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.

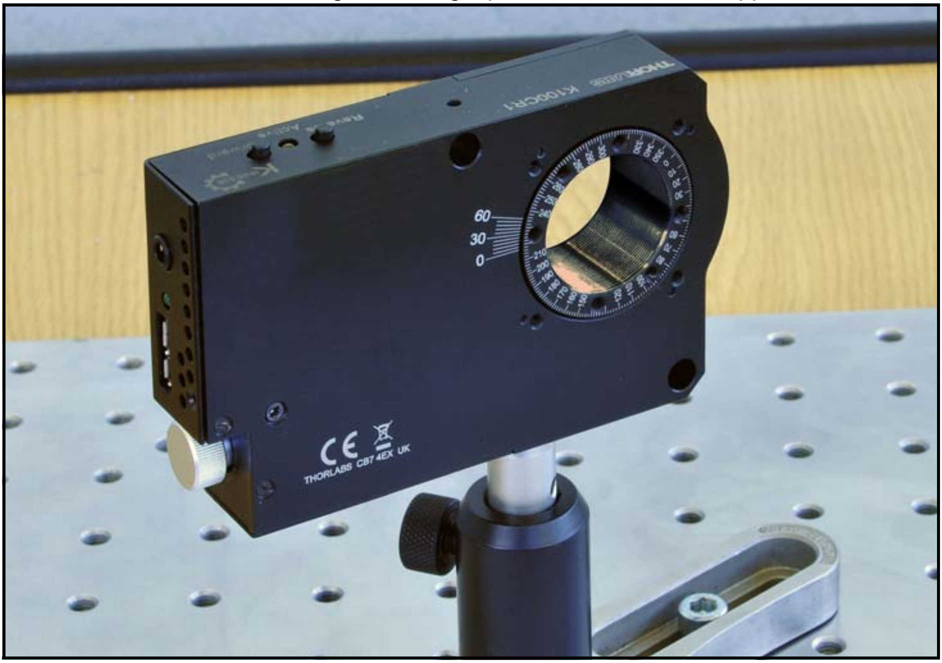


Fig. 2.1 Typical K10CR1 stage

2.2 APT Software Overview

2.2.1 Introduction

As a member of the APT range of controllers, the K10CR1 stages share many of the associated software benefits. This includes USB connectivity (allowing multiple units to be used together on a single PC), fully featured Graphical User Interface (GUI) panels, and extensive software function libraries for custom application development.

The APT software suite supplied with all APT controllers, including the K10CR1 stages, provides a flexible and powerful PC based control system both for users of the equipment, and software programmers aiming to automate its operation.

For users, the APTUser (see Section 2.2.2.) and APTConfig (see Section 2.2.3.) utilities allow full control of all settings and operating modes enabling complete 'out-of-box' operation without the need to develop any further custom software. Both utilities are built on top of a sophisticated, multi-threaded ActiveX 'engine' (called the APT server) which provides all of the necessary APT system software services such as generation of GUI panels, communications handling for multiple USB units, and logging of all system activity to assist in hardware trouble shooting. It is this APT server 'engine' that is used by software developers to allow the creation of advanced automated positioning applications very rapidly and with great ease. The APT server is described in more detail in Section 2.2.4.

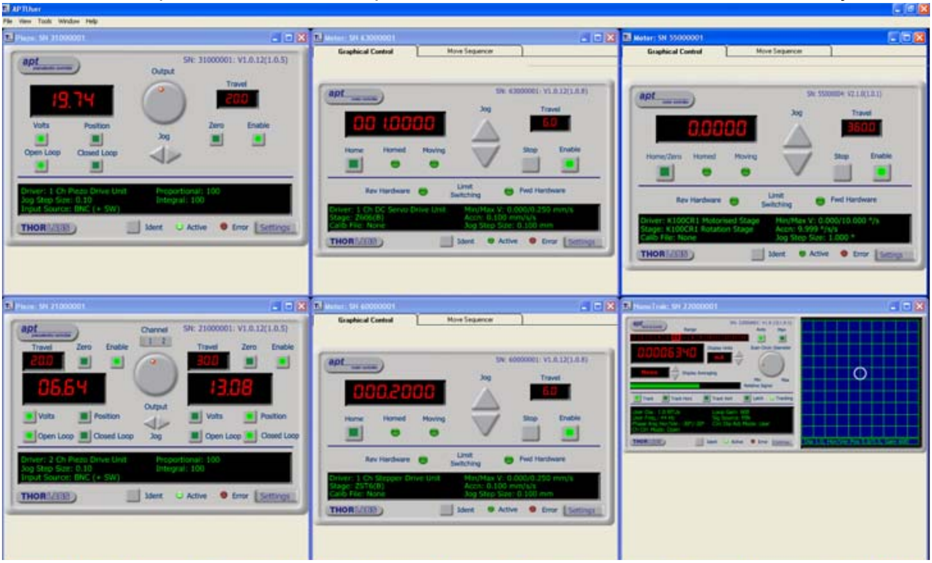
Aside

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

ActiveX controls are a specific form of ActiveX technology that provide both a user interface and a programming interface. An ActiveX control is supplied for each type of APT hardware unit to provide specific controller functionality to the software developer. See Section 2.2.4. for further details.

2.2.2 APTUser Utility

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



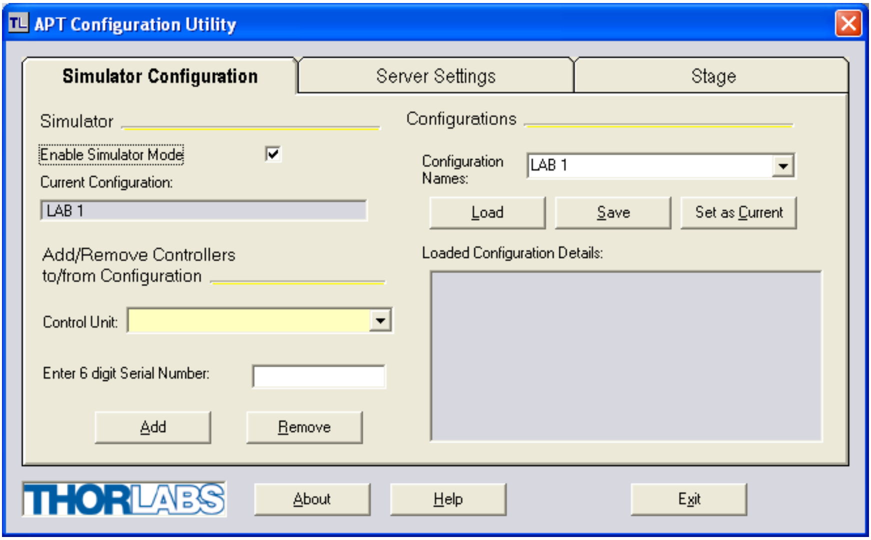
All basic operating parameters can be altered and, similarly, all operations (such as motor moves) can be initiated. Settings and parameter changes can be saved and loaded to allow multiple operating configurations to be created and easily applied.

For many users, the APTUser application provides all of the functionality necessary to operate the APT hardware without the need to develop any further custom software. For those who do need to further customise and automate usage of the controller (e.g. to implement a positioning algorithm), this application illustrates how the rich functionality provided by the APT ActiveX server is exposed by a client application. The complete Visual Basic source project is provided as a useful aid to software developers.

Use of the APT User utility is covered in the PC tutorial (Chapter 5) and in the APTUser online help file, accessed via the F1 key when using the APTUser utility.

2.2.3 APT Config Utility

There are many system parameters and configuration settings associated with the operation of the APT Server. Most can be directly accessed using the various graphical panels, however there are several system wide settings that can be made 'off-line' before running the APT software. These settings have global effect; such as switching between simulator and real operating mode, associating mechanical stages to specific motor actuators and incorporation of calibration data.



The APTConfig utility is provided as a convenient means for making these system wide settings and adjustments. Full details on using APTConfig are provided in the online help supplied with the utility.

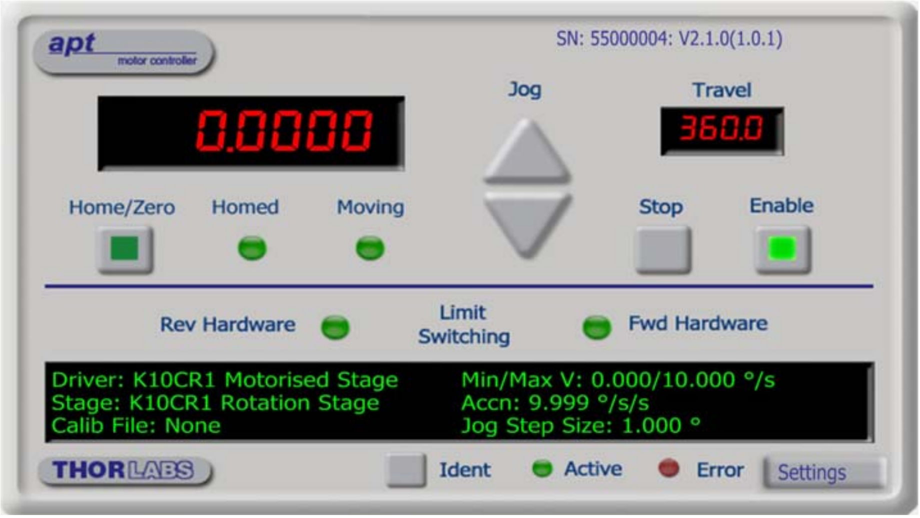
Use of the APT Config utility is covered in the PC tutorial (Chapter 5) and in the APTConfig online help file, accessed via the F1 key when using the APTConfig utility.

2.2.4 APT Server (ActiveX Controls)

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

With the APT system, ActiveX Controls are deployed to allow direct control over (and also reflect the status of) the range of electronic controller units, including the K10CR1 stages. Software applications that use ActiveX Controls are often referred to as 'client applications'. Based on ActiveX interfacing technology, an ActiveX Control is a language independent software component. Consequently ActiveX Controls can be incorporated into a wide range of software development environments for use by client application developers. Development environments supported include Visual Basic, Labview, Visual C++, C++ Builder, HPVEE, Matlab, VB.NET, C#.NET and, via VBA, Microsoft Office applications such as Excel and Word.

Consider the ActiveX Control supplied for the K10CR1 integrated stage & controller.



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

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

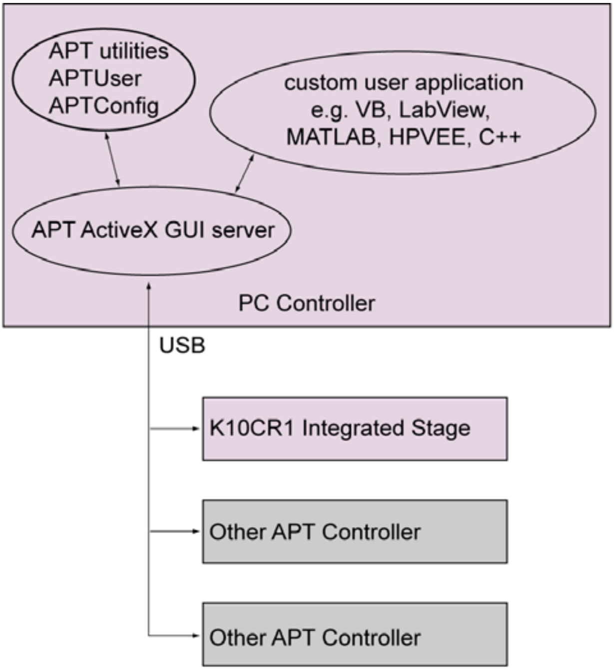


Fig. 2.2 System Architecture Diagram

Refer to the main APT Software online help file, APTServer.hlp, for a complete programmers guide and reference material on using the APT ActiveX Controls collection. Additional software developer support is provided on our website.

2.2.5 Software Upgrades

Thorlabs operate a policy of continuous product development and may issue software upgrades as necessary. The latest software can be downloaded from the 'services' section of www.thorlabs.com.

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").

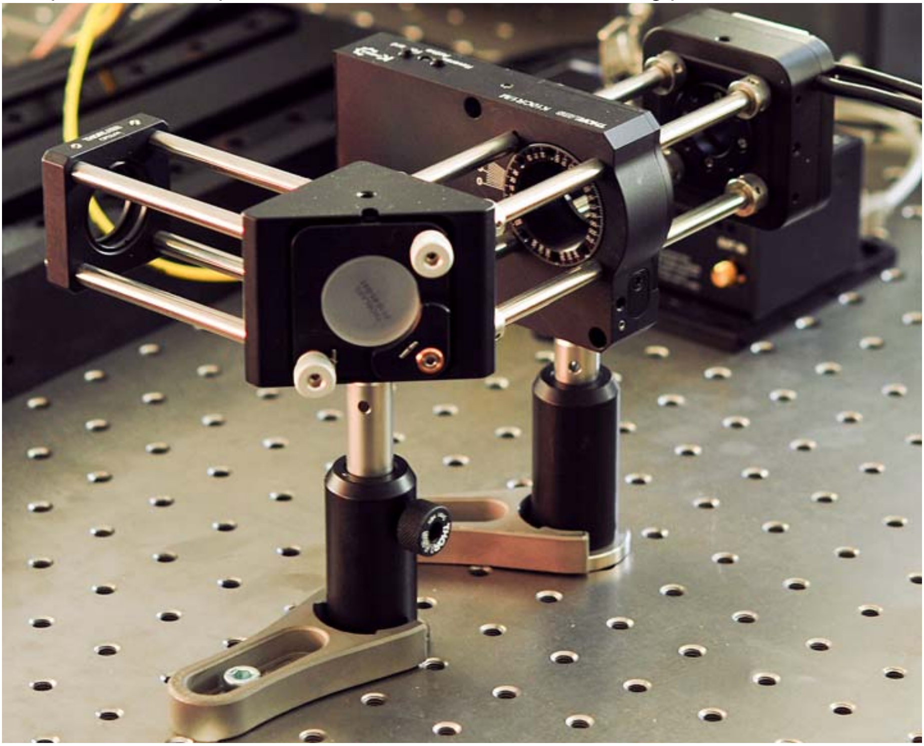
The rotating platform features several options for mounting accessories. The central aperture has a standard SM1 internal thread, for compatibility with a range of optics. Accessories can also be fixed using the series of threaded mounting holes (see Fig. 3.3).

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)

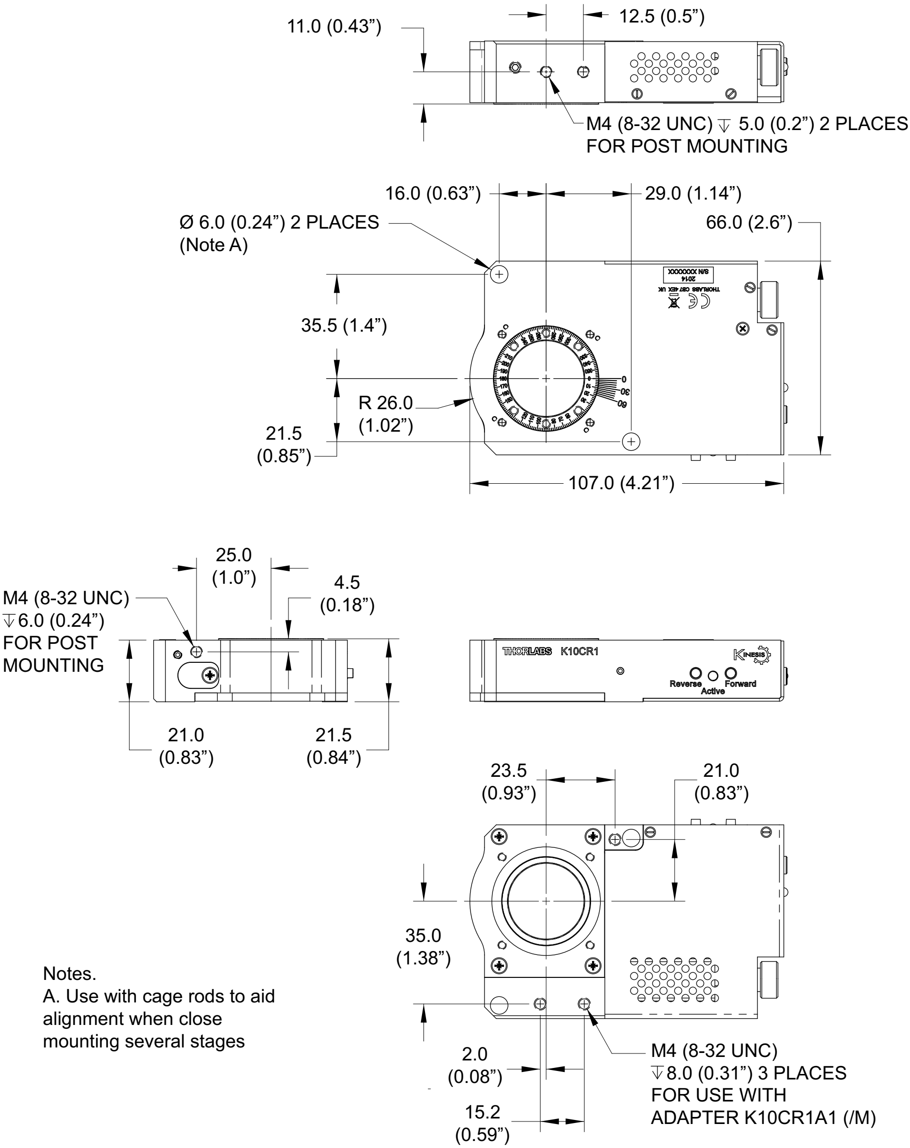


Fig. 3.3 Stage Dimensions

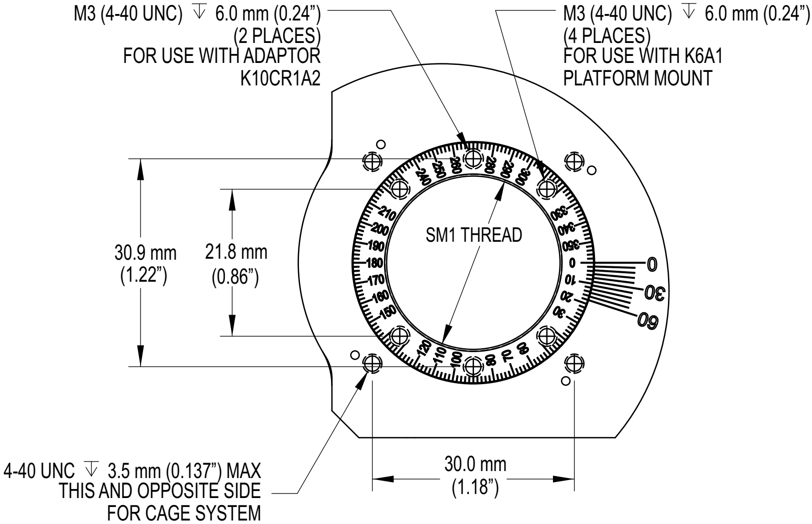


Fig. 3.4 Top Plate Detail

Chapter 4 Software & Electrical Installation

4.1 Installing APT 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 APT 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 APT 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. Obviously, if using a 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:.

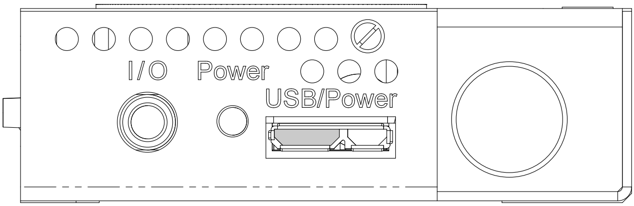


Fig. 4.1 Power and USB Connectors

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.

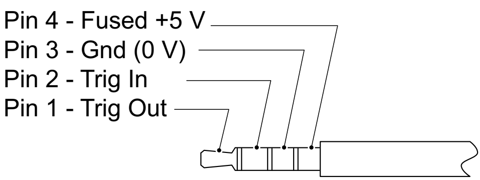


Fig. 4.2 I/O Pin Out Detail

4.4 Connecting The Hardware

1) Perform the mechanical installation as detailed in Section 3.
2) Install the APT 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 APTUser utility and check that the Graphical User Interface (GUI) panel appears and is active.

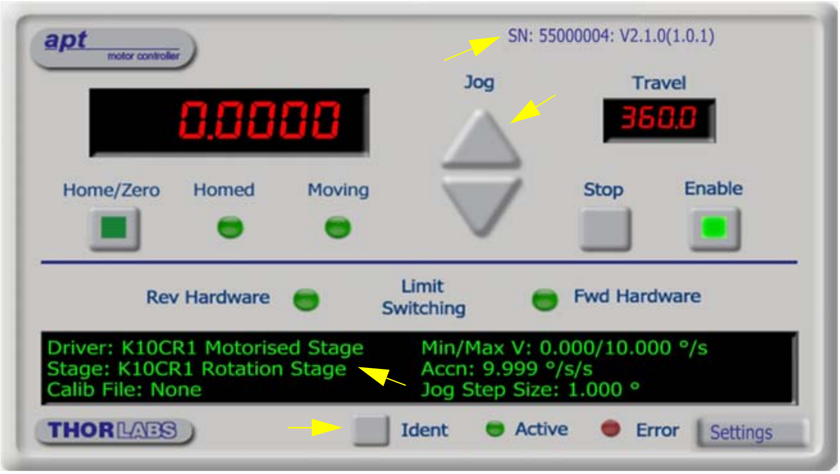


Fig. 4.3 Gui panel showing jog and ident buttons

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.

Note

The 'APT Config' utility can be used to set up simulated hardware configurations and place the APT Server into simulator mode. In this way it is possible to create any number and type of simulated (virtual) hardware units in order to emulate a set of real hardware. This is a particularly useful feature, designed as an aid to application program development and testing. Any number of 'virtual' control units are combined to build a model of the real system, which can then be used to test the application software offline. If using real hardware, ensure that Simulator Mode is disabled. If using a simulated setup, enable Simulator Mode and set up a 'Simulated Configuration' - see Section 5.13. or the *APTConfig* helpfile for detailed instructions.

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 PC based APT software. It assumes that the unit is electrically connected as described in Section 4.4. and that the APT 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.

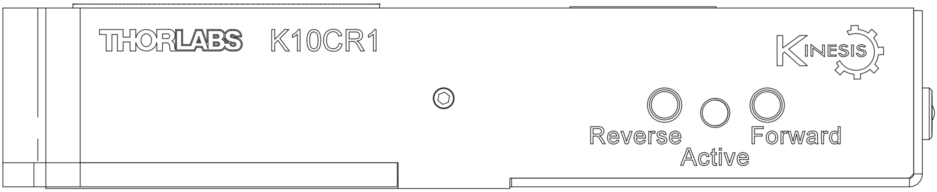


Fig. 5.1 K10CR1 Buttons and LEDs

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 C.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 6.3.4. 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 6.3.4. 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 6.3.1.

5.3.4 Switching Between Button Modes

The button mode can only be changed in the Settings panel, see Chapter 6.3.4.

5.4 Using the APT User Utility

The APT User.exe application allows the user to interact with any number of APT hardware control units connected to the PC USB Bus (or simulated via the APTConfig utility). This program allows multiple graphical instrument panels to be displayed so that multiple APT units can be controlled. All basic operating parameters can be set through this program, and all basic operations (such as motor moves) can be initiated. Hardware configurations and parameter settings can be saved to a file, which simplifies system set up whenever APT User is run up.

Fig. 5.2 Typical APT User Screen

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

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.

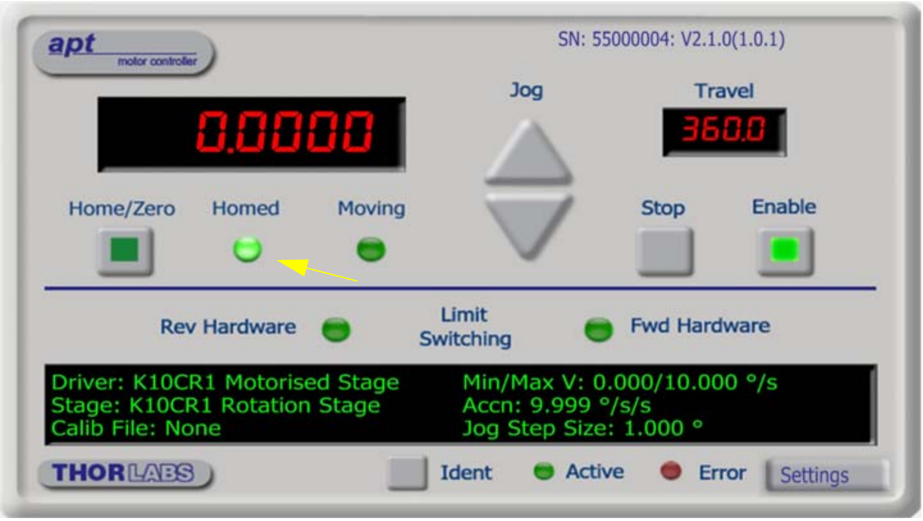


Fig. 5.3 Motor Controller Software GUI

1) Click the ‘Home’ button. Notice that the led in the button lights to indicate that homing is in progress and the displayed position for both channels counts down to 000.000, i.e the home position. The stage can also be homes by pressing the ‘Reverse’ and ‘Forward’ buttons simultaneously on the side panel.
2) When homing is complete, the ‘Homed’ LED is lit as shown above.

5.6 Moving to an Absolute Position

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

1) Click the position display.

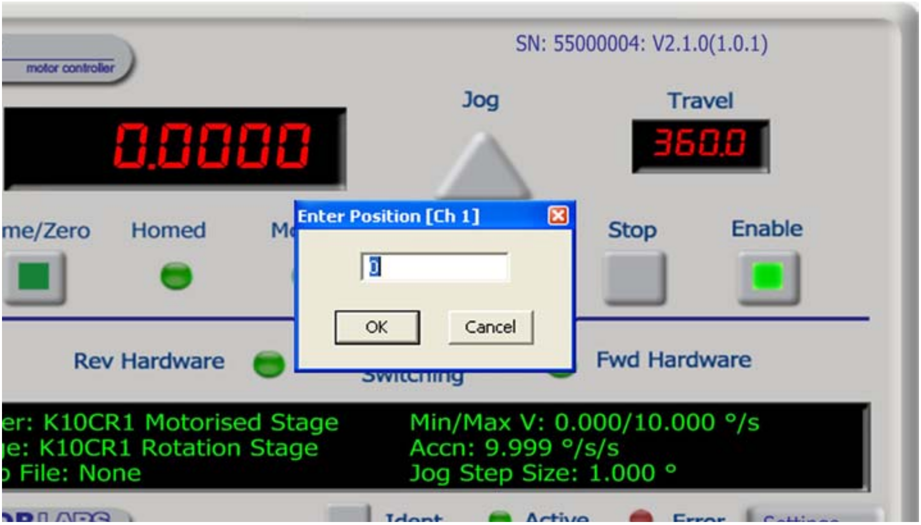


Fig. 5.4 Absolute Position Popup Window

2) Enter 3.0 into the pop up window
3) Click ‘OK’. Notice that the position display counts up to 003.0 to indicate a move to the absolute position 3.0 degrees.

Note

The position display 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.

5.7 Stopping the Stage

The drive channel is enabled and disabled by clicking the ‘Enable’ button on the GUI panel or the top panel of the unit. The green indicator is lit when the drive channel is enabled. Disabling the channel removes the drive power and allows the stage/ actuator to be positioned manually.

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

5.8 Changing Motor Parameters

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

1) On the GUI panel, click the 'Settings' button (bottom right hand corner of the display) to display the Settings panel.

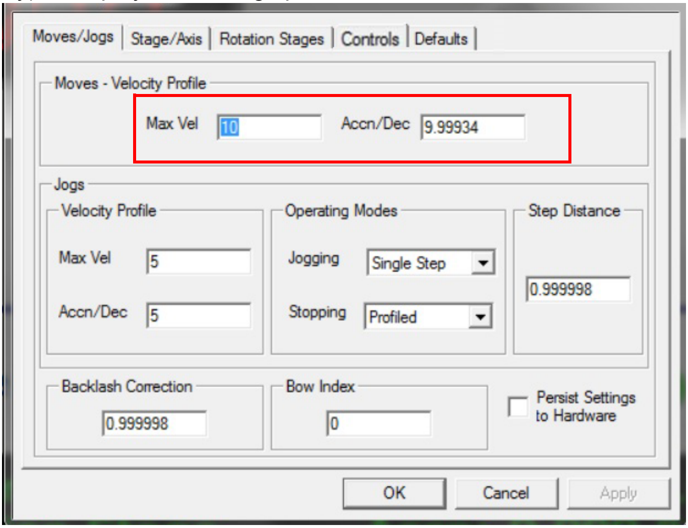


Fig. 5.5 Settings Panel - Move/Jogs Tab

2) Select the Move/Jogs tab as shown in Fig. 5.5.
3) In the 'Moves' field, change the parameters as follows:
   'Max. Vel' - '6'
   'Accn/Dec' - '4'

   Note. In current versions of software, the 'Min Vel' parameter is locked at zero and cannot be adjusted.
4) Click 'OK' to save the settings and close the window.
5) Any further moves will now be performed at a maximum velocity of 6° per second, with an acceleration of 4°/sec/sec.

5.9 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. 5.6. In 'Continuous' mode, the motor actuator will accelerate and move at the jog velocity while the button is held down.

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

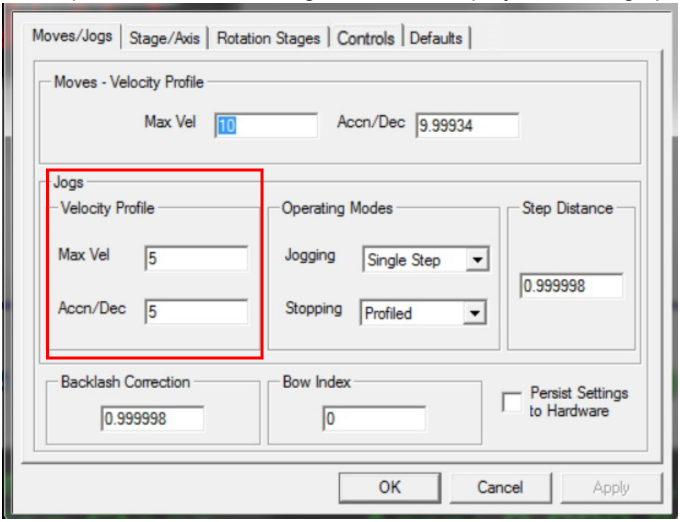


Fig. 5.6 Settings Panel - Move/Jogs Tab

2) Select the Move/Jogs tab as shown in Fig. 5.6.

3) In the 'Jogs' field, enter parameters as follows:
'Max. Vel' - '1'
'Accn/Dec' - '2'

Note

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

'Jogging' - 'Single Step'
'Stopping' - 'Profiled'

'Step Distance' - '0.05'

4) Click 'OK' to save the settings and close the window.

5) Click the Jog Arrows on the GUI panel to jog the motor. Notice that the position display increments 0.05 every time the button is clicked.

5.10 Graphical Control Of Motor Positions (Point and Move)

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

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

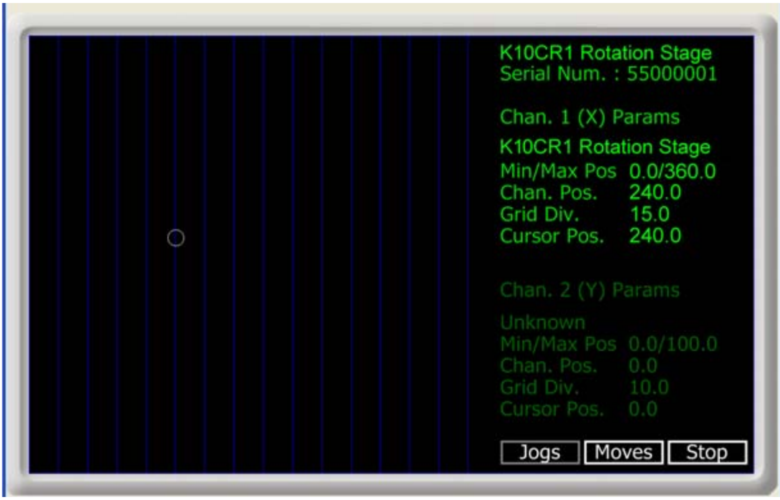


Fig. 5.7 K10CR1 Stage GUI Panel - Graphical View

Consider the display shown above for a K10CR1 Integrated Stage.

The right hand display shows the channel and motor unit parameters; i.e. controller unit type and serial number, stage type, minimum and maximum positions, current position, units per grid division and cursor position. All units are displayed in real world units, i.e. millimetres.

Note. For single channel units such as the K10CR1, the Channel 2 parameters are greyed out.

The left hand display shows a circle, which represents the current position of the stage associated with the ActiveX Control Instance (absolute position data is displayed in the 'Chan Pos' field).

The vertical divisions relate to the travel of the associated stage. For example, the screen shot above shows the parameters for a K10CR1 rotation stage. The graph shows 15 divisions in the X axis, which relates to 24° of travel per division.

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

Move Mode

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

To specify a move:

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

Jog Mode

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

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

Stop

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

Returning to Panel View

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

5.11 Setting Move Sequences

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

For details on moving to absolute positions initiated by a mouse click – see Section 5.10.

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

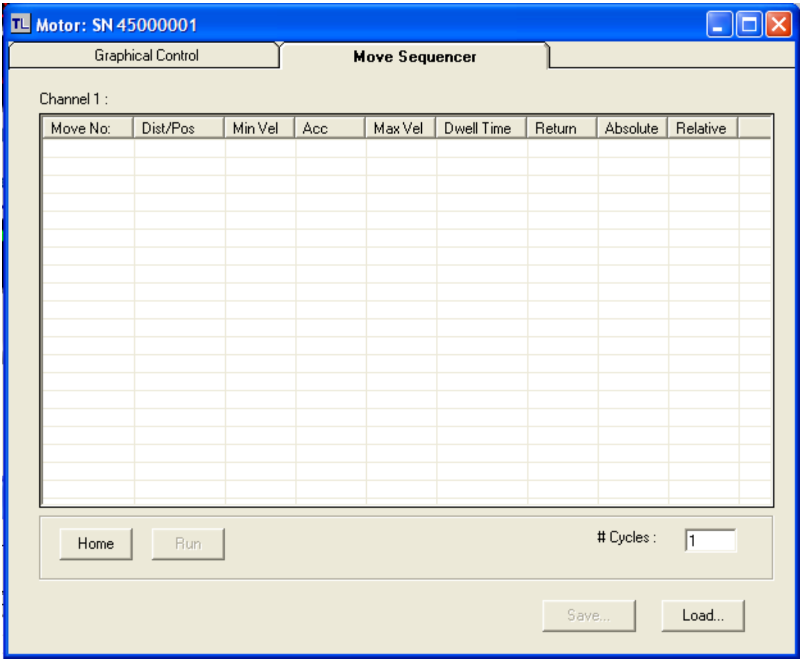


Fig. 5.8 Move Sequencer Window

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

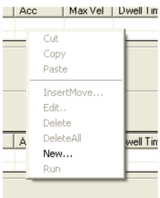


Fig. 5.9 Move Sequencer Pop Up Menu

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

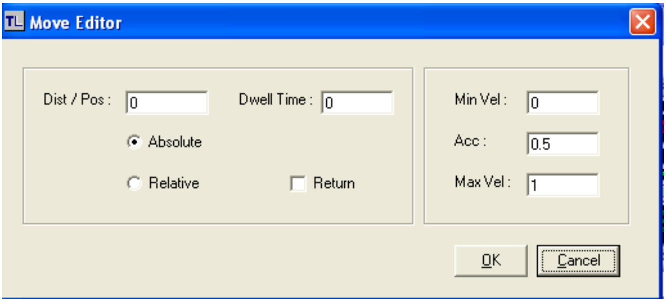


Fig. 5.10 Move Editor Window

Move data is entered/displayed as follows:

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

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

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

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

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

Note

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

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

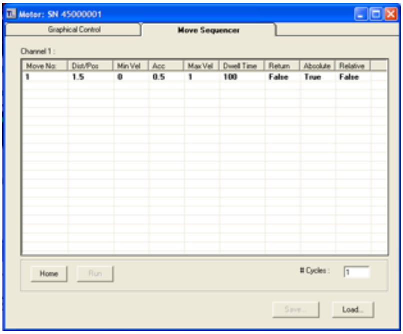


Fig. 5.11 Main Window with Move Data

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

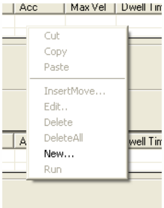


Fig. 5.12 Pop Up Options

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

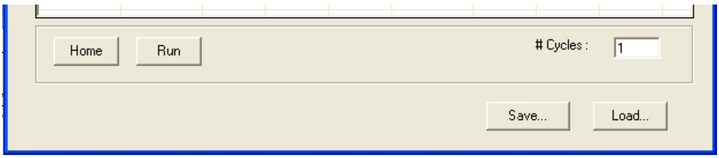


Fig. 5.13 Home and Run Buttons

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

5.12 Minimum and Maximum Position Settings

There are no mechanical end stops on the K10CR1 stage and theoretically, the total (accumulative) angle of the motion could be arbitrarily large. In practice, however, the integer arithmetic used for the position counter poses a restriction on the range of position values that can be represented. To avoid integer overflow and underflow problems, the target position is checked against the limits displayed in the Min Pos and Max Pos values. This check is done to ensure that the position counter always shows a correct value. For the K10CR1 stage, the Min Pos and Max Pos limits are equivalent to around ±43 full rotations (15,480 degrees).

In applications where continuous rotation is required, the Move At Velocity command can be used. This command does not constrain the angle to the Min Pos and Max Pos range and the continuity of the movement will not be interrupted until a Stop command is issued. However, when the integer representing the position counter overflows, the position value will flip sign and will no longer be correct. Any application commanding continuous moves for long period of times must take this into account and accept that once the Min Pos and Max Pos position is exceeded, the value displayed may no longer be correct. Homing the stage will zero the position count and correct the display.

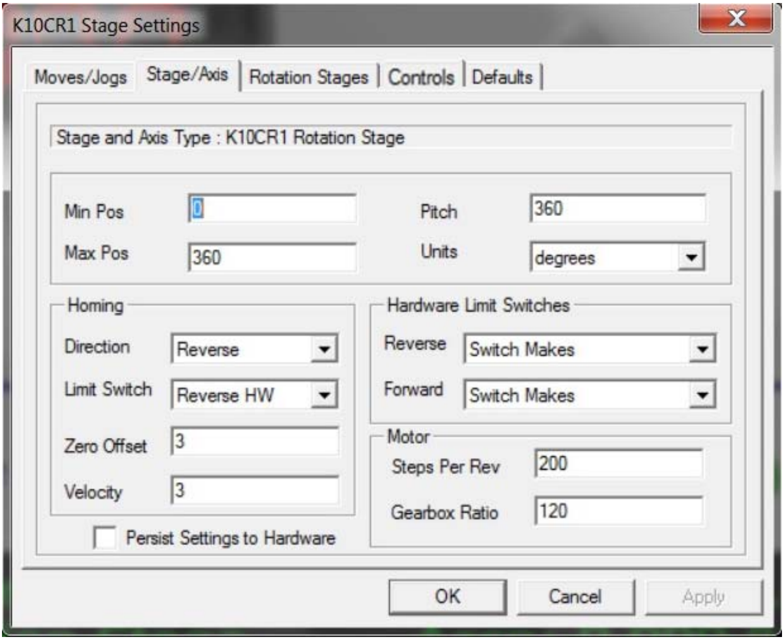


Fig. 5.14 K10CR1 Stage/Axis Settings Tab

5.13 Creating a Simulated Configuration Using APT Config

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

Any number of 'virtual' control units can be combined to emulate a collection of physical hardware units For example, an application program can be written, then tested and debugged remotely, before running with the hardware.

To create a simulated configuration proceed as follows:

1) Run the APT Config utility - Start/All Programs/Thorlabs/APT/APT Config.
2) Click the 'Simulator Configuration' tab.

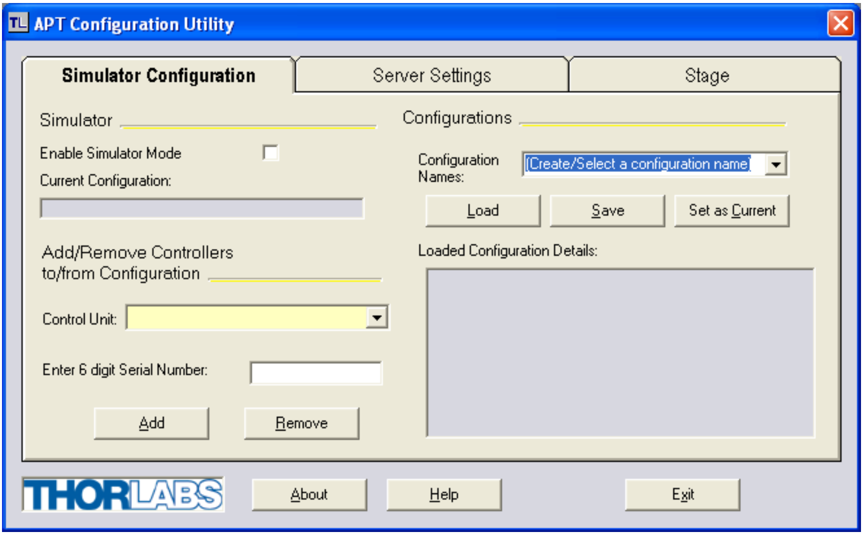
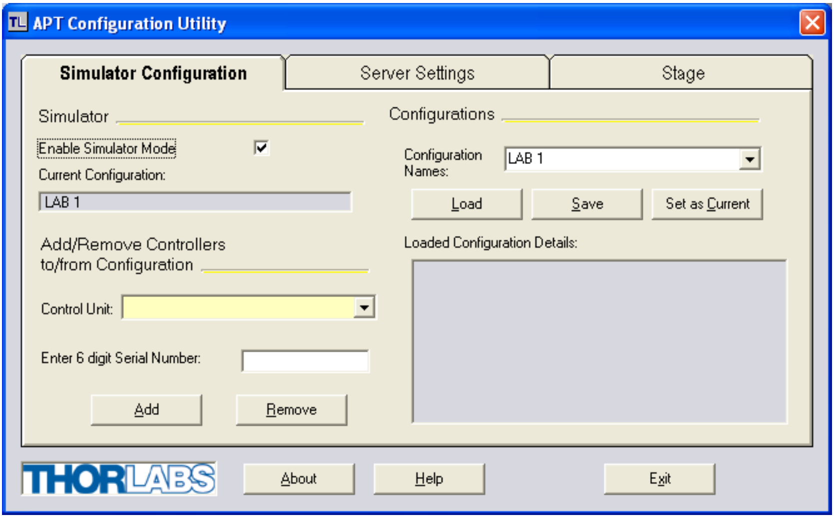


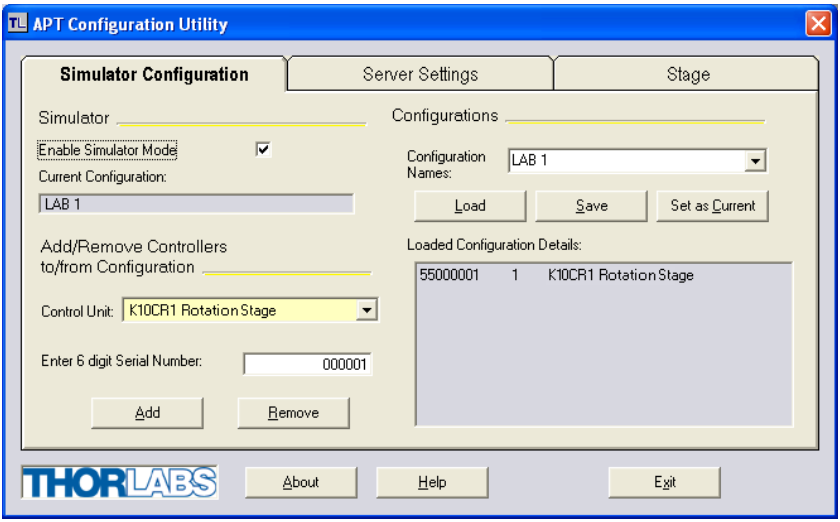
Fig. 5.15 APT Configuration Utility - Simulator Configuration Tab

3) Enter a configuration file name, e.g. ‘LAB1’ in the Configuration Names field.

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



5) In the ‘Control Unit’ field, select the K10CR1 Stage type.



6) Enter a 6 digit serial number.

Note

Each physical APT hardware unit is factory programmed with a unique 8 digit serial number. In order to simulate a set of 'real' hardware the Config utility allows an 8 digit serial number to be associated with each simulated unit. It is good practice when creating simulated configurations for software development purposes to use the same serial numbers as any real hardware units that will be used. Although serial numbers are 8 digits (as displayed in the 'Load Configuration Details' window, the first two digits are added automatically and identify the type of control unit.

The prefixed digits relating to the K10CR1 stage is:
55xxxxxx - K10CR1 Motorized Stage

7) Click the 'Add' button.
8) Repeat items (1) to (7) as required. (A unit can be removed from the configuration by selecting it in the 'Loaded Configuration Details' window and clicking the 'Remove' button or by right clicking it and selecting the 'Remove' option from the pop up window).
9) Enter a name into the 'Configuration Names' field.
10) Click 'Save'.
11) Click 'Set As Current' to use the configuration.

Chapter 6 Software Reference

6.1 Introduction

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

6.2 GUI Panel

The following screen shot shows the graphical user interface (GUI) displayed when accessing the stepper controller using the APTUser utility.

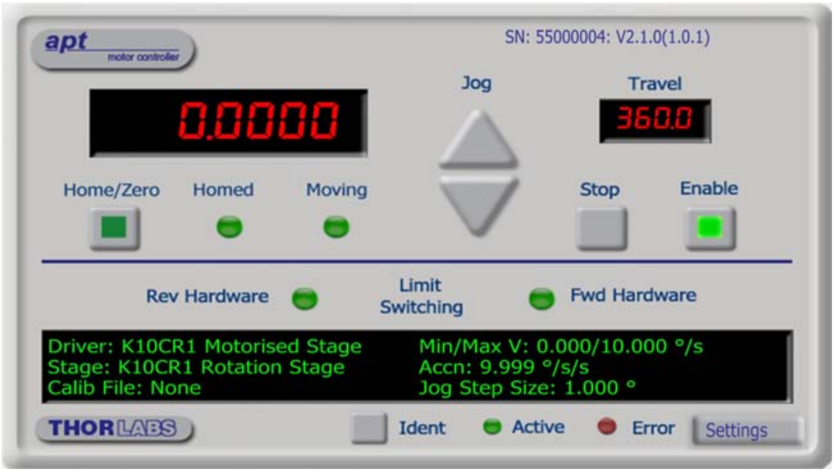


Fig. 6.1 K10CR1 Software GUI

Note

The serial number of the K10CR1 stage associated with the GUI panel, the APT server version number, and the version number (in brackets) of the embedded software running on the unit, are displayed in the top right hand corner. This information should always be provided when requesting customer support.

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

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

Moving - lit when the motor is in motion.

Enable - applies power to the motor. With the motor enabled, the associated Channel LED on the front panel is lit.

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

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

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

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

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

Settings display - shows the following user specified settings:

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

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

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

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

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

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

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

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

Ident - when this button is pressed, the Enable LED on the front panel of the unit associated with the selected channel, will flash for a short period.

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

Error - lit when a fault condition occurs.

6.3 Settings Panel

When the 'Settings' button on the GUI panel is clicked, the 'Settings' window is displayed. This panel allows motor operation parameters such as move/jog velocities, and stage/axis information to be modified. Note that all of these parameters have programmable equivalents accessible through the ActiveX methods and properties on this Control (refer to the *Programming Guide* in the *APTServer helpfile* for further details and to Section 2.2.4. for an overview of the APT ActiveX controls). The various parameters are described below.

6.3.1 Moves/Jogs tab

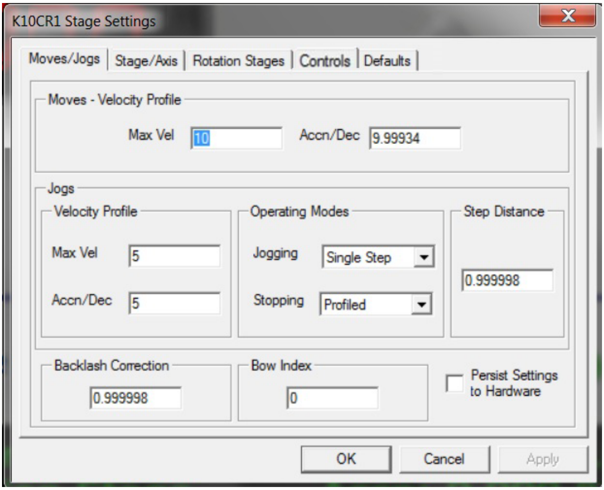


Fig. 6.2 Stepper Motor Controller - Move/Jog Settings

Moves

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 APTServer helpfile). The following settings determine the velocity profile of such moves, and are specified in real world units (millimetres).

Moves - Velocity Profile specified in real world units, (degrees).

Max Vel - the maximum velocity at which to perform a move (0 to 10°/sec).

Accn/Dec - the rate at which the velocity climbs from zero to maximum, and slows from maximum to zero (up to 10° sec^2).

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

Jogs

Jogs are initiated by using the ‘Jog’ keys on the GUI panel (see Section 5.9.), or via the buttons on the control key pad.

Velocity Profile - specified in real world units, (degrees)

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

Max Vel - the maximum velocity at which to perform a jog (0 to 15°/sec).

Accn/Dec - the rate at which the velocity climbs from minimum to maximum, and slows from maximum to minimum (up to 15° sec^2).

Operating Modes

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

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

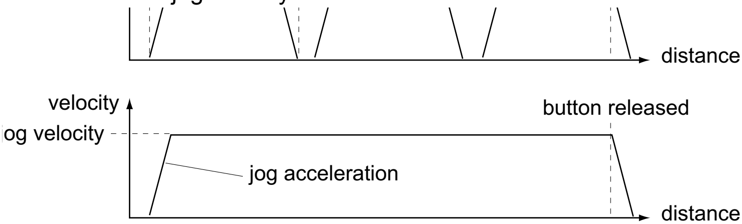


Fig. 6.3 Jog Modes

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

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

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

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

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

Step Distance - The distance to move when a jog command is initiated. The step size is specified in real world units (mm).

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

Position Profiling

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

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

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

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

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

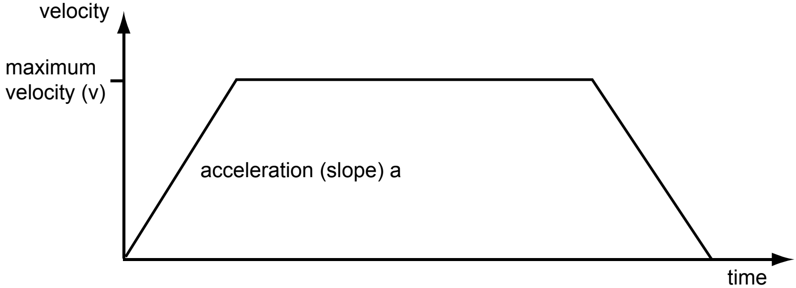


Fig. 6.4 Graph of a trapezoidal velocity profile

The *S-curve* profile is a trapezoidal curve with an additional '*Bow Value*' parameter, which limits the rate of change of acceleration and smooths out the contours of the motion profile. The *Bow Value* is applied in 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

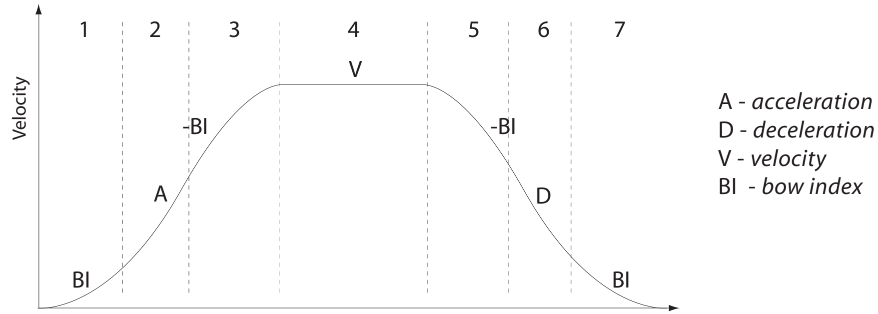


Fig. 6.5 Typical S-Curve Profile

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.

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.

Persist Settings to Hardware

Many of the parameters that can be set for the K10CR1 stages 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 and acceleration parameters described previously are good examples of settings that can be altered and then persisted in the driver for use in absence of a PC. To save the settings to hardware, check the 'Persist Settings to Hardware' checkbox before clicking the 'OK button.

Caution

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

6.3.2 Stage/Axis tab

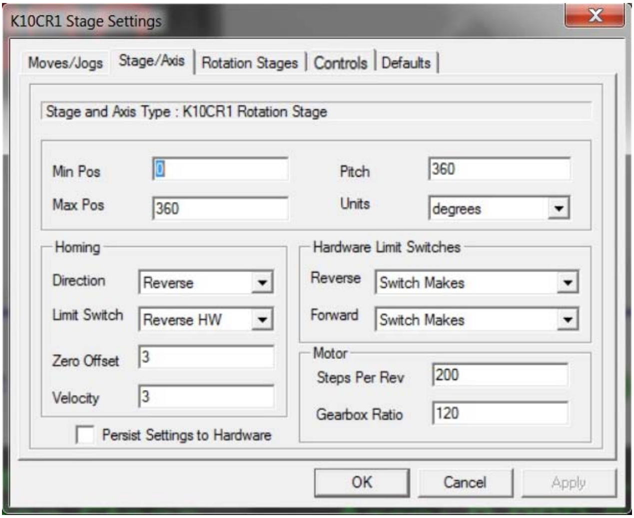


Fig. 6.6 Stepper Motor Controller - Stage/Axis Settings

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

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

Stage and Axis Type - For K10CR1 stages, the stage type is annotated automatically when the stage is connected.

Caution

Extreme care must be taken when modifying the stage related settings that follow. Some settings are self consistent with respect to each other, and illegal combinations of settings can result in incorrect operation of the stage.

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

Max Pos - the stage/actuator maximum position.

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 - see Section 5.12. for more details.

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

Units - the ‘real world’ positioning units (degrees).

Homing.

Note

When homing, the stage moves in the reverse direction, (i.e. towards the home limit switch). This operation is inherent in the design of the stage and the following parameters should not be adjusted. Descriptions are supplied for information only

Direction - the direction sense to move when homing, either *Forward* or *Reverse*.

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

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

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

Note

The homing velocity has been optimized at the factory to enhance the limit switch accuracy and should not normally be adjusted. If this parameter does need to be altered, the Homing velocity is limited to 5 degrees/sec.

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

Hardware Limit Switches

Note

The operation of the limit switch is inherent in the design of the stage. These parameters should not be adjusted. Descriptions are supplied for information only.

The following parameters notify the system to the action of the switches when contact is made.
Switch Makes - The switch closes on contact
Switch Breaks - The switch opens on contact
Ignore/Absent - The switch is missing, or should be ignored.

Motor

These parameters are used to set the 'resolution' characteristics of the stage. The resolution of the motor, combined with other characteristics (such as lead screw pitch) of the associated actuator or stage, determines the overall resolution. The following parameters are set at the factory and should not be adjusted. Descriptions are supplied for information only.

Steps Per Rev - The number of full steps per revolution of the stepper motor (minimum '1', maximum '10000'). The K10CR1 stage has a 200 full step/rev motor.

Note

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

Gearbox Ratio - The ratio of the gearbox. For example, if the gearbox has a reduction ratio of X:1 (i.e. every 1 turn at the output of the gearbox requires X turns of the motor shaft) then the Gearbox Ratio value is set to X. (minimum '1', maximum '1000'). The K10CR1 stage has a greabox ratio of 120:1.

Notes

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

The K10CR1 use a 120:1 reduction gearbox. The equivalent calibration constant is calculated as:

200 x 2048 x 120 = 49,152,000.0 microsteps per rev of the top platform

49,152,000.0/360 = 136533.33 microsteps per degree movement

200 steps per revolution
2048 microsteps per full step
120:1 reduction gearbox

The correct default values for Steps Per Rev and Gearbox Ratio are applied automatically when the unit is powered up.

Persist Settings to Hardware

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

Caution

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

6.3.3 Rotation Stages Tab

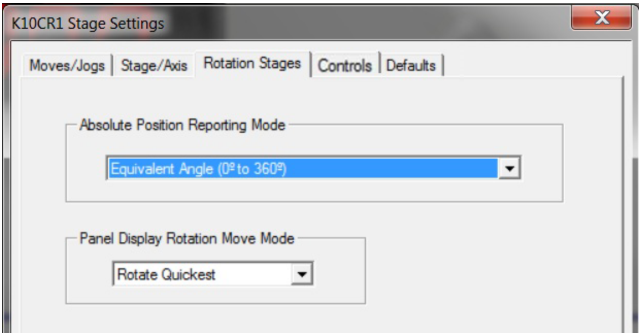


Fig. 6.7 Advanced Settings

Absolute Position Reporting Mode

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

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

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

Note

The 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 Absolute Position Reporting Mode is set to 'Equivalent Angle 0 to 360 degrees'.

Panel Display Rotation Move Mode

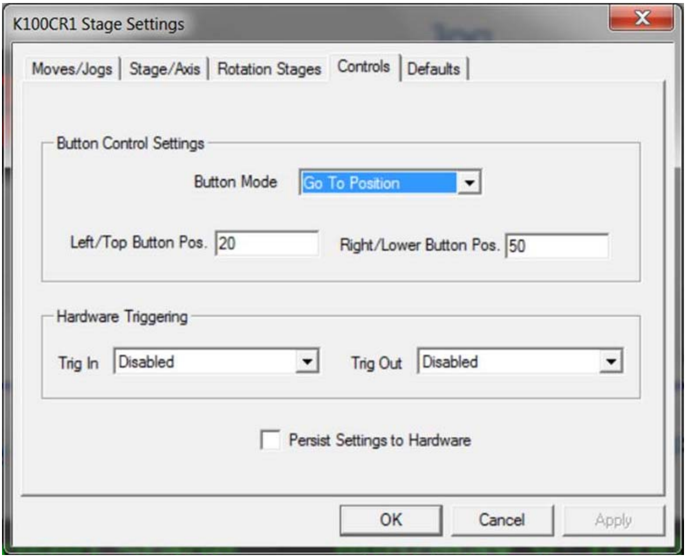
This setting specifies the move direction.

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 Controls Tab



Button Control Settings

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

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

> *Jogging*: Once set to this mode, the move parameters for the buttons are taken from the 'Jog' parameters on the 'Move/Jogs' settings tab.
>
> *Go to Position*: In this mode, each button can be programmed with a different position value, such that the controller will move the motor to that position when the specific button is pressed.

Note

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

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

Right/Bottom Button Pos.: The position to which the motor will move when the 'Forward' 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.

Triggering

The unit is fitted with a 3.5 mm 4-way jack I/O connector that allows the connection of external TTL compatible signals to initiate moves (Trigger In) and generate a hardware signal when certain motion related conditions are met (Trigger Out). It is possible to configure a particular controller to respond to trigger inputs, generate trigger outputs or both simultaneously. For those units configured for both input and output triggering, a move can be initiated via a trigger input while at the same time, a trigger output can be generated to initiate a move on another unit.

The trigger settings can be used to configure multiple units in a master – slave set up, thereby allowing multiple channels of motion to be synchronized. Multiple moves can then be initiated via a single software or hardware trigger command.

Trig In

The Trigger In input can be configured to initiate a relative, absolute or homing home, either on the rising or falling edge of the signal driving it. As the trigger input is edge sensitive, it needs to see a logic LOW to HIGH transition ("rising edge") or a logic HIGH to LOW transition ("falling edge") for the move to be started. Additionally, the move parameters must be downloaded to the unit prior to the move using the relevent relative move or absolute move software methods as described following. A move already in progress will not be interrupted; therefore external triggering will not work until the previous move has been completed.

In order to avoid unexpected moves being executed on start-up, the trigger input settings cannot be persisted and will default to the input being disabled on power-up.

Even when input triggering is disabled, the state of the Trigger In input can be read at any time by using the LLGetStatusBits software method to read the status register bit 1. This allows application software to use the Trigger In input as a general-purpose digital input - see the *APTServer helpfile* for details on using the LLGetStatusBits method and the status register.

Trigger In options are set as follows:

Disabled – triggering operation is disabled

Rel Move (Trig Rise) – a relative move (specified using the latest MoveRelative or MoveRelativeEx method settings) is initiated on the specified channel when a rising edge input signal is received on the TRIG IN connector.

Rel Move (Trig Fall) – as above, but the relative move is initiated on receipt of a falling edge signal.

Abs Move (Trig Rise) – an absolute move (specified using the latest MoveAbsolute or MoveAbsoluteEx method settings) is initiated on the specified channel when a rising edge input signal is received on the TRIG IN connector.

Abs Move (Trig Fall) – as above, but the absolute move is initiated on receipt of a falling edge signal.

Home Move (Trig Rise) – a home move (specified using the latest MoveHome method settings) is initiated on the specified channel when a rising edge input signal is received on the TRIG IN connector.

Home Move (Trig Fall) – as above, but the home move is initiated on receipt of a falling edge signal.

Trig Out

The Trigger Out output can be configured to be asserted to either logic HIGH or LOW as a function of certain motion-related conditions, such as when a move is in progress (In Motion), complete (Move Complete) or reaches the constant velocity phase on its trajectory (Max Vel). The logic state of the output will remain the same for as long as the chosen condition is true. The logic state associated with the condition can be selected to be either LOW or HIGH.

The Trigger Out output settings can be persisted and the persisted settings will be automatically applied once phase initialisation has completed after the next power-up. Whilst this can be advantageous of in some applications, please note that immediately after power-up, while the unit is going through its normal boot-up and initialisation process, the state of the Trigger Out output may not be its expected state.

In addition to the trigger out options listed above, it is also possible to set or clear the Trigger Out output under software-only control. As with the Trigger In input, this allows application software to use the Trigger Out output as a general-purpose digital output. To use this option, select the Trigger Out option to be Disabled and use the LLSetGetDigOPs method to control the state of the output directly - see the *APTServer helpfile* for details on how to use the LLSetGetDigOPs method.

Trigger Out options are set as follows:

Disabled – triggering operation is disabled

In Motion (Trig HI) – The output trigger goes high (5V) when the stage is in motion.

In Motion (Trig Lo) – The output trigger goes low (0V) when the stage is in motion.

Move Complete (Trig HI)

Move Complete (Trig HI) - The output trigger goes high (5V) when the current move is completed.

Move Complete (Trig LO) – The output trigger goes low (0V) when the current move is completed.

Max. Vel. (Trig HI) – The output trigger goes high (5V) when the stage reaches max velocity (as set using the SetVelParams method).

Max. Vel. (Trig LO) – The output trigger goes low (0V) when the stage reaches max velocity (as set using the SetVelParams method).

Persist Settings to Hardware

Many of the parameters that can be set for the K10CR1 stages 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 button parameters described above are good examples of settings that can be altered and then persisted in the driver for use in absence of a PC. To save the settings to hardware, check the 'Persist Settings to Hardware' checkbox before clicking the 'OK button.

Caution

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

6.3.5 Triggering Latency

The detection of whether a trigger condition has occurred is carried out periodically at 102 μs intervals. As a result, there is a maximum 102 μs delay between the condition occurring and the trigger output being updated. The following timing diagram illustrates this latency:

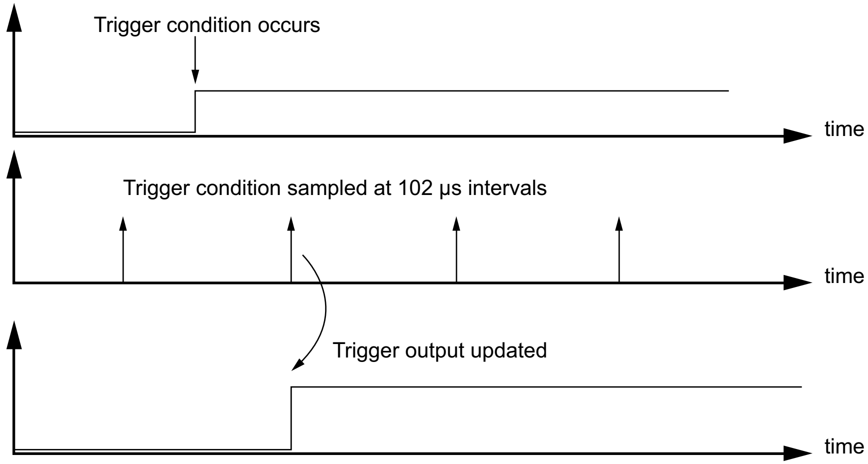


Fig. 6.8 Triggering Latency

6.3.6 Defaults Tab

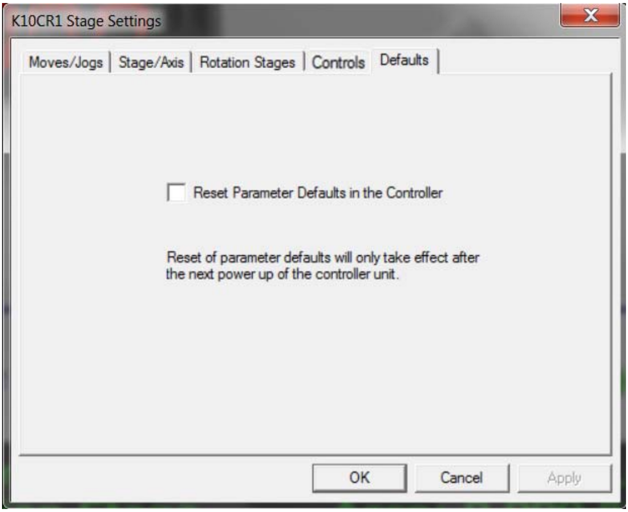


Fig. 6.9 Defaults Tab

If adjustment of the parameter values previously described has resulted in unstable or unsatisfactory system response, this tab can be used to reset all parameter values to the factory default settings.

To restore the default values, click the ‘Reset Parameter Defaults in the Controller’ check box, then click OK.

The controller must then be power cycled before the default values can take effect.

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 APT 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

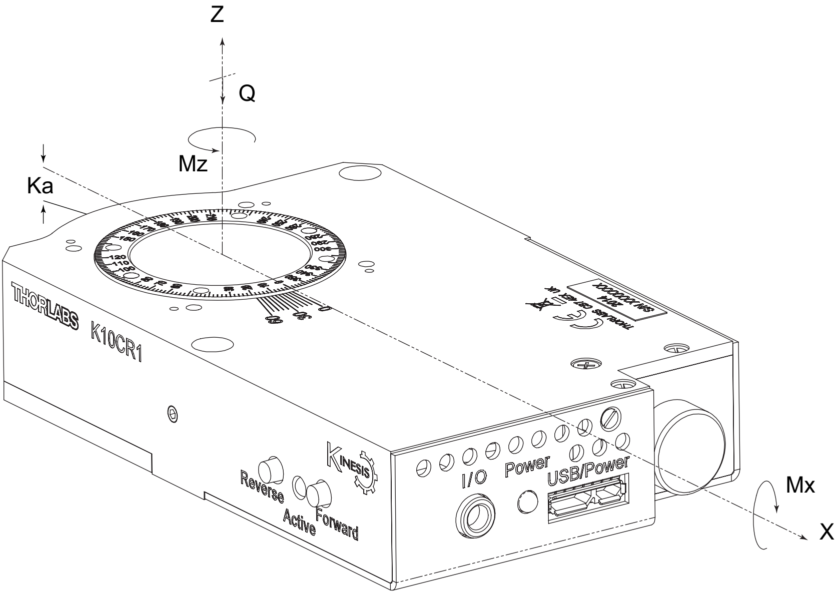


Fig. A.1 Load Capacity Definitions

Appendix B Motor Control Method Summary

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

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

The Methods and Properties of the Motor ActiveX Control can be used to perform activities such as homing stages, absolute and relative moves, and changing velocity profile settings. A brief summary of each method and property is given below, for more detailed information and individual parameter descriptions please see the on-line help file supplied with the APT server.

Methods

CalibrateEnc	Calibrates encoder equipped stage.
DeleteParamSet	Deletes stored settings for specific controller.
DisableHWChannel	Disables the drive output.
DoEvents	Allows client application to process other activity.
EnableHWChannel	Enables the drive output.
GetAbsMovePos	Gets the absolute move position.
GetAbsMovePos_AbsPos	Gets the absolute move position (returned by value).
GetBLashDist	Gets the backlash distance.
GetBLashDist_BLashDist	Gets the backlash distance (returned by value).
GetCtrlStarted	Gets the ActiveX Control started flag.
GetDispMode	Gets the GUI display mode.
GetEncCalibTableParams	Gets the encoder calibration table parameters for encoder equipped stages.
GetEncPosControlParams	Gets the encoder position control parameters for encoder equipped stages.
GetEncPosCorrectParams	Gets the encoder position correction parameters for encoder equipped stages.

GetHomeParams	Gets the homing sequence parameters.
GetHomeParams_HomeVel	Gets the homing velocity parameter (returned by value).
GetHomeParams_ZeroOffset	Gets the homing zero offset parameter (returned by value).
GetHWCommsOK	Gets the hardware communications OK flag.
GetHWLimSwitches	Gets the limit switch configuration settings.
GetJogMode	Gets the jogging button operating modes.
GetJogMode_Mode	Get the jogging button operating mode (returned by value).
GetJogMode_StopMode	Gets the jogging button stopping mode (returned by value).
GetJogStepSize	Gets the jogging step size.
GetJogStepSize_StepSize	Gets the jogging step size (returned by value).
GetJogVelParams	Gets the jogging velocity profile parameters.
GetJogVelParams_Accn	Gets the jogging acceleration parameter (returned by value).
GetJogVelParams_MaxVel	Gets the jogging maximum velocity parameter (returned by value).
GetMotorParams	Gets the motor gearing parameters.
GetParentHWInfo	Gets the identification information of the host controller.
GetPhaseCurrents	Gets the coil phase currents.
GetPosition	Gets the current motor position.
GetPosition_Position	Gets the current motor position (returned by value).
GetPositionEx	Gets the current motor position.
GetPositionEx_UncalibPosition	Gets the current uncalibrated motor position (returned by value).
GetPositionOffset	Gets the motor position offset.
GetRelMoveDist	Gets the relative move distance.
GetRelMoveDist_RelDist	Gets the relative move distance (returned by reference).
GetStageAxis	Gets the stage type information associated with the motor under control.
GetStageAxisInfo	Gets the stage axis parameters.
GetStageAxisInfo_MaxPos	Gets the stage maximum position (returned by value).

GetStageAxisInfo_MinPos	Gets the stage minimum position (returned by value).
GetStatusBits_Bits	Gets the controller status bits encoded in 32 bit integer (returned by value).
GetTriggerParams	Gets the move triggering parameters.
GetVelParamLimits	Gets the maximum velocity profile parameter limits.
GetVelParams	Gets the velocity profile parameters.
GetVelParams_Accn	Gets the move acceleration (returned by value).
GetVelParams_MaxVel	Gets the move maximum velocity (returned by value).
Identify	Identifies the controller by flashing unit LEDs.
LLGetDigIPs	Gets digital input states encoded in 32 bit integer.
LLGetStatusBits	Gets the controller status bits encoded in 32 bit integer.
LLSetGetDigOPs	Sets or Gets the user digital output bits encoded in 32 bit integer.
LoadParamSet	Loads stored settings for specific controller.
MoveAbsolute	Initiates an absolute move.
MoveAbsoluteEnc	Initiates an absolute move with specified positions for encoder equipped stages.
MoveAbsoluteEx	Initiates an absoloute move with specified positions.
MoveAbsoluteRot	Initiates an absolute move with specified positions for rotary stages.
MoveHome	Initiates a homing sequence.
MoveJog	Initiates a jog move.
MoveRelative	Initiates a relative move.
MoveRelativeEnc	Initiates a relative move with specified distances for encoder equipped stages.
MoveRelativeEx	Initiates a relative move with specified distances.
MoveVelocity	Initiates a move at constant velocity with no end point.
SaveParamSet	Saves settings for a specific controller.
SetAbsMovePos	Sets the absolute move position.
SetBLashDist	Sets the backlash distance.
SetChannelSwitch	Sets the GUI channel switch position.
SetDispMode	Sets the GUI display mode.
SetEncCalibTableParams	Sets the encoder calibration table parameters for encoder equipped stages.

SetEncPosControlParams	Sets the encoder position control parameters for encoder equipped stages.
SetEncPosCorrectParams	Sets the encoder position correction parameters for encoder equipped stages.
SetHomeParams	Sets the homing sequence parameters.
SetHWLimSwitches	Sets the limit switch configuration settings.
SetJogMode	Sets the jogging button operating modes.
SetJogStepSize	Sets the jogging step size.
SetJogVelParams	Sets the jogging velocity profile parameters.
SetMotorParams	Sets the motor gearing parameters.
SetPhaseCurrents	Sets the coil phase currents.
SetPositionOffset	Sets the motor position offset.
SetPotParams	Sets the velocity control potentiometer parameters (Cube drivers).
SetRelMoveDist	Sets the relative move distance.
SetStageAxisInfo	Sets the stage axis parameters.
SetTriggerParams	Sets the move triggering parameters.
SetVelParams	Sets the velocity profile parameters.
ShowSettingsDlg	Display the GUI Settings panel.
StartCtrl	Starts the ActiveX Control (starts communication with controller)
StopCtrl	Stops the ActiveX Control (stops communication with controller)
StopImmediate	Stops a motor move immediately.
StopProfiled	Stops a motor move in a profiled (decelleration) manner.

Properties

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

Appendix C Stepper Motor Operation

C.1 How A Stepper Motor Works

C.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. C.1.

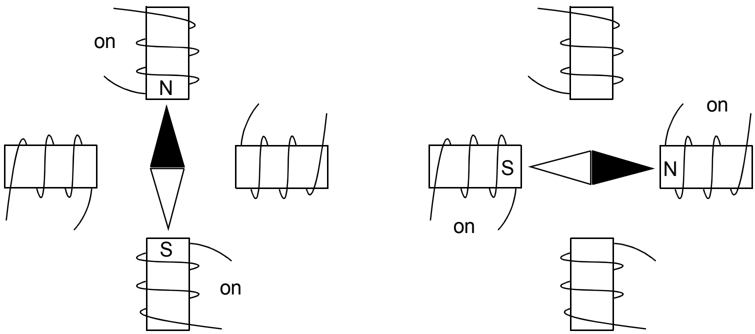


Fig. C.1 Simplified concept of stepper motor operation

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.

C.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.

C.1.3 Velocity Profiles

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

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

The specific move profile created by the system depends on several factors, such as the profile mode and profile parameters presently selected, and other conditions such as whether a motion stop has been requested. The profile mode can be set to 'Trapezoidal' or 'Bow Index' as described in Section 6.3.1.

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

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

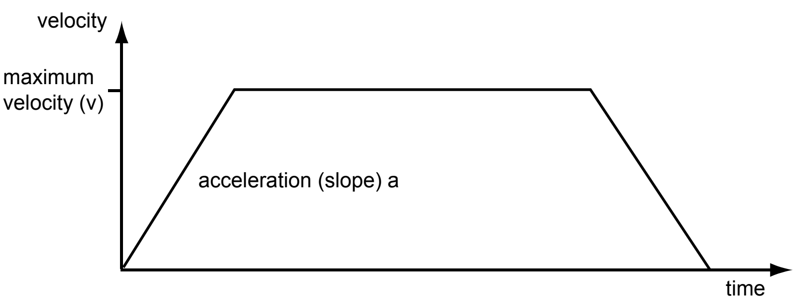


Fig. C.2 Graph of a trapezoidal velocity profile

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

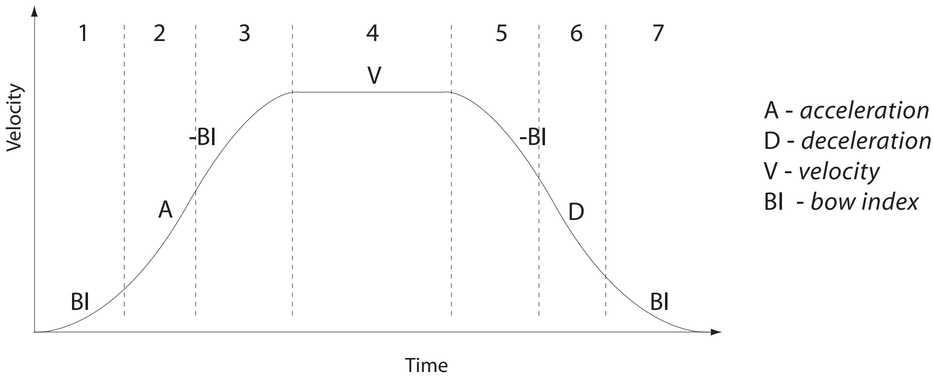


Fig. C.3 Typical S-Curve Profile

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.

C.2 Positioning a Stage

C.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 APT software.

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

C.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.

C.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.

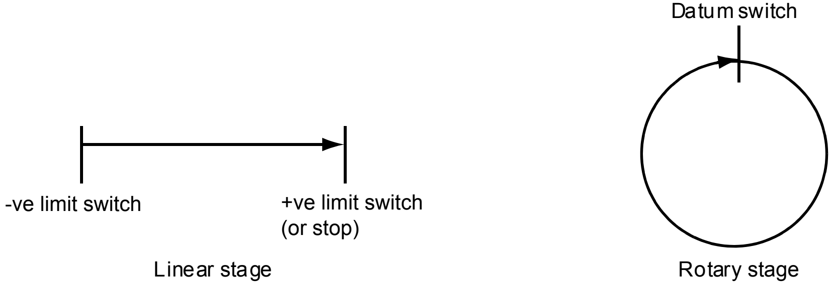


Fig. C.4 Stage limit switches

C.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 6.3.3. for more details on these power settings.

C.3 Error Correction

C.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. 3.5, 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.

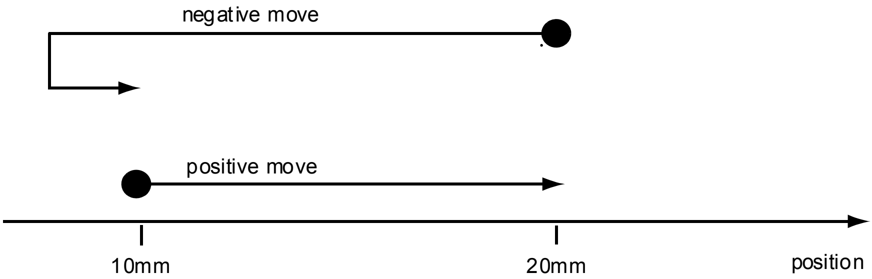


Fig. 3.5 Backlash correction

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 6.3.1. for details on setting the backlash correction.

Appendix D Regulatory

D.1 Declarations Of Conformity

D.1.1 For Customers in Europe

A CE certificate is included in Section D.3.

D.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.

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

D.2.1 Compliance

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

This offer is valid for electrical and electronic equipment

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

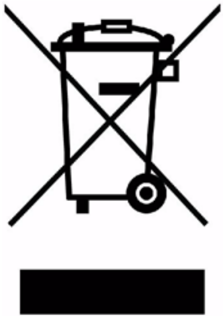


Fig. 4.1 Crossed out "wheelie bin" symbol

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

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

If you wish to return a unit for waste recovery, please contact Thorlabs or your nearest dealer for further information.

D.2.2 Waste treatment on your own responsibility

If you do not return an "end of life" unit to the company, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

D.2.3 Ecological background

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

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

D.3 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: *On:* 12 March 2015

Name: Keith Dhese

Position: General Manager

EDC - K10CR1 Series -2015-03-12

CE

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