KST101

K-Cube Stepper Motor Controller

APT User Guide

Original Instructions

Contents

Continued...

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 symbo ls may be u sed throughout the h andbook 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 K-Cube Stepper Motor Controller (KST101) 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 KST101 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 (2.36" x 2.36" x 1.85") 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 K-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 K-Cube Controller Hub (see over) for multi-axis motion control applications. Coupling this with the very 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 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.

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 K-Cube Controller Hub

For power, a single way wall plug supply (KPS101) is available for powering a single K-Cube Driver.

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

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

Internally the Controller Hub contains a fully compliant USB 2.0 hub circuit to provide communications for all K-Cubes – a single USB connection to the Controller Hub is all that is required for PC control. The Controller Hub also provides power distribution for the K-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 Stepper Driver K-Cube shares many of the associated software benefits. This includes USB connectivity (allowing multiple units to be used together on a single PC), fully featured Graphical User Interface (GUI) panels, and extensive software function libraries for custom application development.

The APT software suite supplied with all APT controllers, including the Stepper Driver K-Cube, 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 ho st PC. This program displays multiple graphical instrument panels to allow multiple APT units to be controlled simultaneously.

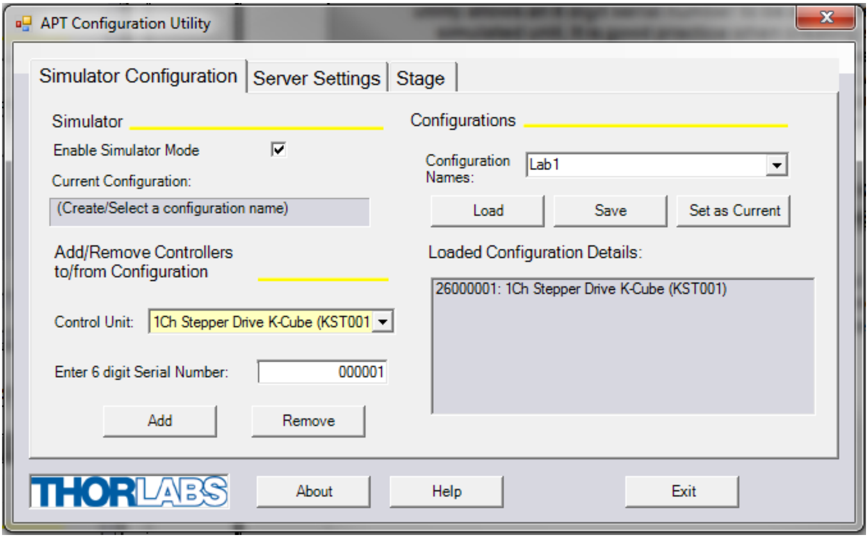
All basic operating parameters can be altered and, similarly, all operations (such as motor moves) can be initiated. Settings and parameter changes can be saved and loaded to allow multiple operating configurations to be created and easily applied.

For many users, the APTUser application provides all of the functionality necessary to operate the APT hardware without the need to deve lop any further custom software. For those wh o do need to further customise and automate u sage of the Stepper Driver K-Cube (e.g. to implement a positioning algorithm), this a pplication illustrates how the rich function ality provided by the APT Acti veX 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 Stepper Driver K-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 KST101 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 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).

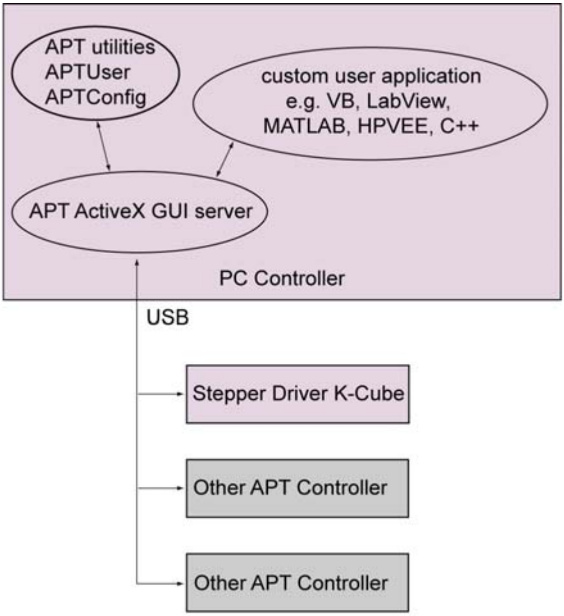


Fig. 2.2 System Architecture Diagram

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.

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 K-Cube Stepper Driver is shipped with a baseplate, for use when fitting the unit to a breadboard, optical table or similar surface - see Section 3.2.3.

For multiple cube systems, a 3-channel and 6-channel K-Cube Controller Hub (KCH301 and KCH601).) are also available - see Section 2.2. for further details. Full instructions on the fitting and use of the controller hub are contained in the handbook available at www.thorlabs.com.

Caution

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

3.2.3 Using the Baseplate

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

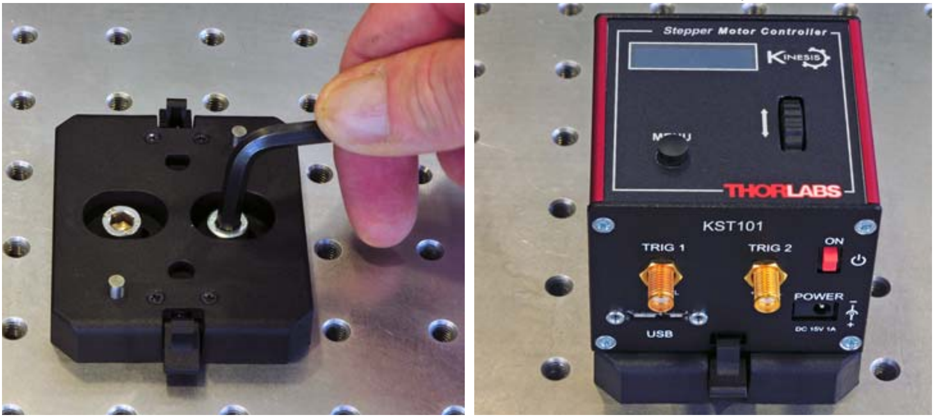


Fig. 3.1 Using The Baseplate

3.3 Electrical Installation

3.3.1 Rear Panel

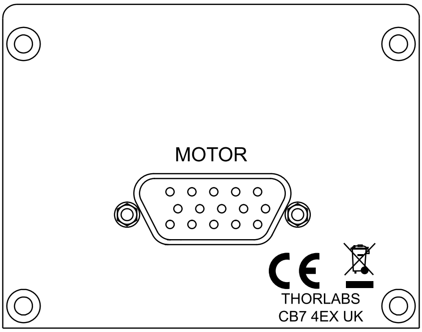


Fig. 3.2 Rear Panel Connections

The rear panel of the unit is fitted with a 15 pin D-type connector as shown above, which is compatible with all new Thorlabs DC servo motor a ctuators (refer to Appendix A for details of pin outs).

Caution

DO NOT connect a motor actuator while the K-Cube is powered up.

Only use motor drive cables supplied by Thorlabs, other cables may have incompatible wiring.

3.3.2 Front Panel

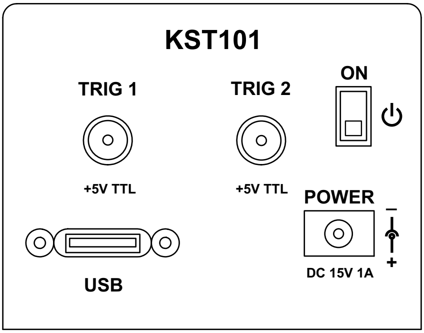


Fig. 3.3 Front Panel Power Supply Connections

Shock 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.

POWER - A Standard 3.5 mm front panel jack connector for connecting 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 K-Cubes to be powered from a single mains outlet. A single way wall plug supply (KPS101) for powering a single Driver K-Cube is also available.

USB - USB port for system communications.

Note

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

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

TRIG 1 and TRIG 2 - SMA connectors for use with external trigger input and output signals (5V TTL levels). The function is set to trigger IN or OUT via the settings panel - see Section 6.3.3.

3.4 Connect The Hardware

1) Perform the mechanical installation as detailed in Section 3.2.
2) Install the APT Software.

Caution

During items (3) to (6) the instructions should be followed in the order stated. Problems may occur if the process is not performed in the correct sequence.

3) 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)
4) Connect the stepper motor actuator to the Controller unit - see Section 3.3.1..

Caution

During item (5) ensure the power switch on the front panel of the unit is switched off before connecting power to the K-Cube. Always power up the K-Cube unit by its ON switch. DO NOT connect the K-Cube unit to a 'live' external power supply. Doing so (i.e. "hot plugging") carries the risk of PERMANENT damage to the unit. Similarly, to power down the unit, turn the power switch off before disconnecting the power supply.

5) Connect the Controller unit to the power supply - see Section 3.3.
6) Connect the PSU to the main supply.
7) Switch 'ON' the unit using the switch on the front panel.

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

```
Thorlabs KST101
SwRev 10001
```

```
Stage Connected:
ZFS25
```

```
At +0.0000 mm
Stopped       V
```

Fig. 3.4 KST101 start up screens

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

Note

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

3.5 Use with Legacy Actuators and Stages

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.).

Later version actuators and stages have an identification eprom fitted such that the system will recognise the actuator type and install suitable defaults. Older version devices must be associated manually using the top panel menu - see Section 4.4.11. Once this association has been made, the APT server applies automatically, suitable default parameter values on boot up of the software.

Note

If the actuator/stage has been recognised automatically via the eprom, the start up screens will display 'Stage connected xxxx' as shown in Fig. 3.4. If the stage is not fitted with an eprom, the display will show the last stage type persisted, e.g. Stage persisted: ZST13B

3.6 Verifying Software Operation

3.6.1 Initial Setup

The APT Software should be installed (Section 3.1.) and the stage association performed (Section 3.5.) before software operation can be verified.

1) Ensure power is applied to the unit, then switch the unit ON using the switch on the front panel.
2) If required, make the stage/actuator association as detailed in Section 4.4.11.
3) Run the APTUser utility and check that the Graphical User Interface (GUI) panel appears and is active.

Fig. 3.5 Gui panel showing jog and ident buttons

4) Check that the actuator type associated is displayed in the GUI panel.
5) Click the ‘Ident’ button. The top panel display of the Stepper Driver K-C ube flashes. This is useful in multi-channel systems for identifying which driver unit is associated with which GUI.
6) Click the jog buttons on the GUI panel and check that the motor or axis connected to the Stepper Driver K-Cube moves. The position display for the associated GUI should increment and decrement accordingly.

Follow the tutorial steps described in Chapter 4 for further verification of 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 5.8. or the *APTConfig* helpfile for detailed instructions.

Chapter 4 Standalone Operation

4.1 Introduction

The Stepper Driver K-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 APT 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 E .

4.2 Control Panel

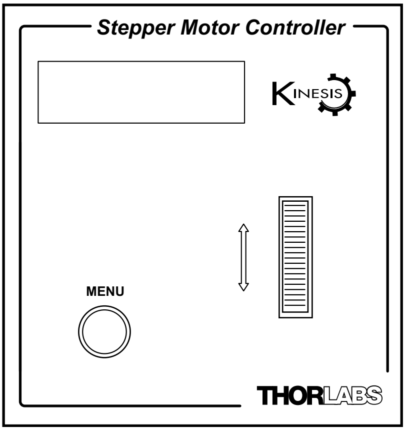


Fig. 4.1 Front Panel Controls and Indicators

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

Velocity Wheel - 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.

Digital Display - The display shows the menu options and settings, accessed via the menu button - see Section 4.4. When the Ident button on the associated GUI panel is clicked, the display will flash for a short period.

MENU - used to access the settings menu - see Section 4.4. Also used to stop a move when the stage is in motion.

4.2.1 Digital Display - Operating Mode

During normal operation, the digital display shows the current position (in millimeters or degrees) and the current state of the motor (Stopped or Moving). If the stage being driven has been homed, the display will also show ‘Homed’.

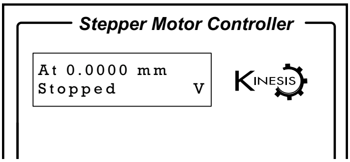


Fig. 4.2 Digital Display - Normal Operation

For rotation stages, the position display will be restricted to the "Equivalent Angle" display mode (see Section 6.3.4. for more details), so the position displayed will always be a positive number between 0 and 360 degrees. If set to Total Angle in the settings panel, the LED display will still show the equivalent 0 to 360° value but the GUI screen will show the total rotation.

4.3 Velocity Wheel Operation

The velocity wheel is a sprung potentiometer, such that when released it returns to it’s central position. In this central position the motor is stationary. Different types of move can be initiated by the wheel, depending on its mode setting. The mode can be set either via the GUI Settings panel, see Section 6.3.3. or via the top panel display menu, see Section 4.4. The various operating modes are described in Section 4.3.1. to Section 4.3.3.

4.3.1 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 E.2.2. for further information on the home position).

To initiate a ‘Home’ see Section 4.4.3.

4.3.2 Go to Position

In ‘Go To Position’ mode, two preset position values can be specified, such that the motor moves to position 1 when the wheel is moved down, and to position 2 when it is moved up. These 'taught' positions can be set through the software GUI - see Section 6.3.3. or via the display menu, see Section 4.4.7.

This mode of operation is enabled by setting the ' Wheel Mode' to 'Go To Position' through the software GUI - see Section 6.3.3. or via the display menu, see Section 4.4.5.

Note for Rotation Stage Users

If the current absolute position is outside the 0 to 360 degree range, then "go to position" will result in a move to the correct angular position within the same 0..360 degree full turn "segment". This means that the move will always stay in the current full turn segment, and from this point of view it is not always the quickest position move. For example, if you are at 350 degrees and you enter a "go to" position of 10 degrees, the stage will rotate anticlockwise 340 degrees and not clockwise 20 degrees.

4.3.3 Jogging

The top panel wheel can also be configured to 'jog' the motor. This mode of operation is enabled by setting the 'Wheel Mode' parameter to 'Jogging' through the software GUI - see Section 6.3.3. or via the display menu, see Section 4.4.5.

Once set to this mode, the jogging parameters for the wheels are taken from the 'Jog' parameters on the 'Move/Jogs' settings tab - see Section 6.3.1. or via the display menu, see Section 4.4.6.

4.3.4 Velocity Moves

Lastly, the wheel can be used to initiate a move at a specified velocity. As the wheel is moved away from the centre, the motor begins to move. Bidirectional control of the motor is possible by moving the wheel in both directions. The speed of the motor increases by discrete amounts as a function of wheel deflection, up to a maximum as set in through the soft ware GUI - see Section 6.3.3. or via the display menu, see Section 4.4.4. The move stops when the wheel is returned to its centre position.

4.4 Settings Menu

4.4.1 Overview

Press the MENU button

```
At 0.0000 mm
Stopped        V
```

MENU

Use the wheel to scroll through the menu options

Press the MENU button to enter a particular option

```
Menu options
Use wheel
```

Move the stage to an absolute position - see Section 4.4.2.

```
Menu options
1 Go to position
```

Move the stage to the Home position - see Section 4.4.3.

```
Menu options
2 Start homing
```

Set the Max Velocity - see Section 4.4.4.

```
Menu options
3 Velocity
```

Set the joystick wheel mode - see Section 4.4.5.

```
Menu options
4 Joystick mode
```

Set the Jog Step Size - see Section 4.4.6.

```
Menu options
5 Jog step size
```

Set the teach positions - see Section 4.4.7.

```
Menu options
6 Teach position
```

Set the display brightness - see Section 4.4.8.

```
Menu options
7 Brightness
```

Set the display time out period - see Section 4.4.9.

```
Menu options
8 Disp.Timeout
```

Disable the wheel - see Section 4.4.10.

```
Menu options
9 Disable
```

Set the stage being driven - see Section 4.4.11.

```
Menu options
10 Select Stage
```

4.4.2 Menu Option - Go to position

```
At 0.0000 mm
Stopped     V
```

This mode is used to move to an absolute position.

MENU

```
Menu options
Use wheel
```

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

```
Menu options
1 Go to position
```

Press the MENU button to enter the Go to positions option.

```
P = 0.00 mm
⇕ adjust Pos
```

Use the wheel to adjust the position value, (within the travel range for linear stages, or 0 to 360 ° for rotation stages) then press the MENU button to store the selection.

Note for rotation stages. If the current absolute position is outside the 0 to 360 degree range, then "go to position" will result in a move to the correct angular position within the same 0..360 degree full turn "segment". This means that the move will always stay in the current full turn segment, and from this point of view it is not always the quickest position move. For example, if you are at 350 degrees and you enter a "go to" position of 10 degrees, the stage will rotate anticlockwise 340 degrees and not clockwise 20 degrees.

```
At 2.0000 mm
Stopped     V
```

The stage moves to the position entered, and the display shows the change in position.

To stop the move, press the MENU button.

4.4.3 Menu Option - Start homing

This mode is used to home the stage.

```
At 2.0000 mm
Stopped     V
```

MENU

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

```
Menu options
Use wheel
```

Press the MENU button to enter the Start Homing option.

```
Menu options
2 Start homing
```

The display shows a decreasing position count while the stage is homing.

```
At 2.0000 mm
Homing      V
```

Once homing is complete, the display shows the position at 0.0000 mm and ‘Homed’ is displayed.

```
At 0.0000 mm
Homed Stopped V
```

To stop the move, press the MENU button.

4.4.4 Menu Option - Velocity

This mode is used to move to set the max velocity.

```
At 0.0000 mm
Homed Stopped V
```

MENU

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

```
Menu options
Use wheel
```

Press the MENU button to enter the Velocity option.

```
Menu options
3 Velocity
```

Use the wheel to adjust the max velocity, e.g. 0.168 mm/s, then press the MENU button to store the setting.

```
1.680 mm/s
↕ adjust MaxVel
```

Subsequent moves will be performed at the velocity entered.

```
At 0.0000 mm
Homed Stopped V
```

4.4.5 Menu Option - Joystick Mode

```
At 0.0000 mm
Homed Stopped V
```

This mode is used to set the operating mode of the joystick wheel.

MENU

```
Menu options
Use wheel
```

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

```
Menu options
4 Joystick Mode
```

Press the MENU button to enter the Joystick mode option. Use the wheel to scroll through the options, then press MENU when the required option is displayed.

```
Velocity control
⇕ to select
```

In *Velocity control mode*, deflecting the wheel starts a move with the velocity proportional to the deflection. The maximum velocity (i.e. velocity corresponding to the full deflection of the joystick wheel) is set in the preceding *3 Velocity* option. The move will stop when the wheel is released.

```
Jog to positions
⇕ to select
```

In *Jog to positions mode*, deflecting the wheel starts a move from the current position to one of the two predefined "teach" positions. The teach positions are specified in option *6 Teach Position*.

```
Jogging in steps
⇕ to select
```

In *Jog in steps mode*, deflecting the wheel initiates a jog move, using the parameters specified by the *3 Velocity* and *5 Jog step size* options. Keeping the wheel deflected repeats the move automatically after the current move has completed.

MENU

```
At 0.0000 mm
Homed Stopped V
```

Use the wheel to display the required option, then press MENU to store the selection and return to the main display.

The selected mode is indicated at the right hand side of the bottom line:

```
At 0.0000 mm
Homed Stopped V
```

```
Homed Stopped P
```

```
Homed Stopped J
```

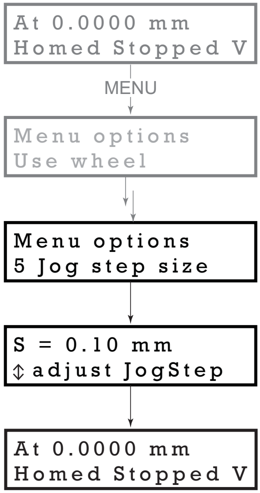
V = Velocity mode

P = Jog to position mode

J = Jog in steps mode

4.4.6 Menu Option - Jog Step Size

This mode is used to set the jog step size.



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

Press the MENU button to enter the Jog step size option.

Use the wheel to adjust the step size, e.g. 0.10 mm, then press the MENU button to store the selection.

When *Jog in steps* mode is selected in the *Joystick mode* option (see Section 4.4.5.), subsequent moves will be performed at the step size entered.

4.4.7 Menu Option - Teach Position

This mode is used to set the teach positions, used when the *Joystick mode* option is set to *Jog to positions* mode - see Section 4.4.5.

```
At 10.0000 mm
Homed Stopped V
```

To set Teach Position 1...

Move the stage to the position to use as teach position 1.

MENU

```
Menu options
Use wheel
```

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

```
Menu options
6 Teach position
```

Press the MENU button to enter the Teach position option.

```
P1 = 10.0000 mm
⇕num ⇕store
```

Use the wheel to select P1, then press the MENU button to store the current position as teach position 1 and return to the main display.

```
At 10.0000 mm
Homed Stopped V
```

```
At 5.0000 mm
Homed Stopped V
```

To set Teach Position 2...

Move the stage to the position to use as teach position 2.

MENU

```
Menu options
Use wheel
```

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

```
Menu options
6 Teach position
```

Press the MENU button to enter the Teach position option.

```
P2 = 5.0000 mm
⇕num ⇕store
```

Use the wheel to select P2, then press the MENU button to store the current position as teach position 2 and return to the main display.

```
At 5.0000 mm
Homed Stopped V
```

When *Jog to position* mode is selected in the *Joystick mode* option (see Section 4.4.5.), a downwards deflection of the wheel moves the stage to position 1, and an upwards deflection moves to position 2.

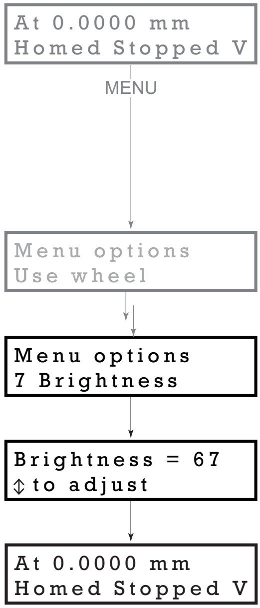
4.4.8 Menu Option - Brightness

In certain applications, it may be necessary to adjust the brightness of the LED display. The brightness is set as a value from 0 (Off) to 100 (brightest). The display can be turned off completely by entering a setting of zero, however, pressing the MENU button on the top panel will temporarily illuminate the display at its lowest brightness setting to allow adjustments. When the display returns to its default position display mode, it will turn off again.

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

Press the MENU button to enter the Brightness option.

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



4.4.9 Menu Option - Disp.Timeout

'Burn In' of the display can occur if it remains static for a long time. To prevent this, the display is automatically dimmed after a specified time interval.

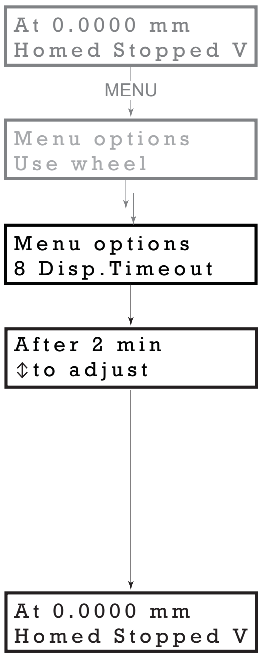
Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the Disp.Timeout option.

The time out interval is specified in minutes in the range 1 to 480. The adjustment is done in steps of 1 minute if the timeout is between 1 to 10 minutes, 10 minute steps between 10 minutes and 1 hour, and 30 minute steps above, up to a maximum of 480 minutes. After 480 minutes there is an option for Never.

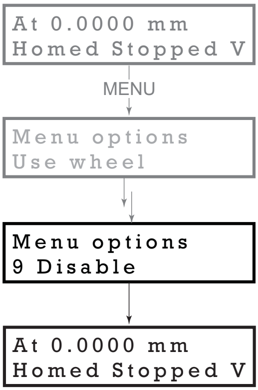
The dim level can only be adjusted via the Settings panel - see Section 6.3.3.

Press the MENU button to store the selection and return to the main display.



4.4.10 Menu Option - Disable

In certain applications, it may be advantageous to disable the wheel to remove the possibility of unwanted motion due to accidental movement of the wheel.



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

Press the MENU button to enter the Disable option.

Press the MENU button to store the selection and return to the main display.

4.4.11 Menu Option - Select stage

Note

Later version actuators and stages have an identification eprom fitted such that the system will recognise automatically the actuator type and install suitable defaults at start up. In this case, the start up screens will show 'Stage connected xxx' as shown in Fig. 3.4 and this menu option is not visible.

If this menu option is visible then the stage/actuator connected is not fitted with an eprom and the stage association must be performed manually as detailed below.

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.).

Older version devices must be associated manually using the top panel menu. Once this association has been made, the APT server applies automatically, suitable default parameter values on boot up of the software.

```
At 0.0000 mm
Homed Stopped V
```

MENU

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

```
Menu options
Use wheel
```

Press the MENU button to enter the Select stage option.

```
Menu options
10 Select stage
```

Use the wheel to scroll through the options to the required stage type. The stage types supported are:

```
Select stage
DRV014
```

NR360S, FW103, DRV013, DRV014, PLS2, PLS3, ZFS25, ZFS13, ZFS06, ZST225, ZST213, ZST206, and legacy designed ZST25, ZST13, ZST6..

Note

The last 3 products can be identified by detachable cables.

Press the MENU button to store the selection and return to the main display

```
At 0.0000 mm
Stopped         V
```

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., and that the APT 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 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) If required, perform the stage association as detailed in Section 4.4.11.
2) Run the APT User program - Start/Programs/Thorlabs/APT/APT User.

3) The actuator type recognised/associated is displayed in the 'Settings' window. See Section 5.11. and Section 6.3. for further details on the parameter values shown in the 'Settings' display.

Fig. 5.2 Stepper Driver K-Cube Software GUI

The APT User utility will be used throughout the rest of this tutorial to interface with the Stepper Driver K-Cube.

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. 5.3 Stepper Driver K-Cube GUI

1) Click the ‘Home’ button. Notice that the led in the button lights to indicate that homing is in progress and the displayed position counts down to 000.000, i.e the home position.

Note

Homing can also be performed 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 E , Section E.2.2. for background information on the home position.

5.4 Moving to an Absolute Position

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

1) Click the position display.

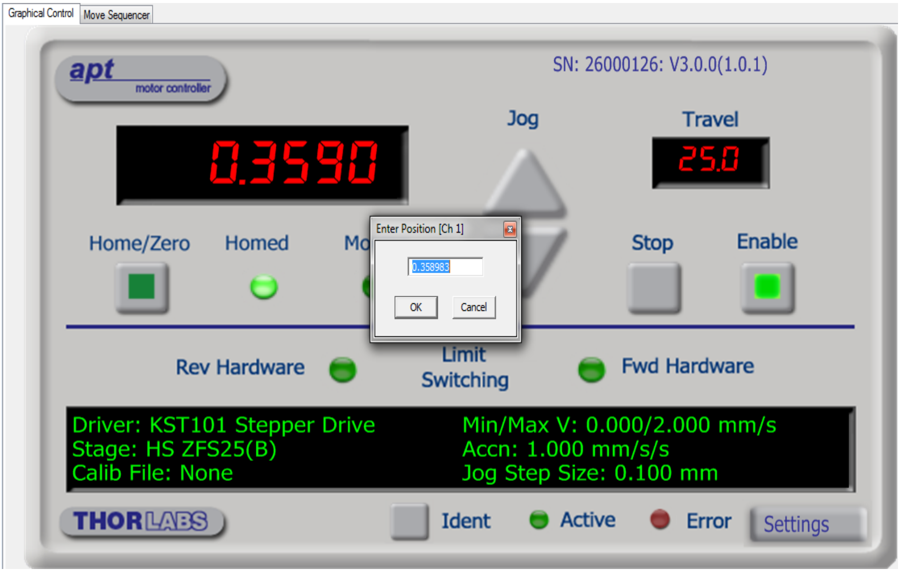


Fig. 5.4 Absolute Position Popup Window

2) Enter 0.3589 into the pop up window

3) Click 'OK'. Notice that the position display counts up to 0.35900 to indicate a move to the absolute position entered.

5.5 Changing Motor Parameters

Moves are performed using a trapezoidal velocity profile (see Appendix E , Section E.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 'Settings' button (bottom right hand corner of the display) to show the Settings panel.

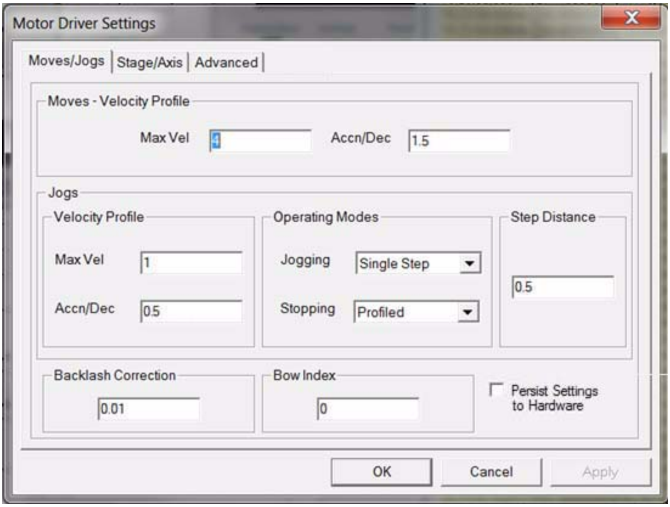


Fig. 5.5 Settings Panel - Move/Jogs Tab

2) Select the Move/Jogs tab as shown in Fig. 5.5.
3) In the 'Moves' field, enter parameter values as follows:
'Max. Vel' - '4'
'Accn/Dec' - '1.5'

Note

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

4) Click 'OK' to save the settings and close the window.
5) Any further moves initiated will now be performed at a maximum velocity of 4.0 mm per second, with an acceleration of 1.5 mm/sec/sec.

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 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 ‘Settings’ button to display the Settings panel.

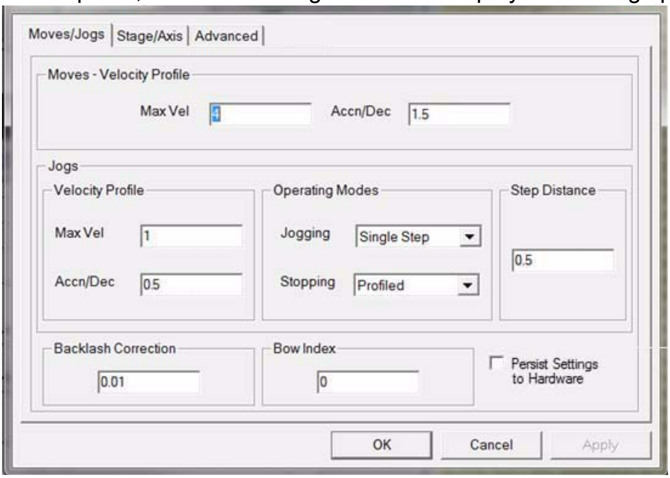


Fig. 5.6 Settings Panel - Move/Jogs Tab

2) Select the Move/Jogs tab as shown in Fig. 5.6.
3) In the ‘Jogs’ field, enter parameter values as follows:
   Velocity Profile
   ‘Max. Vel’ - ‘1’
   ‘Accn/Dec’ - ‘0.5’

Note

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

   Operating Modes
   ‘Jogging’ - ‘Single Step’
   ‘Stopping’ - ‘Profiled’
   ‘Step Distance’ - ‘0.5’
4) Click ‘OK’ to save the settings and close the window.
5) Click the Jog Arrows on the GUI panel to jog the motor. Notice that the position display increments 0.5 every time the button is clicked.

5.7 Stopping the Stage

The drive channel is enabled and disabled by clicking the ‘Enable’ button on the GUI panel. The green indicator in the button center is lit when the drive channel is enabled. Disabling the channel removes the drive power.

During operation, the stage can be stopped at any time by clicking the ‘Stop’ button on the GUI panel. Using this button does not remove power to the drive channel.

.

Fig. 5.7 APT GUI User Screen

5.8 Graphical Control Of Motor Positions (Point and Move)

The GUI panel display can be changed to a graphical display, showing the position of the motor channel(s). Moves to absolute positions can then be initiated by positioning the mouse within the display and clicking.

To change the panel view to graph ical view, right click in the screen and select 'Graphical View'.

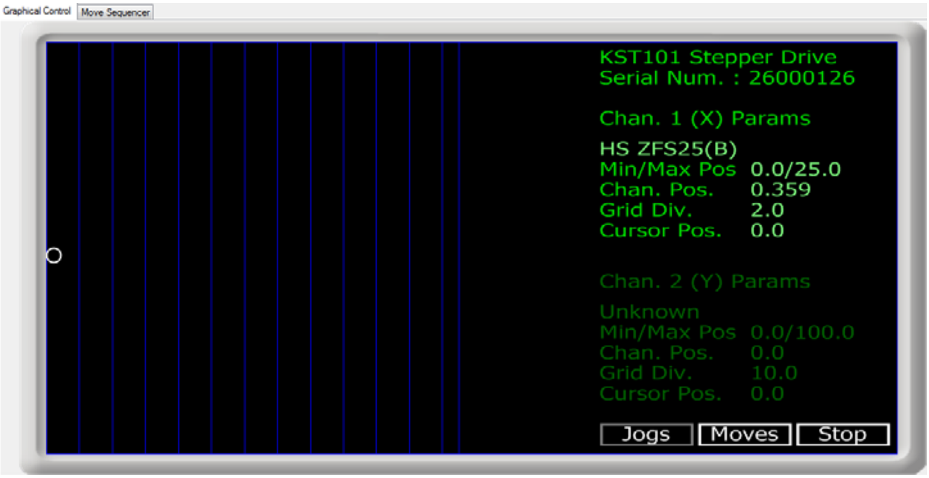


Fig. 5.8 Stepper Driver K-Cube GUI Panel - Graphical View

Consider the display shown above for an Stepper Driver K-Cube .

The right hand display shows the channel and motor unit parameters; i.e. controller unit type and se rial number, associated stage and actuator type, min imum and maximum positions, current position, units per grid division and cursor position. All units are displayed in real world units, either millimetres or degrees.

Note

For single channel units such as the Stepper Driver K-Cube, the Channel 2 parameters are greyed out.

The left h and display shows a circle , which represents the current position of the motor associated with the specified controller (absolute position data is displayed in the 'Chan Pos' field).

The vertical divisions relate to the travel of the stage/actuator associated with the Stepper Driver K-Cube (the stage/actuator is selected in the 'APT Config' utility). For example, the screen shot above shows the parameters for a 25mm travel ZFS25(B) motor actuator. The graph shows 10 divisions in the X axis, which relates to 2.5 mm of travel per division (25mm in total).

The graphical panel has two modes of operation, 'Jog' and 'Move', which are selected by clicking the buttons at the bottom right of the screen.

Move Mode

When 'Move' is selected, the motors move to an absolute position which corresponds to the position of the cursor within the screen.

To specify a move:

1) Position the mouse within the window. For reference, the absolute motor position values associated with the mouse position is displayed in the 'Cursor Position field.
2) Click the left hand mouse button to initiate the move.

Jog Mode

When 'Jogging' mode is selected, the motors are jogged each time the left mouse button is clicked.

The Jog direction corresponds to the position of the cursor relative to the circle (current motor position), e.g. if the cursor is to the left of the circle the motor will jog left. The Jog Step size is that selected in the Settings panel - see Section 6.3.

Stop

To stop the move at any time, click the 'Stop' button.

Returning to Panel View

To return to panel view, right click in the graphical panel and select 'Panel View'.

5.9 Setting Move Sequences

This section explains how to set move sequences, allowing several positions to be visited without user intervention.

For details on moving to absolute positions initiated by a mouse click – see Section 5.8.

1) From the Motor GUI Panel, select 'Move Sequencer' tab to display the Move Sequencer window.

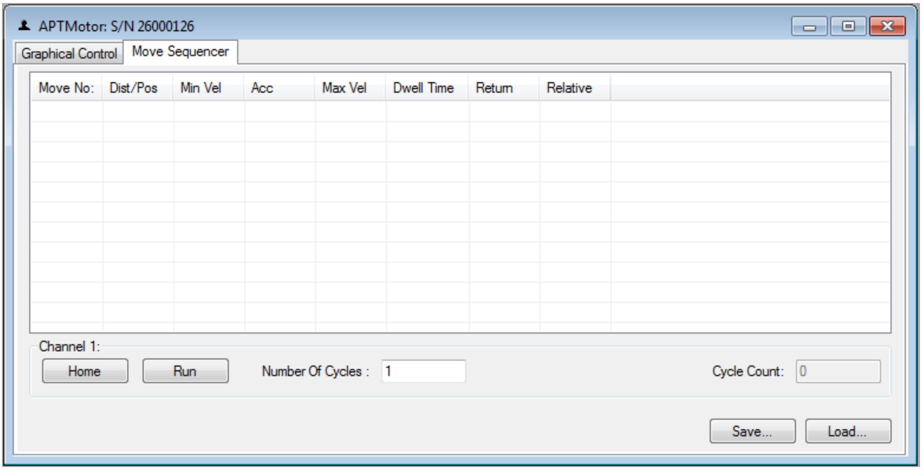


Fig. 5.9 Move Sequencer Window

2) Right click, in the move data field to display the pop up menu.

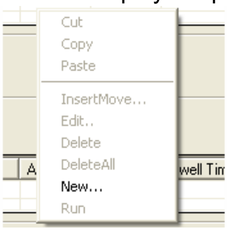


Fig. 5.10 Move Sequencer Pop Up Menu

3) Select 'New' to display the 'Move Editor' panel.

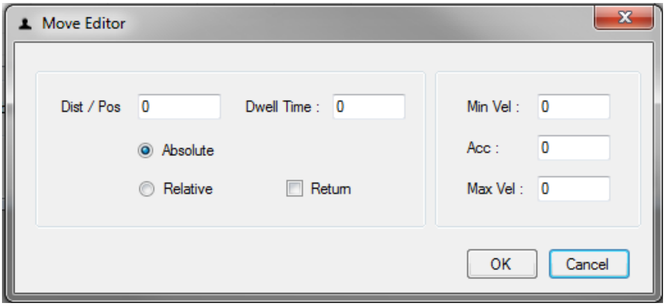


Fig. 5.11 Move Editor Window

Move data is entered/displayed as follows:

Dist/Pos: - the distance to move from the current position (if 'Relative' is selected) or the position to move to (if 'Absolute' is selected).

Dwell Time: - after the move is performed, the system can be set to wait for a specified time before performing the next move in the sequence. The Dwell time is the time to wait (in milliseconds).

Return - if checked, the system will move to the position specified in the Dist/Pos field, wait for the specified Dwell time, and then return to the original position.

4) **Min Vel: Acc: and Max Vel:** - the velocity profile parameters for the move.

Note

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

The motor accelerates at the rate set in the Acc field up to the speed set in the Max Vel field. As the destination approaches, the motor decelerates again to ensure that there is no overshoot of the position.

5) Enter the required move data into the Move Editor and click OK. The move data is displayed in the main window as shown below.

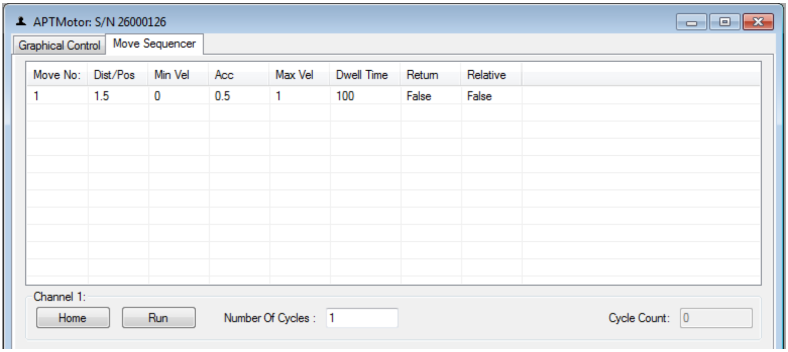


Fig. 5.12 Main Window with Move Data

6) Repeat step 4 as necessary to build a sequence of moves. Move data can be copied, deleted, cut/pasted and edited by right clicking the data line(s) and selecting the appropriate option in the pop up menu (shown below).

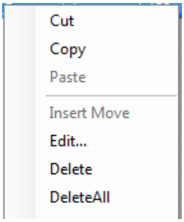


Fig. 5.13 Pop Up Options

7) To run a single line of data, right click the appropriate data and select 'Run' from the pop up menu (shown above).
8) To run the entire sequence, click the 'Run' button (shown below). A Home move can also be performed from this panel by clicking the ‘Home’ button.

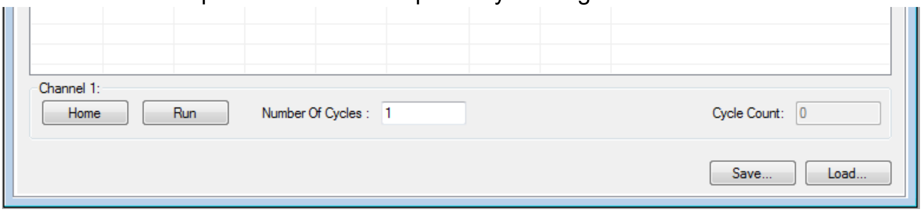


Fig. 5.14 Home and Run Buttons

9) To save data to a file, or load data from a previously saved file, click the ‘Save’ or ‘Load’ button and browse to the required location.

5.10 Creating a Simulated Configuration Using APT Config

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

Any number of 'virtual' control units can be combined to emulate a 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/All Programs/Thorlabs/APT/APT Config.
2) Click the 'Simulator Configuration' tab.

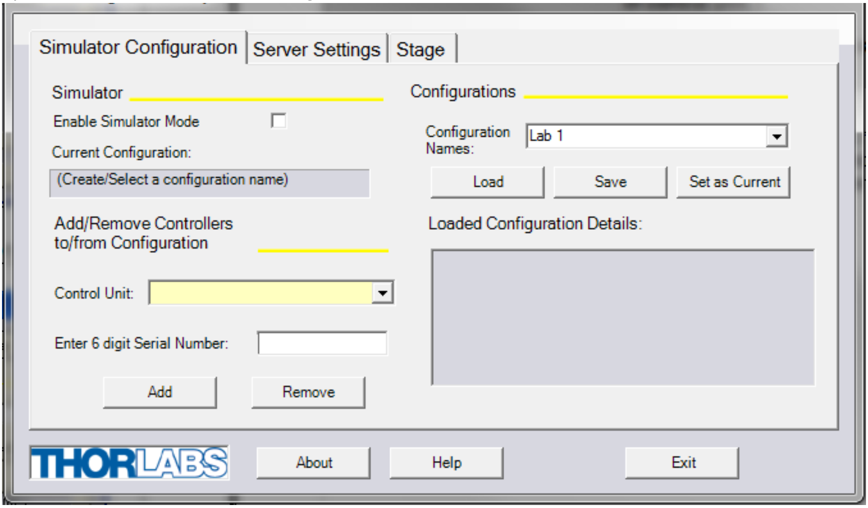
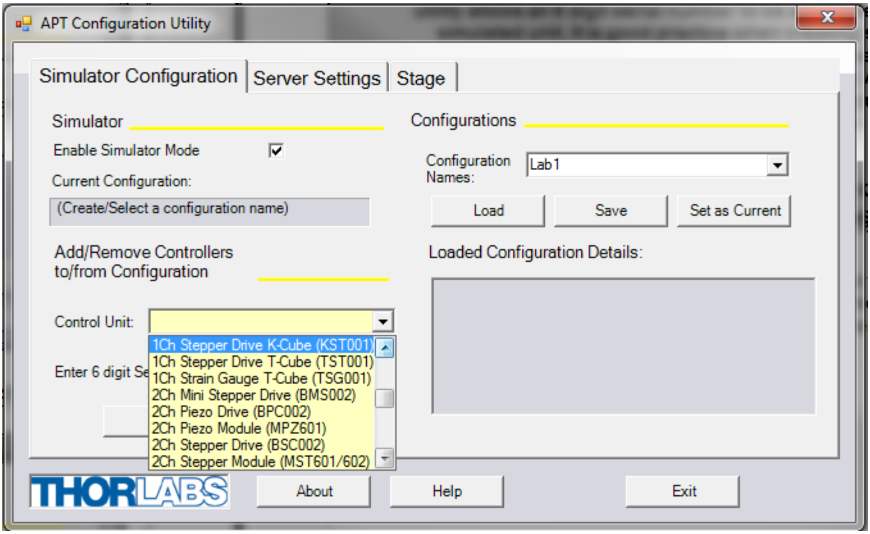


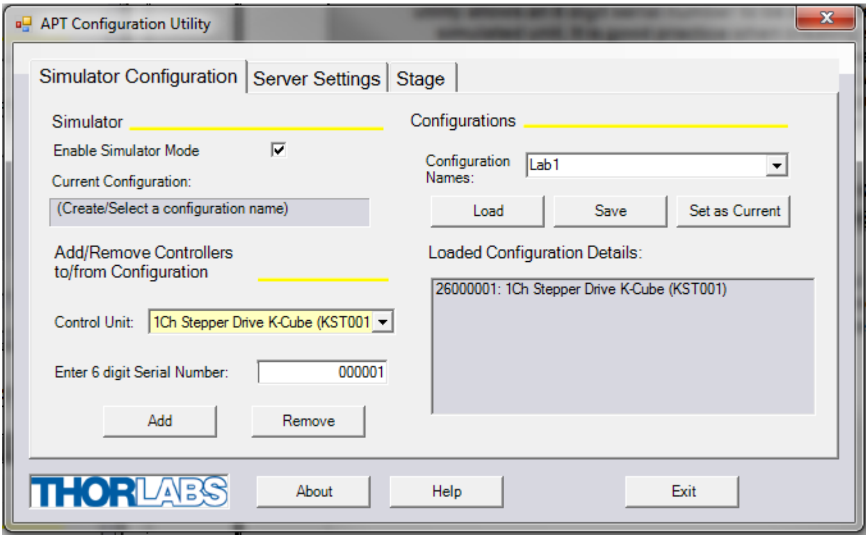
Fig. 5.15 APT Configuration Utility - Simulator Configuration Tab

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

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



5) In the ‘Control Unit’ field, select ‘1 Ch Stepper Driver K-Cube (KST101)’.



6) In the ‘Enter 6 digit serial number’ field, enter the serial number of your stepper drive 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 Stepper Driver K-Cube are:
26xxxxxx - 1 Ch Stepper Drive K-Cube

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.

5.11 Stage/Axis Tab

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

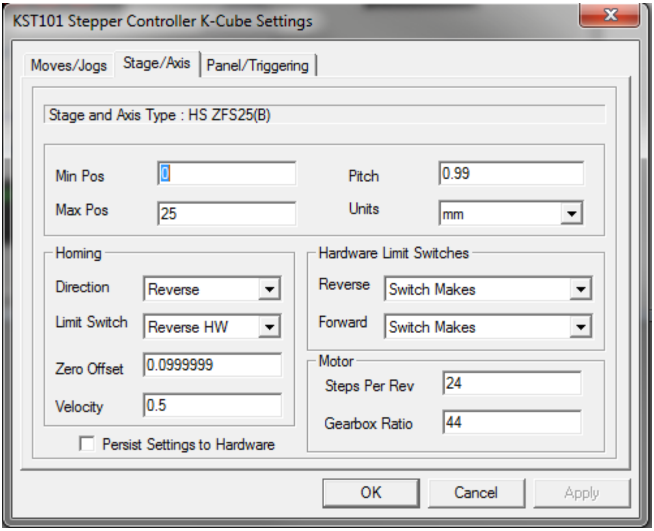


Fig. 5.16 Stage/Axis Tab

These parameters were set automatically when the ZST6 actuator was selected using the APTConfig utility in Section 3.5. The APT server automatically applied suitable defaults for the parameters on this tab during boot up of any client software such as APTUser. These parameters should not be altered for pre-defined Thorlabs stages and actuators selected using APT Config, as it may adversely affect the performance of the stage.

For third party stage types not available using the APT Config utility, these stage details must be entered manually.

Individual parameters are described in Section 6.3.

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. 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) d isplayed when accessing the Stepper Driver K-Cube using the APTUser utility.

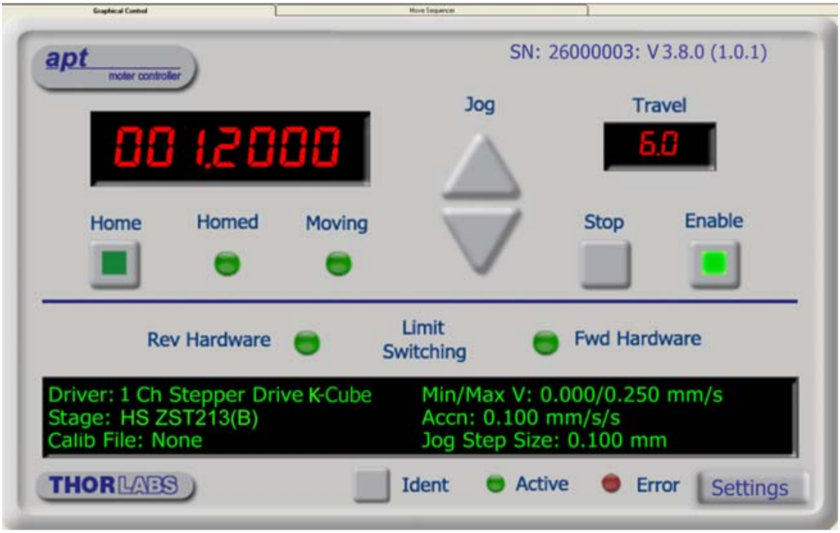


Fig. 6.1 Stepper Driver K-Cube Software GUI

Note

The serial number of the Stepper Driver K-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.

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.).

Travel - displays the range of travel (in millimeters or degrees) of the motor.

Moving - lit when the motor is in motion.

Enable - applies power to the motor. With the motor enabled, the LED in the button is lit.

Digital display - 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).

Home - sends the motor to its 'Home' position - see Appendix E Section E.2.2. The LED in the button is lit while the motor is homing.

Homed - lit when the motor has previously been 'Homed' (since power up).

Stop - halts the movement of the motor.

Limit switches - the LEDs are lit when the associated limit switch has been activated - see Appendix E Section E.2.3. for further details on limit switches.

Settings display - shows the following user specified settings:

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

Stage - the stage type and axis associated with the specified channel.

Note. By default, the software associates a ZST6 type actuator, unless the user has used the APTConfig utility to associate a particular stage.

Calib File - the calibration file associated with the specified channel.

See the APTConfig utility helpfile for more details on assigning and using calibration files.

Min/Max V - the minimum velocity at which a move is initiated, and the maximum velocity at which the move is performed. Values are displayed in real world units (mm/s or degrees/s), and can be set via the 'Settings' panel (see Section 6.3.).

Accn - the rate at which the velocity climbs to, and slows from, maximum velocity, displayed in real world units (mm/s/s or degrees/s/s). The acceleration can be set via the 'Settings' panel (see Section 6.3.) and is used in conjunction with the Min/Max velocity settings to determine the velocity profile of a motor move. See Appendix E Section E.1.3. for more information on velocity profiles.

Jog Step Size - the size of step (in mm or degrees) taken when the jog signal is initiated. The step size can be set either via the Settings panel or by calling the SetJogStepSize method.

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

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.

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 accessible through the ActiveX methods and properties on this Control (refer to the *Programming Guide* in the *APTServer helpfile* for further details and to Section 2.3.4. for an overview of the APT ActiveX controls).

6.3.1 Moves/Jogs Tab

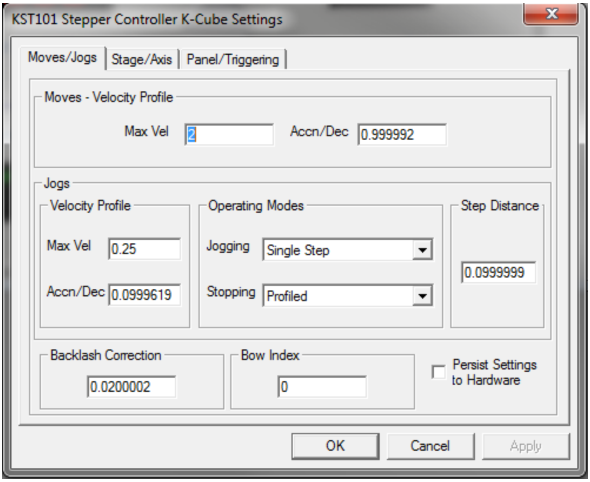


Fig. 6.2 Stepper Driver K-Cube - Move/Jog Settings

Moves - Velocity Profile

Moves can be initiated via the GUI panel, by using the velocity wheel (see Section 4.3.) or by entering a position value after clicking on the position display box (see Section 5.4.). The following settings determine the velocity profile of such moves, and are specified in real world units, millimetres or degrees.

Note

The minimum velocity is locked at zero and cannot be adjusted.

MaxVel - the maximum velocity at which to perform a move.

Accn/Dec - 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).

Jogs

Jogs are initiated by using the 'Jog' keys on the GUI panel (see Section 5.6.), or the Jog Buttons on the front panel of the unit.

Velocity Profile (specified in real world units, millimetres or degrees)

MaxVel - the maximum velocity at which to perform a jog

Accn/Dec - the rate at which the velocity climbs from minimu m to maximum, and slows from maximum to minimum.

Operating Modes

Jogging - 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 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..

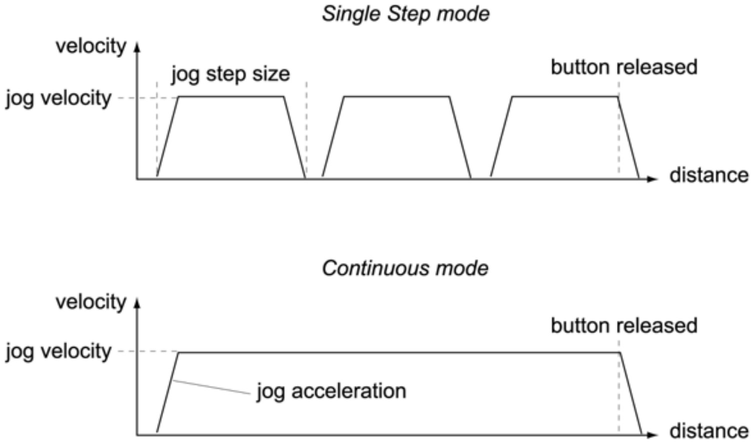


Fig. 6.3 Jog Modes

Single Step - the motor moves by the step size specified in the Step Distance parameter.

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

Stopping - 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.

Step Distance - 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).

Backlash Correction - 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 Correction Distance is specified in real world units (millimeters or degrees). To remove backlash correction, this value should be set to zero.

Position Profiling

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.

Bow Index – This field is used to set the profile mode to either Trapezoidal or S-curve. A *Bow Index* of '0' selects a trapezoidal profile. An index value of '1' to '18' selects an S-curve profile. In either case, the velocityand 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. This profile is selected when the *Bow Index* field is set to '0'.

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.

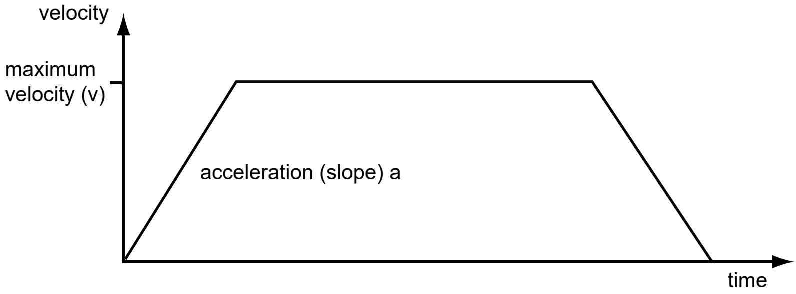


Fig. 6.4 Graph of a trapezoidal velocity profile

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

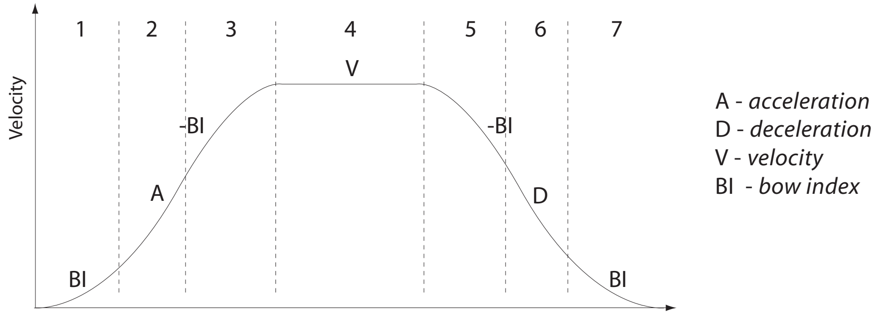


Fig. 6.5 Typical S-Curve Profile

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.

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

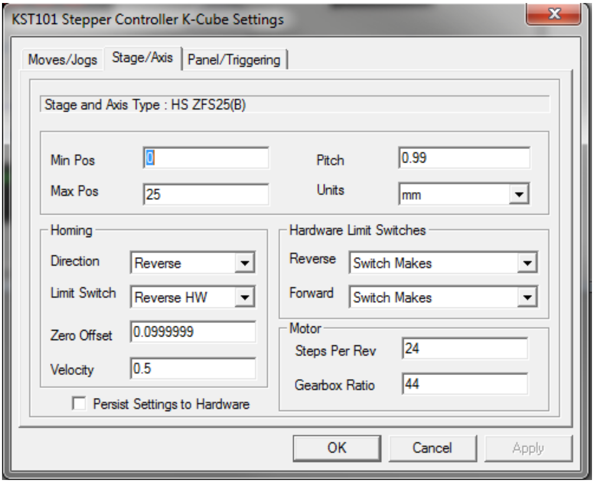


Fig. 6.6 Stepper Driver K-Cube - Stage/Axis Settings

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 APT Config utility can be used to associate a specific stage and axis type with the motor channel (refer to the APT Config helpfile for further details on how to associate a stage and axis). Once this association has been made, the APT server will automatically apply suitable defaults for the parameters on this tab during boot up of the software. These parameters should not be altered for pre-defined Thorlabs stages selected using APT Config, as it may adversely affect the performance of the stage.

For custom stage types not available using the APT Config utility, the stage details must be entered manually. Individual parameters are described in the following paragraphs.

Stage and Axis Type - For Thorlabs stages, the stage type is displayed automatically once the axis has been associated using the APTConfig utility. For third party stages, the display shows '*Unknown*'.

Caution

Extreme care must be taken when modifying the stage related settings that follow. Some settings are self consistent with respect to each other, and illegal combinations of settings can result in incorrect operation of the physical motor/stage combination being driven. Consult Thorlabs for advice on settings for stage/actuator types that are not selectable via the APTConfig utility.

Min Pos - the stage/actuator minimum position (typically zero).

Max Pos - the stage/actuator maximum position.

Pitch - the pitch of the motor lead screw (i.e. the distance travelled (in mm or degrees) per revolution of the leadscrew).

Units - the 'real world' positioning units (mm or degrees).

Homing

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 to move when homing, either *Forward* or *Reverse*.

Limit Switch - The hardware limit switch associated with the home position, either *Forward HW or Reverse HW*.

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.

Caution

The homing velocity should not be increased above the 250 µm/s factory setting as this may damage the limit switches.

For further information on the home position, see Section E.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 Rev Switch or Fwd Switch 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.

Motor

These parameters are used to set the 'resolution' characteristics of the stepper motor connected to the selected channel. The resolution of the motor, combined with other characteristics (such as lead screw pitch) of the associated actuator or stage, determines the overall resolution.

Steps Per Rev - The number of full steps per revolution of the stepper motor (minimum '1', maximum '10000').

Note

The *Gearbox Ratio* parameter is applicable only to motors fitted with a gearbox.

Gearbox Ratio - The ratio of the gearbox. For example, if the gearbox has a reduction ratio of X:1 (i.e. every 1 turn at the output of the gearbox requires X turns of the motor shaft) then the Gearbox Ratio value is set to X. (minimum '1', maximum '1000').

Note

The 'Steps Per Rev' and 'Gearbox Ratio' parameters, together with the 'Pitch' and 'Units' parameters are used to calculate the calibration factor for use when converting real world units to microsteps. However, the 'Steps Per Rev' parameter is entered as full steps, not microsteps. The system automatically applies a factor of 2048 microsteps per full step.

The majority of Thorlabs stepper motor actuators have 200 full steps per rev and no gearbox fitted. For these motors the Steps Per Rev and Gearbox Ratio parameters have values of 200 and 1 respectively. As an exception to this, the ZST family of actuators use 24 steps per rev stepper motors fitted with a 41:1 reduction gearbox. In this case, the Steps Per Rev and Gearbox Ratio should be set to '24' and '41' respectively. The equivalent calibration constant is then calculated as:

24 x 2048 x 41 = 2,015,232

24 steps per revolution
2048 microsteps per full step
41:1 reduction gearbox
1.0 mm lead screw pitch

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

6.3.3 Panel/Triggering Tab

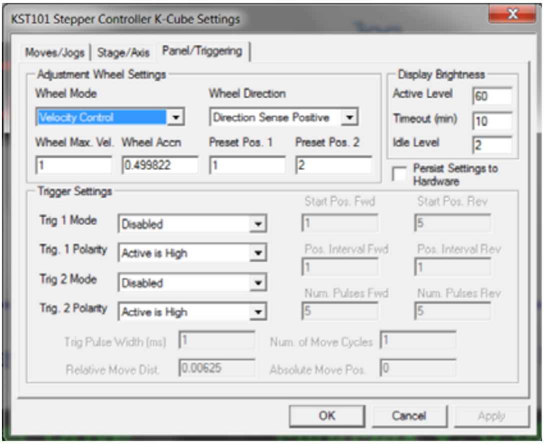


Fig. 6.7 Stepper Driver K-Cube - Advanced Settings

Adjustment Wheel Settings

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

Wheel Mode

Velocity Control - Deflecting the wheel starts a move with the velocity proportional to the deflection. The maximum velocity (i.e. velocity corresponding to the full deflection of the joystick wheel) and acceleration are set in the *Max Wheel Vel*. and *Wheel Accn*. parameters.

Position Jogging - Deflecting the wheel initiates a jog move, using the parameters specified by the Move/Jogs tab. Keeping the wheel deflected repeats the move automatically after the current move has completed.

Go To Position - Deflecting the wheel starts a move from the current position to one of the two predefined “teach” positions. The teach positions are specified in the *Preset Pos. 1* and *Preset Pos. 2* parameters, and are measured in number of steps from the home position.

Wheel Direction

The direction of a move initiated by the velocity wheel is specified as follows:

Disabled - The wheel is disabled to remove any unwanted motion due to accidental movement of the wheel.

Direction Sense Positive - Upwards rotation of the wheel results in a positive motion (i.e. increased position count).

Note. The following option applies only when the Wheel Mode is set to Velocity Control. If set to Position Jogging or Go to Position Mode, the following option is ignored.

Direction Sense Negative - Upwards rotation of the wheel results in a negative motion (i.e. decreased position count).

Display Brightness

In certain applications, it may be necessary to adjust the brightness of the LED display on the top of the unit. The brightness is set in the *Active Level* parameter, as a value from 0 (Off) to 100 (brightest). The display can be turned off completely by entering a setting of zero, however, pressing the MENU button on the top panel will temporarily illuminate the display at its lowest brightness setting to allow adjustments. When the display returns to its default position display mode, it will turn off again.

Furthermore, 'Burn In' of the display can occur if it remains static for a long time. To prevent this, the display is automatically dimmed after the time interval specified in the *Timeout (min)* parameter has elapsed. The time interval is specified in minutes in the range 0 (never dimmed) to 480. The dim level is set in the *Idle Level* parameter, as a value from 0 (Off) to 10 (brightest) but is also limited by the *Active Value* parameter if this is lower.

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

Triggering Introduction

The K-Cube motor controllers have two bidirectional trigger ports (TRIG1 and TRIG2) that can be used to read an external logic signal or output a logic level to control external equipment. Either of them can be independently configured as an input or an output and the active logic state can be selected High or Low to suit the requirements of the application. Electrically the ports output 5 Volt logic signals and are designed to be driven from a 5 Volt logic.

When the port is used in the input mode, the logic levels are TTL compatible, i.e. a voltage level less than 0.8 Volt will be recognised as a logic LOW and a level greater than 2.4 Volt as alogic HIGH. The input contains a weak pull-up, so the state of the input with nothing connected will default to a logic HIGH. The weak pull-up feature allows a passive device, such as a mechanical switch to be connected directly to the input.

When the port is used as an output it provides a push-pull drive of 5 Volts, wi th the maximum current limited to approximately 8 mA. The current limit prevents damage when the output is accidentally shorted to ground or driven to the opposite logic state by external circuity.

Warning: do not drive the TRIG ports from any voltage source that can produce an output in excess of the normal 0 to 5 Volt logic level range. In any case the voltage at the TRIG ports must be limited to -0.25 to +5.25 Volts.

Input Trigger Modes

When configured as an input, the TRIG ports can be used as a general purpose digital input, or for triggering a relative, absolute or home move. When used for triggering a move, the port is edge sensitive. In other words, it has to see a transitio n from the inactive to the active logic state (Low->High or High->Low) for the trigger input to be recognized. For the sa me reason a sustained logic level will not trigg er repeated moves. The trigger input has to return to its inactive state first in order to start the next trigger. The mode is set in the *Trig 1 Mode* and *Trig 2 Mode* parameters as follows:

Disabled - The trigger IO is disabled

Digital Input - General purpose logic input (read through status bits using the LLGetStatusBits method).

Trig In Rel. Move - Input trigger for relative move.

Trig In Abs. Move - Input trigger for absolute move.

Trig In Home - Input trigger for home move.

When the trigger mode is selected to *Trig In Rel Move* or *Trig In Abs Move*, the relative distance or absolute position to move, can be entered in the *Relative Move Dist* and *Absolute Move Pos*. parameters.

Output Trigger Modes

When the *Trig 1 Mode* and *Trig 2 Mode* parameters are configured as outputs, the TRIG ports can be used as a general purpose digital output, or to indicate motion status or to produce a trigger pulse at configurable positions as follows:

Digital Output - General purpose logic output (set using the LLSetGetDigOPs method).

Trig Out In Motion - Trigger output active (level) when motor 'in motion'. The output trigger goes high (5V) or low (0V) (as set in the Trig 1. Polarity and Trig. 2 Polarity parameters) when the stage is in motion.

Trig Out Max Vel - Trigger output active (level) when motor at 'max velocity'.

Trig Out Pos. Steps Fwd - Trigger output active (pulsed) at pre-defined positions moving forward. Only one Trigger port at a time can be set to this mode . See Trigger Out Position Steps for further details.

Trig Out Pos. Steps Rev - Trigger output active (pulsed) at pre-defined positions moving backwards. Only one Trigger port at a time can be set to this mode. See Trigger Out Position Steps for further details.

Trig Out Pos. Steps Both - Trigger output active (pulsed) at pre-defined positions moving forwards and backward. Only one Trigger port at a time can be set to this mode. See Trigger Out Position Steps for further details.

Trigger Out Position Steps

Note

If the trigger mode is not set to one of the three position modes described previously, then the following parameters are not applicable and will be greyed out.

In the last three modes described above, the controller outputs a configurable number of pulses (set in the *Num. Pulses Fwd* and *Num. Pulses Rev* parameters), of configurable width (*Trig Pulse Width*), when the actual position of the stage matches the position values configured as the Start Position and Position Interval (*Start Pos. Fwd* and *Start Pos. Rev*. These modes allow external equipment to be triggered at exact position values.

Using the last three modes, position triggering can be configured to be unidirectional (*Trig Out Pos. Steps Fwd* or *Trig Out Pos. Steps Rev*) or bidirectional (*Trig Out Pos. Steps Both*). In bidirectional mode the forward and reverse pulse sequences can be configured separately. A cycle count setting (*Num. of Move Cycles*) allows the uni- or bidirectional position triggering sequence to be repeated a number of times.

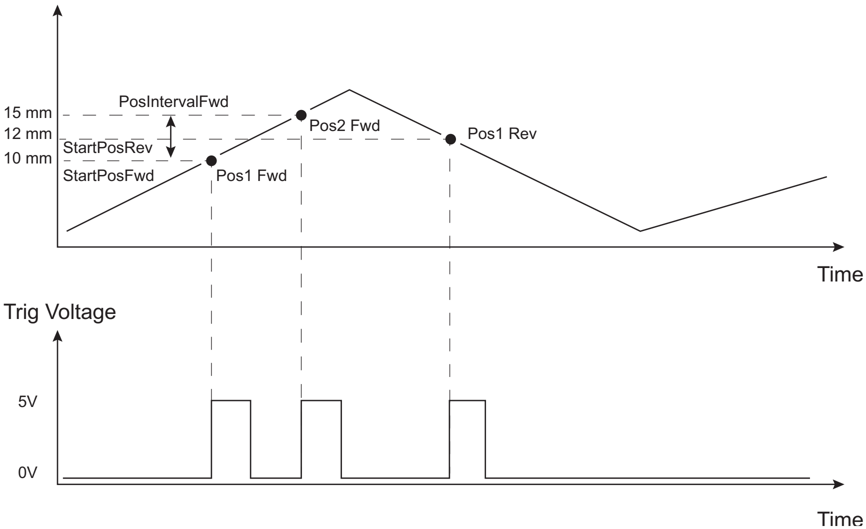


Fig. 6.8 Position Steps Triggering

Example for a move from 0 to 20 mm and back.

In forward direction: The first trigger pulse occurs at 10 mm (StartPosFwd), the next trigger pulse occurs after another 5 mm (PosIntervalFwd), the stage then moves to 20 mm.

In reverse direction: The next trigger occurs when the stage gets to 12 mm.

Note that position triggering can only be used on one TRIG port at a time, as there is only one set of position trigger parameters.

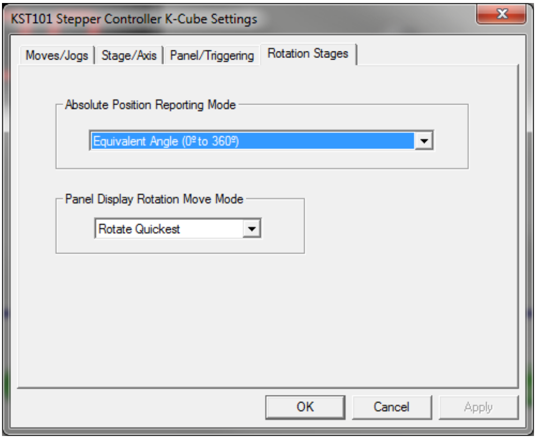
Triggering Polarity

The polarity of the trigger pulse is specified in the *Trig. 1 Polarity* and *Trig 2 Polarity* parameters as follows:

Active is High - The active state of the trigger port is logic HIGH 5V (trigger input and output on a rising edge).

Active is Low - The active state of the trigger port is logic LOW 0V (trigger input and output on a falling edge).

6.3.4 Rotation StagesTab



Absolute Position Reporting Mode

This setting relates to the way in which the angular position is displayed on the GUI panel. There are two options:

Equivalent Angle 0 to 360 degrees – The maximum displayed position is 359.99°. If a stage is driven past the 360° rotation point, the display reverts back to zero and counts up to 360° again.

Total Angle (360 x Num Revs + Angular Offset) – The total angular rotation is displayed, e.g. for a movement of two full rotations plus 10°, the display will show 730°.

Note. The following parameters are applicable only if the Abso lute Position Reporting Mode is set to 'Equivalent Angle 0 to 360 degrees'.

Panel Display Rotation Move Mode

This setting specifies the move direction. There are three options:

Rotate Positive – The move is performed in a positive direction

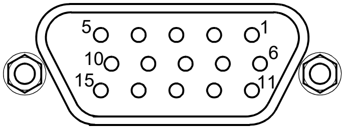
Rotate Negative - The move is performed in a negative direction

Rotate Quickest - The move is performed in the quickest direction

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	Stage Identification
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		

Caution

DO NOT connect a motor actuator while the K-Cube is powered up.

Only use motor drive cables supplied by Thorlabs, other cables may have incompatible wiring.

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 Resolution Stepping	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 Wheel	Bidirectional Velocity Control, 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) Excluding Buttons and Baseplate	60 x 60 x 47 mm (2.36" x 2.36" x 1.85)
Instrument Weight	140 g (5.0 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 Motor Control Method Summary

The 'Motor' ActiveX Control provides the functionality required for a client application to control one or more of the APT series of 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 Motor ActiveX Control can be used to perform activities such as homing stages, absolute and relative moves, and changing velocity profile settings. A brief summary of ech method and property 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.
DisableHWChannel	Disables the drive output.
DoEvents	Allows client application to process other activity.
EnableHWChannel	Enables the drive output.
GetAbsMovePos	Gets the absolute move position.
GetAbsMovePos_AbsPos	Gets the absolute move position (returned by value).
GetBLashDist	Gets the backlash distance.
GetBLashDist_BLashDist	Gets the backlash distance (returned by value).
GetCtrlStarted	Gets the ActiveX Control started flag.
GetDispMode	Gets the GUI display mode.
GetHomeParams	Gets the homing sequence parameters.
GetHomeParams_HomeVel	Gets the homing velocity parameter (returned by value).
GetHomeParams_ZeroOffset	Gets the homing zero offset parameter (returned by value).
GetHWCommsOK	Gets the hardware communications OK flag.

GetHWLimSwitches	Gets the limit switch configuration settings.
GetJogMode	Gets the jogging button operating modes.
GetJogMode_Mode	Get the jogging button operating mode (returned by value).
GetJogMode_StopMode	Gets the jogging button stopping mode (returned by value).
GetJogStepSize	Gets the jogging step size.
GetJogStepSize_StepSize	Gets the jogging step size (returned by value).
GetJogVelParams	Gets the jogging velocity profile parameters.
GetJogVelParams_Accn	Gets the jogging acceleration parameter (returned by value).
GetJogVelParams_MaxVel	Gets the j ogging maximum velocity parameter (returned by value).
GetKCubePanelParams	Gets the operating parameters of the velocity wheel on the top panel
GetKCubePosTriggerParams	Gets operating parameters used when the triggering mode is set to a trigger out position steps mode
GetKCubeTriggerParams	Gets the operating parameters of the TRIG1 and TRIG2 connectors on the front panel.
GetMotorParams	Gets the motor gearing parameters.
GetPhaseCurrents	Gets the coil phase currents.
GetPosition	Gets the current motor position.
GetPosition_Position	Gets the current motor position (returned by value).
GetPositionEx	Gets the current motor position.
GetPositionEx_UncalibPosition	Gets the current uncalibrated motor position (returned by value).
GetPositionOffset	Gets the motor position offset.
GetRelMoveDist	Gets the relative move distance.
GetRelMoveDist_RelDist	Gets the relative move distance (returned by reference).
GetStageAxis	Gets the stage type information associated with the motor under control.
GetStageAxisInfo	Gets the stage axis parameters.
GetStageAxisInfo_MaxPos	Gets the stage maximum position (returned by value).
GetStageAxisInfo_MinPos	Gets the stage minimum position (returned by value).
GetStatusBits_Bits	Gets the contro ller status bits encoded in 32 bit integer (returned by value).

GetVelParamLimits	Gets the maximum velocity profile parameter limits.
GetVelParams	Gets the velocity profile parameters.
GetVelParams_Accn	Gets the move acceleration (returned by value).
GetVelParams_MaxVel	Gets the mo ve maximum velocity (returned by value).
Identify	Identifies the controller by flashing unit LEDs.
LLGetStatusBits	Gets the controller status bi ts encoded in 32 bit integer.
LoadParamSet	Loads stored settings for specific controller.
MoveAbsolute	Initiates an absolute move.
MoveAbsoluteEnc	Initiates an absolute m ove with specified positions for encoder equipped stages.
MoveAbsoluteEx	Initiates an absoloute move with specified positions.
MoveAbsoluteRot	Initiates an absolute m ove with specified positions for rotary stages.
MoveHome	Initiates a homing sequence.
MoveJog	Initiates a jog move.
MoveRelative	Initiates a relative move.
MoveRelativeEnc	Initiates a relative move with specified distances for encoder equipped stages.
MoveRelativeEx	Initiates a relative move with specified distances.
MoveVelocity	Initiates a move at constant velocity with no end point.
SaveParamSet	Saves settings for a specific controller.
SetAbsMovePos	Sets the absolute move position.
SetBLashDist	Sets the backlash distance.
SetDispMode	Sets the GUI display mode.
SetHomeParams	Sets the homing sequence parameters.
SetHWLimSwitches	Sets the limit switch configuration settings.
SetJogMode	Sets the jogging button operating modes.
SetJogStepSize	Sets the jogging step size.
SetJogVelParams	Sets the jogging velocity profile parameters.
SetKCubePanelParams	Sets the operating parameters of the velocity wheel on the top panel
SetKCubePosTriggerParams	Sets operating parameters used when the triggering mode is set to a trigger out position steps mode
SetKCubeTriggerParams	Sets the op erating parameters of th e TRIG1 and TRIG2 connectors on the front panel of the unit.

SetMotorParams	Sets the motor gearing parameters.
SetPhaseCurrents	Sets the coil phase currents.
SetPositionOffset	Sets the motor position offset.
SetPotParams	Sets the velocity control potentiometer parameters (Cube drivers).
SetRelMoveDist	Sets the relative move distance.
SetStageAxisInfo	Sets the stage axis parameters.
SetVelParams	Sets the velocity profile parameters.
ShowSettingsDlg	Display the GUI Settings panel.
StartCtrl	Starts the ActiveX Control (start s communication with controller)
StopCtrl	Stops the ActiveX Control (stops co mmunication with controller)
StopImmediate	Stops a motor move immediately.
StopProfiled	Stops a mo tor move in a p rofiled (decelleration) manner.

Properties

APTHelp	Specifies the help file that will be accessed when the user presses the F1 key. If APTHelp is set to 'True', the main server helpfile MG17Base will be launched.
DisplayMode	Allows the display mode of the virtual display panel to be set/read.
HWSerialNum	specifies the se rial number of the hardware unit to be associated with an ActiveX control instance.

Appendix E Stepper Motor Operation - Background

E.1 How A Stepper Motor Works

E.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. E.1.

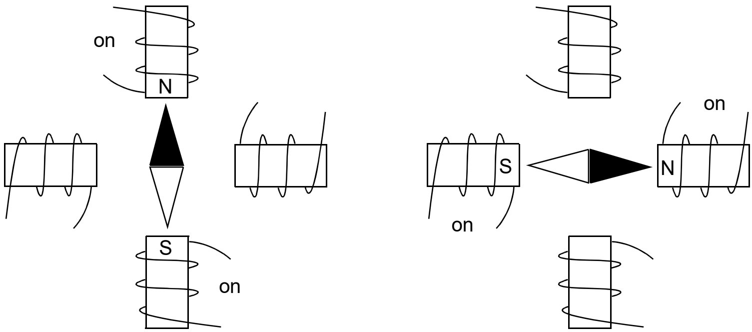


Fig. E.1 Simplified concept of stepper motor operation

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 K-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.

E.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.

E.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 6.3.1.

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. E.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.

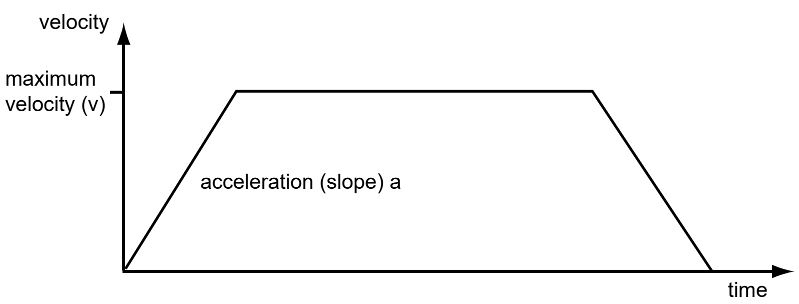


Fig. E.2 Graph of a trapezoidal velocity profile

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

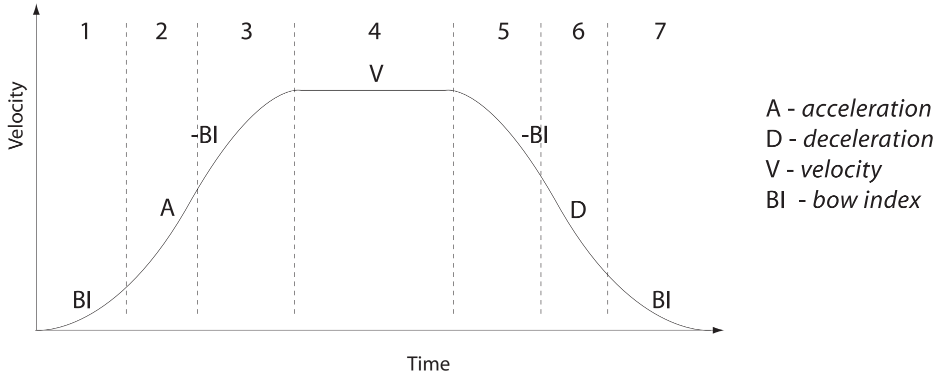


Fig. E.3 Typical S-Curve Profile

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.

E.2 Positioning a Stage

E.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 APT 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.

E.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 there by 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.

E.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.

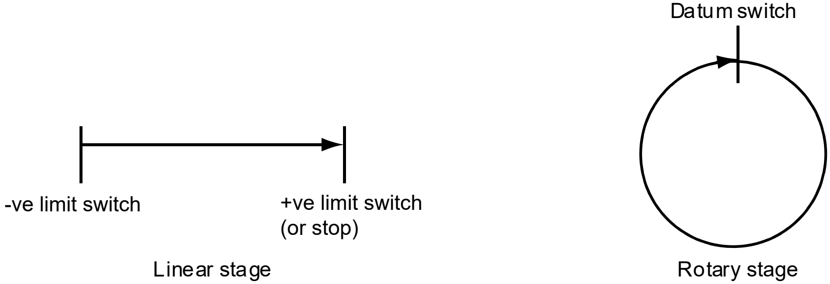


Fig. E.4 Stage limit switches

E.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. E.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 limit s 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.

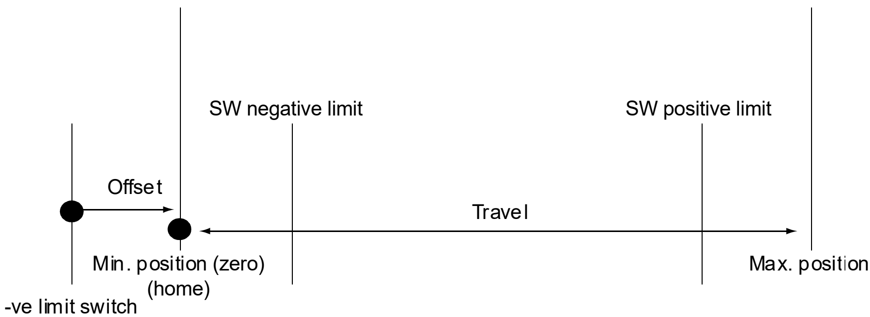


Fig. E.5 Minimum and Maximum Positions

E.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 6.3.3. *Stage/Axis Tab* for more details on these power settings.

E.3 Error Correction

E.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. E.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.

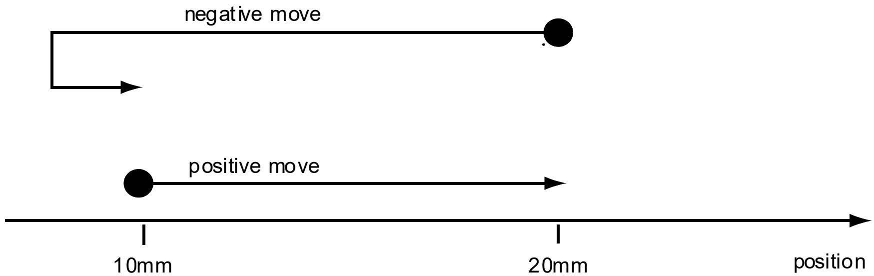


Fig. E.6 Backlash correction

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 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. F.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

THORLABS
www.thorlabs.com

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):

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

hereby declare that:

Model: ***KST101***

Equipment: ***K-Cube Stepper Driver***

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

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

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

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:* 17 December 2015

Name: Keith Dhese

Position: General Manager

EDC - KST101 -2015-12-17

CE

Appendix G Thorlabs Worldwide Contacts

USA, Canada, and South America
Thorlabs, Inc.
56 Sparta Avenue
Newton, NJ 07860
USA
Tel: 973-300-3000
Fax: 973-300-3600
www.thorlabs.com
www.thorlabs.us (West Coast)
Email: sales@thorlabs.com
Support: techsupport@thorlabs.com

UK and Ireland
Thorlabs Ltd.
1 Saint Thomas Place
Ely B7 4EX
Great Britain
Tel: +44 (0) 1353-654440
Fax: +44 (0) 1353-654444
www.thorlabs.com
Email: sales.uk@thorlabs.com
Support: techsupport.uk@thorlabs.com

Europe
Thorlabs GmbH
Hans-Böckler-Str. 6
85221 Dachau / Munich
Germany
Tel: +49-(0) 8131-5956-0
Fax: +49-(0) 8131-5956-99
www.thorlabs.de
Email: europe@thorlabs.com

Scandinavia
Thorlabs Sweden AB
Bergfotsgatan 7
431 35 Mölndal
Sweden
Tel: +46-31-733-30-00
Fax: +46-31-703-40-45
www.thorlabs.com
Email: scandinavia@thorlabs.com

France
Thorlabs SAS
109, rue des Côtes
78600 Maisons-Laffitte
France
Tel: +33 (0) 970 444 844
Fax: +33 (0) 825 744 800
www.thorlabs.com
Email: sales.fr@thorlabs.com

Brazil
Thorlabs Vendas de Fotônicos Ltda.
Rua Riachuelo, 171
São Carlos, SP 13560-110
Brazil
Tel: +55-16-3413 7062
Fax: +55-16-3413 7064
www.thorlabs.com
Email: brasil@thorlabs.com

Japan
Thorlabs Japan, Inc.
3-6-3, Kitamachi,
Nerima-ku, Tokyo 179-0081
Japan
Tel: +81-3-6915-7701
Fax: +81-3-6915-7716
www.thorlabs.co.jp
Email: sales@thorlabs.jp

China
Thorlabs China
Room A101, No. 100, Lane 2891
South Qilianshan Road
Putuo District
Shanghai
China
Tel: +86 (0) 21-60561122
Fax: +86 (0) 21-32513480
www.thorlabschina.cn
Email: chinasales@thorlabs.com

Thorlabs Inc.
56 Sparta Ave
Newton, NJ07860
USA
Tel: +1 973 579 7227
Fax: +1 973 300 3600
www.thorlabs.com

Thorlabs Ltd.
Saint Thomas Place, Ely
Cambridgeshire CB7 4EX,
UK
Tel: +44 (0) 1353 654440
Fax: +44 (0) 1353 654444
www.thorlabs.com