TST101

T-Cube Stepper Motor Controller

User Guide

Original Instructions

Contents

Appendices

Chapter 1 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.

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 T-Cube Stepper Motor Controller (TST101) is a compact single channel controller for easy manual and automated control of small 2-phase bi-polar stepper motors. This driver has been designed to operate with a variety of lower powered motors (up to 15V at 12W operation) equipped with or without encoder feedback. Although targeted at lower power operations this product is fully featured with a highly flexible and powerful DSP controller that provides a unique high resolution microstepping capability for such a compact unit. The TST101 is optimised for 'out of the box' operation with the Thorlabs range of ZST stepper motor actuators, however its highly flexible parameter set also supports operation a wide range of stepper motors and associated stages/actuators.

For convenience the footprint of this unit has been kept to a minimum, measuring only 60 mm x 60 mm x 47 mm (2.4" x 2.4" x 1.8") and with the facility to directly mount to the optical table close to the motorised device - convenient when manually adjusting motor 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 Stepper Motor Driver

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 new T-Cube Controller Hub (see over) for multi-axis motion control applications. Coupling this with the very user friendly Kinesis™ 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 for Thorlabs stage/actuator products. Advanced custom motion control applications and sequences are also possible using the extensive Microsoft® .Net 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 8 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 (TPS001) is also available 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 new 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 (from a separate supply unit TPS006 supplied by Thorlabs).

2.3 Kinesis PC Software Overview

2.3.1 Introduction

The T-Cube range of controllers share many of the benefits of the Thorlabs range of motor controllers. These include 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 Kinesis software suite provides a flexible and powerful PC based control system both for users of the equipment, and software programmers aiming to automate its operation.

The User Interface allows full control of all settings and operating modes enabling complete 'out-of-box' operation without the need to develop any further custom software. It provides all of the necessary 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. The Kinesis server is also used by software developers to allow the creation of advanced automated positioning applications very rapidly and with great ease. The Kinesis server is described in more detail in Section 2.3.2.

2.3.2 Kinesis Server

Kinesis 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 Kinesis system, .Net Controls are deployed to allow direct control over (and also reflect the status of) the range of electronic controller units, including the Stepper Driver T-Cube. Software applications that use .Net Controls are often referred to as 'client applications'. A .Net Control is a language independent software component. Consequently the 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 .Net Control supplied for the T-Cube stepper driver unit.

This Control provides a complete user graphical instrument panel to allow the 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 stepper 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 Kinesis Controls collection provides a rich set of graphical user panels and programmable interfaces allowing users and client application developers to interact seamlessly with the Kinesis hardware. Each of the Kinesis controllers has an associated .Net Control and these are described fully in the handbooks associated with the controllers..

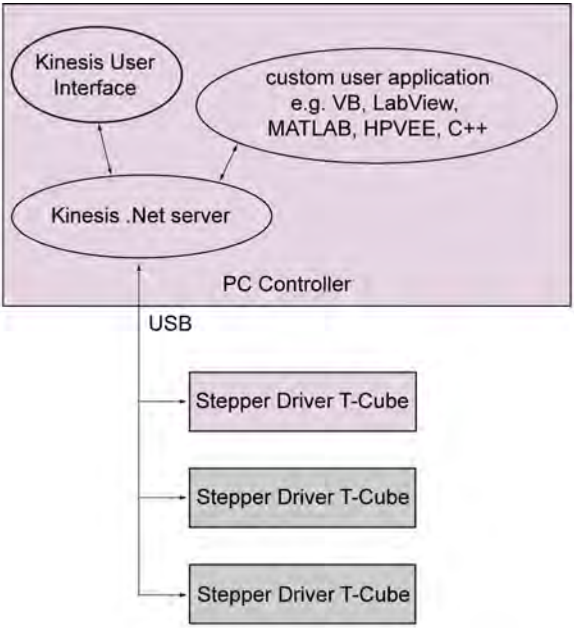


Fig. 2.2 System Architecture Diagram

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

2.3.3 Software Upgrades

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

Chapter 3 Getting Started

3.1 Install The Software

Note

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

Caution

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

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

DO NOT CONNECT THE CONTROLLER TO YOUR PC YET

1) Download the software from www.thorlabs.com.
2) Locate the downloaded setup.exe file and move to a suitable file location.
3) Double-click the setup.exe file and follow the on-screen instructions.

3.2 Mechanical Installation

3.2.1 Environmental Conditions

Caution

This unit is designed for operation within normal operational limits. It is not recommended to use this equipment outside the following limits.

Location	Indoor use only
Maximum altitude	2000 m
Temperature range	5^{o}C to 40^{o}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 Stepper 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 the associated 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 of the unit.

3.2.3 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

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 Motor

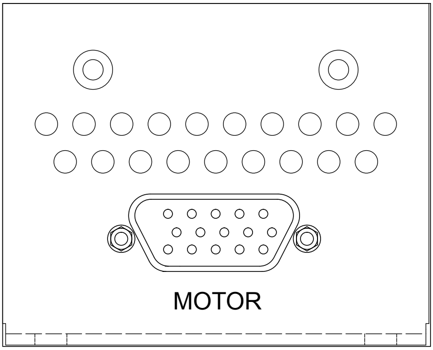


Fig. 3.2 Rear Panel Connections

The unit is supplied with a 15 pin D-type connector as shown above, which is compatible with all Thorlabs stepper motor actuators (refer to Appendix A for details of pin outs).

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 (from a separate supply unit TPS006 supplied by Thorlabs). Further details are contained in the associated handbook available from www.thorlabs.com.

Warning

DO NOT PLUG A POWERED UP T-CUBE INTO THE TCH002 USB CONTROLLER HUB. Always ensure that all power is disconnected from the Stepper Driver 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

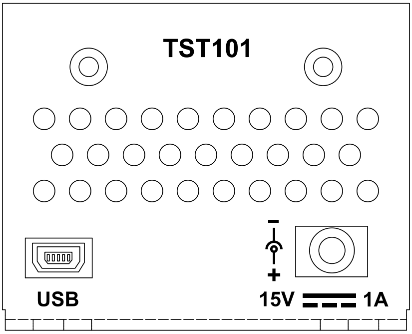


Fig. 3.3 Front Panel Power Supply Connector

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

Thorlabs offers a compact, multi-way power supply unit (TPS008), allowing up to eight Driver T-Cubes to be powered from a single mains outlet. A single way wall plug supply (TPS001) for powering a single Driver T-Cube is also available.

Warning

The unit must be connected only to a DC supply of 15V, 1A regulated. Connection to a supply of a different rating may cause damage to the unit and could result in injury to the operator.

3.4 Connect The Hardware

1) Perform the mechanical installation as detailed in Section 3.2.
2) Install the Kinesis Software - see Section 3.1.
3) Connect the stepper motor actuator to the Controller unit - see Section 3.3.1.
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 length should be no more than 3 metres unless a powered USB hub is being used.

7) Windows™ should detect the new hardware. Wait while Windows™ installs the drivers for the new hardware.

3.5 Select the Stage Type

To ensure that a particular stage is driven properly by the system, a number of parameters must first be set. These parameters relate to the physical characteristics of the stage being driven (e.g. min and max positions, leadscrew pitch, homing direction etc.).

To assist in setting these parameters correctly, you must first associate a specific stage type and axis with the motor controller. Once this association has been made, the Kinesis server applies automatically, suitable default parameter values on boot up of the software.

Note

Even if a stage type and axis has been associated with the controller, it is still possible to alter these parameters if required, (e.g. for a custom stage type not selectable using the Kinesis software) - see Section 6.3.4.

Note

To use the increased resolution and velocity funcitionality offered by these controllers, the stage types prefixed by 'HS' (e.g. HS NanoMax 300 X Axis) must be selected. Failure to select the correct stage type will result in reduced velocity and resolution.

1) Ensure that the device is connected to the PC and powered up.
2) Run the Kinesis software - Start/All Programs/Thorlabs/Kinesis/Kinesis.
3) The 'Actuator/Startup Settings ' window is displayed.

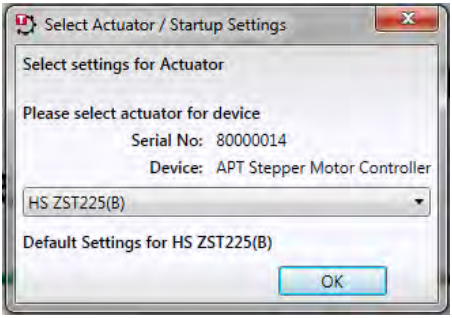


Fig. 3.4 Stage Configuration Window

4) Select your actuator type (e.g. HS ZST225(B)) from the list displayed.

Note

To use the increased resolution and velocity funcitionality offered by these controllers, the stage types prefixed by 'HS' (e.g. HS ZST213(B)) must be selected. Selecting a stage/actuator type without the 'HS' prefix will result in reduced velocity and resolution.

5) Click OK.
6) The server reads in the stage and controller information automatically. Proceed to Section 3.6. to verify the software operation.

3.6 Verifying Software Operation

3.6.1 Initial Setup

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

Fig. 3.5 Gui panel showing jog and ident buttons

2) Check that the actuator type associated at start up is displayed in the GUI panel.
3) Click the 'Identify' button. The ACTIVE LED on the front panel of the Stepper Driver T-Cube flashes. This is useful in multi-channel systems for identifying which driver unit is associated with which GUI.
4) Click the jog buttons on the GUI panel and check that the motor or axis connected to the Stepper Driver T-Cube moves. The position display for the associated GUI should increment and decrement accordingly.

Follow the tutorial steps described in Chapter 5 for further verification of operation.'

Chapter 4 Standalone Operation

4.1 Introduction

The Stepper Driver T-Cube has been designed specifically to operate with lower power stepper motors such as the Thorlabs ZST series, however it can also drive a variety of other stepper motors (15V operation) equipped with or without encoder feedback.

The unit offers a fully featured motion control capability including velocity profile settings, limit switch handling, homing sequences and, for more advanced operation, adjustment of settings such as lead screw pitch and gearbox ratio, allowing support for many different actuator configurations. These parameters can be set via the Kinesis Server software - see Chapter 5. Furthermore, when used with the extensive range of Thorlabs ZST motorised opto-mechanical products, 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.

In conjunction with this chapter, it also may be useful to read the background on stepper motor operation contained in Appendix D .

4.2 Front Panel Controls and Indicators

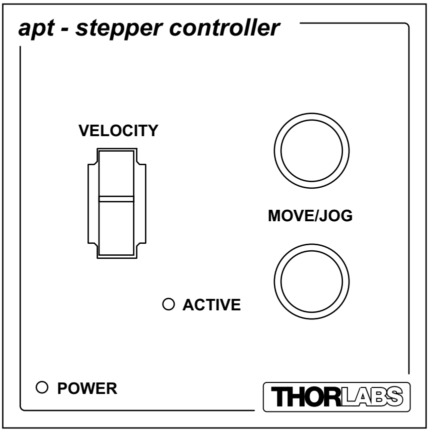


Fig. 4.1 Front Panel Controls and Indicators

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

Jog Buttons - Used to jog the motors and make discrete position increments in either direction - see Section 5.5. for more details on jogging.

VELOCITY Potentiometer - Used to drive the motor at a pre-defined speed (set in the settings panel - see Section 4.3.) in either forward or reverse directions for full and easy motor control

Active LED - The Active LED can be configured to flash when the motor reaches a forward or reverse limit switch, and to be lit when the motor is moving - see Section 6.3.5. for further details.

POWER LED - Lit when power is applied to the unit. This LED can be configured to flash when the 'Ident' button is clicked on the Kinesis Software GUI panel - see Section 6.3.5. for further details.

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 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 velocity of this move is set in real world units (mm or degrees) in the 'Potentiometer Control Settings' parameter in the 'Advanced' settings tab. The velocity profile is derived from the 'Velocity Profile' settings in the 'Move/Jogs' settings tab - see Section 6.3.2. and the Potentiometer Control Settings in the Advanced tab - see Section 6.3.5.

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.

4.4.1 Homing

A 'Home' move is performed to establish a datum from which subsequent absolute position moves can be measured (see Section 5.3. and Section D.2.2. for further information on the home position).

To initiate a 'Home' move, press and hold both buttons for 2 seconds.

4.4.2 Go to Position

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.

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

4.4.3 Teaching 'Go To Position' Values

In addition to entering values in the Advanced Tab as described in Section 4.4.2. above, 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.

4.4.4 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 'Advanced' 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.

4.4.5 Switching Between Button Modes

The button mode can only be changed in the Settings panel, see Chapter 6.3.5.

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 Kinesis software. It assumes that the unit is electrically connected as shown in Section 3.3., and that the Kinesis Software is already installed - see Section 3.1. For illustration purposes, it also assumes that a ZST motor is connected to the 'Motor' connector on the rear panel.

5.2 Using the Kinesis Software

The Kinesis software application allows the user to interact with any number of hardware control units connected to the PC USB Bus. This program allows multiple graphical instrument panels to be displayed so that multiple 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. Parameter settings can be saved, which simplifies system set up whenever the software is run up.

1) Run the Kinesis software - Start/All Programs/Thorlabs/Kinesis/Kinesis.
2) Notice how the ZST225(B) actuator type, selected at start up, is displayed in the window. See Section 6. and Section 6.3. for further details on the parameter values shown in the 'Settings' display.

Fig. 5.1 Stepper Driver T-Cube Software GUI

5.3 Homing Motors

Homing the motor moves the actuator to the home limit switch and resets the internal position counter to zero. The limit switch provides a fixed datum that can be found after the system has been powered up.

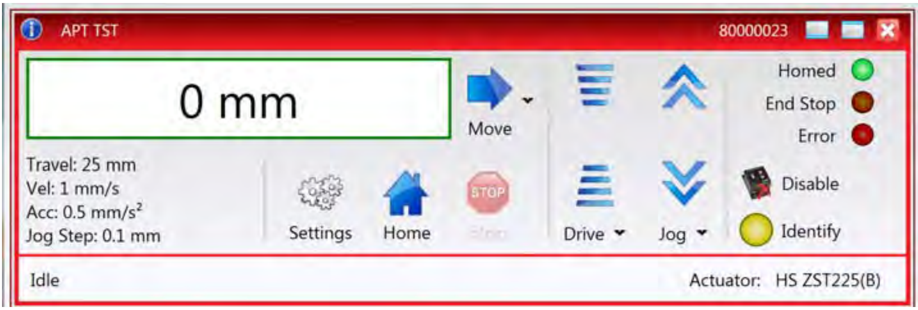


Fig. 5.2 Stepper Driver T-Cube GUI

1) Click the ‘Home’ button. Notice that the ‘Not Homed’ LED changes to ‘Homed’, and that the LED flashes to indicate that homing is in progress. The displayed position counts down to 0, i.e the home position.

Note

Homing can also be performed at the unit, by holding down both front panel buttons for around 2 seconds.

2) When homing is complete, the ‘Homed’ LED is lit as shown above.

See Appendix D , Section D.2.2. for background information on the home position.

5.4 Changing Motor Parameters and Moving to an Absolute Position

Absolute moves are measured in real world units (e.g. millimetres), relative to the Home position.

Moves are performed using a trapezoidal velocity profile (see Appendix D , Section D.1.3.). 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.

1) On the GUI panel, click the Move arrow to show the Settings panel.

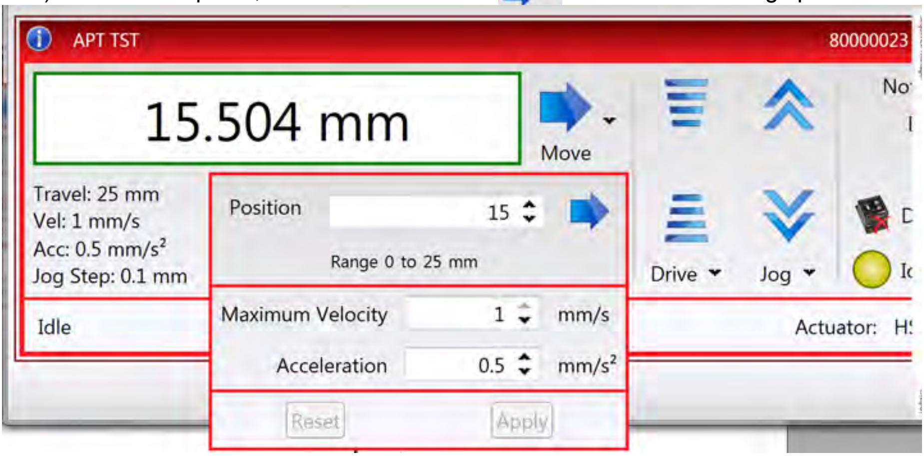
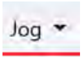


Fig. 5.3 Move Settings Panel

2) Enter the required absolute position and/or parameter values.
3) To move to the position entered click the arrow
4) Click 'Apply' to save the parameter settings and close the window, click Reset to return to the previously saved values.

5.5 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 Distance 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.

1) On the GUI panel, click the word ‘Jog’ 

to display the Settings panel.

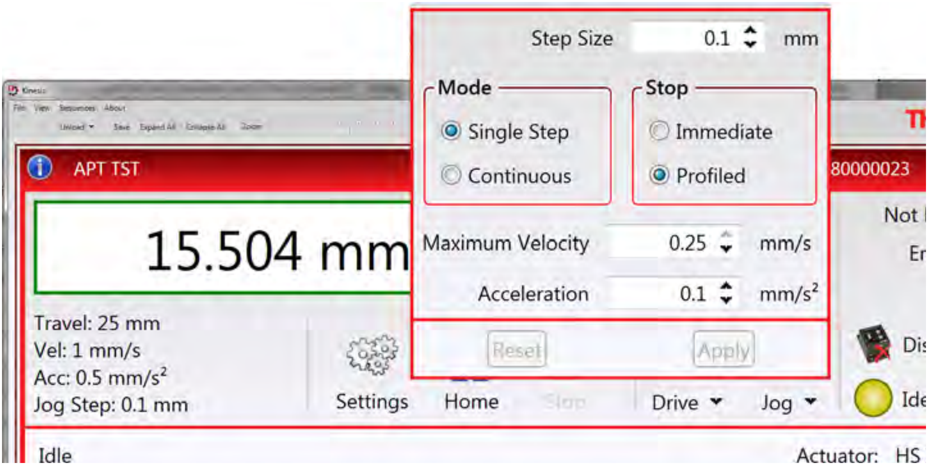


Fig. 5.4 Jog Settings Panel

2) Make parameter changes as required.

Note

In current versions of software, the ‘Min Vel’ parameter is locked at zero and cannot be adjusted.

3) Click ‘Apply’ to save the settings and close the window, click Reset to return to the previously saved values.

5.6 Setting Move Sequences

The Kinesis software allows move sequences to be programmed, allowing several positions to be visited without user intervention. For more details and instructions on setting move sequences, please see the *Kinesis Helpfile*.

5.7 Changing and Saving Parameter Settings

During operation, certain settings (e.g. max velocity, jog step size etc) can be changed as required. Other settings (e.g. PID parameter values) cannot be changed so easily. When the Kinesis Server is run up and the stage/acuator association made, suitable default settings are loaded and these values have been chosen to provide safe performance in the majority of applications. However, for applications where these settings need to be changed, a new set of Device Start Up settings', must be created which can then be applied and/or uploaded on subsequent start up. See the *Kinesis Helpfile* for more details.

Chapter 6 Software Reference

6.1 Introduction

This chapter gives an explanation of the parameters and settings accessed from the Kinesis software running on a PC. For information on the methods and properties which can be called via a programming interface, see Appendix D .

6.2 GUI Panel

The following screen shot shows the graphical user interface (GUI) displayed when accessing the Stepper Driver T-Cube using the Kinesis software.

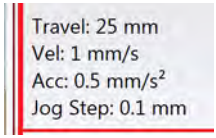
Fig. 6.1 Stepper Driver T-Cube Software GUI

Note

The serial number of the Stepper Driver T-Cube associated with the GUI panel is displayed in the top right hand corner. This information should always be provided when requesting customer support.

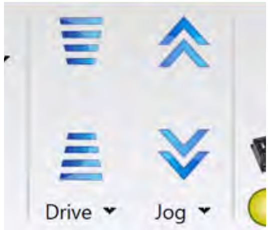
Position window - shows the position (in millimetres or degrees) of the motor. The motor must be 'Homed' before the display will show a meaningful value, (i.e. the displayed position is relative to a physical datum, the limit switch).

 **Move** - Opens the settings window, so that position data and velocity parameters can be entered - see Section 5.4. Moves are performed using the current velocity parameters which can be changed in the same panel. The present settings are displayed below the window.



Velocity Parameters - the present setting for the move velocity parameters and the jog step size. The travel range of the associated stage/actuator is also displayed.

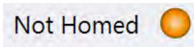
These settings can be adjusted as described previously, or by clicking the Settings button to display the settings window, see Section 6.3.2.



Jog Controls - used to increment or decrement the motor position. The controls comprise a bar graph and a set of jog arrows.

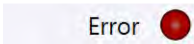
Each division of the bar graph represents a different velocity. The velocities are entered in the settings panel which is displayed by clicking ‘Drive’ or the small down arrow.

When the arrows are clicked, the motor is driven in the selected direction at the jog velocity, one step per click. The step size and jog velocity parameters can be changed by clicking ‘Jog’ or the small down arrow to display the settings panel.



Homed/Not Homed - lit when the motor has not been 'Homed' since power up. When the home button is clicked, the caption changes to ‘Homed’ and the LED flashes while the home move is being performed. The LED is lit green once the move is complete.

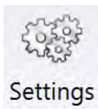
End Stop - lit when a limit switch is activated, i.e. the motor is at its end stop.



Error - lit when a fault condition occurs.

Enable/Disable - applies and removes power to the motor. With the motor enabled, only the Disable button is visible, and with the motor disabled only the Enable button is visible.

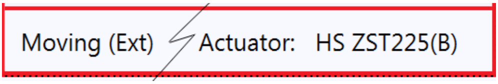
Identify - when this button is pressed, the ACTIVE LED on the front panel of the associated hardware unit will flash for a short period.



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

Home - sends the motor to its 'Home' position - see Appendix D Section D.2.2.

Stop - halts the movement of the motor.



Lower Display - Shows the present state of the motor, e.g. Idle, Moving, Moving EXT or Homing.

Also shows the part number of the associated actuator or stage.

6.2.1 Keyboard Shortcuts

Certain functionality can also be accessed via PC keyboard shortcuts as follows:

Jog Forwards	‘Ctrl’ + ’F’, ‘Ctrl’ + ’+’
Jog Backwards	‘Ctrl’ + ‘B’, ‘Ctrl’ + ‘-’
Home	‘Ctrl’ + ‘H’, ‘Ctrl’ + ‘Home’
Stop	‘Ctrl’ + ‘0’
Jog Forward1	‘LeftCtrl’ + ‘1’ (Hold to move)
Forward2	‘LeftCtrl’ + ‘2’ (Hold to move)
Forward3	‘LeftCtrl’ + ‘3’ (Hold to move)
Forward4	‘LeftCtrl’ + ‘4’ (Hold to move)
Backward1	‘RightCtrl’ + ‘1’ (Hold to move)
Backward2	‘RightCtrl’ + ‘2’ (Hold to move)
Backward3	‘RightCtrl’ + ‘3’ (Hold to move)
Backward4	‘RightCtrl’ + ‘4’ (Hold to move)
GoTo	‘Enter’ (On target position box)

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, and stage/axis information to be modified. Note that all of these parameters have programmable equivalents (refer to the *Kinesis Server helpfile* for further details.

6.3.1 Persisting Settings to Hardware

Many of the parameters that can be set for the Stepper 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 Velocity Profile 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 the Device’* 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 KinesisUser, the default KinesisServer settings will be loaded at boot up, even if the ‘Persist Settings’ option has been checked.

6.3.2 Moves/Jogs Tab

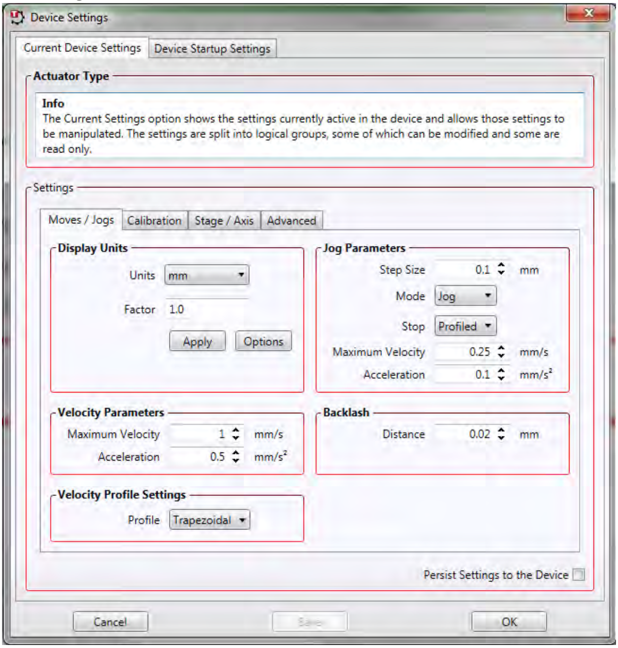


Fig. 6.2 Stepper Driver T-Cube - Move/Jog Settings

Display Units

By default, the unit will display position in real world units (mm or degrees). If required, the units can be changed to so that the display shows other positional units (cm, µm, µrad etc).

Units - the positioning units used on the GUI display.

Factor - the scaling factor associated with the selected units.

Jog Parameters

Jogs are initiated by using the ‘Jog’ keys on the GUI panel (see Section 5.5.), or the Jog Buttons on the front panel of the unit.

Step Size - The distance to move when a jog command is initiated. The step size is specified in real world units (mm or degrees dependent upon the stage).

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, ‘Jog’ and ‘Continuous’. In ‘Jog’ 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 and move at the jog velocity while the button is held down..

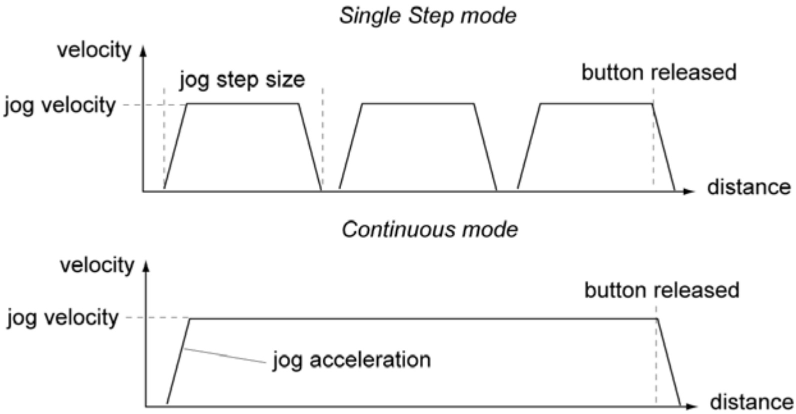


Fig. 6.3 Jog Modes

Jog - the motor moves by the distance specified in the Step Size parameter.

Continuous - the motor continues to move until the jog signal is removed (i.e. jog button is released).

Stop - the way in which the jog motion stops when the demand is removed.

Immediate - the motor stops quickly, in a non-profiled manner

Profiled - the motor stops in a profiled manner using the jog Velocity Profile parameters set above.

Maximum Velocity - the maximum velocity at which to perform a move.

Acceleration - the rate at which the velocity climbs from zero to maximum, and slows from maximum to zero.

Velocity Parameters

Moves can be initiated via the GUI panel by entering a position value after clicking on the position display box (see Section 5.4.), or by calling a software function (see the KinesisServer helpfile). The following settings determine the velocity profile of such moves, and are specified in real world units, millimetres or degrees.

Maximum Velocity - the maximum velocity at which to perform a move.

Acceleration - the rate at which the velocity climbs from zero to maximum, and slows from maximum to zero.

Note

Under certain velocity parameter and move distance conditions, the maximum velocity may never be reached (i.e. the move comprises an acceleration and deceleration phase only).

Backlash

Distance - The system compensates for lead screw backlash during reverse direction moves, by moving passed the demanded position by a specified amount, and then reversing. This ensures that positions are always approached in a forward direction. The Backlash Distance is specified in real world units (millimeters or degrees). To remove backlash correction, this value should be set to zero.

Velocity Profile Settings

To prevent the motor from stalling, it must be ramped up gradually to its maximum velocity. Certain limits to velocity and acceleration result from the torque and speed limits of the motor, and the inertia and friction of the parts it drives.

The system incorporates a trajectory generator, which performs calculations to determine the instantaneous position, velocity and acceleration of each axis at any given moment. During a motion profile, these values will change continuously. Once the move is complete, these parameters will then remain unchanged until the next move begins.

The specific move profile created by the system depends on several factors, such as the profile mode and profile parameters presently selected, and other conditions such as whether a motion stop has been requested.

Profile – This field is used to set the profile mode to either Trapezoidal or S-curve. In either case, the velocity and acceleration of the profile are specified using the *Velocity Profile* parameters on the *Moves/Jogs tab.*

The *Trapezoidal* profile is a standard, symmetrical acceleration/deceleration motion curve, in which the start velocity is always zero.

In a typical trapezoidal velocity profile, (see Fig. 6.4.), the stage is ramped at acceleration '*a*' to a maximum velocity '*v*'. As the destination is approached, the stage is decelerated at '*a*' so that the final position is approached slowly in a controlled manner.

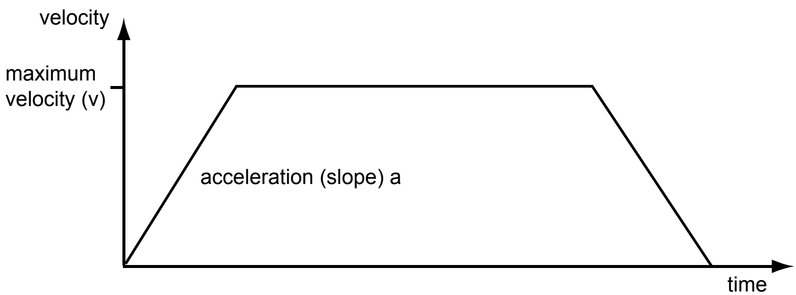


Fig. 6.4 Graph of a trapezoidal velocity profile

The *S-curve* profile is a trapezoidal curve with an additional '*Bow Value*' parameter, which limits the rate of change of acceleration and smooths out the contours of the motion profile. The *Bow Value* is applied in mm/s^3 and is derived from the *Bow Index* field as follows:

Bow Value = 2 $^{\text{(Bow Index -1)}}$ within the range 1 to 262144 (Bow Index 1 to 18).

In this profile mode, the acceleration increases gradually from 0 to the specified acceleration value, then decreases at the same rate until it reaches 0 again at the specified velocity. The same sequence in reverse brings the axis to a stop at the programmed destination position.

Example

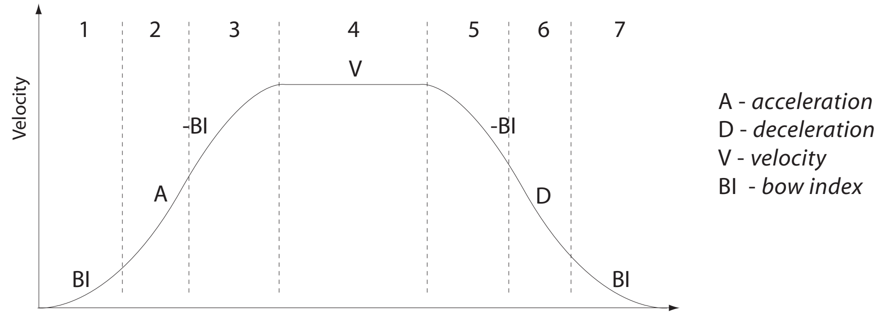


Fig. 6.5 Typical S-Curve Profile

The figure above shows a typical S-curve profile. In segment (1), the S-curve profile drives the axis at the specified Bow Index (BI) until the maximum acceleration (A) is reached. The axis continues to accelerate linearly (Bow Index = 0) through segment (2). The profile then applies the negative value of Bow Index to reduce the acceleration to 0 during segment (3). The axis is now at the maximum velocity (V), at which it continues through segment (4). The profile then decelerates in a similar manner to the acceleration phase, using the Bow Index to reach the maximum deceleration (D) and then bring the axis to a stop at the destination.

Note

The higher the Bow Index, then the shorter the BI phases of the curve, and the steeper the acceleration and deceleration phases. High values of Bow Index may cause a move to overshoot or may result in instability.

6.3.3 Calibration Tab

Note

This section is applicable only to NRT100, NRT150, LTS150, LTS300 and MLJ050 series stages, DRV013 and DRV014 actuators.

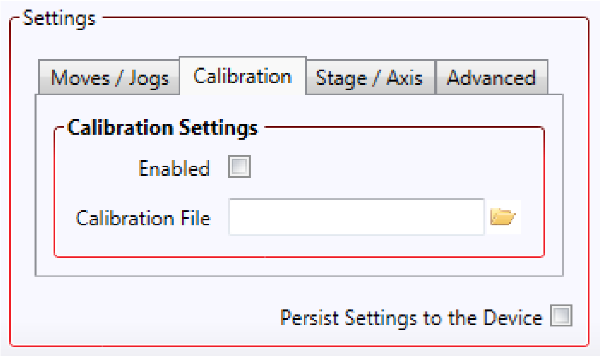


Fig. 6.6 Stepper Driver T-Cube - Calibration Settings

Calibration enables the server to correct for any mechanical errors inherent in the system. Mechanical components, such as the leadscrew and linkages, can be machined only within a certain tolerance, e.g. the leadscrew may be nominally 1mm but actually 1.0005mm, giving a 0.5 micron error. In practice, these errors accumulate from a number of sources, however they are repeatable and therefore, can be compensated.

During calibration, the total positional error is measured at a large number of points and these errors are stored as a look up table (LUT). The LUT is saved as a calibration file, one file for each particular stage. Whenever the stage is moved, the LUT is consulted to ascertain the precise movement required to achieve the demanded position.

A calibration file is shipped with each unit. The use of a calibration file is optional. Without it, the repeatability and resolution of the stage are unaffected, but no compensations are made to enhance the accuracy.

To assign a calibration file:

1) Click the 'Enabled' Checkbox.
2) Click the folder icon and navigate to the location of the required calibration file.
3) Select the file so that the file name is displayed in the 'Calibration File' field.
4) Click OK.

6.3.4 Stage/Axis Tab

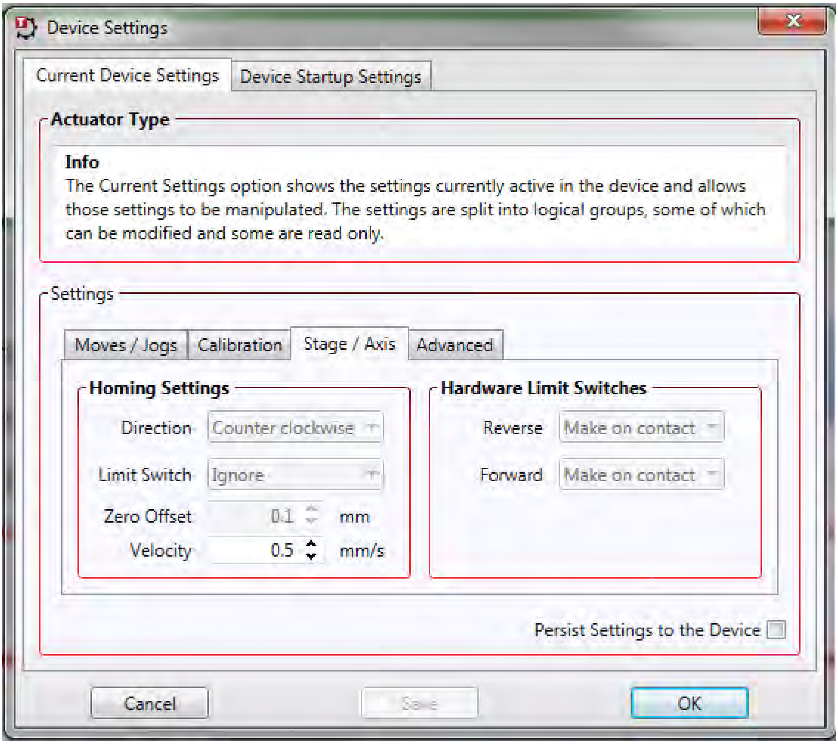


Fig. 6.7 Stepper Driver T-Cube - Stage/Axis Settings

Note

This tab contains a number of parameters which are related to the physical characteristics of the particular stage being driven. They need to be set accordingly such that a particular stage is driven properly by the system.

For Thorlabs stages, the Kinesis software can be used to associate a specific stage and axis type with the motor channel (see Section 3.5. for further details on how to associate a stage and axis). Once this association has been made, the Kinesis server will automatically apply suitable defaults for the parameters on this tab during boot up of the software and these parameters cannot be altered subsequently as it may adversely affect the performance of the stage. Descriptions are provided for information only.

For custom stage types not available using the Kinesis software, the stage details must be entered manually - see the software overview for more details.

Homing Settings

When homing, a stage typically moves in the reverse direction, (i.e. towards the reverse limit switch). The following settings allow support for stages with both Forward and Reverse limits.

Note

Typically, the following two parameters are set the same, i.e. both Forward or both Reverse.

Direction - the direction sense that the motor moves when homing, either *Clockwise* or *Counter Clockwise*.

Limit Switch - The hardware limit switch associated with the home position, either Ignore, *Clockwise or Counter Clockwise*.

Zero Offset - the distance offset (in mm or degrees) from the limit switch to the Home position.

Velocity - the maximum velocity at which the motors move when Homing.

For further information on the home position, see Section D.2.2.

Hardware Limit Switches

Note

The minimum velocity and acceleration/deceleration parameters for a home move are taken from the existing move velocity profile parameters.

The operation of the limit switches is inherent in the design of the associated stage or actuator. The following parameters notify the system to the action of the switches when contact is made. Select Reverse or Forward as required, then select the relevant operation.

Switch Makes - The switch closes on contact
Switch Breaks - The switch opens on contact
Ignore/Absent - The switch is missing, or should be ignored.

6.3.5 Advanced Tab

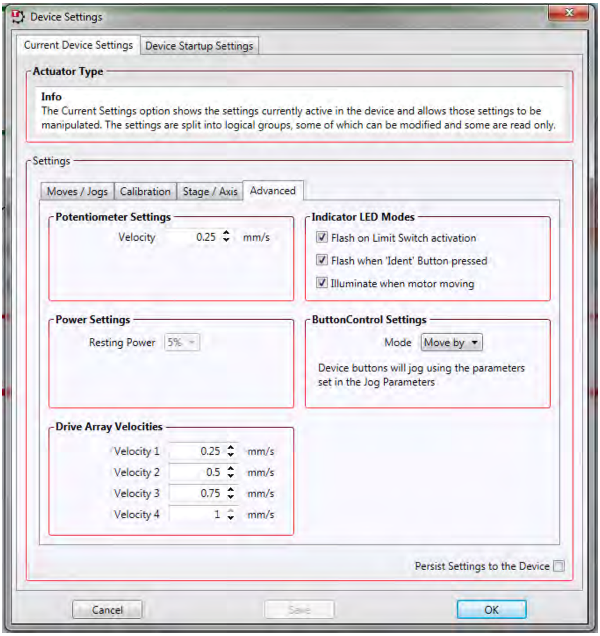


Fig. 6.8 Stepper Driver T-Cube - Advanced Settings

Potentiometer 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 centre, the motor begins to move. Bidirectional control of motor moves is possible by moving the slider in both directions. The speed of the motor increases up to the value set in the *Velocity* parameter.

The velocity profile is derived from the 'Velocity Profile' settings in the 'Move/Jogs' settings tab.

Power Settings

The Stepper Driver T-Cube is designed to vary the phase powers (current) in the motor coils depending on the operating state of the motor - moving or stationary. Typically, when a stepper motor is at rest it is advisable to reduce the phase (holding) currents so that the motor does not overheat. When moving, these phase currents are boosted to provide sufficient motor torque and minimise the possibility of stalling (missed steps) The moving phase powers are set automatically by the unit and cannot be adjusted.

The Resting Power is entered as a percentage of full power.

Note

The default values applied by the software have been selected based on the type of stage or actuator associated with the motor drive. Modify these values with caution (particularly the rest power) as the risk of damage to the motor due to overheating is significant.

Indicator LED Modes

The 'ACTIVE' LED fitted to the front panel of the unit can be configured to indicate certain driver states as follows:

Limit Switch Activation: When this option is selected, the Active LED will flash when the motor reaches a forward or reverse limit switch.

Ident Button Pressed: When this option is selected, the Power LED will flash when the 'Identify' button is clicked on the Software GUI panel.

Motor Moving: When this option is selected, the Active LED is lit when the motor is moving.

It is recognised that, in a light sensitive environment stray light from the LEDs could be undesirable. Therefore it is possible to disable selectively, one or all of the LED indicator modes described above by clearing the associated check boxes in the 'Indicator LED Modes' field.

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.

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

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

Move To: 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 'Move To' is selected in the '*Mode*' field.

Left/Top Button Pos.: The position to which the motor will move when the top button is pressed.

Right/Lower Button Pos.: The position to which the motor will move when the bottom button is pressed.

Note

A 'Home' move can be performed by pressing and holding both buttons for 2 seconds. This function is irrespective of the *'Button Mode'* setting.

Drive Array Velocities

These parameters relate to the velocity for moves initiated by the DRIVE bar graph. Each specifies a velocity to apply when the associated bar is clicked. These settings are applicable in either direction of pot deflection, i.e. 4 possible velocity settings in the forward or reverse motion directions.

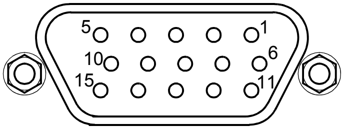
Note

It is acceptable to set velocities equal to each other to reduce the number of speeds.

Appendix A Rear Panel Connector Pinout Details

A.1 Rear Panel Motor Control Connector

The 'Motor' connector provides connection to the stepper motor actuator. The pin functions are detailed in Fig. A.1.



Pin	Description	Pin	Description
1	Ground	9	
2	CCW Limit Switch	10	+5V
3	CW Limit Switch	11	Enc A +ve
4	Phase B -ve	12	Enc A -ve
5	Phase B +ve	13	Enc B +ve
6	Phase A -ve	14	Enc B -ve
7	Phase A +ve	15	For Future Use
8	For Future Use		

Notes.

* Pull low to enable.

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

Appendix B Preventive Maintenance

Note

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

B.1 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

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.

Appendix C Specifications

C.1 Specifications

Parameter	Value
Motor Output	
Motor Drive Voltage	12-15 V (Depending on Supply)
Motor Drive Current	750 m A (peak)
Motor Drive Type	12-bit PWM Control
Control Algorithm	Open Loop Microstepping
High ResolutionStepping	2048 Microsteps per Full Step 49,152 Microsteps per Revolution (24 Step Motor)(409600 Microsteps per Revolution (200 Step Motor)
Position Feedback	Quadrature Encoder (QEP) Input, 5 V Differential
Encoder Feedback Bandwidth	500 kHz
Position Counter	32-bit
Operating Modes	Position, Velocity
Velocity Profile	Trapezoidal or ‘S’ Profile
Motor Drive Connector (15 Way D-Type)	
Motor Drive Outputs	Phase A & B
Quadrature Encoder (QEP) Input	Differential
Limit Switch Inputs	Forward, Reverse (+ Common Return)
Encoder Supply	5 V
Front Panel Controls	
Sprung Potentiometer Slider	Variable Speed Bidirectional Velocity Control
Dual Buttons	Forward/Reverse Jogging or Position Presets
Input Power Requirements	
Voltage	12 - 15V Regulated DC (15V recommended)
Current	1 A (peak)
General	
Housing Dimensions (W x D x H)	60 x 60 x 47 mm (2.4" x 2.4" x 1.8")
Instrument Weight	220 g (7.74 oz)

Recommended Motor Requirements	
Peak Powers	15 W
Step Angle Range	20° to 1.8°
Rated Phase Current	up to 1 A Peak
Motor Mode	Current
Coil Resistance (nominal)	5 to 20 Ω
Coil Inductance (nominal)	2 to 5.5 mH
Phases	2
Position Control	Open Loop

Appendix D Stepper Motor Operation - Background

D.1 How A Stepper Motor Works

D.1.1 General Principle

Thorlabs' actuators use a stepper motor to drive a precision lead screw.

Stepper motors operate using the principle of magnetic attraction and repulsion to convert digital pulses into mechanical shaft rotation. The amount of rotation achieved is directly proportional to the number of input pulses generated and the speed is proportional to the frequency of these pulses. A basic stepper motor has a permanent magnet and/or an iron rotor, together with a stator. The torque required to rotate the stepper motor is generated by switching (commutating) the current in the stator coils as illustrated in Fig. D.1.

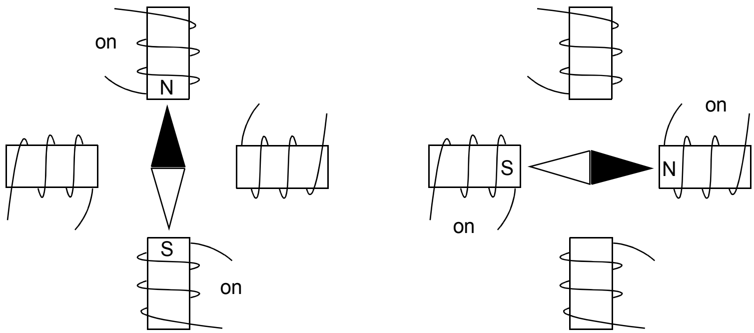


Fig. D.1 Simplified concept of stepper motor operation

Although only 4 stator poles are shown above, in reality there are numerous tooth-like poles on both the rotor and stator. For example, with a 24 step motor such as that used in the ZST actuators positional increments (steps) of 15 degrees can be achieved by switching the coils. If the current through one coil is increased as it is decreased in another, the new rotor position is somewhere between the two coils and the step size is a defined fraction of a full step (microstep).

The size of the microstep depends on the resolution of the driver electronics. When used with the Thorlabs Stepper Driver T-Cube,128 microsteps per full step can be achieved, giving a total resolution of 3072 microsteps per revolution for a 24 full step motor. In the case of the ZST actuators, further mechanical gearing provides a higher effective angular resolution.

In practise, the mechanical resolution achieved by the system may be coarser than a single microstep, primarily because there may be a small difference between the orientation of the magnetic field generated by the stator and the orientation in which the rotor shaft comes to rest.

D.1.2 Positive and Negative Moves

Positive and *negative* are used to describe the direction of a move. A positive move means a move from a smaller absolute position to a larger one, a negative move means the opposite.

In the case of a linear actuator, a positive move takes the platform of the stage further away from the motor.

In a rotational stage, a positive move turns the platform clockwise when viewed from above.

D.1.3 Velocity Profiles

To prevent the motor from stalling, it must be ramped up gradually to its maximum velocity. Certain limits to velocity and acceleration result from the torque and speed limits of the motor, and the inertia and friction of the parts it drives.

The system incorporates a trajectory generator, which performs calculations to determine the instantaneous position, velocity and acceleration of each axis at any given moment. During a motion profile, these values will change continuously. Once the move is complete, these parameters will then remain unchanged until the next move begins.

The specific move profile created by the system depends on several factors, such as the profile mode and profile parameters presently selected, and other conditions such as whether a motion stop has been requested. The profile mode can be set to 'Trapezoidal' or 'Bow Index' as described in Section 6.3.2.

The *Trapezoidal* profile is a standard, symmetrical acceleration/deceleration motion curve, in which the start velocity is always zero. This profile is selected when the *Bow Index* field is set to '0'.

In a typical trapezoidal velocity profile, (see Fig. D.2.), the stage is ramped at acceleration '*a*' to a maximum velocity '*v*'. As the destination is approached, the stage is decelerated at '*a*' so that the final position is approached slowly in a controlled manner.

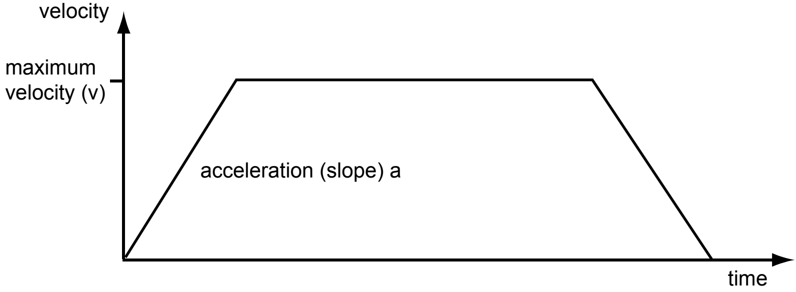


Fig. D.2 Graph of a trapezoidal velocity profile

The *S-curve* profile is a trapezoidal curve with an additional '*Bow Value*' parameter, which limits the rate of change of acceleration and smooths out the contours of the motion profile. The *Bow Value* is specified in mm/s^3 and is derived from the Bow Index field as follows:

The *Bow Value* is applied in mm/s^3 and is derived from the Bow Index field as follows:

Bow Value = 2 $^{(\text{Bow Index} - 1)}$ within the range 1 to 262144 (Bow Index 1 to 18).

In this profile mode, the acceleration increases gradually from 0 to the specified acceleration value, then decreases at the same rate until it reaches 0 again at the specified velocity. The same sequence in reverse brings the axis to a stop at the programmed destination position.

Example

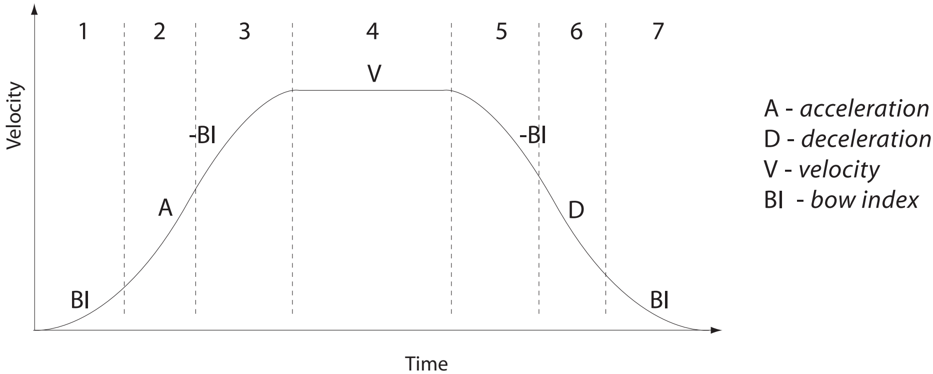


Fig. D.3 Typical S-Curve Profile

The figure above shows a typical S-curve profile. In segment (1), the S-curve profile drives the axis at the specified Bow Index (BI) until the maximum acceleration (A) is reached. The axis continues to accelerate linearly (Bow Index = 0) through segment (2). The profile then applies the negative value of Bow Index to reduce the acceleration to 0 during segment (3). The axis is now at the maximum velocity (V), at which it continues through segment (4). The profile then decelerates in a similar manner to the acceleration phase, using the Bow Index to reach the maximum deceleration (D) and then bring the axis to a stop at the destination.

Note

The higher the Bow Index, then the shorter the BI phases of the curve, and the steeper the acceleration and deceleration phases. High values of Bow Index may cause a move to overshoot.

D.2 Positioning a Stage

D.2.1 General

Whenever a command is received to move a stage, the movement is specified in motion units, (e.g. millimetres). This motion unit value is converted to microsteps before it is sent to the stage by the Kinesis software.

Each motor in the system has an associated electronic counter in the controller, which keeps a record of the net number of microsteps moved. If a request is received to report the position, the value of this counter is converted back into motion units.

D.2.2 Home position

When the system is powered up, the position counters in the controller are all set to zero and consequently, the system has no way of knowing the position of the stage in relation to any physical datum.

A datum can be established by sending all the motors to their ‘Home’ positions. The ‘Home’ position is set during manufacture and is determined by driving the motor until the negative limit switch is reached and then driving positively a fixed distance (zero offset). When at the Home position, the counters are reset to zero thereby establishing a fixed datum that can be found even after the system has been switched off.

See Section 5.3. for details on performing a Home move.

D.2.3 Limit Switches

A linear stage moves between two stops, and movement outside these limits is physically impossible. Linear stages can include stages that control the angle of a platform within a certain range, although the movement of the platform is not really linear but angular. Rotary stages can rotate indefinitely, like a wheel.

Linear and rotary stages can contain microswitches that detect certain positions of the stage, but they differ in the way these switches are used.

All linear stages have a –ve limit switch, to prevent the stage from accidentally being moved too far in the –ve direction. Once this switch is activated, movement stops. The switch also provides a physical datum used to find the Home position. Some linear stages and actuators also have a +ve limit switch (such as the ZST range of actuators), whereas others rely on a physical stop to halt the motion in the positive direction. A rotary stage has only one switch, used to provide a datum so that the

Home position can be found. Movement is allowed right through the switch position in either direction.

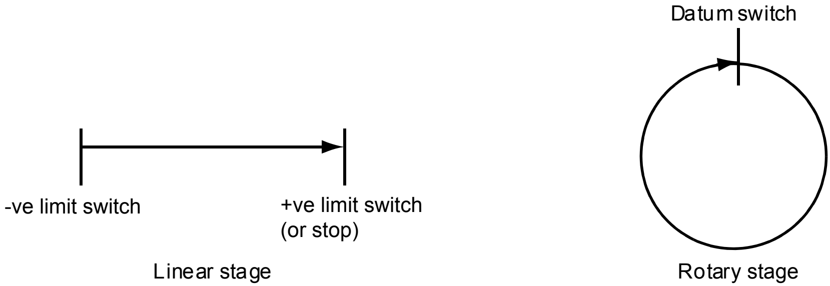


Fig. D.4 Stage limit switches

D.2.4 Minimum and Maximum Positions

These positions are dependent upon the stage or actuator to which the motors are fitted, and are defined as the minimum and maximum useful positions of the stage relative to the 'Home' position - see Fig. D.5.

The distance from the Minimum position to the Maximum position is the 'useful travel' of the stage. It is often the case that the Minimum position is zero. The Home and Minimum positions then coincide, with movement always occurring on the positive side of the Home position.

Rotary stages have effectively no limits of travel. The Minimum and Maximum positions are conventionally set to 0 and 360 degrees respectively. When the position of a rotary stage is requested, the answer will be reported as a number between 0 and 360 degrees, measured in the positive direction from the Home position.

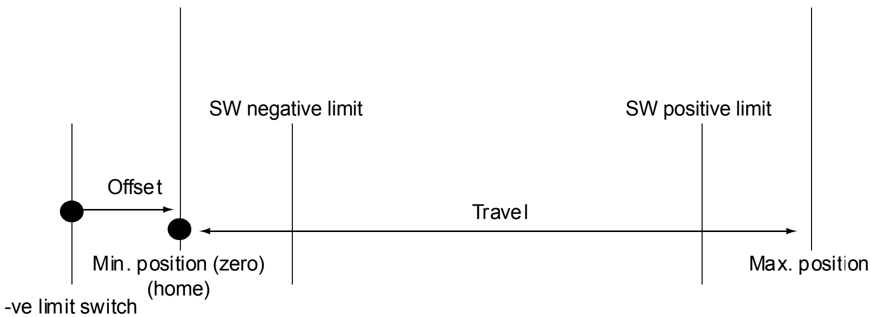


Fig. D.5 Minimum and Maximum Positions

D.2.5 Power Saving

The current needed to hold a motor in a fixed position is much smaller than the current needed to move it. When a stepper motor is at rest it is advisable to reduce the phase (holding) currents so that the motor does not overheat. Furthermore, this heating can cause thermal movements through expansion of the metal of the stage.

For this reason, power saving is implemented by default from the software drivers.

When a motor is moving, the 'Move Power' is applied. When a motor is stationary, the 'Rest Power' is applied. See 'Phase Powers' in Section 6.3.5. *Stage/Axis Tab* for more details on these power settings.

D.3 Error Correction

D.3.1 Backlash correction

The term *backlash* refers to the tendency of the stage to reach a different position depending on the direction of approach.

Backlash can be overcome by always making the last portion of a move in the same direction, conventionally the positive direction. Consider the situation in Fig. D.6, a *positive* move, from 10 to 20 mm, is carried out as one simple move, whereas a *negative* move, from 20 to 10 mm, first causes the stage to overshoot the target position and then move positively through a small amount.

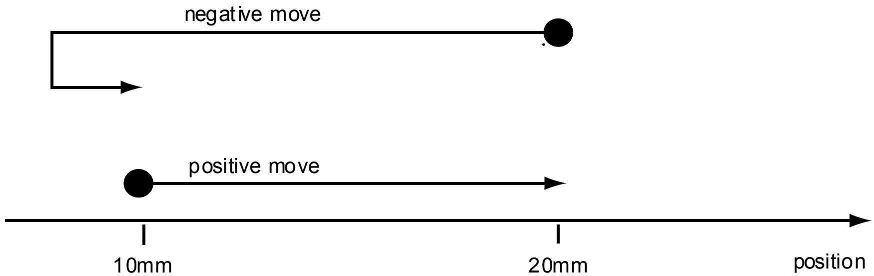


Fig. D.6 Backlash correction

The particular stage selection will usually have this type of 'backlash correction' enabled as its default mode of operation, but it can be overridden if the overshoot part of the move is unacceptable for a particular application.

See Chapter 6 Software Reference, Move/Jogs Tab for details on setting the backlash correction.

Appendix E Regulatory

E.1 Declarations Of Conformity

E.1.1 For Customers in Europe

See Section E.3.

E.1.2 For Customers In The USA

This equipment has been tested and found to comply with the limits for a Class A digital device, 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.

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

E.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. E.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.

E.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.

E.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.

E.3 CE Certificate

THORLABS
www.thorlabs.com

EU Declaration of Conformity

in accordance with EN ISO 17050-1:2010

We Thorlabs Ltd.
Of 1 Saint Thomas Place, Ely, Cambridgeshire, CB7 4EX

in accordance with the following Directive(s):

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

hereby declare that:

Model: ***TST101***

Equipment: ***T-Cube Stepper Motor Controller***

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

EN61326-1	Electrical Equipment for Measurement, Control and Laboratory Use - EMC Requirements	2013

and which 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:

A 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: Keith Dhese *On:* 25 June 2014

Name: Keith Dhese
Position: General Manager

EDC - TST101 -2014-06-25

CE

Appendix F Thorlabs Worldwide Contacts

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

USA, Canada, and South America
Thorlabs, Inc.
sales@thorlabs.com
techsupport@thorlabs.com

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

Europe
Thorlabs GmbH
europe@thorlabs.com

Scandinavia
Thorlabs Sweden AB
scandinavia@thorlabs.com

France
Thorlabs SAS
sales.fr@thorlabs.com

Brazil
Thorlabs Vendas de Fotônicos Ltda.
brasil@thorlabs.com

Japan
Thorlabs Japan, Inc.
sales@thorlabs.jp

China
Thorlabs China
chinasales@thorlabs.com

THORLABS

www.thorlabs.com