THORLABS

TIM101
Piezo Inertia Motor Controller

User Guide

Original Instructions

Contents

Continued...

Appendices

Chapter 1   For Your Safety

1.1   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.

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

Warning
Given when there is a risk of injury to users.

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

Note
Clarification of an instruction or additional information.

1.2   General Warnings

Warnings
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.
This product generates, uses and outputs high voltages from the SMC connector (HV Output) that are hazardous and can cause serious injury. In any installation that uses the TIM101 it is the user's responsibility to ensure adequate insulation and precautions are taken to avoid shock risk. Cables for HV Out must be rated for 250 V RMS.
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 2   Overview and Setup

2.1   Introduction

The TIM101 Piezo Inertia Motor Controller is designed to control our series of piezo inertia-driven positioning stages. It offers 4 channels of stand-alone manual control (one channel at a time) for continuous movement/jogging and remote PC control via USB. As a member of the APT family of products, all the features of the user friendly and versatile APT interface are available for customers. The product will support external triggering of movements, joystick control and fully configurable limit switches.

Although compact in footprint, this unit offers a fully featured control capability including jog settings, limit switch handling, "on the fly" changes in move direction, and, for more advanced operation, control over the number of steps performed.

For convenience the footprint of this unit has been kept to a minimum, measuring only 120mm x 60mm x 47mm (4.8" x 2.4" x 1.8") and with the facility to directly mount to the optical table close to the devices being driven - convenient when manually adjusting positions using the top panel controls (jog buttons and velocity control slider). Table top operation also allows minimal drive cable lengths for easier cable management.

Fig. 2.1   T-Cube Piezo Inertia Motor Controller

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 (see below) for multi-axis control applications. Coupling this with the user friendly apt™ software (supplied) allows the user to very quickly get up and running with complex move sequences in a short space of time – for example all relevant operating parameters are set automatically by the software for Thorlabs stage/actuator products. 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.

For power, a compact multi-way power supply unit (TPS008) is available from Thorlabs allowing up to 4 T-Cube Drivers to be powered from a single mains outlet. This power supply unit is also 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. A single way wall plug supply (TPS003) is also available separately for powering a single T-Cube Driver.

In the remainder of this handbook, operation of the unit is described for both front panel and PC operation. Tutorial sections (Chapter 4 and Chapter 5) provide a good initial understanding on using the unit and reference section (Chapter 6) covers all operating modes and parameters in detail.

2.2   T-Cube Controller Hub

As a further level of convenience when using the T-Cube Controllers, Thorlabs also offers the T-Cube Controller Hub (TCH002). This product has been designed specifically with multiple T-Cube operation in mind in order to simplify issues such as cable management, power supply routing, multiple USB device communications and different optical table mounting scenarios.

The T-Cube Controller Hub comprises a slim base-plate type carrier (375mm x 86mm x 21.5mm, 14.75" x 3.4" x 0.85") with electrical connections located on the upper surface to accept up to six T-Cubes.

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

2.3   APT PC Software Overview

2.3.1   Introduction

As a member of the APT range of controllers, the T-Cube Piezo Inertia Motor 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 (see Section 2.3.2.) and APTConfig (see Section 2.3.3.) utilities allow full control of all settings and operating modes enabling complete 'out-of-box' operation without the need to develop any further custom software. Both utilities are built on top of a sophisticated, multi-threaded ActiveX 'engine' (called the APT server) which provides all of the necessary APT system software services such as generation of GUI panels, communications handling for multiple USB units, and logging of all system activity to assist in hardware trouble shooting. It is this APT server 'engine' that is used by software developers to allow the creation of advanced automated positioning applications very rapidly and with great ease. The APT server is described in more detail in Section 2.3.4.

Aside

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

ActiveX controls are a specific form of ActiveX technology that provide both a user interface and a programming interface. An ActiveX control is supplied for each type of APT hardware unit to provide specific controller functionality to the software developer. See Section 2.3.4. for further details.

2.3.2 APTUser Utility

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

All basic operating parameters can be altered and, similarly, all operations (such as motor 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 T-Cube Piezo Motor Driver (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.

2.3.3 APT Config Utility

There are many system parameters and configuration settings associated with the operation of the APT Server. Most can be directly accessed using the various graphical panels, however there are several system wide settings that can be made 'off-line' before running the APT software. These settings have global effect; such as switching between simulator and real operating mode, associating mechanical stages to specific motor actuators and incorporation of calibration data.
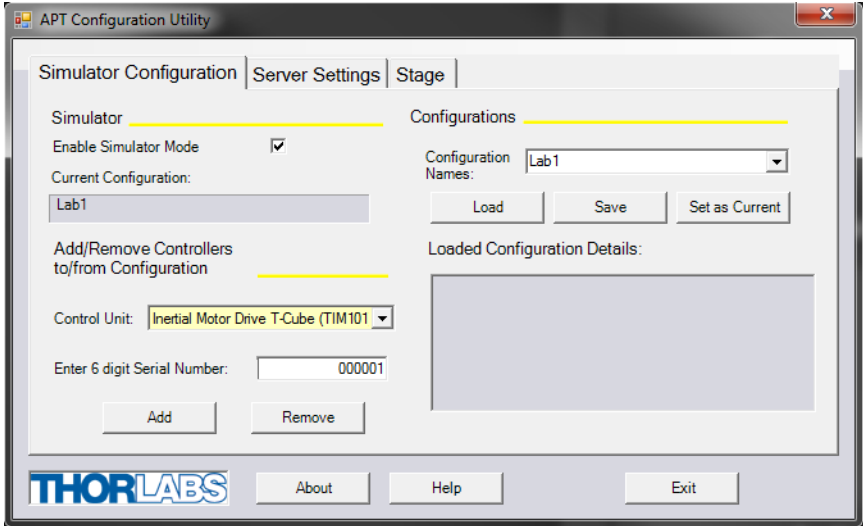
The APTConfig utility is provided as a convenient means for making these system wide settings and adjustments. Full details on using APTConfig are provided in the online help supplied with the utility.

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.

2.3.4 APT Server (ActiveX Controls)

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

With the APT system, ActiveX Controls are deployed to allow direct control over (and also reflect the status of) the range of electronic controller units, including the Piezo Motor Driver T-Cube. 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 the APT Piezo Motor driver unit.

This Control provides a complete user graphical instrument panel to allow the piezo inertia motor 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 motor 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 motor position). 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 Piezo motor Control to move a motor, the progress of that move is reflected automatically by changing position readouts on the graphical interface, without the need for further programming intervention.

The APT ActiveX Controls collection provides a rich set of graphical user panels and programmable interfaces allowing users and client application developers to interact seamlessly with the APT hardware. Each of the APT controllers has an associated ActiveX Control and these are described fully in system online help or the handbooks associated with the controllers. Note that the APTUser and APTConfig utilities take advantage of and are built on top of the powerful functionality provided by the APT ActiveX Server (as shown in Fig. 2.2).
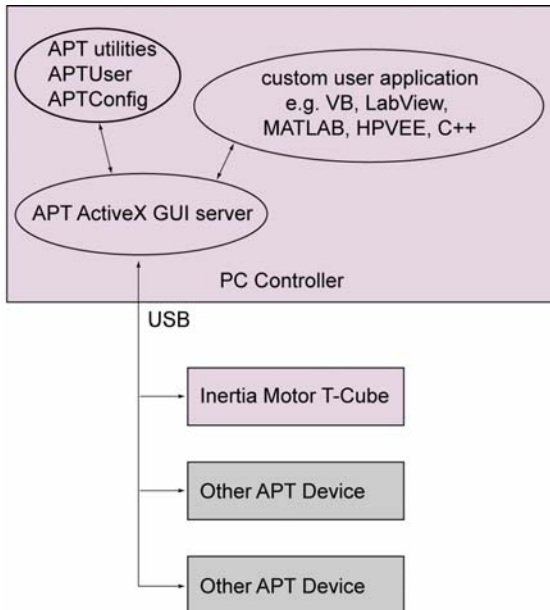
Fig. 2.2   System Architecture Diagram

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

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

Note
When the firmware is updated, the colling fans will run at maximum speed while the unit is reprogrammed.

Chapter 3   Getting Started

3.1   Install The Software

<table>
<tr><td align="center">Note</td></tr>
<tr><td>

This section is applicable only if the T-Cube is to be used with a PC. If your application consists only of local operation via the T-Cube front face, proceed to Chapter 4.

When operating via a PC, direct user interaction with the Piezo 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.

</td></tr>
</table>

<table>
<tr><td align="center">⚠ Cautions ⚠</td></tr>
<tr><td>

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.

</td></tr>
</table>

DO NOT CONNECT THE CONTROLLER TO YOUR PC YET

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

3.2 Mechanical Installation

⚠	Warning	⚠
	The safety of any system incorporating this equipment is the responsibility of the person performing the 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 T-Cube Inertial Piezo Motor Driver 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 - see Section 3.2.3.

For multiple cube systems, a USB controller hub (TCH002) is available - see Section 2.2. for further details. Full instructions on the fitting and use of the controller hub are contained in handbook *ha0146 T-Cube Controller Hub*, shipped with the product.

⚠	Cautions	⚠
	When siting the unit, it should be positioned so as not to impede the operation of the control panel buttons. **Ensure that proper airflow is maintained to the rear of the unit**	

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3.2.3 Removing the Baseplate

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

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

Detail A
Baseplate attachment screws

Detail B
Baseplate removed and rubber feet fitted

Fig. 3.1   Removing The Baseplate

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

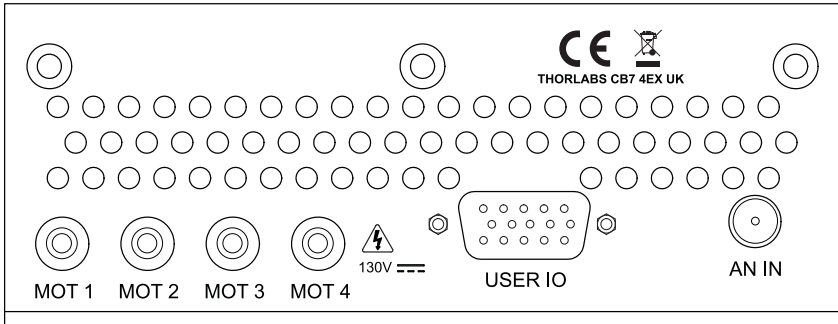## 3.3   Electrical Installation

3.3.1   Connecting a Piezo Motor

Fig. 3.2   Rear Panel Connections

MOT Terminals - (SMC Connectors) The unit is supplied with four SMA O/P connectors as shown above, which is compatible with all Thorlabs inertial piezo motor driven positioning stages and actuators**.**

Caution
The PIA series piezo inertia actuators are shipped with 1 1 m (3.3') of cable. Thorlabs offer 1.5m extension cables (PAA101) and male adapters (T5026) to extend the drive cable length to 2.5m, see www.thorlabs.com.
Due to the capacitance of the cables, do not use cables longer than 2.5 m in total.

USER I/O - For future use.

AN IN - (SMA Connector) Analog input, used to control the position of the piezo actuator from an external source. This input allows a 0V to 10V input to drive the output to its full scale. A 0V input gives max velocity backwards, whereas 10V input gives max velocity forwards; a 5V input results in no movement.

3.3.2   Using The TCH002 Controller Hub
The TCH002 USB Controller Hub provides power distribution for up to six T-Cubes, and requires only a single power connection. Further details are contained in handbook *ha0146T, T-Cube Controller Hub*, supplied with the unit.

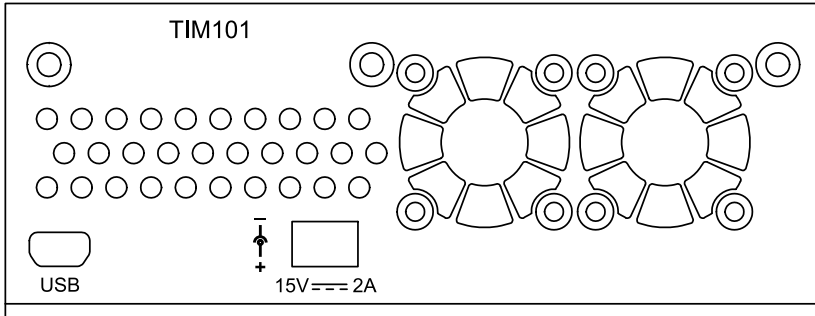| Warning |
|---|
| **DO NOT PLUG A POWERED UP T-CUBE INTO THE TCH002 USB CONTROLLER HUB. Always ensure that all power is disconnected from the T-Cube AND the hub before the T-Cube is plugged into the hub. Failure to observe this precaution will seriously damage the T-Cube unit and could result in personal injury.** |

3.3.3   Connecting To A Standalone Power Supply

Fig. 3.3   Front Panel Power Supply Connector

1) Using the front panel connector as shown above, connect the unit to a regulated DC power supply of 15 V, 2A.

Thorlabs offers a compact, multi-way power supply unit (TPS008), allowing up to four Inertial Piezo Driver T-Cubes to be powered from a single mains outlet. A single way wall plug supply (TPS003) for powering a single Driver T-Cube is also available.

⚠	**Warning**	⚠
	The unit must be connected only to a DC supply of 15V, 2A regulated. 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 piezo 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 piezo unit. **Always power up the piezo unit by connecting its power supply to the mains. Similarly, to power down the unit, disconnect the power suply from the mains before disconnecting the piezo unit.**	

3.3.4   Powering Down The Unit

⚠	**Warning**	⚠
	The controller may cause drive voltage spikes on power down. In applications requiring the highest sensitivity, the piezo drive voltage should be set to zero, and the HV cable disconnected before the unit is powered down.	

3.4   Connect The Hardware

1) Perform the mechanical installation as detailed in Section 3.2.
2) Install the APT Software.
3) Connect the Piezo motor stage to the Controller unit - see Section 3.3.1.

⚠	Caution	⚠
	During item (4) ensure the power supply unit is isolated from the mains before connecting to the T-Cube unit. Always power up the T-Cube unit by connecting its power supply to the mains. DO NOT connect the T-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, disconnect the power suply from the mains before disconnecting the T-Cube unit.	

4) Connect the Controller unit to the power supply - see Section 3.3.3.
5) Connect the PSU to the main supply and switch 'ON'.
6) Connect the Controller unit to your PC.

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

7) Windows^{TM} should detect the new hardware. Wait while Windows^{TM} installs the drivers for the new hardware - see the Getting Started guide for more information.
8) For maximum accuracy, wait approximately 30 mins for the unit to thermally stabalize to the environment.

3.5   Verifying Software Operation

The APT Software should be installed (Section 3.1.) and the controller connected to the actuators (see Section 3.4.) and the PC, before verifying software operation.

⚠	Caution	⚠
	In applications requiring the highest level of accuracy and repeatability, it is recommended that the controller unit is powered up approximately 30 minutes before use, in order to allow the internal temperature to stabilize.	

1) Run the APTUser utility and check that the Graphical User Interface (GUI) panel appears and is active.

Fig. 3.4 GUI panel showing jog and ident buttons

2) Click the 'Ident' button. The ACTIVE LED 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.

3) Click the jog buttons on the GUI panel to move the piezo or axis connected to the controller. The voltage display for the associated GUI 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' - see Section 5.7. See also the *APTConfig* helpfile and the tutorial videos for detailed instructions.

Chapter 4 Standalone Operation

<table>
<tr><td>⚠</td><td align="center">**Shock Warning**</td><td>⚠</td></tr>
<tr><td colspan="3" align="center">**Persons using the TIM101 controller must understand the hazards associated with using high voltages and the steps necessary to avoid risk of electrical shock. If the TIM101 is used in a manner not specified by Thorlabs, the protective features provided by the product may be impaired.**</td></tr>
</table>

4.1 Introduction

The T-Cube Piezo Inertia Motor Driver has been designed specifically to operate with the latest range of Thorlabs piezo inertia motor driven products. The unit offers a fully featured control capability including max drive voltage settings, step rate and step acceleration, allowing support for many different actuator configurations. These parameters can be set via the APT Server software - see Chapter 6. Furthermore, many of these parameters are automatically set to allow "out of the box" operation with no further "tuning" required.

The following brief overview explains how the front panel controls can be used to perform a typical series of motor moves. It is assumed that the unit has already been installed and configured for the particular actuator or stage to which it is associated - see Chapter 3 for more details.
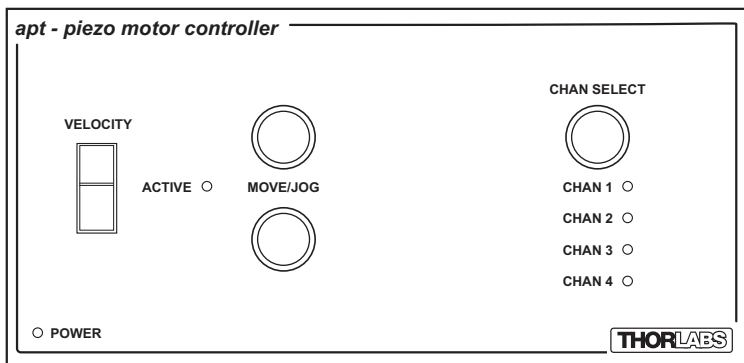
4.2 Control Panel Buttons and Indicators

Fig. 4.1 Panel Controls and Indicators

MOVE Controls - These controls allow all motor moves to be initiated.

Move/Jog Buttons - Used to jog the motors and make discrete position increments in either direction - see Section 5.6. for more details on jogging. Also used to switch between 'Jogging' and 'Go To Position' modes - see Section 4.4.2. and to zero the GUI display at the current position - see Section 4.4.1.

Velocity Potentiometer - Used to drive the motor at a varying speed in either forward or reverse directions for full and easy motor control - see Section 4.3.

Active LED - The Active LED can be configured to flash when the Ident button is pressed in the GUI panel. It can also be configured to be lit when the motor is moving. - see Section 6.3.2. for further details.

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

CHAN SELECT - Used to select the appropriate motor channel. When selected, the associated CHAN LED is lit.

4.3 Potentiometer Operation

The potentiometer slider is sprung such that when released it returns to it's central position. In this central position the piezo inertia motor is stationary. As the slider is moved away from the centre, the motor begins to move. Bidirectional control of the motor is possible by moving the slider in both directions. The speed of the motor increases as a function of slider deflection. The maximum speed is entered as a step rate (steps (drive pulses) per second) in the 'Max Step Rate' parameter in the 'Pot/ Buttons' settings tab - see Section 6.3.

4.4 Button Operation

The buttons on the front of the unit can be used to control the motor in a number of ways, as described below.

Caution
If the actuator is driven into its end stops, the motor may stick and may not respond to subsequent motion demands. If this is the case, turn the adjustment knob of the actuator manually to move the device away from its end stop, then the motor should move normally.

4.4.1 Zeroing

To establish a datum from which subsequent moves can be measured, move the motor to the required zero position, and then press and hold both jog buttons for 2 seconds.

The counter can also be zeroed by clicking the ZERO button on the GUI panel (see Section 5.4.), or by calling the SetPositionSteps method and setting the position to zero (see the APTServer helpfile for more details).

4.4.2 Go to Position

In 'Go To Position' mode, each front panel button can be programmed with a different position value, such that the controller will move the motor to that position when the specific button is pressed. These 'taught' positions can be set through the software GUI - see Section 6.3.2.

In addition to entering values in the Pot/Buttons Tab as described in Section 6.3.2., when operating in 'Go To Position' mode it is possible from the front panel, to save the current position as the 'Go To Position' value.

To save the current position as the 'Go To Position' value, press and hold the required button for 2 seconds.

When the button has been programmed the 'Active' LED on the unit will flash five times. Typically you would use the pot to move the motor to the required position and then 'teach' the button by pressing and holding it.

The move can be stopped at any time by pressing either of the move buttons.

This mode of operation is enabled by setting the 'Button Mode' parameter to 'Go To Position' on the Pot/Buttons settings tab - see Section 6.3. for further information.

4.4.3 Jogging

The front panel buttons can also be configured to 'jog' the motor. This mode of operation is enabled by setting the 'Button Mode' parameter to 'Jogging' on the 'Pot/ Buttons' settings tab - see Section 6.3. Once set to this mode, the jogging parameters for the buttons are taken from the 'Jog' parameters on the 'Move/Jogs' settings tab - see Section 6.3.

Chapter 5   PC Operation - Tutorial

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 shown in Section 3.3.1. and that the APT Software is already installed - see Section 3.1.

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 motor moves) can be initiated. Hardware configurations and parameter settings can be saved, which simplifies system set up whenever APT User is run up.

Fig. 5.1   Typical APT User Screen

1) Run the APT User program - Start/Programs/Thorlabs/APT/APT User.

2) The GUI panel shown below is displayed..

Fig. 5.2   Piezo Motor T-CubeSoftware GUI

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

5.3   Moving to a Position

Moves are measured in the number of steps, relative to the zero position.
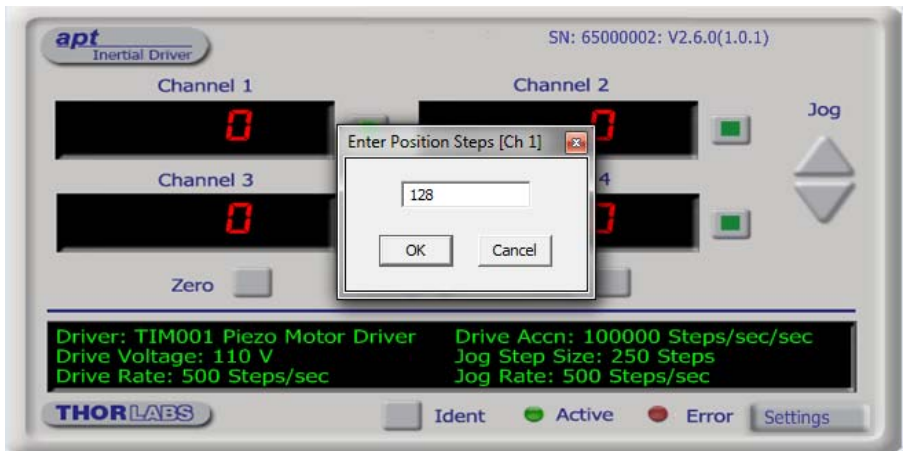
1) Click the position display.

Fig. 5.3   Position Popup Window

2) Enter the required number of steps into the pop up window, e.g. 128

3) Click 'OK'. Notice that the position display counts up to 128 to indicate a move to the absolute position commanded.

5.4 Zeroing

To establish a datum from which subsequent position moves can be measured, move the motor to the required zero position, and then click the ZERO button on the GUI panel. The motor can also be zeroed from the hardware unit by pressing and holding both jog buttons for 2 seconds (see Section 4.4.1.) or by calling the SetPositionSteps method and setting the position to zero (see the APTServer helpfile for more details).

5.5 Changing Motor Parameters

The velocity settings relate to the maximum velocities at which a move is performed, and the acceleration at which the motor speeds up from zero to maximum velocity. Moves are performed using the drive velocity parameters set in the Move/Jogs tab (see Section 6.3.1.).

5.6 Jogging

During PC operation, the motor actuators are jogged using the GUI panel arrow keys. There are two jogging modes available, 'Single Step' and 'Continuous'. In 'Single Step' mode, the motor moves by the step size specified in the Step Size parameter. If the jog key is held down, single step jogging is repeated until the button is released - see Fig. 6.3.

In 'Continuous' mode, the motor actuator will accelerate and move at the jog velocity while the button is held down.

⚠	Caution	⚠
	If the actuator is driven into its end stops, the motor may stick and may not respond to subsequent motion demands. If this is the case, turn the adjustment knob ob the actuator manually to move the device away from its end stop, then the motor should move normally.	

5.7   Creating a Simulated Configuration

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 colection 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/Programs/Thorlabs/APT/APT Config.
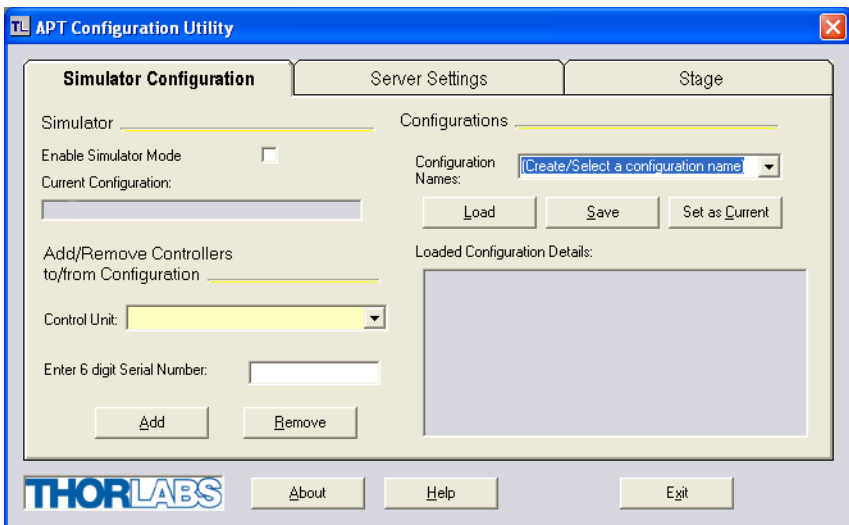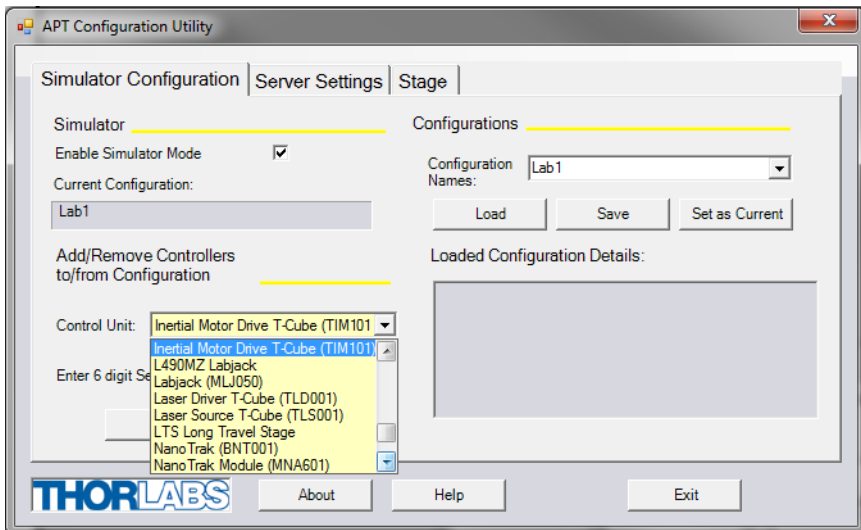2) Click the 'Simulator Configuration' tab.

Fig. 5.4   APT Configuration Utility - Simulator Configuration Tab

3) Enter a name, e.g. 'LAB 1' 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 'Inertial Motor Drive T-Cube (TIM101)'.
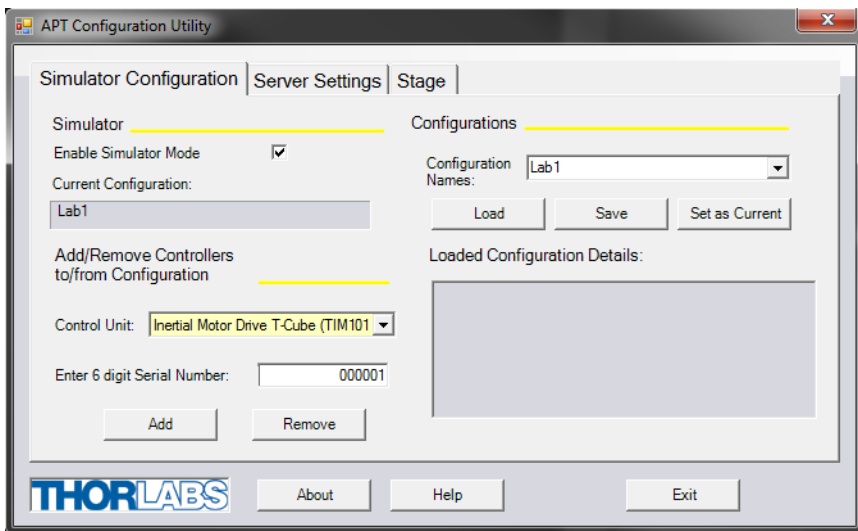
6) In the 'Enter 6 digit serial number' field, enter the serial number of your TIM101 unit.

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 TIM101 Piezo Inertia Motor Controller are 65xxxxxx**

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) Click 'Save'.
10) Click 'Set As Current' to use the configuration.

Chapter 6   Software Reference

6.1   Introduction

This chapter gives an explanation of the parameters and settings accessed from the APT software running on a PC.

6.2   GUI Panel

The following screen shot shows the graphical user interface (GUI) displayed when accessing the Piezo Motor Driver T-Cube using the APTUser utility.

Fig. 6.1   Piezo Motor Driver T-Cube Software GUI

Note. The serial number of the Piezo Motor Driver T-Cube 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.

Digital displays - Shows the position (drive pulses) of the motor associated with the drive channel. The motor must be 'zeroed' before the display will show a meaningful value, (i.e. the displayed position is relative to a physical datum). Only one channel at at ime can be enabled, and this is indicated by the LED in the adjacent button.

Jog - used to increment or decrement the motor position. When the button is clicked, the motor is driven in the selected direction at the jog velocity one step per click. The step size and jog velocity parameters are set in the 'Settings' panel (see Section 6.3.).

Zero - Zeroes the position counter at the current motor position. Subsequent moves are then measured from the current position.

Moving - lit when the motor is in motion.

Stop - halts the movement of the motor.

Settings display - shows the following user specified settings:

Driver - the type of control unit associated with the specified channel.

Drive Voltage - the maximum piezo drive voltage. Set in the range 80V to 130V.

Drive Rate - The velocity to move when a move command is initiated. It is specified in drive pulses/sec, in the range 1 to 2,000.

Drive Accn - The acceleration up to the drive rate. It is specified in pulses/sec/sec in the range 1 to 100,000.

Jog Step Size - the size of step (ie. number of drive pulses) taken when the jog signal is initiated.

Jog Rate - The velocity to move when a jog command is initiated. It is specified in drive pulses/sec, in the range 1 to 2,000.

Ident - when this button is pressed, the Channel LED on the front panel of the associated hardware unit will flash for a short period.

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

Error - lit when a fault condition occurs.

Settings button - Displays the 'Settings' panel, which allows the operating parameters to be entered for the motor drive - see Section 6.3.

6.3   Settings Panel

When the 'Settings' button on the GUI panel is clicked, the 'Settings' window is displayed. This panel allows motor operation parameters such as move/jog velocities to be modified. Note that all of these parameters have programmable equivalents accessible through the ActiveX methods and properties on this Control (refer to the *APTServer helpfile* for further details and to Section 2.3.4. for an overview of the APT ActiveX controls). The various parameters are described below.

6.3.1 Moves/Jogs Tab
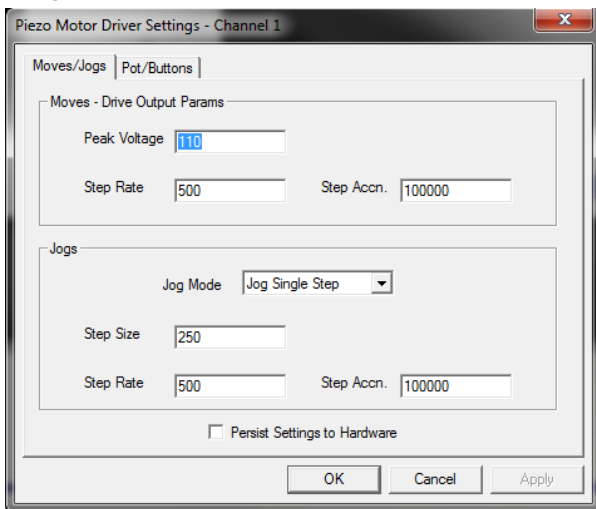
Fig. 6.2   Piezo Motor Driver T-Cube - Move/Jog Settings

Moves can be initiated via the GUI panel, either by using the jog buttons (see Section 5.6.) or by entering a position value after clicking on the position display box (see Section 5.3.), or by pressing the buttons on the unit.

Moves - Drive Output Params

These parameters define the speed and acceleration of moves initiated by clicking in the position display, or via the buttons when 'Go To Position' mode is selected.

Peak Voltage - the maximum piezo drive voltage. Set in the range 85V to 125V.

Step Rate - The piezo motor moves by ramping up the drive voltage to the value set in the *Peak Voltage* parameter and then dropping quickly to zero, then repeating (see Fig. 6.3). One cycle is termed a step. The Step Rate is the velocity to move when a command is initiated. It is specified in steps/sec, in the range 1 to 2,000.

Step Accn - The acceleration up to the step rate. It is specified in steps/sec/sec in the range 1 to 100,000.

Note
The step size is defined as the distance moved in one step or pulse. This distance can be adjusted up to about 30% by changing the piezo drive voltage. The actual step size achieved for a given drive voltage will be dependant on application.

Jogs

These parameters define the speed and acceleration of moves by jog command, either from the panel buttons, GUI panel or via software.

Jog Mode - The way in which the motor moves when a jog command is received (i.e. front panel button pressed or GUI panel button clicked).

There are two jogging modes available, '*Single Step*' and '*Continuous*'. In 'Single Step' mode, the motor moves by the distance specified in the Step Size parameter. If the jog key is held down, single step jogging is repeated until the button is released - see Fig. 6.3. In 'Continuous' mode, the motor actuator will accelerate at the Step Accn value and move at the Step Rate while the button is held down..
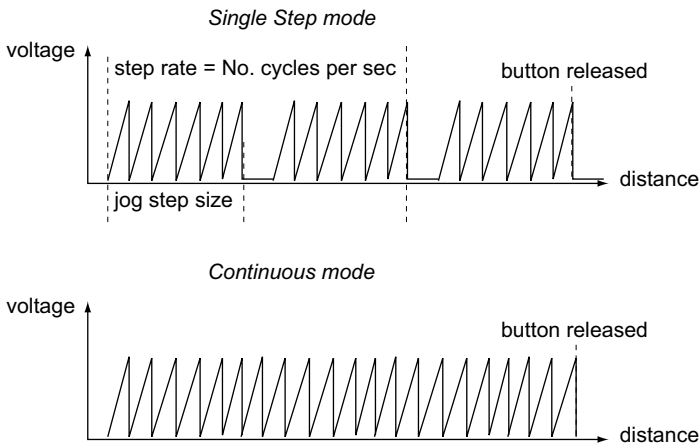
Fig. 6.3   Jog Modes

Jog Step Size - The distance to move when a jog command is initiated. The step size is specified by the 'number of steps' (or pulses)', in a jog step, in the range 1 to 2,000.

The optimum step size depends on several parameters including the resistive torque against which the actuator tip is pushing, the drive voltage, the step rate, active preload, variance in the frictional behaviour of assembly components, the direction of actuation and the condition of the actuator.

Step Rate - The velocity to move when a jog command is initiated. The step rate is specified in pulses per second, in the range 1 to 2,000.

Step Accn - The acceleration up to the step rate. It is specified in pulses/sec/sec in the range 1 to 100,000.

Persist Settings to Hardware - Many of the parameters that can be set for the Inertial Driver 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 Move and Jogging 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.

⚠️	**Caution**	⚠️
	The 'Persist Settings' functionality is provided to simplify use of the unit in the absence of a PC. When the unit is connected to a PC and is operated via APTUser, the default APTServer settings will be loaded at boot up, even if the 'Persist Settings' option has been checked.	

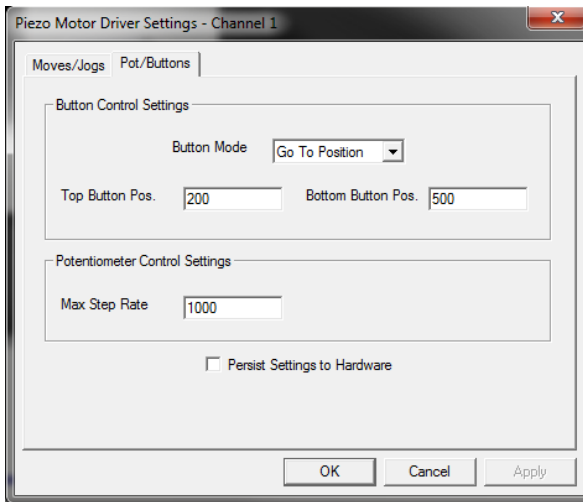### 6.3.2   Pot/Buttons Tab

Fig. 6.4   Piezo Motor Driver T-Cube - Pot/Button Settings

Button Control Settings

The buttons on the front of the unit can be used either to jog the motor, or to perform moves to absolute positions.

Button Mode: This setting determines the type of move performed when the front panel buttons are pressed.

Jogging: Once set to this mode, the move parameters for the buttons are taken from the 'Jog' parameters on the 'Move/Jogs' settings tab.

Go to Position: In this mode, each button can be programmed with a different position value, such that the controller will move the motor to that position when the specific button is pressed.

Note. The following parameters are applicable only if 'Go to Position is selected in the '*Button Mode*' field.

Top Button Position: The position to which the motor will move when the top button is pressed. The position is entered in 'Steps, measured from the Zero position.

Bottom Button Position: The position to which the motor will move when the bottom button is pressed.

Note. The motor can be zeroed by clicking the 'Zero' button on the gui panel, or by pressing and holding both buttons on the hardware unit for 2 seconds. Doing this will zero the position counter, and subsequent moves will be measured from the position the motor was at when the counter was zeroed..

Potentiometer Control Settings

The potentiometer slider is sprung such that when released it returns to it's central position. In this central position the motor is stationary. As the slider is moved away from the center, the motor begins to move; the speed of this movement increases as a function of slider deflection. Bidirectional control of motor moves is possible by moving the slider in both directions.

The speed is entered as a step rate (drive pulses per second) in the *Max Step Rate* parameter, in the range 1 to 2,000.

Persist Settings to Hardware

Many of the parameters that can be set for the Piezo Driver 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 potentiometer, button and LED parameters described above 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.

Caution
The 'Persist Settings' functionality is provided to simplify use of the unit in the absence of a PC. When the unit is connected to a PC and is operated via APTUser, the default APTServer settings will be loaded at boot up, even if the 'Persist Settings' option has been checked.

Appendix A   Rear Panel Connector Pinout Details

A.1   Rear Panel USER IO Connector

The 'USER IO' connector is for future use and no functionality is implemented at this time.
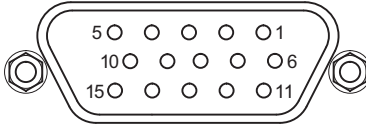
Pin	Description	Pin	Description
1	N/A	9	N/A
2	N/A	10	N/A
3	N/A	11	N/A
4	N/A	12	N/A
5	N/A	13	N/A
6	N/A	14	N/A
7	N/A	15	N/A
8	N/A		

Fig. A.1 USER I/O Connector Pin Identification

Appendix B   Preventive Maintenance

Shock Warning

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

B.1   Safety Testing

PAT testing in accordance with local regulations, should be performed on a regular basis, (typically annually for an instrument in daily use).

B.2   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
Piezoelectric Output (SMC)	
Voltage Output	85 to 125 V DC/channel
External Input (SMA)	
Input Type	Single Ended
Input Voltage	0 to 10 V ±2%
Input Power Requirements	
Voltage	15 VDC
Current	2 A
Micro USB Port	Version 2.0 Full Speed Compatible
General Data	
Housing Dimensions Excluding Baseplate (W x D x H)	120 x 60 x 47 mm (4.8 x 2.4 x 1.8 in.)
Weight:	340 g

C.2 Associated Products

Product Name	Part Number
Piezo Inertia Motor Actuator, 13 mm Travel	PIA13
Piezo Inertia Motor Actuator, 25 mm Travel	PIA25
Piezo Inertia Motor Actuator, 50 mm Travel,	PIA50
Piezo Inertia Motor Actuator, 10 mm Travel, Kinematic Mounting	PIAK10
T-Cube Controller USB Hub	TCH002
Single Way Power Supply	KPS101
8-way Power Supply	TPS008

Appendix D   Piezo Motor Control Method Summary

The 'Piezo Motor' ActiveX Control provides the functionality required for a client application to control one or more piezo motor controller units.

To specify the particular controller being addressed, every unit is factory programmed with a unique 8-digit serial number. This serial number is key to the operation of the APT Server software and is used by the Server to enumerate and communicate independently with multiple hardware units connected on the same USB bus. The serial number must be specified using the HWSerialNum property before an ActiveX control instance can communicate with the hardware unit. This can be done at design time or at run time. Note that the appearance of the ActiveX Control GUI (graphical user interface) will change to the required format when the serial number has been entered.

The Methods and Properties of the Piezo Motor ActiveX Control can be used to perform activities such as selecting output voltages, reading the position, setting jog parameters and moving to an absolute or relative distance.   A brief summary of the methods and properties applicable to the TIM101 unit is given below, for more detailed information and individual parameter descriptiond please see the on-line help file supplied with the APT server.

Methods

DeleteParamSet	Deletes stored settings for specific controller.
DoEvents	Allows client application to process other activity.
EnableEventDlg	Enables or disables the event dialog box.
EnableHWChannel	Enables the drive output.
GetButtonParams	Gets the operation mode of the front panel buttons
GetDriveOPParams	Gets various drive parameters which define the speed and acceleration of moves.
GetJogMode	Gets the jogging button operating modes.
GetJogOPParams	Gets various drive parameters which define the speed and acceleration of jog moves.
GetJogStepSize	Gets the jogging step size.
GetPositionSteps	Gets the position counter value.
GetPotParams	Gets the speed of a move initiated by the potentiometer on the top panel of the hardware unit.
Identify	Identifies the controller by flashing unit LEDs.
LoadParamSet	Load the settings associated with a particular ActiveX Control instance.

LLGetStatusBits	Gets the controller status bits encoded in 32 bit integer.
MoveAbsoluteStepsEx	Initiates an Absolute move.
MoveJog	Initiates a jog move.
MoveRelativeStepsEx	Initiates a relative move.
MoveVelocity	Initiates a move at constant velocity with no end point.
SaveParamSet	Saves settings for a specific controller.
SetButtonParams	Sets the operation mode of the front panel buttons
SetDriveOPParams	Sets various drive parameters which define the speed and acceleration of moves.
SetJogMode	Sets the jogging button operating modes.
SetJogOPParams	Sets various drive parameters which define the speed and acceleration of jog moves.
SetJogStepSize	Sets the jogging step size.
SetPositionSteps	Sets the position counter value.
SetPotParams	Sets the speed of a move initiated by the potentiometer on the top panel of the hardware unit.
ShowEventDialog	Shows the event dialog when it has previously been disabled using the EnableEventDlg method
StartCtrl	Starts the ActiveX Control (starts communication with controller)
Stop	Stops the motor.
StopCtrl	Stops the ActiveX Control (stops communication with controller)

Properties

APTHelp	Specifies the help file that will be accessed when the user presses the F1 key. If APTHelp is set to 'True', the main server helpfile will be launched.
HWSerialNum	Specifies the serial number of the hardware unit to be associated with an ActiveX control instance.

Appendix E   Piezo Operation - Background

E.1   Piezoelectric Controller

E.1.1   The Piezoelectric Effect

Piezoelectricity is the effect whereby certain types of crystal expand reversibly when subjected to an electric field.

Although the amount of expansion is usually very small (corresponding to less than 1% strain in the material) it can be controlled extremely finely by varying the strength of the electric field. Piezoelectric materials therefore form the basis of very high precision actuators. The resolution of these actuators is effectively only limited by the noise and stability of the drive electronics. Moreover, the force generated by the expanding piezo is very large, typically hundreds of newtons.

Perhaps the most useful property of these actuators is their ability to produce oscillating motion at considerable frequencies, usually limited by the mechanical system driven rather than by the piezo actuator itself. This ability is used to advantage in the NanoTrak control system, for example.

The electric field gradient needed to produce a useful amount of expansion is quite large. Thus to avoid excessive drive voltages, the actuator is constructed as a stack, consisting of lamina of active material sandwiched among electrodes – see Fig. E.1. In this way, the distance from positive to negative electrodes is very small. A large field gradient can therefore be obtained with a modest drive voltage (75 V in the case of Thorlabs actuators).
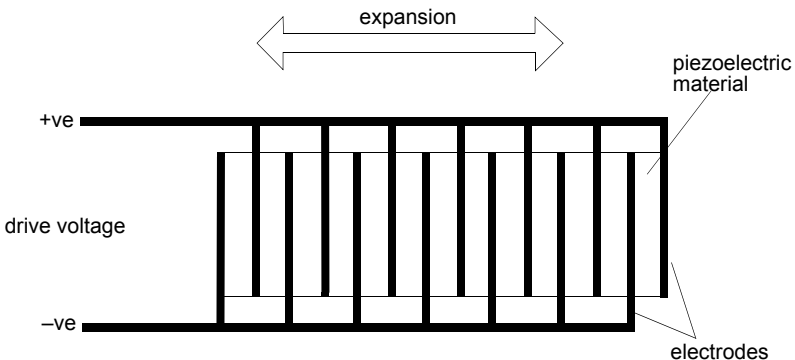

Fig. E.1 Piezo-electric actuator schematic diagram

E.1.2   Hysteresis

Despite the very high resolution of piezoelectric actuators, an inherent problem is the significant amount of hysteresis they exhibit, (i.e., the tendency of the actuator to reach a final position that lags behind the demand position).

If a cyclic voltage is applied to the actuator the positions reached on the upward sweep are smaller than those achieved on the downward sweep. If position is plotted against voltage, the graph describes a hysteresis loop – see Fig. E.2.
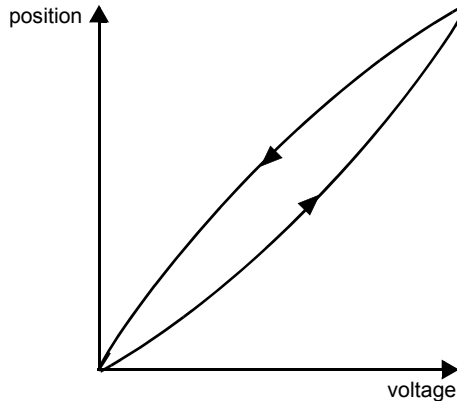
Fig. E.2 Piezo-electric hysteresis

E.1.3   Position Sensing and Feedback Control

Hysteresis can be eliminated by using a position sensor and feedback loop, i.e., the sensor measures the position, the circuit subtracts the measured position from the demand position to get the error, and a proportional-integral feedback loop adjusts the voltage to the actuator until the error is virtually zero.

Some Thorlabs nanopositioning actuators have position sensing, others do not. The Piezoelectric control module allows both types to be controlled.

To control an actuator with position sensing, the Piezoelectric control module should be set to closed-loop mode. To control an actuator without position sensing, the Piezoelectric Control module should be set to open-loop mode.

Note
An actuator with position sensing can also be driven in open-loop mode if desired, since the feedback part of the circuit can be switched off. An advantage of open-loop mode is the greater bandwidth of the system.

Block diagrams for both modes of operation are shown in Fig. E.1.

open loop control

closed loop control
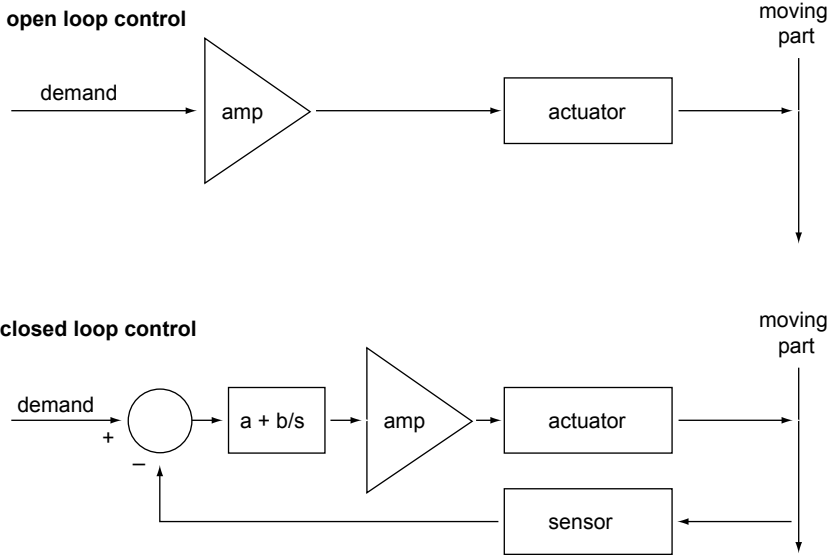
Fig. E.3 Open loop and closed loop control

The result of using closed-loop control is a linear relationship between demand (voltage) and measured position – see Fig. E.4, in contrast to open loop control – see Fig. E.2.
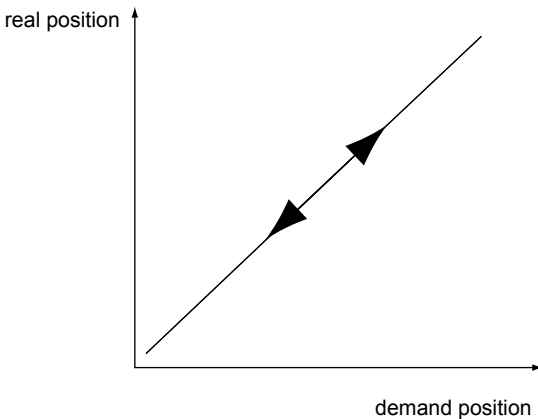
Fig. E.4 Closed loop response

Appendix F   Regulatory

F.1   Declarations Of Conformity

F.1.1   For Customers in Europe
See Section F.3.

F.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.

F.2   Waste Electrical and Electronic Equipment (WEEE) Directive

F.2.1   Compliance
As required by the Waste Electrical and Electronic Equipment (WEEE) Directive of the European Community and the corresponding national laws, we offer all end users in the EC the possibility to return "end of life" units without incurring disposal charges.

This offer is valid for electrical and electronic equipment
- sold after August 13th 2005
- marked correspondingly with the crossed out "wheelie bin" logo (see Fig. 1)
- sold to a company or institute within the EC
- currently owned by a company or institute within the EC
- still complete, not disassembled and not contaminated

Fig. 6.1   Crossed out "wheelie bin" symbol

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

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

If you wish to return a unit for waste recovery, please contact Thorlabs or your nearest dealer for further information.
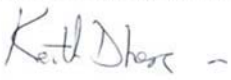
F.2.2   Waste treatment on your own responsibility
If you do not return an "end of life" unit to the company, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

F.2.3   Ecological background
It is well known that WEEE pollutes the environment by releasing toxic products during decomposition. The aim of the European RoHS directive is to reduce the content of toxic substances in electronic products in the future.

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

F.3 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):

2006/95/EC	Low Voltage Directive (LVD)
2004/108/EC	Electromagnetic Compatibility (EMC) Directive
2011/65/EU	Restriction of Use of Certain Hazardous Substances (RoHS)

hereby declare that:

Model: **TIM101**

Equipment: **Inertial Piezo Driver T-Cube**

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

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

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

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

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

Signed: *On:*   04 December 2015

Name: Keith Dhese

Position: General Manager   EDC - TIM101 -2015-12-04

CE 15

Appendix G   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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THORLABS

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