K10CR1

Motorized Cage Rotator

User Guide

Original Instructions

Contents

Chapter 1 For Your Safety

1.1 Safety Information

For the continuing safety of the operators of this equipment, and the protection of the equipment itself, the operator should take note of the **Warnings, Cautions** and **Notes** throughout this handbook and, where visible, on the product itself.

The following safety symbols may be used throughout the handbook and on the equipment itself.

Shock Warning

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

Warning

Given when there is a risk of injury to users.

Caution

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

Note

Clarification of an instruction or additional information.

1.2 General Warnings

Warnings

If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. In particular, excessive moisture may impair operation.

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.

The equipment is for indoor use only.

When running custom move sequences, or under fault conditions, the stage may move unexpectedly. Operators should take care when working inside the moving envelope of the stage.

Chapter 2 Overview

2.1 Introduction

The Kinesis K10CR1 is a compact, precision motorized rotation mount that accepts Ø1" optics and SM1-threaded components. It is also compatible with our 30 mm cage systems (and 60 mm cage systems when used with adapter K10CR1A3)

Rotation is driven via a stepper motor equipped with high ratio worm gear (120:1). The integrated stepper motor driver is powered by the host PC USB port and delivers smooth continuous motion which can be controlled both through the software interfaces and by using the buttons on the top face of the unit. The rotating plate features a main scale with 2° graduations and a vernier scale with 12 arc-minute intervals. This rotation stage is also equipped with a precision home limit switch to facilitate automated rotation to the zero datum position, allowing absolute angular positioning thereafter.

The limit switch is designed to allow continuous rotation of the stage over multiple 360° cycles. For complete flexibility the stage can be mounted in a 30 mm cage system, vertically on a post or horizontally using an adapter plate - see Section 3.3 .

For attachment to other stages or fittings, please contact Tech Support.

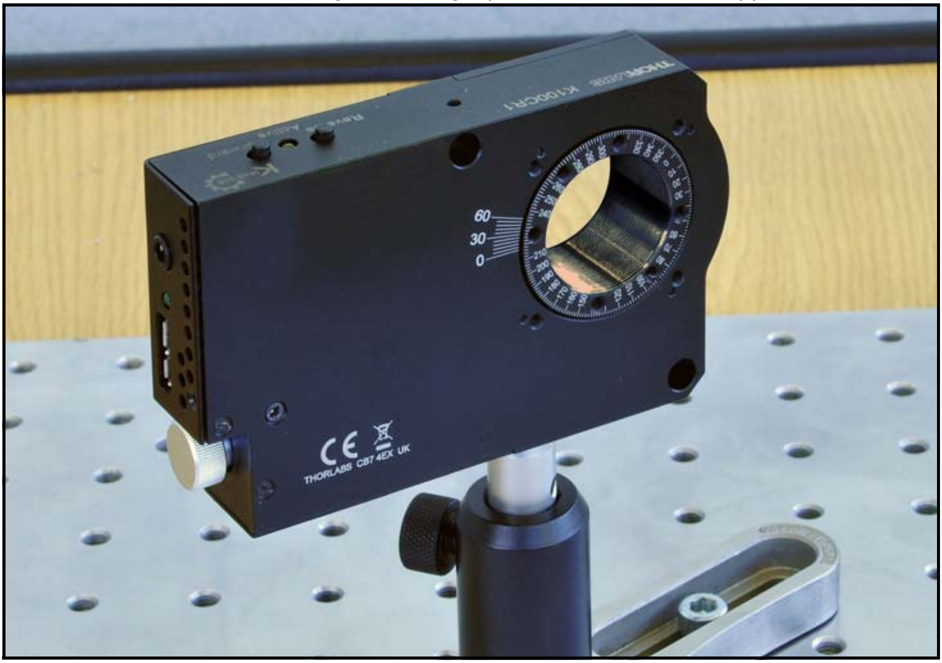


Fig. 2.1 Typical K10CR1 stage

2.2 Kinesis PC Software Overview

2.2.1 Introduction

The driver in the K10CR1 stage shares many of the benefits of the Thorlabs range of motor controllers. These include USB connectivity (allowing multiple units to be used together on a single PC), fully featured Graphical User Interface (GUI) panels, and extensive software function libraries for custom application development.

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

The User Interface allows full control of all settings and operating modes enabling complete ‘out-of-box’ operation without the need to develop any further custom software. It provides all of the necessary system software services such as generation of GUI panels, communications handling for multiple USB units, and logging of all system activity to assist in hardware trouble shooting. The Kinesis server is also used by software developers to allow the creation of advanced automated positioning applications very rapidly and with great ease. The Kinesis server is described in more detail in Section 2.2.2.

2.2.2 Kinesis Server

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

With the Kinesis system, .Net Controls are deployed to allow direct control over (and also reflect the status of) the range of electronic controller units, including the K10CR1 stage. 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 K10CR1 stage.

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

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

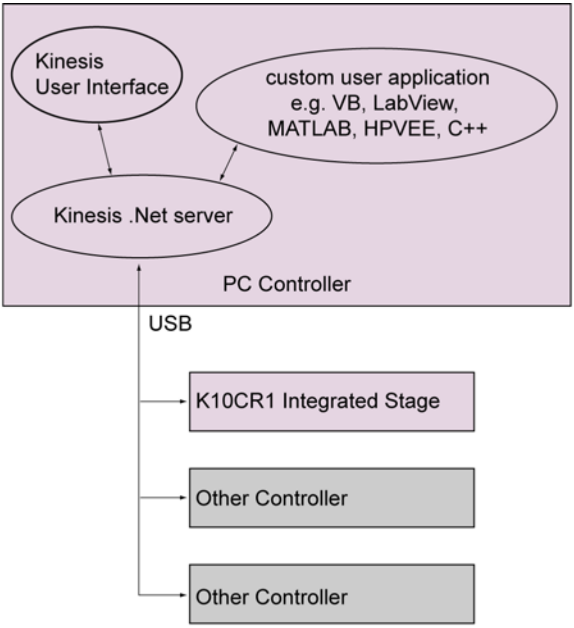


Fig. 2.2 System Architecture Diagram

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

2.2.3 Software Upgrades

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

Chapter 3 Mechanical Installation

3.1 Unpacking

Note

Retain the packing in which the unit was shipped, for use in future transportation.

Caution

Once removed from its packaging, the stage is easily damaged by mishandling. The unit should only be handled by its base, not by the motor or any attachments to the moving platform.

3.2 Environmental Conditions

Warning

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

Location	Indoor use only
Maximum altitude	2000 m
Temperature range	5 to 40°C (41 to 104°F)
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.

The unit must not be used in an explosive environment.

3.3 Mounting

The stage can be mounted to a standard 1/2” post, via the M4 (8-32) threaded holes in the side faces (as shown in Fig. 3.1.). For horizontal use, the stage can be fixed to the worksurface by using adapter plate K10CR1A1 (see Fig. 3.2). The combined deck height is 26 mm (1.02”).

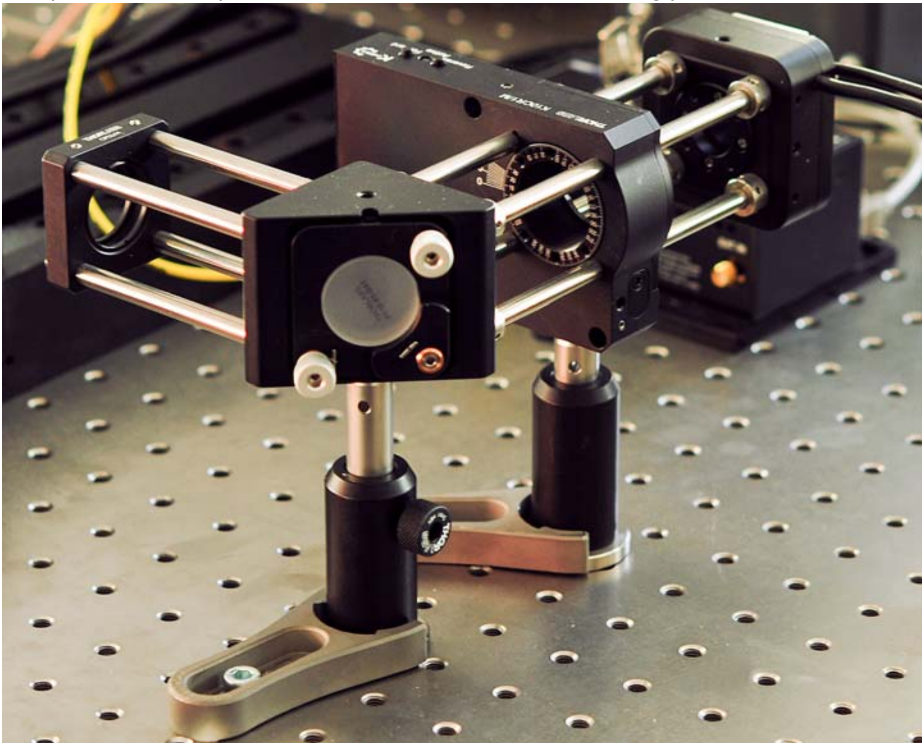
The rotating platform features several options for mounting accessories. The central aperture has a standard SM1 internal thread, for compatibility with a range of optics. Accessories can also be fixed using the series of threaded mounting holes (see Fig. 3.3).

Standard ‘tongue and groove’ accessories can be mounted using the K10CR1A2(/M) grooved adapter plate (see Fig. 3.2), which raises the deck height to 30 mm (1.18”).

The casing of the K10CR1 is fitted with a series of holes for mounting the unit in a 30 mm cage system (see Fig. 3.1 and Fig. 3.3).

The K10CR1A3 adapter plate allows the stage to be fitted within a 60 mm cage system. Using this adapter, the stage can be moved into and out of the cage system quickly and easily, allowing optics to be changed without disassembly of the cage structure.

The stage can also be used with our K6A1 platform mount (see Fig. 3.3) which allows a prism or other optical device to be mounted to the rotating platform..



Caution

When mounting components, or fitting the stage within an application, do not apply excessive pressure to the moving platform.

Fig. 3.1 K10CR1 Mounted in a 30 mm Cage System

Fig. 3.2 K10CR1 Stage with K10CR1A1 and K10CR1A2 Adapter Plates Fitted

3.4 Transportation

Caution

When packing the unit for shipping, use the original packing. If this is not available, use a strong box and surround the unit with at least 100 mm of shock absorbent material.

3.5 Dimensions

3.5.1 K10CR1 Dimensions

All dimensions in millimeters (inches)

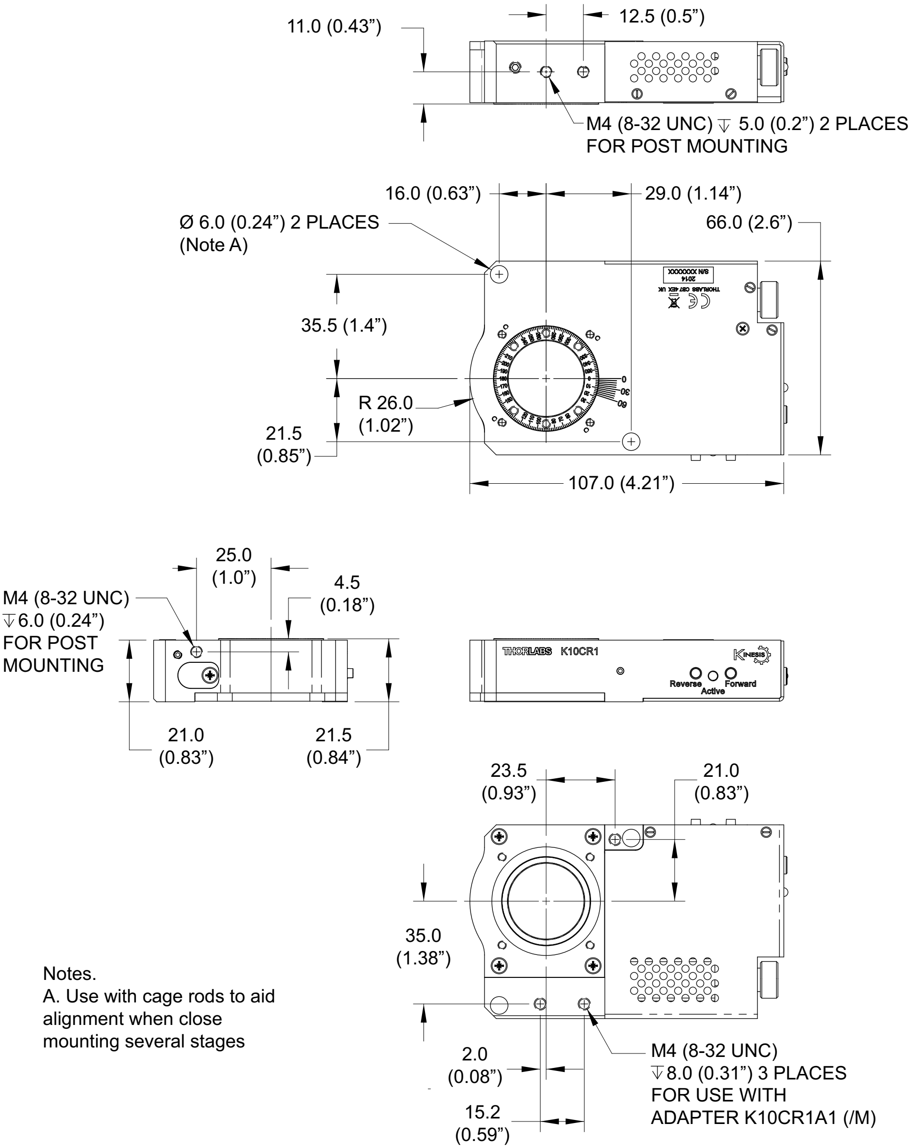


Fig. 3.3 Stage Dimensions

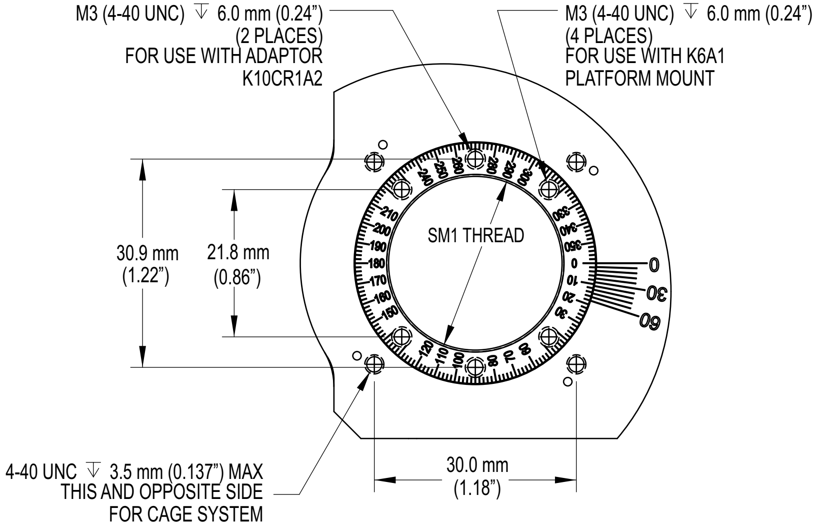


Fig. 3.4 Top Plate Detail

Chapter 4 Software & Electrical Installation

4.1 Installing the Software

Caution

If your PC becomes unresponsive (e.g due to an operating system problem, entering a sleep state condition, or screen saver operation) for a prolonged period, this may interrupt communication between the Software and the hardware, and a communications error may be generated. To minimize the possibility of this happening it is strongly recommended that any such modes that result in prolonged unresponsiveness be disabled before the software is run. Please consult your system administrator or contact Thorlabs technical support for more details.

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 STAGE 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.

4.2 Power Supplies

Power is supplied via the USB port on the side panel. Power can come from the host PC, a powered USB hub or from a single or multi-port USB charging unit. Control is via the top panel buttons and any software settings that have been persisted (saved) to the unit.

In each case, consideration should be given to the amount of devices being driven and care should be taken not to overload the power supply. if the power to the unit is reduced significantly, the motor could stall and the processor within the unit could reset due to a dip in voltage.

4.3 Connector Detail

The side of the unit is fitted with a number of connectors as shown below:.

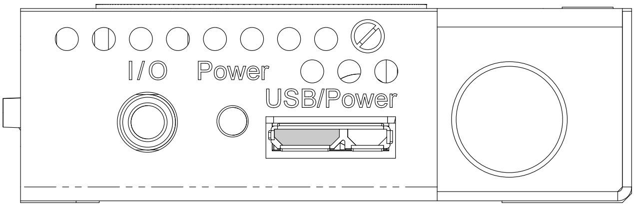


Fig. 4.1 Power and USB Connectors

USB/Power - Provides connection to the PC USB port or the USB hub. Although the port is designed to mate with a USB 3.0 connector, it can also be used with a 'USB Micro B' type connector, which plugs into the left hand side shown shaded above.

Power LED - Green LED, lit when power is applied to the unit.

I/O - 3.5 mm 4-way jack socket, provides connection to an external Trigger IN/Out source. Pin out is as shown below.

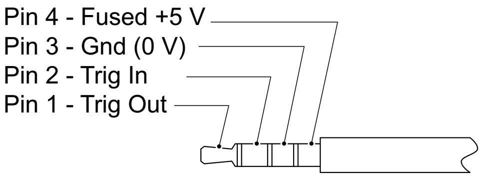


Fig. 4.2 I/O Pin Out Detail

4.4 Connecting The Hardware

1) Perform the mechanical installation as detailed in Section 3.
2) Install the Kinesis Software - see Section 4.1.
3) Using the USB cable provided, connect the stage unit to your PC or a powered USB hub.

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).

The USB connection provides both power and comms. When power is applied, the green 'Power' LED is lit.

4) Wait for the unit to initialize (about 5 sec). Do not press any controls during this time. The ENABLE LED is lit when the unit is ready for use.
5) Windows^{TM} should detect the new hardware. Wait while Windows^{TM} installs the drivers for the new hardware.

4.5 Verifying Software Operation

4.5.1 Initial Setup

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

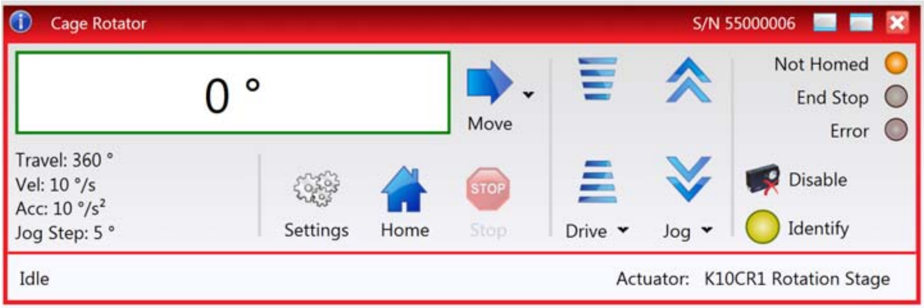


Fig. 4.3 Gui panel showing jog and ident buttons

2) Check that the correct stage type and serial number are displayed in the GUI panel.
3) Click the ‘Ident’ button. The ACTIVE LED on the side of the unit flashes - see Section 5.2. 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 associated stage 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 5 Operation

5.1 Introduction

The following brief tutorial guides the user through a typical series of moves and parameter adjustments performed using the software. It assumes that the unit is electrically connected as described in Section 4.4. and that the Software is already installed - see Section 4.1.

5.2 Standalone Operation

The unit is shipped with a set of default parameters already loaded, and can be operated via the buttons on the top face of the unit.

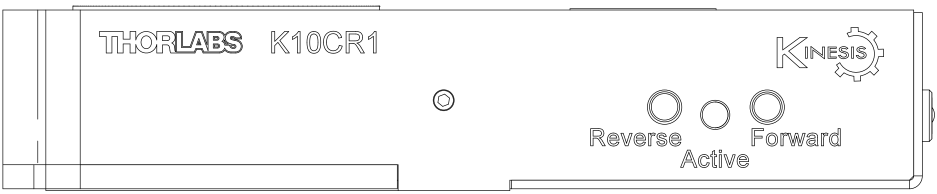


Fig. 5.1 K10CR1 Buttons and LEDs

Active LED - Yellow LED, lit when the stage is in motion. Flashes when the Ident button on the GUI panel is clicked - see Section 4.5.1..

Reverse - Press to move the stage in the reverse (clockwise) direction.

Forward - Press to move the stage in the forward (counter-clockwise) direction.

5.3 Button Operation

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

5.3.1 Homing

A 'Home' move is performed to establish a datum from which subsequent absolute position moves can be measured (see Section 5.5. and Section B.2.2. for further information on the home position).

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

5.3.2 Go to Position

Each button can be programmed with a different position value, such that the controller will move the motor to that position when the specific button is pressed.

This mode of operation is enabled by setting the 'Button Mode' parameter to 'Go To Position' on the Controls settings tab, and then entering the required position values. See Section 6.3.5. for further information.

5.3.3 Jogging

The side panel buttons can also be configured to 'jog' the motor. This mode of operation is enabled by setting the 'Button Mode' parameter to 'Jogging' on the 'Controls' settings tab - see Section 6.3.5. Once set to this mode, the jogging parameters for the buttons are taken from the 'Jog' parameters on the 'Move/Jogs' settings tab - see Section 6.3.2.

5.3.4 Switching Between Button Modes

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

5.4 Using the Kinesis Software

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

1) Run the Kinesis software - Start/All Programs/Thorlabs/Kinesis/Kinesis.

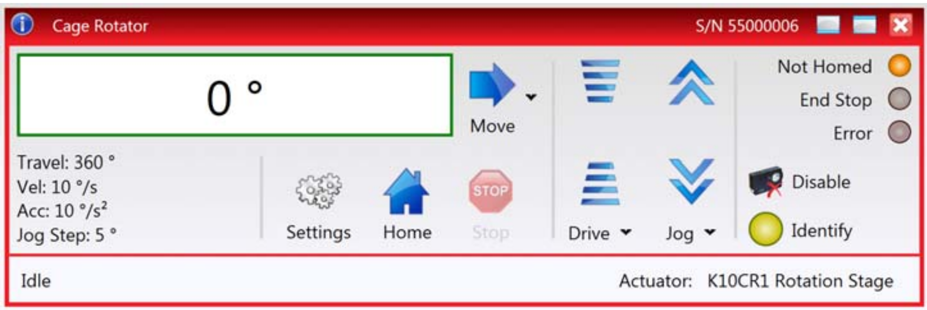


Fig. 5.2 K10CR1 Stage Software GUI

5.5 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.

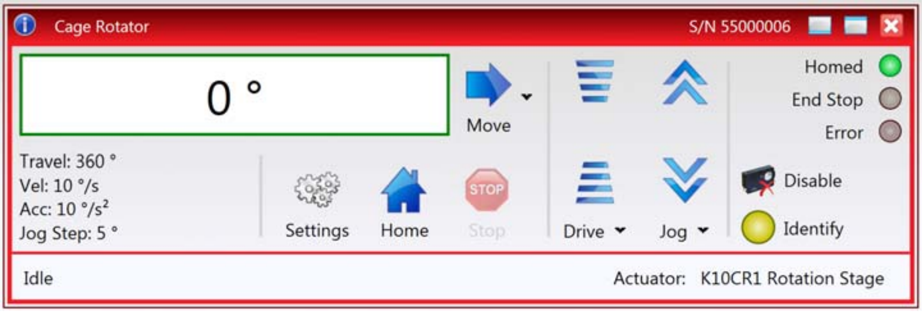


Fig. 5.3 K10CR1 Stage GUI

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

Note

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

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

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

5.6 Changing Motor Parameters and Moving to an Absolute Position

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

Moves are performed using a trapezoidal velocity profile (see Appendix B , Section B.1.3.). The velocity settings relate to the maximum velocities at which a move is performed, and the acceleration at which the motor speeds up from zero to maximum velocity.

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

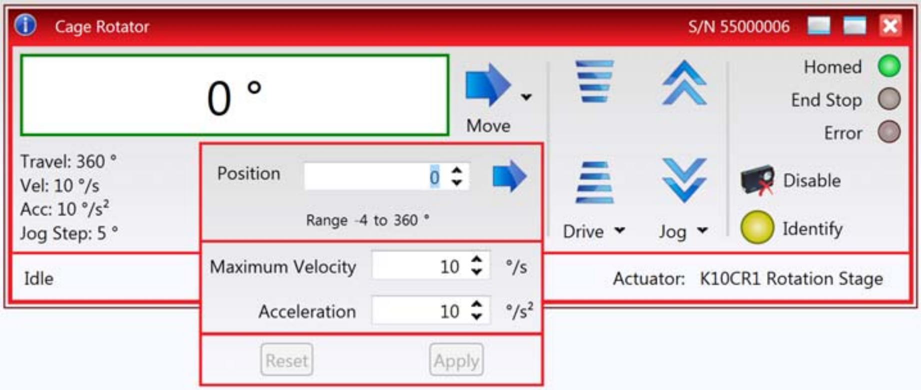


Fig. 5.4 Move Settings Panel

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.

5.7 Jogging

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

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

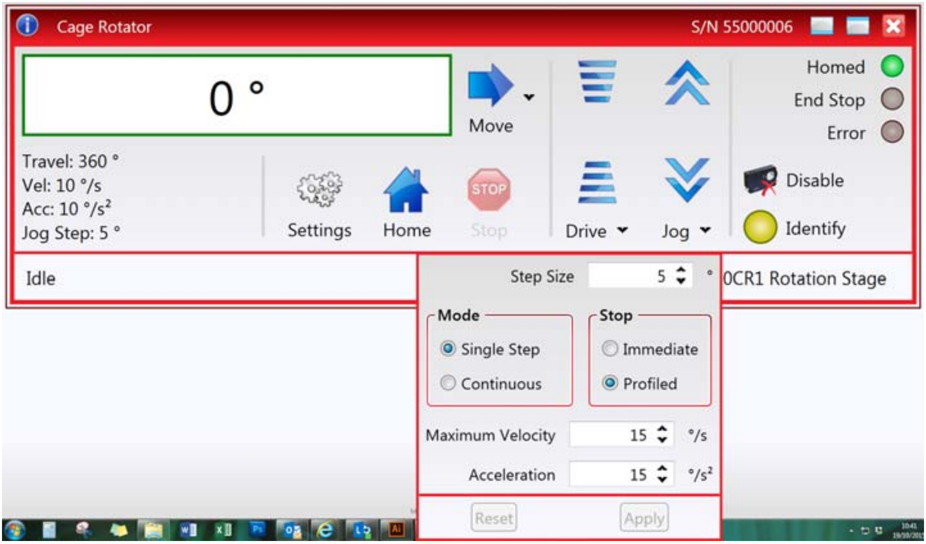


Fig. 5.5 Jog Settings Panel

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.

5.8 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*.

5.9 Changing and Saving Parameter Settings

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

Chapter 6   Software Reference

6.1   Introduction

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

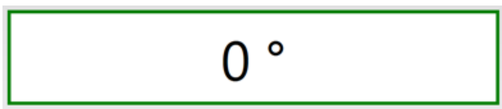
6.2   GUI Panel

The following screen shot shows the graphical user interface (GUI) displayed when accessing the stage using the Kinesis software.

Fig. 6.1   K10CR1 Stage Software GUI

Note

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

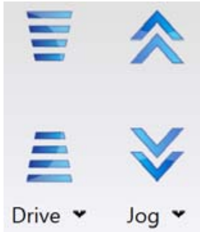


Position window - shows the position (in millimetres or degrees) of the motor. The motor must be 'Homed' before the display will show a meaningful value, (i.e. the displayed position is relative to a physical datum, the limit switch).

Move - Opens the settings window, so that position data and velocity parameters can be entered - see Section 5.6. Moves are performed using the current velocity parameters which can be changed in the same panel. The present settings are displayed below the window.

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

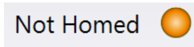
These settings can be adjusted as described previously, or by clicking the Settings button to display the settings window, see Section 6.3.2.



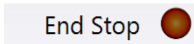
Jog Controls - used to increment or decrement the motor position. The controls comprise a bar graph and a set of jog arrows.

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

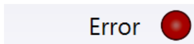
When the arrows are clicked, the motor is driven in the selected direction at the jog velocity, one step per click. The step size and jog velocity parameters can be changed by clicking 'Jog' or the small down arrow to display the settings panel.



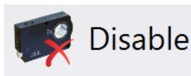
Homed/Not Homed - lit when the motor has not been 'Homed' since power up. When the home button is clicked, the caption changes to 'Homed' and the LED flashes while the home move is being performed. The LED is lit green once the move is complete.

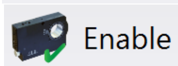


End Stop - lit when a limit switch is activated, i.e. the motor is at its end stop.



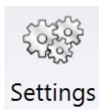
Error - lit when a fault condition occurs.





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

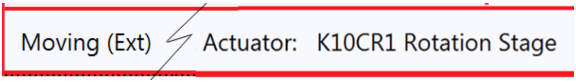
Identify - when this button is pressed, the ACTIVE LED on the front panel of the associated hardware unit will flash for a short period.



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

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

Stop - halts the movement of the motor.



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

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

6.2.1 Keyboard Shortcuts

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

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

6.3 Settings Panel

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

6.3.1 Persisting Settings to Hardware

Many of the parameters that can be set for the K10CR1 stage can be stored (persisted) within the unit itself, such that when the unit is next powered up these settings are applied automatically. This is particularly important when the driver is being used manually in the absence of a PC and USB link. The Velocity Profile and Jogging parameters described previously are good examples of settings that can be altered and then persisted in the driver for use in absence of a PC. To save the settings to hardware, check the '*Persist Settings to the Device'* checkbox before clicking the 'OK button.

Caution

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

6.3.2 Moves/Jogs Tab

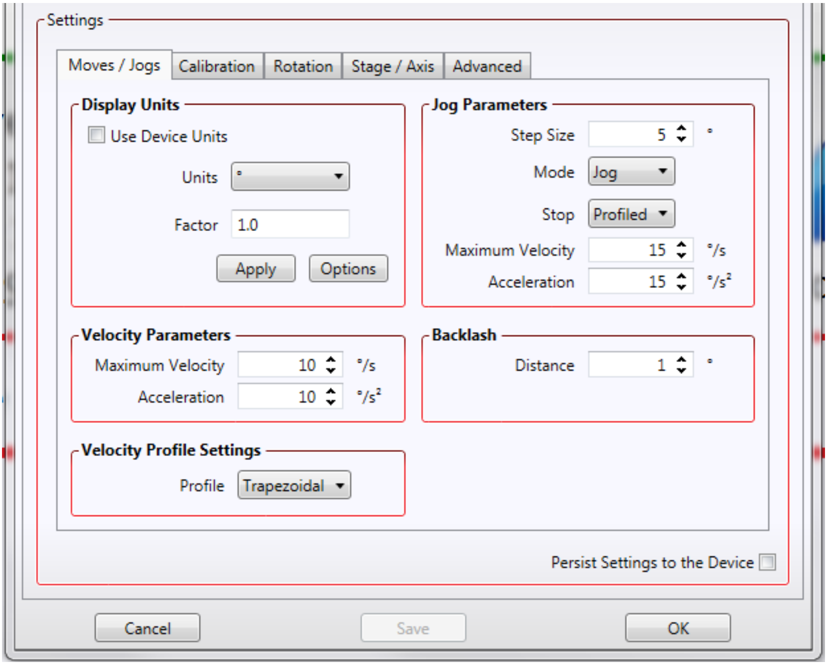


Fig. 6.2 Move/Jog Settings

Display Units

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

Units - the positioning units used on the GUI display.

Factor - the scaling factor associated with the selected units.

Jog Parameters

Jogs are initiated by using the 'Jog' keys on the GUI panel (see Section 5.7.), 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 (degrees).

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

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

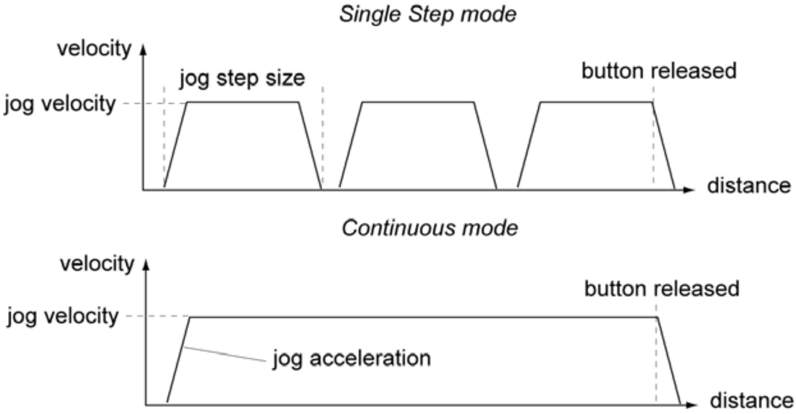


Fig. 6.3 Jog Modes

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

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

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

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

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

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

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

Velocity Parameters

Moves can be initiated via the GUI panel by entering a position value after clicking on the position display box (see Section 5.6.), or by calling a software function (see the KinesisServer helpfile). The following settings determine the velocity profile of such moves, and are specified in real world units, millimetres or degrees.

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

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

Note

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

Backlash

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

Velocity Profile Settings

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

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

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

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

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

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

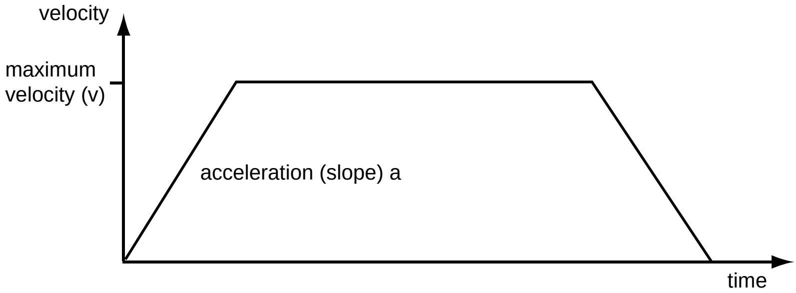


Fig. 6.4 Graph of a trapezoidal velocity profile

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

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

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

Example

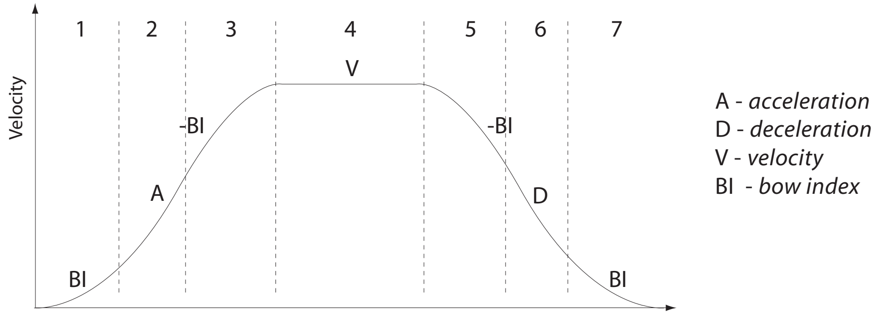


Fig. 6.5 Typical S-Curve Profile

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

Note

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

6.3.3 Rotation Stages Tab

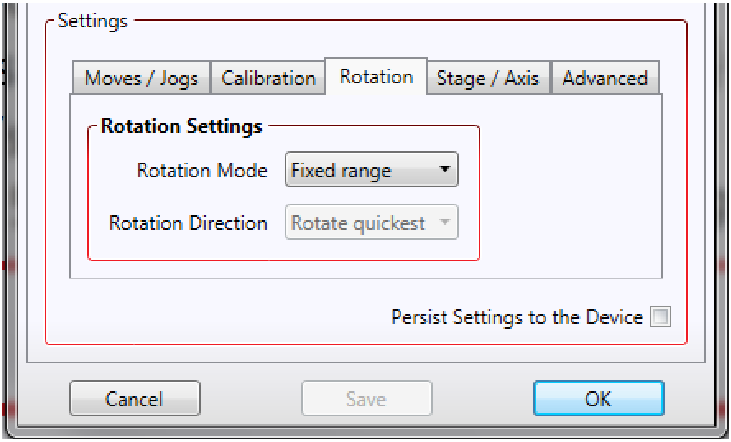


Fig. 6.6 Advanced Settings

Rotation Mode

This setting relates to the way in which the angular position is displayed on the GUI panel.

Fixed Range - The rotation is limited to a single revolution of 360°.

Equivalent Angle – 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 – The total angular rotation is displayed, e.g. for a movement of two full rotations plus 10°, the display will show 730°.

Note

The position display on the GUI panel will show the position up to a maximum of 15,480° or 43 full revolutions. Beyond this, the platform will continue to rotate but the position display is no longer accurate. To restore the positional accuracy of the display the stage should be homed.

Note. The following parameters are applicable only if the Rotation Mode is set to ‘Equivalent Angle’.

Rotation Direction

This setting specifies the move direction.

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

6.3.4 Stage/Axis Tab

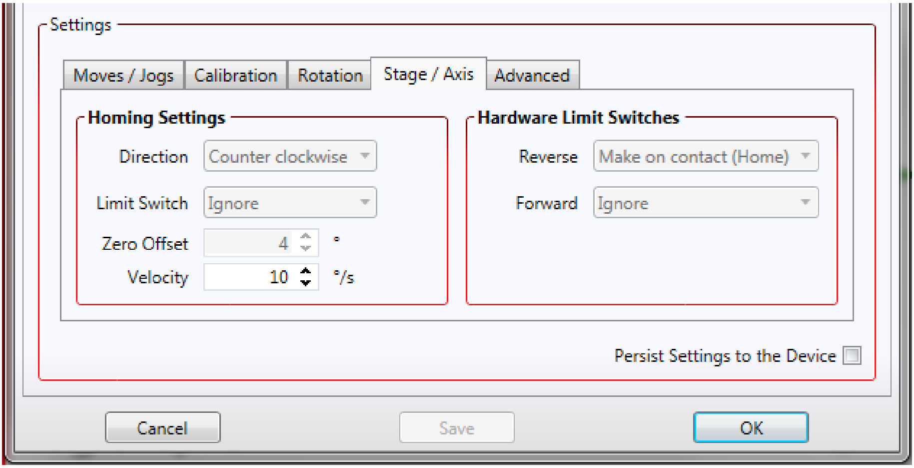


Fig. 6.7 Stage/Axis Settings

Note

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

For K10CR1 stages, the server will automatically apply suitable defaults for the parameters on this tab during boot up of the software. These parameters should not be altered subsequently, as this may adversely affect the performance of the stage.

For background information, the individual parameters are described in the following paragraphs.

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 Clockwise or both Counter Clockwise.

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

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

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

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

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

Hardware Limit Switches

Note

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

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

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

6.3.5 Advanced Tab

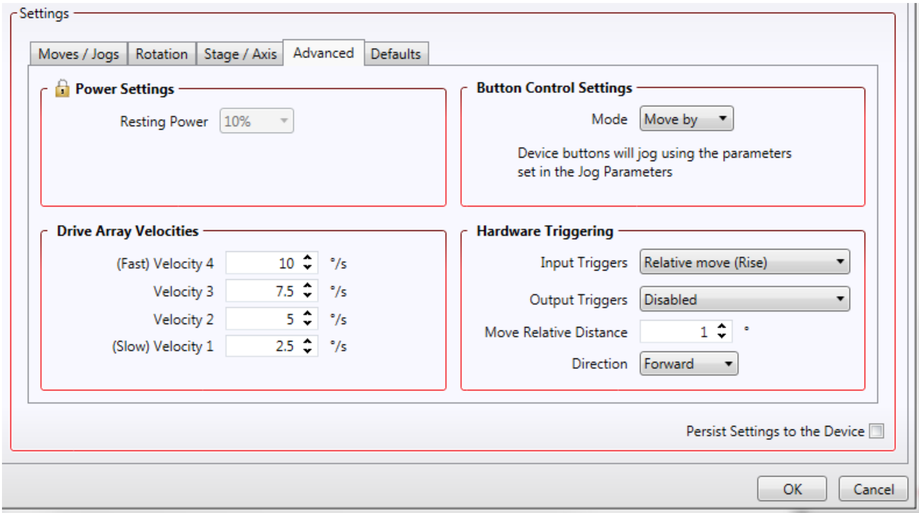


Fig. 6.8 Advanced Settings

Power Settings

The K10CR1 stage is designed to vary the phase powers (current) in the motor coils depending on the operating state of the motor - moving or stationary. Typically, when a stepper motor is at rest it is advisable to reduce the phase (holding) currents so that the motor does not overheat. When moving, these phase currents are boosted to provide sufficient motor torque and minimise the possibility of stalling (missed steps) The moving phase powers are set automatically by the unit and cannot be adjusted.

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

Note

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

Button Control Settings

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

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

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

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

Note

The following parameters are applicable only if 'Move To' is selected in the '*Mode*' field.

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

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

Note

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

Drive Array Velocities

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

Note

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

6.3.6 Hardware Triggering

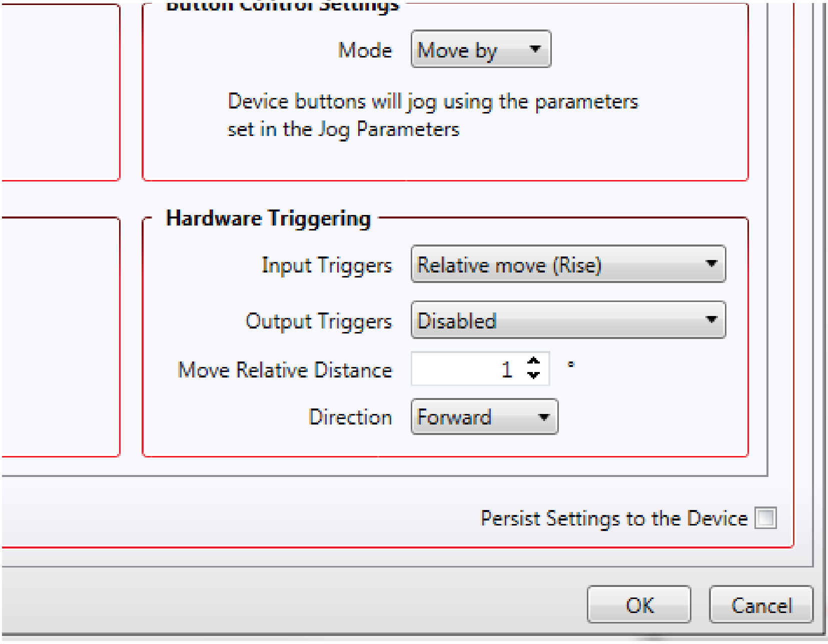


Fig. 6.9 Stepper Driver K-Cube - Triggering Settings

Triggering Introduction

The K10CR1 controller has a bidirectional trigger port (IO) that can be used to read an external logic signal and 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 port outputs 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 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 IO port 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 IO ports must be limited to -0.25 to +5.25 Volts.

Input Trigger Modes

When configured as an input, the IO port can be used 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 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 has to return to its inactive state first in order to start the next trigger. The input trigger mode is set in the *Input Trigger* parameters as follows:

Disabled - The trigger IO is disabled

Relative move (Fall) - Input trigger for relative move on a falling edge. The relative distance to move is set in the *Move Relative Distance* parameter.

Relative move (Rise) - Input trigger for relative move on a rising edge. The relative distance to move is set in the *Move Relative Distance* parameter.

Absolute move (Fall)- Input trigger for absolute move on a falling edge. The absolute position to move is set in the *Move Absolute Position* parameter.

Absolute move (Rise)- Input trigger for absolute move on a rising edge. The absolute position to move is set in the *Move Absolute Position* parameter.

Home move (Fall) - Input trigger for home move on a falling edge.

Home move (Rise) - Input trigger for home move on a rising edge.

Output Trigger Modes

When the configured as an output, the IO port can be used to indicate motion status or to produce a trigger pulse at configurable positions as follows:

In motion (Low) - The output trigger goes low (0V) when the stage is in motion.

In motion (High) - The output trigger goes high (5V) when the stage is in motion.

Move completed (Low) - The output trigger goes low (0V) when the demanded move has been completed.

Move completed (High) - The output trigger goes high (5V) when the demanded move has been completed.

At maximum velocity (Low) - The output trigger goes low (0V) when the motor has reached the max velocity set in the Move/Jogs tab - see Section 6.3.2.

At maximum velocity (High) - The output trigger goes high (5V) when the motor has reached the max velocity set in the Move/Jogs tab - see Section 6.3.2.

Appendix A Specifications

A.1 Stage Specifications

Parameter	Value
Travel Range	360° Continuous
Max Speed	10 °/s
Min Speed	0.005 °/s
Max Acceleration	20° /s/s
***Note**	
The acceleration is limited by the motor force, and must be reduced for higher loads.	
Unidirectional Repeatability[1]	± 60 µrad
Backlash	±200 µrad
Resolution (Theoretical)	0.0073° (~127 µrad)
Min. Repeatable Incremental Movement [2]	0.03°
Maximum Load Capacity	22 N (see Section A.3.)
Absolute Accuracy[1]	±0.14°
Home Location Accuracy	±100 µrad
Max Wobble (Axial)	500 µrad

[1] Bi-directional repeatability and accuracy will be the same if Backlash Correction is enabled in the Kinesis Software.

[2] Min. Repeatable Incremental Movement is the smallest controlled movement that the stage can be positioned repeatedly where the error is less than 10% of the specified step size at a 99.5% confidence level.

A.2 Design Specification

Parameter	Value
Base Material	Aluminum
Bearing Type	4-point Ball Bearing
Drive Mechanism	Worm Gear, Ratio 1:120
Homing Limit Switch	Hall Effect
Central Aperture	SM1 Threaded
Operating Temperature Range	5 to 40°C (41 to 104°F)
Motor Type	2-Phase Stepper Motor
Motor Drive Voltage	8 V Nominal
Terminal Resistance	20 Ω
Output Power	2.5 W Nominal
Step Size	1.8 °
Rotor Inductance	4.2 mH per Phase
Dimensions (L x W x H))	107 mm x 66.0 mm x 21.5 mm (4.21” x 2.6” x 0.84”)
Weight	0.22 kg

A.3 Load Capacity Specifications

Parameter	Value
Max Load (Q)	22 N (2.25 kg or 5.0 lbs)
Max Torque (Mz)	140 mNm
Max Transversal Torque (Mx)	1.5 Nm
Typical Stiffness (Ka)	380 µrad/Nm

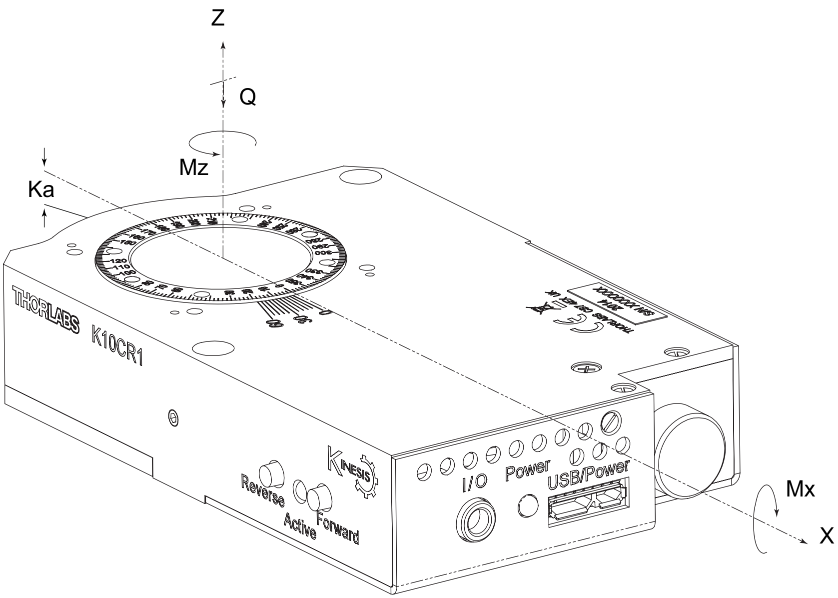


Fig. A.1 Load Capacity Definitions

Appendix B Stepper Motor Operation

B.1 How A Stepper Motor Works

B.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. B.1.

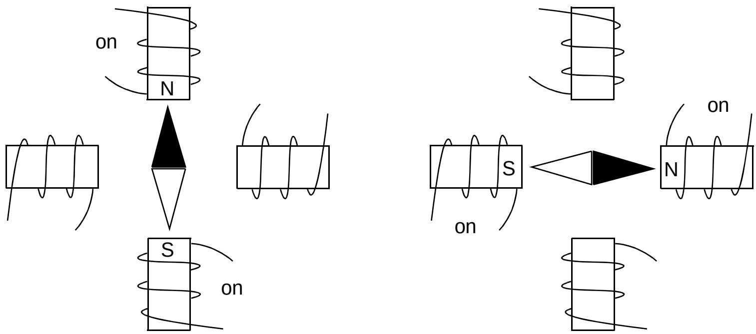


Fig. B.1 Simplified concept of stepper motor operation

Although only 4 stator poles are shown above, in reality there are numerous tooth-like poles on both the rotor and stator. The result is that positional increments (steps) of 1.8 degrees can be achieved by switching the coils (i.e. 200 steps per revolution). 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. The integral driver of the LTS stages gives a smallest angular adjustment of 0.00088 degrees (i.e. 1.8/0.00088 = 2048 microsteps per full step), resulting in a resolution of 409,600 microsteps per revolution of the motor.

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 comes to rest.

B.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.

B.1.3 Velocity Profiles

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

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

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

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

In a typical trapezoidal velocity profile, (see Fig. B.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.

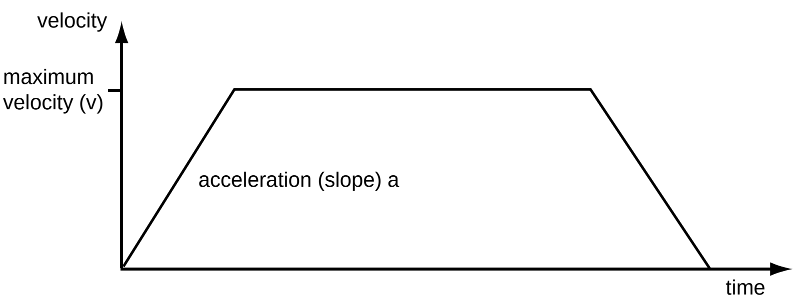


Fig. B.2 Graph of a trapezoidal velocity profile

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 degrees/s^3 and is derived from the Bow Index field as follows:

The *Bow Value* is applied in degrees/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

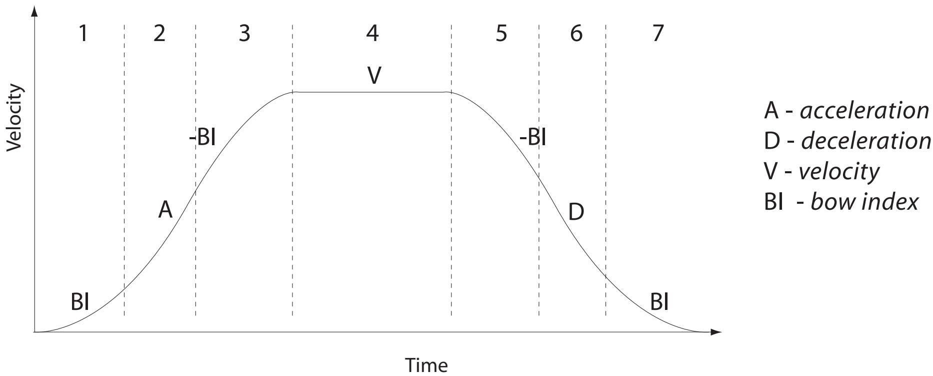


Fig. B.3 Typical S-Curve Profile

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.

Conversely, low values of Bow Index result in much shallower (longer duration) acceleration and deceleration curves. When these are combined with high velocities, the average power consumption increases and some heating may be apparent.

B.2 Positioning a Stage

B.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. If operating the unit by the front panel (local mode) this conversion is performed internally by the controller. If operating via a PC (remote mode) then the conversion is performed 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.

B.2.2 Home position

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

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

See Section 5.5. for details on performing a Home move.

B.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 both 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 , 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.

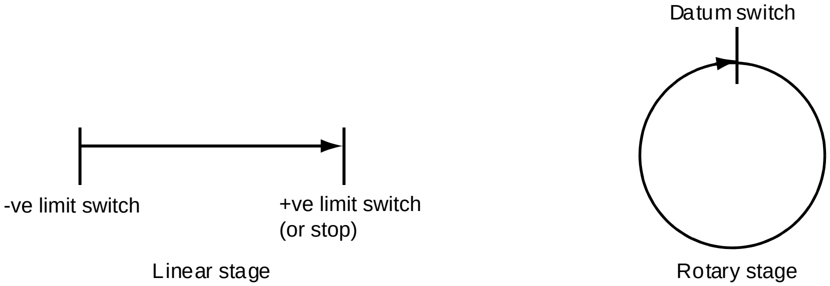


Fig. B.4 Stage limit switches

B.2.4 Power Saving

The current needed to hold a motor in a fixed position is much smaller than the current needed to move it, and it is advantageous to reduce the current through a stationary motor in order to reduce heating. Although this heating does not harm the motor or stage, it is often undesirable because it can cause thermal movements through expansion of the metal of the stage.

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

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

B.3 Error Correction

B.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. 2.5, 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.

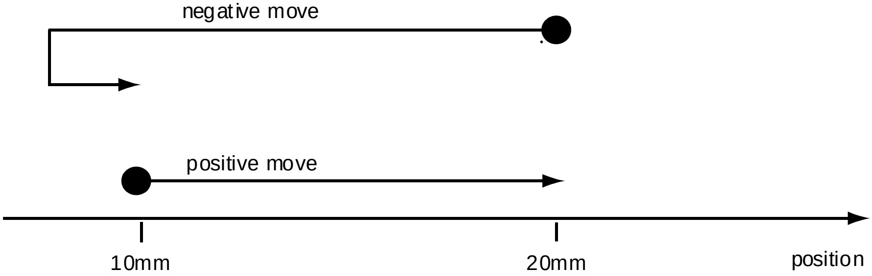


Fig. 2.5 Backlash correction

The controller has 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 Section 6.3.2. for details on setting the backlash correction.

Appendix C Regulatory

C.1 Declarations Of Conformity

C.1.1 For Customers in Europe

See Section C.2.

C.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.

C.2 CE Certificates

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):

2006/42/EC	Machinery Directive (MD)
2004/108/EC	Electromagnetic Compatibility (EMC) Directive
2011/65/EU	Restriction of Use of Certain Hazardous Substances (RoHS)

hereby declare that:

Model: ***K10CR1 Series***

Equipment: ***Motorized Rotation Mount for Ø1" Optics***

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

EN ISO 12100	Safety of Machinery. General Principles for Design. Risk Assessment and Risk Reduction	2010
EN 61326-1	Electrical Equipment for Measurement, Control and Laboratory Use - EMC Requirements	2013

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

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

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

Signed: Keith Dhese *On:* 12 March 2015

Name: Keith Dhese

Position: General Manager

EDC - K10CR1 Series -2015-03-12

CE

Appendix D Thorlabs Worldwide Contacts

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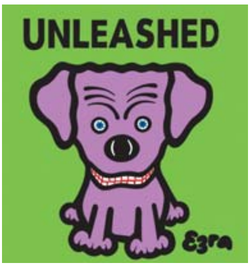
Thorlabs verifies our compliance with the WEEE (Waste Electrical and Electronic Equipment) directive of the European Community and the corresponding national laws. Accordingly, all end users in the EC may return "end of life" Annex I category electrical and electronic equipment sold after August 13, 2005 to Thorlabs, without incurring disposal charges. Eligible units are marked with the crossed out "wheelie bin" logo (see right), were sold to and are currently owned by a company or institute within the EC, and are not dissembled or contaminated. Contact Thorlabs for more information. Waste treatment is your own responsibility. "End of life" units must be returned to Thorlabs or handed to a company specializing in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.



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