<b>Path to PD BIAs voltage</b>	<input checked="" type="checkbox"/>
[:DC] {MIN MAX DEF <volts>}	Sets BIAS voltage value	<input checked="" type="checkbox"/>
[:DC]? [{MIN MAX DEF}]	Returns BIAS voltage value	<input checked="" type="checkbox"/>

## PD current sensing subsystem commands

Command	Description	SCPI
<b>SENSe[1]</b>	<b>Path to photodiode current sensing</b>	<input checked="" type="checkbox"/>
[:CURREnt] [:DC]		<input checked="" type="checkbox"/>
:RANGE[:UPPer] {MIN MAX <amps>}	Sets the photodiode range	<input checked="" type="checkbox"/>
:RANGE[:UPPer]? [{MIN MAX}]	Returns the photodiode range	<input checked="" type="checkbox"/>
:CORRECTION:POWER		
[:PDIode] [:RESPonse]	Sets the photodiode response value	
{MIN MAX DEF <amps>}		
[:PDIode] [:RESPonse]?	Returns the photodiode response value	
[{MIN MAX DEF}]		
[:DATA]? [{MIN MAX}]	Returns the measured PD current	
:POWER[:DC]		
[:DATA]? [{MIN MAX}]	Returns the measured opt. LD power	

## LD current sensing subsystem commands

Command	Description	SCPI
<b>SENSe3</b> [:CURREnt] [:DC] [:DATA]? [{MIN MAX}]	Path to laser diode current sensing Returns the measured LD current	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>

## LD voltage sensing subsystem commands

Command	Description	SCPI
<b>SENSe4</b> [:VOLTage] [:DC] [:DATA]? [{MIN MAX}]	Path to laser diode voltage sensing Returns the measured LD voltage	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>

## LD source subsystem commands

Command	Description	SCPI
<b>SOURCE[1]</b>		<input checked="" type="checkbox"/>
:FUNCTION		<input checked="" type="checkbox"/>
[:MODE] {CURREnt POWer}	Sets LD driver source function	<input checked="" type="checkbox"/>
[:MODE]?	Returns LD driver source function	<input checked="" type="checkbox"/>
:CURREnt		<input checked="" type="checkbox"/>
:LIMIT		<input checked="" type="checkbox"/>
[:AMPLitude] {MIN MAX}<amps>	Sets limit current value	<input checked="" type="checkbox"/>
[:AMPLitude]?	Returns limit current value	<input checked="" type="checkbox"/>
:TRIPped?	Returns limit detection tripped	<input checked="" type="checkbox"/>
[:LEVEL] [:IMMEDIATE]		<input checked="" type="checkbox"/>
[:AMPLitude] {MIN MAX}<amps>	Sets LD current setpoint value	<input checked="" type="checkbox"/>
[:AMPLitude]?	Returns LD current setpoint value	<input checked="" type="checkbox"/>
:POWER		<input checked="" type="checkbox"/>
[:LEVEL]		<input checked="" type="checkbox"/>
[:IMMEDIATE]		<input checked="" type="checkbox"/>
[:AMPLitude] {MIN MAX}<watts>	Sets LD power setpoint value	<input checked="" type="checkbox"/>
[:AMPLitude]?	Returns power setpoint value	<input checked="" type="checkbox"/>
:DIODe[:CURREnt] [:IMMEDIATE]	Sets LD power via photodiode current	<input checked="" type="checkbox"/>
[:AMPLitude] {MIN MAX}<amps>	Sets photodiode current setpoint	<input checked="" type="checkbox"/>
[:AMPLitude]?	Returns the photodiode current setpoint	<input checked="" type="checkbox"/>
:AM		<input checked="" type="checkbox"/>
[:STATE] {ON 1 OFF 0}	Enables (ON), disables (OFF) modulation	<input checked="" type="checkbox"/>
[:STATE]?	Returns modulation state	<input checked="" type="checkbox"/>

## TEC output subsystem commands

Command	Description	SCPI
<b>OUTPut2</b>	<b>Path to TEC output</b>	<input checked="" type="checkbox"/>
[:STATE] {ON 1 OFF 0}	Enable (ON) or disable (OFF) TEC output	<input checked="" type="checkbox"/>
[:STATE]?	Returns output state	<input checked="" type="checkbox"/>
:PON		<input checked="" type="checkbox"/>
[:STATE] {ON 1 OFF 0}	Sets the power-on TEC output state	<input checked="" type="checkbox"/>
[:STATE]?	Returns power-on TEC output state setting	<input checked="" type="checkbox"/>
:PROTection	<b>Path to TEC output protection</b>	<input checked="" type="checkbox"/>
:TRANSDucer[:TRIPPed]?	Returns temperature transducer failure tripped	<input checked="" type="checkbox"/>
:OTEMperature[:TRIPPed]?	Returns over temperature protection tripped	<input checked="" type="checkbox"/>
:CONNection[:TRIPPed]?	Returns connection failure protection tripped	<input checked="" type="checkbox"/>
:COMPliance	(for firmware level 1.1.2 and higher)	

Command	Description	SCPI
:MODE {OFF PROtection}	Sets the 'compliance voltage protection' mode	
:MODE?	Returns the 'compliance voltage protection' mode	
{:TRIPPed}?	Returns 'compliance voltage protection' tripped	

## TEC driver source subsystem commands

Command	Description	SCPI
SOURce2		
:FUNCTION		
[:MODE] {TEMPerature CURRent}	Sets TEC driver source function	
[:MODE]?	Returns TEC driver source function	
:CURRent		
:LIMIT		
[:AMPLitude] {MIN MAX <amps>}	Sets limit current value	
[:AMPLitude]?	Returns limit current value	
[:LEVEL] [:IMMEDIATE]		
[:AMPLitude] {MIN MAX <amps>}	Sets current setpoint value	
[:AMPLitude]?	Returns current setpoint value	
:DATA? [{MIN MAX}]	Returns the TEC current value	
[:TEMPerature]		
[:SPOINT] {MIN MAX DEF <temp>}	Sets temperature setpoint	
[:SPOINT]?	Returns temperature setpoint	
:LIMIT		
[:UPPer] {MIN MAX <temp>}	Sets settable temperature high limit	
[:UPPer]?	Returns settable temperature high limit	
:LOWER {MIN MAX <temp>}	Sets settable temperature low limit	
:LOWER?	Returns settable temperature low limit	
:LCONSTants		
[:GAIN] {MIN MAX DEF <value>}	Sets PID loop P value	
[:GAIN]?	Returns PID loop P value	
:INTEGRAL {MIN MAX DEF <value>}	Sets PID loop I value	
:INTEGRAL?	Returns PID loop I value	
:DERIVATIVE {MIN MAX DEF <value>}	Sets PID loop D value	
:DERIVATIVE?	Returns PID loop D value	
:PERIOD {MIN MAX DEF <sec>}	Sets thermal load oscillation period	
:PERIOD?	Returns thermal load oscillation period	

**Note** In local operation mode (front panel operation) it is not possible to operate the TEC-Source (SOURce2) in current mode. When switching from remote mode to local operation mode the source function automatically switches to temperature mode.

## Temperature sensing subsystem commands

Command	Description	SCPI
SENSe2 [:TEMPerature] :DATA? [{MIN MAX}] [:THERmistor] :METHOD {EXPonential SHH} :METHod? [:SHH] :A [{MIN MAX DEF <value>}] :A? [{MIN MAX DEF}] :B [{MIN MAX DEF <value>}] :B? [{MIN MAX DEF}] :C [{MIN MAX DEF <value>}] :C? [{MIN MAX DEF}] :EXPonential :R0 [{MIN MAX DEF <ohms>}] :R0? [{MIN MAX DEF}] :T0 [{MIN MAX DEF <temp>}] :T0? [{MIN MAX DEF}] :BETA [{MIN MAX DEF <value>}] :BETA? [{MIN MAX DEF}] :PROTection :DELy {MIN MAX DEF <sec>} :DELy? [{MIN MAX DEF}] :WINDOW[:AMPLitude] [{MIN MAX DEF <temp>}] :WINDOW[:AMPLitude]? [{MIN MAX DEF}] [:TRIPPed]? :RESistance [:DATA]? [{MIN MAX}]	Returns the temperature value Sets thermistor calculation method Returns thermistor calculation method Sets Steinhart-Hart parameter A Returns Steinhart-Hart parameter A Sets Steinhart-Hart parameter B Returns Steinhart-Hart parameter B Sets Steinhart-Hart parameter C Returns Steinhart-Hart parameter C Sets exponential parameter $R_0$ Returns exponential parameter $R_0$ Sets exponential parameter $T_0$ Returns exponential parameter $T_0$ Sets exponential parameter beta Returns exponential parameter beta Sets protection delay Returns protection delay Sets temperature window amplitude Returns temperature window amplitude Returns protection tripped Returns the resistance value	<input checked="" type="checkbox"/>

## UNIT subsystem commands

Command	Description	SCPI
UNIT :TEMPerature {C CEL CELSius F FAR FAHReinheit K KELVin} :TEMPerature?	Sets the temperature unit Returns the temperature unit	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>

## CALibration subsystem commands

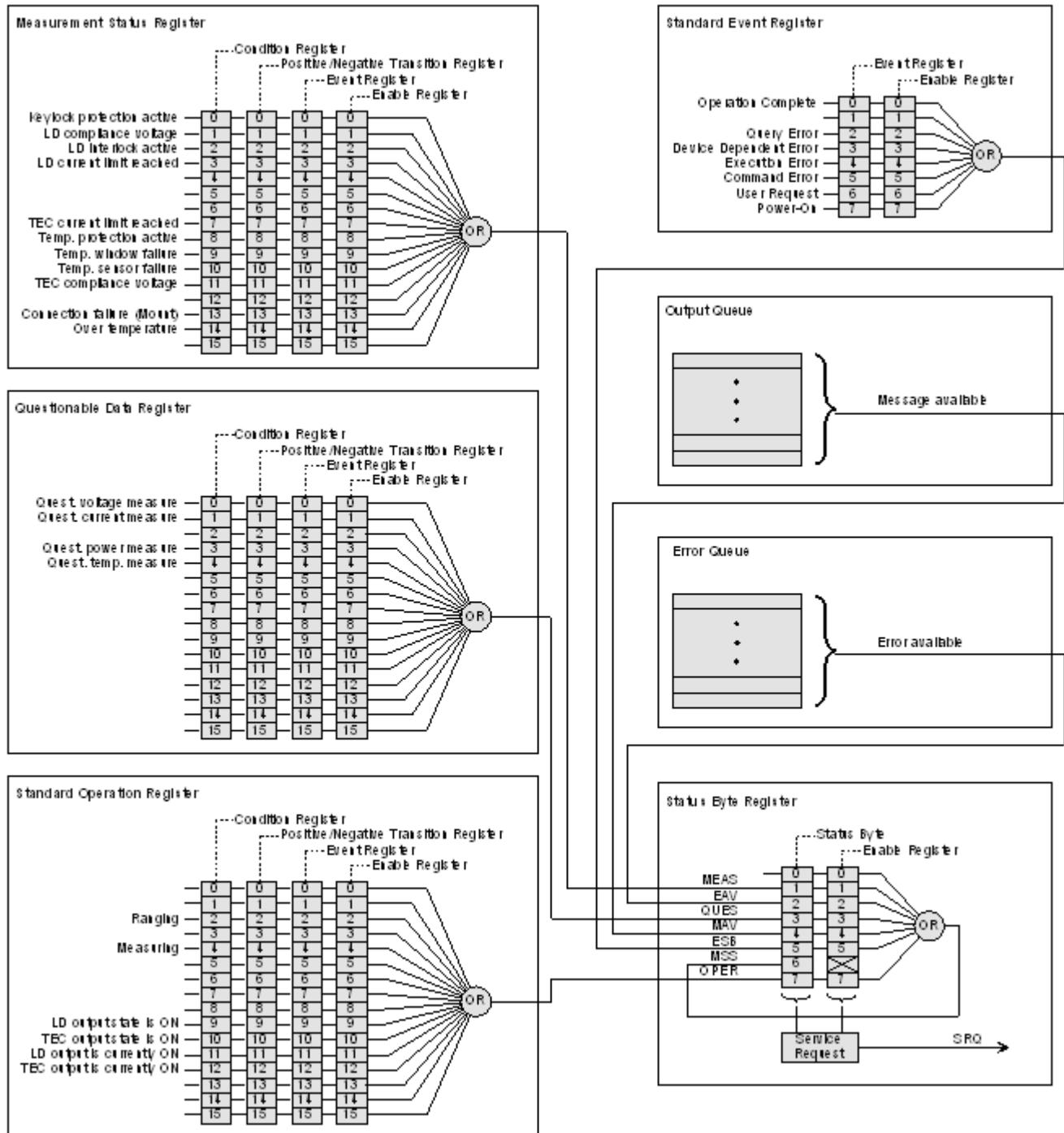
Command	Description	SCPI
CALibration :STRing?	Returns the calibration string	<input checked="" type="checkbox"/>

## Measurement commands

Command	Description	SCPI
<b>ABORT</b>	Aborts current measurement	<input checked="" type="checkbox"/>
<b>CONFigure[:SCALar]</b>		<input checked="" type="checkbox"/>
<b>:CURRent[1][:DC]</b>	Configures instrument LD current measurement	<input checked="" type="checkbox"/>
<b>:VOLTage[1][:DC]</b>	Configures instrument LD voltage measurement	<input checked="" type="checkbox"/>
<b>:CURRent2[:DC]</b>	Configures instrument PD current measurement	<input checked="" type="checkbox"/>
<b>:POWER[1]</b>	Configure for opt. power measurement via PD current	
<b>:TEMPerature</b>	Configures instrument for temperature measurement	<input checked="" type="checkbox"/>
<b>:RESistance</b>	Configures instrument for NTC resistance measurement	<input checked="" type="checkbox"/>
<b>CONFigure?</b>	Query configuration	<input checked="" type="checkbox"/>
<b>INITiate[:IMMEDIATE]</b>	Starts measurement	<input checked="" type="checkbox"/>
<b>FETCh?</b>	Returns last measurement data	<input checked="" type="checkbox"/>
<b>FETCh</b>		<input checked="" type="checkbox"/>
<b>:CURRent[1][:DC]?</b>	Return last LD current measurement	
<b>:VOLTage[1][:DC]?</b>	Return last LD voltage measurement	
<b>:CURRent2[:DC]?</b>	Return last PD current measurement	
<b>:POWER[1]?</b>	Return last opt. power measurement via PD current	
<b>:TEMPerature?</b>	Return last temperature measurement	
<b>:RESistance?</b>	Return last NTC resistance measurement	
<b>READ?</b>	Starts new measurement (as configured) and read data	<input checked="" type="checkbox"/>
<b>MEASure[:SCALar]</b>		<input checked="" type="checkbox"/>
<b>:CURRent[1][:DC]?</b>	Perform LD current measurement	<input checked="" type="checkbox"/>
<b>:VOLTage[1][:DC]?</b>	Perform LD voltage measurement	<input checked="" type="checkbox"/>
<b>:CURRent2[:DC]?</b>	Perform PD current measurement	<input checked="" type="checkbox"/>
<b>:POWER[1]?</b>	Perform opt. power measurement via PD current	
<b>:TEMPerature?</b>	Perform temperature measurement	<input checked="" type="checkbox"/>
<b>:RESistance?</b>	Perform NTC resistance measurement	<input checked="" type="checkbox"/>

### 4.3.3 Status Reporting

The figure below gives an overview of the device's status reporting structure. See also section [STATus subsystem commands](#)<sup>49</sup> for a detailed description of the related commands and their syntax.



## Status Byte Register

The Status Byte Register gives a summary of all underlying status structures. See also IEEE488.2-1992-§11.2.

Bit #	Mnemonic	Description
7	<b>OPER</b>	Standard Operation Status Structure Summary Bit
6	<b>RQS/MSS</b>	Request Service / Master Summary Status
5	<b>ESB</b>	Standard Event Status Bit
4	<b>MAV</b>	Message Available. There is response data available for readout
3	<b>QUES</b>	Questionable Status Structure Summary Bit
2	<b>EAV</b>	Error Available. There is at least one error in the error queue.
1	<b>MEAS</b>	Measurement Status Structure Summary Bit
0		reserved, read as 0

## Standard Event Status Structure

The Standard Event Status Structure is described in IEEE488.2-1992-§11.5.

## Standard Operation Register

The Standard Operation Status Structure is described in SCPI1999.0-Vol1-§9.3. In addition bit 8..12 are used as output state/on indicators.

Bit #	Mnemonic	Description
15..13		See SCPI1999.0-Vol1-§9.3
12	<b>TECON</b>	TEC output is currently ON
11	<b>LDON</b>	LD output is currently ON
10	<b>TECST</b>	TEC output state is ON
9	<b>LDST</b>	LD output state is ON
8		reserved, read as 0
7..0		See SCPI1999.0-Vol1-§9.3

## Questionable Data Register

The Questionable Data Status Structure is described in SCPI1999.0 Vol1 §9.4.

## Measurement Status Register

The Measurement Status Register Status Byte Register reports device operation and measurement states.

Bit #	Description
15	reserved, read as 0
14	Over temperature (Instrument is too hot)

Bit #	Description
13	Socket connection failure (Socket missing or unknown socket detected)
12	reserved, read as 0
11	TEC output compliance voltage reached
10	Temperature sensor failure.
9	Temperature window failure.
8	Temperature protection is active.
7	TEC current limit reached
6	reserved, read as 0
5	reserved, read as 0
4	reserved, read as 0
3	LD current limit reached
2	LD interlock is active
1	LD output compliance voltage reached
0	Keylock protection is active

#### 4.3.4 Error Reporting

The device stores errors in a queue containing up to 10 entries. The error queue may be read out by the `SYSTem:ERRor [:NEXT] ?` command. The following table lists all error numbers and the according descriptive messages. Note: negative numbers are defined by SCPI while positive error numbers are device dependent.

Error	Description
0	No error
1	The error couldn't be specified more precisely
2	Floating point domain error
3	Device temperature too high
4	General GUI error
5	Authentication required for operation
6	Authentication process failed
7	Operation is not allowed in service mode
8	Operation is allowed in service mode only
9	A measurement is currently in process
20	Operation not allowed while LD output is on
21	Wrong operating mode for this operation
22	INTERLOCK circuit is open
23	KEYLOCK is active
24	Operation not allowed because of a 'OPEN CIRCUIT' condition

Error	Description
<b>26</b>	Temperature protection is active
<b>30</b>	Operation not allowed while TEC output is on
<b>31</b>	Wrong operating mode for this Operation
<b>32</b>	Operation not allowed while a procedure is running
<b>34</b>	Operation not allowed because of a 'SENSOR FAILURE' condition
<b>40</b>	The device's setup is not valid
<b>120</b>	I <sup>2</sup> C wires stuck
<b>121</b>	Illegal START/STOP condition
<b>122</b>	Slave address not acknowledged (Not a valid bus address?)
<b>123</b>	Incomplete write operation (Slave rejected to receive all data in the buffer)
<b>124</b>	Arbitration lost
<b>130</b>	EEPROM Timeout
<b>131</b>	Checksum error
<b>140</b>	General keyboard bootloader error
<b>141</b>	Keyboard bootloader write error
<b>142</b>	Keyboard bootloader read error
<b>143</b>	Keyboard bootloader verify error
<b>144</b>	Keyboard data link error
<b>145</b>	Keyboard command error
<b>146</b>	Keyboard nonvolatile memory error
<b>150</b>	General DTC bootloader error
<b>151</b>	DTC bootloader write error
<b>152</b>	DTC bootloader verify error
<b>153</b>	DTC communication error
<b>154</b>	unknown DTC error
<b>155</b>	DTC adjustment is invalid
<b>-100</b>	General command error
<b>-101</b>	Invalid character
<b>-102</b>	Syntax error
<b>-103</b>	Invalid separator
<b>-104</b>	Data type error
<b>-105</b>	GET not allowed
<b>-108</b>	Parameter not allowed

Error	Description
-109	Missing parameter
-110	Command header error
-111	Header separator error
-112	Program mnemonic too long
-113	Undefined header (Unknown command)
-114	Header suffix out of range
-115	Unexpected number of parameters
-120	Numeric data error
-151	Invalid string data
-200	General execution error
-210	General trigger error
-211	Trigger ignored
-212	ARM ignored
-213	Init ignored
-220	Parameter error
-221	Settings conflict
-222	Data out of range
-223	Too much data
-230	Data corrupt or stale
-240	Hardware error
-310	System error
-313	Calibration memory lost
-314	Save/recall memory lost
-315	Configuration memory lost
-321	Out of memory
-330	Self-test failed
-340	Calibration failed
-350	Queue overflow
-363	Input buffer overrun
-410	Query INTERRUPTED

## 5 Maintenance and Service

Protect the CLD101x from adverse weather conditions. The CLD101x is not water resistant.

### Attention

**To avoid damage to the instrument, do not expose it to spray, liquids or solvents!**

The unit does not need a regular maintenance by the user. It does not contain any modules and/or components that could be repaired by the user himself. If a malfunction occurs, please contact Thorlabs for return instructions.

Do not remove covers!

### 5.1 Version Information

All available information on the CLD101x is displayed at power up and can be retrieved from the [Information menu](#)<sup>29</sup> as well:

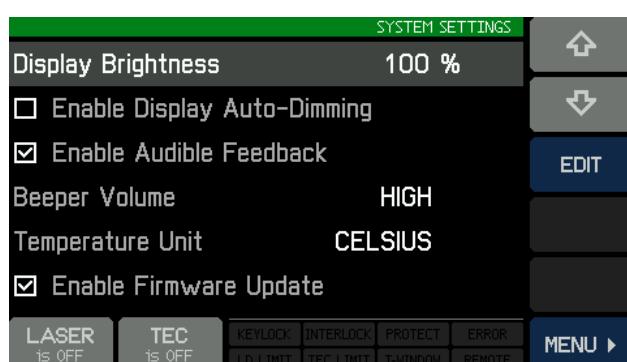


### 5.2 Firmware Upgrade

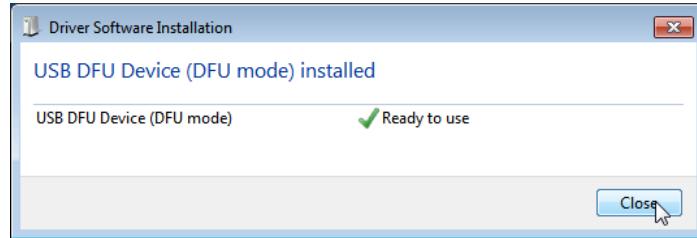
For a firmware update, a newer firmware image (file extension \*.dfu) and the DFU Wizard to upload this firmware to the CLD101x are required. Please download the firmware image and remember the location you have saved it to.

#### 5.2.1 Uploading new Firmware

As a next step, enable the Firmware Update in the CLD101x:

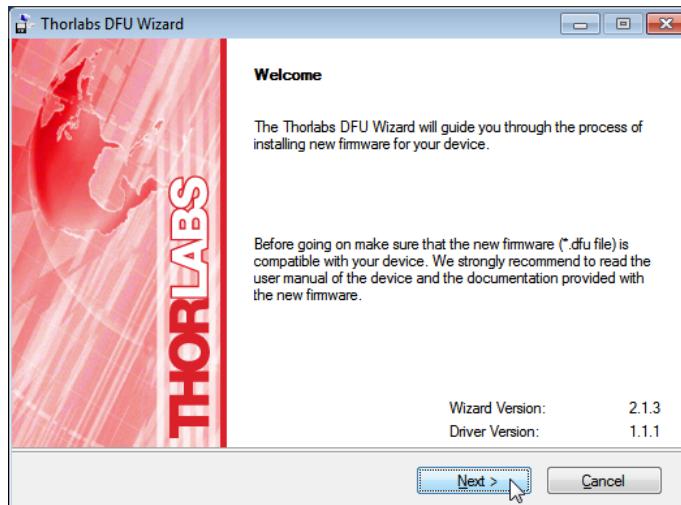


Then connect the CLD101x to the PC via the USB cable. The operating system recognizes a DFU capable device and installs the necessary driver software:

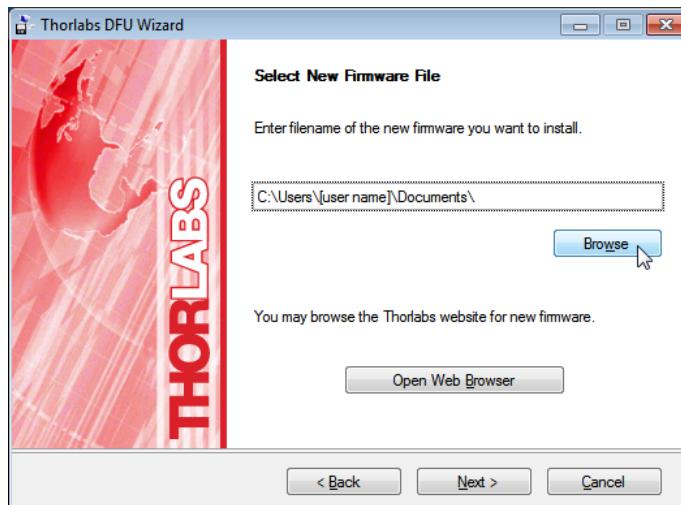


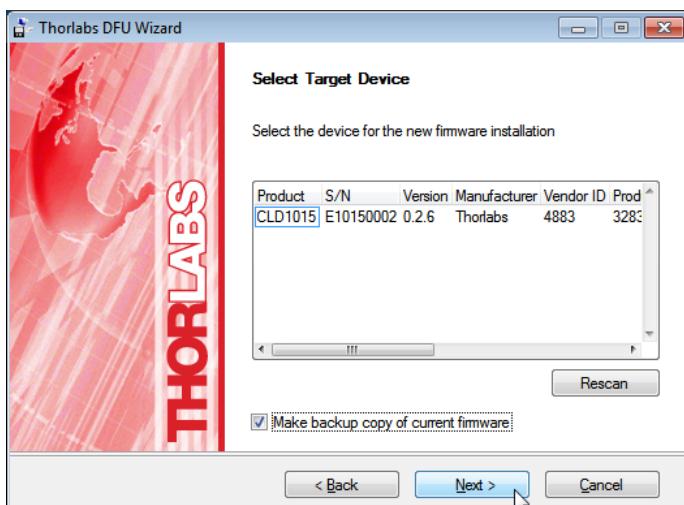
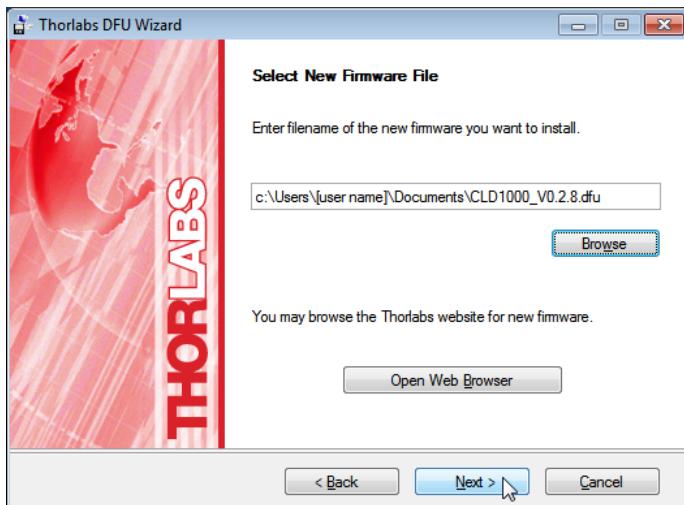
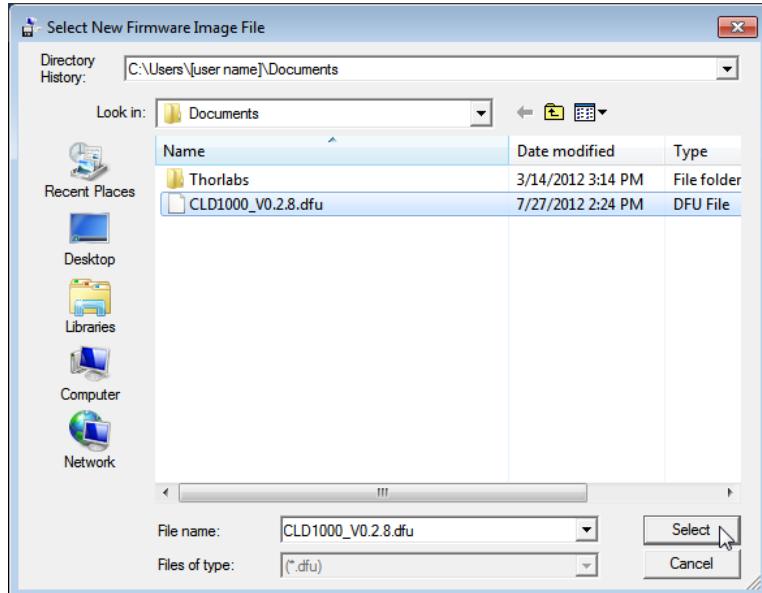
Start from the WINDOWS button All Programs -> Thorlabs -> Device Firmware upgrade Wizard-> DFU Wizard.

(Can be found also at C:\Program Files\Thorlabs\DFU Wizard\DFU\_Wizard.exe).



Click 'Next>>' to continue. Select the new firmware to be uploaded and follow the steps as shown in the following screen shots:



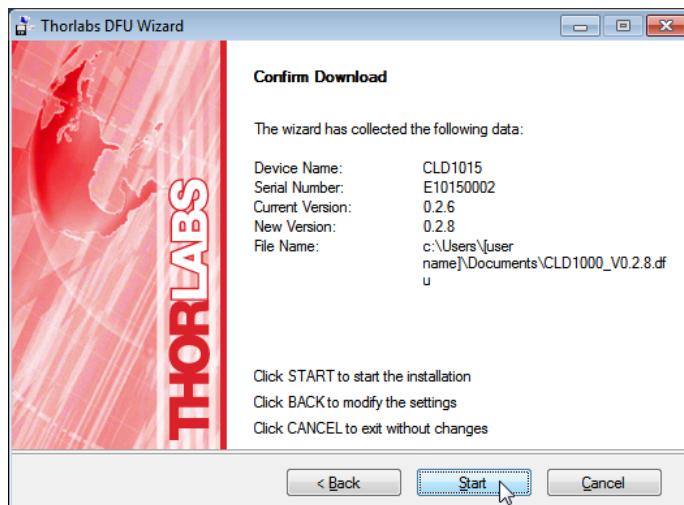


The DFU Wizard recognizes the connected DFU device. If you wish to save a backup copy of the present firmware, check the appropriate box.

**Note**

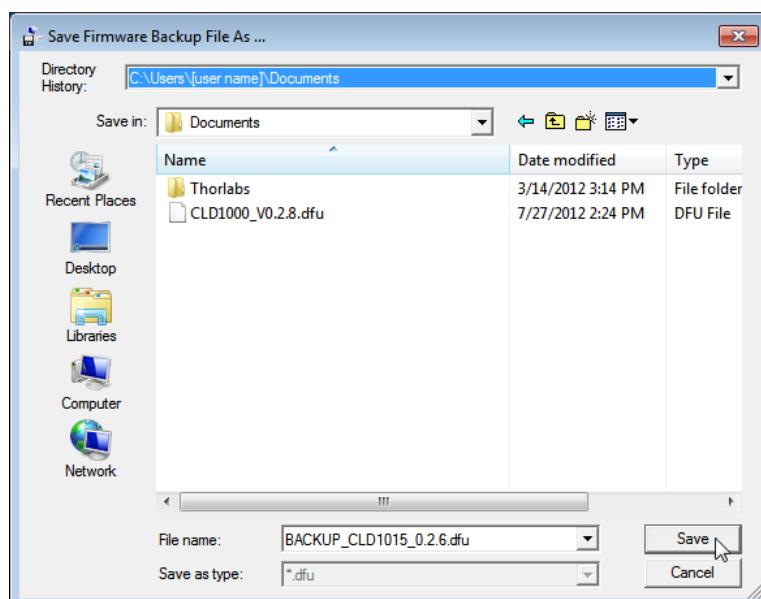
Starting from CLD101x's bootloader version 3.2.0, a backup of the existing firmware cannot be retrieved from the CLD101x anymore. In this case, the check box "Make backup copy of current firmware" is disabled.

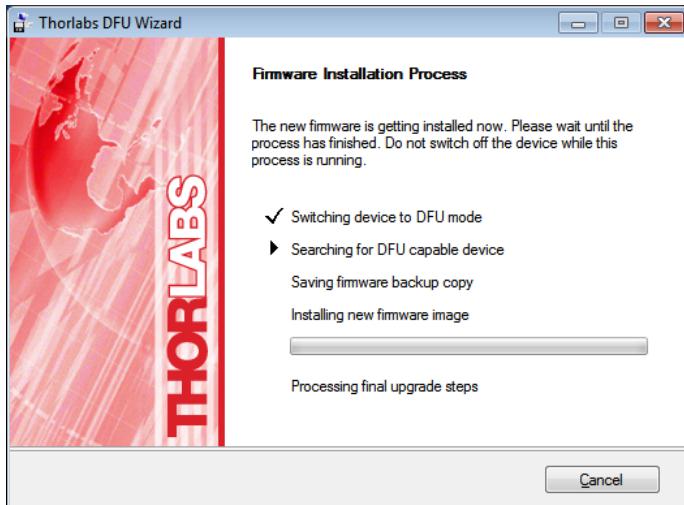
Click 'Next>>' to continue.



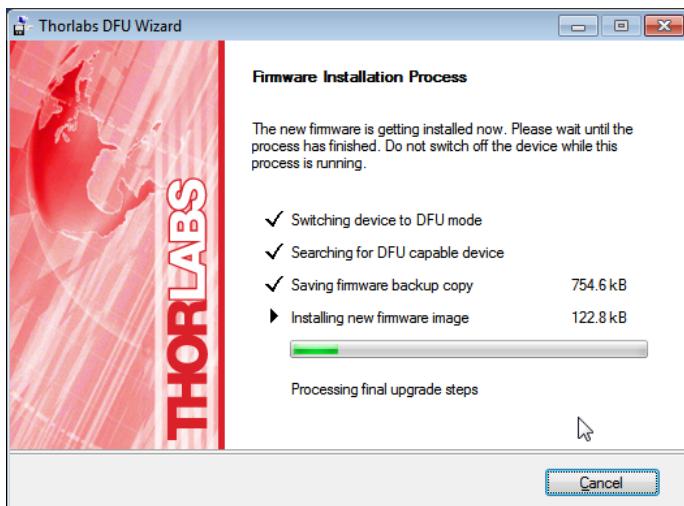
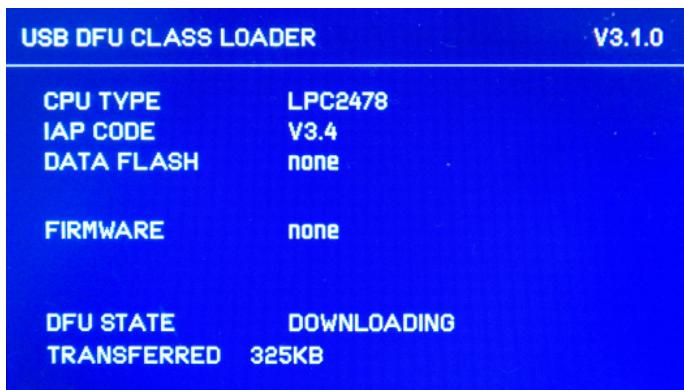
Click 'Start' to proceed with the required actions.

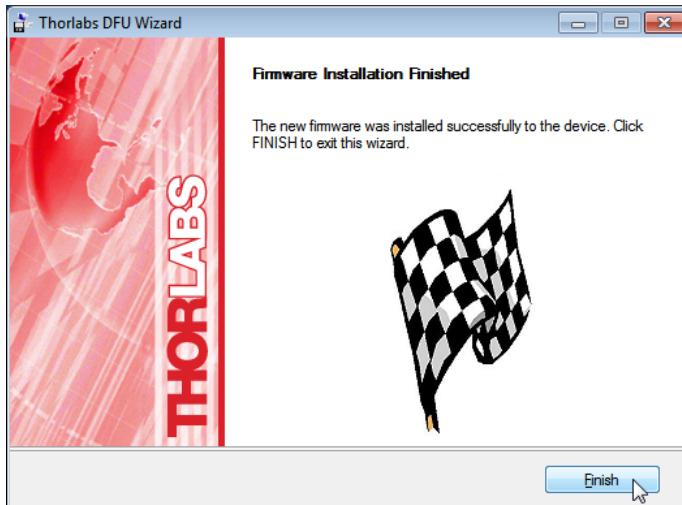
If a backup copy shall be saved, the DFU wizard requests a file location. Select the destination folder and click 'Save'





The DFU Wizard connects to the CLD101x and switches it to the DFU mode, which is reflected in a change of the LCD panel, stating beside other information the DFU state and process status:



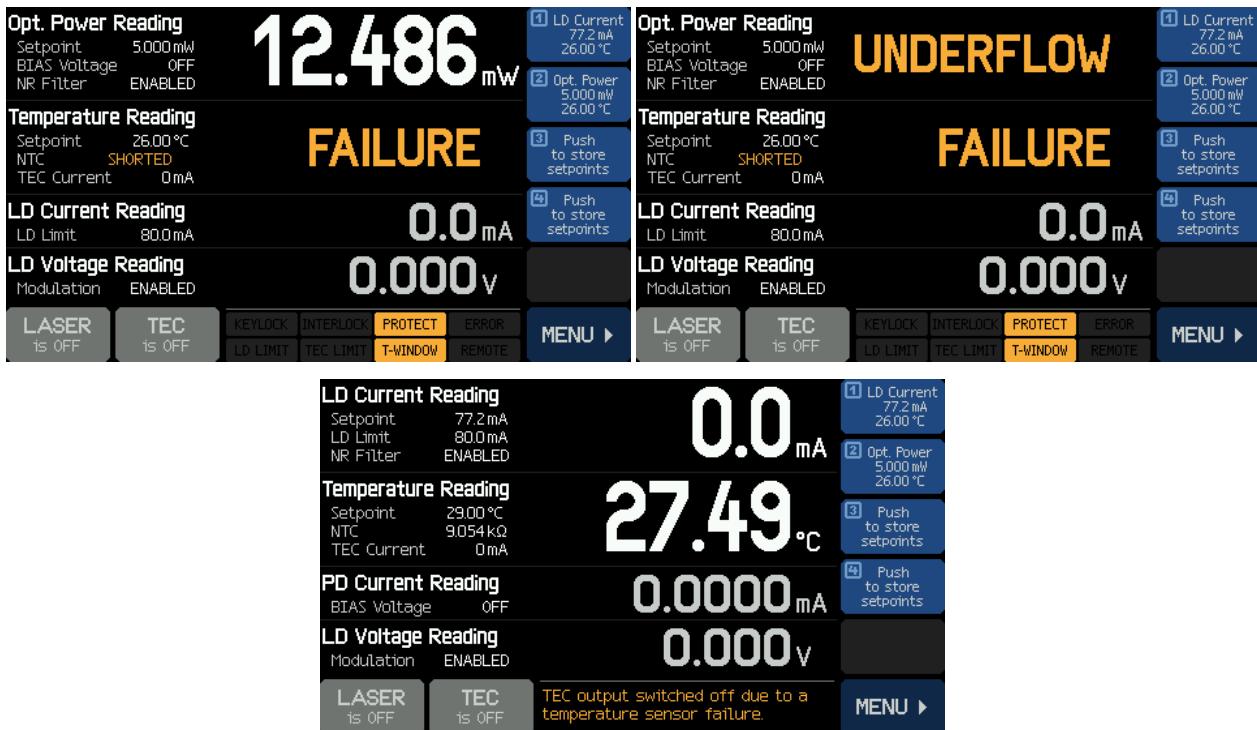


After firmware upload, the DFU Wizard switches the CLD101x back to normal operation. Click 'Finish' to complete.

## 5.3 Troubleshooting

### Strange display messages

The CLD101x shows unexpected display values, as for example:



- The laser diode might not be installed correctly and/or the wrong pin type is selected.
  - ✓ Check the [pin-out of the laser](#)<sup>75</sup> to determine type1 or type2 standard pin-out.
  - ✓ Check if the laser diode [adapter is installed](#)<sup>10</sup> correctly.

### Cannot switch on the TEC

- NTC resistance measurement resulted in invalid values (too high or too low values)
- Temperature reading shows "FAILURE" (NTC "OPEN" or "SHORT")
- An error message "TEC output voltage protection was tripped - ..." appears, TEC does not switch on: The laser current circuit seems to be interrupted.
  - ✓ Check the laser pin-out - only [standard pin styles](#)<sup>75</sup> type1 and type2 can be used
  - ✓ Check if the laser is installed [correctly](#)<sup>10</sup> (pin type 1 or 2, pin 1 at correct location)
  - ✓ The laser diode may be defective

### Cannot switch on the laser

- NTC resistance measurement resulted in invalid values (too high or too low). Temperature reading shows "FAILURE" (NTC "OPEN" or "SHORT")
  - ✓ Check the laser pin-out - only [standard pin styles](#)<sup>75</sup> type1 and type2 can be used
  - ✓ Check if the laser is installed [correctly](#)<sup>10</sup> (pin type 1 or 2, pin 1 at correct location)
  - ✓ The laser diode may be defective
- When the laser is switched on, the display shows LASER is PAUSED 
  - ✓ The [laser protection](#)<sup>22</sup> feature "Pause Laser" was activated due to laser temperature out of range. The display also shows **PROTECT** and **T-WINDOW**

- ✓ Switch on TEC - as soon as the laser temperature is within the [allowed range](#)<sup>[23]</sup>, the laser switches on automatically.
  
- The display shows **PROTECT** and **T-WINDOW**. When trying to switch on the laser, an error message "LD output can't switch on" comes up:
  - ✓ The [laser protection](#)<sup>[22]</sup> feature "Switch off Laser" was activated due to the laser temperature being out of range.
  - ✓ Switch on TEC - as soon as the laser temperature is within the [allowed range](#)<sup>[23]</sup>, the **PROTECT** and **T-WINDOW** icons disappear. Now, the laser can be switched on.
  
- The display shows **KEYLOCK** or **INTERLOCK**. When trying to switch on the laser, an error message "LD output can't switch on" comes up:
  - ✓ If **KEYLOCK**: Make sure the key switch (7<sup>[7]</sup>) is in unlock position
  - ✓ If **INTERLOCK**: Check [interlock circuit](#)<sup>[23]</sup>.
  
- When the laser is switched on, the error message "LD output voltage protection was tripped - ..." appears, LD does not switch on - The laser current circuit seems to be interrupted.
  - ✓ Check the laser pin-out - only [standard pin styles](#)<sup>[75]</sup> type1 and type2 can be used
  - ✓ Check if the laser is installed [correctly](#)<sup>[10]</sup> (pin type 1 or 2, pin 1 at correct location)
  - ✓ The laser diode may be defective

#### The laser suddenly reaches the LD Limit **LD LIMIT**

- The CLD101x is operated in CP (constant power) mode, LD current entered limit after change of temperature set point
  - ✓ When changing the temperature, the laser output power changes as well. In CP mode, the CLD101x maintains the monitor current by changing the laser injection current. As a result the LD current may reach the limit
  - ✓ Adopt the output power accordingly. Alternatively, LD Limit may be increased, but not beyond the specified max. rating according to the data sheet.

## 6 Appendix

### 6.1 Technical Data

Specification CLD1015	Front Panel*		Remote Control*
<b>Current Control (Constant Current Mode); AG</b>			
Control Range	0 to 1.5 A		
Compliance Voltage	>4 V		
Resolution	100 µA	50 µA	
Accuracy	$\pm(0.1\% + 500 \mu\text{A})$		
Noise and Ripple (10 Hz to 10 MHz, rms, typ.) w/o Filter with Filter	(Load 3.3 Ω, current < 1.2 A) 10 µA 5 µA		
Drift, 24 hours (0-10 Hz, typ., at Constant Ambient Temperature)	<50 µA		
Temperature Coefficient	<50 ppm/°C		
<b>Current Limit</b>			
Setting Range	1 mA to 1.5 A		
Resolution	100 µA	50 µA	
Accuracy	$\pm(0.12\% + 800 \mu\text{A})$		
<b>Photodiode Input (CG)</b>			
Photo Current Measurement Ranges	2 mA / 20 mA		
Photo Current Resolution	100 nA / 1 µA	70 nA / 700 nA	
Photo Current Accuracy	$\pm(0.08\% + 0.5 \mu\text{A}) / \pm(0.08\% + 5 \mu\text{A})$		
Photodiode Reverse Bias Voltage	0.1 to 6 V		
Photodiode Input Impedance	$\sim 0 \Omega$ (Virtual Ground)		
<b>Power Control (Constant Power Mode)</b>			
Photo Current Control Ranges	0 to 2 mA / 0 to 20 mA		
<b>Laser Voltage Measurement</b>			
Resolution	1 mV	200 µV	
Accuracy	$\pm(1\% + 40 \text{ mV})$		
<b>Laser Overvoltage Protection</b>			
Trip Voltage (typ.)	4.2 V		
<b>Modulation Input</b>			
Input Impedance	10 kΩ		
Input Voltage; max. CC Mode CP Mode	$\pm 10 \text{ V}$ $\pm 10 \text{ V}$		
Small Signal 3dB Bandwidth, CC Mode w/o filter with filter	DC to 250 kHz DC to 7.5 kHz		
Modulation Coefficient, CC Mode	150 mA/V $\pm 5\%$		
Modulation Coefficient, CP Mode Photo Current Range Low Photo Current Range High	200 µA/V $\pm 5\%$ 2 mA/V $\pm 5\%$		

\*) Via front panel the resolution is limited by the display. Via Remote Control a higher resolution is offered.

\*\*) Control range and thermal stability depend on thermistor parameters and operating point.

Specification CLD1010LP	Front Panel*	Remote Control*
<b>Current Control (Constant Current Mode); AG</b>		
Control Range	0 to 1.0 A	
Compliance Voltage	>8 V	
Resolution	100 µA	50 µA
Accuracy	±(0.1% + 500 µA)	
Noise and Ripple (10 Hz to 10 MHz, rms, typ.) w/o Filter with Filter	(Load 4.7 Ω) 10 µA 5 µA	
Drift, 24 hours (0-10 Hz, typ., at Constant Ambient Temperature)	<50 µA	
Temperature Coefficient	<50 ppm/°C	
<b>Current Limit</b>		
Setting Range	1 mA to 1.0 A	
Resolution	100 µA	50 µA
Accuracy	±(0.12% + 800 µA)	
<b>Photodiode Input (CG)</b>		
Photo Current Measurement Ranges	2 mA / 20 mA	
Photo Current Resolution	100 nA / 1 µA	70 nA / 700 nA
Photo Current Accuracy	±(0.08% + 0.5 µA) / ±(0.08% + 5 µA)	
Photodiode Reverse Bias Voltage	0.1 to 6 V	
Photodiode Input Impedance	~0 Ω (Virtual Ground)	
<b>Power Control (Constant Power Mode)</b>		
Photo Current Control Ranges	0 to 2 mA / 0 to 20 mA	
<b>Laser Voltage Measurement</b>		
Resolution	1 mV	400 µV
Accuracy	±(1% + 80 mV)	
<b>Laser Overvoltage Protection</b>		
Trip Voltage (typ.)	8.2 V	
<b>Modulation Input</b>		
Input Impedance	10 kΩ	
Input Voltage; max. CC Mode CP Mode	±7 V ±10 V	
Small Signal 3dB Bandwidth, CC Mode w/o filter with filter	DC to 300 kHz DC to 9.0 kHz	
Modulation Coefficient, CC Mode	150 mA/V ±5%	
Modulation Coefficient, CP Mode Photo Current Range Low Photo Current Range High	200 µA/V ±5% 2 mA/V ±5%	
<b>RF Input</b>		
RF Input Impedance	50 Ω	
Small Signal 3 dB Bandwidth	200 kHz to > 1 GHz	
Maximum RF Power	500 mW	

\*) Via front panel the resolution is limited by the display. Via Remote Control a higher resolution is offered.

\*\*) Control range and thermal stability depend on thermistor parameters and operating point.

Specification CLD1011LP	Front Panel*	Remote Control*
<b>Current Control (Constant Current Mode); CG</b>		
Control Range	0 to 1.0 A	
Compliance Voltage	>8 V	
Resolution	100 µA	50 µA
Accuracy	±(0.1% + 500 µA)	
Noise and Ripple (10 Hz to 10 MHz, rms, typ.) w/o Filter with Filter	(Load 4.7 Ω) 10 µA 5 µA	
Drift, 24 hours (0-10 Hz, typ., at Constant Ambient Temperature)	<50 µA	
Temperature Coefficient	<50 ppm/°C	
<b>Current Limit</b>		
Setting Range	1 mA to 1.0 A	
Resolution	100 µA	50 µA
Accuracy	±(0.12% + 800 µA)	
<b>Photodiode Input (CG or AG, switchable)</b>		
Photo Current Measurement Ranges	2 mA / 20 mA	
Photo Current Resolution	100 nA / 1 µA	70 nA / 700 nA
Photo Current Accuracy	±(0.08% + 0.5 µA) / ±(0.08% + 5 µA)	
Photodiode Reverse Bias Voltage	0.1 to 6 V	
Photodiode Input Impedance	~0 Ω (Virtual Ground)	
<b>Power Control (Constant Power Mode)</b>		
Photo Current Control Ranges	0 to 2 mA / 0 to 20 mA	
<b>Laser Voltage Measurement</b>		
Resolution	1 mV	400 µV
Accuracy	±(1% + 80 mV)	
<b>Laser Overvoltage Protection</b>		
Trip Voltage (typ.)	8.2 V	
<b>Modulation Input</b>		
Input Impedance	10 kΩ	
Input Voltage; max. CC Mode CP Mode	±7 V ±10 V	
Small Signal 3dB Bandwidth, CC Mode w/o filter with filter	DC to 300 kHz DC to 9.0 kHz	
Modulation Coefficient, CC Mode	150 mA/V ±5%	
Modulation Coefficient, CP Mode Photo Current Range Low Photo Current Range High	200 µA/V ±5% 2 mA/V ±5%	
<b>RF Input</b>		
RF Input Impedance	50 Ω	
Small Signal 3 dB Bandwidth	200 kHz to > 1 GHz	
Maximum RF Power	500 mW	

\*) Via front panel the resolution is limited by the display. Via Remote Control a higher resolution is offered.

\*\*) Control range and thermal stability depend on thermistor parameters and operating point.

Specification CLD1015 / CLD1010LP / CLD1011LP	Front Panel*	Remote Control*
<b>TEC Current Output</b>		
Control Range	-3.0 to 3.0 A	
Compliance Voltage	> 4.7 V	
Maximum Output Power	> 14.1 W	
Resolution	1 mA	100 µA
Accuracy	± (0.2% + 20 mA)	
<b>TEC Current Limit</b>		
Setting Range	5 mA to 3.0 A	
Resolution	1 mA	100 µA
Accuracy	± (0.2% + 20 mA)	
<b>NTC Thermistor Sensors</b>		
Resistance Measurement Range	300 Ω to 150 kΩ	
Control Range Max.**	-55 °C to +150 °C	
Temperature Resolution	0.01 °C	
Resistance Resolution	1 Ω	
Accuracy	± (0.1% + 1 Ω)	
Temperature Stability (24 Hours typ.)**	<0.005 °C	
Temperature Coefficient	<5 mK/°C	
<b>Temperature Window Protection</b>		
Setting Range $T_{win}$	0.01 °C to 100.0 °C	
Protection Reset Delay	0 to 600 s	
<b>Interface</b>		
USB 2.0	According to USBTMC/USBTMC-USB488 Specification Rev. 1.0	
Protocol	SCPI Compliant Command Set	
Drivers	<ul style="list-style-type: none"> <li>• VISA VXIpnP™</li> <li>• MS Visual Studio™</li> <li>• MS Visual Studio.net™</li> <li>• LabView™</li> <li>• LabWindows/CVI™</li> </ul>	

\*) Via front panel the resolution is limited by the display. Via Remote Control a higher resolution is offered.

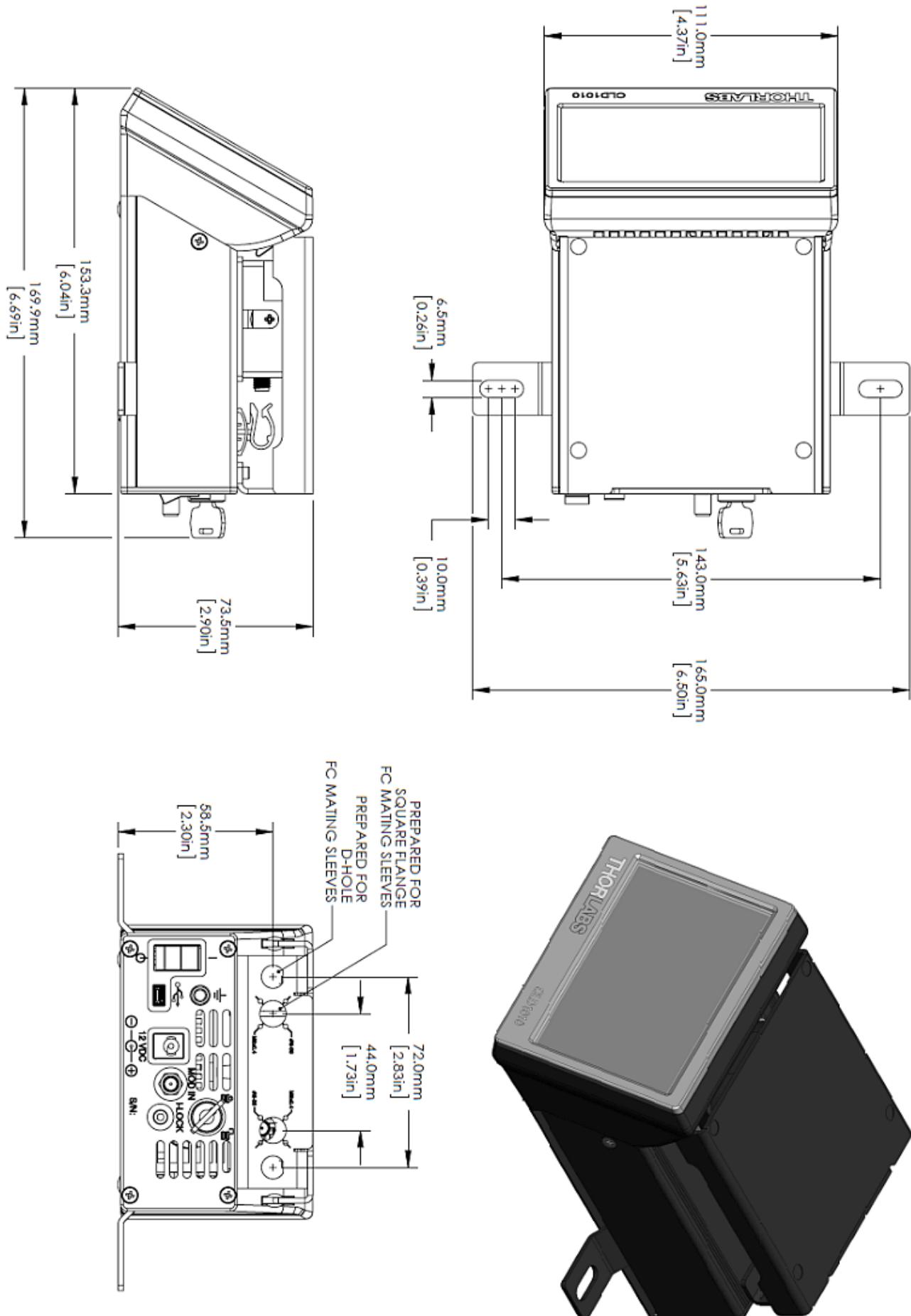
\*\*) Control range and thermal stability depend on thermistor parameters and operating point.

<b>General data CLD1015 / CLD1010LP / CLD1011LP</b>	
Safety Features	<ul style="list-style-type: none"> <li>• Interlock</li> <li>• Keylock Switch</li> <li>• Laser Current Limit</li> <li>• Soft Start</li> <li>• Short Circuit when Laser off</li> <li>• Laser Overvoltage Protection</li> <li>• Over Temperature Protection</li> <li>• Temperature Window Protection</li> </ul>
Display	4.3 " LCD TFT, 480 x 272 Pixel
CLD1015 Socket for Laser Diode	14 pin "Butterfly" Type 1 (Pump) / Type 2 (Telecomm)
CLD1010LP Socket for Laser Diode	LP Pigtailed TO Can Laser Diodes, Pin Codes A, D, E, G
CLD1011LP Socket for Laser Diode	LP Pigtailed TO Can Laser Diodes, Pin Codes B, C, H
Connector for DC Power Input	2.0 mm center pin connected to +
Connector for Modulation Input	SMA
Connector for Interlock & Laser On Signal	2.5 mm Mono Phono Jack
Connector for USB-Interface	USB Type Mini-B
Chassis Ground Connector	4 mm Banana Jack
Desktop Power Supply	AC: 100 to 240 V ±10%, 47 to 63 Hz DC: 12 V +/- 5 % / 3.5 A
Maximum Power Consumption	40 VA
Operating Temperature <sup>1)</sup>	0 to +40 °C
Storage Temperature	- 40 to +70°C
Warm-up Time for Rated Accuracy	30 min
CLD1015 Weight (with power supply)	1.0 kg
CLD1010LP Weight (with power supply)	1.1 kg
CLD1011LP Weight (with power supply)	1.1 kg
Dimensions w/o Operating Elements (W x H x D)	111 x 73.5 x 153.3 mm <sup>3</sup> (4.37 x 2.9 x 6.04 in <sup>3</sup> )
Dimensions with Operating Elements (W x H x D)	111 x 73.5 x 169.9 mm <sup>3</sup> (4.37 x 2.9 x 6.69 in <sup>3</sup> )

<sup>1)</sup> non-condensing

All technical data are valid at 23 ± 5°C and 45 ± 15% rel. humidity (non condensing)

## 6.2 Dimensions CLD101x

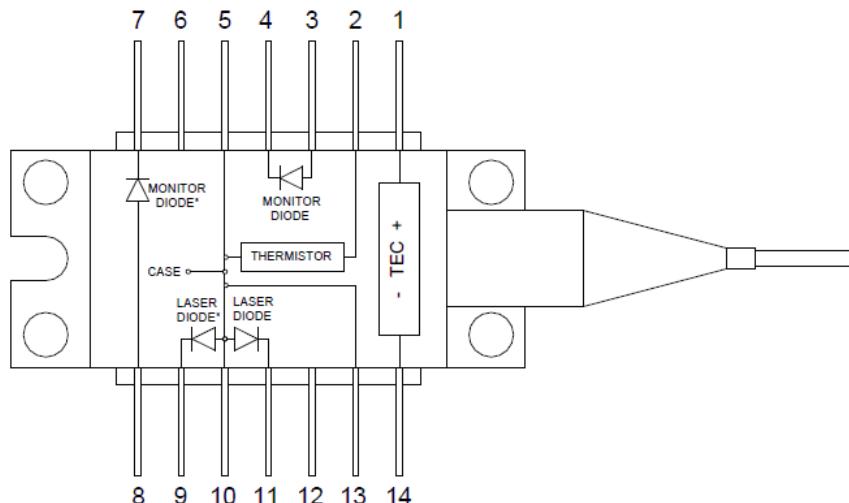


## 6.3 Standard Laser Diode Pinouts

### BFY (Butterfly Style) Laser Diodes

There are two standard pin-outs for 14 pin "butterfly" (BFY) housing laser diodes:

#### Type 1 - Pump Laser Diodes

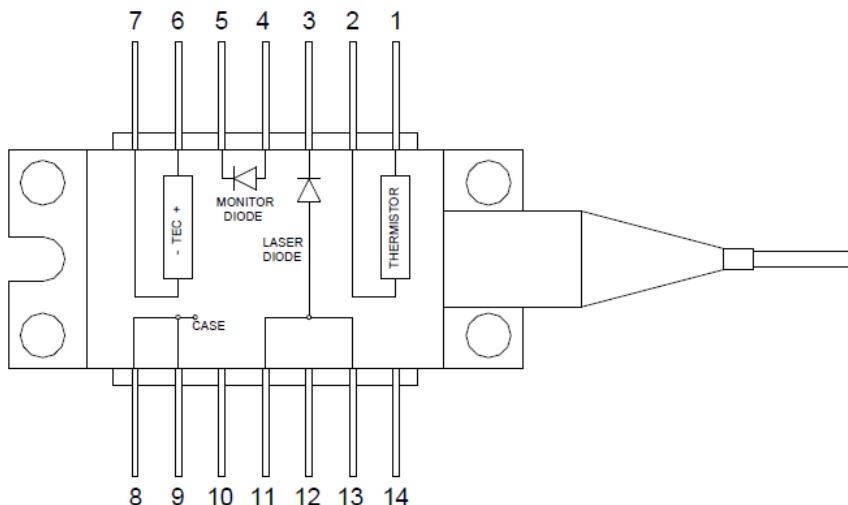


1	TEC +	14	TEC -
2	Thermistor	13	GND
3	Photo Diode Anode <sup>1)</sup>	12	N.C.
4	Photo Diode Cathode <sup>1)</sup>	11	Laser Diode Cathode <sup>2)</sup>
5	Thermistor	10	Laser Diode Anode
6	N.C.	9	Laser Diode Cathode <sup>2)</sup>
7	Photo Diode Cathode <sup>1)</sup>	8	Photo Diode Anode <sup>1)</sup>

<sup>1)</sup> Alternative connection for photodiode

<sup>2)</sup> Alternative connection for laser cathode

## Type 2 - DFB Laser Diodes

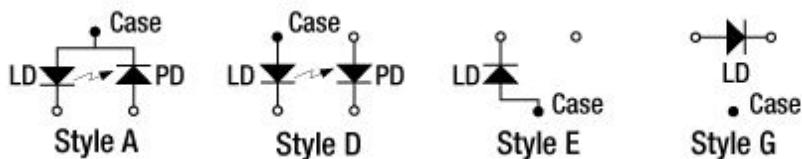


1	Thermistor	14	N.C.
2	Thermistor	13	Laser Diode Anode
3	Laser Diode Cathode	12	N.C.
4	Photo Diode Anode	11	Laser Diode Anode
5	Photo Diode Cathode	10	NC
6	TEC +	9	GND
7	TEC -	8	GND

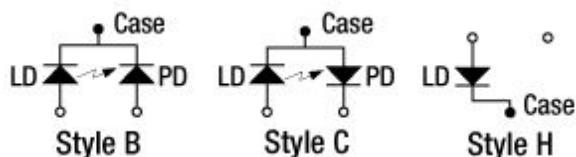
### Supported TO Can Pin Styles

Thorlabs TO can laser diodes are categorized in 8 pin styles, called A to H.

The CLD1010LP supports all pin styles with laser diode anode grounded or floating, these are the pin styles A, D, E and G:



The CLD1011LP supports all pin styles with laser diode cathode grounded, these are the pin styles B, C, and H:

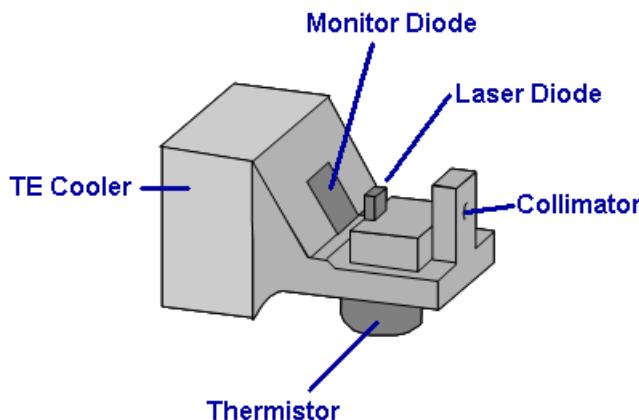


### Note

Above presentation is the bottom view to the laser. The pin style for each individual laser diode is stated on the web site and in the individual Product Data Sheet, coming with the laser diode.

## 6.4 Laser Control Tutorial

### Structure of a laser diode



The "heart" of a butterfly laser is the laser diode chip. It emits into two directions - towards the collimator and into the reverse direction. The power in both directions is exactly the same. As for this reason, opposite to the output collimator a photodiode is placed, also known as monitor diode. The current of this photodiode is proportional to the optical output power of the laser and used for observing and controlling the optical power.

The collimator focuses the laser beam and feeds it into the optical fiber ("fiber pigtail"). Often, an isolator is placed between collimator and fiber in order to suppress back reflections from the fiber end back into the laser.

Important for a stable operation of the laser is a constant chip temperature, as this influences both the emitted wavelength and optical output power. For temperature control, a TEC (Thermoelectric Cooler, aka Peltier element) is used, it can cool or heat depending on the direction of the current through the TEC. A thermistor placed close to the laser substrate is sensing the temperature.

### Laser Operating Mode

A laser diode can be operated in constant current (CC) or constant power (CP) modes.

In CC mode, the injection current of the laser is maintained constant with a high accuracy. It can be changed rapidly, so the CC mode is preferred for modulation of the laser output signal at frequencies up to several hundreds of kHz.

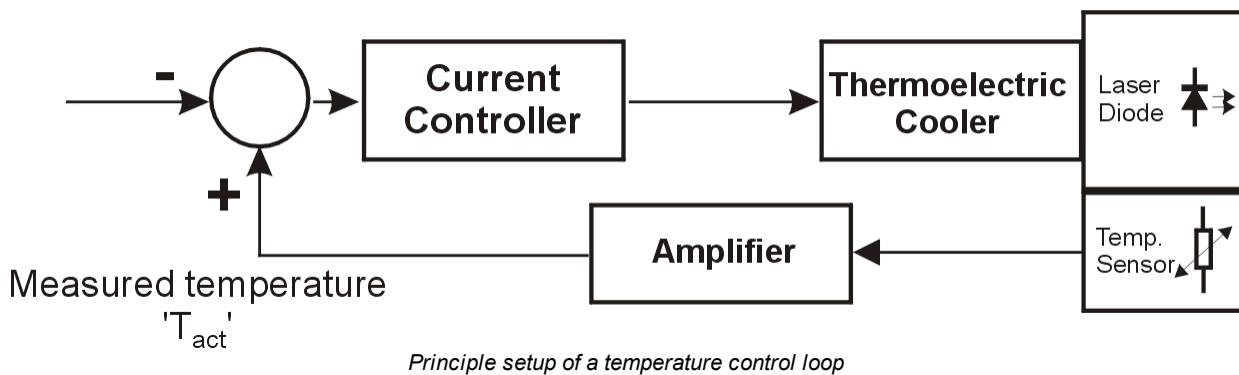
In CP mode, the optical output power of the laser chip is maintained constant. This is achieved by keeping constant the monitor current: The laser controller compares the actual monitor current with its set value and controls the injection current of the laser accordingly. This control loop is reacting relatively slowly, that's why in CP mode the laser is used rarely for modulation.

## PID Tutorial

Temperature controllers are used to manage the temperature of thermoelectrically heated/cooled components in experimental setups, independent of external influences. To adapt a controller to different thermal loads, and to optimize the controller's response characteristics, the controlling parameters of the system's feedback loop must be optimized. All Thorlabs temperature controllers provide a PID control loop whose shares (P-, I- and D-share) must be matched to the thermal load of the device under test. For an optimum adaptation, these parameters have to be adjusted separately and independent of each other. This application note describes the PID parameters, and how to set them to get optimum performance from your controller.

### What is a 'PID' controller?

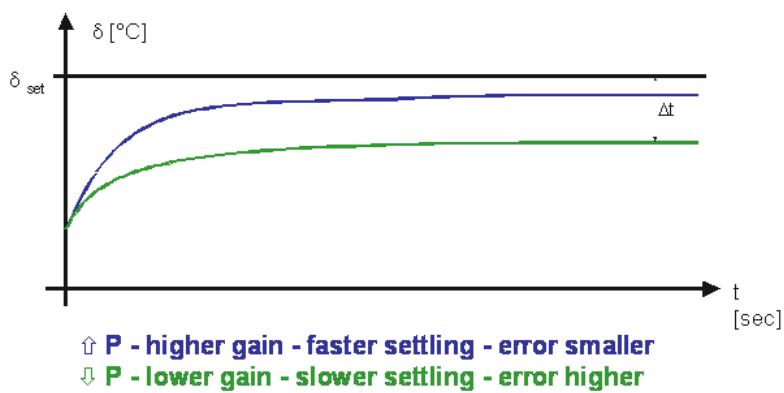
*PID* is an acronym for *Proportional, Integral and Differential*. It describes a certain method, and the parameters used to control it, for closed-loop circuits.



The figure above shows a standard laser diode setup with temperature control. The laser diode is in thermal contact with a thermoelectric cooler (TEC, Peltier element) and a temperature sensor. The TEC is fed by a bipolar current controller which itself gets a signal from a comparator: The Set Temperature ( $T_{set}$ ) is compared to the measured temperature ( $T_{act}$ ) at the laser diode. If the difference between both signals is negative, i.e. the set temperature is higher than the measured temperature, the current controller decreases the current to the TEC or even reverts the polarity to change from cooling to heating, and vice versa.

Ideally this process should be continued until the difference between both signals is zero, the TEC current stays constant, as well as the laser diode temperature.

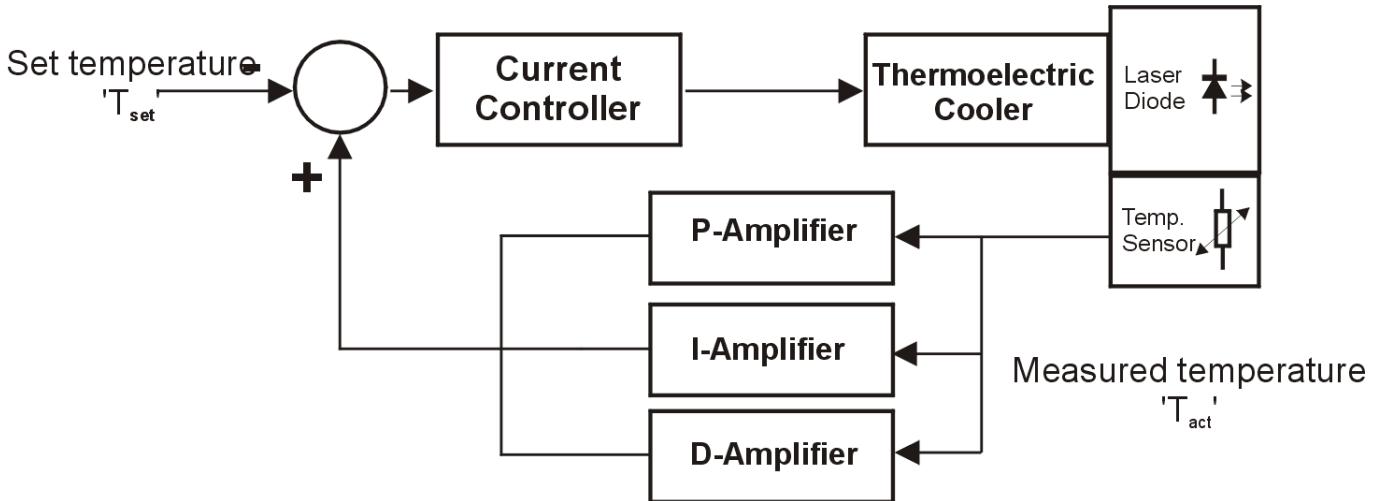
The amplifier which processes the signal of the temperature sensor plays an important role for the settling behavior of the complete system. There are different types of control circuits. One type is a strictly linear amplifier. In this case we have a proportional or *P*-controller. Below is shown an example of the settling behavior of a *P*-controller.



The higher the gain of the amplifier, the faster the system approaches a steady-state temperature. With a simple P-controller, a small temperature error  $\Delta t$  (this is the difference between the set temperature and the steady-state temperature) will always be present.

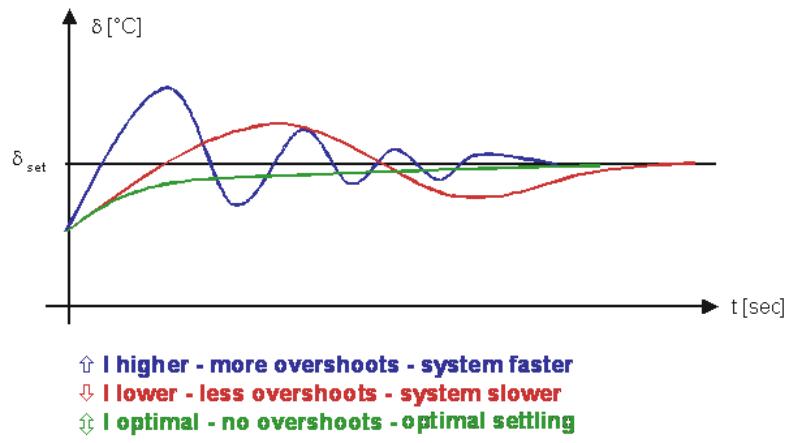
To eliminate this control error the amplification must go to infinity. Doing this, however, will result in the system oscillating around the set temperature, and the control system and temperature will never stabilize. Consequently, the optimum setting of the amplification for a P-controller (the so called P-share) is the maximum amplification that does not result in the system oscillating.

To further improve the settling behavior of the system two other kinds of amplifiers can be switched in parallel to the P-controller: an amplifier with integrating capability (I-controller) and an amplifier with differentiating properties (D-controller).



The I-controller enables the feedback loop to have greater amplification at low frequencies and less amplification at higher frequencies. Because of this, the control error resulting from the P-controller is eliminated.

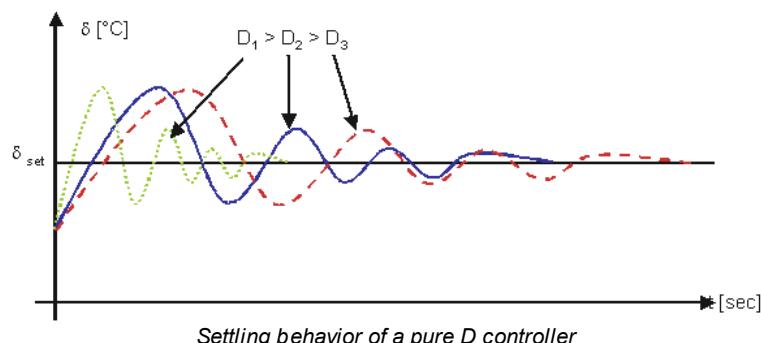
When the I-share is high, the system response tends to overshoot (see figure below).



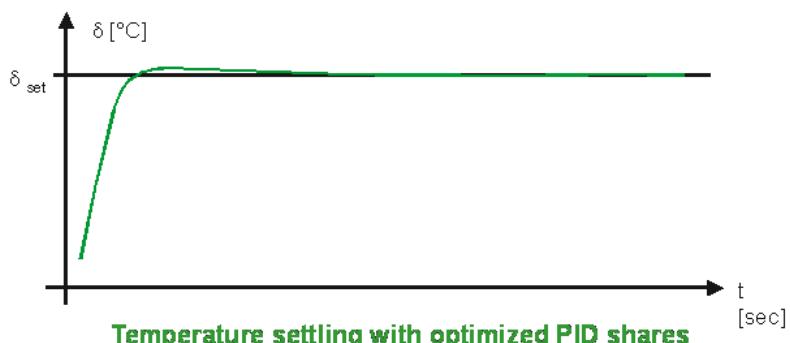
Setting the P- and I-shares optimally means ensuring that the actual temperature does not oscillate or overshoot. This setting for the P- and I-shares also results in the fastest system approach to the set temperature. With the P- and I-shares chosen this way, however, the system cannot react quickly to sudden changes in ambient temperature.

To allow the system to react more quickly to sudden changes in temperature an amplifier with differentiating characteristic (D-controller) is added to the PI controller to establish a so-called 'PID' control loop. With the D controller the amplification is raised at higher frequencies associated with

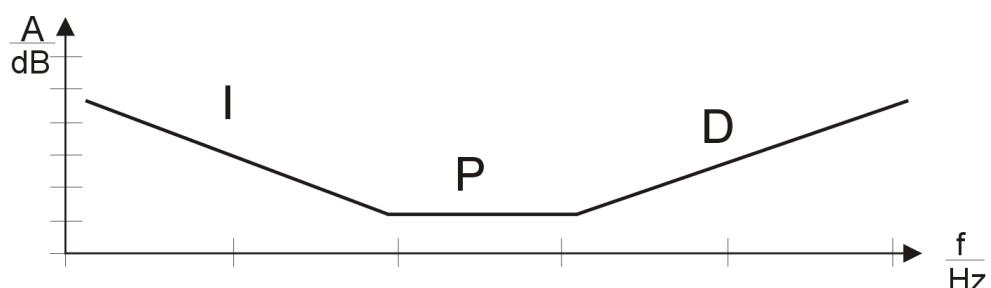
sudden events. The optimum setting strongly depends on the systems thermal behavior and thermal load. As can be seen in the figure below, only D-share would always lead to overshoots.



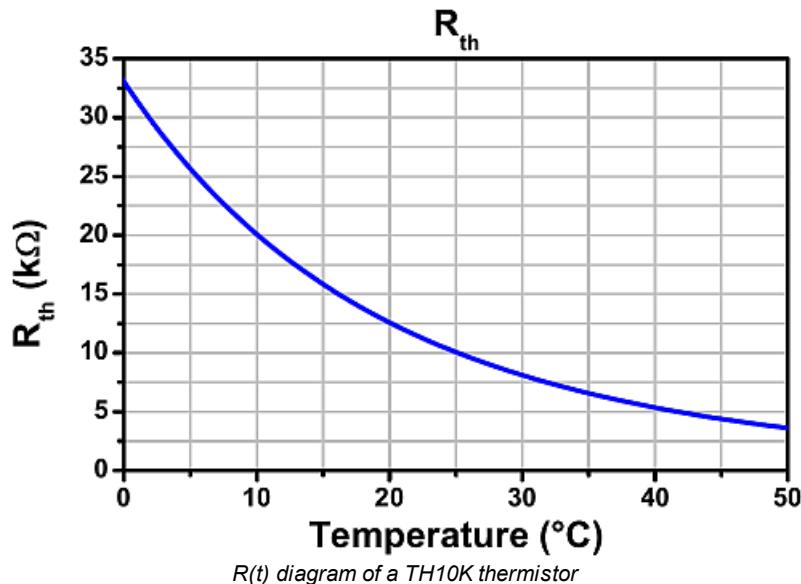
When used in combination with the P-share, the D-share is used to minimize the overshoots caused by the P-share. By optimizing all three shares, a very fast settling to the desired temperature can be achieved without oscillation of the system:



The typical amplification vs. frequency (frequency response) of a PID-controller is shown in figure below:



## Thermistor - Properties and Calculations



A thermistor is a resistor with a negative temperature coefficient (as for this, also known as NTC). Its resistance decreases exponentially with temperature. The significant change of resistance with temperature predestines a NTC for temperature measurements. The diagram to the left shows the typical curve for a 10kΩ thermistor.

Usually, its nominal resistance is referenced to 25°C. The dependency of resistance vs. temperature can be described using several methods.

The most accurate method is the

**Steinhart-Hart equation**, a third-order approximation, it delivers an error less than 0.02°C over a 200°C range.

$$\frac{1}{T} = A + B \ln(R) + C \ln^3(R)$$

where  $A$ ,  $B$  and  $C$  are the Steinhart-Hart coefficients, to be specified for each individual device.

A commonly used alternative to the Steinhart-Hart equation is the  **$\beta$  equation** (often called **exponential method**) which is derived from the Steinhart-Hart model:

$$\frac{1}{T} = \frac{1}{T_0} + \frac{1}{\beta} \ln\left(\frac{R}{R_0}\right) \quad R = R_0 e^{\beta\left(\frac{1}{T} - \frac{1}{T_0}\right)}$$

where  $T_0$  and  $R_0$  are the reference values and  $\beta$  - the device-specific constant.

## 6.5 Certifications and Compliances

### *EU Declaration of Conformity*

*in accordance with EN ISO 17050-1:2010*

We: Thorlabs GmbH

Of: Hans-Boeckler-Str. 6, 85221 Dachau/München, Deutschland

*in accordance with the following Directive(s):*

2014/35/EU	Low Voltage Directive (LVD)
2014/30/EU	Electromagnetic Compatibility (EMC) Directive
2011/65/EU	Restriction of Use of Certain Hazardous Substances (RoHS)

*hereby declare that:*

Model: **CLD101x(LP), EM595**

Equipment: **Compact Laser Diode Controller**

*is in conformity with the applicable requirements of the following documents:*

EN 61010-1	Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use.	2010
EN 61326-1	Electrical Equipment for Measurement, Control and Laboratory Use - EMC Requirements	2013

*and which, issued under the sole responsibility of Thorlabs, is in conformity with Directive 2011/65/EU of the European Parliament and of the Council of 8th June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, for the reason stated below:*

*does not contain substances in excess of the maximum concentration values tolerated by weight in homogenous materials as listed in Annex II of the Directive*

*I hereby declare that the equipment named has been designed to comply with the relevant sections of the above referenced specifications, and complies with all applicable Essential Requirements of the Directives.*

Signed:

On: 19 August 2016

Name: Dorothee Jennrich

Position: General Manager

EDC - CLD101x(LP), EM595 -2016-08-19

**CE 16**

## 6.6 Warranty

Thorlabs warrants material and production of the CLD101x for a period of 24 months starting with the date of shipment. During this warranty period Thorlabs will see to defaults by repair or by exchange if these are entitled to warranty.

For warranty repairs or service the unit must be sent back to Thorlabs. The customer will carry the shipping costs to Thorlabs, in case of warranty repairs Thorlabs will carry the shipping costs back to the customer.

If no warranty repair is applicable the customer also has to carry the costs for back shipment.

In case of shipment from outside EU duties, taxes etc. which should arise have to be carried by the customer.

Thorlabs warrants the hard- and/or software determined by Thorlabs for this unit to operate fault-free provided that they are handled according to our requirements. However, Thorlabs does not warrant a fault free and uninterrupted operation of the unit, of the software or firmware for special applications nor this instruction manual to be error free. Thorlabs is not liable for consequential damages.

### Restriction of Warranty

The warranty mentioned before does not cover errors and defects being the result of improper treatment, software or interface not supplied by us, modification, misuse or operation outside the defined ambient stated by us or unauthorized maintenance.

Further claims will not be consented to and will not be acknowledged. Thorlabs does explicitly not warrant the usability or the economical use for certain cases of application.

Thorlabs reserves the right to change this instruction manual or the technical data of the described unit at any time.

## 6.7 Copyright and Exclusion of Reliability

*Thorlabs* has taken every possible care in preparing this document. We however assume no liability for the content, completeness or quality of the information contained therein. The content of this document is regularly updated and adapted to reflect the current status of the hardware and/or software. We furthermore do not guarantee that this product will function without errors, even if the stated specifications are adhered to.

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## 6.8 Thorlabs 'End of Life' Policy (WEEE)

As required by the WEEE (Waste Electrical and Electronic Equipment Directive) of the European Community and the corresponding national laws, Thorlabs offers all end users in the EC the possibility to return "end of life" units without incurring disposal charges.

This offer is valid for Thorlabs electrical and electronic equipment

- sold after August 13<sup>th</sup> 2005
- marked correspondingly with the crossed out "wheelie bin" logo (see figure below)
- sold to a company or institute within the EC
- currently owned by a company or institute within the EC
- still complete, not disassembled and not contaminated

As the WEEE directive applies to self contained operational electrical and electronic products, this "end of life" take back service does not refer to other Thorlabs products, such as

- pure OEM products, that means assemblies to be built into a unit by the user (e. g. OEM laser driver cards)
- components
- mechanics and optics
- left over parts of units disassembled by the user (PCB's, housings etc.).

### **Waste treatment on your own responsibility**

If you do not return an "end of life" unit to Thorlabs, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

WEEE Number (Germany) : DE97581288

### **Ecological background**

It is well known that waste treatment pollutes the environment by releasing toxic products during decomposition. The aim of the European RoHS Directive is to reduce the content of toxic substances in electronic products in the future.

The intent of the WEEE Directive is to enforce the recycling of WEEE. A controlled recycling of end-of-life products will thereby avoid negative impacts on the environment.



*Crossed out  
"Wheelie Bin" symbol*

## 6.9 List of Acronyms

The following acronyms and abbreviations are used in this manual:

AC	Alternating Current
BFY	Butterfly (style of laser housing)
CC	Constant Current
CP	Constant Power
DC	Direct Current
DFB	Distributed Feedback
DFU	Device Firmware Upgrade
ESD	Electrostatic discharges
GND	Ground
GUI	Graphic User Interface
LD	Laser Diode
NR	Noise Reduction (filter)
NTC	Negative Temperature Coefficient (synonym for thermistor)
PD	Photo Diode
PID	Proportional-Integral-Derivative
SCPI	Standard Commands for Programmable Instruments
TEC	Thermoelectric cooler
USB	Universal Serial Bus
USBTMC	USB Test and Measurement Class (device)
ZIF	Zero Insertion Force

## 6.10 Thorlabs Worldwide Contacts

For technical support or sales inquiries, please visit us at [www.thorlabs.com/contact](http://www.thorlabs.com/contact) for our most up-to-date contact information.



### **USA, Canada, and South America**

Thorlabs, Inc.  
[sales@thorlabs.com](mailto:sales@thorlabs.com)  
[techsupport@thorlabs.com](mailto:techsupport@thorlabs.com)

### **Europe**

Thorlabs GmbH  
[europe@thorlabs.com](mailto:europe@thorlabs.com)

### **France**

Thorlabs SAS  
[sales.fr@thorlabs.com](mailto:sales.fr@thorlabs.com)

### **Japan**

Thorlabs Japan, Inc.  
[sales@thorlabs.jp](mailto:sales@thorlabs.jp)

### **UK and Ireland**

Thorlabs Ltd.  
[sales.uk@thorlabs.com](mailto:sales.uk@thorlabs.com)  
[techsupport.uk@thorlabs.com](mailto:techsupport.uk@thorlabs.com)

### **Scandinavia**

Thorlabs Sweden AB  
[scandinavia@thorlabs.com](mailto:scandinavia@thorlabs.com)

### **Brazil**

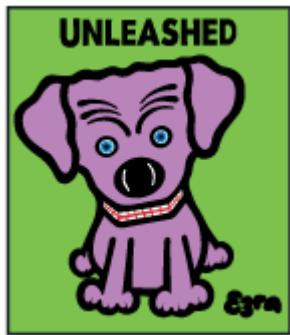
Thorlabs Vendas de Fotônicos Ltda.  
[brasil@thorlabs.com](mailto:brasil@thorlabs.com)

### **China**

Thorlabs China  
[chinasales@thorlabs.com](mailto:chinasales@thorlabs.com)







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