

TLD001 Laser Diode Driver

APT User Guide



Original Instructions

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Chapter 1 Overview

1.1 Introduction

The TLD001 T-cube is a versatile, high precision laser diode/LED driver, designed to drive a wide range of semiconductor laser diodes. It supports operating currents of up to 200 mA, a high compliance voltage of 8 Volts and both constant current and constant power operating modes. As a member of the T-cube family of products, the TLD001 allows both standalone use or PC-based operation via USB interface.

This laser diode driver is a highly compact yet fully functional unit. It is provided with a USB interface for easy PC control and also a manual interface panel containing a 5 digit 7 Segment display, adjustment potentiometer, Mode, Display and Laser ON buttons, and safety key switch.

The unit can be set to control either the injection current or the optical output power of the laser diode.

For convenience the footprint of this unit has been kept to a minimum, measuring only 120mm x 60mm x 47mm (4.8" x 2.4" x 1.8") and with the facility to directly mount to the optical table. The manual controls for this unit are conveniently located on the upper surface. The Mode and Display buttons allow the various operating modes to be selected easily. There is also a key switch and interlock connector fitted to this compact unit for use in laser applications requiring such functionality.



Fig. 1.1 T-Cube laser diode driver (TLD001)

USB connectivity provides easy 'Plug and Play' PC controlled operation - multiple T-Cube units can be connected to a single PC via standard USB hub technology, or by using the T-Cube Controller Hub (see over). Coupling this with the user friendly apt™ software (supplied) allows the user to get up and running in a short space of time. Advanced custom applications and sequences are also possible using the extensive

ActiveX® programming environment also supplied. This programming library is compatible with many development tools such as LabView, Visual Basic, Visual C++, C++ Builder, LabWindows/CVI, Matlab and Delphi.

See Section 1.3. for a full description of the APT system software.

In the remainder of this handbook, the Tutorial section (Chapter 5) provides a good initial understanding on using the unit, and the reference section (Chapter 6) covers all operating modes and parameters in detail.

1.2 Power Supply Options

Thorlabs offers a compact, two-way power supply unit (TPS002), allowing up to two Laser Diode driver T-Cubes to be powered from a single mains outlet.

As a further level of convenience when using these Controllers, Thorlabs also offers the 3-channel and 6-channel K-Cube Controller Hubs (KCH301 and KCH601). These products have been designed specifically with multiple Cube operation in mind, in order to simplify issues such as cable management, power supply routing, multiple USB device communications and different optical table mounting scenarios.

The K-Cube Controller Hub comprises a slim base-plate type carrier with electrical connections located on the upper surface to accept the Cubes.

Internally the Controller Hub contains a fully compliant USB 2.0 hub circuit to provide communications for all Cubes – a single USB connection to the Controller Hub is all that is required for PC control. The Controller Hub also provides power distribution for the Cubes, requiring only a single power connection.



Caution

The KCH301 and KCH601 Controller Hubs have been designed primarily for use with the K-Cube range of controller units. T-Cube controllers such as the TDC001 TEC Controller can still be used on this hub, but will require an adapter plate (KAP102) before they can be fitted.

1.3 APT PC Software Overview

1.3.1 Introduction

As a member of the APT range of controllers, the TLD001 Laser Driver shares many of the associated software benefits. This includes USB connectivity (allowing multiple units to be used together on a single PC), fully featured Graphical User Interface (GUI) panels, and extensive software function libraries for custom application development.

The APT software suite supplied with all APT controllers provides a flexible and powerful PC based control system both for users of the equipment, and software programmers aiming to automate its operation.

For users, the APTUser (see Section 1.3.2.) and APTConfig (see Section 1.3.3.) utilities allow full control of all settings and operating modes enabling complete 'out-of-box' operation without the need to develop any further custom software. Both utilities are built on top of a sophisticated, multi-threaded ActiveX 'engine' (called the APT server) which provides all of the necessary APT system software services such as generation of GUI panels, communications handling for multiple USB units, and logging of all system activity to assist in hardware trouble shooting. It is this APT server 'engine' that is used by software developers to allow the creation of advanced automated positioning applications very rapidly and with great ease. The APT server is described in more detail in Section 1.3.4.

Aside

ActiveX®, a Windows®-based, language-independent technology, allows a user to quickly develop custom applications that automate the control of APT system hardware units. Development environments supported by ActiveX® technology include Visual Basic®, LabView™, Borland C++ Builder, Visual C++, Delphi™, and many others. ActiveX® technology is also supported by .NET development environments such as Visual Basic.NET and Visual C#.NET.

ActiveX controls are a specific form of ActiveX technology that provide both a user interface and a programming interface. An ActiveX control is supplied for each type of APT hardware unit to provide specific controller functionality to the software developer. See Section 1.3.4. for further details.

1.3.2 APTUser Utility

The APTUser application allows the user to interact with a number of APT hardware control units connected to the host PC. This program displays multiple graphical instrument panels to allow multiple APT units to be controlled simultaneously.

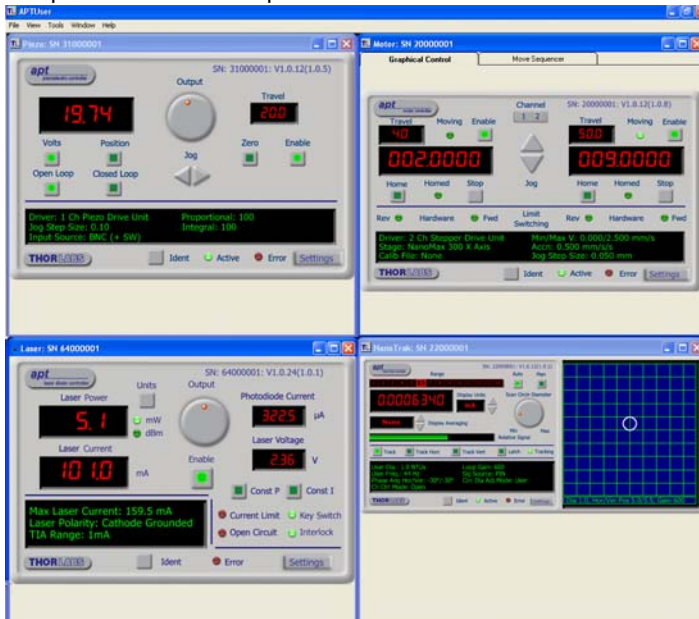


Fig. 1.2 Typical APTUser Screen Shot

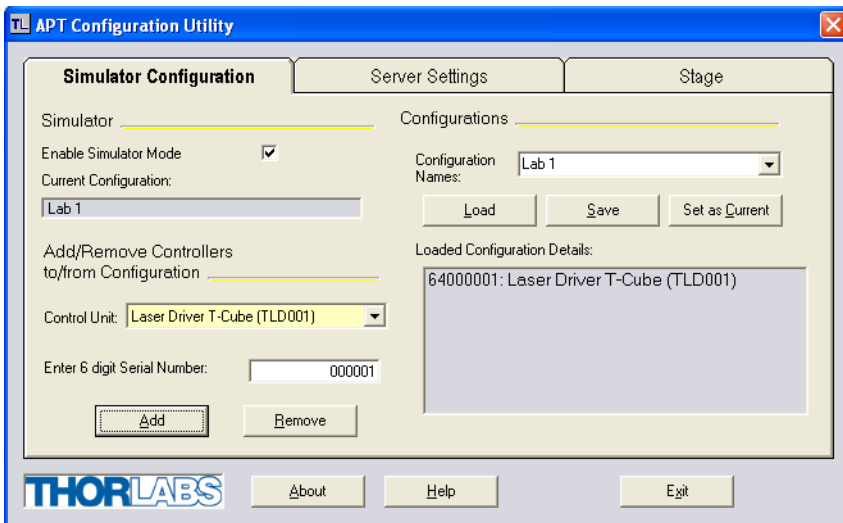
All basic operating parameters can be altered and, similarly, all operations (such as laser intensity adjustment) can be initiated. Settings and parameter changes can be saved and loaded to allow multiple operating configurations to be created and easily applied.

For many users, the APTUser application provides all of the functionality necessary to operate the APT hardware without the need to develop any further custom software. For those who do need to further customize and automate usage of the controller, this application illustrates how the rich functionality provided by the APT ActiveX server is exposed by a client application.

Use of the APT User utility is covered in the PC tutorial (Chapter 5) and in the APTUser online help file, accessed via the F1 key when using the APTUser utility.

1.3.3 APT Config Utility

There are many system parameters and configuration settings associated with the operation of the APT Server. Most can be directly accessed using the various graphical panels, however there are several system wide settings that can only be made 'off-line' before running the APT software. These settings have global effect; such as switching between simulator and real operating mode and incorporation of calibration data.



The APTConfig utility is provided as a convenient means for making these system wide settings and adjustments. Full details on using APTConfig are provided in the online help supplied with the utility.

Use of the APT Config utility is covered in the PC tutorial (Chapter 5) and in the APTConfig online help file, accessed via the F1 key when using the APTConfig utility.

1.3.4 APT Server (ActiveX Controls)

ActiveX Controls are re-usable compiled software components that supply both a graphical user interface and a programmable interface. Many such Controls are available for Windows applications development, providing a large range of re-usable functionality. For example, there are Controls available that can be used to manipulate image files, connect to the internet or simply provide user interface components such as buttons and list boxes.

With the APT system, ActiveX Controls are deployed to allow direct control over (and also reflect the status of) the range of electronic controller units, including the TLD001 laser diode driver. Software applications that use ActiveX Controls are often referred to as 'client applications'. Based on ActiveX interfacing technology, an ActiveX

Control is a language independent software component. Consequently ActiveX Controls can be incorporated into a wide range of software development environments for use by client application developers. Development environments supported include Visual Basic, Labview, Visual C++, C++ Builder, HPVEE, Matlab, VB.NET, C#.NET and, via VBA, Microsoft Office applications such as Excel and Word.

Consider the ActiveX Control supplied for a TLD001 APT Laser Diode driver



This Control provides a complete user graphical instrument panel to allow the Laser Diode unit to be manually operated, as well as a complete set of software functions (often called methods) to allow all parameters to be set and laser control operations to be automated by a client application. The instrument panel reflects the current operating state of the driver unit to which it is associated. Updates to the panel take place automatically when a user (client) application is making software calls into the same Control. For example, if a client application instructs the associated Laser Diode Control to set a particular output power, progress is monitored automatically by changing power readout on the graphical interface, without the need for further programming intervention.

The APT ActiveX Controls collection provides a rich set of graphical user panels and programmable interfaces allowing users and client application developers to interact seamlessly with the APT hardware. Each of the APT controllers has an associated ActiveX Control and these are described fully in system online help.

Note that the APTUser and APTConfig utilities take advantage of and are built on top of the powerful functionality provided by the APT ActiveX Server (as shown in Fig. 1.3).

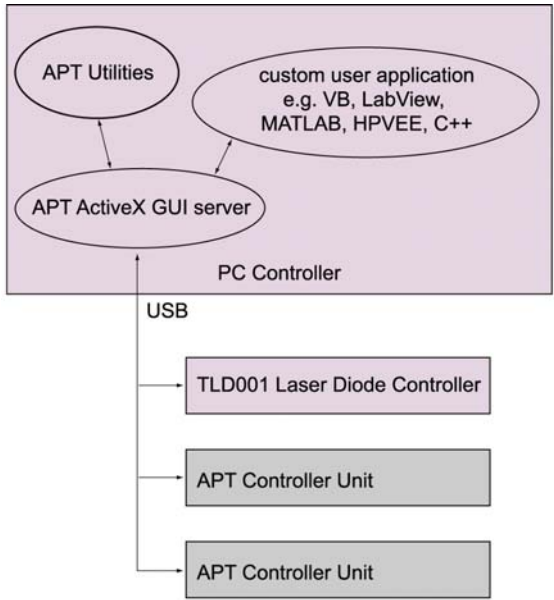


Fig. 1.3 System Architecture Diagram

Refer to the main APT Software online help file, for a complete programmers guide and reference material on using the APT ActiveX Controls collection. This is available either by pressing the F1 key when running the APT server, or via the Start menu, Start\Programs\Thorlabs\APT\APT Help.

1.3.5 Software Upgrades

Thorlabs operate a policy of continuous product development and may issue software upgrades as necessary.

Chapter 2 Safety

2.1 Safety Information

For the continuing safety of the operators of this equipment, and the protection of the equipment itself, the operator should take note of the **Warnings, Cautions** and **Notes** throughout this handbook and, where visible, on the product itself.

The following safety symbols may be used throughout the handbook and on the equipment itself.



Warning: Risk of Electrical Shock

Given when there is a risk of injury from electrical shock.



Warning

Given when there is a risk of injury to users.



Caution

Given when there is a risk of damage to the product.

Note

Clarification of an instruction or additional information.

2.2 General Warnings



Warning

If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. In particular, excessive moisture may impair operation.

Spillage of fluid, such as sample solutions, should be avoided. If spillage does occur, clean up immediately using absorbant tissue. Do not allow spilled fluid to enter the internal mechanism.

2.3 Warnings Relating To Laser Safety



Warning

In itself, this laser driver does not produce any laser radiation, and Thorlabs has no control over the rating of the laser diodes this product may be used to drive. It is the users responsibility to ensure that the appropriate protection is used, and that standard safety precautions observed. The users attention is drawn to the following precautions:

Inappropriate use of any Laser product could result in permanent eye damage.

To prevent injury, all personnel in the vicinity of the laser driver should wear appropriate eye protection.

Chapter 3 Getting Started

3.1 Mechanical Installation

3.1.1 Environmental Conditions

**Warning**

Operation outside the following environmental limits may adversely affect operator safety.

Location	Indoor use only
Maximum altitude	2000 m
Temperature range	5°C to 40°C
Maximum Humidity	Less than 80% RH (non-condensing) at 31°C

To ensure reliable operation the unit should not be exposed to corrosive agents or excessive moisture, heat or dust.

If the unit has been stored at a low temperature or in an environment of high humidity, it must be allowed to reach ambient conditions before being powered up.

3.1.2 Mounting Options

The T-Cube Laser Driver is shipped with a baseplate fitted, ready to be bolted to a breadboard, optical table or similar surface.

If required, the baseplate can be removed and the unit can be stood on rubber feet - see Section 3.1.3.

For multiple cube systems, a USB controller hub is available - see Section 1.2. for further details. Full instructions on the fitting and use of the controller hub are contained in handbook for the product.

**Caution**

When siting the unit, it should be positioned so as not to impede the operation of the control panel buttons.

Ensure that proper airflow is maintained to the rear of the unit. Do not cover the ventilation holes in the case.

Note

During its operation the T-Cube Laser Driver dissipates some heat that causes a temperature rise inside the unit. This in turn, can reduce the precision of the unit slightly, especially at high output currents. For the highest level of precision it is therefore beneficial to mount the unit onto the optical table (or other metal surface) where the large metal surface of the table will conduct most of the heat away from unit. Mounting the unit on the TCH002 hub will also have the same benefit

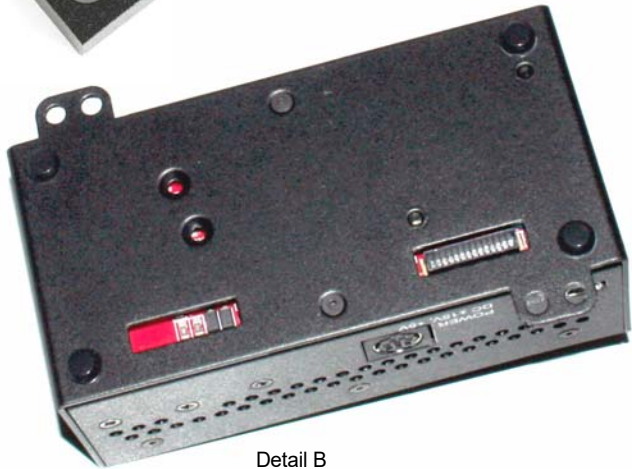
3.1.3 Removing the Baseplate

In order to help mounting the unit to an optical table, a baseplate is provided with the unit. However, if the unit is required to be operated free-standing (for example on a bench), the baseplate can be removed and rubber feet fitted.

The baseplate must be removed before the rubber feet (supplied) can be fitted, or the unit is connected to the USB controller hub.



Detail A
Baseplate attachment screws



Detail B

Fig. 3.1 Removing The Baseplate

- 1) Using a hexagon key, remove the bolts securing the unit to the baseplate. Retain the bolts for future use if the baseplate is refitted.
- 2) Turn the unit upside down.
- 3) Remove the backing paper from the rubber feet (supplied) taking care not to touch the exposed adhesive surface.
- 4) Position the feet as desired, then press and hold for a few seconds until the adhesive has bonded.
- 5) The unit may now be used freestanding, sitting on its rubber feet.

3.2 Rear Panel Connections Overview

3.2.1 Rear Panel Description

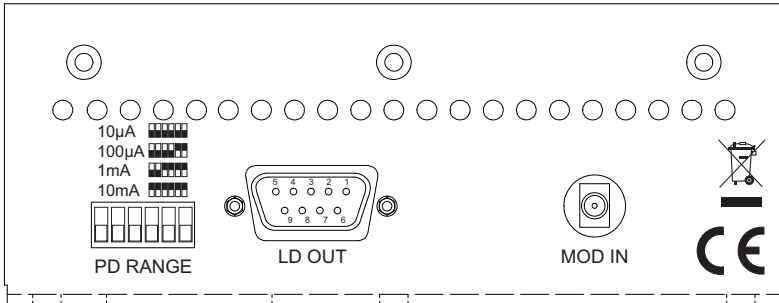


Fig. 3.2 Rear Panel Connections

PD RANGE – These micro switches are used to set the current range appropriate for the photo diode being used 10 mA, 1 mA, 100 μA or 10 μA. - see Section 3.3.7.

LD OUT (9-Pin D-Type) – The 'LD OUT' connector exposes a number of electrical terminals used when connecting the laser diode or photo diode - see Section 3.3.4.

It also exposes the Interlock connection, which must be closed before the laser diode can be turned on - see Section 3.3.11. For pin out details, see Appendix A.2

MOD IN (SMA connector) – Modulation or analog control input, -10V to +10V - see Section 5.5.

Note

Thorlabs supply a variety of SMA to BNC and SMC to BNC adaptor and extension cables. Please see our catalog, or visit www.thorlabs.com for further details.

3.3 Power Supply Connection

3.3.1 Supply Voltage and Current Requirements



Warning

Exceeding the power supply maximum voltage, or connecting a reverse polarity voltage can cause permanent damage to the unit and could result in personal injury.

Supply	Minimum	Maximum	Max Operating Current
+5V	+4.9V	+5.1V	400 mA
+15V	+14.5V	+15.5V	250 mA
-15V	-14.5V	-15.5V	250 mA

3.3.2 Connection To A Standalone Power Supply



Warning

The unit must be connected only to a DC supply as detailed in Section 3.3.1. Connection to a supply of a different rating may cause damage to the unit and could result in injury to the operator.

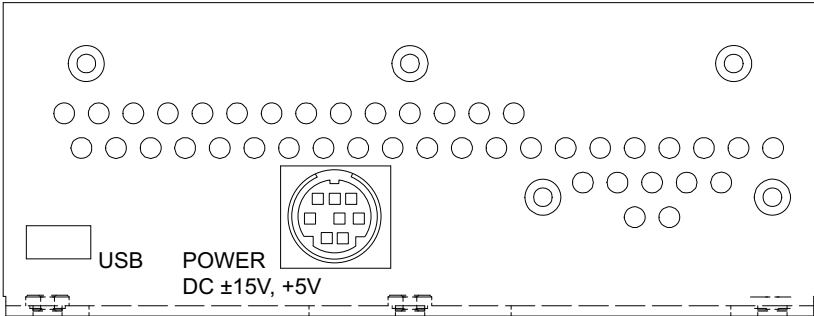


Fig. 3.3 Front Panel Power Supply Connector

- 1) Using the front panel connector as shown above, connect the unit to a regulated DC power supply of the rating detailed in Section 3.3.1.
- 2) Switch on the Power Supply unit.
- 3) The Version number of the embedded software is displayed for a few seconds.
- 4) If the unit is to be used with a PC, connect the USB cable.

Thorlabs offers a compact, two-way power supply unit (TPS002), allowing up to two Laser Diode driver T-Cubes to be powered from a single mains outlet. However, if an external supply is to be used, see Appendix A.1 for power supply connector pin out details.



Caution

If an external power supply is used, ensure that the 3 supply voltages are turned on and off simultaneously. Applying the supply voltages with a large (> 1s) delay between them can result in the laser diode driver cube showing an incorrect reading.

3.3.3 Configuring The Unit to the Laser Diode

Before the laser diode controller can be used, it must be configured to operate with the specific laser diode it is intended to drive. The following section explains why certain parameters must be set for specific types of laser diode. The set up procedure may be performed manually, using the top panel buttons (see Section 4.4.) or remotely via a PC (see Section 5.4.).

The configuration process consists of the following main steps:

- setting the laser diode polarity,
- setting the maximum laser current,
- adjusting the photodiode range and gain,
- optical power calibration.

These steps only need to be done once for a given laser diode. Once the setup has been completed, the TLD001 stores the corresponding parameters in non-volatile memory and they are loaded automatically at each power-up.

3.3.4 Laser Diode Polarity

Laser diodes are manufactured in a variety of packages and pin configurations, with or without an internal photodiode. In addition, normally one terminal of the laser diode is connected to the metal case and commoned with either the anode and cathode of the photodiode.

The TLD001 has been designed to drive all the possible configurations but care is needed to ensure that the laser diode is connected to the controller correctly. Although the TLD001 provides some protection against some common wiring errors, some faults, such as accidentally swapping the laser diode and the photodiode or connecting the laser diode with reverse polarity can still cause damage to the laser diode module.

For the lowest noise and highest level of protection, the case of the laser diode package should always be connected to the electrical system ground. Since normally the case will also be electrically connected to either the anode or the cathode of the laser diode, this results in two common configurations: anode grounded (AG) and cathode grounded (CG). This can be established from the laser diode data sheet and the device should be connected to the D-type connector on the TLD001 accordingly. Additionally, in most cases either the anode or the cathode of the internal photodiode (if there is one) is also connected to the case, resulting in four possible configurations, as shown in Fig. 3.4.

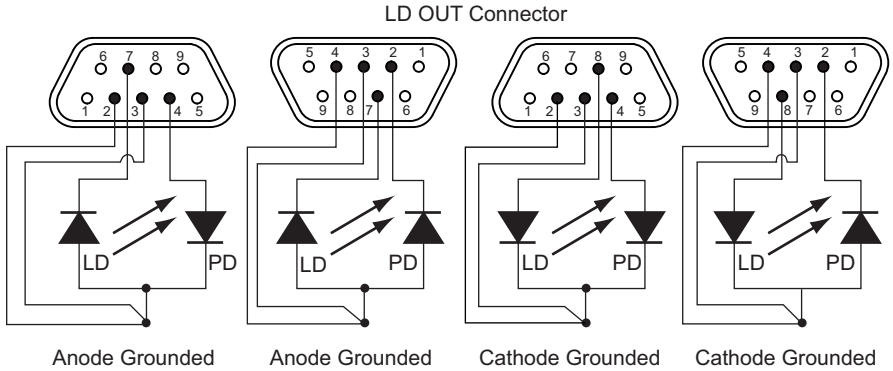


Fig. 3.4 Laser diode connections

Whilst these four configurations are the most commonly found, in some cases the laser diode, or the photodiode or both are isolated, i.e. electrically not connected to the case. For these types of laser diode to be used with the TLD001 unit, one terminal of the laser diode and/or photodiode **MUST BE** grounded externally, ideally as close to the case as possible.

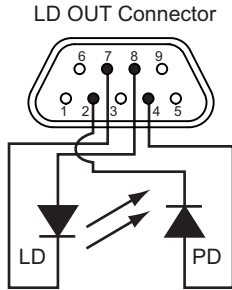


Fig. 3.5 Floating laser diode & photodiode connections

Note

In this case, the ground connection (pin 3) may be connected to the anode (pin 8) or the cathode (pin 7) of the laser diode, and to the anode (pin 4) or the cathode (pin 2) of the photodiode. In order to prevent measuring errors, this connection should be made as close as possible to the laser diode.

The polarity of the laser diode may be set via the top panel buttons (see Section 4.4.) or through the GUI settings panel (see Section 5.4.):

3.3.5 Connecting the Photodiode with Bias

There are 2 modes of operation for photodiodes; zero bias (photovoltaic mode) or reverse bias (photoconductive mode). When operating with zero bias, light falling on the diode causes a current across the device, leading to forward bias which in turn induces "dark current" in the opposite direction to the photocurrent. The normal operating mode for the TLD001 is photovoltaic (zero bias) mode.

With reverse bias, a battery is connected in series with the photodiode to hold the device in reverse bias. This is normally done to improve the transient response (i.e. speed) of the photodiode. If the photodiode is to be operated with reverse bias, the battery can be connected as shown in Fig. 3.6 below.

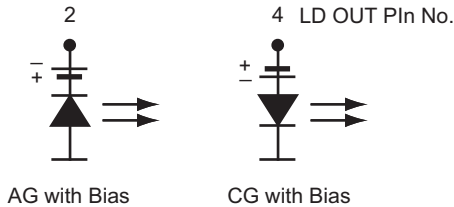


Fig. 3.6 Battery connections for biased operation

3.3.6 Laser Diode Drive Current Limit

Setting the maximum current the unit can output under any operating conditions ensures that the laser diode cannot be damaged by accidental overdriving. Individual laser diodes show a very large production spread, and the maximum current that a given device can be operated at varies from device to device.

From an electrical point of view, laser diodes are similar to LEDs, in that both devices are semiconductor diodes that emit light. However, while LEDs are very simple to use, require no device-to-device characterization, and are relatively resilient to damage, laser diodes need far more sophisticated driver electronics.

For example, most common small LEDs work reasonably well at 10mA. Laser diodes on the other hand, need to be individually set to an operating current. Furthermore, because of their inherent sensitivity to the operating conditions, some devices may not produce any laser light at a particular current, while others may become damaged at the same current.

In addition, it is helpful to consider the output power versus drive current characteristics of laser diodes as shown on the next page.

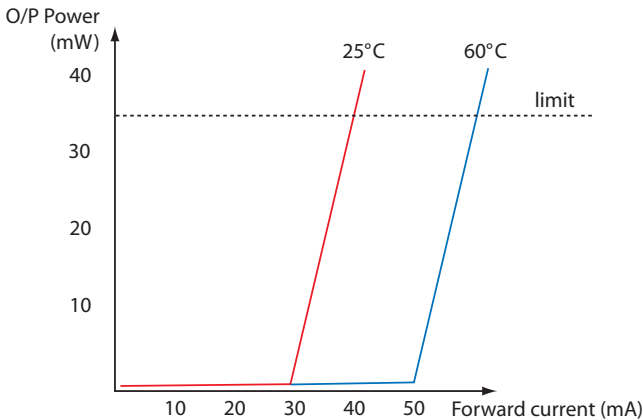


Fig. 3.7 Laser Diode Power v Current Characteristics

Fig. 3.7 shows a typical laser diode power v current behavior. At currents below a certain 'threshold current', the laser diode produces very little optical power. Once a threshold current is exceeded, the output power starts increasing very rapidly. At a particular current the optical power reaches a maximum value specified for the device, and any further increase can easily damage the laser diode, even if it occurs only for a very short length of time (a few % above the maximum operating current for a microsecond can cause a catastrophic failure).

The threshold current and maximum operating current vary from device to device, therefore the operating conditions for individual laser diodes must be set very carefully. The threshold and maximum operating current values are also very sensitive to temperature, therefore it is recommended that laser diodes are not operated above 80% of their rated maximum output power.

Generally, unless the electrical parameters of the given laser diode are already known (i.e. the diode has been characterized), the drive current limit must be derived by experiment. This involves connecting an optical power meter to the laser diode and continually monitoring the optical power whilst gradually increasing the drive current, taking care to stay within the maximum optical power quoted by a safe margin (usually 20%).

In general, setting the maximum current must be performed with extreme caution. The process is complicated by the temperature dependence of the laser power: as the laser diode chip warms up, the optical power decreases. This can create a potentially dangerous situation during current limit adjustment. The problem is that since during the current limit adjustment the laser chip warms up, the maximum laser current adjustment will be made for a warm laser diode chip. If now the laser diode is turned off, allowed to cool down and then turned back on again with the maximum laser current applied, the cold laser diode chip will produce a much higher optical power

output. If this exceeds the limit specified for the laser diode, the device can get damaged.

3.3.7 Photodiode Current (I_{PD}) Range

Regardless of whether the photodiode is operated in zero bias or reverse bias mode, the current range applicable to the photodiode selected must be set.

This is because each photodiode produces a different photocurrent, and therefore it is not possible to cover all possible devices with a single range. For photodiodes that are part of a laser diode package, the photocurrent produced at the rated maximum power is normally published in the data sheet, so setting the range can be done easily.

Note

It is not unusual for the published value to be specified with a factor of 4 tolerance (e.g. min. 0.5mA, max 2.0mA) and sometimes the values may fall in different ranges. In other instances, for example when an external photodiode is used, the range may not be known. Even if the range is unknown, the TLD001 offers a quick and simple procedure to allow the correct range to be set.

The unit has 4 settings to accommodate photodiode current ranges from 10 μ A to 10mA. The range can be selected using the micro switches accessible via the rear panel.

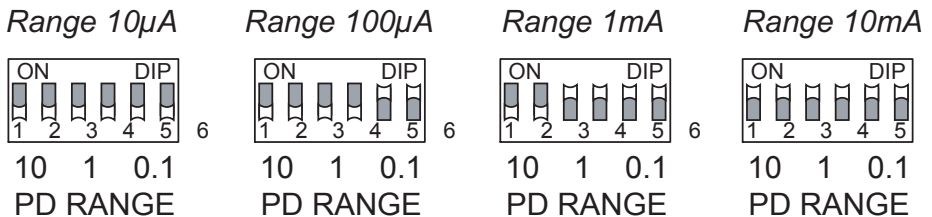


Fig. 3.8 Rear panel PD RANGE micro switches

The photodiode current range is normally done with the laser diode operating at the drive current limit, when the photodiode will produce a specific photo current. If this photocurrent value is known, the PD RANGE switches on the rear panel can simply be set to the correct range. If the photocurrent value is not known, then the procedure involves switching the TLD001 into a special PD RANGE adjustment mode and trying all ranges from 10mA downwards. The unit will indicate whether a given range is too high, too low, or correct. - see Section 4.4. or Section 5.4.

3.3.8 Optimization of the PD Current Gain

Optimization of the PD Current Gain, is an automated process performed internally by the unit, and should be performed only after the PD RANGE has been adjusted.

In the APT system, the software “demand” of how much current (in constant current mode) or optical power (in closed loop mode) is being generated by the laser diode is

set by a digital to analog converter (DAC). This DAC produces a voltage that the software can set to be between zero and a fixed reference voltage.

When constant power mode is selected, a closed loop controller is set up that continuously reads the photocurrent and adjusts the laser power accordingly, so that the photocurrent is always equal to a “setpoint” value (the optical power is kept constant by keeping the photocurrent constant.). To enable the full range of the DAC to be used, the photodiode current readings must be “normalized”, so that the full range (i.e. maximum photocurrent) corresponds to the DAC full range. The “optimize current gain” button carries out this normalization.

For example, assume the DAC generates a voltage between zero and 5 Volts maximum.

In a particular set up, we may find that at maximum optical power, the photodiode produces 25 μA . When the “Optimize TIA current gain” button is pressed, the system adjusts the photodiode TIA gain to $0.2 \text{ V} / \mu\text{A}$ so that the photodiode amplifier outputs 5 Volts.

In another setup, the photodiode produces a different current for max optical power, so a different photodiode amplifier gain is required.

For convenience, it is preferable to initiate the optimization process from the GUI Settings panel because this is more visually intuitive - see Section 5.4. (once the unit has been configured to work with the chosen laser diode, further operation can then be performed without a PC). However, it is also possible to perform the optimization process from the top panel buttons, without a control PC - see Section 4.4.

3.3.9 Calibrating the Power Display

The displayed power is derived from the photodiode current, and the relationship between these parameters will differ between laser diodes. Therefore, the power display must be tuned to the diode being driven before the output power of the laser diode can be shown or adjusted accurately. This can be achieved via the front panel configuration menu (see Section 4.4.) or by entering a Watts/Amps calibration factor in the GUI Settings panel (see Section 5.4.).

3.3.10 Summary

- 1) For the TLD001 unit to drive a laser diode satisfactorily, the following prerequisites must be met:
 - Either the anode or the cathode of the laser diode must be connected to ground.
 - If a particular laser diode has the anode or cathode connected to the case, then this terminal is the grounded terminal.
 - Most laser diodes also have a built in photodiode. If the photodiode is present, then its anode or cathode must also be connected to ground.
 - In most cases, if the laser diode is supplied in a package with a built in photodiode, one of the photodiode terminals will be connected to the case. This configuration is dictated by the package.
 - You must not use a 'floating' photodiode. Either the anode or cathode must be connected to the system ground.

- 2) The displayed power is derived from the Photodiode current, which is wavelength and temperature dependent. The wavelength also varies with temperature. Therefore, the power readout will not be stable unless a TEC stabilized mount (such as the LDM90) and compatible controller (TTC001) is used.

3.3.11 Using the Safety Interlock and Key Switch

The Controller is fitted with a functional interlock and key switch. The key switch must be turned on, and a short circuit must be applied across the terminals of the interlock (pins 1 and 5) before the unit can be enabled.

If the unit is used with a Thorlabs LM14S2, LDM21, LDM56 or LDM90 laser diode mount, the interlock connection is integral within the mount (cable CAB400 required). Alternatively, the contact can be controlled externally; the user can connect the pins to a remote actuated (normally open) switch (e.g. an open door indicator), which must be closed before the unit can operate. In this case, the resistance of the connection must be $<430\Omega$.

The interlock input also doubles up as an external 'Laser On' LED driver output. For visual indication of the laser operating, it is possible to connect an LED to the interlock input. If this option is required, any standard LED can be used that has a forward voltage of less than 3 Volts. Most common red, orange, yellow and green LEDs meet this condition.

Note

When open circuit, the INTERLOCK pin (pin 1) is at about +5.0V. When shorted, the current is typically 10mA.

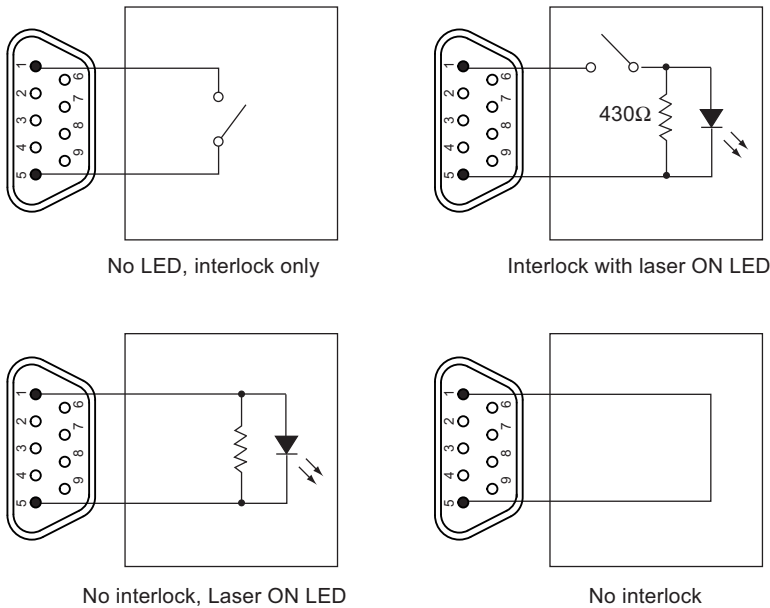


Fig. 3.9 Interlock Connection Options



Caution

The interlock lines can be permanently shorted if no interlock function is required (see Fig. 3.9). This option should be used **ONLY** if there is no possible safety hazard associated with using the product.

Chapter 4 Standalone Operation

4.1 Introduction

The control panel of the TLD001 Laser Diode Controller T-Cube contains a 5 digit 7 Segment display, adjustment potentiometer, Mode, Display and Laser ON buttons, and a keyswitch.

The following brief overview explains how the front panel controls can be used to perform a typical series of operations.

4.2 Control Panel Buttons and Indicators

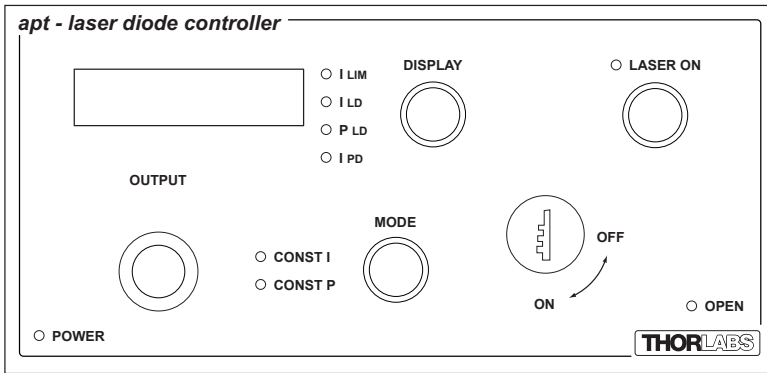


Fig. 4.1 Panel Controls and Indicators

Main Display - 5 digit LED display. Can be set to show one of 4 operating parameters as follows:

- I_{LIM} - the maximum drive current limit (see Section 3.3.6. and Section 4.4.)
- I_{LD} - the laser diode drive current in mA

Note. The maximum value available is dependent upon the laser diode drive current limit - see Section 3.3.6. and Section 4.4.

- P_{LD} - the laser diode optical output power in mW

Note. The maximum value is dependent upon the photodiode current range (I_{PD}), set by the rear panel micro switches (Section 3.3.7.), and the power display calibration setting see Section 4.4.

- I_{PD} - photo diode current in mA.

Note. The maximum value is dependent upon the photodiode current range (I_{PD}), set by the rear panel micro switches (see Section 3.3.7.).

The corresponding LED is lit when a parameter is selected. In addition, the I_{LIM} LED starts flashing if the max drive current limit is reached.

DISPLAY Button - Switches between the operating parameters described above.

OUTPUT Potentiometer - Used to set the output intensity (power) of the laser.

MODE Button - Switches between CONSTANT POWER and CONSTANT CURRENT modes - see Section 4.8.

LASER ON Button - Turns the laser output ON and OFF. The LED is lit when the laser is on.

OPEN LED - Lit when the INTERLOCK is open - see Section 3.3.11. Flashes when the laser diode is open circuit.

POWER LED - Lit when power is applied to the unit.

KEYSWITCH - Turns the laser output ON and OFF. The KEYSWITCH LED on the GUI panel is lit green when the key switch is turned ON and red when the switch is OFF - see Section 6.1.

Note

The main display and the POWER LED will flash when the 'Ident' button is clicked on the APT Software GUI panel - see Section 6.1. for further details.

4.3 Set Up Preparation

The following procedure assumes that the laser diode is mounted in a Thorlabs LM14S2, LDM56, LDM90 or LDM21 diode mount. If this is not the case, care must be taken to ensure that the laser diode is connected to the rear panel D-Type connector with the correct polarity - refer to Section 3.3.4. for more details. A power meter and suitable detector head are also required.

- 1) Insert the laser diode into the diode mount, taking care to observe the correct orientation.
- 2) Set the switches on the diode mount to select the correct polarity (AG or CG) for the diode being used.
- 3) Using cable CAB400, connect the diode mount to the TLD001 unit.
- 4) Connect the TLD001 to the power supply.
- 5) Attach the power meter to the diode mount.
- 6) Ensure that the KEYSWITCH on the TLD001 is set to OFF, then turn on the power to all units.

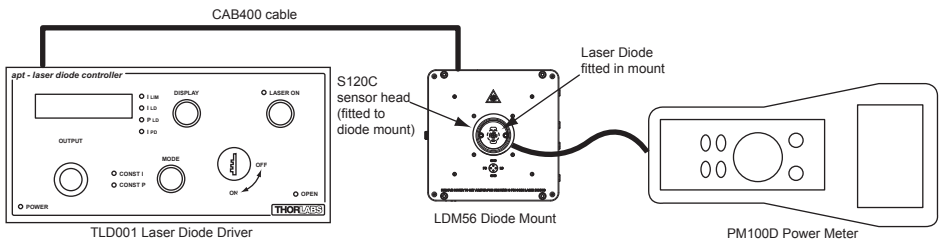
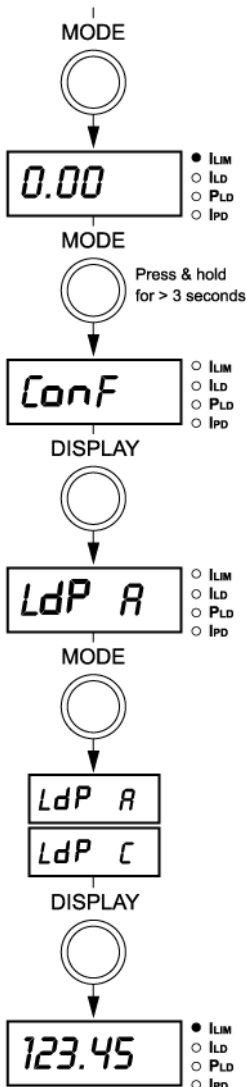


Fig. 4.2 Typical System

4.4 Front Panel Set Up Procedure

Before the laser diode driver can be used, it must be configured to operate with the specific laser diode it is intended to drive. The following section explains how the unit can be set up using the top panel buttons, and assumes that the preparation procedure detailed at Section 4.3. has already been performed.



Accessing the Configuration Menu

Press the MODE button until the ILIM LED is lit, and turn the KEYSWITCH to OFF.

Press and hold the MODE button for more than 3 seconds.

The display shows *Conf* to indicate that the unit is in 'configuration' mode.

Press the DISPLAY button to access the Laser Polarity parameter.

Laser Diode Polarity

This parameter allows the polarity of the laser diode to be set - see Section 3.3.4.

Press the MODE button to edit this parameter, or press the DISPLAY button to skip to the next parameter.

Press the MODE button to select the required polarity.

LdP A - Anode Grounded

LdP C - Cathode Grounded

Press the DISPLAY button to access the Max Laser Current parameter.

Continued on next page...

Max Laser Current

This parameter allows the laser diode drive current limit to be set - see Section 3.3.6. The maximum laser current adjustment can be done with the laser on or off.

Press the MODE button to edit this parameter, or press the DISPLAY button to skip to the next parameter.

When the MODE button is pressed, the display reverts to the minimum drive current value (around 17.0 mA).

To turn the laser on now, turn the KEYSWITCH to ON and press the LASER ON button.

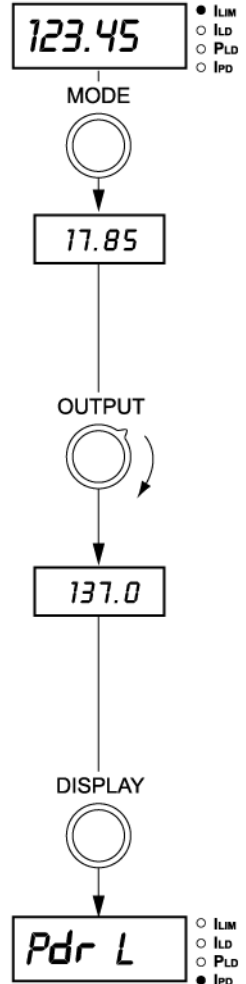
Turn the OUTPUT knob to set the max laser current value for the laser diode being driven. If this value is not known, turn the OUTPUT knob until the power displayed on the power meter is at the required level.

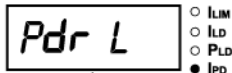
Take extreme care never to exceed the maximum power level specified in the data sheet, and take into account the possible thermal effects described in Section 3.3.6. It is highly recommended to stay well below (at least 20%) the maximum laser power specified for the given laser diode.

Note. Note that the maximum laser current is adjustable in about 235 steps, with each step changing the current by about 0.7 mA.

Press the DISPLAY button to access the Photodiode Range parameter.

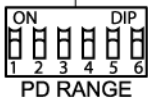
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Photodiode Range

This parameter allows the correct photodiode current amplifier range to be set - see Section 3.3.7. Note that in order to be able to do this, the laser must be turned on as otherwise the photocurrent will be zero. Also, it makes sense to carry out this step at the maximum laser power where the photocurrent is also at its maximum. If the laser diode was turned on at the previous step (during the maximum laser current adjustment), it will stay on. If it was not, it can now be turned on by setting the KEYSWITCH to the ON position and pressing the LASER ON button. In either case, the laser will be operated at the maximum current setting.

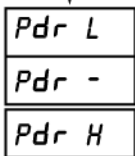


Initially always set the PD RANGE switches to the 10 mA range (all switches must be in the upwards, ON position).

Note that during the adjustment I_{PD} LED is lit to indicate that photodiode current is being displayed.

Adjust the PD RANGE microswitches on the rear panel until *Pdr -* is displayed (i.e. the range is OK.)

The switches should always be adjusted from a higher range towards the lower ranges, i.e. in the 10 mA -> 1 mA -> 100 uA -> 10 uA order. If the sequence is not followed, the display may be incorrect.



Pdr L Range too low (under range)

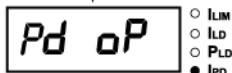
Pdr - Range OK

Pdr H Range too high (over range)

DISPLAY



Press the DISPLAY button to access the Photodiode Gain Optimization parameter.



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Photodiode Gain Optimization

This parameter allows the photodiode gain to be optimized - see Section 3.3.8. Optimization is performed automatically by the unit.

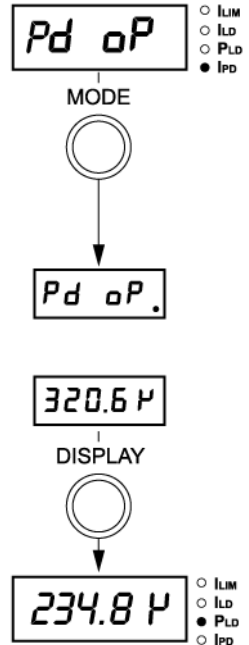
Press the MODE button to perform the optimization, or press the DISPLAY button to skip to the next parameter.

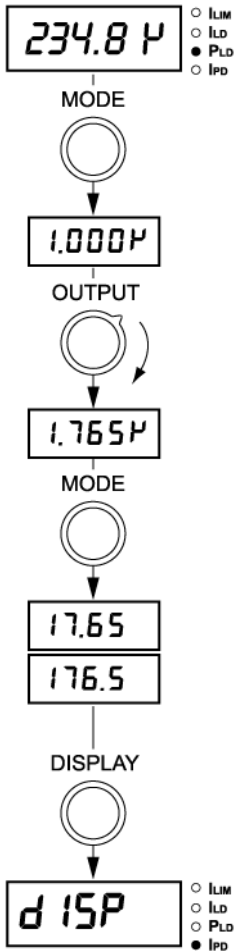
When the MODE button is pressed, the display shows $Pd \ \alpha P$ and a dot flashes to indicate that the optimization sequence is in progress.

Once optimization is complete, the display shows the photocurrent.

Press the DISPLAY button to access the Laser Power parameter.

Continued on next page...





Laser Power Display Calibration

This parameter allows the laser power reading on the unit to be calibrated to the display on the power meter.

Press the MODE button to edit this parameter, or press the DISPLAY button to skip to the next parameter.

When the MODE button is pressed, the display shows an uncalibrated power value. The power meter shows a value which corresponds to the actual laser current.

Turn the OUTPUT pot to set the TLD001 display to read the same numerical digits as the power meter (Ignore the decimal point and the 'u' sign for now, this will be set in the next step). The value displayed can be changed between 1.000 and 9.999. For example, if the power meter shows 5 mW, set the display to 5.000u.

Now press the MODE button to set the range.

The decimal point moves to the right with each press, and the μ sign disappears when the mW range is selected.

After the highest range is reached, the process goes back to the lowest range, so if a range is missed, it can still be reached by further presses.

Following on from the same example as above, if the power meter shows 5 mW, press the MODE button until the display shows 5.000 (no 'u' sign).

Press the DISPLAY button to access the Display Brightness parameter.

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Display Brightness

This parameter allows the display brightness to be adjusted.

Press the MODE button to edit this parameter, or press the DISPLAY button to skip to the next parameter.

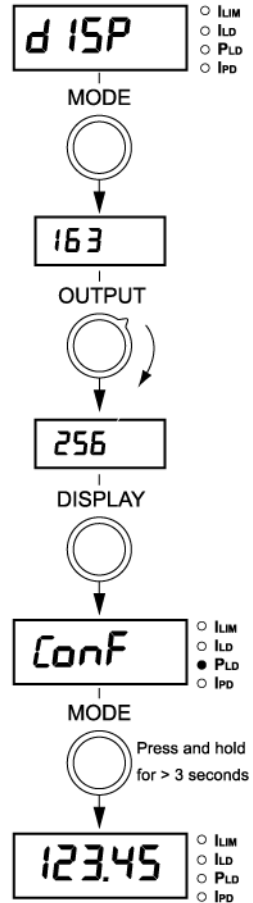
When the MODE button is pressed, the display shows a value from 0 to 256, which represents the brightness setting.

Turn the OUTPUT pot to set the required brightness level. As the number changes, the display brightness also changes accordingly. When the desired brightness is found, stop.

Press the DISPLAY button to return to the start of the configuration menu.

Press the DISPLAY button to repeat the cycle, or press and hold the MODE button for more than 3 seconds to return to the normal operating mode.

When the unit returns to the normal operating mode, the setup is automatically saved into non-volatile memory and the corresponding parameters will be automatically loaded when the unit is next powered up. This means that the setup process will not normally need to be repeated unless a different laser diode is used.



4.5 Manual Operation Tutorial

- 1) Connect a laser diode to the LD OUT socket on the rear panel.
- 2) Make power supply connections as detailed in Section 3.3.1.
- 3) Turn ON the power supply unit.
- 4) Close the INTERLOCK connection - see Section 3.3.11. If the unit is used with a Thorlabs LM14S2, LDM21 LDM56 or L DM90 laser diode mount, the mount incorporates the interlock connection.
- 5) Turn the Key Switch ON.
- 6) Press the ENABLE button to turn ON the laser output.
- 7) Turn the OUTPUT control to adjust the laser intensity.

Note

The keyswitch must be turned 'ON' and the interlock fitted before the laser can be enabled. During normal operation, if the interlock is removed or the keyswitch turned 'OFF', the unit must be re-enabled before it can operate.

4.6 Error Codes

In order to protect the laser diode connected to the TLD001, the processor constantly monitors the power supply voltages. If any of the PSU voltages is out of tolerance, the processor disables the laser output, suspends any further action and displays an error message on the numerical display. as follows:

"E9" : +9 V supply failure "E-9": -9V supply failure
"E15": +15V supply failure "E-15": -15V supply failure
"E915": multiple supply failures

Note

The +9V and -9V supplies are internal to the cube and error messages relating to them are usually only a side effect of failing external supply voltages (+5V, +15V and -15V).

4.7 Output Potentiometer Operation

The OUTPUT potentiometer is an infinite turn encoder, used to adjust the output of the laser diode. To increase the output, turn the potentiometer clockwise - once the maximum output is attained, subsequent clockwise turns have no effect, however the output decreases immediately the control is turned anticlockwise. Similarly, once the output has been decreased to zero, subsequent anticlockwise turns have no effect, but the output increases immediately the control is turned clockwise.

The pot is also sensitive to the speed of how fast it is turned. If the pot is turned fast a few times, the rate of change accelerates. In this way accurate adjustments can be made quickly in a wide range. The desired value can be approached quickly by turning the knob fast, then fine tuned by slower rotation.

4.8 Mode Button Operation

The TLD001 laser diode driver can be operated in either Constant Current or Constant Power mode.

4.8.1 Constant Current Mode (CONST I)

As the name implies, this mode applies a constant drive current to the laser diode. However, due to temperature fluctuations this does not result in a constant optical power output. As the diode warms up, the optical power will increase noticeably from the level at initial switch on. Ambient temperature changes will also effect the output.

This mode is used when the lowest noise and highest response speed is required. Most applications in this mode will also require the temperature to be stabilized by an additional temperature controller. Thorlabs offers the TTC001 TEC Controller T-Cube for such applications, see www.thorlabs.com for more details.

4.8.2 Constant Power Mode (CONST P)

To minimize the output power fluctuations described above, the laser diode can be operated in Constant Power mode. This involves a signal from the internal photodiode, integrated into most laser diode packages, being fed back to the TLD001 unit in order to monitor and correct the power output.

In constant power mode, the feedback loop inside the TLD001 attempts to maintain constant optical power by continuously monitoring the photocurrent and if necessary adjusting the output current to maintain the same photocurrent. As the photocurrent is proportional to the optical power, the scheme ensures that the optical power remains stable. The laser diode current limit setting still applies in this mode; the output current will not be increased above the limit.

Note that whilst in constant power mode the optical power is normally more stable than in constant current mode, the scheme is still limited by the fact that the photocurrent generated by the photodiode is dependent on both the temperature and the wavelength. If the temperature of the laser diode fluctuates, the wavelength shifts and this in itself also causes a change in photocurrent. For highest accuracy, laser diodes are therefore normally operated in a temperature-stabilized manner. Thorlabs offers the TTC001 TEC Controller T-Cube for such applications, see www.thorlabs.com for more details.

An adjustment of the full scale photodiode current in CONST P mode is provided in order to compensate for the differences in the photodiode currents between different laser diodes - see Section 3.3.7.

Chapter 5 PC Operation - Tutorial

5.1 Introduction

The following brief tutorial guides the user through a typical series of actions and parameter adjustments performed using the PC based APT software. It assumes that the unit is electrically connected as shown in Section 3.2.

5.2 Install The Software

Note

When operating via a PC, direct user interaction with the laser diode driver is accomplished through intuitive graphical user interface panels (GUIs), which expose all key operating parameters and modes. The user can select multiple panel views displaying different information about a particular hardware unit. The multitasking architecture ensures that the graphical control panels always remain live, showing all current hardware activity.



Caution

The software must be installed BEFORE the driver is connected to your PC.

If you experience any problems when installing software, contact Thorlabs on +44 (0)1353 654440 and ask for Technical Support.

- 1) Download the APT software from www.thorlabs.com.
- 2) Double click the setup.exe file and follow the on-screen instructions.

5.3 Set Up Preparation

The following procedure assumes that the laser diode is mounted in a Thorlabs LM14S2, LDM56, LDM90, or LDM21 diode mount. If this is not the case, care must be taken to ensure that the laser diode is connected to the rear panel D-Type connector with the correct polarity - refer to Section 3.3.4. for more details. A power meter equipped with a suitable sensor is also required.

- 1) Insert the laser diode into the diode mount, taking care to observe the correct orientation.
- 2) Set the switches on the diode mount to select the correct polarity (AG or CG) for the diode being used.
- 3) Using cable CAB400, connect the diode mount to the TLD001 unit.
- 4) Connect the TLD001 to the power supply.
- 5) Connect the power meter sensor to the diode mount.
- 6) Ensure that the KEYSWITCH on the TLD001 is set to OFF, then turn on the power to all units.
- 7) Connect the TLD001 unit to the control PC.
- 8) Run the APT User program - Start/All Programs/Thorlabs/APT User/APT User. The APT server registers automatically the units connected on the USB bus and displays the associated GUI panels as shown in Fig. 5.1.



Fig. 5.1 Laser Driver Software GUI

5.4 Set Up Via The GUI Panel

Before the laser diode driver can be used, it must be configured to operate with the specific laser diode it is intended to drive. The following section explains how the unit can be set up using GUI Settings panel, and assumes that the preparation procedure detailed at Section 5.3. has already been performed.

Setting the Laser Diode Polarity

As described in Section 3.3.4., the TLD001 laser diode driver supports all possible polarities of laser diode and the correct polarity must be set before a diode is powered up.

- 1) Make connections and run the APTUser utility as described in Section 5.3.
- 2) On the GUI panel, click the 'Settings' button to display the 'Laser Driver Settings' panel, then select the 'General' tab.

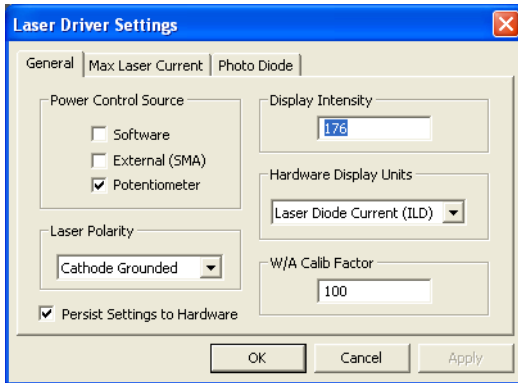


Fig. 5.2 Laser Driver Settings Panel - Photo Diode Tab

- 3) In the 'Laser Polarity' field, select either 'Anode Grounded' or 'Cathode Grounded' whichever is applicable.
- 4) Click the 'Persist Settings to Hardware' checkbox to save the settings to the unit. These settings will then be loaded on power up.

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Adjusting the Laser Diode Drive Current Limit

As previously explained in Section 3.3.6., the laser diode drive current limit must be set to ensure the diode is not overdriven.

- 5) Select the 'Max Laser Current' tab.

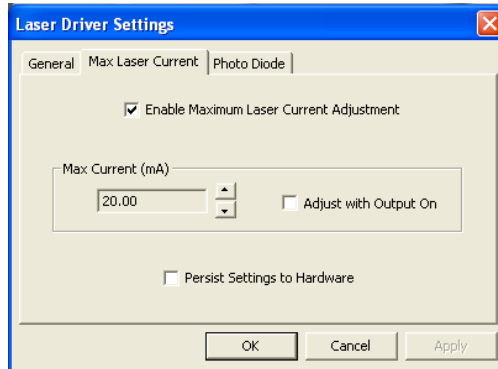


Fig. 5.3 Laser Driver Settings Panel - Photo Diode Tab

- 6) Click the 'Enable Maximum Laser Current Adjustment' check box. When this box is ticked, the maximum laser current immediately decreases to the lowest possible value (around 17.0 mA). This is to protect the laser diode so that maximum laser adjustments always start from the lowest possible value.
- 7) If the maximum laser diode current is already known, the adjustment can be done with the laser diode turned off. Click the up and down arrows to adjust the laser current until the desired value is reached.
- 8) If the maximum laser diode adjustment needs to be done with the laser diode enabled, turn the KEYSWITCH to ON on the module front panel and tick the 'Adjust with Output On' box on the GUI. Click the arrows to slowly increase the drive current until the power displayed on the power meter reaches the desired value. *Take extreme care never to exceed the maximum power level specified in the data sheet, and take into account the possible thermal effects described in section 3.5.3. It is highly recommended to stay well below (at least 20%) the maximum laser power specified for the given laser diode. Also note that if the up and down arrows are clicked and held, the rate of change will accelerate. This functionality is provided so that large changes can be made more quickly but conversely it can lead to the maximum laser current exceeding the safe operating limit for the given laser diode; so this feature must be used very carefully. Using individual clicks on the arrow is the safest option.*
- 9) Click the 'Persist Settings to Hardware' checkbox.

Note that the maximum laser current is adjustable in about 235 steps (clicks), with each step changing the current by about 0.7 mA.

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Setting the Photodiode Current Range

Set the PD Current Range as follows:

10) Select the 'Photo Diode' tab.

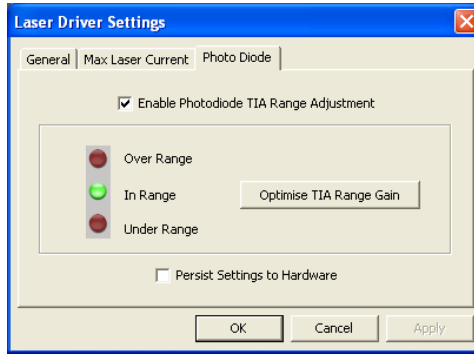


Fig. 5.4 Laser Driver Settings Panel - Photo Diode Tab

11) Click the 'Enable Photodiode TIA Range Adjustment' checkbox.

Note. The photodiode range adjustment should be performed at maximum laser drive current.

12) Using the rear panel PD RANGE microswitches (see Section 3.3.7.), select the 10mA range and check whether the 'In Range' LED on the settings panel is lit.

13) If not, select the each range in turn from 10 mA down to 10 uA, until the 'In Range' LED is lit. It is important to change ranges in decreasing order otherwise the display may be incorrect.

Photodiode Gain Optimization

As previously explained in Section 3.3.8., in order for the laser power display to be accurate, the photodiode current amplifier must be tuned to the specific diode being driven. This optimization is performed internally by the unit as follows:

14) Click the 'Optimize TIA Range Gain' button and wait until the "Photodiode current" reading on the GUI main panel settles (takes about 2 seconds).

15) Click the 'Persist Settings to Hardware' checkbox.

16) Click OK to save the settings.

Setting the Watts/Amps Calibration Factor

The displayed power is derived from the photodiode current, and the relationship between these parameters will differ between laser diodes. Therefore, the power display must be tuned to the diode being driven before the output power of the laser diode can be shown or adjusted accurately.

- 17) On the GUI panel, click the CONST P button.
- 18) Turn the OUTPUT knob to decrease the drive current to a value less than the Max Current limit. (At maximum current limit the optical power may not be constant because if the feedback loop senses a drop in the optical power, it will be unable to compensate for it by increasing the laser current.)
- 19) Note the power reading on the power meter and the Photodiode current displayed on the GUI.
- 20) Calculate the Watts/Amps calibration factor as:

$$\frac{\text{Measured Power (mW)}}{\text{PD Current (mA)}}$$

- 21) Click the Settings button and select the 'General' tab.
- 22) Enter the calibration factor into the 'W/A Calib Factor' field.
- 23) Click the 'Persist Settings to Hardware' checkbox, then click OK.

5.5 Modulation of the Laser Diode Output

It is possible that an application may demand a time dependent laser current (I_{LD}) or photodiode current (I_{PD}) instead of the normal constant output. This is achieved by connecting a modulating signal to the rear panel MOD IN connector. The voltage range is -10V to 10V, input resistance is $>10k\Omega$.

The external input is always scaled so that 0 to 10V is equivalent to 0 to I_{LIM} (in open loop) or 0 to max optical power (in closed loop), regardless of the value of I_{LIM} or P_{Max} . For example, if the maximum laser current is set to 75mA, then the 0 to 10V will result in an output current of 0 to 75mA (i.e. the transconductance of the system is not constant, but depends on the initial set up). Note that this is in addition to the current already set by the software or the OUTPUT control knob. The contribution of the external input can also be negative, i.e. a negative voltage on this input can reduce the output current or power.

The procedure for modulating the laser diode output is as follows:

- 1) Switch on the unit and select either constant current or constant power mode - see Section 4.8.
- 2) Turn the OUTPUT pot to set the desired value.
- 3) Connect the modulation source to the rear panel MOD IN connector, ensuring that ground loops are avoided.
- 4) In the GUI Settings panel, select the 'General tab', and set the Power Control Source as 'External (SMA)'.

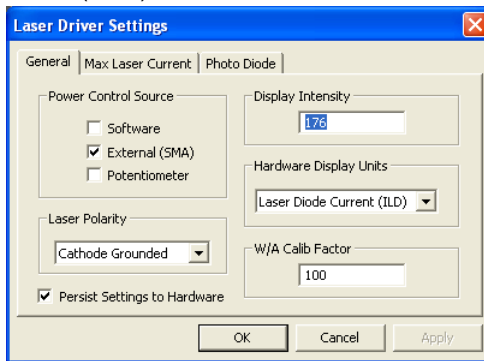


Fig. 5.5 Alser Driver Settings - General Tab

- 5) Click the 'Persist Settings to Hardware' box, then click OK.
- 6) Switch on the modulation source.
- 7) The diode current or power can be monitored on the display by selecting the various display modes - see Section 4.1.
- 8) During operation, if the current (I_{LD}) reaches the limit set (I_{LIM}), then the I_{LIM} LED flashes and the current is limited to the I_{LIM} value.

5.6 Creating a Simulated Configuration Using APT Config

The 'APT Config' utility can be used to set up simulated hardware configurations and place the APT Server into simulator mode. In this way it is possible to create any number and type of simulated (virtual) hardware units in order to emulate a set of real hardware. This is a particularly useful feature, designed as an aid learning how to use the APT software and as an aid to developing custom software applications 'offline'.

Any number of 'virtual' control units can be combined to emulate a collection of physical hardware units. For example, an application program can be written, then tested and debugged remotely, before running with the hardware.

To create a simulated configuration proceed as follows:

- 1) Run the APT Config utility - Start/All Programs/Thorlabs/APT/APT Config.
- 2) Click the 'Simulator Configuration' tab.

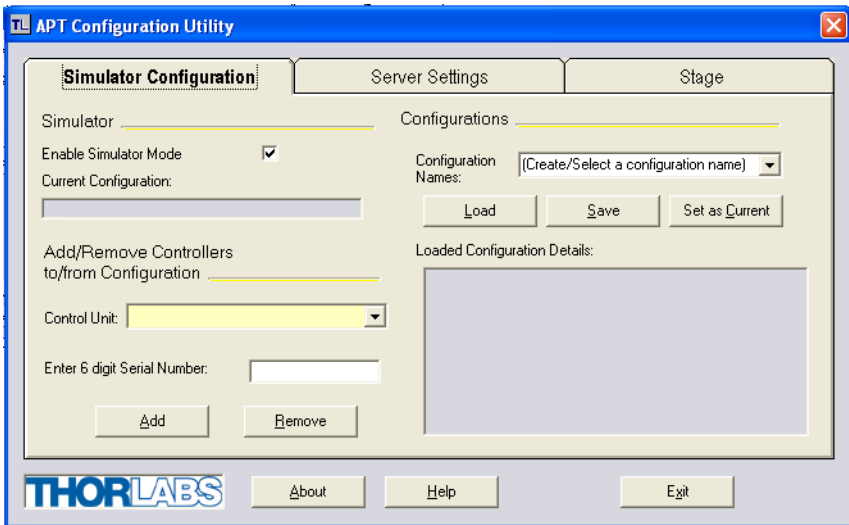
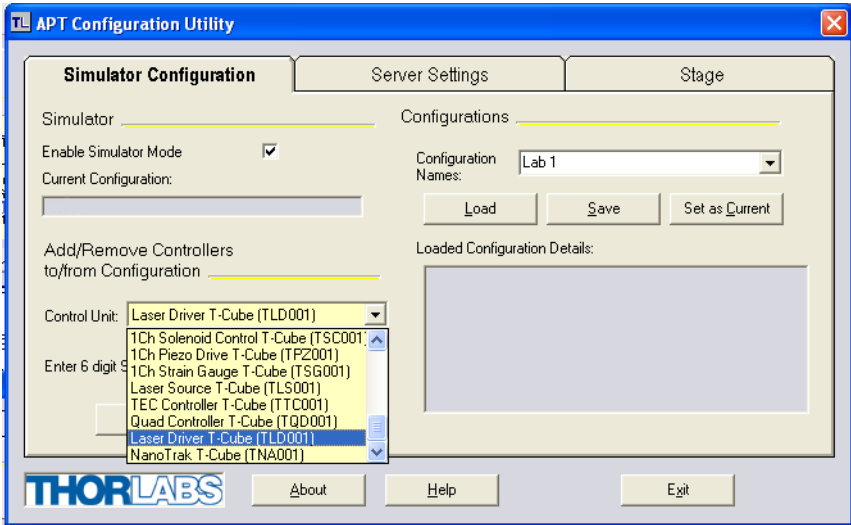


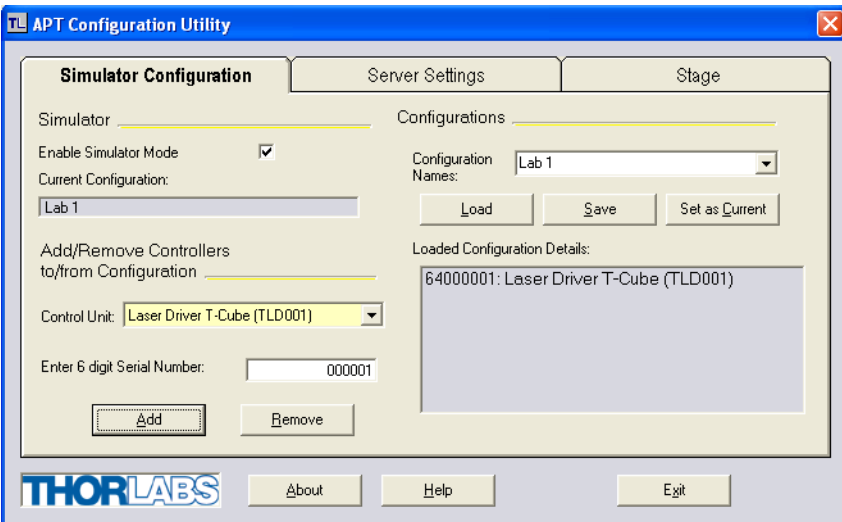
Fig. 5.6 APT Configuration Utility - Simulator Configuration Tab

- 3) Enter 'LAB1' in the Configuration Names field.

- 4) In the 'Simulator' field, check the 'Enable Simulator Mode' box. The name of the most recently used configuration file is displayed in the 'Current Configuration' window.



- 5) In the 'Control Unit' field, select 'Laser Driver T-Cube (TLD001)'.



- 6) Enter a 6 digit serial number.

Note

Each physical APT hardware unit is factory programmed with a unique 8 digit serial number. In order to simulate a set of 'real' hardware the Config utility allows an 8 digit serial number to be associated with each simulated unit. It is good practice when creating simulated configurations for software development purposes to use the same serial numbers as any real hardware units that will be used. Although serial numbers are 8 digits (as displayed in the 'Load Configuration Details' window), the first two digits are added automatically and identify the type of control unit.

The prefixed digits relating to the TLD001 T-Cube Laser Diode Driver are: 64xxxxxx

- 7) Click the 'Add' button.
- 8) Repeat items (1) to (7) as required. (A unit can be removed from the configuration by selecting it in the 'Loaded Configuration Details' window and clicking the 'Remove' button or by right clicking it and selecting the 'Remove' option from the pop up window).
- 9) Enter a name into the 'Configuration Names' field.
- 10) Click 'Save'.
- 11) Click 'Set As Current' to use the configuration.

Chapter 6 Software Reference

6.1 GUI Panel

The following screen shot shows the graphical user interface (GUI) displayed when accessing the driver using the APTUser utility.

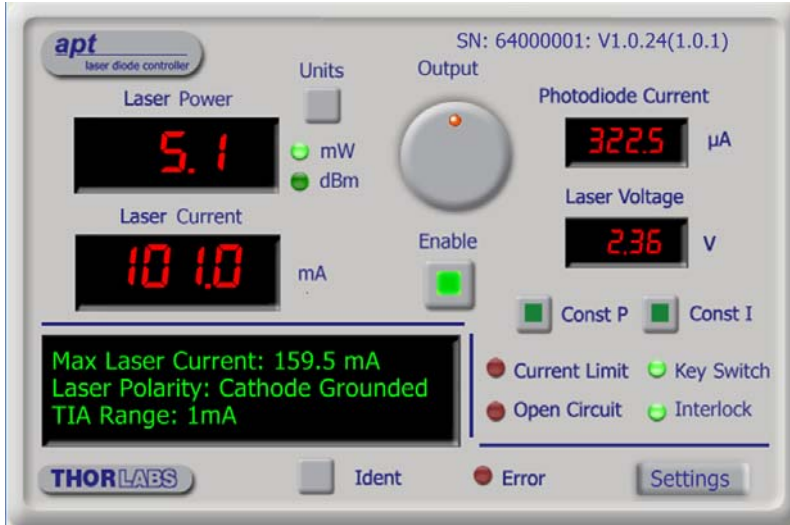


Fig. 6.1 TLD001 Laser Diode Driver Software GUI

Note. The serial number of the TLD001 unit associated with the GUI panel, the APT server version number, and the version number (in brackets) of the embedded software running on the unit, are displayed in the top right hand corner. This information should always be provided when requesting customer support.

Laser Power display - shows the output power of the laser diode (P_{LD}). **Note.** The maximum value is dependent upon the photodiode current reading (I_{PD}), the photodiode current range, set by the rear panel micro switches (Section 3.3.7.), and the Watts/Amp calibration factor, specified in the Settings panel (see Section 6.2.) or by calling the `SetWACalibFactor` method (see the APTServer helpfile).

Laser Current display - shows the drive current applied to the laser diode (I_{LD}). **Note.** The maximum value available is dependent upon the laser diode drive current limit, set via the Settings panel - see Section 3.3.6.

Units button - switches the Laser Power display between mW/uW and dBm modes
mW and dBm LEDs - lit when the associated display units are selected.

Output Control - used to adjust and set the output power or current of the laser diode, as displayed in the digital displays.

Enable Button - turns the drive current to the laser diode ON and OFF.

Note. The laser driver output cannot be enabled unless the interlock connection is made and the key switch is turned on.

Photodiode Current display - shows the photodiode current (I_{PD}). **Note.** The maximum value is dependent upon the photodiode current range (I_{PD}), set by the rear panel micro switches (Section 3.3.7.).

Laser Voltage display - shows the laser diode drive voltage. For grounded cathode laser diodes, the voltage is positive, for grounded anode diodes it is negative.

Const P & Const I buttons - the TLD001 laser diode driver can be operated in either Constant Current or Constant Power mode.

In *Constant Current Mode (CONST I)*, a constant drive current is applied to the laser diode. However, due to temperature fluctuations this does not result in a constant optical power output. As the diode warms up, the optical power will change noticeably from the level at initial switch on. Ambient temperature changes will also effect the output. This mode is used when the lowest noise and highest response speed is required. Most applications in this mode will also require the temperature to be stabilized by an additional temperature controller. Thorlabs offers the TTC001 TEC Controller T-Cube for such applications, see www.thorlabs.com for more details.

Constant Power Mode (CONST P) is used to minimize the output power fluctuations described above. This involves a signal from the internal photodiode, integrated into most laser diode packages, being fed back to the TLD001 unit in order to monitor and correct the power output.

This feedback loop attempts to maintain constant optical power by continuously monitoring the photocurrent and if necessary adjusting the output current to maintain the same photocurrent. Since the photocurrent is proportional to the optical power, this ensures that the optical power remains stable. The laser diode current limit setting still applies in this mode; the output current will not be increased above the limit.

Note that whilst in constant power mode the optical power is normally more stable than in constant current mode, the scheme is still limited by the fact that the photocurrent is dependent on the temperature. In addition to the photodiode itself being sensitive to temperature, if the temperature of the laser diode fluctuates, the wavelength shifts and this also causes a change in photocurrent. For highest accuracy, laser diodes are therefore normally operated in a temperature-stabilized manner.

Current Limit LED - lit when the laser diode drive current limit (see Section 3.3.6.) has been reached.

Open Circuit LED - If the electrical connection to the laser diode gets interrupted (i.e. the output goes open circuit) the internal protection circuit disables the laser output and turns on the Open Circuit LED. After the fault is cleared, the laser output can be re-enabled.

Key Switch LED - lit green when the front panel key switch is turned ON, red when the switch is OFF - see Section 4.2.

Interlock LED - lit green when the 'Interlock' connection is made (short circuit), red when open circuit - see Section 3.3.11.

Settings display - shows the name of the associated T-Cube together with the following user specified settings:

Max Laser Current - the maximum current limit of the laser diode being driven - see Section 5.4. or Section 4.4.

Laser Polarity - the polarity of the laser diode, either *Anode Grounded* or *Cathode Grounded*.

TIA Range - the photo diode current limit, set via the rear panel PD RANGE microswitches - Section 3.8.

Power Control: the source(s) which control the output from the laser unit:

Software - the unit responds to software commands and the output to the laser is that set using the SetPowerSetpoint method, or the 'OUTPUT' control on the GUI panel.

External (SMA) - the unit responds to the analog signal on the rear panel EXT IN SMA connector (0 to 10V).

Potentiometer - the output to the laser is the value set using the top panel OUTPUT potentiometer.

Settings button - Displays the 'Settings' panel, which allows the operating parameters described above to be entered - see Section 6.2.

Ident - when this button is pressed, the front panel POWER LED and digital display of the associated controller T-Cube will flash for a short period.

Active - lit when the unit is operating normally and no error condition exists.

Error - lit when the photodiode current is out of range. If this LED is lit, then the photo current and optical power readings are potentially incorrect. The most probable cause is that the photodiode current gain was not optimized during the configuration process - see Section 4.4. or Section 5.4.

6.2 Settings Panel

When the 'Settings' button on the GUI panel is clicked, the 'Settings' window is displayed. This panel allows data such as front panel display units and input sources to be entered. Note that all of these parameters have programmable equivalents accessible through the ActiveX methods and properties on this Control (refer to the *Programming Guide* in the *APTServer helpfile* (accessed via the Windows 'Start' menu) for further details and to Section 1.3.4. for an overview of the APT ActiveX controls).

6.2.1 General Tab

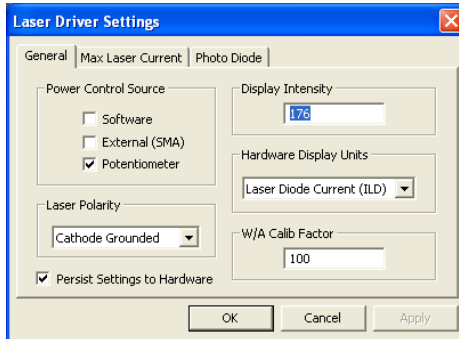


Fig. 6.1 Laser Driver Settings Panel - General Tab

Power Control Source - the source(s) which control the output from the laser unit:

If *Software* is selected, the unit responds to software commands and the output to the laser is that set using the SetPowerSetpoint method, or the 'OUTPUT' control on the GUI panel.

If *External (SMA)* is selected, the unit responds to the analog signal on the rear panel EXT IN SMC connector (0 to 10V).

If *Potentiometer* is selected, the output to the laser is the value set using the top panel OUTPUT potentiometer.

Note

It is possible to select all, or a combination of sources; the sum of the combination is then applied to the unit.

Display Intensity - determines the brightness of the control panel display.

Enter a value from 0 to 255.

Hardware Display Units - this parameter sets the 7-segment display on the control panel of the unit to show one of 4 operating parameters: current limit (I_{LIM}) in mA, laser diode current (I_{LD}) in mA, laser diode optical output power (P_{LD}) in mW or μ W, or photo diode current (I_{PD}) in mA or μ A.

Note

If the hardware display is set to show laser power (PLD), it displays the power in mW (or μ W), even if the GUI is set to display laser power in dBm.

continued...

Laser Polarity - It is normal for the case of a laser diode to be electrically connected to either the anode or the cathode of the diode. This results in two common configurations: anode grounded (AG) and cathode grounded (CG). This can be established from the laser diode data sheet and the device should be connected to the D-type connector on the TLD001 accordingly - see Section 3.3.4.

Select either *Anode Grounded* or *Cathode Grounded*, whichever is applicable.

Caution. Ensure that the correct polarity is selected. If the wrong polarity is selected, and the laser diode is turned on, the unit will attempt to drive current into a reverse connected laser diode. Although the open loop circuit will detect this and disable the output, the momentary reverse polarity can still damage the diode by reverse breakdown.

W/A Calibration Factor - Each laser diode has specific relationship between the output power and the photodiode current. This parameter sets the calibration factor for converting between these two values.

The calibration factor can be set between 0.00001 and 10,000.

For example, if set to '10' a photodiode current of 1mA produces an output power of 10mW.

Persist Settings to Hardware - The settings on this tab can be stored (persisted) within the unit itself, such that when the unit is next powered up these settings are applied automatically. This is useful when the driver is next being used manually in the absence of a PC and USB link. The *Power Control Source* parameter described previously is a good example of a setting that can be altered and then persisted in the driver for use in absence of a PC.

To save the settings to hardware, check the 'Persist Settings to Hardware' checkbox before clicking the 'OK' button.

6.2.2 Max Laser Current Tab

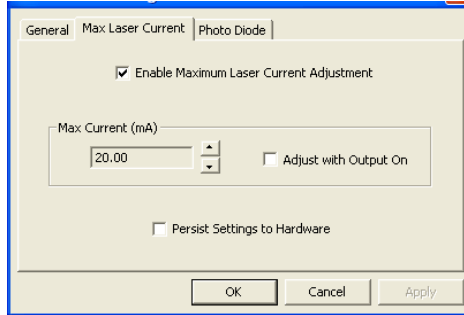


Fig. 6.2 Laser Driver Settings Panel - Max Laser Current Tab

In order to protect against damage which could be caused by operating errors, the limit for the Laser Diode drive current should be set before diode is operated.

Before any adjustments can be made to the settings on this tab, the '*Enable Maximum Laser Current Adjustment*' box must be checked.

Note. When this box is checked, the maximum current is reset to its minimum value (around 17mA). This ensures that initially, the laser current is at its lowest value.

Max Current (mA) - The maximum laser drive current for the laser diode being used. This information may available from the data sheet supplied with the laser diode. If not, it must be derived by testing - see Section 5.4.

Press the up/down arrows to increase/decrease the max current setting.

During operation, if the laser current reaches the limit set, the ILIM LED flashes.

Caution. If these arrows are pressed and held, this will cause an accelerated value change. This could damage the laser diode if the current is increased with the output on - see below.

Adjust with Output On - Check this box to allow the Current limit to be adjusted while the output is on.

Note. The maximum laser diode current can be adjusted with the output off. In this operating mode, the max current will be generated and measured internally, but will not be routed to the laser diode terminals (the unit contains a relay that short circuits the laser diode terminals when the output is disabled). This offers additional safety against damage to the laser diode from a accidentally exceeding its current limit. However, because the laser diode is off, there is no light output so the technique can be used only if the required maximum current limit is known.

Persist Settings to Hardware - The parameter settings on this tab can be stored (persisted) within the unit itself, such that when the unit is next powered up these settings are applied automatically. This is useful when the driver is next being used manually in the absence of a PC and USB link.

To save the settings to hardware, check the '*Persist Settings to Hardware*' checkbox before clicking the 'OK' button.

6.2.3 Photo Diode Tab

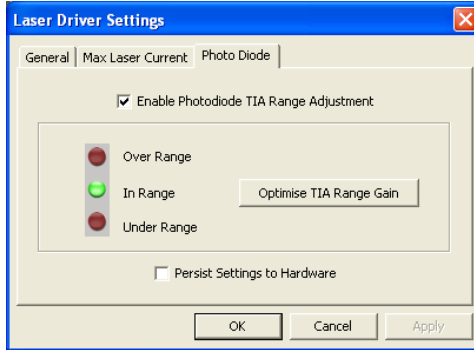


Fig. 6.3 Laser Driver Settings Panel - Photo Diode Tab

In order to ensure correct readings during operation, the Photo Diode operating range must be set before the laser diode is used.

Note

Before any adjustments can be made to the settings on this tab, the 'Enable Photodiode TIA Range Adjustment' box must be checked.

Range LEDs - These LEDs indicate the present range setting for the photo diode. The PD RANGE microswitches on the rear panel should be adjusted such that the green *In Range* LED is lit - see Section 3.8. for more information.

Optimise TIA Range Gain - Click this button to optimize the gain of the TIA - see Section 3.3.8.

Persist Settings to Hardware - The parameter settings on this tab can be stored (persisted) within the unit itself, such that when the unit is next powered up these settings are applied automatically. This is useful when the driver is next being used manually in the absence of a PC and USB link.

To save the settings to hardware, check the '*Persist Settings to Hardware*' checkbox before clicking the 'OK' button.

Appendix A Rear Panel Connector Pinout Details

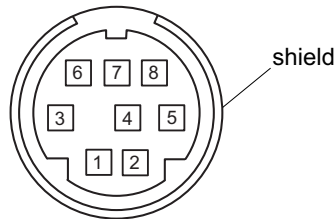
A.1 Power Connector

Thorlabs recommends that the Laser Diode Driver T-Cube is operated with Thorlabs power supply TPS002, as it was specifically designed for use with this product. However, to enable customers to use the cube in installations where a $\pm 15\text{V}$ and 5V power is already available, the laser diode driver cube can be operated with a different external power supply, such as a bench or lab supply.

In this case however, extreme care must be taken to ensure that it meets the specifications and is connected to the cube correctly. Out of tolerance supply voltages or incorrect connection, applied even momentarily, can result in the sensitive electronic components inside the cube getting damaged, invalidating warranty.

The cube uses a standard “mini-DIN” type of input connector, the corresponding plug is available from most standard electronics suppliers.

Fig. A.1 shows the mini-DIN socket as viewed by looking at the rear panel of the cube. The pin numbering follows the standard for mini-DIN connectors.



Pin	Description	Pin	Description
1	+5V	6	Common Ground
2	+5V	7	Common Ground
3	-15V	8	Common Ground
4	+15V	Shield	Common Ground
5	+5V		



Warning

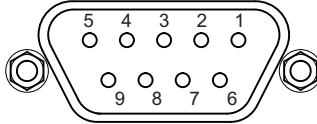
When wiring the mini-DIN plug, ensure that all the ground pins are used and the shield is connected to common ground. This provides a level of protection against overvoltages due to loss of ground. A “loss of ground” condition can seriously damage the electronics inside the cube.

Fig. A.1 POWER Connector Pin Identification

A.2 Rear Panel LD OUT Connector.

The 'LD OUT' connector exposes a number of electrical terminals used when connecting the laser diode or photo diode. It also exposes the Interlock connection, which must be closed before the laser diode can be turned on - see Section 3.3.11.

The pin functions are detailed in Fig. A.2.



Pin	Description	Return	Pin	Description	Return
1	† Interlock	5	6	Not used	–
2	Photodiode Cathode	–	7	* Laser Diode Cathode	–
3	Laser Diode Ground	–	8	** Laser Diode Anode	–
4	Photodiode Anode	–	9	Not Used	–
5	Ground for Pin 1	–			

Notes.

* Polarity Anode Grounded (AG).

** Polarity Cathode Grounded (CG).

† The Interlock (Pin 1) must be shorted to the Ground (pin 5) before the laser can be enabled - see Section 3.3.11.

Fig. A.2 LD OUT connector pin identification

Appendix B Preventive Maintenance



Warning: Risk of Electrical Shock

The equipment contains no user serviceable parts. There is a risk of electrical shock if the equipment is operated with the covers removed. Only personnel authorized by Thorlabs Ltd and trained in the maintenance of this equipment should remove its covers or attempt any repairs or adjustments. Maintenance is limited to safety testing and cleaning as described in the following sections.

B.1 Cleaning



Warning

Disconnect the power supply before cleaning the unit.

Never allow water to get inside the case.

Do not saturate the unit.

Do not use any type of abrasive pad, scouring powder or solvent, e.g. alcohol or benzene.

The panel may be cleaned with a soft cloth, lightly dampened with water or a mild detergent.

Appendix C Specifications and Associated Products

C.1 Specifications

Parameter	Value
Laser Diode (LD) Output	9-Pin D-Type
Maximum LD Current	200mA
Max LD Current Limit Range	20mA to 200mA
LD Compliance Voltage:	>8V
LD Current Setting Resolution	10 μ A
LD Power Setting Resolution	1 μ W
LD Current/Power Measurement Resolution	10 μ A (14bit)
Temperature Drift	<70ppm/ $^{\circ}$ C typical
LD Current Noise	<3 μ A rms typical
Supported LD/PD Configurations	All
LD Protection	Relay - Open Circuit, Under/over Voltage
Operating Modes	Constant Current/Constant Power
Modulation Input	SMA 0 to 10V = 0 to Full Power, DC or Sine Wave Input Only
Modulation Bandwidth	20kHz Full Depth
Power Input	+15V,-15V,+5V
Housing Dimensions (W x D x H)	120 x 60 x 47mm (4.8" x 2.4" x 1.8")
Weight	160g (5.5 oz.)

C.2 Associated Products

Product Name	Part Number
Power Supply Unit for up to two Laser Diode driver Cubes	TPS002
T-Cube Controller Hub and Power Supply	TCH002
TLD001 to LD Connector Cable	SR9x-DB9
TLD001 to LD Mount Connector Cable	CAB400
SMA to BNC Converter Cable 6"	CA2806
SMC to BNC Male Converter	T4289
SMC to BNC Female Converter	T4290

Please see www.thorlabs.com for our full range of laser diodes and diode mounts.

Appendix D APTLaser Control Method Summary

The ActiveX functionality for the TLD001 Laser Driver T-Cube is accessed via the APTLaser Control Object, and provides the functionality required for a client application to control a number of T-Cube Laser units.

Every hardware unit is factory programmed with a unique 8-digit serial number. This serial number is key to operation of the APT Server software and is used by the Server to enumerate and communicate independently with multiple hardware units connected on the same USB bus.

The serial number must be allocated using the HWSerialNum property, before an ActiveX control can communicate with the hardware unit. This can be done at design time or at run time.

The methods of the Laser Control Object can then be used to control the T-Cube Laser Driver, and activities such as switching between display modes, setting the laser power set point, reading the laser power or current and setting the LED display intensity can be performed.

Methods

DeleteParamSet	Deletes stored settings for specific controller.
DisableOutput	Disables the optical output of the laser unit associated with the ActiveX control instance.
DoEvents	Allows client application to process other activity.
EnableEventDlg	Enables or disables the event dialog box.
EnableOutput	Enables the optical output of the laser unit associated with the ActiveX control instance.
GetWACalibFactor	Returns the calibration factor for converting between the output power and the photodiode current.
GetControlMode	Returns the present setting for the control mode of the laser unit associated with the ActiveX control instance, either Constant Power or Constant Current.
GetControlSrc	Returns the present setting for the control source of the laser unit associated with the ActiveX control instance.
GetDispIntensity	Gets the front panel LED display intensity.
GetGUIDispUnits	Returns the present setting of the GUI display mode.
GetHWDISPUnits	Returns the present setting of the display mode of the associated hardware unit.

GetLaserPolarity	Returns the present setting of the polarity of the laser diode connected to the TLD001 unit.
GetMaxLimits	Gets the maximum power (in mW) and current (in mA) limits of the laser unit associated with the ActiveX control instance.
GetPowerSetPoint	Gets the output set point of the laser unit associated with the ActiveX control instance.
GetWavelength	Gets the output wavelength of the laser source associated with the ActiveX control instance.
Identify	Identifies the controller by flashing unit LEDs.
LLGetStatusBits	Gets the controller status bits encoded in 32 bit integer.
LLSetGetDigOPs	Sets or Gets the user digital output bits encoded in 32 bit integer.
LoadParamSet	Loads stored settings for specific controller.
ReadLaserVoltage	Returns the drive voltage applied to the Laser Diode.
ReadLaserPower	Returns the actual output power of the laser unit associated with the ActiveX control instance.
ReadLaserCurrent	Returns the actual output current of the laser unit associated with the ActiveX control instance.
SaveParamSet	Saves settings for a specific controller.
SetWACalibFactor	Sets the calibration factor for converting between the output power and the photodiode current.
SetControlMode	Sets the control mode of the laser unit associated with the ActiveX control instance, either Constant Power or Constant Current.
SetControlSrc	Sets the control source of the laser unit associated with the ActiveX control instance.
SetDispIntensity	Sets the front panel LED display intensity.
SetGUIDispUnits	Sets the display mode of the associated GUI panel..
SetHWDispUnits	Sets the display mode of the associated hardware unit.
SetLaserPolarity	Sets the polarity of the laser diode connected to the TLD001 unit.
SetPowerSetPoint	Sets the output set point of the laser unit associated with the ActiveX control instance.
ShowEventDlg	Shows the event dialog when it has previously been disabled using the EnableEventDlg method
StartCtrl	Starts the ActiveX Control (starts communication with controller)

StopCtrl Stops the ActiveX Control (stops communication with controller)

Properties

APTHelp Specifies the help file that will be accessed when the user presses the F1 key. If APTHelp is set to 'True', the main server helpfile MG17Base will be launched.

HWSerialNum specifies the serial number of the hardware unit to be associated with an ActiveX control instance.

Appendix E Regulatory

E.1 Declarations Of Conformity



E.1.1 For Customers in Europe
See Section E.2.

E.1.2 For Customers In The USA

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. 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.

Changes or modifications not expressly approved by the company could void the user's authority to operate the equipment.

E.2 CE Certificate

	THORLABS www.thorlabs.com	
EU Declaration of Conformity <i>in accordance with EN ISO 17050-1:2010</i>		
We:	Thorlabs Ltd.	
Of:	1 St. Thomas Place, Ely, CB7 4EX, United Kingdom	
<i>in accordance with the following Directive(s):</i>		
2014/30/EU	Electromagnetic Compatibility (EMC) Directive	
2011/65/EU	Restriction of Use of Certain Hazardous Substances (RoHS)	
 <i>hereby declare that:</i>		
Model:	TLD001	
Equipment:	T-Cube Laser Diode Driver	
<i>is in conformity with the applicable requirements of the following documents:</i>		
EN 61326-1	Electrical Equipment for Measurement, Control and Laboratory Use - EMC Requirements	2013
 <i>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:</i>		
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>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.</i>		
Signed:		On: 23 January 2014
Name:	Keith Dhese	CE
Position:	General Manager	
		EDC - TLD001 -2014-01-23

Appendix F Thorlabs Worldwide Contacts

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



USA, Canada, and South America

Thorlabs, Inc.
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techsupport@thorlabs.com

UK and Ireland

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techsupport.uk@thorlabs.com

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europe@thorlabs.com

Scandinavia

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scandinavia@thorlabs.com

France

Thorlabs SAS
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Brazil

Thorlabs Vendas de Fotônicos Ltda.
brasil@thorlabs.com

Japan

Thorlabs Japan, Inc.
sales@thorlabs.jp

China

Thorlabs China
chinasales@thorlabs.com

Thorlabs verifies our compliance with the WEEE (Waste Electrical and Electronic Equipment) directive of the European Community and the corresponding national laws. Accordingly, all end users in the EC may return "end of life" Annex I category electrical and electronic equipment sold after August 13, 2005 to Thorlabs, without incurring disposal charges. Eligible units are marked with the crossed out "wheelie bin" logo (see right), were sold to and are currently owned by a company or institute within the EC, and are not disassembled or contaminated. Contact Thorlabs for more information. Waste treatment is your own responsibility. "End of life" units must be returned to Thorlabs or handed to a company specializing in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.



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