KST201
K-Cube Stepper Motor Controller

User Guide



Table of Contents

Chapter 1 Safety Information 1
1.1 General Warnings 1

Chapter 2 Overview 2
2.1 Introduction 2
2.2 K-Cube Controller Hub 3
2.3 Kinesis PC Software Overview 3
2.3.1 Introduction 3
2.3.2 Kinesis Server 3
2.3.3 Software Upgrades 4

Chapter 3 Getting Started 5
3.1 Environmental Conditions 5
3.2 Install the Software 5
3.3 Mechanical Installation 5
3.3.1 Mounting Options 5
3.3.2 Using the Baseplate 6
3.4 Electrical Installation 6
3.4.1 Rear Panel 6
3.4.2 Front Panel 7
3.5 Connect The Hardware 7
3.6 Use with Legacy Actuators and Stages 8
3.7 Verifying Software Operation 9
3.7.1 Initial Setup 9

Chapter 4 Standalone Operation 10
4.1 Introduction 10
4.2 Control Panel 10
4.2.1 Digital Display- Operating Mode 11
4.3 Velocity Wheel Operation 11
4.3.1 Homing 11
4.3.2 Go to Position 11
4.3.3 Jogging 11
4.3.4 Velocity Moves 12
4.4 Settings Menu 12
4.4.1 Overview 12
4.4.2 Menu Option - Go To Position 13
4.4.3 Menu Option - Start Homing 13
4.4.4 Menu Option - Velocity 14
4.4.5 Menu option - Joystick Mode 14
4.4.6 Menu Option - Jog Step Size 15
4.4.7 Menu Option - Teach Position 15
4.4.8 Menu Option - Brightness 16
4.4.9 Menu option – Disp. Timeout 16
4.4.10 Menu Option - Disable 17
4.4.11 Menu Option - Select Stage 17

Chapter 5 PC Operation – Tutorial 18

5.1 Introduction 18
5.2 Using the Kinesis Software 18
5.3 Homing Motors 18
5.4 Changing Motor Parameters and Moving to an Absolute Position 19
5.5 Jogging 20
5.6 Setting Move Sequences 20
5.7 Changing and Saving Parameter Settings 20
Chapter 6 Software Reference 21
6.1 Introduction 21
6.2 GUI Panel 21
6.2.1 Keyboard Shortcuts 22
6.3 Settings Panel 23
6.3.1 Persisting Settings to Hardware 23
6.3.2 Moves/Jogs Tab 23
6.3.3 Calibration Tab 26
6.3.4 Stage/Axis Tab 28
6.3.5 Advanced Tab 29
6.3.6 Triggering Tab 31
6.3.7 Rotation/Stages Tab 35
Chapter 7 Rear Panel Connector Pinout Details 36
7.1 Real Panel Motor Control Connector 36
Chapter 8 Preventive Maintenance 37
8.1 Safety Testing 37
8.2 Cleaning 37
Chapter 9 Specifications 38
Chapter 10 Stepper Motor Operation - Background 39
10.1 How a Stepper Motor Works 39
10.1.1 General Principle 39
10.1.2 Positive and Negative Modes 39
10.1.3 Velocity Profiles 39
10.2 Positioning a Stage 41
10.2.1 General 41
10.2.2 Home position 41
10.2.3 Limit Switches 41
10.2.4 Minimum and Maximum Positions 42
10.2.5 Power Saving 42
10.3 Error Correction 42
10.3.1 Backlash correction 42
Chapter 11 Certifications and Compliance 43
Chapter 12 Thorlabs Worldwide Contacts 44

Chapter 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.



Warning: Risk of Electrical Shock

Given when there is a risk of electrical shock.



Warning

Given when there is a risk of injury to users.



Caution

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

Note

Clarification of an instruction or additional information.

1.1 General Warnings

Warning



If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. Excessive moisture may impair operation. Spillage of fluid, such as sample solutions, should be avoided. If spillage does occur, clean up immediately using absorbent tissue. Do not allow spilled fluid to enter the internal mechanism.

Chapter 2 Overview

2.1 Introduction

The K-Cube Stepper Motor Controller (KST201) 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 15 V at 12 W 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 KST201 is optimized for 'out of the box' operation with the Thorlabs range of ZST and ZFS 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 with the facility to directly mount to the optical table close to the motorized device - convenient when manually adjusting motor positions using the top panel controls (jog buttons and velocity control slider). Tabletop operation also allows minimal drive cable lengths for easier cable management.



Figure 1 K- Cube Stepper Motor Controller

USB connectivity provides easy 'Plug and Play' PC controlled operation - multiple units can be connected to a single PC via standard USB hub technology or by using the new K-Cube Controller Hub (Refer to section 2.2) for multi-axis motion control applications. Coupling this with one of our user-friendly software options allows the user to get up and running with complex move sequences in a short time. For example, all relevant operating parameters are set automatically for Thorlabs stages and actuators. Advanced custom motion control applications and sequences are also possible using the extensive Microsoft® .Net programming environment also supplied. This programming library is compatible with many development tools such as LabView, Visual Basic, Visual C++, C++ Builder, LabWindows/CVI, Matlab and Delphi. For convenience, a 1.5 m long Type A to Type Micro B USB 3.0 cable is included with the KST201 cube.

The KST201 Stepper Motor Controller can be operated from the front panel (see Chapter 4) or from a PC (see Chapter 5). This controller is fully compatible with Thorlabs' Kinesis® and XA software applications. This manual describes use of the KST201 controller with Thorlabs' Kinesis software. For information about operation using Thorlabs' XA software, please refer to the XA User Guide.

2.2 K-Cube Controller Hub

For power, a single wall plug supply (KPS201) is available for powering a single K-Cube Driver.

For multiple cube systems, a 3-channel (KEH3) or 6-channel (KEH6) K-Cube Controller Hub are offered. Previous generation 3- and 6-channel controllers (KCH301 and KCH601, respectively) may also be used, but are no longer available for individual purchase. These products have been designed specifically with multiple K-Cube operation in mind 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 Kinesis PC Software Overview

2.3.1 Introduction

The K-Cube range of controllers share many of the benefits of the Thorlabs range of motor controllers. These include USB connectivity (allowing multiple units to be used together on a single PC), fully featured Graphical User Interface (GUI) panels, and extensive software function libraries for custom application development.

The Kinesis software suite provides a flexible and powerful PC based control system both for users of the equipment, and software programmers aiming to automate its operation.

The User Interface allows full control of all settings and operating modes enabling complete ‘out-of-box’ operation without the need to develop any further custom software. It provides all of the necessary system software services such as generation of GUI panels, communications handling for multiple USB units, and logging of all system activity to assist in hardware trouble shooting. The Kinesis server is also used by software developers to allow the creation of advanced automated positioning applications very rapidly and with great ease. The Kinesis server is described in more detail in 2.3.2.

2.3.2 Kinesis Server

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

With the Kinesis system, .Net Controls are deployed to allow direct control over and reflect the status of the range of electronic controller units, including the Stepper Driver K-Cube. Software applications that use .Net Controls are often referred to as 'client applications'. A .Net Control is a language independent software component. Consequently, the controls can be incorporated into a wide range of software development environments for use by client application developers. Development environments supported include Visual Basic, Labview, Visual C++, C++ Builder, HPVEE, Matlab, VB.NET, C#.NET and, via VBA, Microsoft Office applications such as Excel and Word.

Consider the .Net Control supplied for the K-Cube stepper driver unit.

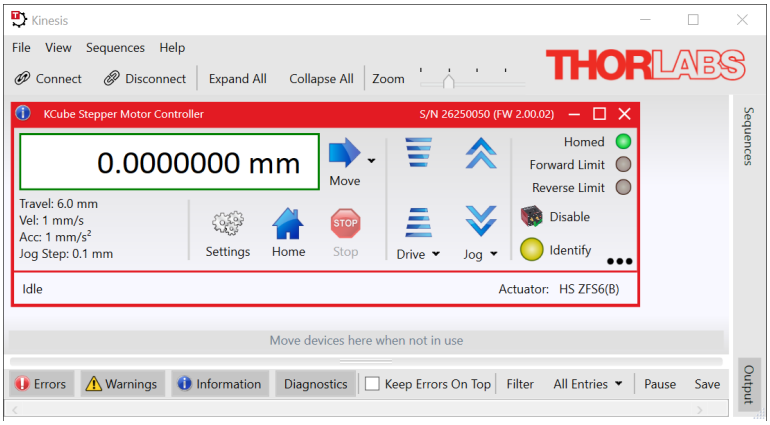


Figure 2 Kinesis Server

This Control provides a complete user graphical instrument panel to allow the motor unit to be manually operated, as well as a complete set of software functions (often called methods) to allow all parameters to be set and motor operations to be automated by a client application. The instrument panel reflects the current operating state of the controller unit to which it is associated (e.g., such as motor position). Updates to the panel take place automatically when a user (client) application is making software calls into the same Control. For example, if a client application instructs the associated stepper motor Control to move a motor, the progress of that move is reflected automatically by changing position readouts on the graphical interface, without the need for further programming intervention.

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

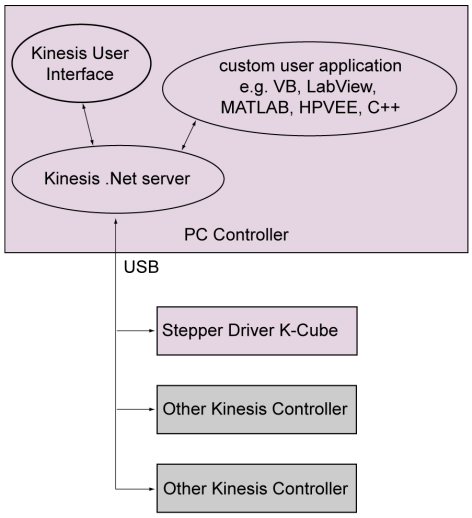


Figure 3 System Architecture Diagram

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

2.3.3 Software Upgrades

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

Chapter 3 Getting Started

3.1 Environmental Conditions



Warning

Operation outside the following environmental limits may adversely affect operator safety.

The unit is designed for indoor use only.

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

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

If the unit has been stored at a low temperature or in an environment of high humidity, it must be allowed to reach ambient conditions before being powered up.

3.2 Install the Software

Note

When operating via a PC, direct user interaction with the 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 user's ability to load software, and on these systems the software may not install/run. If you are in any doubt about your rights to install/run software, please consult your system administrator before attempting to install.

If you experience any problems when installing software, contact Thorlabs Technical Support (techsupport@thorlabs.com).

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.

3.3 Mechanical Installation

3.3.1 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 - refer to Section 3.3.2.

For multiple cube systems, a 3-channel (KEH3) or 6-channel (KEH6) K-Cube Controller Hub are offered. Previous generation 3- and 6-channel controllers (KCH301 and KCH601, respectively) may also be used, but are no longer available for individual purchase. Refer to 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 buttons. Ensure that proper airflow is maintained to the unit.

3.3.2 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.

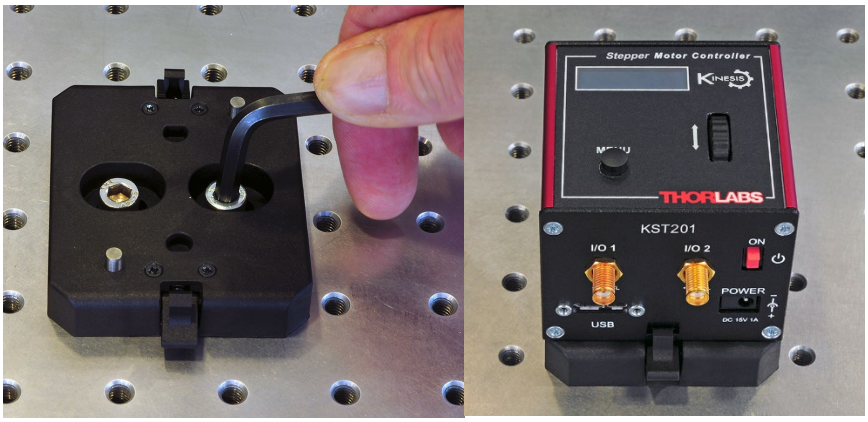


Figure 4 Using the Baseplate

3.4 Electrical Installation

3.4.1 Rear Panel

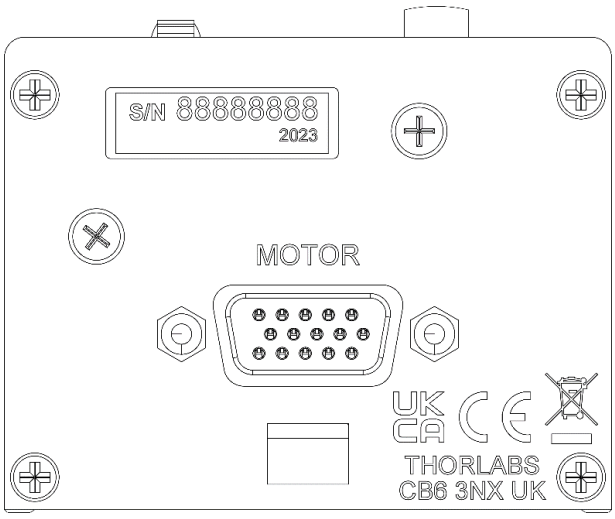


Figure 5 Rear Panel Connections

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 actuators (refer to Chapter 7 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.

3.4.2 Front Panel

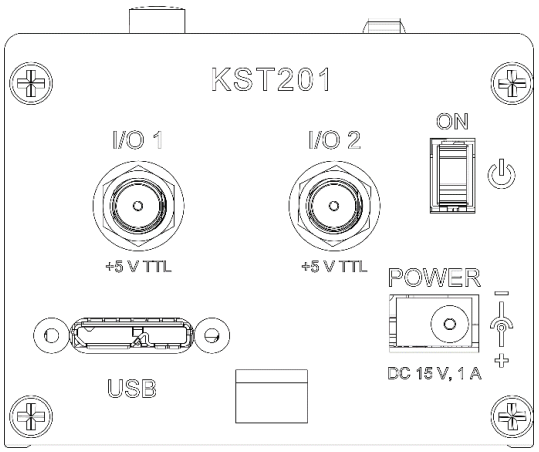


Figure 6 Front Panel Power Supply Connections

Warning: Risk of Electrical Shock

The unit must be connected only to a DC supply of 15 V, 1 A 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, 1 A.

A single way wall plug supply (KPS201 or KPS101) for powering a single Driver K-Cube is also available.

USB - USB port for system communications.

Note

The USB cable should be no more than 3 meters in length unless using a powered USB hub.

ON - Power ON/Standby switch. In the 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.

I/O 1 and I/O 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 - refer to Section 6.3.5.

3.5 Connect The Hardware

Perform the following:

1. Perform the mechanical installation as detailed in Section 3.3.
2. Install the Kinesis 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 meters in length. Communication lengths more than 3 meters can be achieved by using a powered USB hub.

4. Connect the stepper motor actuator to the Controller unit- refer to Section 3.4.1.

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 - refer to Section 3.4.
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 the following screen is displayed.

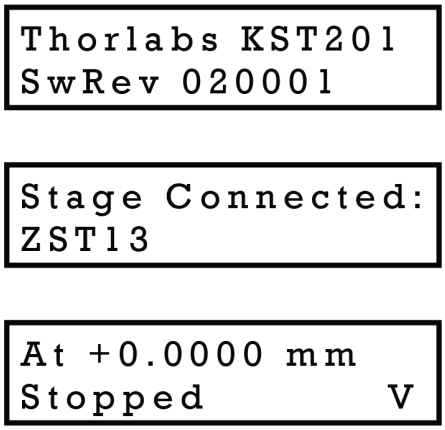


Figure 7 KST201 Start Up Screens

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.

3.6 Use with Legacy Actuators and Stages

To ensure that a particular stage is driven properly by the system, several 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 recognize the actuator type and install suitable defaults. Older version devices must be associated manually using the top panel menu - refer to Section 4.4.11. Once this association has been made, the Kinesis server applies automatically, suitable default parameter values on boot up of the software.

Note

If the actuator/stage has been recognized automatically via the eprom, the startup screens will display ‘Stage connected xxxx’ as shown in Figure 7. If the stage is not fitted with an eprom, the display will show the last stage type persisted, e.g., Stage persisted: ZST13B.

3.7 Verifying Software Operation

3.7.1 Initial Setup

Perform the following:

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

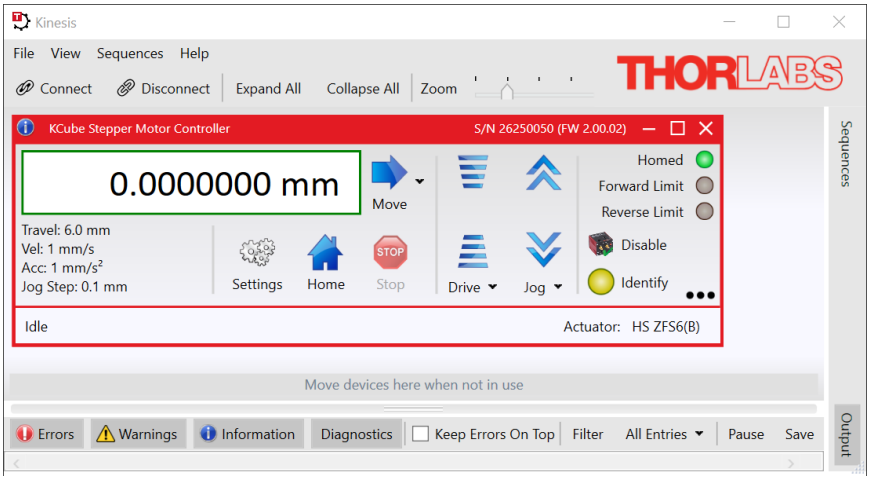


Figure 8 GUI Panel showing Jog and Identify Buttons

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

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

Chapter 4 Standalone Operation

4.1 Introduction

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

The unit offers a fully featured motion control capability including velocity profile settings, limit switch handling, homing sequences and, for more advanced operation, adjustment of settings such as lead screw pitch and gearbox ratio, allowing support for many different actuator configurations. These parameters can be set via the Kinesis Server software - refer Chapter 5. Furthermore, when used with the extensive range of Thorlabs ZST and ZFS motorized 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 Chapter 10.

4.2 Control Panel

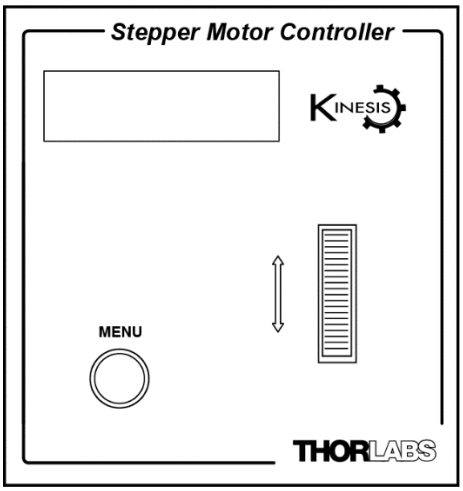


Figure 9 Front Panel Controls and Indicators

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 - refer to 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 - refer to 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'.

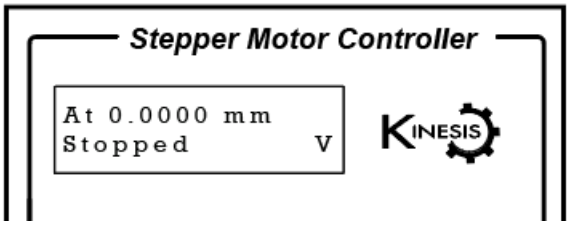


Figure 10 Digital display-Normal Operation

For rotation stages, the position display will be restricted to the "Equivalent Angle" display mode (refer to Section 6.3.7 for more details), so the position displayed will always be a positive number between 0 and 360°. 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 its central position. In this central position the motor is stationary. Different types of moves can be initiated by the wheel, depending on its mode setting. The mode can be set either via the GUI Settings panel, refer to Section 6.3.5 or via the top panel display menu, refer to 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 (refer to Section 5.3 and Section 10.2.2 for further information on the home position).

To initiate a 'Home' refer to 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 1 when it is moved up. These 'taught' positions can be set through the software GUI – refer to Section 6.3.5 or via the display menu, refer to Section 4.4.7.

This mode of operation is enabled by setting the 'Wheel Mode' to 'Go To Position' through the software GUI – refer to 6.3.5 or via the display menu, refer to 4.4.5.

Note

If the current absolute position is outside the 0 to 360° range, then "go to position" will result in a move to the correct angular position within the same 0 to 360 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° and you enter a "go to" position of 10°, the stage will rotate anticlockwise 340° and not clockwise 20°.

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 – refer to Section 6.3.5 or via the display menu, refer to 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 – refer to Section 6.3.2 or via the display menu, refer to Section 4.4.6.

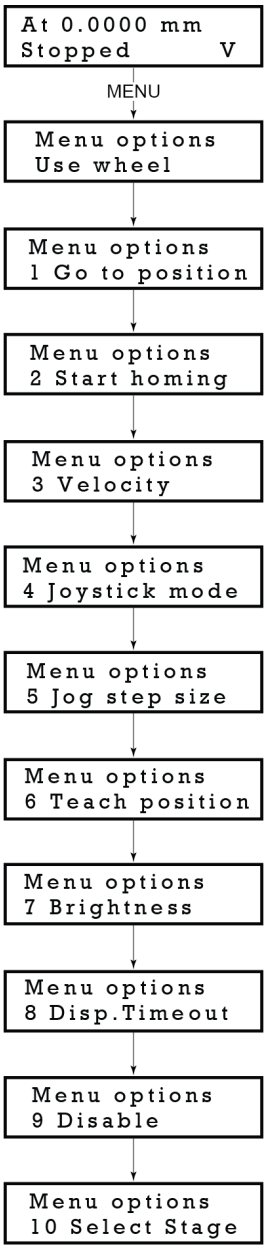
4.3.4 Velocity Moves

Lastly, the wheel can be used to initiate a move at a specified velocity. As the wheel is moved away from the center, 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 software GUI – refer to Section 6.3.5 or via the display menu, refer to Section 4.4.4. The move stops when the wheel is returned to its center position.

4.4 Settings Menu

4.4.1 Overview

Press the MENU button.



Use the wheel to scroll through the menu options.

Press the MENU button to enter a particular option.

Move the stage to an absolute position - see Section 4.4.2

Move the stage to the Home position - see Section 4.4.3

Set the Max Velocity - see Section 4.4.4

Set the joystick wheel mode - see Section 4.4.5

Set the Jog Step Size - see Section 4.4.6

Set the teach positions – see Section 4.4.7

Set the display brightness - see Section 4.4.8

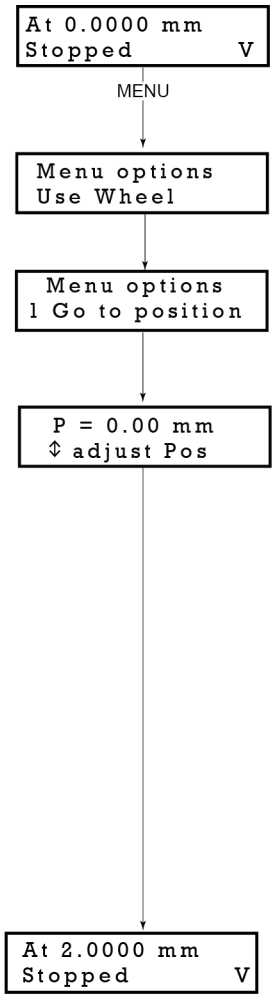
Set the display time out period – see Section 4.4.9

Disable the wheel - see Section 4.4.10

Set the stage being driven - see Section 4.4.11

4.4.2 Menu Option - Go To Position

This mode is used to move to an absolute position.



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

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

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.

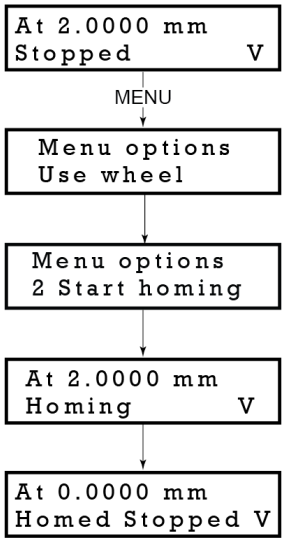
Note for rotation stages. If the current absolute position is outside the 0 to 360° range, then "go to position" will result in a move to the correct angular position within the same 0 to 360° full turn "segment". This means that the move will always stay in the current full turn segment, and from this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

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.



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

Press the MENU button to enter the Start Homing option.

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

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

To stop the move, press the MENU button.

4.4.4 Menu Option - Velocity

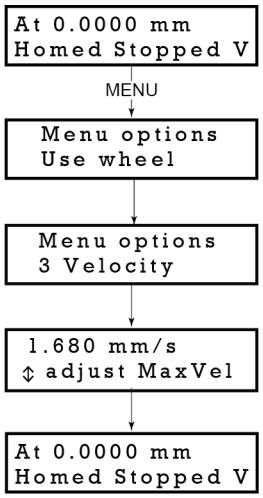
This mode is used to move to set the max velocity.

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

Press the MENU button to enter the Velocity option.

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

Subsequent moves will be performed at the velocity entered.



4.4.5 Menu option - Joystick Mode

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

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

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.

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.

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.*

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.

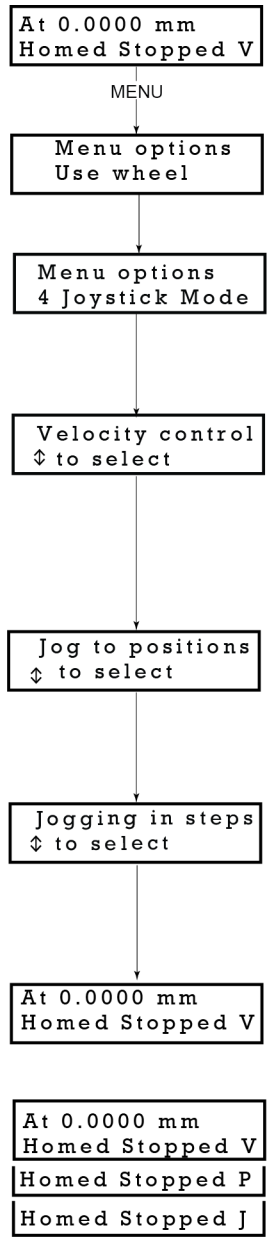
Use the wheel to display the required option, then press MENU to store the selection mode and return to the main display.

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

V = Velocity mode

P = Jog to position mode

J = Jog in steps mode



4.4.6 Menu Option - Jog Step Size

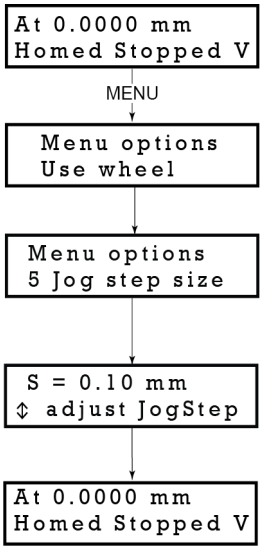
This mode is used to set the jog step size.

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 – refer to Section 4.4.5.

To set Teach Position 1:

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

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

Press the MENU button to enter the Teach position option.

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.

To set Teach Position 2:

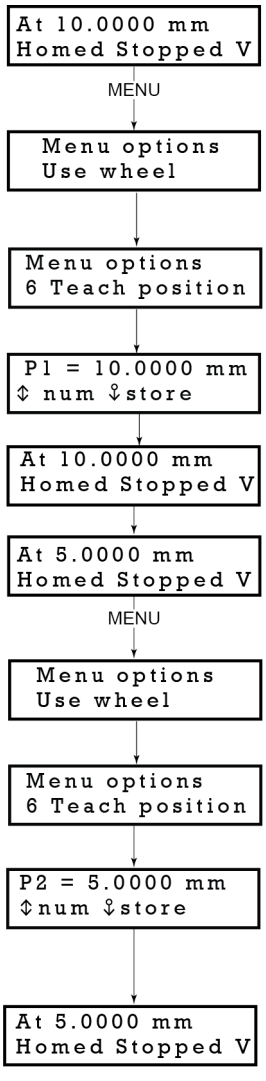
Move the stage to the position to use as teach position 2.

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

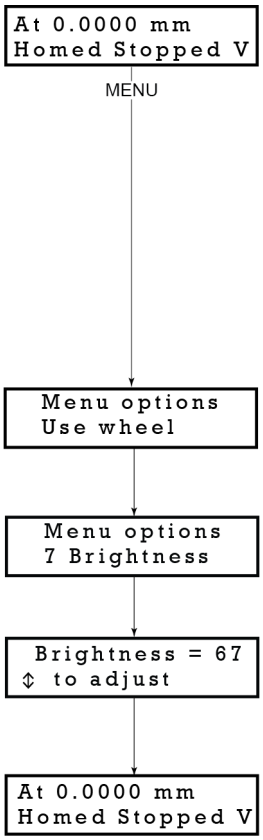
Press the MENU button to enter the Teach position option.

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.

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



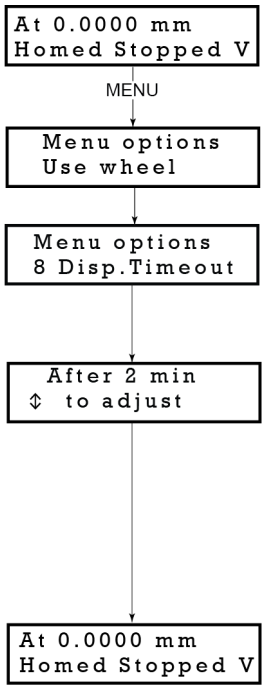
In certain applications, it may be necessary to adjust the brightness of the LED display. The brightness is set as a value from 0 (Off) to 100 (brightest). The display can be turned off completely by entering a setting of zero, however, pressing the MENU button on the top panel will temporarily illuminate 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 Display 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 6.3.5
Press the MENU button to store the selection and return to the main display.

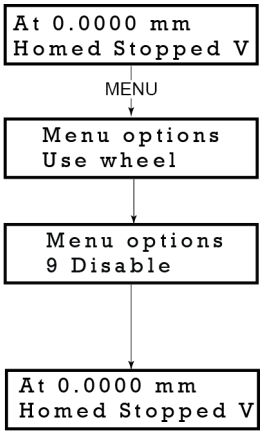
4.4.10 Menu Option - Disable

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 automatically recognize the actuator type and install suitable defaults at start up. In this case, the startup screens will show 'Stage connected xxx' as shown in Figure 7 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, several 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 Kinesis server applies automatically, suitable default parameter values on boot up of the software.

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

Press the MENU button to enter the 9 Select stage option.

Use the wheel to scroll through the options to the required stage type.

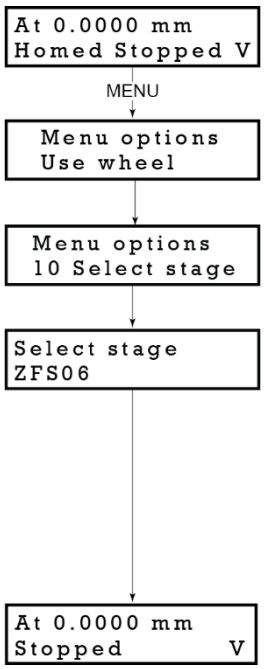
Supported stage types with full performance are:

ZFS06, ZFS13, ZFS25, ZST206, ZST213, ZST225.

Supported stage types with reduced performance are:

DRV225, DRV250, FW103.

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



Chapter 5 PC Operation – Tutorial

5.1 Introduction

The KST201 Stepper Motor Controller is fully compatible with Thorlabs' Kinesis and XA software applications. The remainder of this manual describes the use of the controllers with Kinesis software. For information about operation using Thorlabs' XA software, please refer to the XA User Guide.

The following brief tutorial guides the user through a typical series of moves and parameter adjustments performed using the PC based Kinesis software. It assumes that the unit is electrically connected as shown in Section 3.4, and that the Kinesis Software is already installed – refer to Section 3.2. For illustration purposes, it also assumes that a ZFS motor is connected to the 'Motor' connector on the rear panel.

5.2 Using the Kinesis Software

The Kinesis software application allows the user to interact with any number of hardware control units connected to the PC USB Bus. This program allows multiple graphical instrument panels to be displayed so that multiple units can be controlled. All basic operating parameters can be set through this program, and all basic operations (such as motor moves) can be initiated. Parameter settings can be saved, which simplifies system set up whenever the software is run up.

Perform the following:

1. If required perform the stage association as detailed in Section 4.4.11.
2. Run the kinesis software – Start/All Programs/Thorlabs/Kinesis/Kinesis
3. Refer to the actuator type is displayed in the window. Refer to Section 6.3 for further details on the parameter values shown in the 'Settings' display.

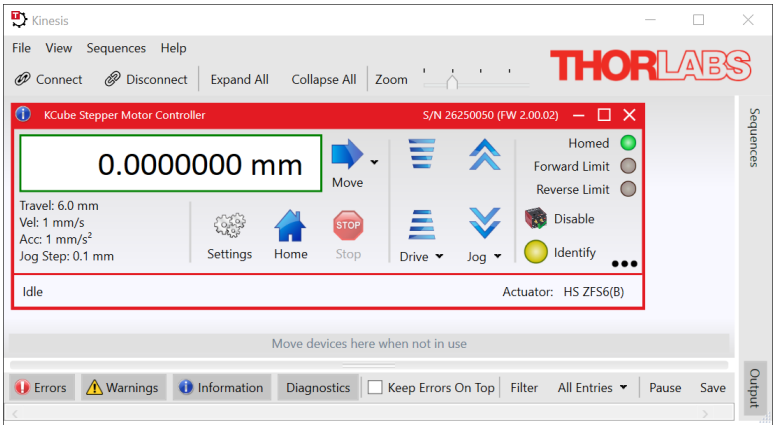


Figure 11 Stepper Driver K-Cube Software GUI

5.3 Homing Motors

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

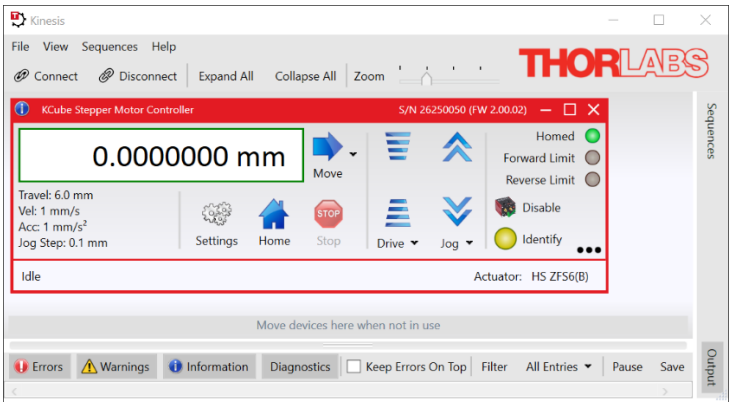


Figure 12 Stepper Driver K-Cube GUI

Perform the following:

1. Click the 'Home' button. Notice that the 'Not Homed' LED changes to 'Homed' and that the LED flashes to indicate that homing is in progress. The displayed position counts down to 0, i.e., the home position.
2. When homing is complete, the 'Homed' LED is lit as shown above. Refer to Section 10.2.2 for background information on the home position.

5.4 Changing Motor Parameters and Moving to an Absolute Position

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

Moves are performed using a trapezoidal velocity profile (refer to Section 10.1.3). 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.

Perform the following:

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

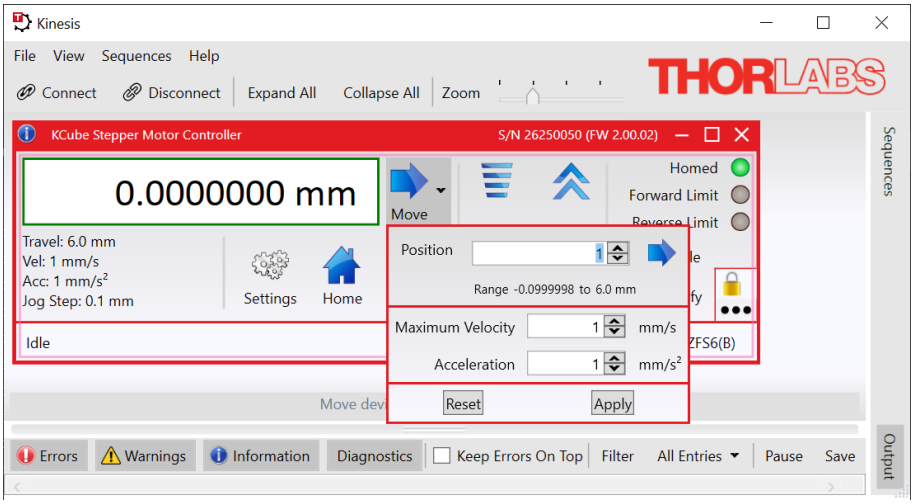


Figure 13 Move Settings Panel

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

5.5 Jogging

During PC operation, the motor actuators are jogged using the GUI panel arrow keys. There are two jogging modes available, 'Single Step' and 'Continuous'. In 'Single Step' mode, the motor moves by the step size specified in the Step Distance parameter. If the jog key is held down, single step jogging is repeated until the button is released – refer Figure 17. In 'Continuous' mode, the motor actuator will accelerate and move at the jog velocity while the button is held down.

Perform the following:

1. On the GUI panel, click the word Jog 'Jog' to display the Settings Panel.

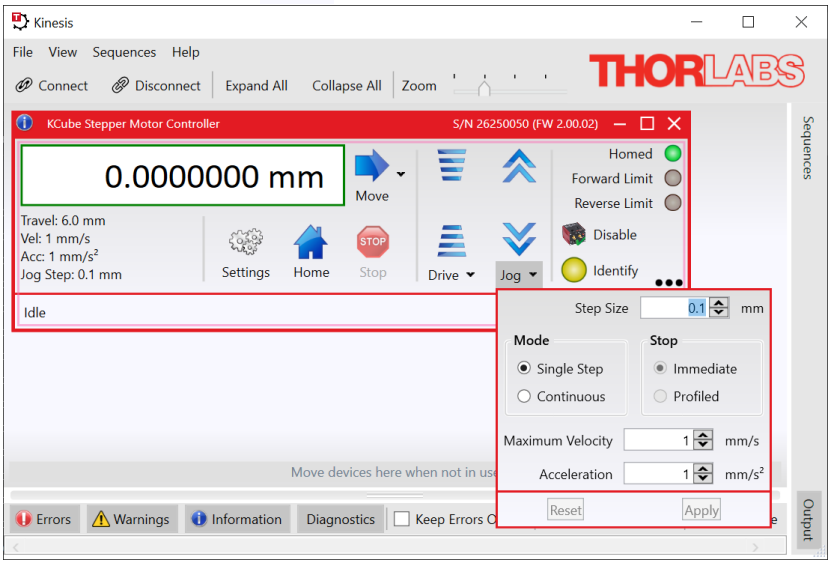


Figure 14 Jog Settings Panel

2. Make parameter changes as required.

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

3. Click 'Apply' to save the settings and close the window. Click 'Reset' to return to the previously saved values.

5.6 Setting Move Sequences

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

5.7 Changing and Saving Parameter Settings

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

Chapter 6 Software Reference

6.1 Introduction

This chapter explains the parameters and settings accessed from the Kinesis software running on a PC.

6.2 GUI Panel

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

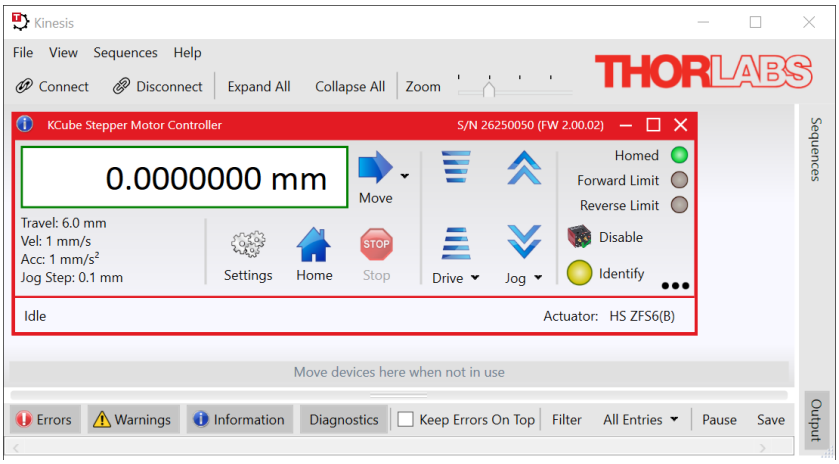
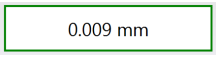


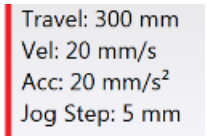
Figure 15 Stepper Driver K-Cube Software GUI

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



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

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



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

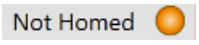
These settings can be adjusted as described previously, or by clicking the Settings button to display the settings window, refer to Section 6.3.2.

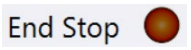


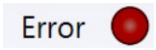
Jog Controls - used to increment or decrement the motor position. The controls comprise a bar graph and a set of jog arrows.

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

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

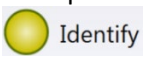
Homed/Not Homed - lit when the motor has not been 'Homed' since power up. When the home button is clicked, the caption changes to 'Homed' and the LED flashes while the home move is being performed. The LED is lit green once the move is complete. 

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

Error - lit when a fault condition occurs. 

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



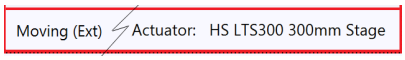
Identify - when this button is pressed, the ACTIVE LED on the front panel of the associated hardware unit will flash for a short period. 

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

Home - sends the motor to its 'Home' position – refer to Section 10.2.2. 

Stop - halts the movement of the motor. 

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

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

6.2.1 Keyboard Shortcuts

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

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

6.3 Settings Panel

When the 'Settings' button on the GUI panel is clicked, the 'Settings' window is displayed. This panel allows motor operation parameters such as move/jog velocities, and stage/axis information to be modified. Note that all these parameters have programmable equivalents (refer to the *Kinesis Server helpfile* for further details).

6.3.1 Persisting Settings to Hardware

Many of the parameters that can be set for the Stepper Driver 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 the Device'* checkbox before clicking the 'OK' button.

Caution

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

6.3.2 Moves/Jogs Tab

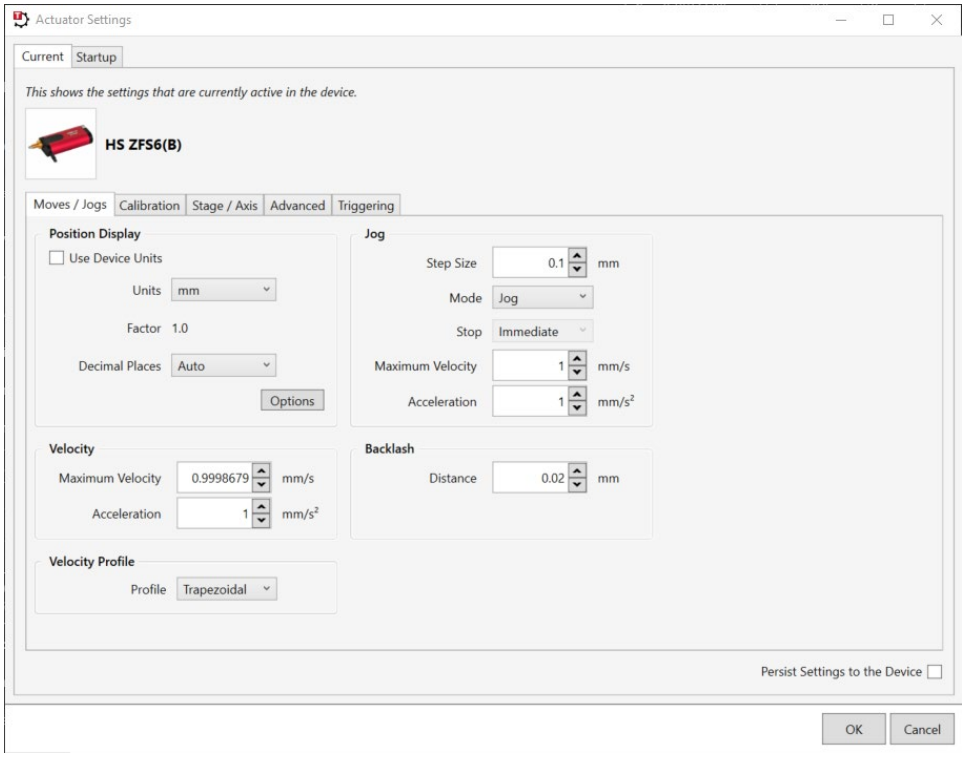


Figure 16 Stepper Driver K-Cube – Move/Jog Settings

Position Display

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

Units - the positioning units used on the GUI display.

Factor - the scaling factor associated with the selected units.

Jog Parameters

Jogs are initiated by using the 'Jog' keys on the GUI panel or the Jog Buttons on the front panel of the unit.

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

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

There are two jogging modes available, 'Jog' and 'Continuous'. In 'Jog' mode, the motor moves by the distance specified in the Step Size parameter. If the jog key is held down, single step jogging is repeated until the button is released – see Figure 17. In 'Continuous' mode, the motor actuator will accelerate and move at the jog velocity while the button is held down.

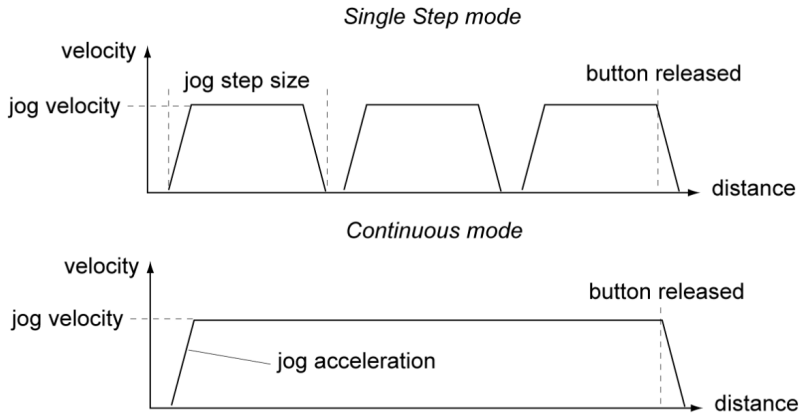


Figure 17 Jog Modes

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

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

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

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

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

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

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

Velocity

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

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

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

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

Backlash

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

Velocity Profile Settings

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

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

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

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

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

In a typical trapezoidal velocity profile, (see Figure 18), 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.

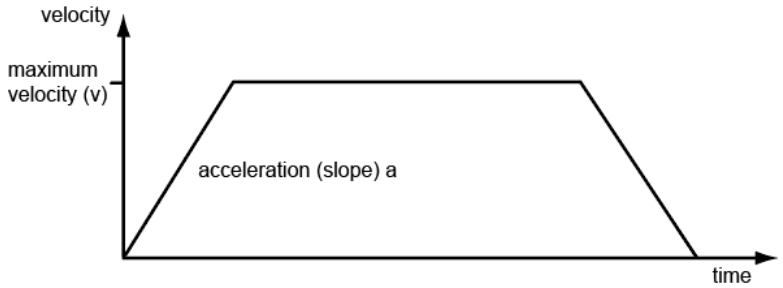


Figure 18 Graph of a Trapezoidal Velocity Profile

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 262 144 (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

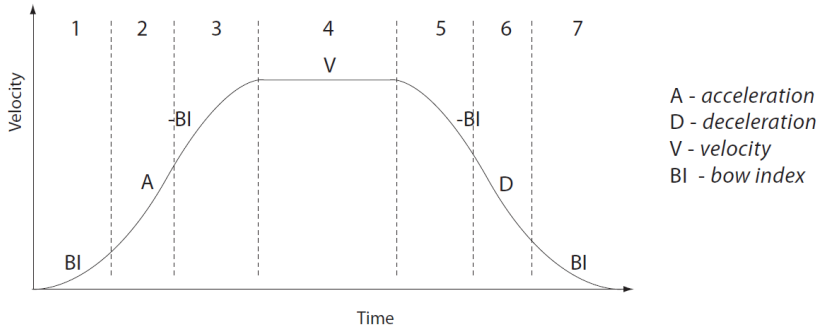


Figure 19 Typical S-Curve Profile

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

Note

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

6.3.3 Calibration Tab

Note

Currently, Thorlabs does not supply calibration files for any stages or actuators compatible with the KST201 Stepper Motor Controller. The following information is supplied to allow calibration data compiled by the customer to be uploaded.

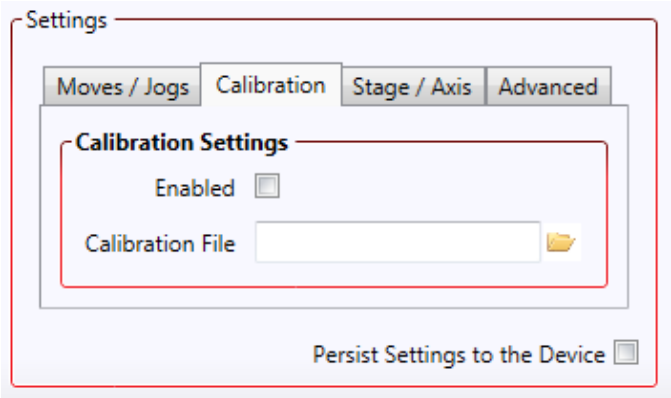


Figure 20 Stepper Drive K-Cube Calibration Settings

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

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

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

Calibration files can be downloaded from the support documents section on the product web page, one file for each serial number.

To assign a calibration file:

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

6.3.4 Stage/Axis Tab

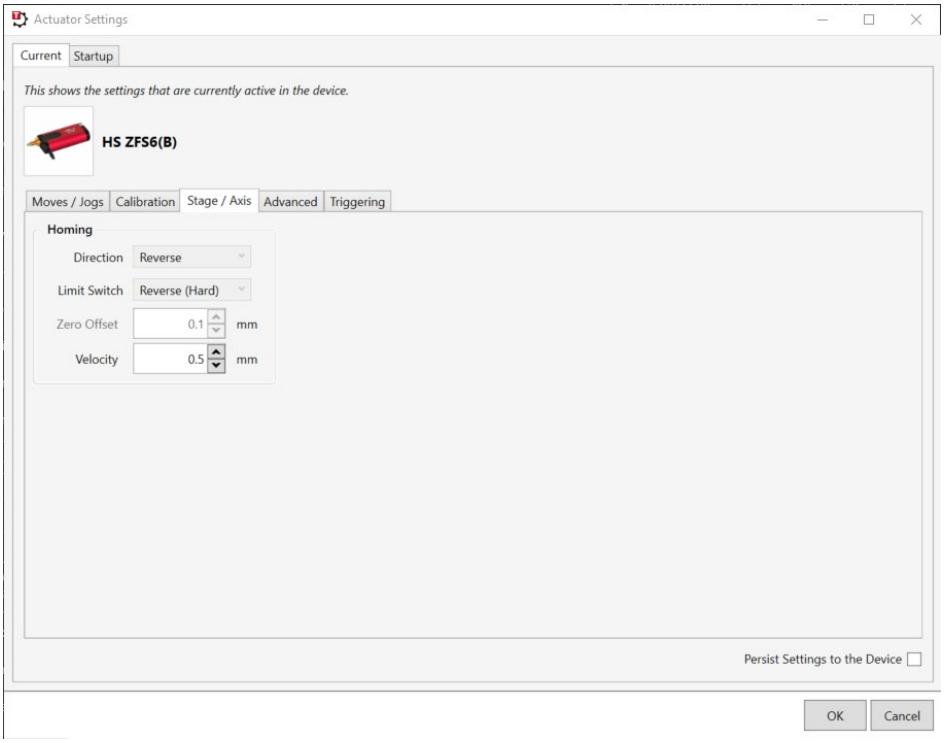


Figure 21 Stepper Driver K-Cube – Stage/Axis Settings

Note

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

For Thorlabs stages, the stage being driven must be associated with the driver, refer to Section 4.4.11. Once this association has been made, the Kinesis server will automatically apply suitable defaults for the parameters on this tab during boot up of the software and these parameters cannot be altered subsequently as it may adversely affect the performance of the stage. Descriptions are provided for information only.

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

Homing Settings

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

Note

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

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

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

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

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

For further information on the home position, refer to Section 10.2.2.

6.3.5 Advanced Tab

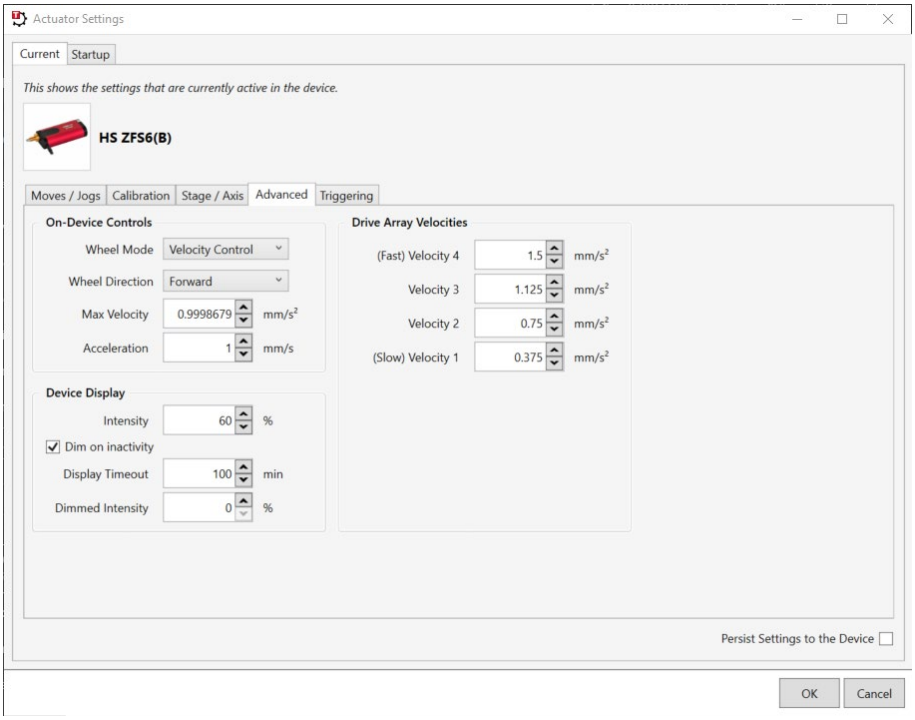


Figure 22 Stepper Driver K-Cube – Advanced Settings

On- Device Controls

The velocity wheel is sprung such that when released it returns to its 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.

Jog - 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.

Move 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 Position 1* and *Preset Position 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:
Forwards - 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.

Reverse- Upwards rotation of the wheel results in a negative motion (i.e., decreased position count).

Device Display

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 *Display Intensity* 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 *Display Timeout* parameter has elapsed. The time interval is specified in minutes in the range 1 to 480. The dim level is set in the *Dimmed Intensity* parameter, as a percentage of full brightness from 0 (Off) to 10 (brightest) but is also limited by the *Display Intensity* parameter if this is lower. These settings are only visible and active if the *Dim device display on inactivity* box is checked.

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.

6.3.6 Triggering Tab

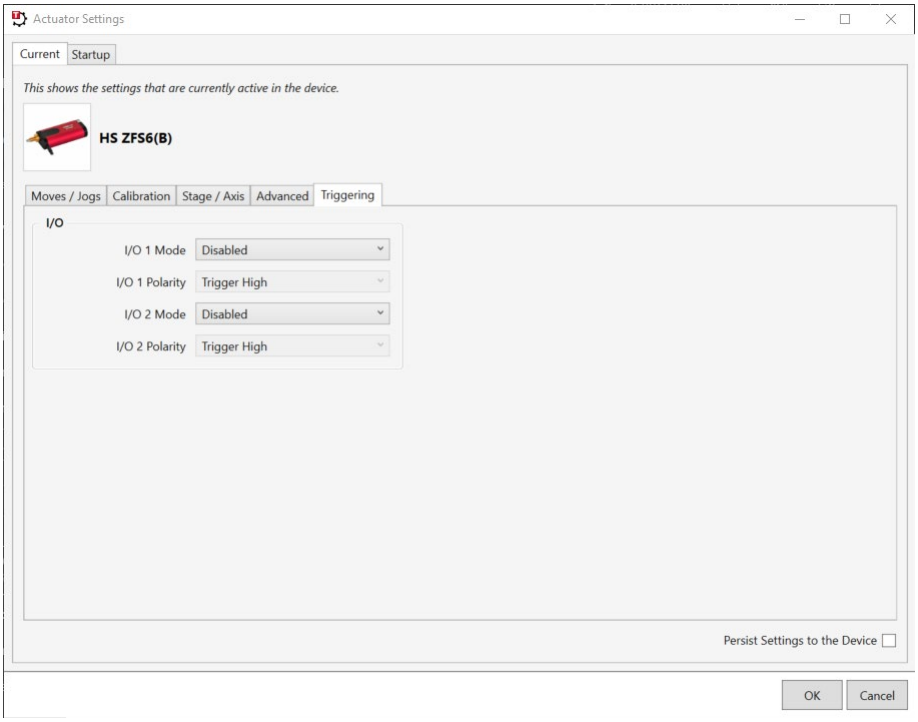


Figure 23 Stepper Driver K-Cube Triggering Settings

Triggering Introduction

The K-Cube motor controllers have two bidirectional trigger ports (I/O 1 and I/O 2) 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 recognized as a logic LOW and a level greater than 2.4 Volt as a logic 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, with 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 I/O ports from any voltage source that can produce an output more than the normal 0 to 5 Volt logic level range. In any case the voltage at the I/O ports must be limited to -0.25 to +5.25 Volts.

Input Trigger Modes

When configured as an input, the I/O 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 must see a transition from the inactive to the active logic state (Low->High or High->Low) for the trigger input to be recognized. For the same reason a sustained logic level will not trigger repeated moves. The trigger input must return to its inactive state first to start the next trigger. The mode is set in the I/O 1 and I/O 2 *Mode* parameters as follows:

Disabled - The trigger IO is disabled.

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

IN - Relative Move - Input trigger for relative move.

IN - Absolute Move - Input trigger for absolute move.

IN - Home - Input trigger for home move.

IN - Stop - Input Trigger for stopping.

Output Trigger Modes

When the I/O 1 *Mode* and I/O 2 *Mode* parameters are configured as outputs, the I/O 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:

OUT GPO - General purpose logic output.
OUT - In Motion - Trigger output active (level) when motor 'in motion'. The output trigger goes high (5V) or low (0V) (as set in the I/O 1 Polarity and I/O 2 Polarity parameters) when the stage is in motion.
OUT - At Max Velocity - Trigger output active (level) when motor at 'max velocity'.
OUT - At Position 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.
OUT - At Position 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.
OUT - At Position 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.
OUT - At Forward Limit - Trigger output active (level) when motor at forward limit switch.
OUT - At Reverse Limit - Trigger output active (level) when motor at reverse limit switch.
OUT - At Limit - Trigger output active (level) when motor at either forward or reverse limit switch.

Trigger Out Position Steps

> **Note**
>
> If the trigger mode is not set to one of the three position step modes mentioned previously, then the following parameters are not applicable and will be hidden.

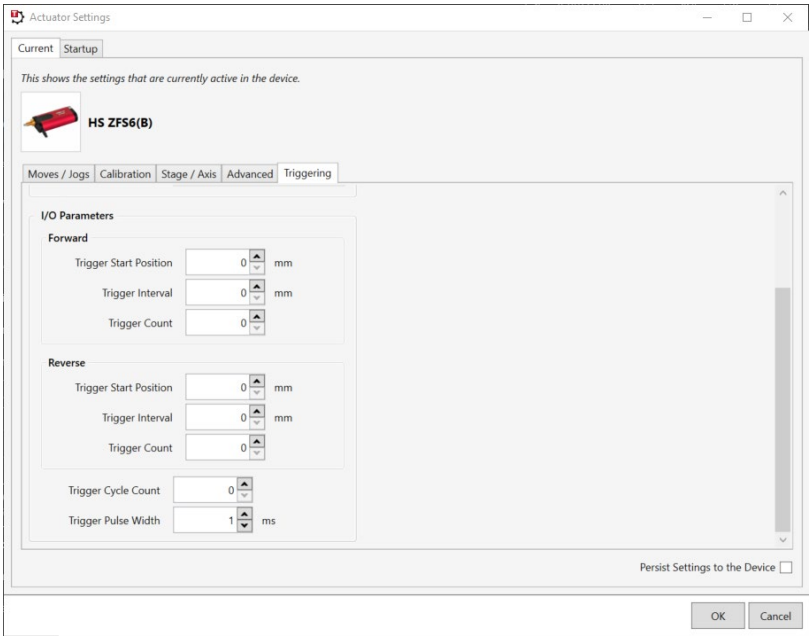


Figure 24 Trigger Out Position Steps

As soon as a position triggering mode is selected on either of the I/O ports, the port will assert the inactive logic state, set in the I/O Polarity parameters.

As the stage moves in its travel range and the actual position matches the position set in the Trigger Start Position parameter, the I/O port will output its active logic state. The active state will be output for the length of time specified by the Trigger Pulse Width parameter, then return to its inactive state and schedule the next position trigger point at the Trigger Start Position value plus the value set in Trigger Interval parameter. Thus, when this second position is reached, the I/O output will be asserted to its active state again. The sequence is repeated the number of times set in the Trigger Count parameter.

When the number of pulses set in the Trigger Count parameter has been generated, the trigger engine will schedule the next position to occur at the position specified in the Reverse Trigger Start Position parameter. The same sequence as the forward direction is now repeated in reverse, except that the Reverse setting parameters apply. When the number of pulses has been output, the entire forward-reverse sequence will repeat the number of times specified by Trigger Cycle Count parameter. This means that the total number of pulses output will be Trigger Cycle Counts x (Forward Trigger Count + Reverse Trigger Count).

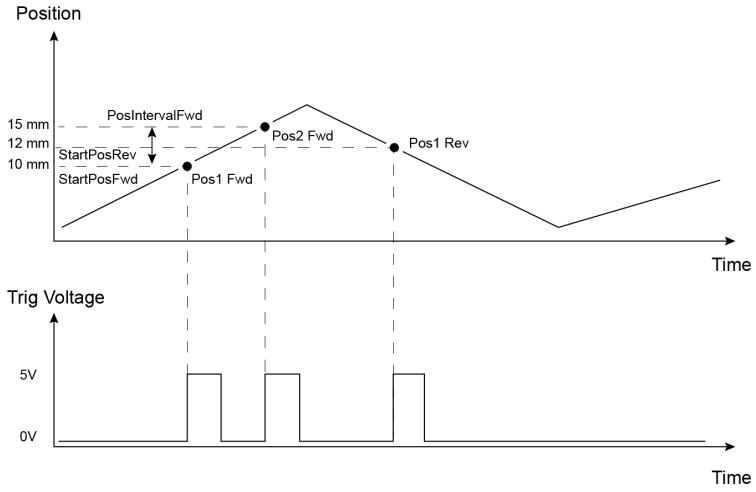


Figure 25 Position Steps Triggering

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 I/O port at a time, as there is only one set of position trigger parameters.

Trigger Polarity

The polarity of the trigger pulse is specified in the I/O *1 Polarity* and I/O *2 Polarity* parameters as follows:

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

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

6.3.7 Rotation/Stages Tab

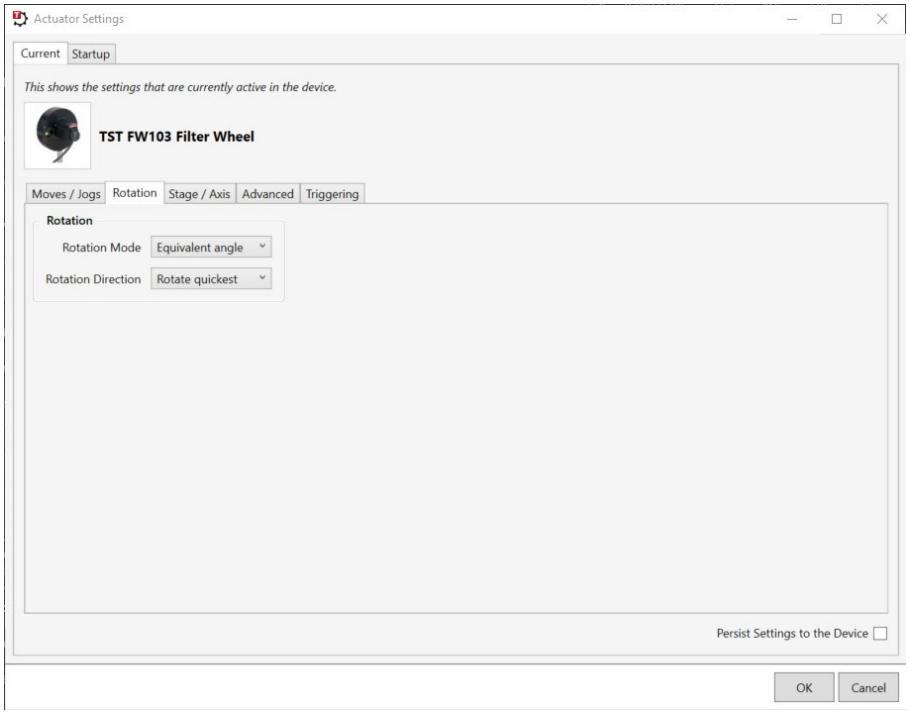


Figure 26 Rotation Stages Tab

Rotation Mode

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

Fixed Range - The angular rotation is limited to 360° i.e., one revolution.

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

Total Angle – 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 Rotation Mode is set to 'Equivalent Angle'.

Rotation Direction

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

Rotate Forwards – The move is performed in a positive direction.

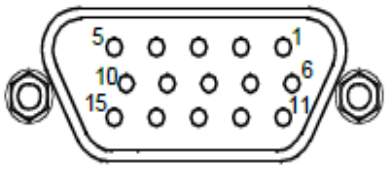
Rotate Reverse - The move is performed in a negative direction.

Rotate Quickest - The move is performed in the quickest direction.

Chapter 7 Rear Panel Connector Pinout Details

7.1 Real Panel Motor Control Connector

The 'Motor' connector provides connection to the stepper motor actuator. The pin functions are detailed below.



Pin	Description	Pin	Description
1	Ground	**9**	Stage Identification
2	CCW Limit Switch	**10**	+5 V DC
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		

Figure 27 Motor I/O Connector Pin Identification

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.

Chapter 8 Preventive Maintenance

Warning



The equipment contains no user serviceable 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.

8.1 Safety Testing

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

8.2 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.

Chapter 9 Specifications

Item #	KST201
Motor Output	
Motor Drive Voltage	12-15 V (Depending on Supply)
Motor Drive Current	750 mA (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, 5V 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	Variable Speed Bidirectional Velocity Control, Forward/Reverse Jogging or Position Preset
Input Power Requirements	
Voltage	12 – 15 V Regulated DC (15 V 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")
USB Connector Type	USB 3.0
USB Connection Speed	USB 1.1 Full Speed (12 Mbps)
Instrument Weight (without baseplate)	140 g (5.0 oz)

Recommended Motor Requirements	
Motor Type	2-Phase Bi-polar Stepper
Peak Power	12 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

Chapter 10 Stepper Motor Operation - Background

10.1 How a Stepper Motor Works

10.1.1 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 Figure 28.

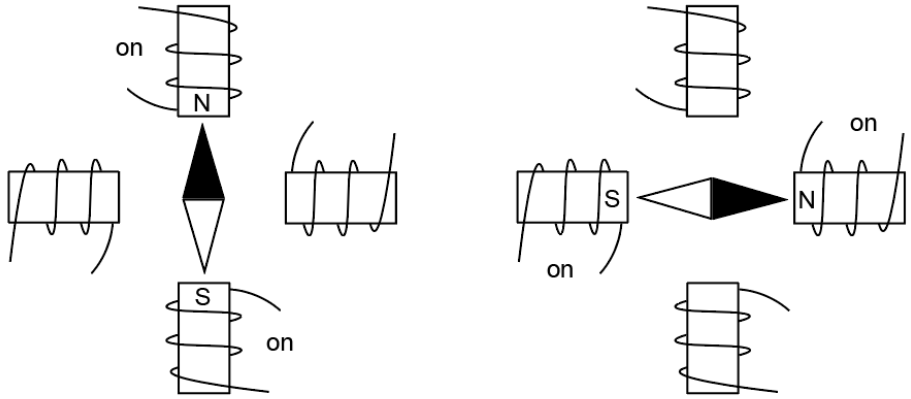


Figure 28 Simplified Concept of Stepper Motor Operation

Although only 4 stator poles are shown above, 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° 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 practice, 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 comes to rest.

10.1.2 Positive and Negative Modes

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.

10.1.3 Velocity Profiles

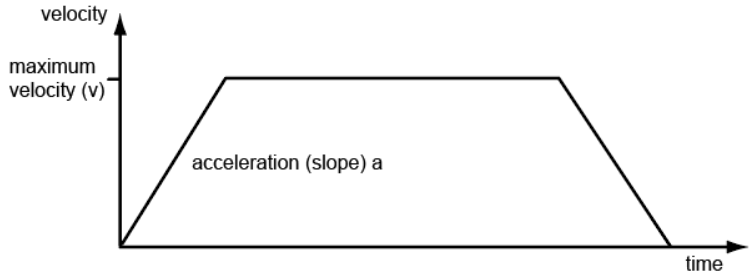
To prevent the motor from stalling, it must be ramped up gradually to its maximum velocity. Certain limits to velocity and acceleration result from the torque and speed limits of the motor, and the inertia and friction of the parts it drives.

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

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

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

In a typical trapezoidal velocity profile, (see 0), 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.



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

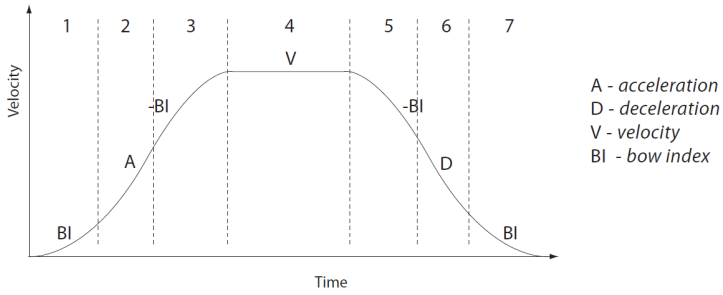


Figure 29 Typical S-Curve Profile

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.

10.2 Positioning a Stage

10.2.1 General

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

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

10.2.2 Home position

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

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

Refer to Section 5.3 for details on performing a Home move.

10.2.3 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 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.

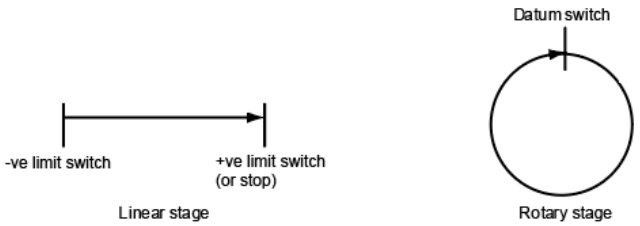


Figure 30 Stage Limit Switches

10.2.4 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 Figure 31.

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

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

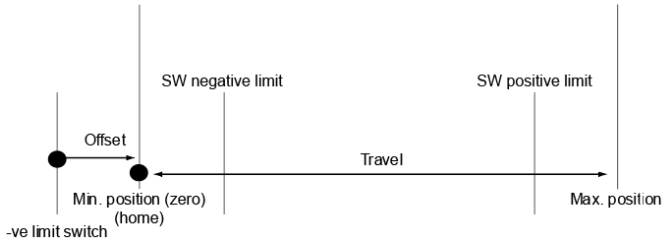


Figure 31 Minimum and Maximum Positions

10.2.5 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 which power saving is implemented by default from the software drivers.

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

10.3 Error Correction

10.3.1 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 Figure 32, 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.

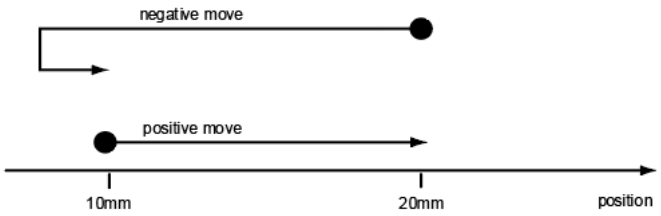


Figure 32 Backlash Correction

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.

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

Chapter 11 Certifications and Compliance



EU Declaration of Conformity

in accordance with EN ISO 17050-1:2010

We: Thorlabs Ltd.

Of: 204 Lancaster Way Business Park, Ely, CB6 3NX, UK

in accordance with the following Directive(s):

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

hereby declare that:

Model: ***KST 201***

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

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

EN 61326-1	Electrical Equipment for Measurement, Control and Laboratory Use - EMC Requirements	2013
EN 63000	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances	2018

and which, issued under the sole responsibility of Thorlabs, is/are 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:

exempt from the requirements of the Directive because its intended application is excluded pursuant to Annex III or Annex IV 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:* 02 February 2023

Name: Keith Dhese

Position: General Manager

EDC - KST 201 -2023-02-02

CE

Chapter 12 Thorlabs Worldwide Contacts

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



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

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

Europe
Thorlabs GmbH
europe@thorlabs.com

Scandinavia
Thorlabs Sweden AB
scandinavia@thorlabs.com

France
Thorlabs SAS
sales.fr@thorlabs.com

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

Japan
Thorlabs Japan, Inc.
sales@thorlabs.jp

China
Thorlabs China
chinasales@thorlabs.com



THORLABS
www.thorlabs.com