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This legacy APT manual is provided for reference only. Our APT software was discontinued on July 1, 2024, and no updates have been made to this document since then. The latest product specifications are contained within the item-specific documentation at www.thorlabs.com

KLD101
K-Cube Laser Driver

APT User Guide

Original Instructions

Contents

Chapter 1 Overview

1.1 Introduction

The KLD101 K-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 230 mA, a high compliance voltage of up to 10 V at 50 mA (>7 V at 230 mA) and both constant current and constant power operating modes. As a member of the K-Cube family of products, the KLD101 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 an LCD display, adjustment wheel, Mode, and Laser ENABLE 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 121 mm x 60 mm x 47 mm (4.76" x 2.36" x 1.85") and with the ability to directly mount to the optical table (using the mounting plate supplied). 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 two interlock connectors fitted to this compact unit for use in laser applications requiring such functionality. One interlock is available via the 2.5 mm jack on the rear panel - see Section 3.3.1. A second interlock is available on the rear panel LD OUT connector - see Section 3.6. for more details.

Fig. 1.1 K-Cube Laser Driver (KLD101)

USB connectivity provides easy 'Plug and Play' PC controlled operation - multiple K-Cube units can be connected to a single PC via standard USB hub technology, or by using the K-Cube Controller Hub (see below). 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 programming environment also supplied. This programming library is compatible with many development tools such as LabView, Visual Basic, Visual C++, C++ Builder, LabWindows/CVI, and Delphi.

See Section 1.3. for a full description of the 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 Options

A compact power supply unit (TPS002) is available from Thorlabs. This power supply unit is designed to take up minimal space and can be mounted to the optical table in close proximity to the driver units, connected via short power leads. Although the TPS002 has two outputs, it should not be used to drive another K-Cube as well as the KLD unit. Doing so could exceed its current limits.

As a further level of convenience when using these controllers, Thorlabs also offers the K-Cube Controller Hubs (KCH301 and KCH601). These products have been designed specifically with multiple K-Cube operation in mind in order to simplify issues such as cable management, power supply routing and different optical table mounting scenarios. The KCH301 hub provides power distribution for up to three K-Cubes, while the KCH601 hub provides power distribution for up to six K-Cubes. Either hub requires only a single power connection.

The Controller Hub comprises a slim base-plate type carrier with electrical connections located on the upper surface: the KCH301 measures 193.5 mm x 70.0 mm x 24.0 mm (7.62" x 2.76" x 0.94") and accepts up to three K-Cubes while the KCH601 measures 376.5 mm x 70.0 mm x 24.0 mm (14.82" x 2.76" x 0.94") and accepts up to six K-Cubes.

See the product page at www.thorlabs.com for more details.

Note

A KCH series hub can only be used to provide power and USB connection to the host PC. A hub cannot be used to communicate between a KNA-IR or KNA-VIS unit and other K-Cubes also fitted to the hub.

1.3 APT Software Overview

As a member of the APT range of controllers, the KLDxxx Laser Driver K-Cube 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 1.3.1.) and APTConfig (see Section 1.3.2.) 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 1.3.3.

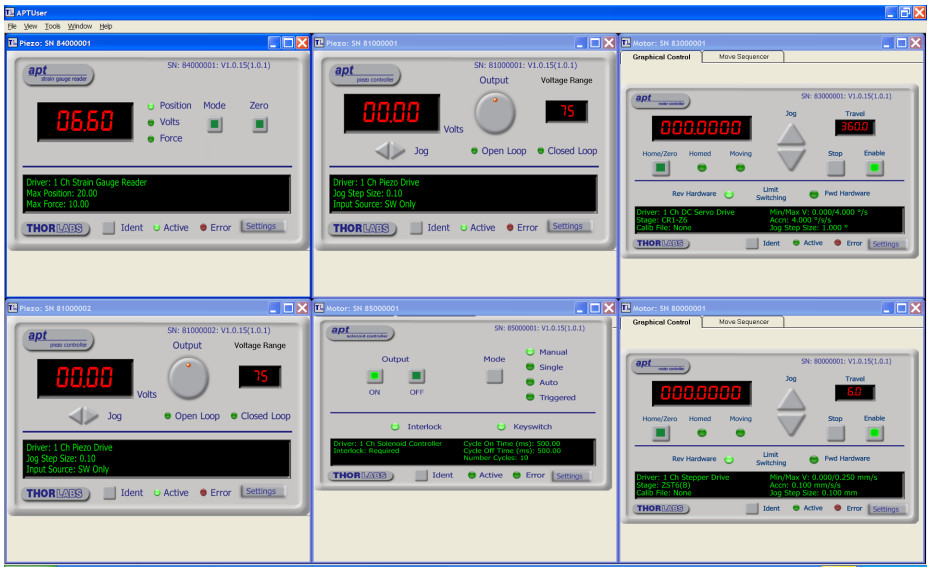
Aside

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 1.3.3. for further details.

1.3.1 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.



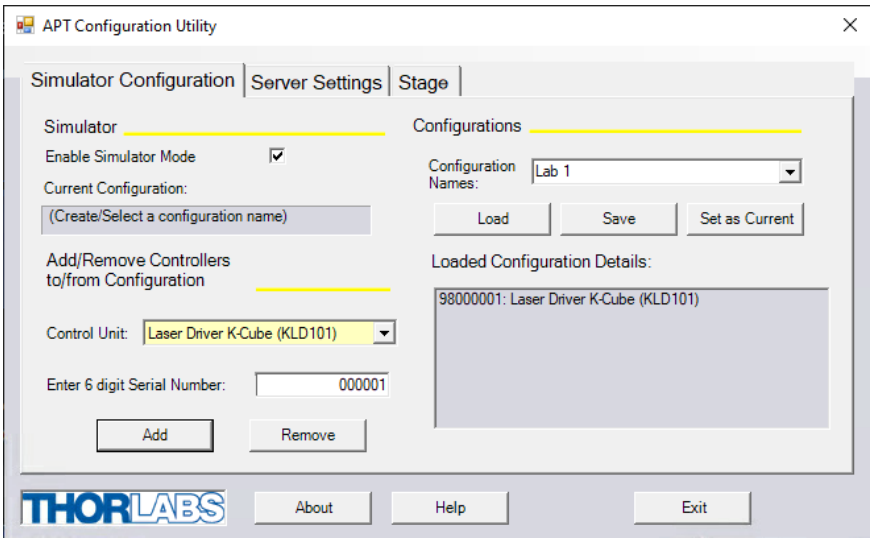
All basic operating parameters can be altered and, similarly, all operations (such as setting the scan circle size) can be initiated. Settings and parameter changes can be saved and loaded to allow multiple operating configurations to be created and easily applied.

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 (e.g. to implement a positioning algorithm), 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.

1.3.2 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.

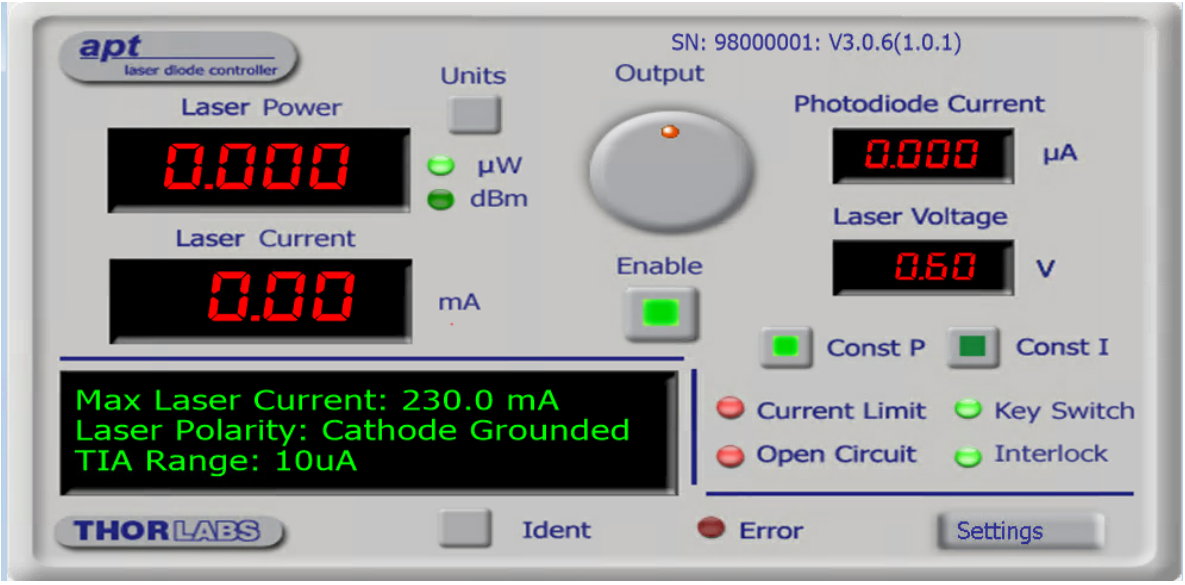
Use of the APT Config utility is covered in the PC tutorial (Chapter 5) and in the APTConfig online help file, accessed via the F1 key when using the APTConfig utility.

1.3.3 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 KSG101 Strain Gauge controller. 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 with the KLD101 Laser Driver K-Cube.



This Control provides a complete user graphical instrument panel to allow the Laser Driver 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 control operations to be automated by a client application. The instrument panel reflects the current operating state of the controller unit to which it is associated (e.g. such as Laser Intensity). 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 Driver Control to track the increase the laser intensity, progress is monitored automatically on the graphical interface, without the need for further programming intervention.

For many users, the GUI application provides all of the functionality necessary to operate the 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 server is exposed by a client application.

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

these are described fully in the handbooks associated with the controllers.

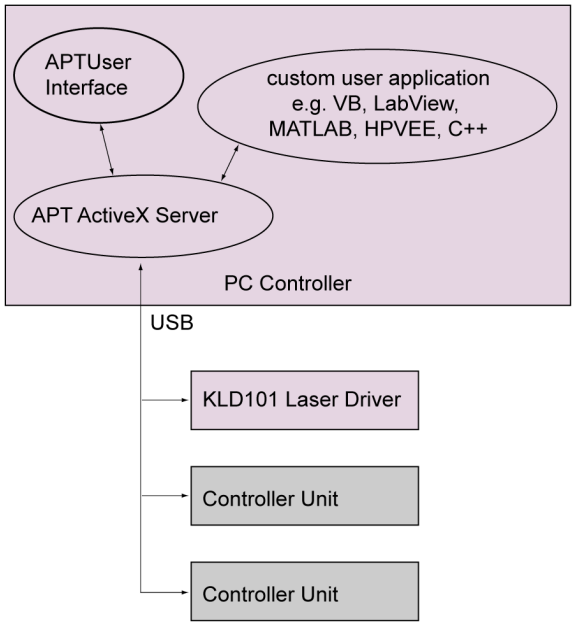


Fig. 1.2 System Architecture Diagram

Refer to the main APT Software online help file, for a complete programmers guide and reference material on using the APT 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.

1.3.4 Software Upgrades

Thorlabs operate a policy of continuous product development and may issue software upgrades as necessary. The latest software can be downloaded from the 'services' section of www.thorlabs.com.

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: Laser Radiation

Given when there is a risk of injury from laser radiation.

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: Laser Radiation

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 Install The Software

Note

When operating via a PC, direct user interaction with the unit 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

Some PCs may have been configured to restrict the users ability to load software, and on these systems the software may not install/run. If you are in any doubt about your rights to install/run software, please consult your system administrator before attempting to install.

If you experience any problems when installing software, contact Thorlabs on

+44 (0)1353 654440 and ask for Technical Support.

DO NOT CONNECT THE CONTROLLER TO YOUR PC YET

1) Go to Services/Downloads at www.thorlabs.com and download the software.
2) Run the .exe file and follow the on-screen instructions.

3.2 Mechanical Installation

3.2.1 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.

3.2.2 Mounting Options

The K-Cube Laser Driver is shipped with a baseplate, ready to be bolted to a breadboard, optical table or similar surface - see Section 3.2.3.

For multiple cube systems, a 3-channel and 6-channel K-Cube Controller Hub (KCH301 and KCH601) are also available - see Section 1.2. for further details. Full instructions on the fitting and use of the controller hub are contained in the handbook available at www.thorlabs.com.

Caution

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

3.2.3 Using the Baseplate

The baseplate must be bolted to the worksurface before the K-Cube is fitted, as shown below. The K-cube is then located on two dowels in the baseplate and secured by four clips.

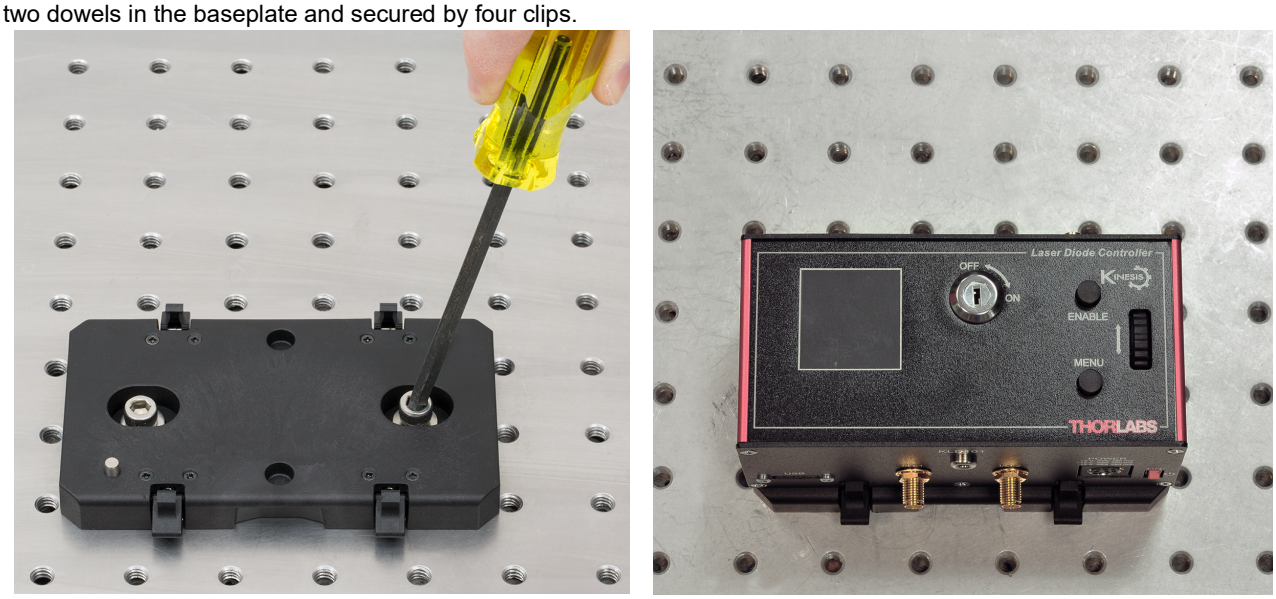


Fig. 3.1 Using The Baseplate

3.3 Electrical Installation

3.3.1 Rear Panel

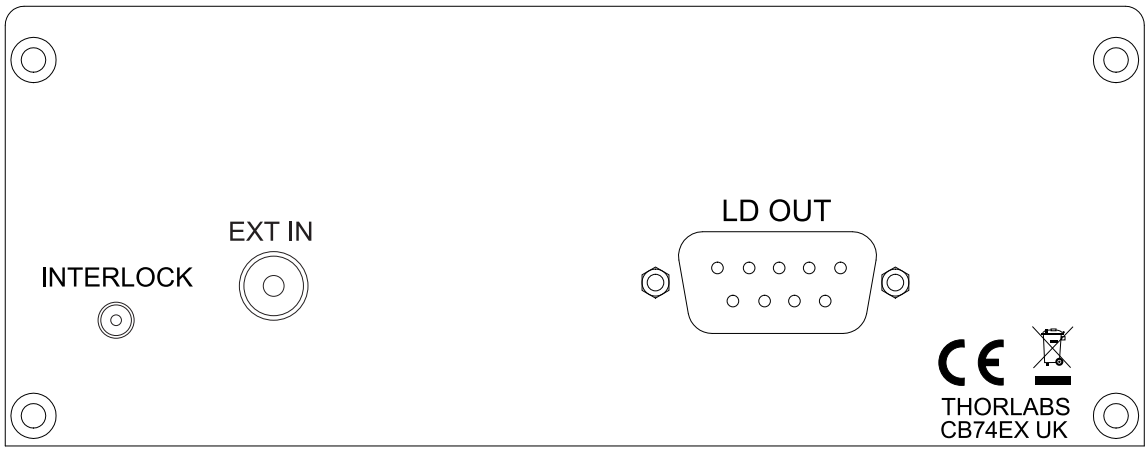


Fig. 3.2 Rear Panel Connections

INTERLOCK – The Controller is fitted with a functional interlock and key switch. The key switch must be turned on, the INTERLOCK pin fitted, and a short circuit must be applied across the interlock terminals of the LD OUT connector (pins 1 and 5 - see Section 3.6.) before the unit can be enabled.

The INTERLOCK LED on the GUI panel is lit green when the 'Interlock' pin is fitted, red when open circuit - see Section 6.1.

Caution

Do not apply a voltage to this connector

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 A.2.

EXT IN (SMA connector) – Used to control the intensity of the laser output from an external source. This input can be driven from a 0 to 10 V voltage source. The input impedance is 16 kΩ.

Note

Thorlabs supplies a variety of SMA to BNC adapter and extension cables. Please visit www.Thorlabs.com for further details.

3.3.2 Front Panel

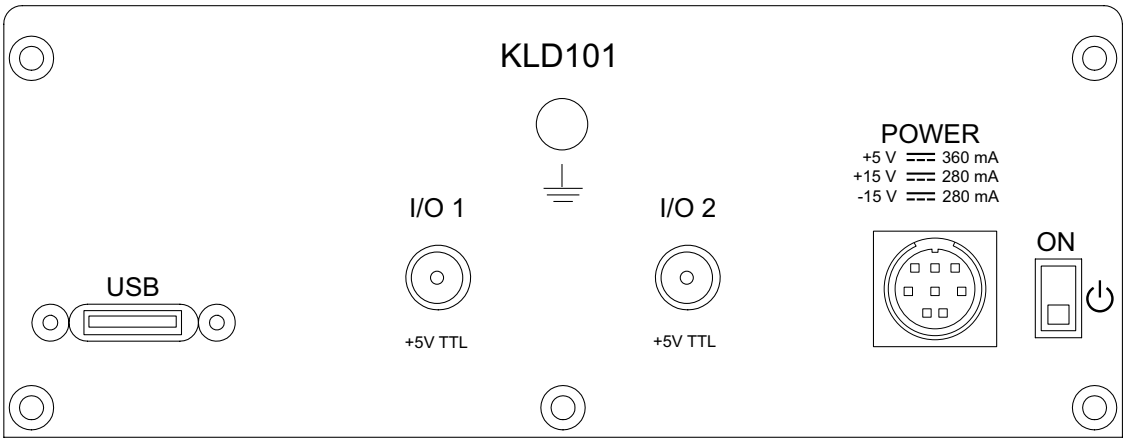


Fig. 3.3 Front Panel Connections

Warning: Risk of Electrical Shock

The unit must be connected only to a DC supply as detailed in Section 3.3.3. Connection to a supply of a different rating may cause damage to the unit and could result in injury to the operator.

POWER - Eight pin connector for connecting the unit to a regulated DC power supply of the rating detailed in Section 3.3.3. See Section A.1. for pin out details, and Section 1.2. for power supply options.

USB - USB port for system communications.

Note

The USB cable length should be no more than 3 metres unless a powered USB hub is being used.

Earth Point - 4 mm banana socket. When handling laser diodes it is advisable to take anti-static discharge precautions. This connector allows static-discharge equipment to be connected to earth, via the internal power supply ground.

Caution

The Earth Point is connected to earth only when the unit is connected to a power supply, and the PSU is connected to the wall socket.

ON - Power ON/Standby switch. When in the ON position, the unit is fully powered up. When the switch is turned to the Standby position, the unit initiates a controlled power down sequence, saving all user-adjustable parameters to non-volatile memory before turning off the power. For the first few seconds, the shutdown can be cancelled by turning the switch on again, in which case the unit will save the parameters but will remain powered up. In a powered down (Standby) state, the logic circuits are powered off and the unit will draw only a small quiescent current. The switch should always be used to power down the unit.

IO 1 and IO 2 - SMA connectors for use with external trigger input and output signals (5 V TTL levels). The function is set to trigger IN or OUT via the settings panel - see Section 6.2.2.

3.3.3 Supply Voltage and Current Requirements

Thorlabs offers a compact two-way power supply (TPS002) or the K-Cube hubs (see Section 1.2. for more details) for use with the K-cube Laser Driver.

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
+5 V	+4.9 V	+5.1 V	360 mA
+15V	+14.5 V	+15.5 V	280 mA
-15 V	-14.5 V	-15.5 V	280 mA

Caution

Do not connect the laser driver to a 'live' external power supply. Doing so (i.e. “hot plugging”) carries the risk of PERMANENT damage to the unit. Always ensure the power supply unit is isolated from the mains and the front panel switch turn OFF before connecting to the unit.

Always power up the laser driver by connecting its power supply to the mains then switch ON using the front panel switch. Similarly, to power down the unit, turn the front panel switch OFF, then disconnect the power supply from the mains before disconnecting the laser driver.

3.4 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 controls (see Section 4.4.) or remotely via a PC (see Section 5.4.).

The configuration process consists of the following main steps:

a) setting the laser diode polarity,
b) setting the maximum laser current,
c) adjusting the photodiode range and gain,
d) optical power calibration.

These steps only need to be done once for a given laser diode. Once the setup has been completed, the KLD101 stores the corresponding parameters in non-volatile memory and they are loaded automatically at each power-up.

3.4.1 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 KLD101 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 KLD101 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 KLD101 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.

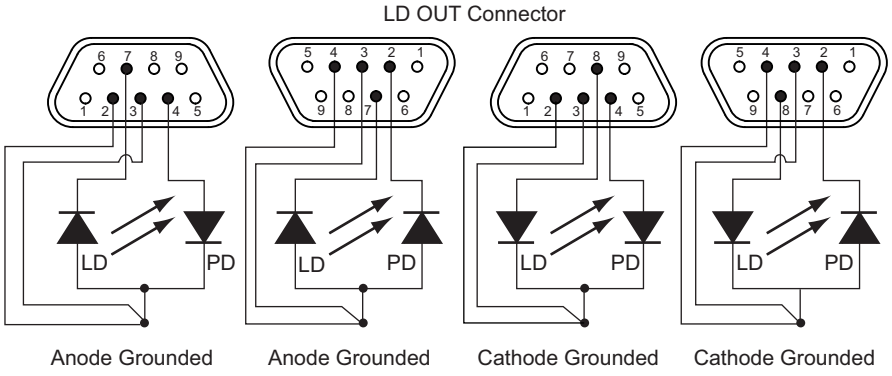


Fig. 3.4 Laser diode connections

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 KLD101 unit, one terminal of the laser diode and/or photodiode MUST BE grounded externally, ideally as close to the case as possible.

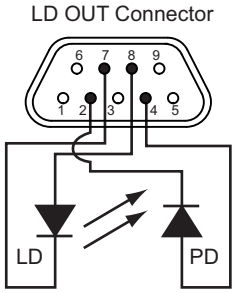


Fig. 3.5 Floating laser diode & photodiode connections

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.):

3.4.2 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 KLD101 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.

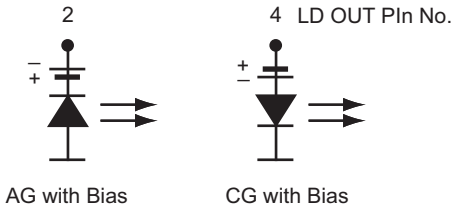


Fig. 3.6 Battery connections for biassed operation

3.4.3 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 semi conductor 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 10 mA. 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.

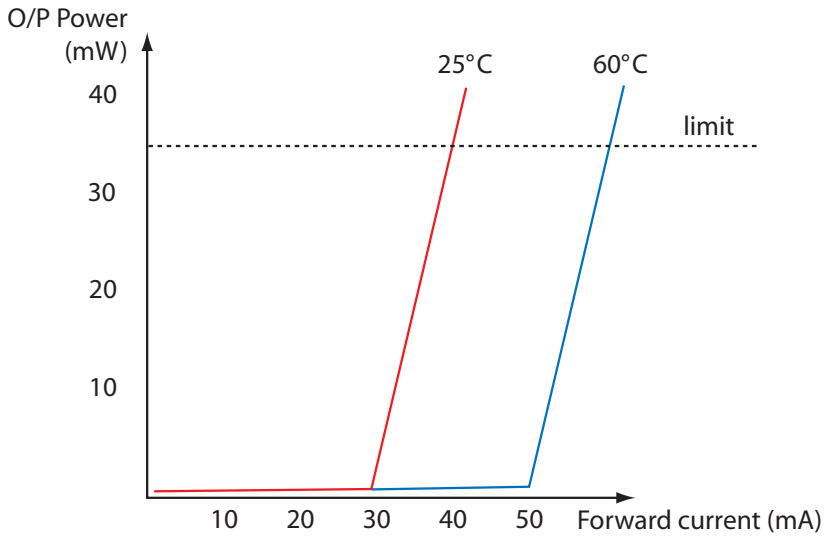


Fig. 3.7 Laser Diode Power versus Current Characteristics

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.

3.4.4 Optimization of the PD Current Gain

Optimization of the PD Current Gain is an automated process performed internally by the unit when the 'Optimize Amplifier Gain' button in the Photodiode Settings tab is pressed (see Section 6.2.4.).

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 GAIN SELFCAL menu option (see Section 4.4.5.) and the "Optimize Amplifier Gain" button on the GUI (see Section 6.2.3.) perform 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 Amplifier Gain" button is pressed, the system adjusts the photodiode current gain to 0.2 V / µA so that the photodiode transimpedance amplifier (TIA) 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, without a control PC - see Section 4.4.5.

Warning

When the self calibration is initiated, the top panel display flashes, to warn that the laser is about to be energized.

Self calibration should be performed in the dark, to minimize the detrimental effect of ambient light.

3.4.5 Calibrating the Power Display

The displayed power is derived from the photodiode current, and the relationship between this parameter and the laser diode power 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 is achieved by entering a Watts/Amps calibration factor, either via the top panel set up menu (see Section 4.4.6.) or in the GUI Settings panel (see Section 5.4.).

3.4.6 Summary

1) For the KLD101 unit to drive a laser diode satisfactorily, the following pre-requisites must be met:
   a) Either the anode or the cathode of the laser diode must be connected to ground.
   b) If a particular laser diode has the anode or cathode connected to the case, then this terminal is the grounded terminal.
   c) 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.
   d) 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.
   e) 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.

3.5 CONSTANT CURRENT and CONSTANT POWER Modes

The KLD101 laser diode driver can be operated in either Constant Current or Constant Power mode.

Constant Current Mode (LC)

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.

Caution

When operating in Constant Current mode, the minimum current set point must be higher than 0.5 mA.

In this mode the photodiode current reading is hidden but it's still available from the "PDF" menu - see Section 4.4.6. The value is correct only if the unit is calibrated otherwise the input signal might be too low or saturating.

Calibration should be performed when the max current or the laser is changed. The self-calibration routines finds the best gain settings - see Section 4.4.5.

Constant Power Mode (LP)

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 KLD101 unit in order to monitor and correct the power output.

In constant power mode, the feedback loop inside the KLD101 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.

Adjustment of the full scale photodiode current in CONST P mode is performed automatically during the self calibration (see Section 4.4.5.) in order to compensate for the differences in the photodiode currents between different laser diodes.

Caution

The minimum noise generation is achieved in current mode. In constant power mode the digital loop introduces a quantization error that depends on the power set point and its position on the laser diode current curve - see Appendix C for more details.

In Constant Power mode, when the available power is above 1 mW the wheel adjusts in 0.1 mW steps, otherwise the sensitivity is in 0.01 mW steps.

3.6 Using the Safety Interlock and Key Switch

The Controller is fitted with a two functional interlocks and key switch. The key switch must be turned on, the INTERLOCK pin fitted (see Section 3.3.1.) and a short circuit must be applied across the interlock terminals of the LD OUT connector (pins 1 and 5 - see Fig. 3.8) 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 on the LD OUT connector 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 <430Ω..

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.

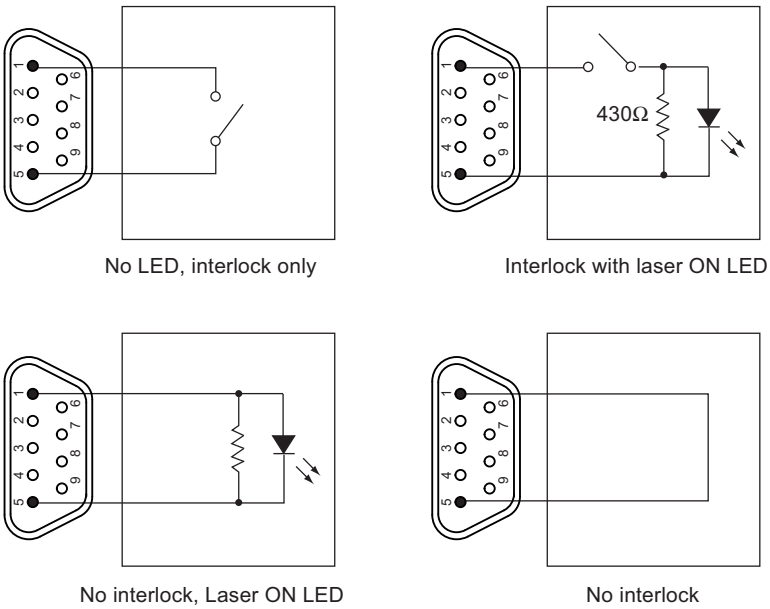


Fig. 3.8 Interlock Connection Options

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.

3.7 Resetting the Factory Defaults

To reset the unit to its default settings:

1) Power down the unit.
2) Press and hold the ENABLE and MENU buttons.
3) Switch the power ON.
4) Wait 3 seconds then release the buttons.

The unit will boot up with the factory default settings loaded.

Chapter 4 Standalone Operation

4.1 Control Panel Buttons and Indicators

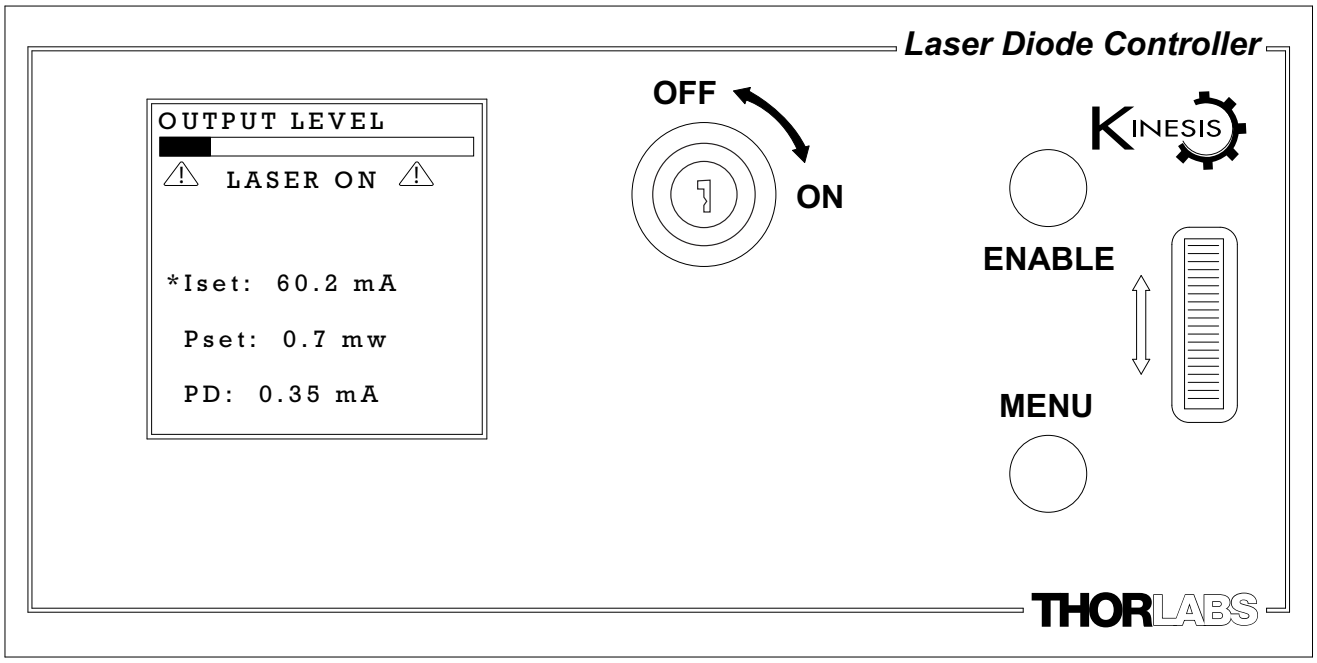


Fig. 4.1 Panel Controls and Indicators

Digital Display - The display shows the menu options and settings, accessed via the menu button - see Section 4.3. When the Ident button on the associated GUI panel is clicked, the display will flash for a short period - see Section 6.1. for further details.

KEY SWITCH - Turns the laser output ON and OFF. The SAFETY KEY 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.

MENU - used to access the settings menu - see Section 4.3.

ENABLE - Turns the laser output ON and OFF.

Wheel - Used to set the laser power and to scroll through the setting menu options - *see Section 4.2.*

During normal operation, the digital display shows the laser current in mA (Iset), laser output power in mW (Pset) and the photodiode current in mA (PD), The operating mode selected (Constant Current or Constant Power) is indicated by an asterisk next to Iset or Pset as required.

When the unit is enabled, if the laser diode goes open circuit (e.g. if the incorrect polarity is selected) the display will show *Open Circuit!* instead of Iset.

It also shows a bar graph which represents the output power level in relation to full power.

The interlock jack pin must be fitted and the key switch turned on (see Section 3.6.) before the laser output can be enabled. Once enabled, a LASER ON warning is displayed on the digital display.

4.2 Top Panel Wheel Operation

The top panel wheel is an infinite turn encoder, used to adjust the output of the laser. To increase the output, turn the wheel upwards - once the maximum output is attained, subsequent upward turns have no effect, however the output decreases immediately the control is turned downwards. Similarly, once the output has been decreased to zero, subsequent downard turns have no effect, but the output increases immediately the control is turned upwards.

Note

Operating the KLD101 unit at maximum power (>70%) for long periods can shorten the life of the product.

The wheel is also used to scroll through the settings menu options as described in Section 4.4.

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 3.4.1. for more details. A power meter and suitable detector head are also required..

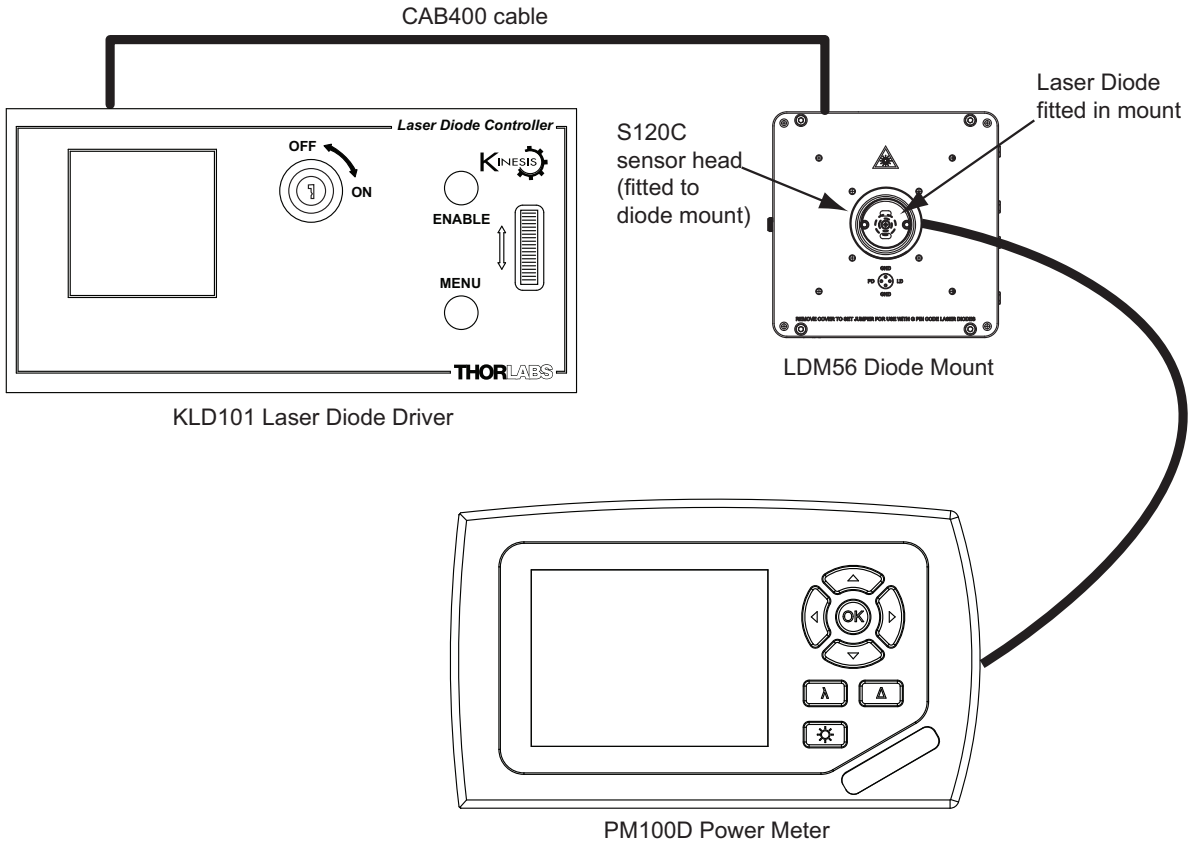


Fig. 4.2 Typical System

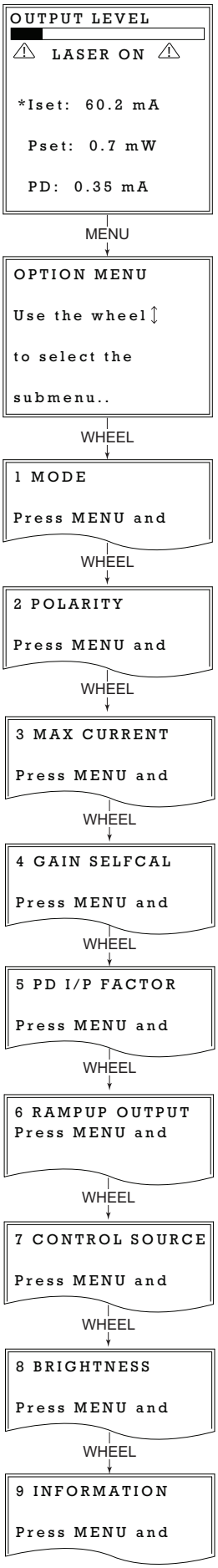
1) Insert the laser diode into the diode mount, taking care to observe the correct orientation.
2) Set the switches on the diode mount to select the correct polarity (AG or CG) for the diode being used.
3) Using cable CAB400, connect the diode mount to the KLD101 unit.
4) Connect the KLD101 to the power supply.
5) Attach the power meter to the diode mount.

Ensure that the KEY SWITCH on the KLD101 is set to OFF, then turn on the power to all units

4.4 Settings Menu

4.4.1 Overview

After the power up sequence is complete, the normal operating screen is displayed.



Press the MENU button to enter the settings mode.

Use the wheel to scroll through the menu options
Press the MENU button to enter a particular option

Set the Operating Mode - see Section 3.5.and Section 4.4.2.

Set the Laser Diode Polarity - see Section 4.4.3.

Set the maximum laser diode current - see Section 4.4.4.

Initiate a photodiode gain calibration - see Section 4.4.5.

Set the photo diode power calibration factor - see Section 4.4.6.

Set the laser diode current rampup option - see Section 4.4.7.

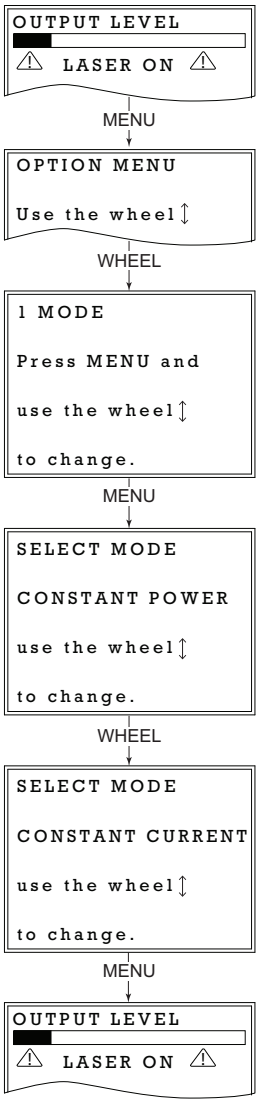
Set the Control Input Source - see Section 4.4.7.

Set the display brightness - see Section 4.4.9.

Display information - see Section 4.4.11.

4.4.2 Menu Option - 1 MODE

The KLD101 laser diode driver can be operated in either Constant Current or Constant Power mode, as described in Section 3.5.



Press the MENU button, then use the wheel to scroll through the menu options

Press the MENU button to enter the 1 MODE option.

Use the wheel to select CONSTANT CURRENT or CONSTANT POWER as described in Section 3.5.,

Caution

When operating in Constant Current mode, the minimum current set poit must be higher than 0.5 mA.

Press MENU when the required option is displayed to save the setting and return to the operating display.

4.4.3 Menu Option - 2 POLARITY

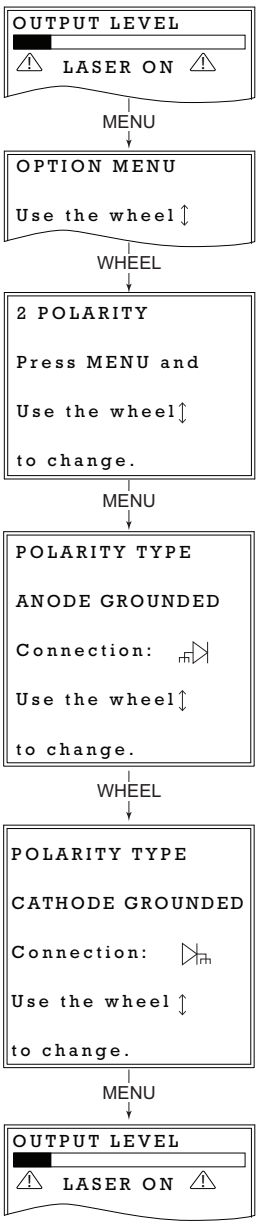
This parameter allows the polarity of the laser diode to be set - see Section 3.4.1.

Press the MENU button, then use the wheel to scroll through the menu options

Press the MENU button to enter the POLARITY mode option.

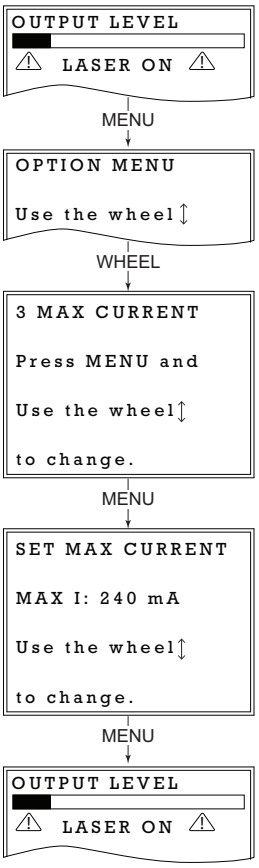
Use the wheel to select either ANODE GROUNDED or CATHODE GROUNDED, whichever is applicable for the laser diode being driven.

Press MENU when the required option is displayed to save the setting.



4.4.4 Menu Option - 3 MAX CURRENT

This parameter is applicable in CONSTANT CURRENT mode, and allows the drive current limit to be set for the laser diode being driven - see Section 3.4.3. The maximum laser current adjustment can be done with the laser on or off.



Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the MAX CURRENT option.

Turn the wheel 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 3.4.3. It is highly recommended to stay well below (at least 20%) the maximum laser power specified for the given laser diode.

Note. The maximum laser current is adjustable from 15 to 230 mA.

Press the MENU button to save the setting and return to the operating screen.

4.4.5 Menu Option - 4 GAIN SELFCAL

This parameter allows the photodiode range and gain to be optimized for the laser diode connected - see Section 3.4.4. Calibration is performed automatically by the unit.

Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the GAIN SELFCAL option.

Turn the wheel to start the calibration sequence or press MENU to abort.

During calibration the display shows a ‘Calibrating now’ message

Warning

When the self calibration is initiated, the top panel display flashes, to warn that the laser is about to be energized.

Self calibration should be performed in the dark, to minimize the detrimental effect of ambient light.

Once optimization is complete, the display shows a ‘Calibration done’ message.

If required, move the wheel to perform the calibration again.

Press the MENU button to return to the operating screen.

4.4.6 Menu Option - 5 PD I/P 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.

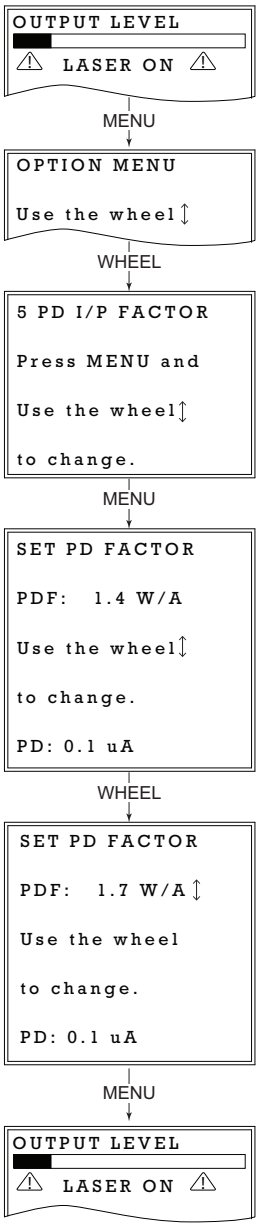
This parameter allows the photodiode power calibration factor to be set.

Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the PD FACTOR option.

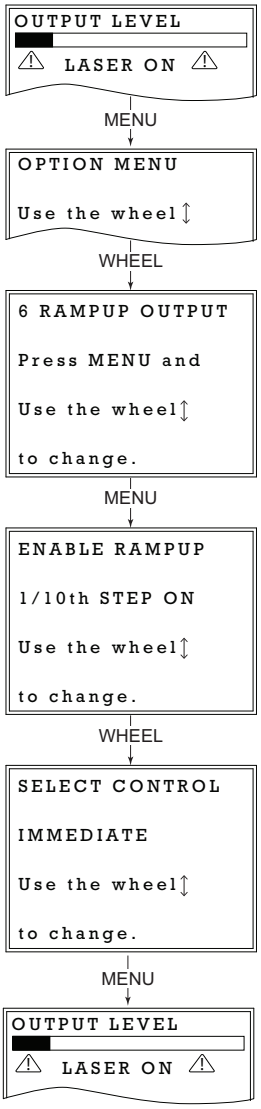
Use the wheel to enter the current factor for the laser diode being driven. This is available from the data sheet supplied with the diode.

Press the MENU button to save the setting and return to the operating screen.



4.4.7 Menu Option - 6 RAMPUP OUTPUT

This option is used to select the method of energizing the laser. By default, when the output is enabled, the laser current will be increased immediately to max current. If required, the output current can be increased gradually in steps 10% of selected max current output.



Press the MENU button, then use the wheel to scroll through the menu options

Press the MENU button to enter the RAMPUP OUTPUT mode option. Use the wheel to scroll through the options.

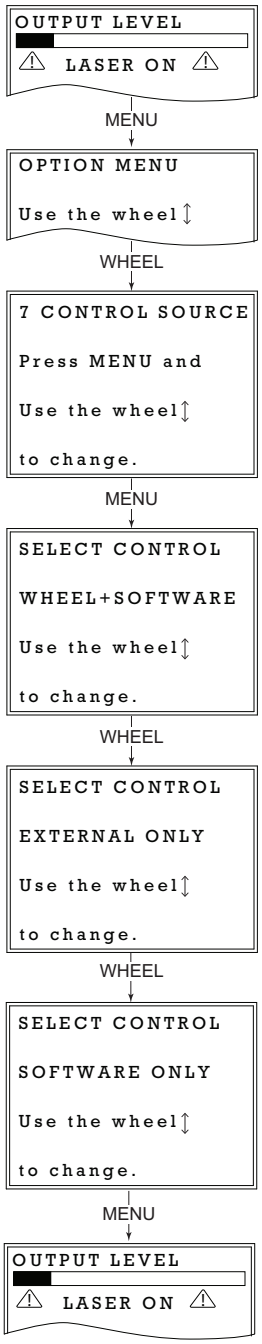
If *ENABLE RAMPUP* is selected, the laser diode output is increased in steps of 10% of max current ouput until the max value is reached. This takes about 1 second.

If *IMMEDIATE* is selected, the laser output is switched to maximum immediately.

Press MENU when the required option is displayed to save the setting and return to the operating screen

4.4.8 Menu Option - 7 CONTROL SOURCE

This option is used to select the method of adjusting the laser power, i.e. software only, external signal via a 0 to 10V source connect to the rear panel EXT IN connector, or a combination of top panel wheel and software.



Press the MENU button, then use the wheel to scroll through the menu options

Press the MENU button to enter the CONTROL SOURCE mode option. Use the wheel to scroll through the options.

If *WHEEL+SOFTWARE* is selected, the output is the sum of the value set in the GUI or via software function calls and that set using the top panel wheel.

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

If SOFTWARE ONLY is selected, the unit responds only to software commands and the output to the laser is that set using the appropriate software function, or the 'SET' control on the GUI panel.

Press MENU when the required option is displayed to save the setting and return to the operating screen

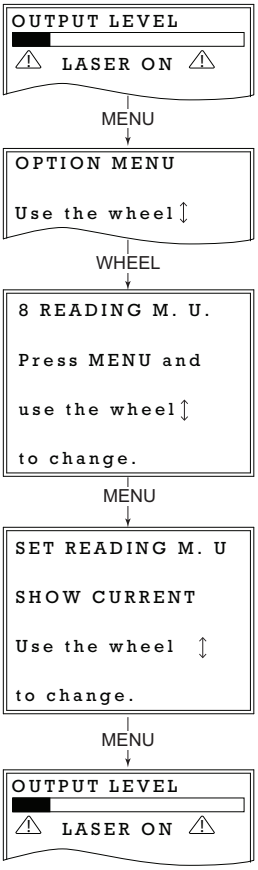
4.4.9 Menu Option - 8 READING M. U.

In certain applications, it may be advantageous to change the display measurement units, without having to run the APT software. The units can be set to show Current to Power.

Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the READING M. U. option.

Use the wheel to select either SHOW CURRENT or SHOW POWER, then press the MENU button to store the selection and return to the main display.



4.4.10 Menu Option - 9 BRIGHTNESS

In certain applications, it may be necessary to adjust the brightness of the LCD display. The brightness is set as a value from 30 (dimmest) to 100 (brightest). The display cannot be turned off completely.

Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the BRIGHTNESS option.

Use the wheel to adjust the brightness, then press the MENU button to store the selection and return to the main display.

4.4.11 Menu Option - 10 INFORMATION

This option is used to display the present settings for Gain Range, Max Current, Max Power, and Software version number.

Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the INFORMATION option.

The present settings for Gain Range, Max Current, Max Power, and the Software version number are displayed.

Press the MENU button to return to the main operating display. The unit will automatically return to the operating display after 5 seconds.

4.5 Manual Operation Tutorial

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 4.3. has already been performed.

1) Perform the mechanical installation as detailed in Section 3.2. and Section 4.3.
2) Connect a laser diode to the LD OUT socket on the rear panel ensuring that the interlock connection is properly made - see Section 3.6. and Section 4.3.
3) Fit the INTERLOCK pin - see Section 3.6.

Caution

During item (4) ensure the power switch on the front panel of the unit is switched off before connecting power to the K-Cube. Always power up the K-Cube unit by its ON switch. DO NOT connect the K-Cube unit to a 'live' external power supply. Doing so (i.e. “hot plugging”) carries the risk of PERMANENT damage to the unit. Similarly, to power down the unit, turn the power switch off before disconnecting the power supply.

4) Connect the Controller unit to the power supply - see Fig. 3.3
5) Connect the PSU to the main supply.
6) Switch ‘ON’ the unit using the switch on the front panel.
7) Windows™ should detect the new hardware. Wait while Windows™ installs the drivers for the new hardware.

The unit takes about 5 seconds from power application until warm up is finished, during which time the following screen is displayed.

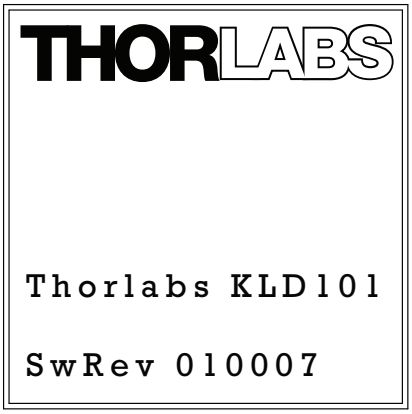


Fig. 4.3 KLD101 start up screen

8) Windows® should detect the new hardware. Wait while Windows installs the drivers for the new hardware.

Note

If any problems are encountered during the connection and power up process, power cycle the unit, which should clear the error.

9) Turn the Key Switch to the ON position.
10) Set the polarity of the laser diode being driven - see Section 4.4.3.
11) Set the Max Current Limit for the laser diode being driven - see Section 4.4.4.
12) Optimize the photodiode current range and gain - see Section 4.4.5.
13) Set the calibration factor for the photodide being driven - see Section 4.4.6.
14) Press the ENABLE button to turn ON the laser.

Note

The key switch must be turned ‘ON’ and the interlock fitted before the laser can be enabled. During normal operation, if the interlock is removed or the key switch turned ‘OFF’, the laser must be re-enabled before it can operate.

15) Turn the wheel to adjust the laser intensity.

For best accuracy, wait approximately 30 mins for the unit to thermally stabilize to the environment.

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 software. It assumes that the unit is electrically connected as shown in Section 3.3. and that the Software is already installed - see Section 3.1.

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 3.4.1. 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 KLD101 unit.
4) Connect the KLD011 to the power supply.
5) Connect the power meter sensor to the diode mount.
6) Ensure that the KEYSWITCH on the KLD101 is set to OFF, then turn on the power to all units.
7) Connect the KLD101 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.

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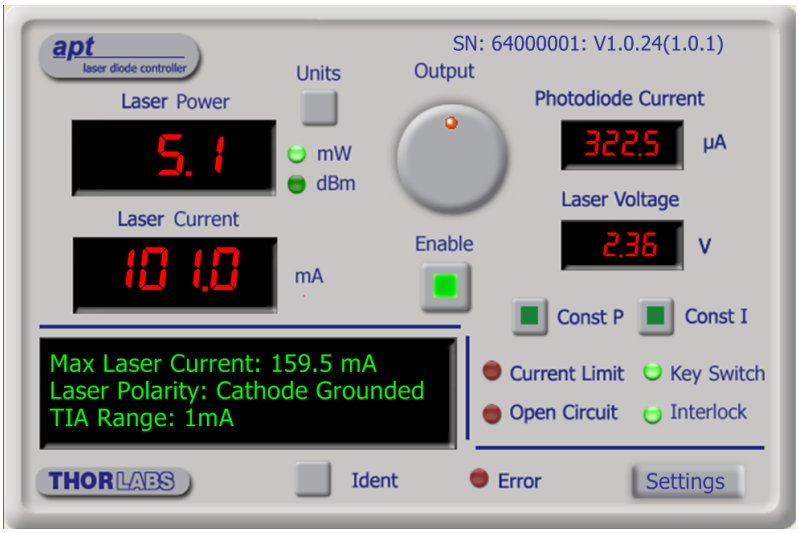

Fig. 5.1 Laser Driver Software GUI

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 3.4.1., the KLD101 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.

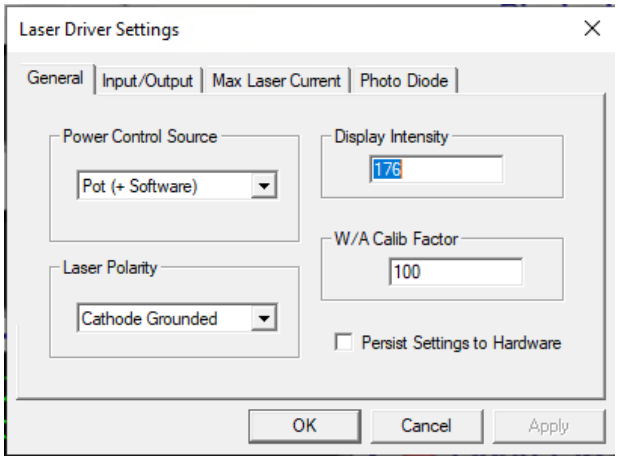

Fig. 5.2 Laser Driver Settings Panel - Photo Diode Tab

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.

...continued on next page

Adjusting the Laser Diode Drive Current Limit

As previously explained in Section 3.4.3., the laser diode drive current limit must be set to ensure the diode is not overdriven.

5) Select the 'Max Laser Current' tab.

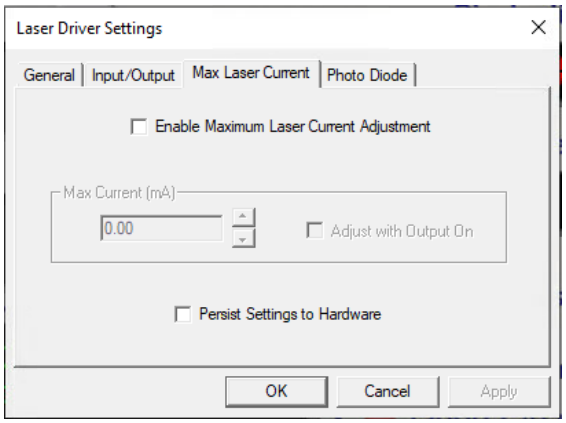

Fig. 5.3 Laser Driver Settings Panel - Photo Diode Tab

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.

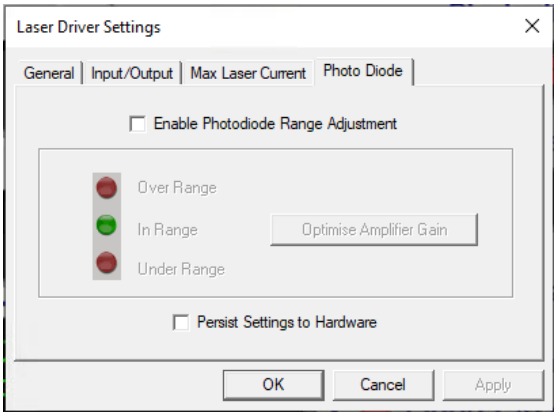


Fig. 5.4 Laser Driver Settings Panel - Photo Diode Tab

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 3.3.1.), 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 3.4.4., 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 EXT IN connector. The voltage range is -10V to 10V, input resistance is >10kΩ.

The external input is always scaled so that 0 to 10V is equivalent to 0 to ILIM (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 4.4.2.
2) Turn the OUTPUT pot to set the desired value.
3) Connect the modulation source to the rear panel EXT 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)’.

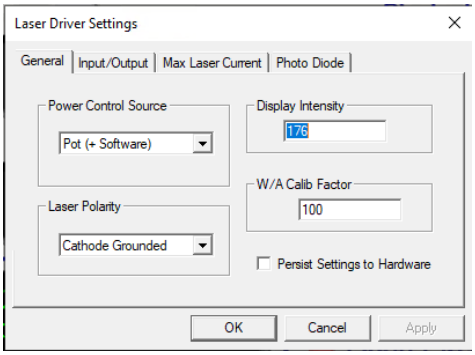


Fig. 5.5 Laser Driver Settings - General Tab

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.

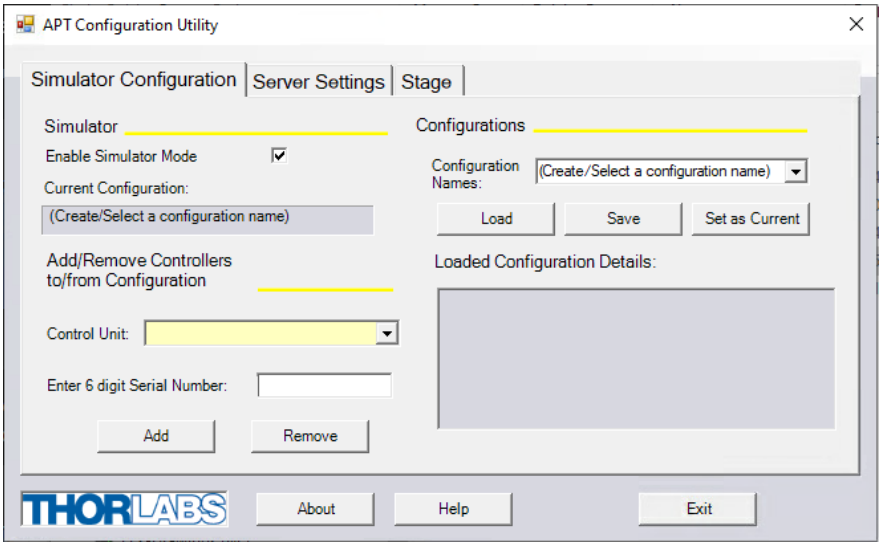
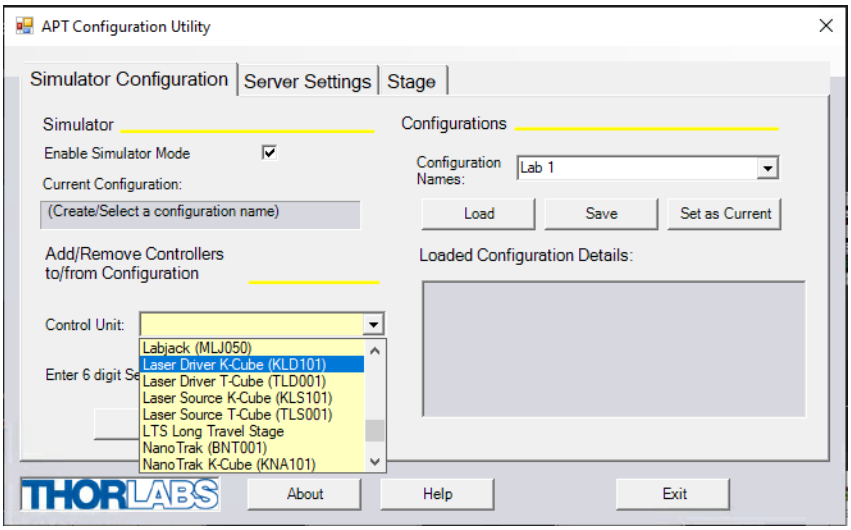
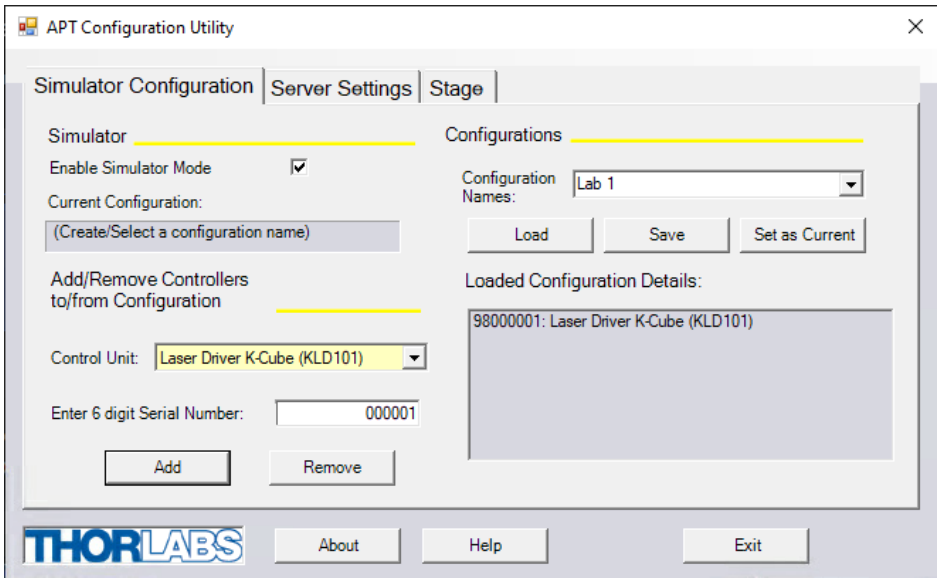


Fig. 5.6 APT Configuration Utility - Simulator Configuration Tab

3) Enter a configuration name, e.g. '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 K-Cube (KLD101)’.



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 KLD101 K-Cube Laser Diode Driver are: 98xxxxxx

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 APT software.

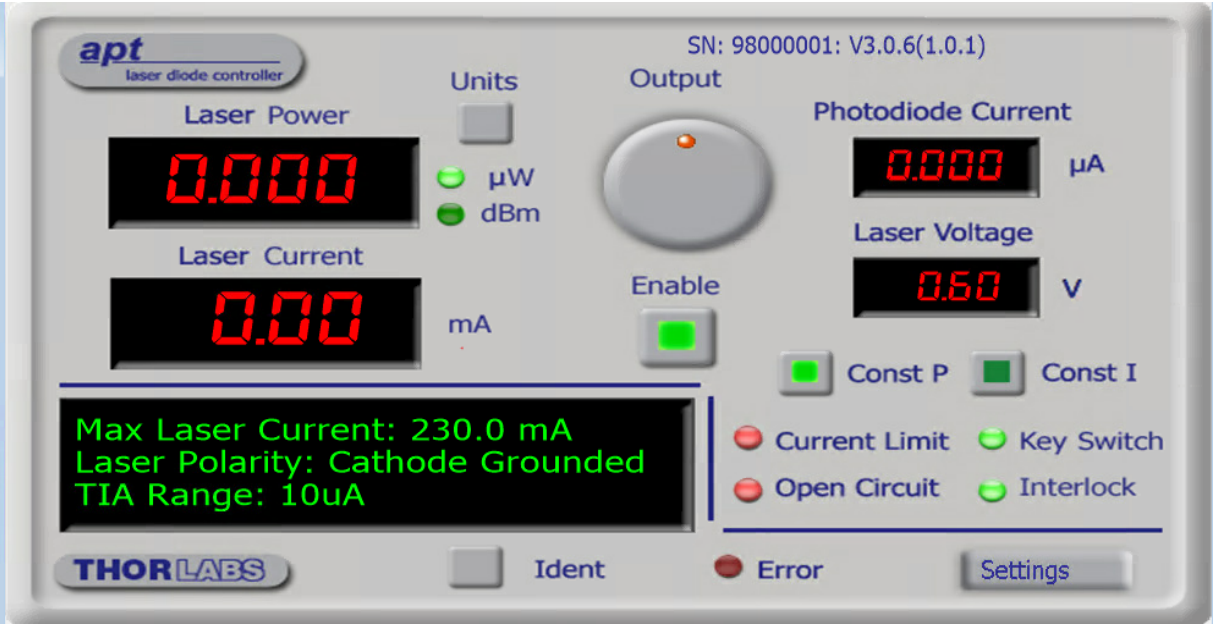


Fig. 6.1 KLD101 Laser Diode Driver Software GUI

Note. The serial number of the KLD101 unit associated with the GUI panel is 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 he photodiode current reading (I_{PD}), the photodiode current range, set by the rear panel micro switches (Section 3.3.1.), 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 3.4.3.

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 3.3.1.).

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 KLD101 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 KLD101 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 3.4.3.) 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 4.1.

Interlock LED - lit green when the 'Interlock' connection is made (short circuit), red when open circuit - see Section 3.3.1.

Settings display - shows 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 Settings panel - Section 6.2.3.

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 4.4.6. 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 methods and properties on this Control (refer to the *Programming Guide* in the *Server online helpfile* (accessed via the Windows 'Start' menu) for further details.

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 1.3.3. for an overview of the APT ActiveX controls).

6.2.1 General Tab

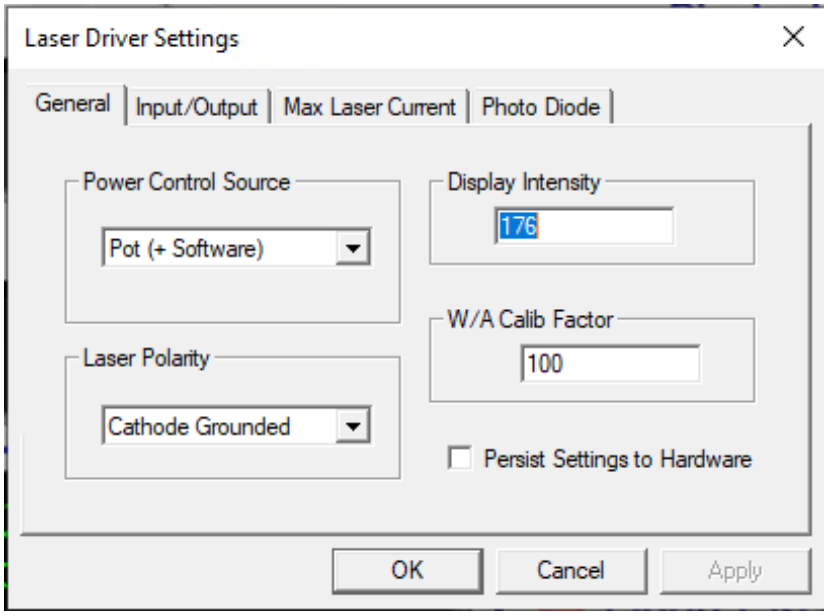


Fig. 6.6 Laser Driver Settings Panel - General Tab

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

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

If *Pot (+Software)* is selected, the output to the laser is the sun of that set using the top panel OUTPUT potentiometer and the Output control on the GUI panel..

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.

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 KLA101 accordingly - see Section 3.4.1.

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 Input Output Tab

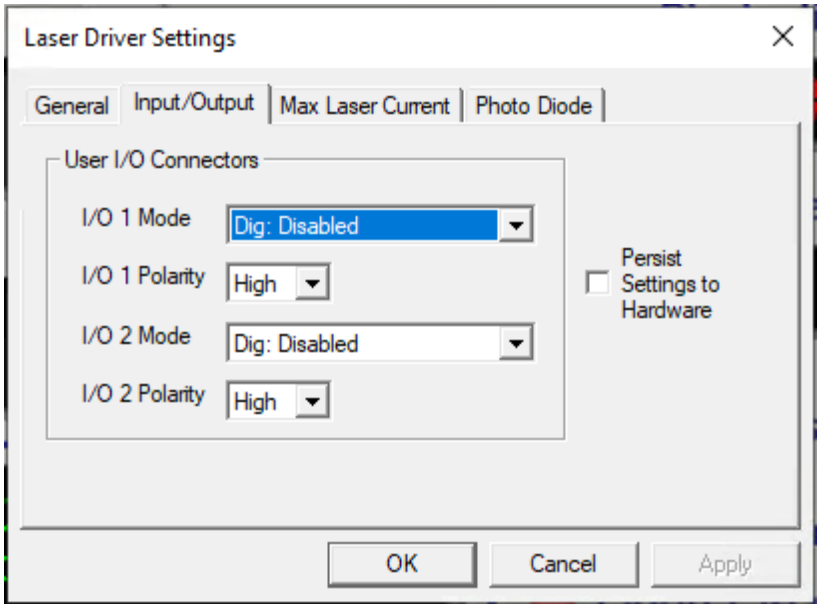


Fig. 6.7 Laser Driver Settings Panel - Input/Output Tab

User I/O Connectors

Note

When used for triggering, the IO port is edge sensitive, i.e. it has to see a transition from the inactive to the active logic state (Low to High or High to Low) for the trigger input to be recognized. For the same reason a sustained logic level will not result in repeated trigger signals. The trigger input has to return to its inactive state first in order to start the next trigger.

I/O 1 and I/O 2 Modes

Input Trigger Modes

When configured as an input, the IO ports can be used as a general purpose digital input, or for triggering a choice of actions as follows:

Disabled - The trigger IO is disabled.

General Input - General purpose logic input (read through status bits using the software messages - see the helpfile for more details).

Output Trigger Modes

When configured as an output, the IO ports can be used as a general purpose digital output, or to indicate laser status or to produce a trigger pulse at specific events as follows:

General Output - General purpose logic output (set using the software messages - (see the helpfile for more details).

Laser ON - Trigger output active when the laser output is ON. The output trigger goes high (5V) or low (0V) (as set in the *Polarity* parameter) when the laser is active.

Interlock Enabled - Trigger output active when the interlock state is Enabled.

Set Point Changed - Trigger output active when the laser set point value is changed.

I/O 1 and I/O 2 Polarity - The active state of the Trigger, Active High (5V) or Active Low (0V)

Persist Settings to the Device - Many of the parameters that can be set for the Laser Driver K-Cube can be stored (persisted) within the unit itself, such that when the unit is next powered up these settings are applied automatically. This is particularly important when the driver is being used manually in the absence of a PC and USB link. The *Input 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.

6.2.3 Max Laser Current Tab

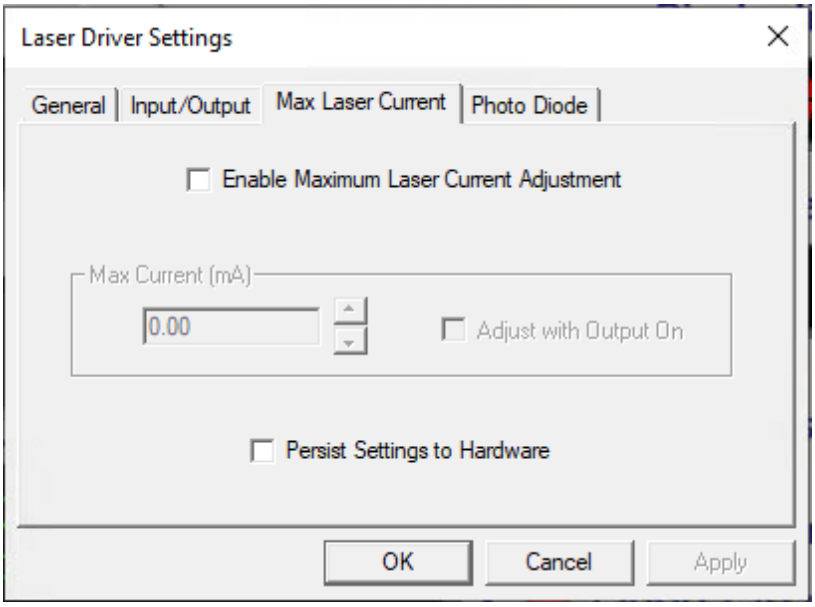


Fig. 6.8 Laser Driver Settings Panel - Max Laser Current Tab

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 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.

6.2.4 Photo Diode Tab

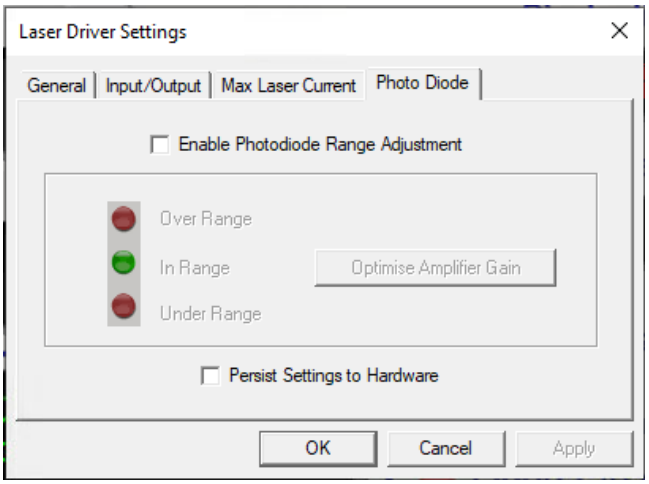


Fig. 6.9 Laser Driver Settings Panel - Photo Diode Tab

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 set in the Settings panel should be adjusted such that the green *In Range* LED is lit - see Section 3.4.4. for more information.

Optimise TIA Range Gain - Click this button to optimize the gain of the TIA - see Section 3.4.4.

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 Panel Connector Pinout Details

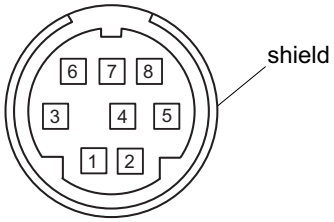
A.1 Power Connector

Thorlabs recommends that the Laser Diode Driver K-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 ±15V 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

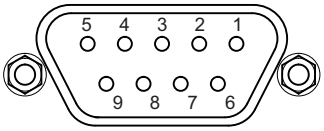
When wiring the mini-DIN plug, ensure that all the ground pins are used and the shield is connected to common ground. This provides a level of protection against overvoltages due to loss of ground. A “loss of ground” condition can seriously damage the electronics inside the cube.

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 3.6.

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 3.6.

Fig. A.2 LD OUT connector pin identification

Appendix B Preventive Maintenance

Warning

The equipment contains no user servicable parts.

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

Warnings

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

Appendix C Specifications and Associated Parts

C.1 Specifications

Parameter	Value
Laser Diode (LD) Output	9-Pin D-Type
Maximum LD Current	230 mA
Max LD Current Limit Range	15 mA to 200 mA
LD Compliance Voltage	Up to 10 V at 50 mA (>7 V at 230 mA)
LD Current Setting Resolution	<8 µA
LD Power Setting Resolution	1 µW
LD Current/Power Measurement Resolution	<0.4 µA (15bit)
Output Current Accuracy (Constant Current Mode)	0.2% (230 mA)
Temperature Drift	<40 ppm/°C typical
LD Current Noise [a]	<3.5 µA rms typical @ 46 mA over 20 Ω
LD Voltage Reading Accuracy	3% of Full Scale (15 V)
Supported LD/PD Configurations	All
LD Protection	Relay - Open Circuit, Under/Over Voltage - 2 Interlocks
Operating Modes	Constant Current/Constant Power
Modulation Input	SMA 0 to 10V = 0 to Full Power, DC or Sine Wave Input Only
Modulation Bandwidth [b]	20 kHz Full Depth (46 ksps)
Trigger Response Time	<10 ms
EXT IN Sampling Rate	47 ksps (22 µs), Typical Delay 100 µs
EXT IN LPF Cut Off Frequency	20 kHz (-6 dB)
EXT IN Accuracy	1% Typical (2% Max)
Power Input	+15 V, -15 V, +5 V
USB Connector Type	USB 3.0
USB Connection Speed	USB 1.1 Full Speed (12 Mbps)
Housing Dimensions (W x D x H)	121 x 60 x 47 mm (4.76" x 2.36" x 1.85")
Weight	400g (0.88 lb)

Notes.

[a] The minimum noise generation is achieved in current mode. In constant power mode the digital loop introduces a quantization error that depends on the power setpoint and its position on the laser diode current curve. Furthermore, the KCH series hubs have been optimized for motion control and are not suitable for use in low noise applications. To achieve the quoted noise specification the TPS002 PSU must be used.

The noise has been measure with a 46mA current (20% of full scale current) on a load of 20 Ω which represents the laser diode using a differential probe.

[b] measured in Constant Current mode.

C.2 Associated Products

Product Name	Part Number
Power Supply Unit for up to two Laser Diode driver Cubes	TPS002
K-Cube 3-channel Controller Hub and power supply	KCH301
K-Cube 6-channel Controller Hub and power supply	KCH601
KLD101 to LD Connector Cable	SR9x-DB9
KLD101 to LD Mount Connector Cable	CAB400
SMA to BNC Converter Cable 6”	CA2806
SMA to BNC Male Converter	T4289
SMA to BNC Female Converter	T4290

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

Appendix D Regulatory

D.1 Declarations Of Conformity

D.1.1 For Customers in Europe

See Section D.2.

D.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, persuant 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.

D.2 CE Certificate

EU Declaration of Conformity

in accordance with EN ISO 17050-1:2010

We: Thorlabs Ltd.

Of: 1 St. Thomas Place, Ely, CB7 4EX, United Kingdom

in accordance with the following Directive(s):

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

hereby declare that:

Model: ***KLD101***

Equipment: ***K-Cube Laser Diode Controller***

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

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

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

is exempt from the requirements of the Directive because its intended application is excluded pursuant to Annex III or Annex IV of the Directive. Exemption 6C.

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

Signed:  *On:* 05 April 2019

Name: Keith Dhese

Position: General Manager

EDC - KLD101 -2019-04-05

CE

Appendix E 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.
sales@thorlabs.com
techsupport@thorlabs.com

Europe
Thorlabs GmbH
europe@thorlabs.com

France
Thorlabs SAS
sales.fr@thorlabs.com

Japan
sales@thorlabs.jp

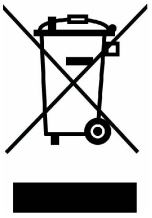
UK and Ireland
sales@uk.thorlabs.com
techsupport.uk@thorlabs.com

Scandinavia
scandinavia@thorlabs.com

Brazil
brasil@thorlabs.com

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 dissembled 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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