



# **MLJ150**

## **Motorized Lab Jack**

### **Kinesis User Guide**



Original Instructions

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## Chapter 1 Overview

### 1.1 Introduction

The MLJ150 is a stepper-motor driven lab jack. The integrated electronic controller can either be driven via a PC or can be controlled manually via the buttons and velocity potentiometer on the control key pad. These Motorized Lab Jacks provide a rugged, height adjustable platform ideal for mounting optomechanical sub-assemblies requiring height adjustment. The MLJ150 Motorized Lab Jack offers excellent rigidity and platform parallelism while providing smooth, quiet motion. Integral limit switches prevent overdriving. The large 148 mm x 131 mm (5.83" x 5.16") mounting platform supports up to 44 lbs (20 kg) with a smooth vertical adjustment range of 2" (50 mm). Both the top and bottom plates offer a generous array of 1/4" - 20 (M6) tapped holes and clearance slots for general mounting requirements.



**Fig. 1.1 MLJ150 Motorized Lab Jack**

The MLJ150 stages share many of the benefits of the Thorlabs range of motor controllers. These include USB connectivity (allowing multiple units to be used together on a single PC), fully featured Graphical User Interface (GUI) panels, and extensive software function libraries for custom application development.

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

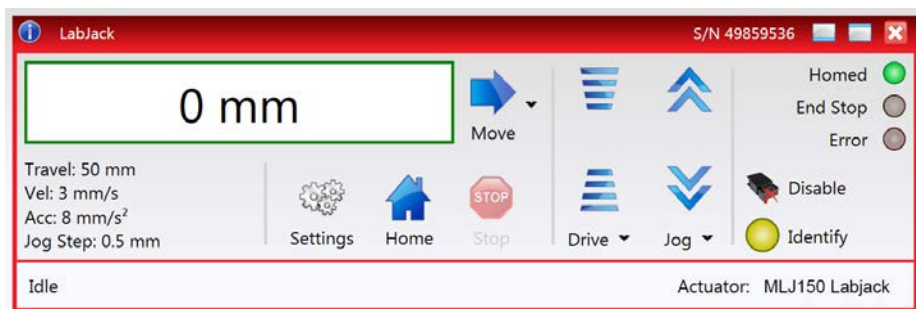
The User Interface allows full control of all settings and operating modes enabling complete 'out-of-box' operation without the need to develop any further custom software. It provides all of the necessary system software services such as generation of GUI panels, communications handling for multiple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

#### 1.1.1 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.

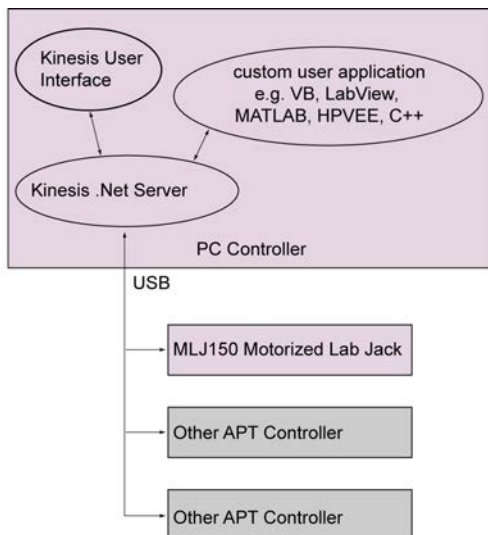
With the Kinesis system, .Net Controls are deployed to allow direct control over (and also reflect the status of) the range of electronic controller units, including the MLJ150 stages. Software applications that use .Net Controls are often referred to as 'client applications'. A .Net Control is a language 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 control supplied for the MLJ150 integrated Labjack & 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 stage to move, 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. 1.2 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.

### 1.1.2 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](http://www.thorlabs.com).

## Chapter 2 Safety

### 2.1 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.



#### **Warning: Risk of Electrical Shock**

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.

### 2.2 General Warnings



#### **Warning**

If this equipment is used in a manner not specified in the handbook, 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 3 Mechanical Installation

### 3.1 Unpacking

**Caution**

Once removed from its packaging, the MLJ150 lab jack 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.

**Note**

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

### 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°C to 40°C

Maximum Humidity Less than 80% RH (non-condensing) at 31°C

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

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

The unit must not be used in an explosive environment.

### 3.3 Mounting to a Work Surface

**Warning**

The safety of any system incorporating this equipment is the responsibility of the person performing the installation.

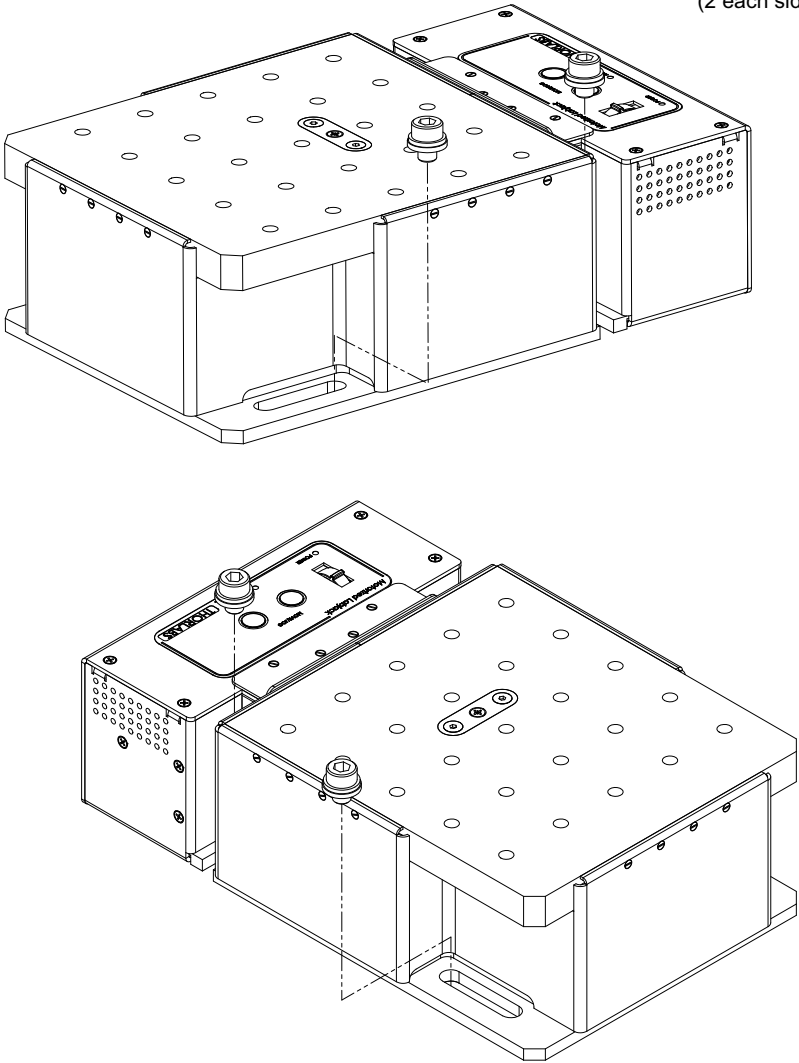
#### 3.3.1 General

When mounting the lab jack close to other equipment, ensure that the travel of the moving platform is not obstructed. If equipment mounted on the moving platform is driven against a solid object, damage to the internal mechanism could occur. The range of travel is 2.0" (50 mm) vertically.

### 3.3.2 Mounting the Stage to the Work Surface

The MLJ150 lab jack is mounted to the working surface by four M6 (1/4-20) screws through the base as shown in Fig. 3.1..

4 Bolts M6 (1/4-20)  
(2 each side)



**Fig. 3.1** Installation

## Chapter 4 Software & Electrical Installation

### 4.1 Installing 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 Kinesis 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) Go to Services/Downloads at [www.thorlabs.com](http://www.thorlabs.com) and download the Kinesis software.
- 2) Run the .exe file and follow the on-screen instructions.

## 4.2 Electrical Installation

### 4.2.1 Connecting To The Supply



#### **Warning: Risk of Electrical Shock**

The PSU unit must be connected only to an earthed fused supply of 100 to 240V.

Use only the power supply supplied by Thorlabs, other units may not be rated to the same current.

The unit is shipped to the UK, Europe and the USA, with the appropriate power plug already fitted. When shipped to other territories the appropriate power plug must be fitted by the user. Cable identification is as follows:

Brown: Live Blue: Neutral Green/Yellow: Earth/Ground

When connecting the power and USB cables, ensure they are routed clear of the moving platform.

## 4.3 Connecting The Hardware

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

#### **Note**

The USB cable should be no more than 3 metres in length. Communication lengths in excess of 3 metres can be achieved by using a powered USB hub).



#### **Caution**

To avoid electrical arcing at the terminals, connect the PSU to the stage BEFORE applying power to the unit.

- 4) Connect the stage to the power supply - - see Section 4.2.1.
- 5) Connect the PSU to the main supply and switch 'ON'.
- 6) Wait for the unit to initialize (about 5 sec). Do not press any controls during this time. The ACTIVE LED is extinguished or flashing when the unit is ready for use.

- 7) Windows™ should detect the new hardware. Wait while Windows™ installs the drivers for the new hardware - see the Getting Started guide for more information.

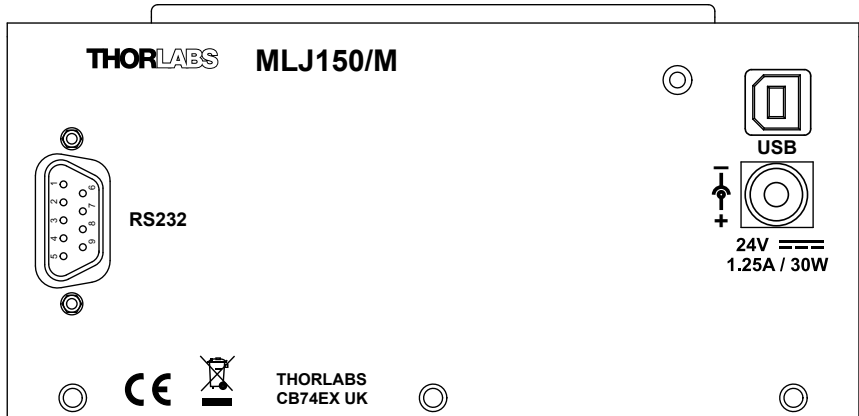


Fig. 4.1 Power and USB Connectors

### 4.4 RS232/USB Comms

Communication with the unit can be performed using either USB or RS232 protocols. When the USB connector is used, USB Comms is dominant, and RS232 Comms cannot be used. If the USB port is not used, then the RS232 port can be used without further set up.

The pin functions are detailed in in Fig. 4.2 .

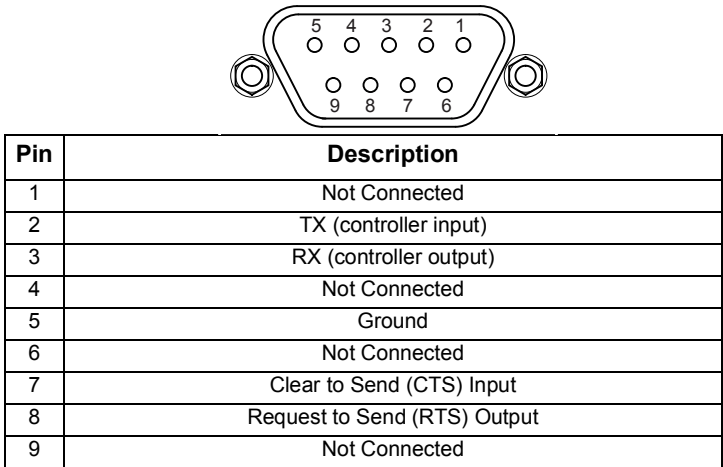


Fig. 4.2 RS232 Connector Pin Identification

**Note**

When using the RS232 Port, or a virtual comms port via USB, communication is achieved using the messages described in the Protocol Document.

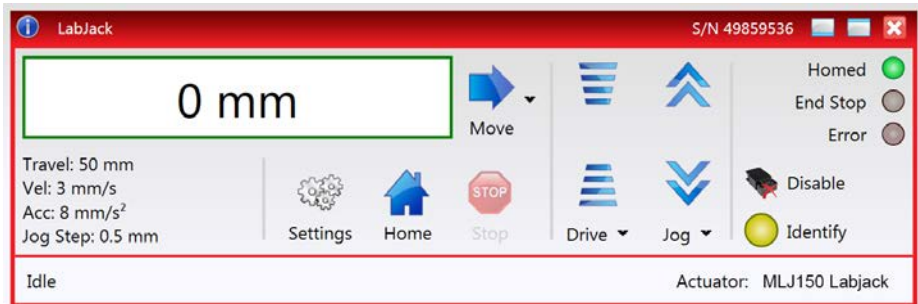
## 4.5 Verifying Software Operation

### 4.5.1 Initial Setup

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

#### Note

If the Kinesis software does not recognise the unit, switch OFF the power but leave the kinesis software running and the USB connected. Wait around 30 seconds then switch the power ON. Kinesis should now load the unit.



**Fig. 4.3** Gui panel showing jog and ident buttons

- 2) Click the 'Identify' button. The POWER LED on the control keypad flashes. This is useful in multi-channel systems for identifying which driver unit is associated with which GUI.
- 3) 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.

## Chapter 5 Standalone Operation

### 5.1 Introduction

The MLJ150 lab jack offers a fully featured motion control capability including velocity profile settings, limit switch handling, and homing sequences. When the unit is connected to the PC, these parameters are automatically set to allow “out of the box” operation with no further “tuning” required. However, further adjustment is possible via the Kinesis Server software - see Chapter 6.

The following brief overview explains how the top panel controls can be used to perform a typical series of motor moves.

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



#### Warning

As the unit is raised and lowered, items can become trapped in the mechanism. During operation, keep fingers, clothing and tools away from any moving parts.

### 5.2 Top Panel Controls and Indicators

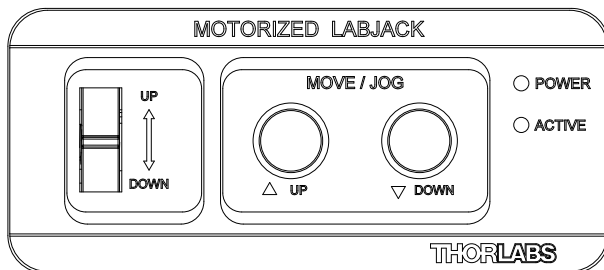


Fig. 5.1 Front Panel Controls and Indicators

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

*Jog Buttons* - Used to jog the motors and make discrete position increments in either direction (left button up, right button down) - see Section 6.6. for more details on jogging.

*Slider Potentiometer* - Used to drive the motor at a pre-defined speed in either forward or reverse directions for full and easy motor control - see Section 5.3.

**ACTIVE LED** - The Active LED will flash when the motor reaches a forward or reverse limit switch, and is lit when the motor is moving.

**POWER LED** - When the stage is enabled, this LED is lit. Furthermore, this LED will flash when the 'Ident' button is clicked on the Kinesis GUI panel.



### 5.3 Potentiometer Operation

The potentiometer slider is sprung such that when released it returns to its central position. In this central position the motor is stationary. As the slider is moved away from the centre, the motor begins to move. Bidirectional control of the motor is possible by moving the slider in both directions.

### 5.4 Button Operation

#### Note

The two buttons and the slider on the user top panel can be disabled if required. To do this, hold down both buttons and then power up the unit. Continue to hold down the buttons until the green POWER LED is lit. This setting is then persisted, and the buttons will remain disabled until the user again holds down both buttons on power up, at which point the user interface becomes operable again.

The keypad can be used to control the motor in a number of ways, as follows.

#### 5.4.1 Homing

A 'Home' move is performed to establish a datum from which subsequent absolute position moves can be measured (see Section 6.3. 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.

#### 5.4.2 Jogging

The front panel buttons can also be used to 'jog' the motor. The jogging parameters for the buttons are taken from the 'Jog' parameters on the 'Move/Jogs' settings tab - see Section 7.3.

## Chapter 6 PC Operation

### 6.1 Introduction

The following brief tutorial guides the user through a typical series of moves and parameter adjustments performed using the Kinesis software. It assumes that the unit is electrically connected as described in Section 4.2. and that the software is already installed - see Section 4.1.



#### Warning

As the unit is raised and lowered, items can become trapped in the mechanism. During operation, keep fingers, clothing and tools away from any moving parts.

### 6.2 Using the Kinesis Software

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

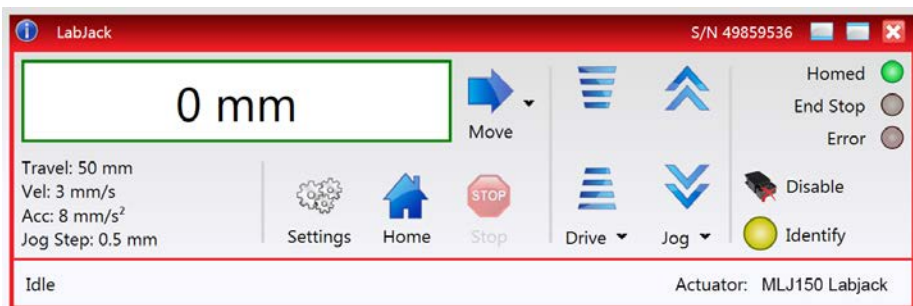


Fig. 6.1 Typical Kinesis User Screen

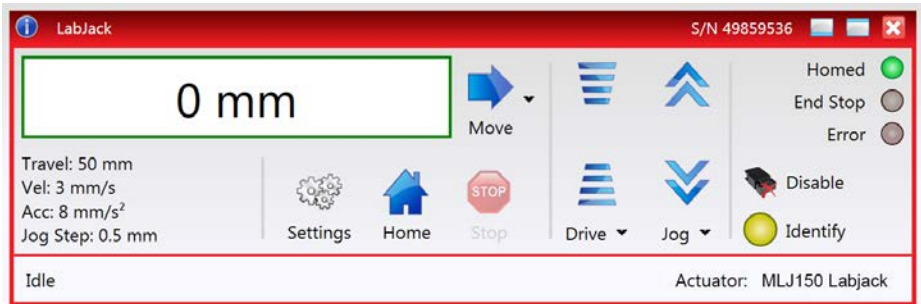
- 1) Run the Kinesis software - Start/All Programs/Thorlabs/Kinesis/Kinesis

#### Note

If the Kinesis software does not recognise the unit, switch OFF the power but leave the kinesis software running and the USB connected. Wait around 30 seconds then switch the power ON. Kinesis should now load the unit.

### 6.3 Homing Motors

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



**Fig. 6.2 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.
  - 2) When homing is complete, the 'Homed' LED is lit as shown above.
- See Appendix C, Section C.2.2. for background information on the home position.

### 6.4 Stopping the Stage

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

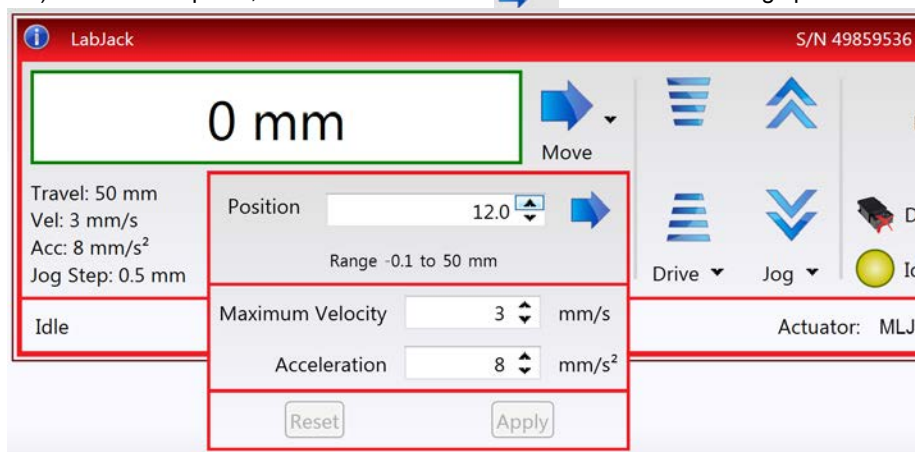
During operation, the stage can be stopped at any time by clicking the 'Stop' button on the GUI panel. Using this button does not remove power to the drive channel. .

## 6.5 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 C, Section C.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.



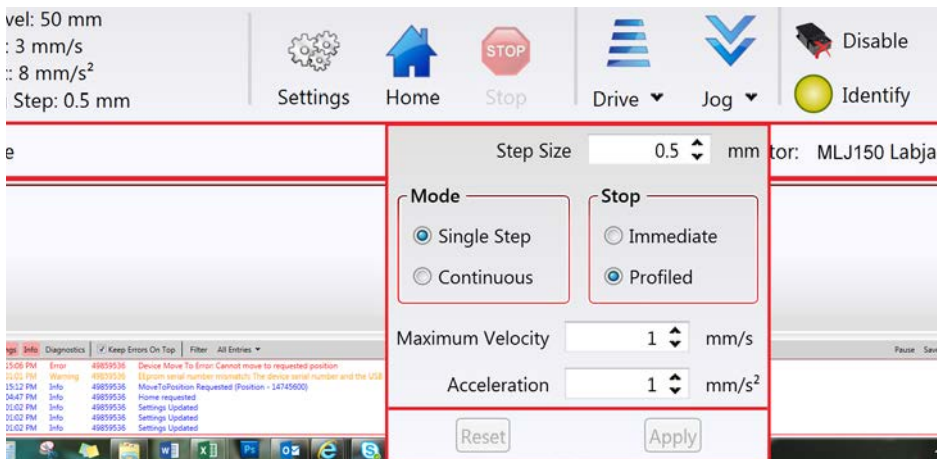
**Fig. 6.3 Move Settings Panel**

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

## 6.6 Jogging

During PC operation, the motor actuators are jogged using the GUI panel arrow keys. There are two jogging modes available, 'Single Step' and 'Continuous'. In 'Single Step' mode, the motor moves by the step size specified in the Step Distance parameter. If the jog key is held down, single step jogging is repeated until the button is released - see Fig. 7.3. 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. 6.4 Jog Settings Panel**

- 2) Make parameter changes as required.

### Note

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

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

## 6.7 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*.

## 6.8 Changing and Saving Parameter Settings

During operation, certain settings (e.g. max velocity, jog step size etc) can be changed as required. Other settings (e.g. PID parameter values) cannot be changed so easily. When the Kinesis Server is run up and the stage/actuator association made, suitable default settings are loaded and these values have been chosen to provide safe performance in 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.

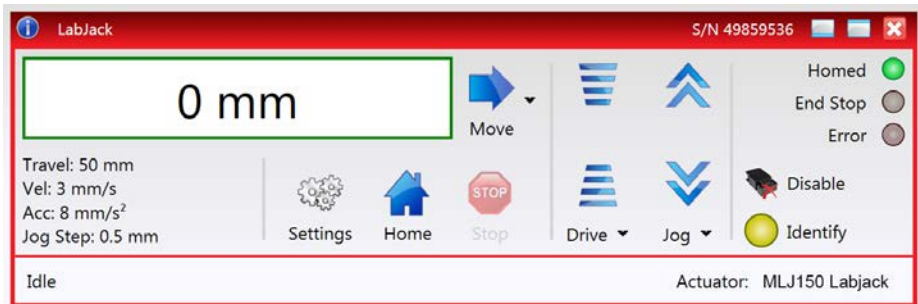
## Chapter 7 Software Reference

### 7.1 Introduction

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

### 7.2 GUI Panel

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



**Fig. 7.1 Motor Controller Software GUI**

#### Note

The serial number of the MLJ150 lab jack associated with the GUI panel is displayed in the top right hand corner. This information should always be provided when requesting customer support.

12 mm

**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 6.5. Moves are performed using the current velocity parameters which can be changed in the same panel. The present settings are displayed below the window.

Travel: 50 mm  
Vel: 3 mm/s  
Acc: 8 mm/s<sup>2</sup>  
Jog Step: 0.5 mm

**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 7.3.2.



**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.

Not Homed 

**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 

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

Error 

**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 7.3.



**Home** - sends the motor to its 'Home' position - see Appendix C Section C.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.

Moving

### 7.3 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).

#### 7.3.1 Persisting Settings to Hardware

Many of the parameters that can be set for the MLJ150 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.

### 7.3.2 Moves/Jogs Tab

The screenshot shows the 'Settings' window for the MLJ150, specifically the 'Moves / Jogs' tab. The window is divided into several sections: 'Display Units', 'Jog Parameters', 'Velocity Parameters', 'Backlash', and 'Velocity Profile Settings'. Each section contains various input fields and dropdown menus for configuring movement parameters. The 'Display Units' section includes a checkbox for 'Use Device Units', a 'Units' dropdown set to 'mm', and a 'Factor' input set to '1.0'. The 'Jog Parameters' section includes 'Step Size' (0.5 mm), 'Mode' (Jog), 'Stop' (Profiled), 'Maximum Velocity' (1 mm/s), and 'Acceleration' (1 mm/s²). The 'Velocity Parameters' section includes 'Maximum Velocity' (3 mm/s) and 'Acceleration' (8 mm/s²). The 'Backlash' section includes 'Distance' (0.075 mm). The 'Velocity Profile Settings' section includes a 'Profile' dropdown set to 'Trapezoidal'. At the bottom right, there is a checkbox for 'Persist Settings to the Device'. The window has 'Cancel', 'Save', and 'OK' buttons at the bottom.

Fig. 7.2 MLJ150 - Move/Jog Settings

#### Display Units

By default, the unit will display position in real world units (mm or degrees). If required, the units can be changed to so that the display shows other positional units (cm,  $\mu\text{m}$ , in. etc).

**Units** - the positioning units used on the GUI display.

**Factor** - the scaling factor associated with the selected units.

#### Jog Parameters

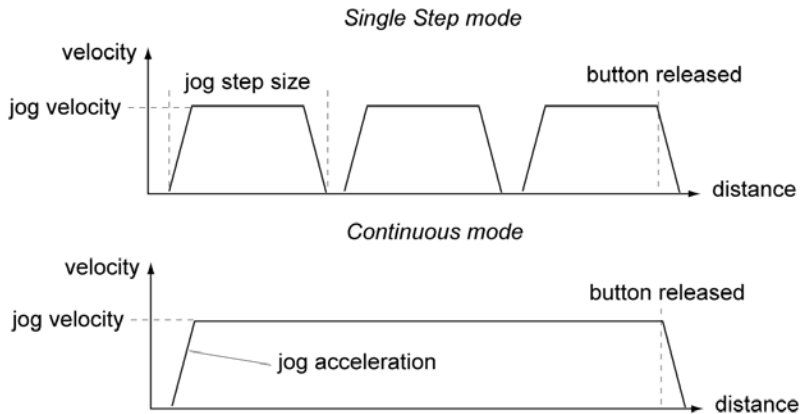
Jogs are initiated by using the 'Jog' keys on the GUI panel (see Section 6.6.), or the Jog Buttons on the front panel of the unit.

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

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

There are two jogging modes available, 'Jog' and 'Continuous'. In 'Jog' mode, the motor moves by the distance specified in the Step Size parameter. If the jog key is held down, single step jogging is repeated until the button is released - see Fig. 7.3.

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



**Fig. 7.3 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 6.5.), 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.

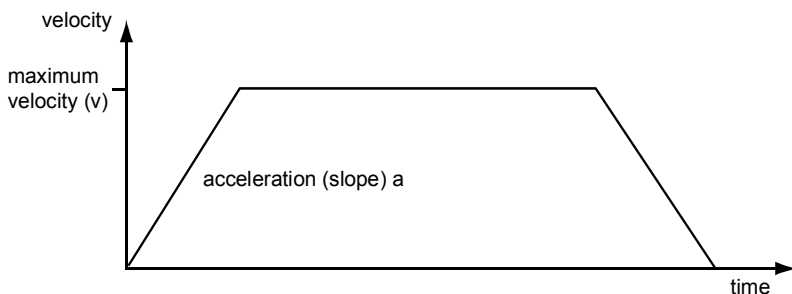
The system incorporates a trajectory generator, which performs calculations to determine the instantaneous position, velocity and acceleration of each axis at any given moment. During a motion profile, these values will change continuously. Once the move is complete, these parameters will then remain 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. 7.4.), 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. 7.4 Graph of a trapezoidal velocity profile**

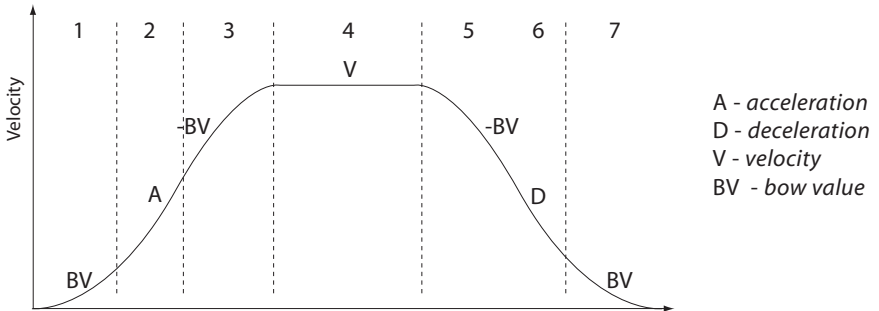
The *S-curve* profile is a trapezoidal curve with an additional '*Bow Value*' parameter, which limits the rate of change of acceleration and smooths out the contours of the

motion profile. The *Bow Value* is applied in  $\text{mm/s}^3$  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



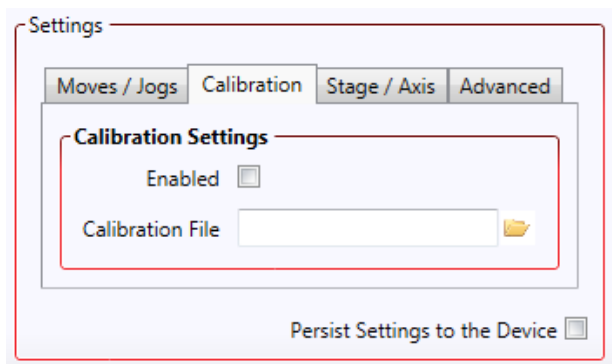
**Fig. 7.5 Typical S-Curve Profile**

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.

### 7.3.3 Calibration Tab



**Fig. 7.6 MLJ150 Stage - Calibration Settings**

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

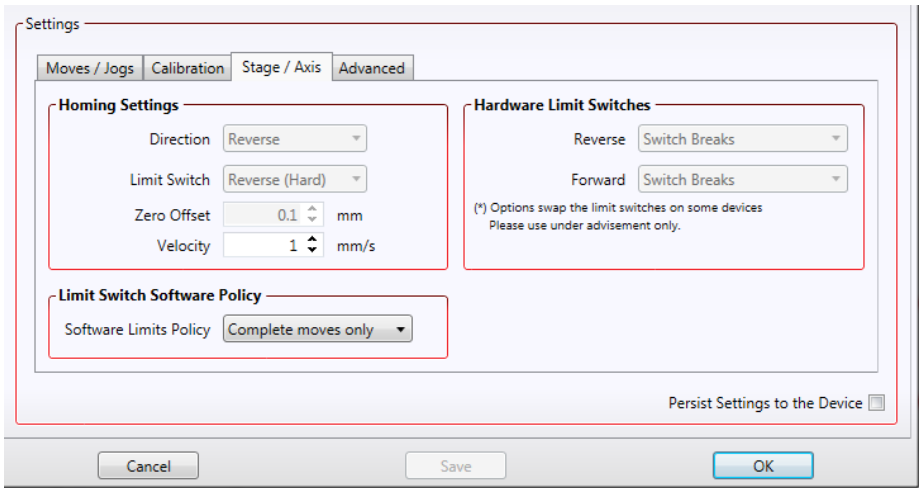
During calibration, the total positional error is measured at a large number of points and these errors are stored as a look up table (LUT). The LUT is saved as a calibration file, one file for each particular stage. Whenever the stage is moved, the LUT is consulted to ascertain the precise movement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

The use of a calibration file is optional. Without it, the repeatability and resolution of the stage are unaffected, but no compensations are made to enhance the accuracy. Calibration files can be downloaded from the support documents section on the product web page, one file for each serial number.

To assign a calibration file:

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

### 7.3.4 Stage/Axis Tab



**Fig. 7.7 MLJ150 Stage - Stage/Axis Settings**

#### Note

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

For MLJ150, the Kinesis software will automatically apply suitable defaults for the parameters on this tab during boot up of the software and these parameters should not normally be altered subsequently as it may adversely affect the performance of the stage. Descriptions are provided for information only.

#### Homing Settings

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

#### Note

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

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

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

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

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

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

Limit Switch Software Policy



### 7.3.5 Advanced Tab

Settings

Moves / Jogs Calibration Stage / Axis **Advanced**

**Power Settings**

Resting Power 15%

**Button Control Settings**

Mode Move by

Device buttons will jog using the parameters set in the Jog Parameters

**Drive Array Velocities**

(Fast) Velocity 4 3 mm/s

Velocity 3 2.25 mm/s

Velocity 2 1.5 mm/s

(Slow) Velocity 1 0.75 mm/s

Persist Settings to the Device ☐

Cancel Save OK

**Fig. 7.8 MLJ150 Stage - Advanced Settings**

#### Power Settings

The MLJ150 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.

## Appendix A Preventive Maintenance



### Warning

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

### A.1 Safety Testing

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



### Caution

The instrument contains a power supply filter. Insulation testing of the power supply connector should be performed using a DC voltage.

### A.2 Cleaning



### Warning

Disconnect the power supply before cleaning the unit.  
Never allow water to get inside the case.  
Do not saturate the unit.  
Do not use any type of abrasive pad, scouring powder or solvent, e.g. alcohol or benzene.

The fascia may be cleaned with a soft cloth, lightly dampened with water or a mild detergent.

### A.3 Troubleshooting

If an unexpected obstruction to the stage motion is encountered, the control system interface software disables the current to the associated drive channel, which may or may not result in the channel being disabled. After the obstruction to be removed, the associated channel of the controller should first be disabled to clear any fault codes, then re-enabled.

In the event of a breakdown, or malfunction of the product please contact Thorlabs Tech Support. Contact details are contained in Appendix E.

## Appendix B Specifications

Parameter	Value
<b>Controller Specifications</b>	
Microsteps per Full Step	2048
Microsteps per Rev. of Motor	409,600
Motor Drive Voltage	24 V
Motor Drive Power	Up to 25 W (Peak)/ 12.5 W (Avg)
Motor Speeds	Up to 720 RPM
<b>Stage Specifications</b>	
Travel	50 mm (1.97")
Gear Ratio	3 to 1 (1228800 microsteps = 1 mm Travel)
Maximum Load	20 kg (44 lbs)
Maximum Moment Load	5 kg (11 lb) 100 mm (3.9") from Center of Platform 5 N.m (44 in lb)
Max Velocity	3.0 mm/sec (All Loads)
Resolution	0.8 nm
Unidirectional Repeatability (Software Corrected)	<10 µm
Bidirectional Repeatability (System Backlash)	<50 µm
Deck Parallelism	<150 µm Over Full Travel Range
Pitch/Roll Error over 50 mm Travel	<500 µrad
Accuracy	<30 µm
Lead Screw Pitch	1.0 mm
<b>Motor Specifications</b>	
Step Angle	1.8°
Step Accuracy	5%
Rated Phase Current	0.85 A
Phase Resistance	5.4 Ohms
Phase Inductance	5.6 mH
Holding Torque	20 N.cm
Detent Torque	2.0 N.cm
Operating Temperature	-20°C to +40°C (Motor Specification Only)
<b>Input Power Requirements</b>	
Current	1.25 A
Voltage	24 VDC

Parameter	Value
Power	30 W (Peak)
<b>Dimensions (W x D x H)</b>	
Extended	131.0 x 216.7 x 115 mm (5.16" x 8.53" x 4.53")
Retracted	131.0 x 216.7 x 65.0 mm (5.16" x 8.53" x 2.56")
Weight	2.47 kg (5.4 lbs)

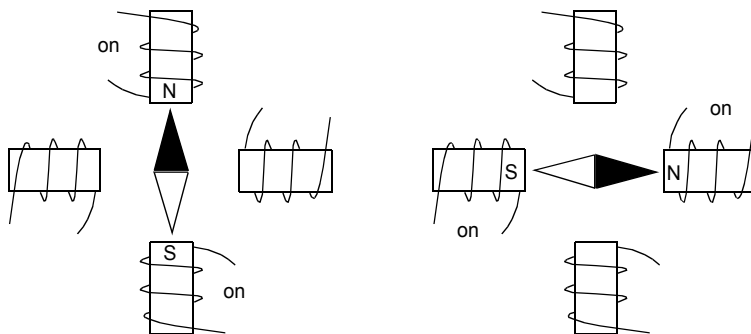
## Appendix C Stepper Motor Operation

### 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 MLJ150 lab jack gives a smallest angular adjustment of 0.000879 degrees (i.e.  $1.8/0.000879 = 2048$  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 motion employed is described by a trapezoidal velocity profile, reflecting the shape of the velocity vs. time graph (see Fig. C.2.), thereby driving the stage to its destination as quickly as possible, without causing it to stall or lose steps.

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.

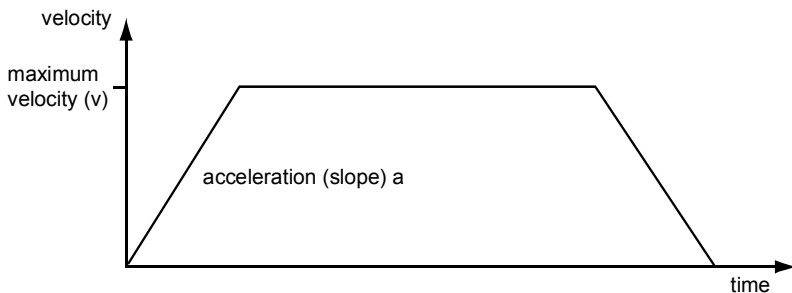


Fig. C.2 Graph of a trapezoidal velocity profile

## 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 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.

### 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.

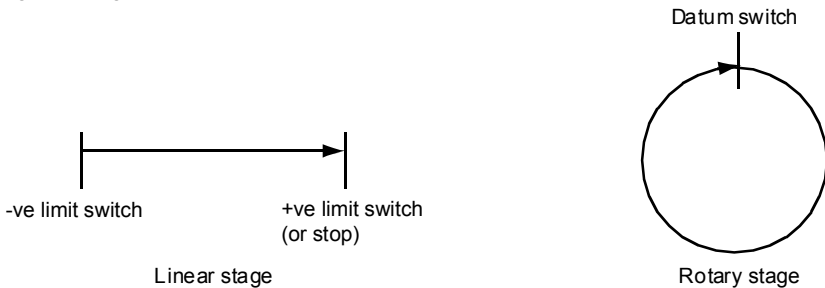
See Section 6.3. for details on performing a Home move.

### 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.3 Stage limit switches**

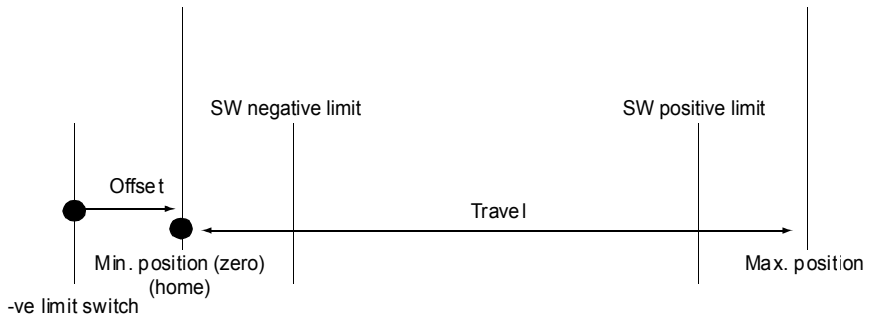


#### C.2.4 Minimum and Maximum Positions

These positions are dependent upon the stage or actuator to which the motors are fitted, and are defined as the minimum and maximum useful positions of the stage relative to the 'Home' position - see Fig. C.4.

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

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



**Fig. C.4 Minimum and Maximum Positions**

#### C.2.5 Power Saving

The current needed to hold a motor in a fixed position is much smaller than the current needed to move it, 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.

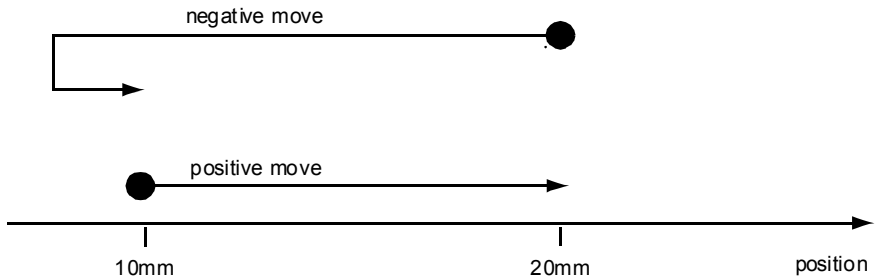
For this reason, power saving is implemented by default from the software drivers.

### 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. C.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. C.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 Chapter 7 for details on setting the backlash correction.

## Appendix D Regulatory




### D.1 Declarations Of Conformity

D.1.1 For Customers in Europe  
See Section D.2.

#### 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, pursuant 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 CE Certificate

	<b>THORLABS</b> www.thorlabs.com	
<b>EU Declaration of Conformity</b> <i>in accordance with EN ISO 17050-1:2010</i>		
<b>We:</b>	Thorlabs Ltd.	
<b>Of:</b>	1 St. Thomas Place, Ely, CB7 4EX, United Kingdom	
<i>in accordance with the following Directive(s):</i>		
2006/42/EC	Machinery Directive (MD)	
2014/30/EU	Electromagnetic Compatibility (EMC) Directive	
2011/65/EU	Restriction of Use of Certain Hazardous Substances (RoHS)	
 <i>hereby declare that:</i>		
<b>Model:</b>	<b>MLJ150 &amp; MLJ150/M</b>	
 <b>Equipment:</b>	<b>Motorized Lab Jack, Imperial &amp; Metric</b>	
 <i>is in conformity with the applicable requirements of the following documents:</i>		
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
 <i>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:</i>		
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>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.</i>		
<b>Signed:</b>		<b>On:</b> 27 October 2017
<b>Name:</b>	Keith Dhese	
<b>Position:</b>	General Manager	
		EDC - MLJ150 & MLJ150/M - 2017-10-27

## Appendix E Thorlabs Worldwide Contacts

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



### USA, Canada, and South America

Thorlabs, Inc.  
[sales@thorlabs.com](mailto:sales@thorlabs.com)  
[techsupport@thorlabs.com](mailto:techsupport@thorlabs.com)

### UK and Ireland

Thorlabs Ltd.  
[sales.uk@thorlabs.com](mailto:sales.uk@thorlabs.com)  
[techsupport.uk@thorlabs.com](mailto:techsupport.uk@thorlabs.com)

### Europe

Thorlabs GmbH  
[europe@thorlabs.com](mailto:europe@thorlabs.com)

### Scandinavia

Thorlabs Sweden AB  
[scandinavia@thorlabs.com](mailto:scandinavia@thorlabs.com)

### France

Thorlabs SAS  
[sales.fr@thorlabs.com](mailto:sales.fr@thorlabs.com)

### Brazil

Thorlabs Vendas de Fotônicos Ltda.  
[brasil@thorlabs.com](mailto:brasil@thorlabs.com)

### Japan

Thorlabs Japan, Inc.  
[sales@thorlabs.jp](mailto:sales@thorlabs.jp)

### China

Thorlabs China  
[chinasales@thorlabs.com](mailto:chinasales@thorlabs.com)

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 disassembled 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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