THORLABS

TTC001 T-Cube TEC Controller

APT User Guide

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Chapter 1   Overview

1.1   Introduction

The T-Cube Thermoelectric Temperature Controller (TTC001) is a precise temperature controller for laser diodes and detectors. The TTC001 is ideally suited for:

- Wavelength Stabilization of Laser Diode

- Noise Reduction of Detectors

- Wavelength Tuning by Regulating the Temperature

- Modulation of Wavelength by Tuning the Temperature

The unit is easy to use due to the clearly arranged controls on the front panel. The measurement values are shown by a 5-digit LED display and are selected via two push buttons and a knob.

The TTC001 is designed to be completely compatible with Thorlabs T-Cube product series. The unit can be controlled via the panel buttons or from a PC via a USB connection (either standalone operation or when mounted to the KCHx01 K-Cube Hub). The operation can be controlled using the provided software package.

Figure 1   T-Cube TEC Controller (TTC001)

The proportional gain, the integral share, and the derivative share of the PID temperature control loop can be set independent of each other to optimize the performance of the controller. The TTC001 also has preloaded setups for each of Thorlabs' TEC mounts to simplify operation. No PID adjustments should be needed for Thorlabs' LDM56, LDM90, LM14S2, and LDM21.

For temperature sensing the TTC001 temperature controller works with both thermistors and temperature IC sensors like the AD590 or AD592. With a thermistor the temperature display is shown as resistance value in kΩ. If the TTC001 is operated with a temperature sensor IC, the temperature is shown in °C or °F.

TEC current output can be enabled or disabled via the Enter button on the front panel. The Mode button allows the user to access the setup menus. The front panel Control Knob can be used to adjust the temperature setting as well as navigate the menu.

The temperature sensor and the TEC element are connected by a 15-pin D-sub jack at the rear of the unit. A 15-pin D-sub to 9-pin D-sub is supplied with the TTC001 to directly connect to Thorlabs LDM56, LDM90, LDM21 and LM14S2 TEC mounts.

The set value of the temperature can be changed with the Control Knob on the front panel or through the provide software when connected through the USB port. Also, an analog input can be used to set the set point temperature or to directly control the output current level. The temperature set point option will scale the

input from the lower temperature limit to the upper temperature limit. These limits are set in the Setup Menu. For current control, the input will scale to the current limit also set in the setup menu.

The unit has been designed for safe operation with environmental temperatures up to 40 °C provided that a free air circulation through the ventilation slots at the rear and at both sides of the unit is maintained.

USB connectivity provides easy Plug and Play PC controlled operation - multiple units can be connected to a single PC via standard USB hub technology or by using the T-Cube Controller Hub for multi-axis motion control applications. 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 motion control applications and sequences are also possible using the extensive ActiveX® programming environment also supplied. This programming library is compatible with many development tools such as LabView, Visual Basic, Visual C++, C++ Builder, LabWindows/CVI, Matlab and Delphi.

Refer to APT Software Overview for a full description of the APT System software.

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

1.2   TEC Element Protection

The temperature control system includes a protective circuit, which limits the TEC current in all operating modes.

The current limit can be set through the menu system via the front panel, and through software method calls. The TTC001 has a maximum current limit of ±1 A but this can be limited to a minimum of ±100 mA. To access this feature, press the Mode button, Adjust the Control Knob until "Cur L" appears, Press the Enter button, use the Control Knob to select the desired limit, and press Enter to accept.

When the unit is first turned on, the TEC current will be disabled. Pressing the Enter button allows the TEC controller to enable / disable the current. When the TEC current is disabled, the display will blink with the set temperature displayed.

1.3   USB Controller Hub

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

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

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

> ⚠️ **Caution**
>
> The KCH301 and KCH601 Controller Hubs have been designed primarily for use with the K-Cube range of controller units. T-Cube controllers such as the TTC001 TEC Controller can still be used on this hub but will require an adapter plate (KAP101) before they can be fitted.

Figure 2   KAP101 T-Cube Adaptor Plate

1.4   APT Software Overview

1.4.1   Introduction

As a member of the APT range of controllers, the TTC001 TEC controller 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 (refer to section 1.4.2) and APTConfig (refer to section 1.4.3) utilities allow full control of all settings and operating modes enabling complete 'out-of-box' operation without the need to develop any further custom software. Both utilities are built on top of a sophisticated, multi-threaded ActiveX 'engine' (called the APT server) which provides all of the necessary APT system software services such as generation of GUI panels, communications handling for multiple USB units, and logging of all system activity to assist in hardware trouble shooting. It is this APT server 'engine' that is used by software developers to allow the creation of advanced automated positioning applications very rapidly and with great ease. The APT server is described in more detail in section 1.4.4.

Aside

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

ActiveX controls are a specific form of ActiveX technology that provide both a user interface and a programming interface. An ActiveX control is supplied for each type of APT hardware unit to provide specific controller functionality to the software developer. Refer section 1.4.4 for further details.

1.4.2   APT User 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.
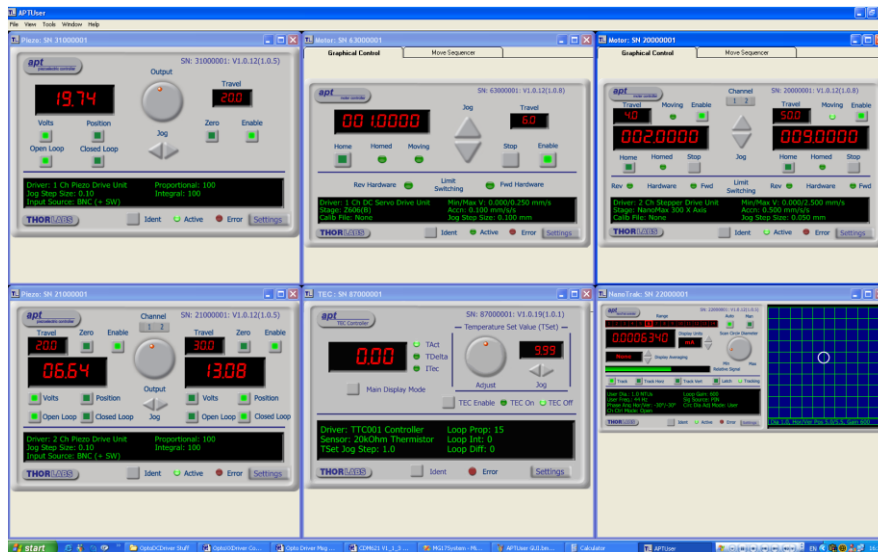
Figure 3   APTUser Utility

All basic operating parameters can be altered and, similarly, all operations (such as piezo moves) 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.

1.4.3 APT Config Utility

There are many system parameters and configuration settings associated with the operation of the APT Server. Most can be directly accessed using the various graphical panels, however there are several system wide settings that can only be made 'off-line' before running the APT software. These settings have global effect, such as switching between simulator and real operating mode and incorporation of calibration data.
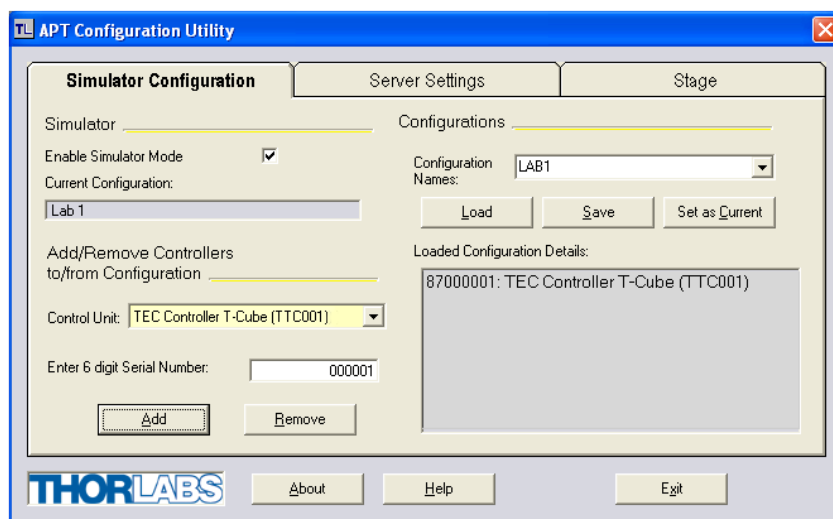
Figure 4   APT Config Utility

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.

1.4.4 APT Server (ActiveX Controls)

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

With the APT system, ActiveX Controls are deployed to allow direct control over (and reflect the status of) the range of electronic controller units, including the TPZ0101 piezo 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 for a TTC001 APT TEC controller unit.
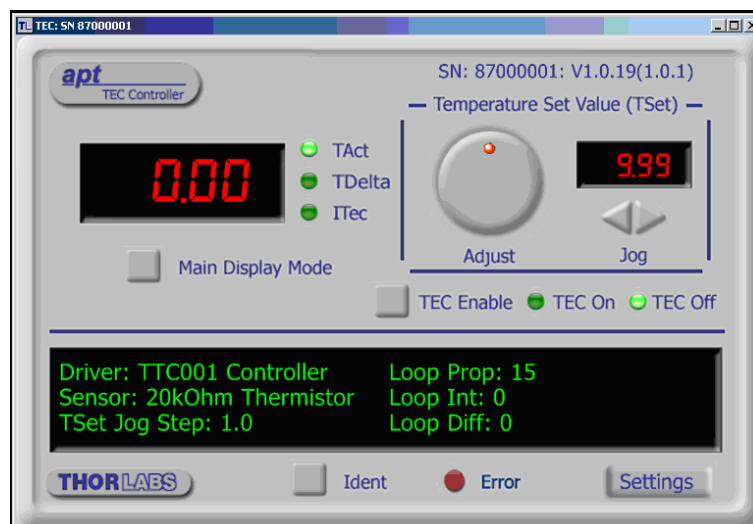
Figure 5   APT Server

This Control provides a complete user graphical instrument panel to allow the TEC 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 TEC 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 actual temperature). Updates to the panel take place automatically when a user (client) application is making software calls into the same Control.

The APT ActiveX Controls collection provides a rich set of graphical user panels and programmable interfaces allowing users and client application developers to interact seamlessly with the APT hardware. Each of the APT controllers has an associated ActiveX Control and these are described fully in system online help. Note that the APTUser and APTConfig utilities take advantage of and are built on top of the powerful functionality provided by the APT ActiveX Server (as shown in Figure 6).
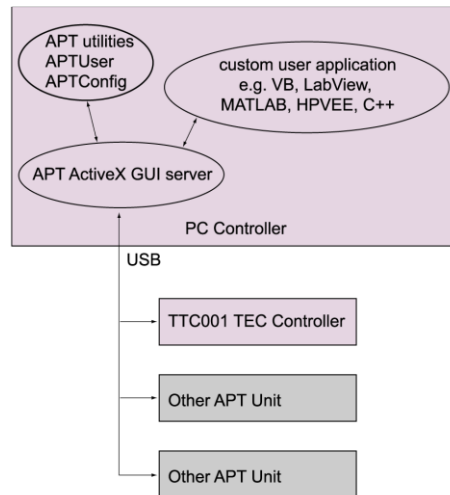
Figure 6   ***System Architecture Diagram***

Refer to the main APT Software help file, APT Server Help (available from the Windows Start menu), for a complete programmers guide and reference material on using the APT ActiveX Controls collection. Additional software developer support is provided on the **APT Software Tutorial** page of the Thorlabs website. This webpage contains a complete range of tutorial samples and coding hints and tips. Handbooks for all the APT Controllers are provided in the "View Help" option under Help tab of the APT User Software.

1.4.5 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 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.

Warning: Risk of Electrical Shock

Given when there is a risk of electrical shock.

Warning

Given when there is a risk of injury to users.

Caution

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

Note

Clarification of an instruction or additional information.

2.1   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. 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.

Chapter 3   Installation

3.1   Environmental Conditions

> **Warning**
>
> Operation outside the following environmental limits may adversely affect operator safety. The safety of any system incorporating this equipment is the responsibility of the person performing the installation.

The unit is designed for indoor use only.

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

The unit is not designed to be used in explosive environments.

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   Install the Software

> **Note**
>
> When operating via a PC, direct user interaction with the solenoid controller is accomplished through intuitive graphical user interface panels (GUIs), which expose all key operating parameters and modes. 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 user's 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. Download the software from **www.thorlabs.com**
2. Locater the downloaded installation file and move to a suitable file location.
3. Run the setup.exe file and follow the on-screen instructions.

3.3   Connect the Hardware

Perform the following:

1. Perform the mechanical installation as detailed in section 3.5.
2. Connect the laser mount or other device to the TEC controller unit- refer to section 3.6.1.

> **Caution**
>
> During item (3) ensure the power supply unit is isolated from the mains before connecting to the TEC unit. Always power up the TEC unit by connecting its power supply to the mains. DO

NOT connect the TEC 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, disconnect the power supply from the mains before disconnecting the TEC unit.

3. Connect the controller unit to the power supply – refer to section 3.9.
4. Connect the PSU to the main supply and switch 'ON'. The version number of the embedded software is displayed while the unit boots up. If the unit is being used with the KCHx01 USB Controller hub, the bay identification number is also displayed. The software version is useful when requesting technical support.
5. Connect the TEC Controller unit to your PC.

Note

The USB cable should be no more than 3 meters in length. Communication lengths more than 3 meters can be achieved by using a powered USB hub).

6. Windows should detect the new hardware. Wait while Windows installs the drivers for the new hardware. Refer to the Getting Stated guide for more information.
7. For maximum accuracy, wait approximately 10 minutes for the unit to thermally stabilize to the environment.
8. Run the APTUser utility.
    Start/All Programs/Thorlabs/APT/APT User.
9. Your T-Cube TEC Controller is now ready to use.
    Refer to Chapter 5 of this manual for a brief tutorial on the unit operation.

3.4   Verify Software Operation

Perform the following for the initial setup:

1. Install the APT software as detailed in section 3.2.
2. Connect the controller to the actuators (refer to section 3.6.1) and the PC, then switch ON. Wait approximately 5 seconds for the system to settle.

Caution

In applications requiring the highest level of accuracy and repeatability, it is recommended that the controller unit is powered up approximately 10 minutes before use, in order to allow the internal temperature to stabilize.

3. Run the APTUser utility and check the Graphical User Interface (GUI) panel appears and is active.
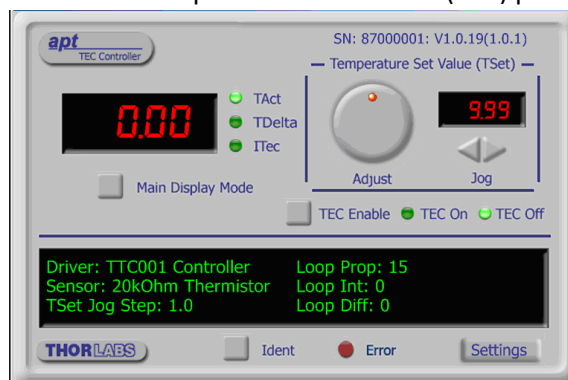
Figure 7   Gui Panel showing jog and ident buttons

4. Click the 'Ident' button. The Power LED and digital display on the front panel of the associated controller flashes. This is useful in multi-channel systems for identifying which channel is associated with which GUI.

5. Click the jog buttons on the GUI panel to adjust the Set temperature. The temperature display on the associated TEC controller unit should increment and decrement accordingly.

   Follow the tutorial described in Chapter 5 for further guidance on basic operation.

Note

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 to application program development and testing. Any number of 'virtual' control units are combined to build a model of the real system, which can then be used to test the application software offline.

If using real hardware, ensure that Simulator Mode is disabled. If using a simulated setup, enable Simulator Mode and set up a 'Simulated Configuration' – refer to section 5.4. See also the APTConfig helpfile and the tutorial videos for detailed instructions.

3.5 Mechanical Installation

3.5.1 Mounting Options

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

If desired, the baseplate can be removed, and the unit can be stood on rubber feet – refer to section 3.5.2.

For multiple cube systems, a 3-channel and 6-channel K-Cube Controller Hub (KCH301 and KCH601) are also available – refer to section 1.3 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.

Ensure that proper airflow is maintained to the rear and sides of the unit. Do not obstruct the ventilation holes.

3.5.2 Removing the Baseplate

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

Detail A Baseplate attachment screws   Detail B Baseplate removed and rubber feet fitted

Figure 8   Removing the Baseplate

Perform the following:

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

3.5.3   Using the TTC001 Controller on the KCH Series Hub

The KCH301 and KCH601 Controller Hubs have been designed primarily for use with the K-Cube range of controller units. T-Cube controllers such as the TTC001 TEC Controller can still be used on this hub but will require an adapter plate (KAP101) before they can be fitted. The baseplate must be removed as described previously, before fitting the KAP101 adapter plate.


Figure 9   TTC001 Controller on the KCH Series Hub

Perform the following:

1. Ensure that all power is disconnected from the hub.
2. Remove the plastic cover from the relevant connector on the KCH hub.
3. Undo the plastic securing clips on each side of the hub at the position to be fitted.
4. Check for correct orientation of the ERNI connector socket on the hub and its mating plug on the adapter plate, then plug the adapter plate into the hub, ensuring that the locating pegs on the hub are correctly fitted into the lugs in the base of the adapter plate.
5. Do up the securing clip.
6. If fitted, remove the base plate from the T-Cube (refer to section 3.5.2). Retain the screws for later use.
7. Check for the correct orientation of the ERNI connector socket on the KAP101 adapter plate and its mating plug on the T-Cube Unit, then plug the T-Cube unit into the hub, ensuring that the locating pegs on the adapter plate are correctly fitted into the lugs on the T-Cube.
8. Using the screws retained at item (6) secure the T-Cube to the adapter plate.

3.6 Electrical Installation

3.6.1 Rear Panel Connector Identification
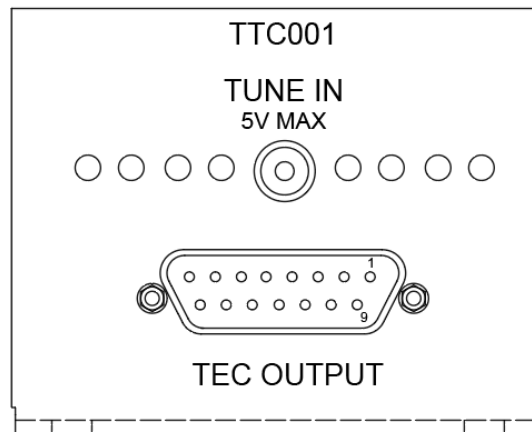
Figure 10   Rear Panel Connections

TEC OUTPUT (15-Pin D-Sub connector) – Provides connection to the Laser Diode Mount or other device. If Laser Diode Mounts by Thorlabs are used, connect the "TEC OUTPUT" of the TTC001 to the 9-pin plug "TEC DRIVER" of the Laser Diode Mount, using the provided shielded cable CAB420-15.

With other equipment, connect the TEC element and the temperature sensor as detailed in section 7.1.

TUNE IN – Used to control the output of the controller from an external source. A zero to 5 V analog input can be used to either adjust the set temperature, allowing the PID loop to maintain the desired temperature, or it can be used to directly control the current output of the controller.

When used to adjust the set temperature, the maximum tuning range for the analog control input "TUNE IN" is detailed in section 4.3.9.

When directly controlling the current output, the current limit (iLim) is used to scale the analog input so that the 0 to 5 V provides a range of ±iLim – section 4.3.4.

3.6.2 Connecting the TEC Element and the Temperature Sensor

If Laser Diode Mounts by Thorlabs are used, connect the "TEC OUTPUT" of the TTC001 to the 9-pin plug "TEC DRIVER" of the Laser Diode Mount, using the provided shielded cable CAB420-15.

The unit can also be used with any standard thermistor or AD590/AD592 temperature sensors. Connect the TEC element and the temperature sensor as detailed in the following sections.

For thermistors, a measurement range of 0 and 20.00 kΩ (TH20) or 0 and 200.0 kΩ (TH200) can be selected – see section 4.3.3 When AD590 (also AD592) temperature sensors are connected, the measurement range is between -45.0 °C and +125.0 °C. The actual control range depends on the sensor ratings and the individual thermal setup. Refer to section Setting the Sensor Type for more information.

3.6.3   Connecting a Thermistor

The thermistor must be connected between pin 3 and pin 4 of the TEC OUTPUT connector as detailed in section 7.1. The polarity is unimportant if the thermistor is floating. If one pin of the thermistor is grounded (for example in a laser module), this pin has to be connected to pin 3.

If the Temperature Controller TTC001 is operated with a thermistor as the temperature sensor, the set temperature and the actual temperature are displayed in kΩ. From the "SEnSr" menu in the Setup Menu, select either 'th20' or 'th200' (refer to section 4.3.3). This selects the resistance range of the thermistor between a maximum thermistor resistance of 20 kΩ (measurement current is 100 µA) and a maximum thermistor resistance of 200 kΩ (measurement current is 10 µA).

In most cases a 10k thermistor will be used. In this case, the 20K range may be selected but this will limit the actual temperature range to approximately 15 °C (see thermistor operating curve for actual values). Usually this is sufficient but if temperatures lower than 15 °C are required, the 200k range should be used. This will lower the overall set point resolution but increase the operating range.

3.6.4   Connecting a Temperature Sensor AD590/AD592

If the temperature/current transducer AD590 (or AD592) is used as the temperature sensor, it is connected between pin 10 (-) and pin 11 (+) of the TEC OUTPUT connector as detailed in section 7.1 .From the "SEnSr" menu in the Setup Menu, select 'Ad590' (refer to section 4.3.3). The accuracy of the displayed temperature depends on the tolerance of the transducer used.

> ⚠️ **Caution**
>
> A reverse poled TEC element may lead to thermal runaway and destruction of the connected components. If there is any doubt concerning the TEC element polarity, perform a polarity check as detailed in section 3.6.5.

3.6.5   Checking the TEC Polarity

Perform the following:

1. Connect the power to TTC001.
2. Connect the temperature sensor to the jack "TEC OUTPUT".
3. Select the appropriate sensor type through the menu by pressing the Mode button once and rotating the Control Knob until "SEnSr" is displayed. Press the Enter button and select the correct sensor with the Control Knob. Press Enter again.

> **Note**
>
> Ad590 and Ad592 are equivalent, select "Ad590" for either one. Once you select the sensor type you will be able to set the temperature upper limits ("HI L") and the temperature lower limit ("LO L").

---

4. Select a suitable current limit in the same way the sensor was selected. Enter the "Cur L" menu and use the Control Knob to set the limit. Press Enter when the desired current limit is displayed.
5. Select the appropriate display type in the "disP" menu using the Control knob and Enter button.

---

6. Press Mode to switch the display to the Monitor mode. The display will be flashing and will show the current set temperature.
7. Select a temperature setting that is higher or lower than the ambient temperature with the Control Knob and press Enter. Press Enter again to enable the TEC current. The display should stop flashing. If the TEC module is connected with the right polarity, the difference between the set value and the actual setting will decrease. If the control loop parameters are set properly (refer to section 3.5) the actual temperature will approach the set temperature in a short time. IF the TEC module is connected with wrong polarity, the difference between the set temperature and the actual temperature will increase continuously. Switch off the TEC current by pressing the Enter button and change the TEC module wiring at the D-sub plug connected to the jack "TEC OUTPUT".

3.7 Using the KCH301/KCH601 Controller Hub

The KCH series USB Controller Hubs provide power distribution for three (KCH301) or six (KCH601) Cubes, and require only a single power connection.

> **Warning**
>
> DO NOT PLUG A POWERED UP T-CUBE INTO THE USB CONTROLLER HUB. Always ensure that all power is disconnected from the TEC Controller T-Cube AND the hub before the T-Cube is plugged into the hub. Failure to observe this precaution will seriously damage the T-Cube unit and could result in personal injury.

3.8 Supply Voltage and Current Requirements

Supply	Minimum	Maximum	Max Operating Current
+5 V	+4.9 V	+5.1 V	1 A

## 3.9 Connecting to a Standalone Power supply

> **Warning**
>
> The unit must be connected only to a DC supply as detailed in section 3.8. Connection to a supply of a different rating may cause damage to the unit and could result in injury to the operator.

> **Caution**
>
> Do not connect the TEC unit 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 before connecting to the TEC unit. Always power up the TEC unit by connecting its power supply to the mains. Similarly, to power down the unit, disconnect the power supply from the mains before disconnecting the TEC unit.
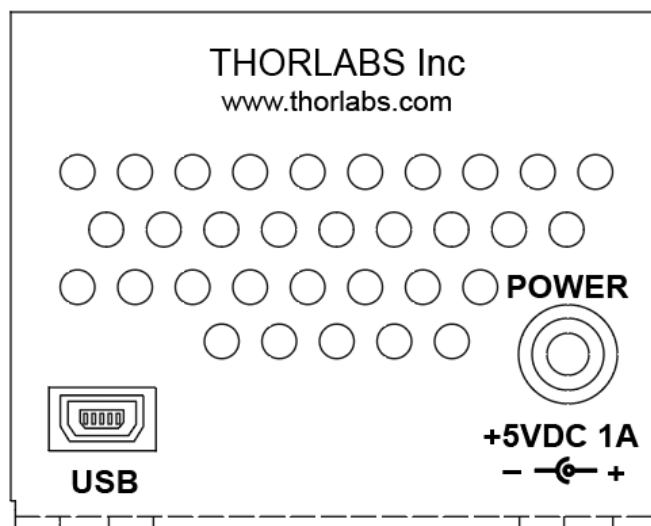
***Figure 11   Front Panel Power Supply Connector***

Perform the following:

1. Using the front panel connector as shown above, connect the unit to a regulated DC power supply of +5V, 1A.
    Thorlabs offer a single way wall plug supply (TPS101) for powering a single Driver T-Cube.
2. Switch on the power supply unit.
3. The version number of the embedded software is displayed for a few seconds.

Chapter 4   Standalone Operation

4.1   Control Panel Buttons and Indicators
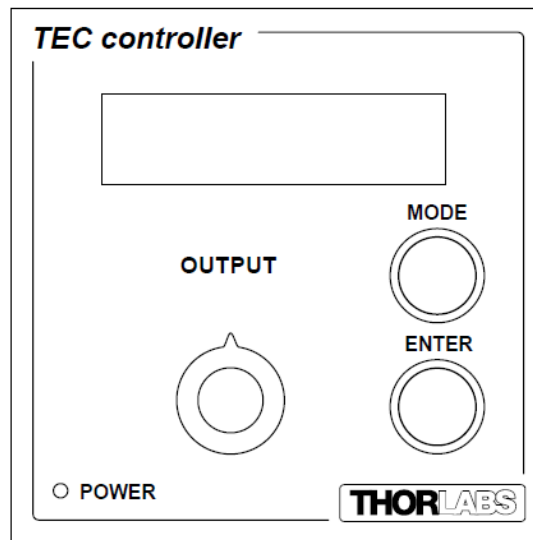
Figure 12   Panel Controllers and Indicators

MAIN Display - Shows the Temperature Set Point applied to the TEC element.

OUTPUT Potentiometer - Used to navigate the setup menus and to adjust parameter settings.

MODE Button - Toggles between the Setup menu (refer to section 4.3) and the Monitor mode.

ENTER Button - In Monitor mode used to enable or disable the TEC element or to select a new desired temperature setting. In Setup mode used to select a new menu item or parameter value.

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

Note

The POWER LED will flash when the 'Ident' button is clicked on the APT Software GUI panel – refer to section 6.1 for further details.

4.2   Output Potentiometer Operation

The OUTPUT potentiometer is an infinite turn encoder, used to adjust the temperature set point. To increase the set point value, turn the potentiometer clockwise - once the maximum value (dependent upon the CUr L setting – refer to section 4.3.4 and section 6.2) is attained, subsequent clockwise turns do not affect the output, however the value decreases immediately when the control is turned anticlockwise. Similarly, once the set point value has been decreased to zero, subsequent anticlockwise turns do not affect the output, but the value increases immediately when the control is turned clockwise.

4.3   Navigating the Menus

Pressing the 'MODE' button toggles the display between the Monitor Mode and the Setup Menu.

In Monitor Mode, with the TEC current disabled, the display will be flashing the Set Temperature. Press the Enter button to enable the TEC current. The display stops flashing and shows the actual temperature, the current, or the difference between the actual temperature and the set temperature. The displayed parameter is selected in the Setup Menu – refer to section 4.3.2.

When the TEC current is enabled, pressing the Enter button disables the TEC current and the display will again flash the set temperature.

The set temperature can be changed by rotating the OUTPUT Knob while in the Monitor Mode. If the TEC current is enabled, the display will temporarily switch to show the current set temperature and allow you to adjust it. Once the desired temperature is displayed, press the Enter button to select it.

In the Setup Menu, the control knob will allow you to navigate through the menu. Once the desired menu item is displayed, it can be selected by pressing the Enter button.

Some of the menu items have sub menus that can also be navigated using the OUTPUT Knob. Other menu items allow you to adjust a value. The values can be adjusted by rotating the OUTPUT Knob until the desired value is displayed and then pressing the Enter button.

Pressing the Mode button while a menu value is displayed will return you to the menu without adjusting the current value. If in a sub menu, pressing Mode will bring you back up to the main Setup Menu.

4.3.1   SETUP Menu Overview

Press the Mode button to enter the SETUP menu.

Use the Output Knob to move through the setup menu items.
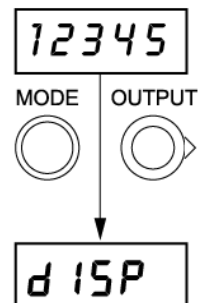
diSP- Selects the parameter to display in Monitor Mode. Refer to section 4.3.2.

GAinS- Allows adjustment of gain values used by PID. Refer to section 4.3.5.

SEnSr- Select the type of sensor connected. Select Ad590 when using a temperature sensor. Select either tH20 or tH200 when using a thermistor. Refer to section 4.3.3 for more details.

CUrL- selcts the maximum current delivered. Refer to section 4.3.4.

BritE- Adjust the brightness of the display. Select 1 for the dimmest output and 16 for Maximum brightness. Refer to section 4.3.7.

Pid – Store or recall operating parameters. Refer to section 4.3.8.

Anin- Configure the control unit to use an analog input signal to correct the temperature. Refer to section 4.3.9 for more details.

4.3.2 Selecting Display Value

The display menu allows you to change the information displayed when the TEC element is enabled.

Press the MODE button to enter the SETUP menu.

Scroll using the OUTPUT knob to select the diSP menu item.

Press the ENTER button to enter the Display menu.

Use the OUTPUT knob to move through the diSP menu items.

T Act- when this item is selected, the current temperature of the laser diode is displayed as measured by the temperature sensor or the thermistor. If a thermistor is being used this value will display the measured resistance (kΩ). If a temperature sensor is connected, then the value will be displayed in °F or °C depending on the unit's parameter setting.

Curr- when selected the amount of current being supplied by the TEC element will be displayed.

dELtA – this parameter displays the difference between the actual temperature and the desired temperature when the TEC is enabled. If a thermistor is connected, then this value will display the difference in the resistance value (kΩ). If a temperature sensor is connected, then this value will be in °F or °C depending on the unit's parameter setting.

UnitS- the menu item allows you to change the display of degrees from Centigrade to Fahrenheit. Select this item with the Enter button and then use the OUTPUT knob to select either C for Centigrade or F for Fahrenheit.
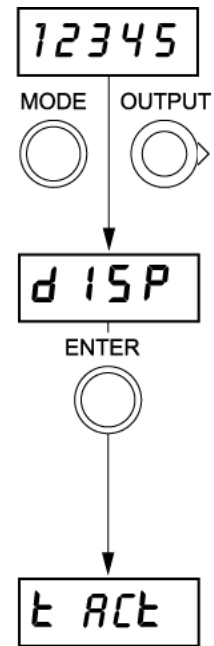
4.3.3   Setting the Sensor Type

The temperature Controller TTC001 can be used with an Ad590 temperature sensor or either a TH20 or TH200 thermistor. Refer to section 3.6.2 for more information.

Press the Mode button to enter the Setup Menu.

Scroll using the OUTPUT knob to select the SEnSr menu item.

Press the ENTER button to enter the Sensor menu.

Use the OUTPUT knob to select the desired sensor type and press Enter. Refer to section 4.4 for details on setting the Hi and LO values.
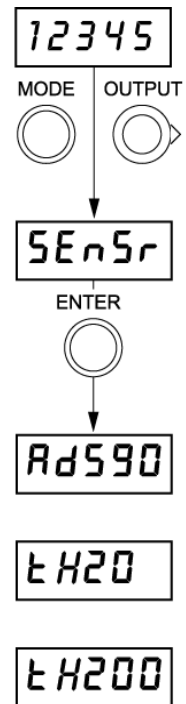
4.3.4   Setting the TEC current Limit "Cur L"
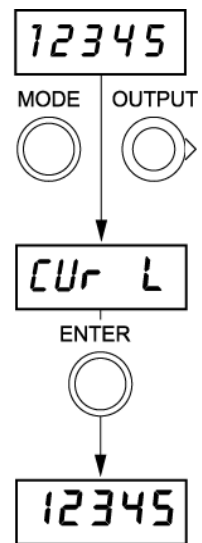
The temperature Controller TTC001 delivers a maximum TEC current of 1 A. The TEC current limit can be set through the "Cur L" menu.

Press the Mode button to enter the Setup Menu.

Scroll using the OUTPUT Knob to select the Cur L menu item.

Press the Enter button to enter the Current Limit menu.

Use the OUTPUT Knob to set the desired current limit and press Enter to set the value.

4.3.5 Adjust the Temperature Control Loop

By setting the control loop parameters of the PID control loop the temperature controller TTC001 can be adapted to most different thermal loads.

Press the Mode button to enter the Setup menu.

Scroll using the OUTPUT knob to select the GAInS menu item.

Press the ENTER button to enter a Gain menu.

Use the OUTPUT knob to move through the menu items and select the desired parameter.

The Proportional gain (PGAIn) adjusts how rapidly the TTC001 responds to differences in the set temperature and the actual temperature. Increasing this value will speed up the heating or cooling of the TTC001 and decrease the time for the actual temperature to reach the set temperature. However, increasing this value also increases the amplitude and the number of overshoots and could make the system unstable if adjusted too high.

The Integral offset control (IGAIn) minimizes any offset from the set temperature caused by thermal loads. Increasing this value will reduce the offset, but like the PGAin, will also increase the amplitude and number of overshoots.

The Derivative gain control (DGain) decreases the amplitude and number of overshoots but also slows down the rate that the actual temperature approaches the set temperature.

The control loop parameters can be set automatically by selecting the menu item 'Auto'.

This procedure takes about 10 minutes to complete. While it is running the display shows the progress by displaying the current step number that is running in the procedure, from step 1 ("S1") through step 4 ("S4"). Once the three control parameters have been automatically set, they can be manually adjusted slightly to further improve the performance of the system.
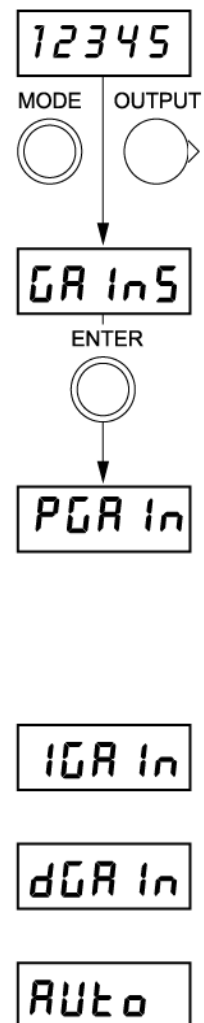
4.3.6 Control Loop Adjustment- Recommended Procedure

1. Set the IGAIn and the DGAIn values to 0.
2. Set the PGAIn value to around 5.
3. Change the set temperature.
4. Enable the TEC current and watch the response of the system. Count the number of overshoots that occur before the temperature settles on the set temperature.
5. Increase the PGAIn value and repeat this procedure until the system remains stable near the set temperature after 3 to 4 overshoots.
6. Slowly increase the DGAIn value while again adjusting the set temperature and counting the number of overshoots. Increase the DGAIn until the temperature becomes stable after only 1 or 2 overshoots.
7. Once the PGAIn and DGAIn values have been adjusted, watch the display for a few minutes with the TEC current enabled. If the actual temperature remains slightly higher or lower from the set temperature after the temperature becomes stable, then increase the IGAIn value until this offset is minimized.

4.3.7 Setting the Display Brightness

The unit will power up with a preset brightness level and during operation, the user can adjust the display intensity to suit the optical environment.

Press the Mode button to enter the Setup Menu.

Scroll using the OUTPUT Knob to select the britE menu item.

Press the ENTER button to enter the Display Brightness menu.

Use the OUTPUT Knob to set the desired brightness between "1" and "16" then press Enter to set the value.
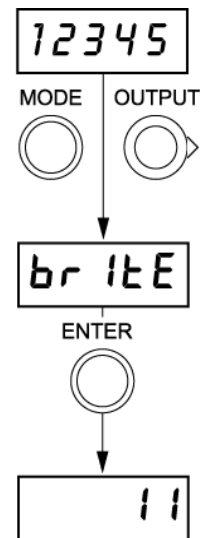
4.3.8 Storing and Recalling Control Parameters

The TTC001 allows you to store up to 5 sets of control parameters. Once you have selected the desired sensor type set the temperature range and current limit and optimize the control parameters. Select the "Pid" from the Setup menu.

Press the Mode button to enter the Setup Menu.

Scroll using the OUTPUT Knob to select the PId menu item
Press the ENTER button to enter the Control Parameters menu

The TTC001 comes preloaded with default values that allow it to be used with Thorlab's mounts LM14S2, LDM56, LDM90, and LDM21, without the need for any adjustments.
Use the OUTPUT Knob to select 'Pid L' and press the ENTER button
Use the OUTPUT Knob to select the desired settings. Use "L1" for the LM14S2, "L2" for LDM56, LDM90, and "L3" for LDM21.

Up to 5 sets of PID control loop values can be saved for later use.

Use the Control Knob to select the menu item "Pid S" and then press the Enter button.
Now use the Control Knob to select between five presets "P1" through "P5". Press the enter button to save the current PID settings (see section 4.3.5) to the selected preset number.

These settings can be recalled by selecting "Pid r" from the "Pid" menu and reselecting the desired preset.
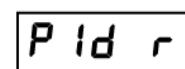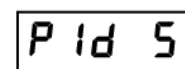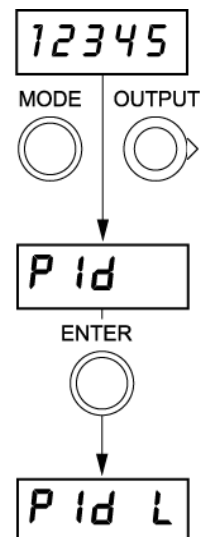
4.3.9 Analog Control of the Temperature

A zero to 5V analog input can be connected to the TUNE IN connector on the rear panel. It can then be used either to adjust the set temperature, allowing the PID loop to maintain the desired temperature, or to control directly the current output of the controller.

Press the Mode button to enter the Setup Menu.

Scroll using the OUTPUT Knob to select the "An In" menu item.

Press the ENTER button to enter the Analog Control menu.

To use an external source to adjust the set temperature, scroll using the OUTPUT Knob to select the PId menu item, then press the ENTER button.

The maximum tuning range for the analog control input 'TUNE IN' is as follows.

Range	Voltage	Operation Mode
0 to 20 kΩ	0 to 5 V	Thermistor, TH 20kΩ Range
0 to 200 kΩ	0 to 5 V	Thermistor, TH 200kΩ Range
-45 to 125 °C	0 to 5 V	AD592

To control the current output, scroll using the OUTPUT Knob to select the CUrr menu item, then press the ENTER button.

The current limit (iLim) is then used to scale the analog input so that the 0 to 5 V provides a range of ±iLim – refer to section 4.3.3.

If control via an external source is not required, scroll using the OUTPUT Knob to select the oFF menu item, then press the ENTER button.
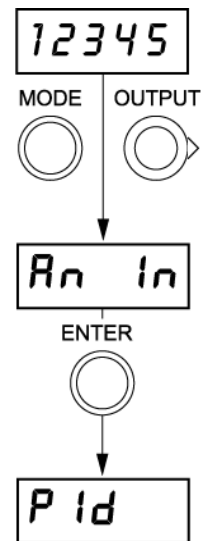
To use an external analog source for control:

    1. Connect the temperature sensor and the TEC element to the "TEC OUTPUT" connector on the rear panel and switch on the Temperature Controller TTC001.

    2. Press the Mode button to enter the Setup Menu and select the proper sensor type from the "SEnSr" menu – refer to section 4.3.3.

    3. From the "An in" menu, select the type of Analog Input control you desire: "Pid" for adjusting the set temperature, and "Curr" for directly controlling the current – refer to section 4.3.9.

    4. Press the Mode button to switch back to the Monitor Mode.

    5. Press the ENTER button to enable the TEC current output of the Temperature Controller. TEC ON mode is indicated when the display stops flashing.

    6. Apply an analog voltage to jack "TUNE IN" at the rear panel of the Temperature Controller TTC001.

Note. only slow variations of the temperature set value (<< 1 Hz) are possible via the analog control input "TUNE IN".

4.4   Typical Operation of the Temperature Controller

    1. Connect power to the TTC001 using the provided power supply or by mounting in the hub system.

    2. Connect the temperature sensor and TEC element to the TEC OUTPUT Terminal on the rear panel – refer to section 3.6.2.

    3. Press the Mode button to enter the Setup Menu. The top menu item, "diSP", is shown.

    4. Turn the OUTPUT Knob until "SEnSr" is displayed.

    5. Press the Enter button, then turn the OUTPUT knob to select the correct sensor. **Note**: Select 'Ad590' for both AD590 and AD592.

    6. Press Enter to save the sensor type.

    7. Turn the OUTPUT Knob until 'HI L' is displayed then press ENTER. Turn the OUTPUT knob to set the desired high temperature limit, then press ENTER to save the setting.

    8. Turn the OUTPUT Knob until 'LO L' is displayed then press ENTER. Turn the OUTPUT knob to set the desired low temperature limit, then press ENTER to save the setting.
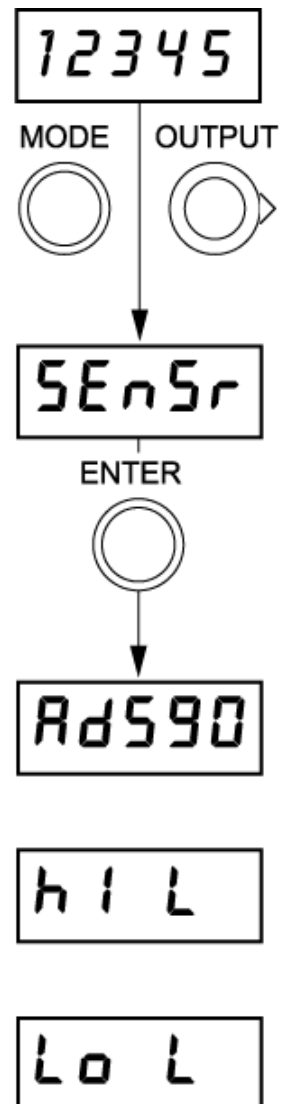
9. Turn the OUTPUT Knob until 'Cur L' is displayed.

10. Press the Enter button, then turn the OUTPUT knob to set the desired current Limit.

```
CUr  L
```

11. Press Enter again when the desired current limit is displayed.

12. Turn the OUTPUT Knob until "dISP" is displayed.

```
d ISP
```

13. Press the Enter button, then turn the OUTPUT knob to select the desired display type (actual temperature, current, or difference between the actual temperature and the set temperature).

14. Press Enter to save the setting.

```
t ACt
CUrr
dELtA
```

15. Turn the OUTPUT Knob until "UnIts" is displayed.

16. Press the Enter button, then turn the OUTPUT knob to select either °C or °F.

```
Un ItS
```

17. Press Enter to save the setting

18. Press Mode until the display is showing the TEC current, temperature, or thermistor value depending on what was selected in the display menu.

```
12345
```

Note: the display will be flashing the set temperature value when the TEC current is disabled. When enabled the actual value will be displayed continuously.

19. Press Enter to enable and disable the TEC current.

"ErrOr" will be displayed if the temperature sensor type selected with the menu is not present. In this case, check the connection and the type of temperature sensor. Set the desired temperature with the knob. If a thermistor is used as temperature sensor, the set temperature has to be set in kΩ. If an AD590 or AD592 is used as the temperature sensor, the set temperature is entered in °C or °F. Enable the Temperature Controller TTC001 by pressing the Enter button. With the output switched on, the display stops blinking. During operation you can chose to display "t ACt", "Curr", or "dEltA" by selecting from the "diSP" menu at any time. "t ACt" displays the actual temperature or resistance, "Curr" displays the TEC element operating current, and "dEltA" displays the difference between the set temperature and the actual temperature or resistance.

Chapter 5   PC Operation

5.1   Introduction

The following brief tutorial guides the user through a typical series of moves and parameter adjustments performed using the PC based APT software. It assumes that the unit is electrically connected as described in Chapter 3 and that the APT software is already installed – refer to section 3.2. It also assumes that a laser mount is connected to the @TEC OUTPUT' connector on the rear panel.

5.2   Using the APT User Utility

The APT User.exe application allows the user to interact with any number of APT hardware control units connected to the PC USB Bus (or simulated via the APTConfig utility). This program allows multiple graphical instrument panels to be displayed so that multiple APT units can be controlled. All basic operating parameters can be set through this program, and all basic operations (such as piezo moves) can be initiated. Hardware configurations and parameter settings can be saved to a file, which simplifies system set up whenever APT User is run up.

This tutorial shows how the APTUser application provides all of the functionality necessary to operate the APT hardware.

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 Figure 13.
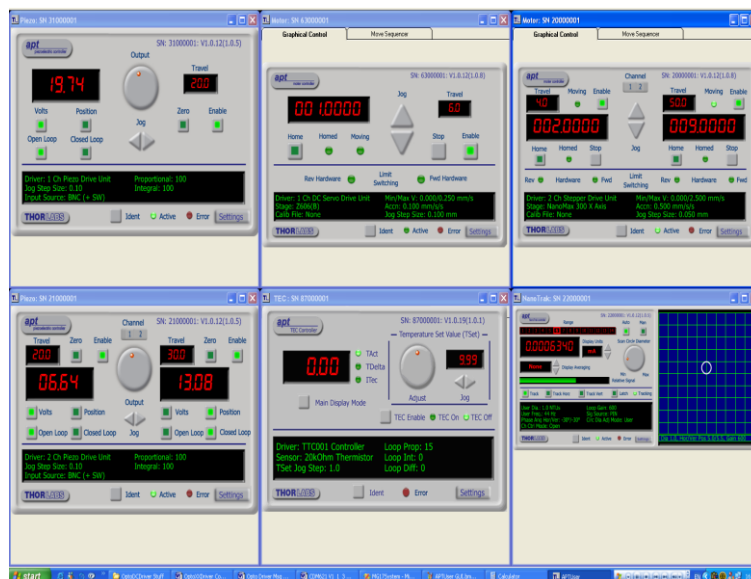
Figure 13   Typical APT User Screen

The panel for the TEC Controller should appear as shown in Figure 14. The Jog buttons and the Adjust Control Knob can be used to adjust the Temperature Set Value. The TEC can be enabled and disabled by clicking on the TEC Enable button. The information displayed when the TEC is enabled can be changed by clicking the Main Display Mode button.
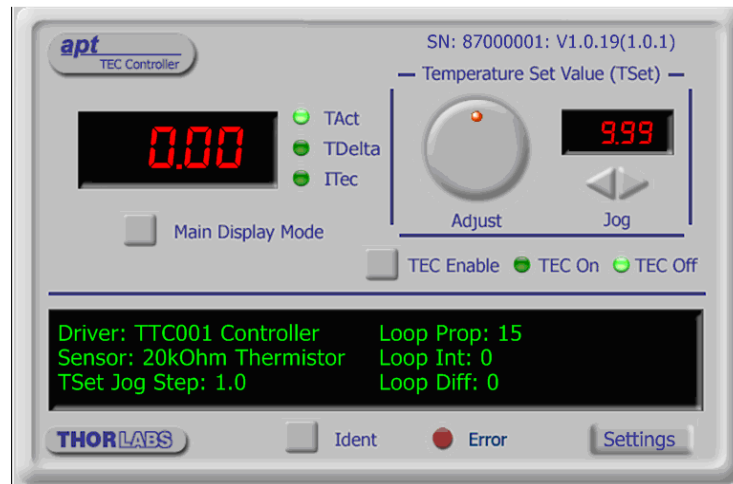
Figure 14 TEC Controller Software GUI

The APT User utility will be used throughout the rest of this tutorial to interface with the piezo controller.

5.3 Typical Operation from GUI Panel

Perform the following:

1. Connect power to the TTC001 using the provided power supply or by mounting in the hub system.

2. Connect the temperature sensor and TEC element to the TEC OUTPUT terminal on the rear panel – refer to section 3.6.2.

3. On the GUI panel, click the 'Settings' button to display the Settings panel, then select the '*Advanced*' tab as shown below.
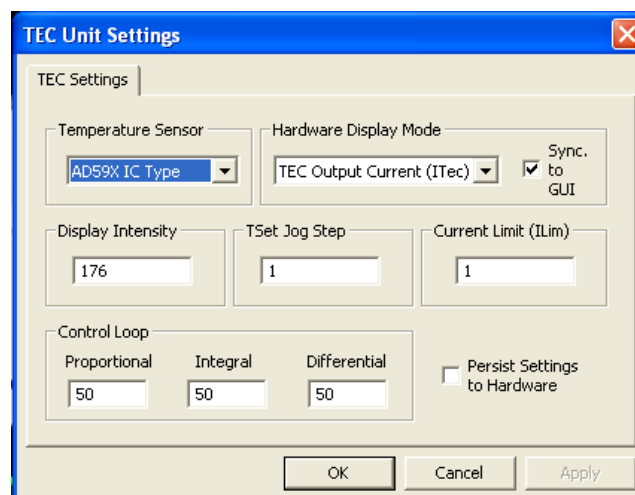
Figure 15 TTC001 TEC Controller Settings Panel

4. In the Temperature Sensor field, select the appropriate temperature sensor for your application.

5. In the Current Limit (ILim) field, enter an appropriate current limit value.

6. Click OK.

7. On the GUI Panel, select the desired display type (actual temperature, current or difference between the actual temperature and the set temperature).

8. Click the TEC Enable button.

9. Turn the 'Adjust' control to set the point value. The GUI display should increment and decrement accordingly.

## 5.4 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, which was designed as an aid for 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:

Perform the following:

1. Run the APT Config utility- Start/All Programs/Thorlabs/APT/APT config.
2. Click the 'Simulator Configuration' tab.
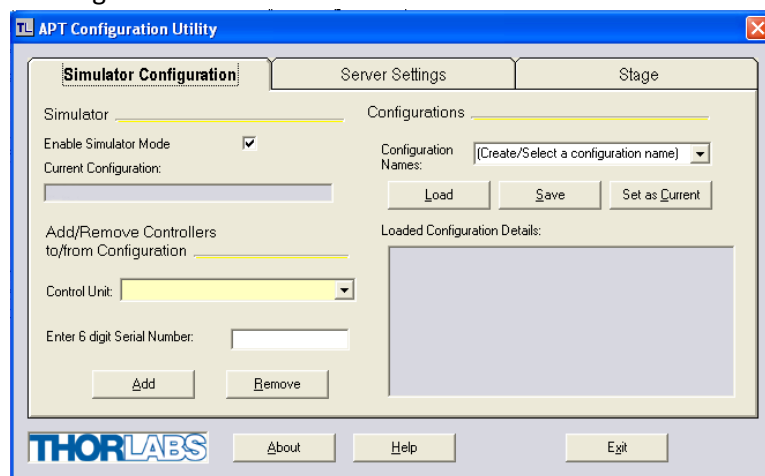
Figure 16   APT Configuration Utility – Simulator Configuration Tab

3. Enter 'LAB1' in the Configuration Names field.
4. In the 'Simulator' field check the 'Enable Simulator Mode' box. The name of the most recently used configuration file is displayed in the 'Current Configuration' window.
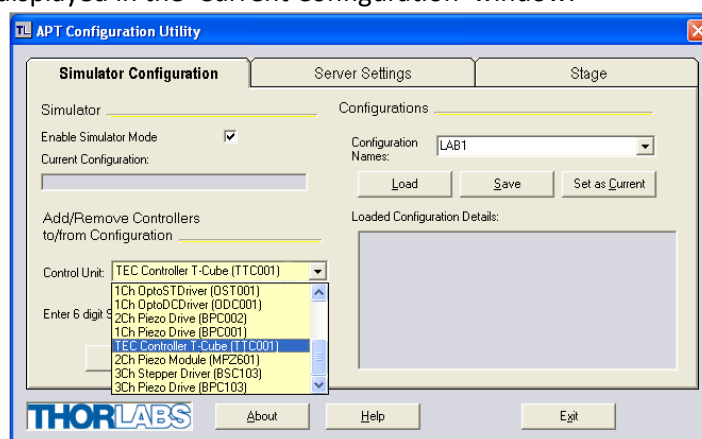
Figure 17   Enable Simulator Mode

5. In the 'Control Unit' field select the 'TEC Controller T-Cube (TTC001)'.

Figure 18   Control unit

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 config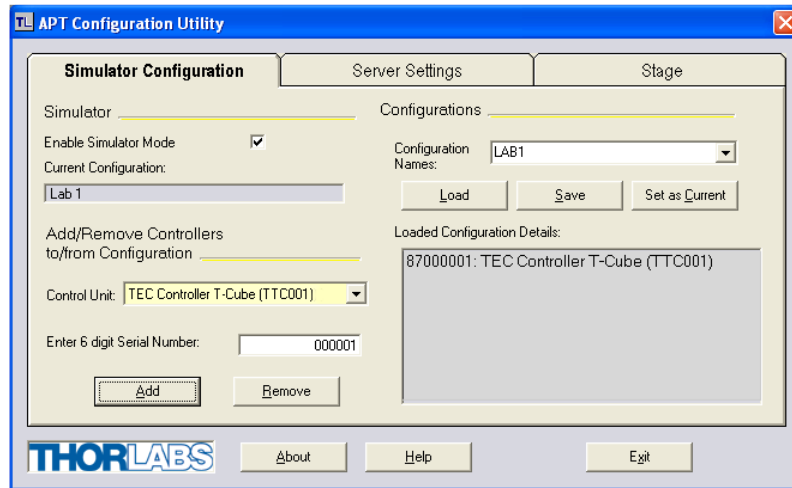urations for software development purposes to use the same serial numbers as any real hardware units that will be used. Although serial numbers are 8 digits (as displayed in the 'Load Configuration Details' window), the first two digits are added automatically and identify the type of control unit.

The prefixed digits relating to the TTC001 T-Cube TEC Controller are: 87xxxxxx.

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 controller using the APTUser utility software.
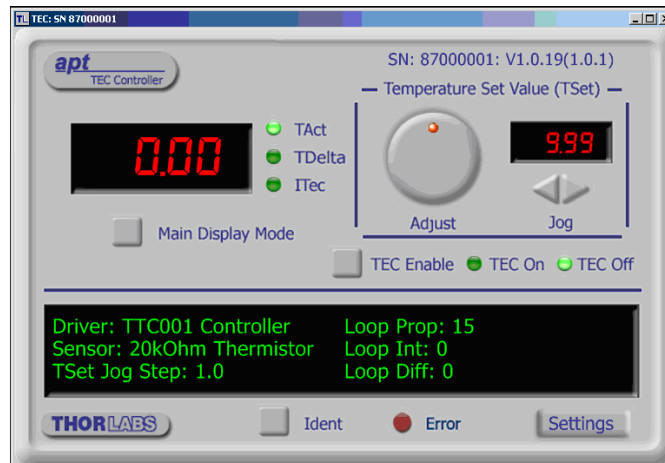
Figure 19   TTC001 TEC Controller Software GUI

> **Note**
>
> The serial number of the TTC001 unit associated with the GUI panel, the APT server version number, and the version number (in brackets) of the embedded software running on the unit, are displayed in the top right-hand corner. This information should always be provided when requesting customer support.

Temperature Setting Controls

These controls are used to adjust and set the TEC element set point value. The units and range are dependent upon the 'Sensor Type' selected in the Settings panel. If an IC type sensor is selected, the set point temperature is displayed in °C and can be set between -45 and +125°C. If a thermistor sensor is selected, the set point is displayed in kΩ. For a 20 kΩ sensor the range is 0 to 20 kW; for a 200 kΩ sensor the range is 0 to 200 kΩ.

  Digital Display – shows the set point value.

  Adjust Pot – used to adjust the set point value.

  Jog Buttons - used to increment or decrement the set point value. Each time the button is clicked, the set point is adjusted by the value set in the Settings panel 'TSet Jog Step' parameter.

Main Display, Mode Button and LEDs – There are three display modes, which are selected using the Main Display Mode Button. The associated LED is lit when the mode is selected.

  TAct – The display shows the actual temperature of the TEC element.

  TDelta – The display shows the difference between the actual temperature (TAct) and the set point temperature (TSet).

  ITec – The display shows the current (in Amps) sourced into the TEC element by the controller.

TEC Enable Button - turns the output of the TEC controller ON and OFF.

TEC On and TEC Off LEDs - lit when the controller output is enabled or disabled (using the button above).

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

Sensor - the type of TEC element associated with the controller. This is selected in the Settings panel as follows:

    AD59X IC Type

    20kOhm Thermistor

    200kOhm Thermistor

TSet Jog Step - the maximum current limit of the laser source. Due to individual variations between laser diodes, this value will differ from unit to unit.

Loop Prop – The current value of the 'Proportional' parameter of the PID loop.

Loop Int – The current value of the 'Integral' parameter of the PID loop.

*Loop Diff* - The current value of the 'Differential' parameter of the PID loop.

Settings button - Displays the 'Settings' panel, which allows the tuning parameters to be entered.

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

Error - lit when an internal fault is detected.

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 jog step size 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 1.4.4 for an overview of the APT ActiveX controls.
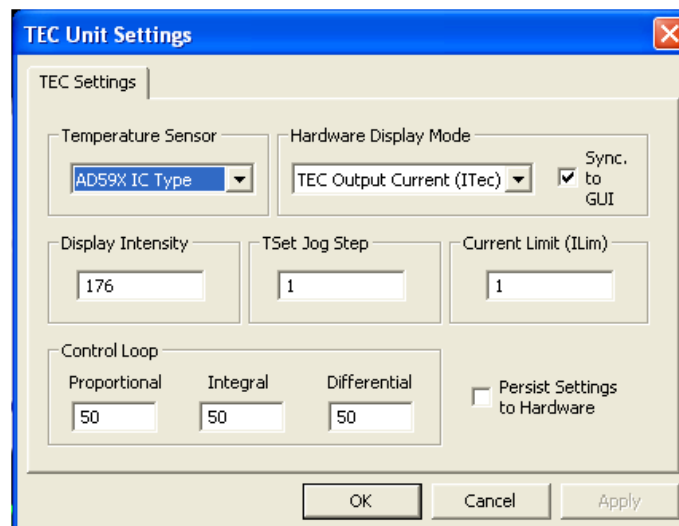
Figure 20   TEC Controller Settings Panel

Temperature Sensor - *the type of TEC element associated with the controller:*

If *AD59X IC Type* is selected, the Main Display shows values in degrees centigrade.

If *20kOhm Thermistor* is selected, the Main Display shows values in kOhms.

If *200kOhm Thermistor* is selected, the Main Display shows values in kOhms.

Hardware Display Mode - this parameter sets the display mode of the 7-segment display on the control panel of the (in the same way as pressing the MODE button). This setting is independent of the display mode set via the 'Main Display Mode' button on the GUI, i.e., the GUI can be set to display TAct and the front panel to display TDelta.

Actual Temp (TAct) – The display shows the actual temperature of the TEC element.

Temp Delta (TAct-TSet)– The display shows the difference between the actual temperature (TAct) and the set point temperature (TSet).

TEC Output Current (ITec) – The display shows the current (in Amps) sourced into the TEC element by the controller.

Sync to GUI - If the checkbox is checked, any changes made to the display mode on the hardware unit (either by button selection or method call) will be reflected on the GUI panel. Furthermore, any changes to the GUI display mode will be reflected on the hardware unit.

Display Intensity - determines the brightness of the control panel display. Enter a value from 0 to 255.

TSet Jog Step – the distance to move when a jog command is initiated. If an IC type sensor is selected, the step size is measured in degrees centigrade. If a thermistor sensor type is selected, the step size is measured in kOhms.

Current Limit (ILim) – The maximum current that the TEC controller can source to the TEC element. Values must be within the range -1 A to +1 A.

Control Loop - The Control Loop parameters can be used to fine tune the behavior of the feedback loop to changes in the output temperature, and these parameters need to be adjusted to suit the different types of sensors that can be connected to the system. The default values have been optimized to work with most standard sensors, so usually these values can be left unchanged.

Proportional - sets the proportional feedback loop gain (1 to 100) (default 60).

Integral - sets the integral feedback loop gain (0 to 100) (default 0).

Differential - sets the integral feedback loop gain (0 to 100) (default 20).

Persist Settings to Hardware - Many of the parameters that can be set for the TEC Controller T-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 Hardware Display Mode and Temperature Sensor parameters described previously are good examples of settings 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.

Chapter 7   Connector Pinout Details

7.1 TEC OUTPUT Connector

The TEC OUTPUT connector on the rear panel provides connection to the Laser Diode Mount or other device. If Laser Diode Mounts by Thorlabs are used, connect the "TEC OUTPUT" of the TTC001 to the 9-pin plug "TEC DRIVER" of the Laser Diode Mount, using the provided shielded cable CAB420-15.

With other equipment, connect the TEC element and the temperature sensor as detailed in Figure 21.
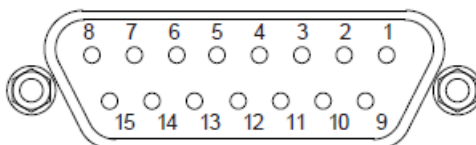
Pin	Description	Pin	Description
1	Not Used	9	Not Used
2	Not Used	10	Transducer AD592 (-ve)
3	Thermistor -ve, ground	11	Transducer AD592 (+ve)
4	Thermistor +ve	12	Not Used
5	TEC (+)	13	TEC (-)
6	TEC (+)	14	TEC (-)
7	TEC (+)	15	TEC (-)
8	Not Used		

Figure 21   TEC OUTPUT Connector Pin Identification

Chapter 8 Maintenance

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

8.1 Cleaning

> **Warning**
>
> Disconnect the power supply before cleaning the unit.
>
> Never allow water to get inside the case.
>
> Do not saturate the unit.
>
> Do not use any type of abrasive pad, scouring powder or solvent, e.g., alcohol or benzene.

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

Chapter 9   Specifications and Associated Parts

9.1   General Specifications

Parameter	Value
Temperature Sensor	
Type of Sensor	Thermistor, AD590, AD592
Thermistor Sensing Current	(TH 20 kΩ / 200 kΩ): 100 µA / 10 µA
Control Range:	AD590 / AD592: -45 to 125 °C Thermistor 20 kΩ: 10 Ω to 20.000 kΩ Thermistor 200 kΩ: 100 Ω to 200.00 kΩ
Setting Measurement Resolution	AD592: 0.1 °C Thermistor 20 kΩ: 10 Ω Thermistor 200 kΩ: 100 Ω
Accuracy: (5%)	AD592: ±1 °C Thermistor 20 kΩ: ±100 Ω Thermistor 200 kΩ: ±1 kΩ
Temperature Stability 24 hours	AD592: <0.5 °C Thermistor 20 kΩ: 5 Ω Thermistor 200 kΩ: 50 Ω
TEC Output	
Control Range of the TEC Current	-1 A to +1 A
Measurement Resolution TEC Current	1 mA
Accuracy TEC Current	±20 mA
Maximum Output Voltage	>4 V
Maximum Output Power	4 W
Noise and Ripple (Typ)	1 mA
TEC Current Limit	
Setting Range	100 mA to 1 A
Accuracy	±1 mA
Temperature Control Input (Tune In)	Input Resistance: 2.5 kΩ Control Voltage: 0 to 5 V
Connectors	
Temperature Sensor, TEC Element	15-Pin D-sub Jack (Female)
Temperature Control Input	TUNE IN SMA
Power Jack	2.1 mm
T-Cube Controller Hub Connector	26-Way ERNI
General Data	
Warm Up Time (for maximum accuracy)	10 mins
Housing Dimensions (W x D x H)	60 x 60 x 47 mm (2.4" x 2.4" x 1.8")
Weight	160 g (5.5 oz)

9.2 Associated Products

Product Name	Part Number
Thermoelectric Temperature Controller with TEC current range of 0 to ± 1 A	TTC001
Temperature IC Sensor	AD590
10k Thermistor	TH10K
Shielded cable to connect the temperature controller to a Thorlabs' Laser Diode Mount	CAB420-15
3-Channel K-Cube Controller Hub with Power Supply	KCH301
6-Channel K-Cube Controller Hub with Power Supply	KCH601
TE-Cooled Mount For 5.6 mm Lasers	LDM56
TE-Cooled Mount For 9.0 mm Lasers	LDM90
Miniature Laser Diode Temperature Controlled Mount	LDM21
Universal 14-Pin Butterfly Laser Diode Mount	LM14S2

Chapter 10   Certifications and Compliance

D.1 Declarations of Conformity

D.1.1 For Customers in Europe

This equipment has been tested and found to comply with the EC Directives 89/336/EEC 'EMC Directive' and 73/23/EEC 'Low Voltage Directive' as amended by 93/68/EEC.

Compliance was demonstrated by conformance to the following specifications which have been listed in the Official Journal of the European Communities:

Safety   EN61010: 2001 Installation Category II, Pollution Degree II.

EMC   EN61326: 1997

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, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

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

Chapter 11   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.

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