THORLABS

This legacy APT manual is provided for reference only. Our APT software was discontinued on July 1, 2024, and no updates have been made to this document since then. The latest product specifications are contained within the item-specific documentation at www.thorlabs.com

LTS150C(/M) and LTS300C(/M)

Long Travel Stages

APT User Guide

Original Instructions

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Chapter 1 Overview

1.1 Introduction

The LTS Series stages are a range of stepper-motor driven long travel stages with ranges of 150mm and 300mm. They have been designed to be light-weight, compact and robust with high performance over the full travel range. With a load capacity of up to 15 kg horizontally (4 kg vertically), these stages are highly suited to applications such as interferometry and M2 measurements and are compatible with our range of optomech and translation stages. Integrated magnetic limit switches allow homing as well as overdriving protection in both directions. The stages are inclusive of the drive electronics which can either be driven via a PC or can be controlled manually via the buttons and velocity potentiometer on the control keypad.

Figure 1 LTS150C and LTS300C Long Travel Stage

1.2 APT Software Overview

1.2.1 Introduction

As a member of the APT range of controllers, the LTS series 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 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 1.2.2) and APTConfig (see Section 1.2.3) 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 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 1.2.4.

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 1.2.4 for further details.

1.2.2 APTUser Utility

The APTUser application allows the user to interact with several 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.

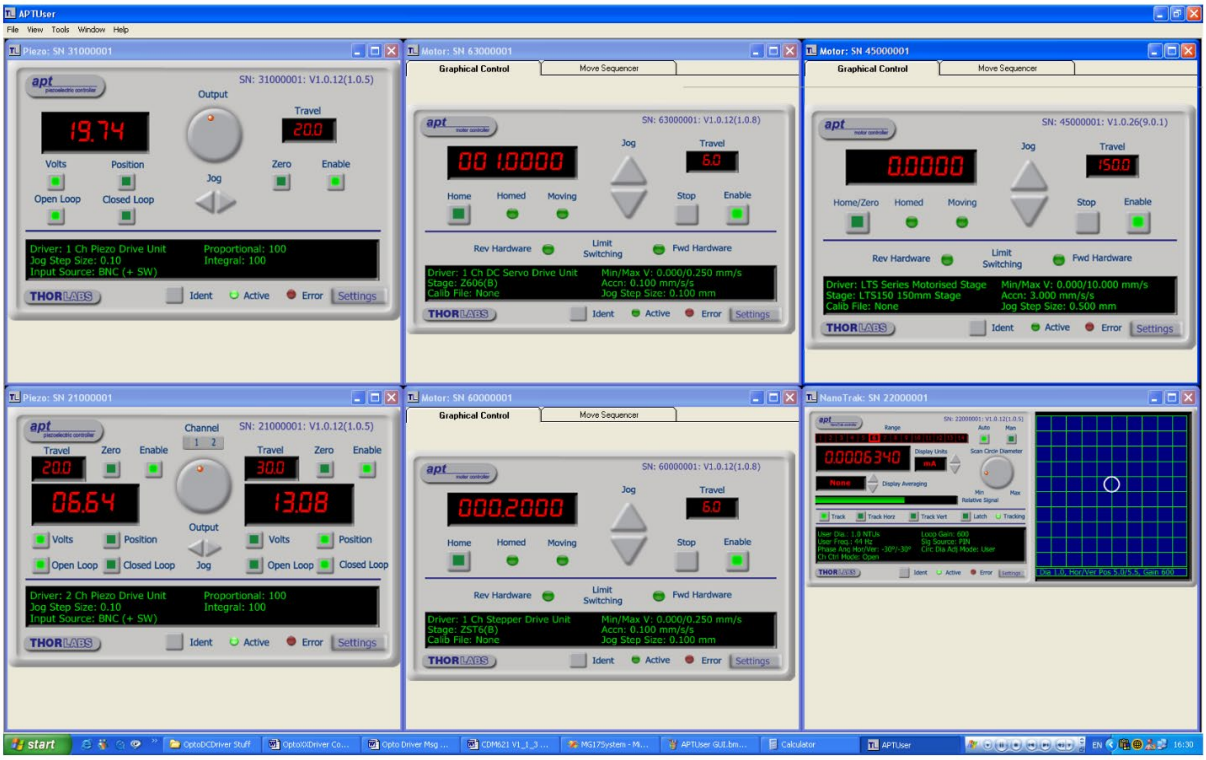

Figure 2 APTUser Utility

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 the functionality necessary to operate the APT hardware without the need to develop any further custom software. For those who do need to further customize 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 and in the APTUser online help file, accessed via the F1 key when using the APTUser utility.

1.2.3 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.

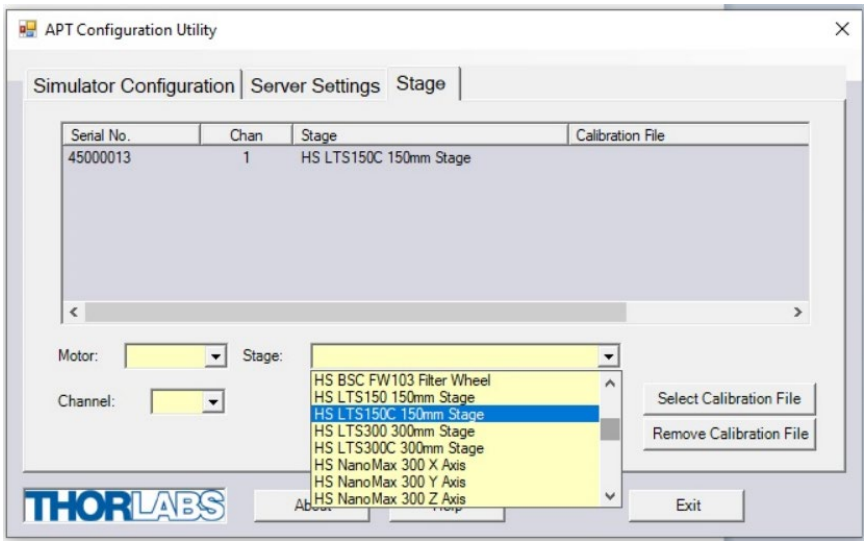

Figure 3 APT Config Utility

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 and in the APTConfig online help file, accessed via the F1 key when using the APTConfig utility.

1.2.4 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 reflect the status of the range of electronic controller units, including the LTS series 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 LTS150C integrated stage & controller.

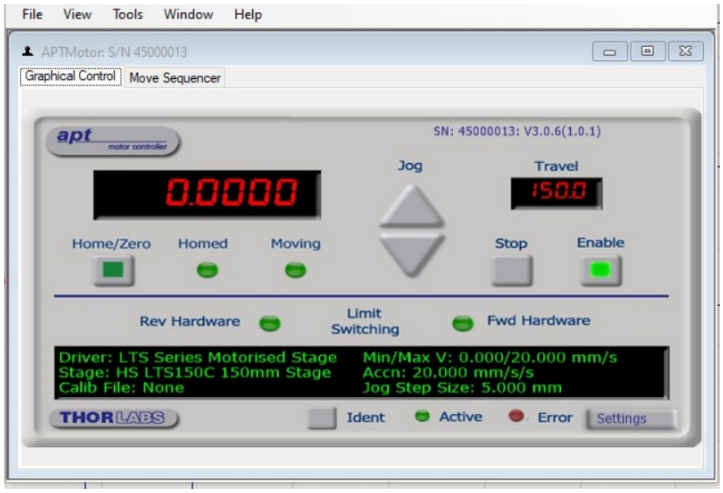

Figure 4 APT Server

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 Figure 5)

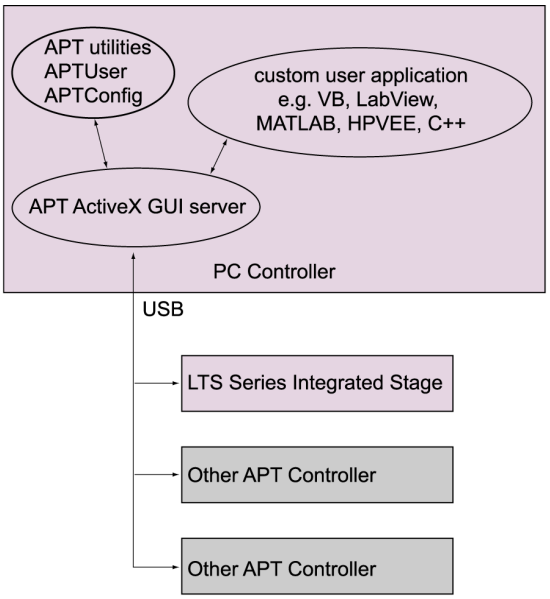

Figure 5 System Architecture Diagram

Refer to the main APT Software online help file, APTServer.hlp, for a complete programmer's guide and reference material on using the APT ActiveX Controls collection. Additional software developer support is provided by the APT Support CD supplied with every APT controller. This CD contains a complete range of tutorial samples and coding hints and tips, together with handbooks for all the APT controllers.

1.2.5 Software Upgrades

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

Chapter 2 Safety Information

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

Warning: Risk of Electrical Shock

Given when there is a risk of electrical shock.

Warning

Given when there is a risk of injury to users.

Caution

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

Note

Clarification of an instruction or additional information.

2.1 General Warnings and Cautions

Warning

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

Spillage of fluid, such as sample solutions, should be avoided. If spillage does occur, clean up immediately using 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 Environmental Conditions

Warning

Operation outside the following environmental limits may adversely affect operator safety. The safety of any system incorporating this equipment is the responsibility of the person performing the installation.

The unit is designed for indoor use only.

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

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

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

3.2 Unpacking

Caution

Once removed from its packaging, the LTS 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.

Note

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

3.3 Mounting to a work Surface

Caution

When siting the unit, it should be positioned so as not to impede the operation of the control panel buttons.

Ensure that proper airflow is maintained to the unit.

Remove power from the unit before bolting or unbolting from the work surface.

3.3.1 General

When mounting the LTS stage 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 for each model is as follows: LTS150C - 150mm, LTS300C- 300mm.

3.3.2 Mounting the Stage to the Work Surface

The LTS stage is mounted to the working surface by 1/4-20 (M6) screws (five for LTS300C, three for LTS150C), which fit through the base. The mounting holes are accessed from the top of the stage. Sleeves are fitted in the moving platform to allow the bolts to pass through from the top surface – see Figure 6

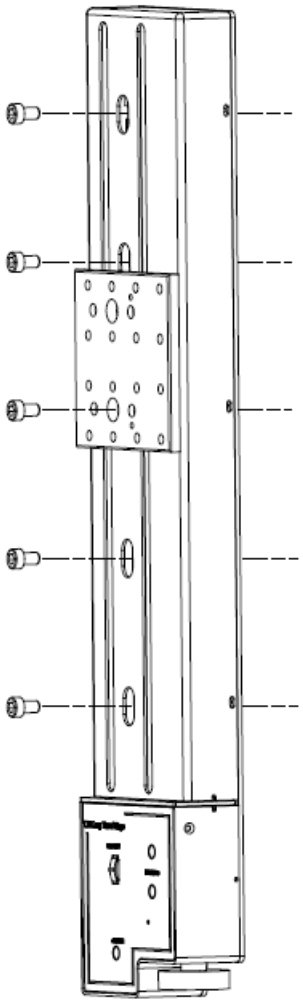

Figure 6 Mounting Holes

3.3.3 Mounting in Multi-Axis Configuration

The LTS series stages can be mounted in XY configurations using the LTSP1 spacer plate. The LTSP2 and LTSP3 angle brackets allow the LTS150C and LTS300C stages respectively to be mounted vertically in Z axis configurations.

Please see the documentation supplied with the adapter plates for more details.

Caution

When mounted in a vertical (Z-axis) orientation, the maximum load capacity is 4 kg, and the maximum velocity is 3 mm/sec. For safety reasons, the Max Vel parameter in the software Settings panel should be set to 3 mm/sec – see 7.3.1 for more details.

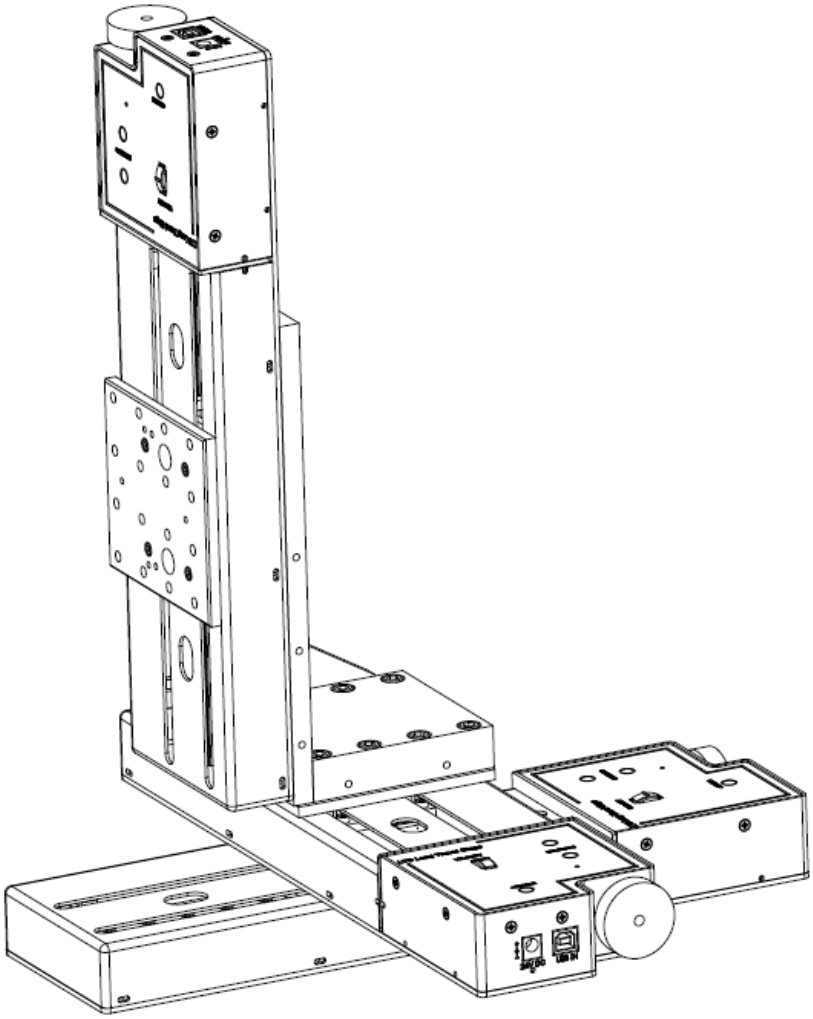

Figure 7 Typical XYZ Configuration

Caution

Ensure that any devices and components attached to the moving platform are securely fastened. Incorrectly attached components could come loose when the stage is operated.

3.4 Calibration of Motor Drives

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 several sources, however they are repeatable and therefore, can be compensated.

During calibration, the total positional error is measured at many points and these errors are stored as a look up table (LUT). The LUT is saved as a calibration file, one file for each stage. The file is then linked to the appropriate stage using the APT Config utility. 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.

Details on assigning a calibration file are contained in the *APTConfig Online Helpfile.*

3.5 Mounting Equipment and Devices

Caution

When attaching accessories, e.g., fiber holders, to the top platform do not use long bolts that protrude into the unit as this could damage the internal mechanism. The fixing thread should be no longer than 6 mm (0.24”).

3.6 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.

Chapter 4 Software & Electrical Connection

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.

Some PCs may have been configured to restrict the user's ability to load software, and on these systems the software may not install/run. If you are in any doubt about your rights to install/run software, please consult your system administrator before attempting to install.

If you experience any problems when installing software, contact Thorlabs 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. Locater 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 Electrical Installation

Connect to the Supply

Warning: Risk of Electrical Shock

The PSU unit must be connected only to an earthed fused supply of 90 - 264 VAC (47 - 63 Hz).

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

Perform the following:

1. Perform the mechanical installation as detailed in Chapter 3
2. Refer 4.1 to install the APT Software.
3. Connect the stage unit to your PC with the USB cable provided.

Note

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

4. Refer 4.2 to connect the stage to the power supply.
5. Connect the PSU to the main supply and switch 'ON'.
6. Wait for the unit to initialize (about 5 second). Do not press any controls during this time. The ENABLE LED is lit when the unit is ready for use.
7. Windows™ should detect the new hardware. Wait while Windows™ install the drivers for the new hardware. Refer Getting Stated guide for more information.

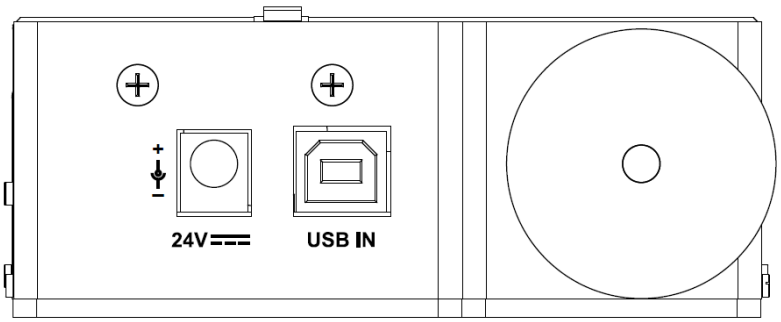

Figure 8 Power and USB Connectors

4.4 Verify Software Operation

Perform the following for the initial setup:

1. Run the APTUser utility and check that the Graphical User interface (GUI) appears and is active.

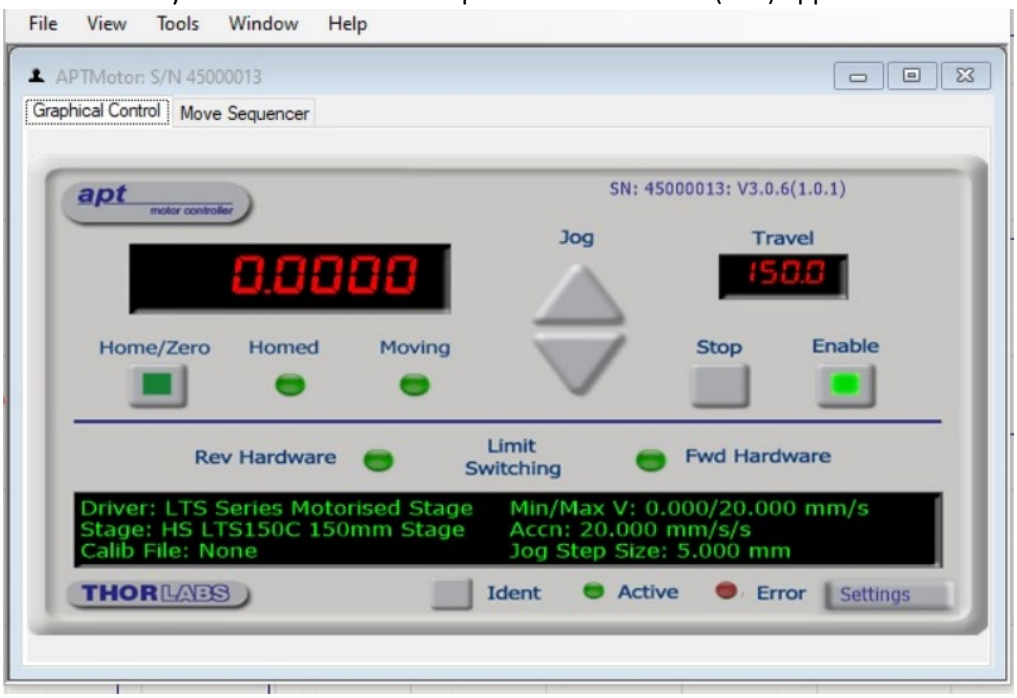

Figure 9 GUI panel showing jog and Ident Buttons

2. Check that the correct stage type and serial number are displayed in the GUI panel.
3. Click the 'Ident' button. The Power LED on the control keypad flashes. This is useful in multi-channel systems for identifying which driver is associated with which GUI.
4. Click the jog buttons on the GUI panel and check the associated stage moves. The position display for the associated GUI should increment and decrement accordingly.

Follow the tutorial steps 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 6.10 or the APTConfig helpfile for detailed instructions.

Chapter 5 Standalone Operation

5.1 Introduction

The LTS series of integrated long travel stages offer 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 APT 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, however it also may be useful to read the background on stepper motor operation contained in Chapter 11.

5.2 Control Keypad

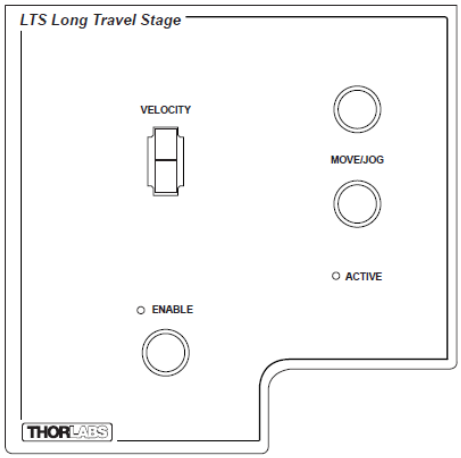

Figure 10 Front Panel Controls and Indicators

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 - see Section 6.7 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.

Enable Button - Used to enable/disable channel functionality. Disabling the channel removes the drive power and allows the motor actuator to be operated manually.

Enable LED - When the stage is enabled, this LED is lit. Furthermore, this LED will flash when the ‘Ident’ button is clicked on the Software 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.

The velocity of this move is set in real world units (mm) in the ‘Potentiometer Control Settings’ parameter in the ‘Advanced’ settings tab - see section 7.3.3 and is limited to a maximum of 20 mm/sec.

5.4 Button operation

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

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 11.2.2 for further information on the home position).

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

5.4.2 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 Advanced settings tab - see Section 7.3 for further information.

5.4.3 Teaching 'Go To position' Values

In addition to entering values in the Advanced Tab as described in Section 5.4.2 above, when operating in Go To Position mode it is possible from the front panel, to save the current position as the 'Go To Position' value.

To save the current position as the 'Go To Position' value, press and hold the required button for 2 seconds.

5.4.4 Jogging

The front 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 'Advanced' settings tab - see Section 7.3.3. 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 7.3.

5.4.5 Switching Between Button Modes

The button mode can only be changed in the Settings panel, see Section 7.3.

5.5 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.

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 PC based APT 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.

6.2 Using the APT User Utility

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

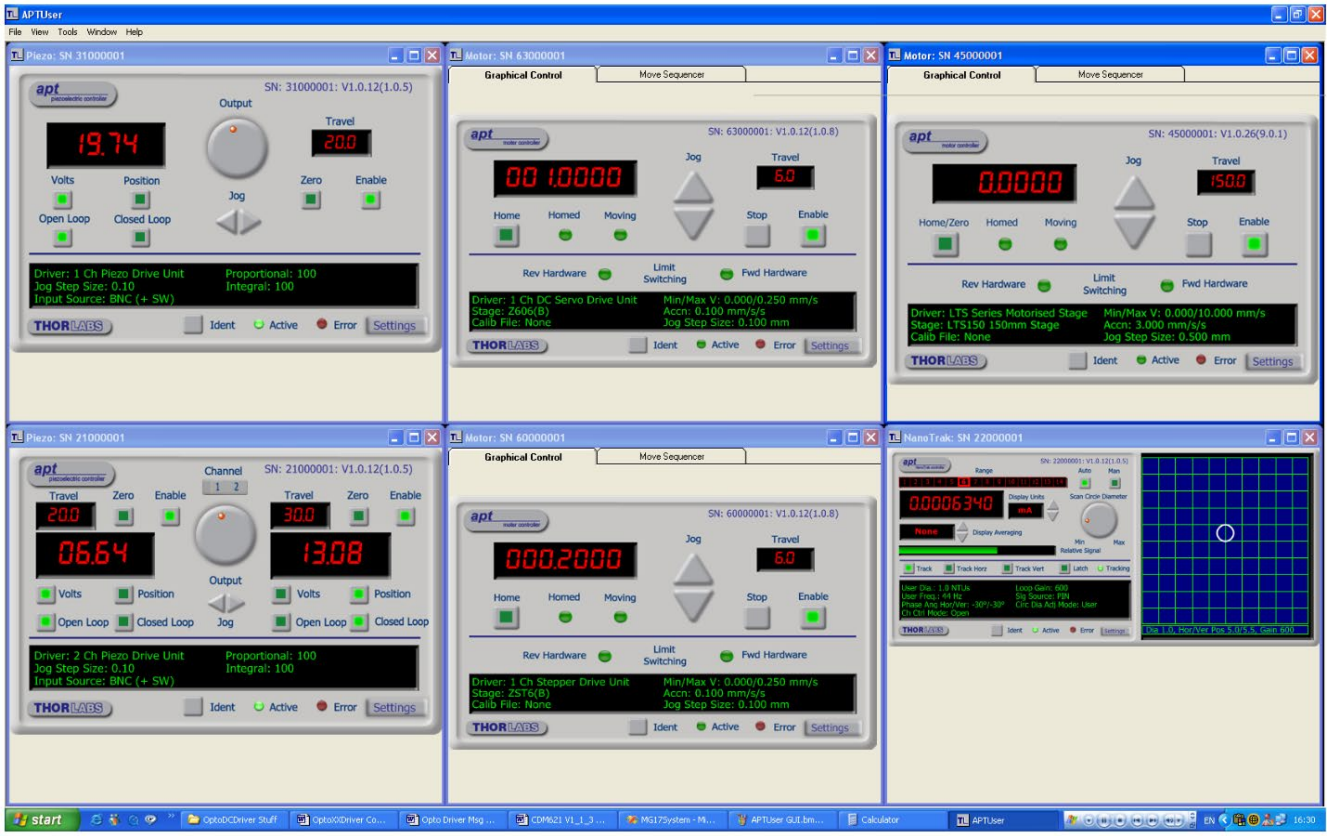

Figure 11 Typical APT User Screen

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

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.

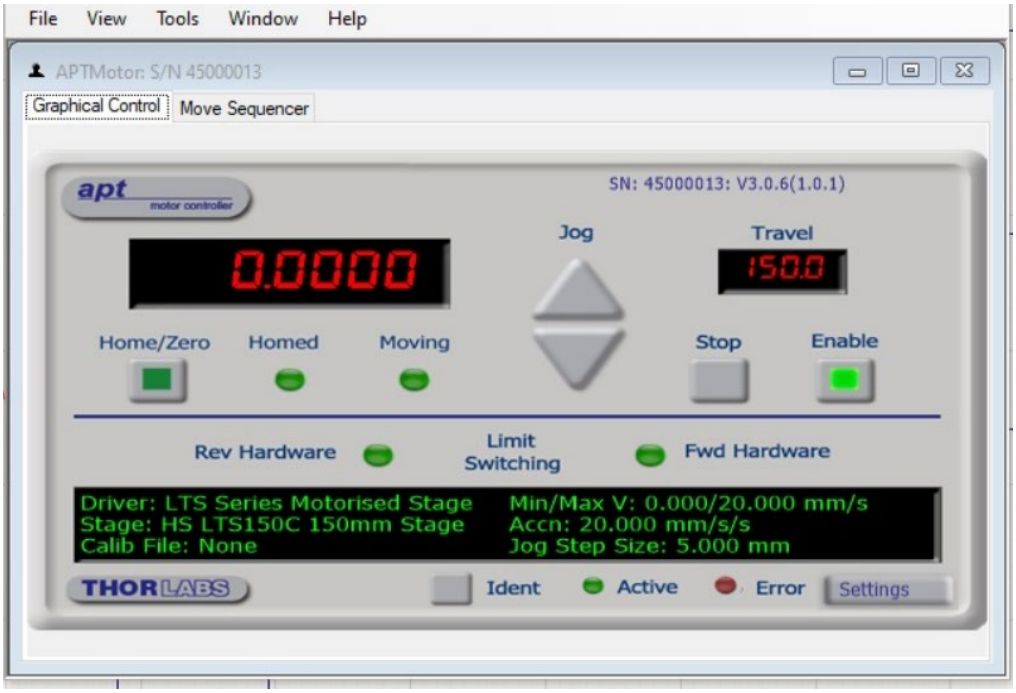

Figure 12 Motor Controller Software GUI

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 count down to 0, i.e., the home position.
2. When homing is complete, the 'Homed' LED is lit as shown above.

See Section 11.2.2 for background information on the home position.

6.4 Moving to an Absolute Position

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

Perform the following:

1. Click the position display.

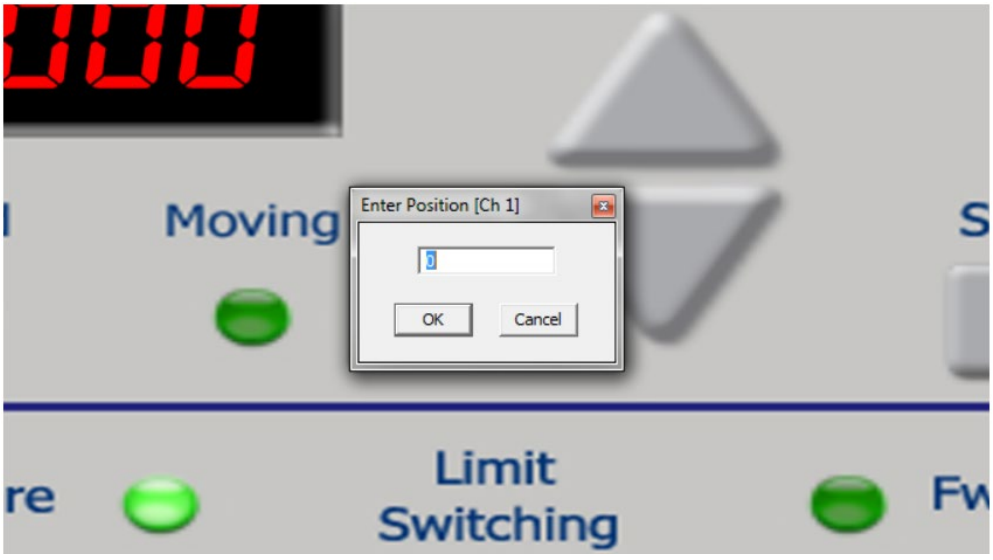

Figure 13 Absolute Position Popup Window

2. Enter the 3.0 into the pop-up window.

3. Click ‘OK’. Observe that the position display counts to 003.000 to indicate a move to the absolute position 3.00mm.

6.5 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.

6.6 Changing Motor Parameters

Moves are performed using a trapezoidal or S-Curve velocity profile (see 11.1.3). 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.

Perform the following:

1. On the GUI panel click the ‘Settings’ button (bottom right-hand corner to display the Settings panel.

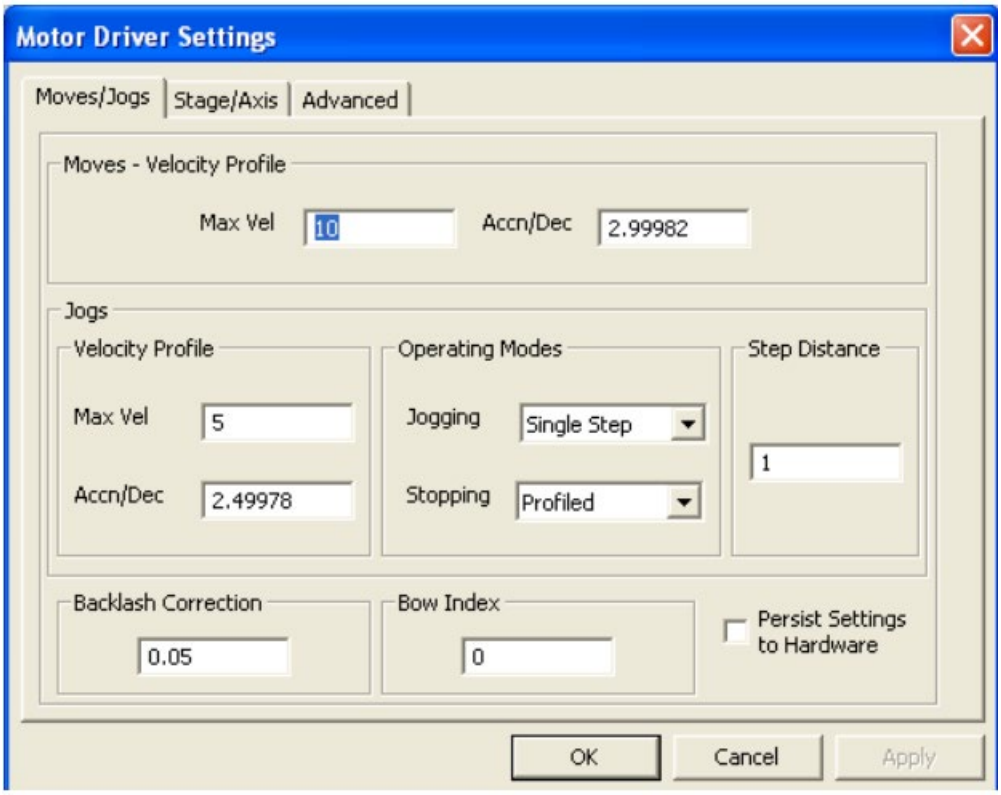

Figure 14 Settings Panel – Move/Jogs Tab

2. Select the Move/Jogs tab as shown in Figure 14.
3. In the ‘Moved’ filed change the parameters as follows:
   ‘Max. Vel’ - 2.5
   ‘Accn/Dec’ - 0.5

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

4. Click 'OK' to save the settings and close the window.
5. Any further moved initiated on channel 1 will now be performed at a maximum velocity of 2.5 mm per second, with an acceleration of 0.5mm/sec.

6.7 Jogging

During PC operation, the motor actuators are jogged using the GUI panel arrow keys. There are two jogging modes available, 'Single Step' and 'Continuous'. In 'Single Step' mode, the motor moves by the step size specified in the Step Distance parameter. If the jog key is held down, single step jogging is repeated until the button is released – refer Figure 15. In 'Continuous' mode, the motor actuator will accelerate and move at the jog velocity while the button is held down.

Perform the following:

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

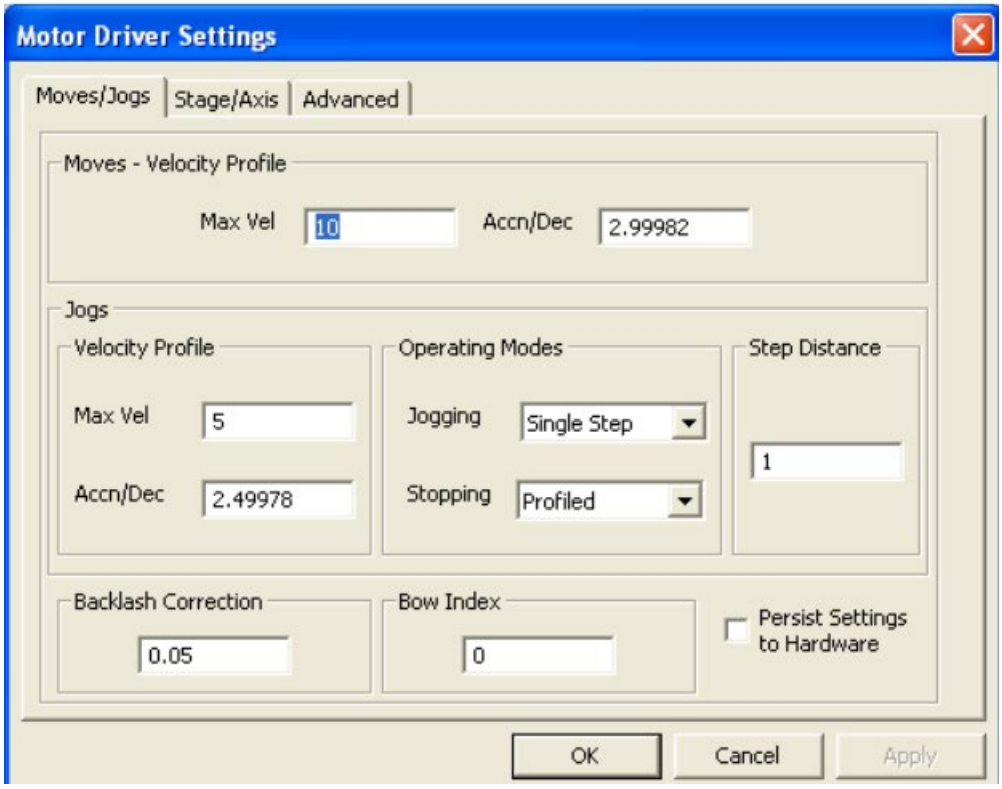

Figure 15 Settings Panel – Move/Jogs Tab

2. Select the Move/Jogs tab as shown in Figure 15.
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.

6.8 Graphical Control of Motor Positions (Point and Move)

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

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

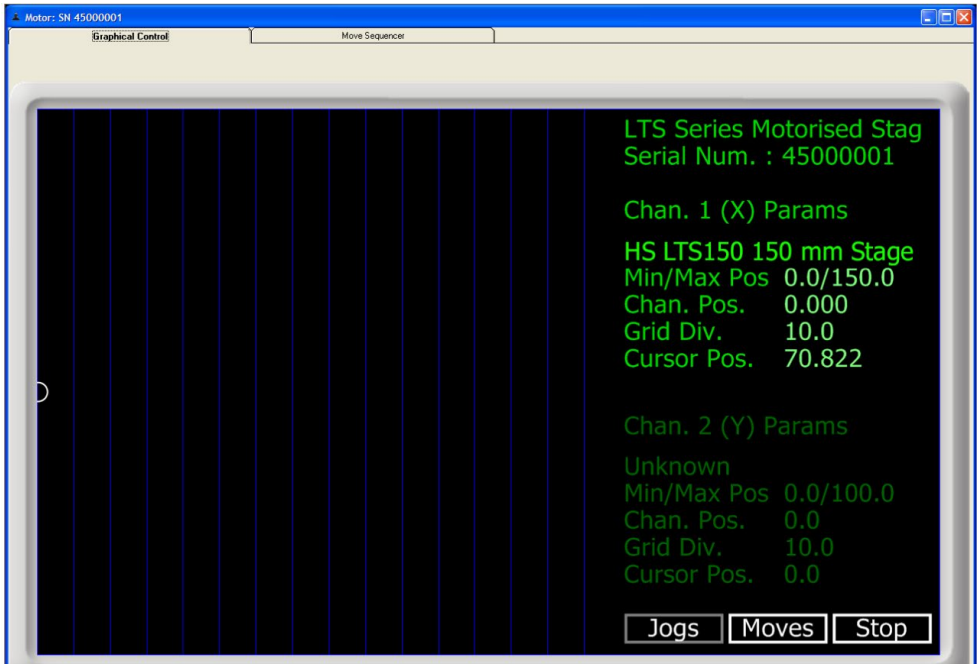

Figure 16 LTS150C Stage GUI Panel – Graphical View

Consider the display shown above for a LTS150C 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 LTS150C, 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 150mm travel LTS150C stage. The graph shows 15 divisions in the X axis, which relates to 10mm of travel per division (150mm in total).

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

Move Mode

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

To specify a move:

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

Jog Mode

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

The Jog direction corresponds to the position of the cursor relative to the circle (current motor position), e.g., if the cursor is to the left of the circle the motor will jog left. The Jog Step size is that selected in the Settings panel - see Section 7.3.

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'.

6.9 Setting Move Sequences

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

For Details on moving to absolute positions initiated by a mouse click – Refer Section 6.10.

Perform the following:

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

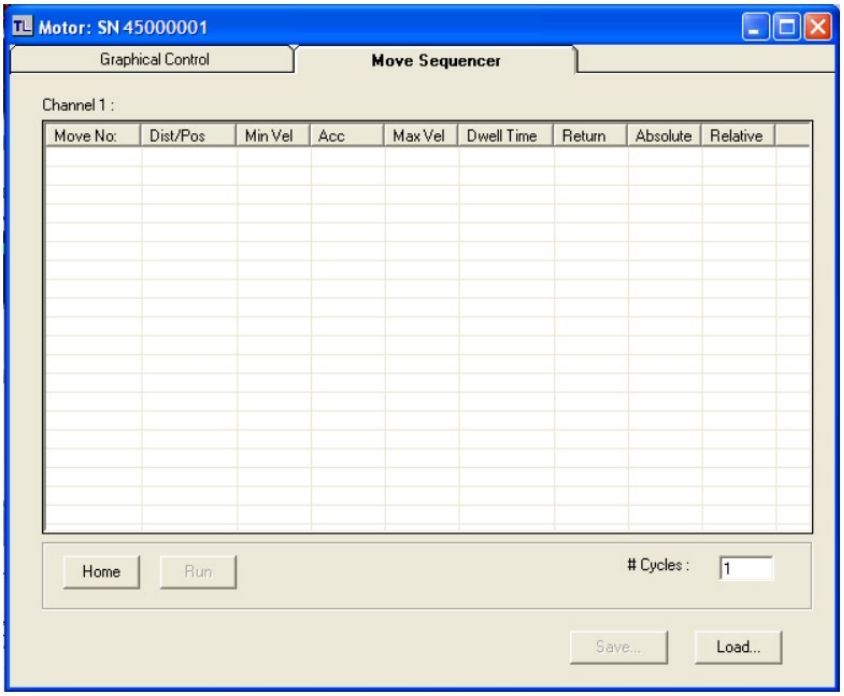

Figure 17 Move Sequencer Window

2. Right Click in the move data field to display the pop-up menu.

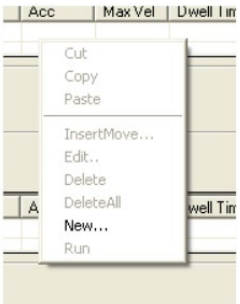

Figure 18 Move Sequencer Pop Up Menu

3. Select ‘New’ to display the ‘Move Editor’ panel.

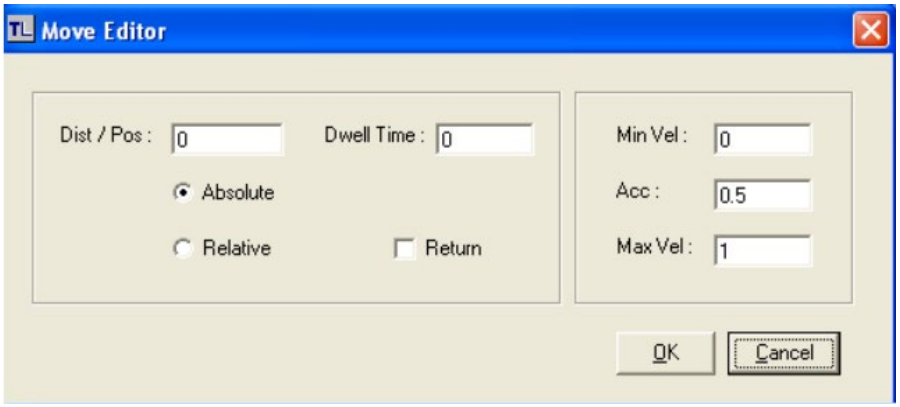

Figure 19 Move Editor Window

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.

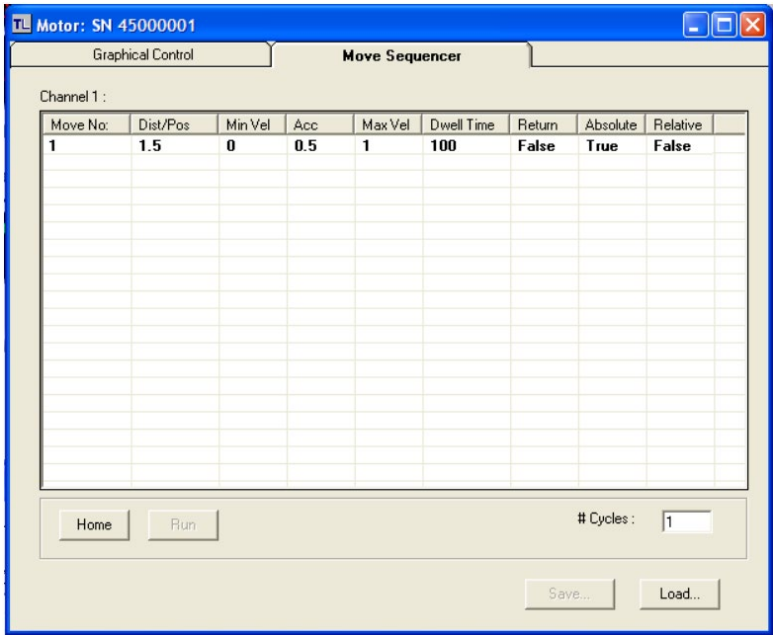

Figure 20 Main Window with Move Data

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).

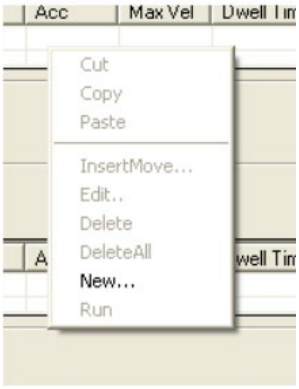

Figure 21 Pop Up Options

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.

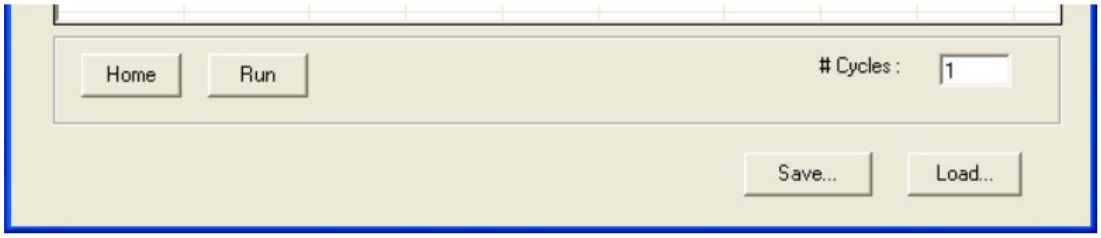

Figure 22 Home and Run Buttons

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.

6.10 Creating a Simulated Configuration using APT Config

The 'APT Config' utility can be used to set up simulated hardware configurations and place the APT Server into simulator mode. In this way it is possible to create any number and type of simulated (virtual) hardware units 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, perform the following:

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

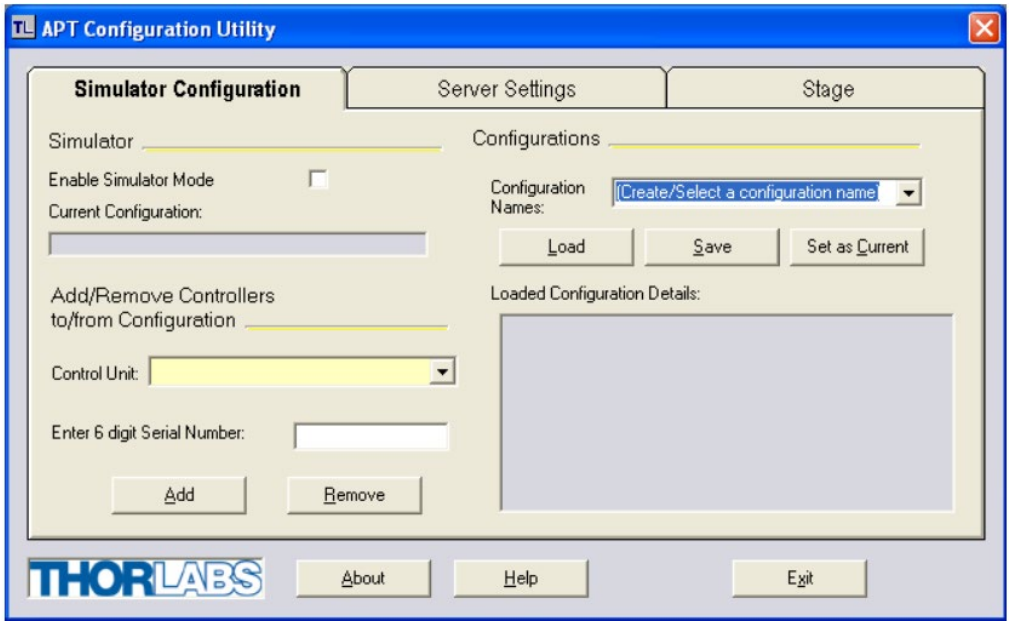

Figure 23 APT Configuration Utility – Simulator Configuration tab

3. Enter ‘LAB1’ in the Configuration Names field.
4. In the ‘Simulator’ field, check the ‘Enable Simulator Mode’ box. The name of the most recently used configuration file is displayed in the ‘Current Configuration’ window.

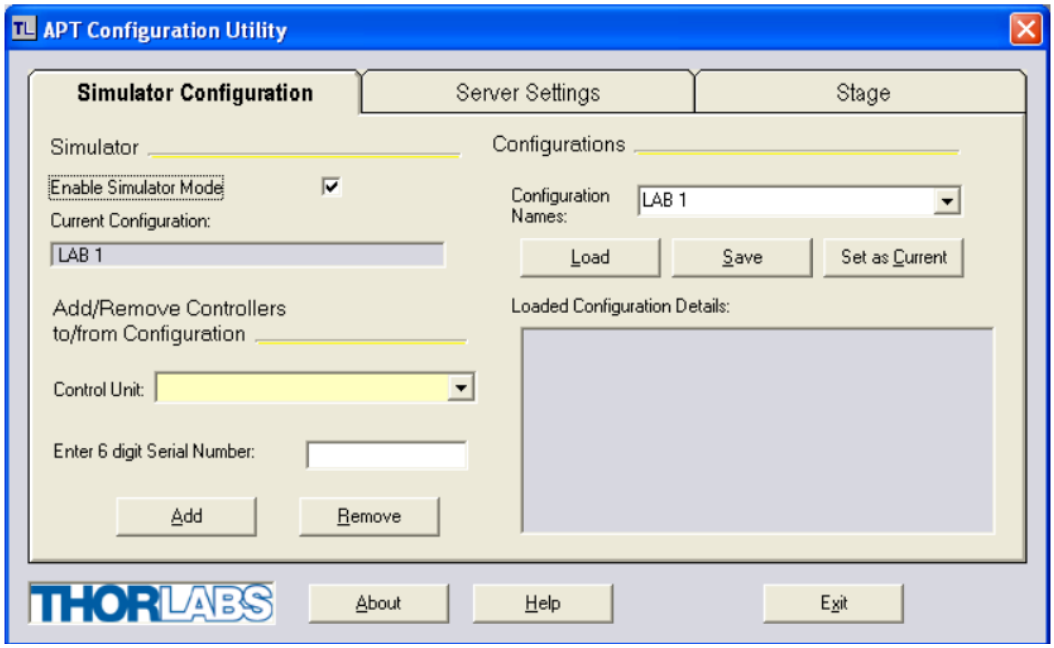

Figure 24 Enable Simulator Mode

5. In the ‘Control Unit’ field, select the appropriate LTS stage ‘LTS300C’ or ‘LTS150C’.

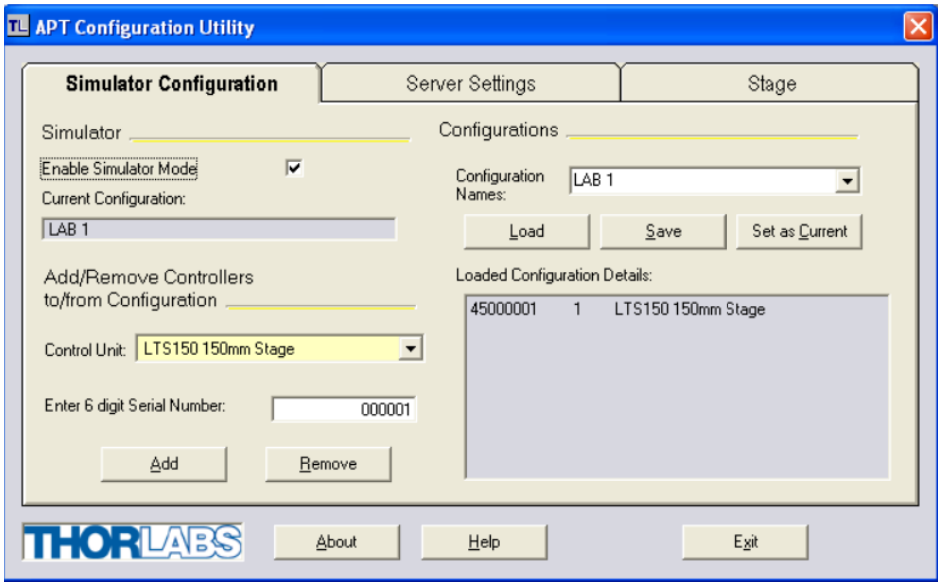

Figure 25 Control Unit

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 LTS series stages are:
>
> 45xxxxxx - LTS Series Motorized Stages.

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 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 7 Software Reference

7.1 Introduction

This chapter explains the parameters and settings accessed from the APT 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 APTUSer utility.

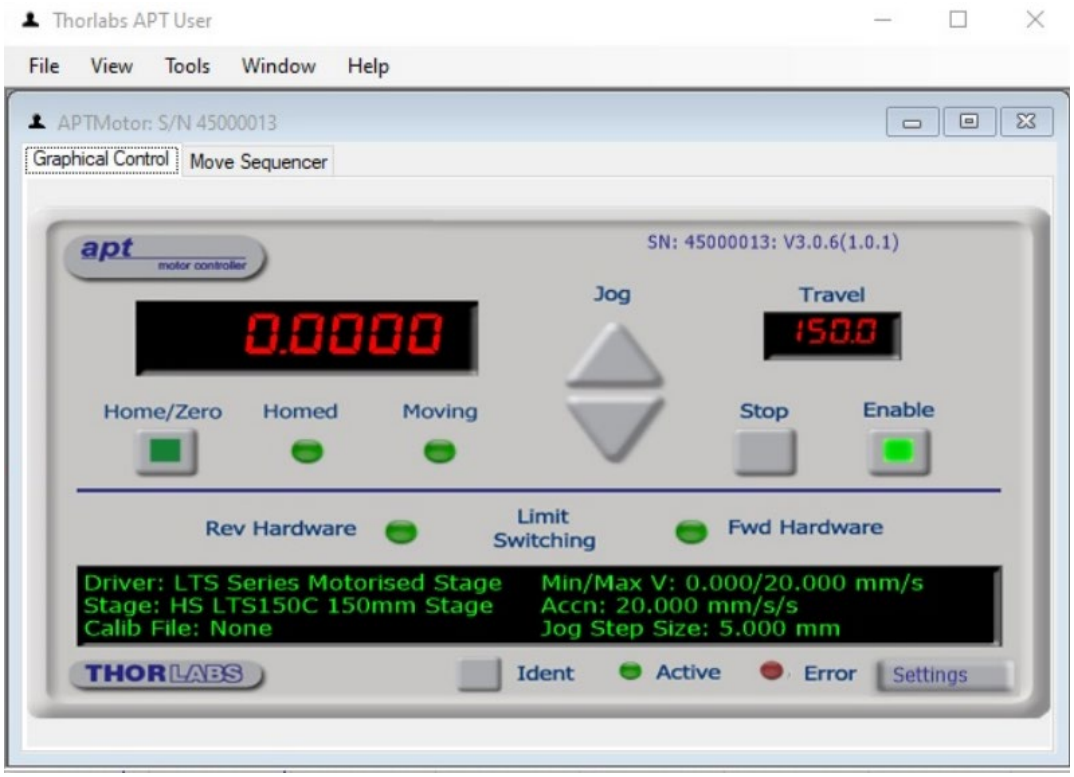

Figure 26 Motor Controller Software GUI

> **Note**
>
> The serial number of the LTS 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 7.3).

Travel - displays the range of travel (in millimeters) 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 – refer section 11.2.2. 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 – refer section 11.2.3 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 (mm/s) and can be set via the 'Settings' panel (see Section 7.3).

Accn - the rate at which the velocity climbs to, and slows from, maximum velocity, displayed in real world units (mm/s/s). The acceleration can be set via the 'Settings' panel (see Section 7.3) and is used in conjunction with the Min/Max velocity settings to determine the velocity profile of a motor move. Refer 11.1.3 for more information on velocity profiles.

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

Settings button - Displays the 'Settings' panel, which allows the motor drive’s operating parameters to be entered - see Section 7.3.

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.

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 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 1.2.4 for an overview of the APT ActiveX controls). The various parameters are described below.

7.3.1 Moves/Jogs Tab

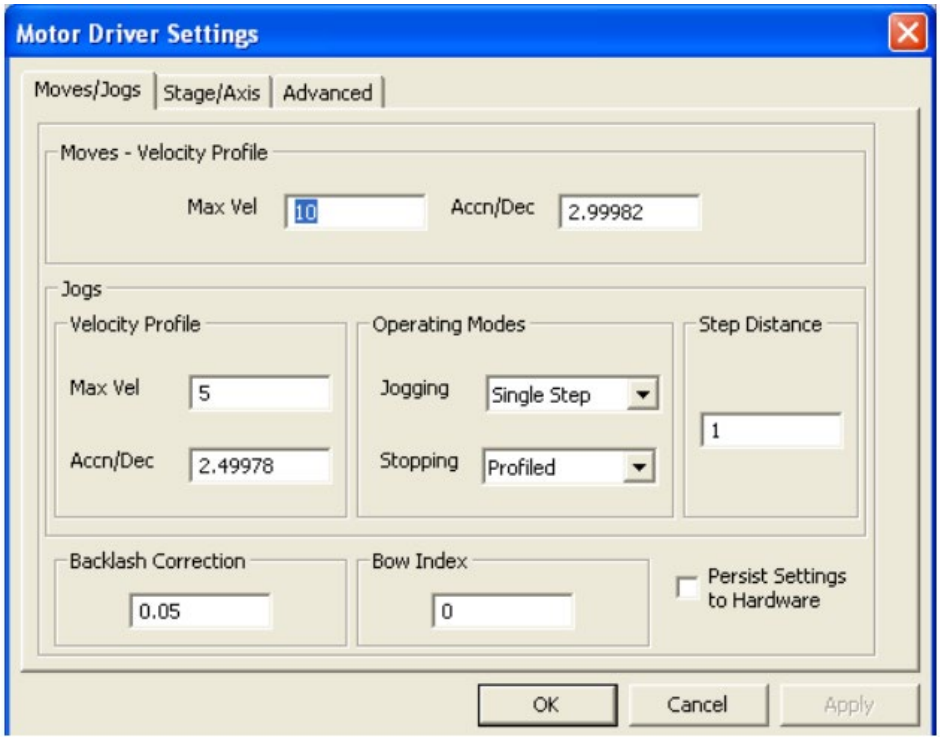

Figure 27 Stepper Motor Controller – Move/Jog Settings

Moves

Moves can be initiated via the GUI panel by entering a position value after clicking on the position display box (see Section 6.4) 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, (millimetres).

Max Vel - the maximum velocity at which to perform a move (0 to 50 mm/sec).

Accn/Dec - the rate at which the velocity climbs from zero to maximum, and slows from maximum to zero (up to 50 mm/sec^2)

Caution

When the stage is mounted vertically, the Max Vel parameter must be set to 3 mm/sec. and the Max Accn parameter to 5 mm/sec^2.

Note

The max velocity and acceleration values quoted opposite are achievable with lighter loads. As the load is increased, the velocity and acceleration should be decreased accordingly. For the maximum 15 kg load, the velocity should be reduced to either 15 mm/s with 3 mm/s^2 acceleration or 12 mm/sec with 5 mm/s^2 acceleration, depending upon whether speed or acceleration is more important for the intended application.

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 6.7), or via the buttons on the control keypad.

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

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.

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

Caution

When the stage is mounted vertically, the Max Vel parameter must be set to 3 mm/sec. and the Max Accn parameter to 5 mm/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 Figure 28. In 'Continuous' mode, the motor actuator will accelerate and move at the jog velocity while the button is held down.

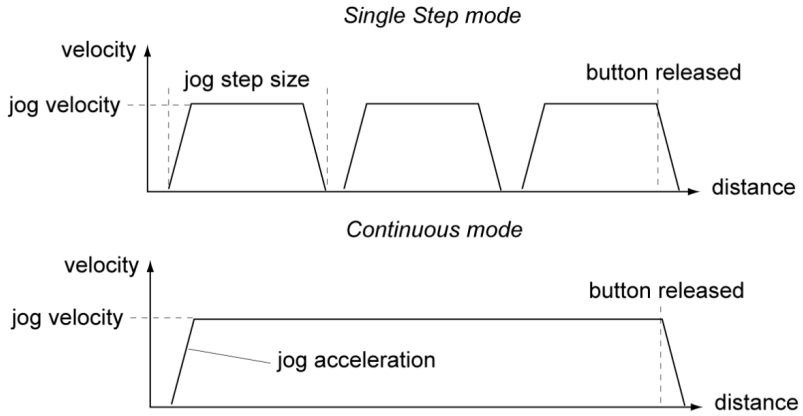

Figure 28 Jog Modes

Single Step - the motor moves by the step size 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.

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 (millimeters). 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 Figure 29), the stage is ramped at acceleration '*a'* to a maximum velocity '*v'*. As the destination is approached, the stage is decelerated at '*a'* so that the final position is approached slowly in a controlled manner.

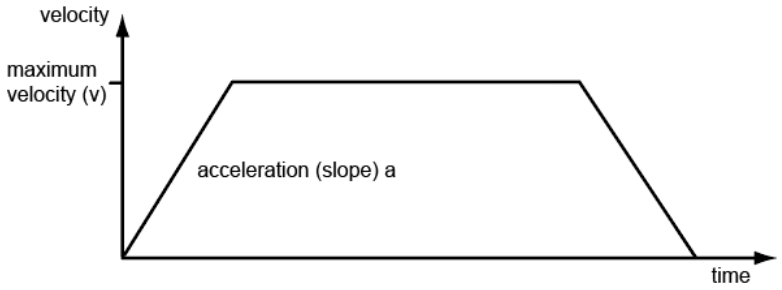

Figure 29 Graph of a trapezoidal velocity profile

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

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

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

Example

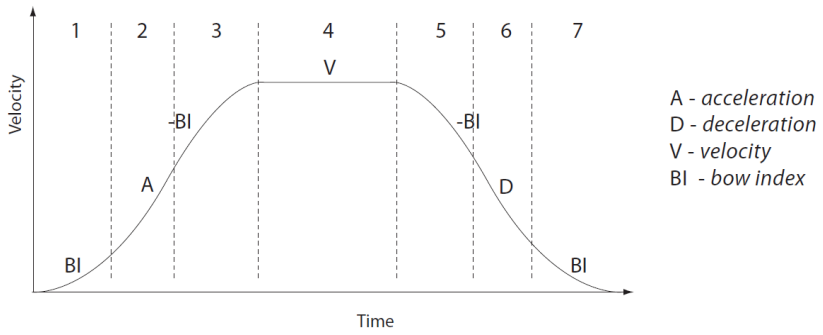

Figure 30 Typical S-curve Profile

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 LTS series 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.

7.3.2 Stage/Axis Tab

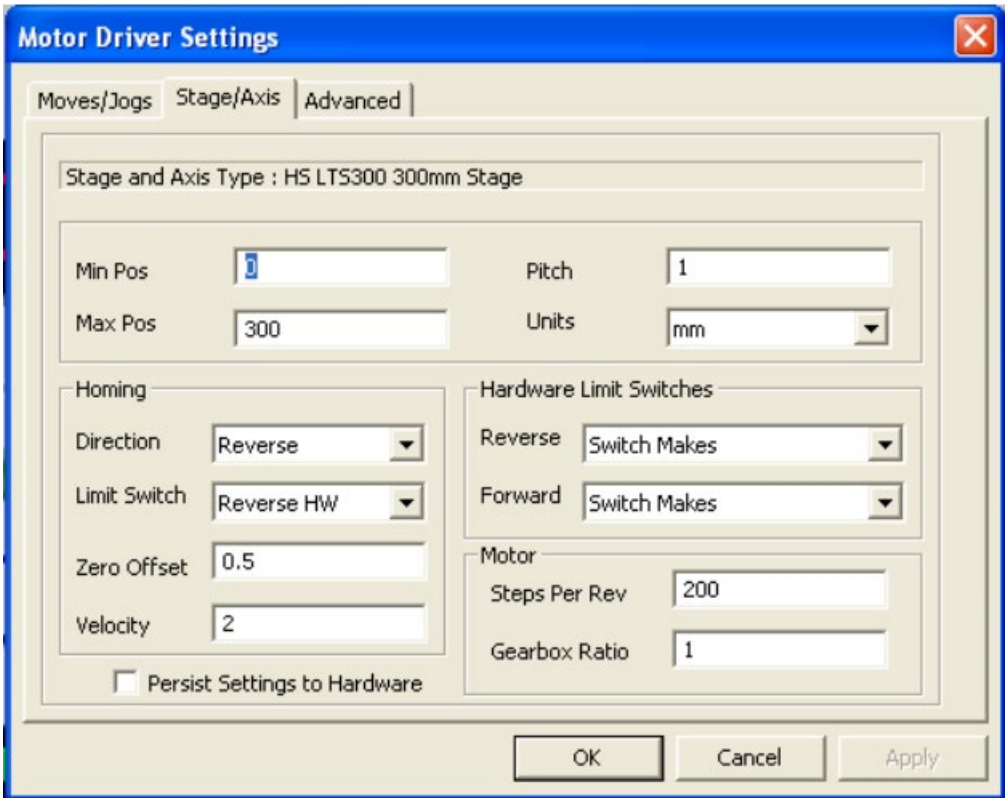

Figure 31 Stepper Motor Controller – Stage/Axis Settings

Note

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

For LTS series stages, the APT server 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.

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

Stage and Axis Type - For LTS series 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.

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

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

Homing

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

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

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

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

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

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

For further information on the home position, see Section 11.2.2.

> **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 mm/sec.

Hardware Limit Switches

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.

Motor

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

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

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

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

> **Note**
>
> The ‘Steps Per Rev’ and ‘Gearbox Ratio’ parameters, together with the ‘Pitch’ and ‘Units’ parameters are used to calculate the calibration factor for use when converting real world units to microsteps. However, the ‘Steps Per Rev’ parameter is entered as full steps, not microsteps. The system automatically applies a factor of 128 microsteps per full step.

The stepper motors used on the LTS series stages have 200 full steps per rev and no gearbox fitted. For these stages the Steps Per Rev and Gearbox Ratio parameters have values of 200 and 1 respectively.

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

7.3.3 Advanced Tab

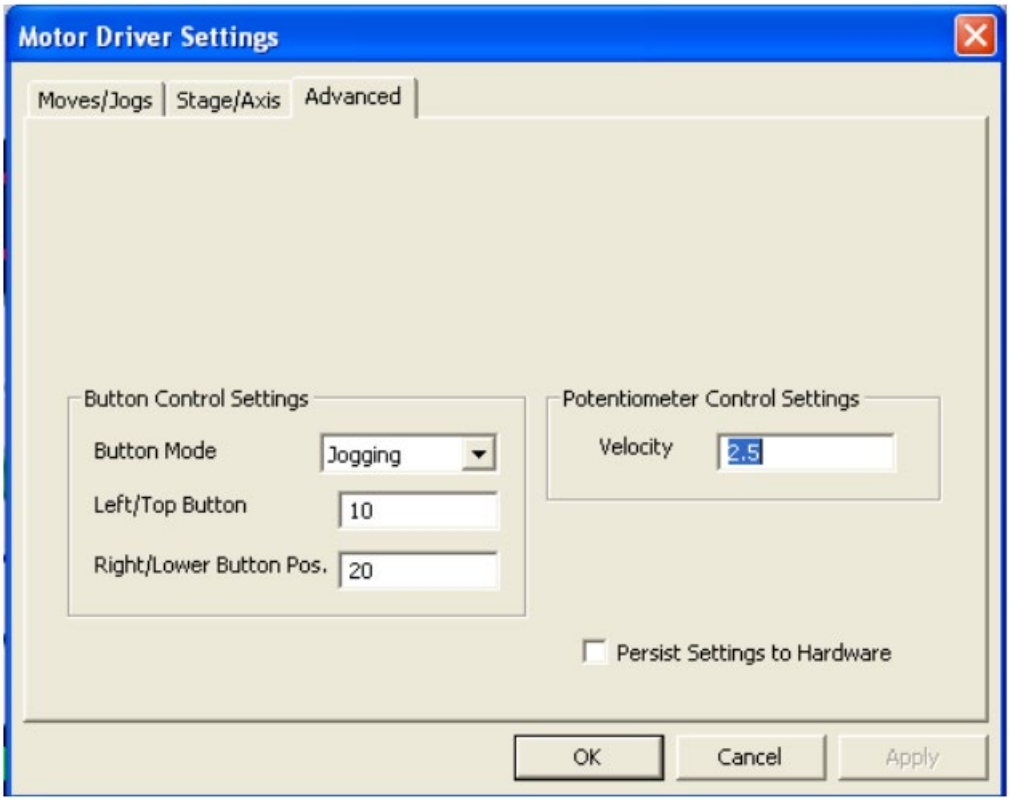

Figure 32 Advanced Settings

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 top button is pressed.

Right/Bottom 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.

Potentiometer Control Settings

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.

Velocity: The velocity of the move in real world units (mm). The velocity profile is derived from the 'Velocity Profile' settings in the 'Move/Jogs' settings tab. The Max velocity when using the pot is limited to 10 mm/sec, irrespective of the velocity setting in the Move/Jogs tab.

Chapter 8 Maintenance

Warning

The equipment contains no user serviceable parts.

Only personnel authorized by Thorlabs Ltd and trained in the maintenance of this equipment should remove its covers or attempt any repairs or adjustments. Maintenance is limited to safety testing and cleaning as described in the following sections.

8.1 Safety Testing

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

8.2 Cleaning

Warning

Disconnect the power supply before cleaning the unit.

Never allow water to get inside the case.

Do not saturate the unit.

Do not use any type of abrasive pad, scouring powder or solvent,

e.g., alcohol or benzene.

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

8.3 Troubleshooting

If an unexpected obstruction to the stage motion is encountered, the motor may stall, and the position datum may be lost. After the obstruction has been removed, the associated channel of the controller should first be homed to re-establish a datum zero point.

In the event of a breakdown, or malfunction of the product please contact Thorlabs Tech Support. Contact details are contained in Chapter 12.

Chapter 9 Specifications

9.1 General Specifications

Parameter	Value
Controller Specifications	
Microsteps per Full Step	2048
Microsteps per Revolution of Motor	409,600 (for 200 step motor)
Motor Drive Voltage	24 V
Motor Drive Power	Up to 25 W (Peak)/ 12.5 W (Avg)
Motor Speeds	Up to 3000 RPM (200 Full Step Motor)
Stage Specifications	
Bidirectional Repeatability	< ±2 µm
Calibrated On-Axis Accuracy	< ±5 µm
Backlash	2 µm
Maximum Acceleration	50 mm/sec^2 Horizontal, 5 mm/sec^2 Vertical
Maximum Horizontal Velocity	50 mm/s
Maximum Vertical Velocity	3 mm/s
Velocity Stability	± 1 mm/sec
Max Load Capacity	15 kg Horizontal, 4 kg Vertical
Recommended Horizontal Load Capacity	< 12 kg
Minimum Achievable Incremental Movement	0.1 µm
Minimum Repeatable Incremental Movement	4 µm
Maximum Percentage Accuracy	LTS150C 0.13 % LTS300C 0.12 %
Home Location Accuracy	±0.6 µm
Pitch	LTS150C < 0.016° LTS300C < 0.022°
Yaw	LTS150C < 0.05° LTS300C < 0.06°
Construction	Aluminium with precision, recirculating linear bearings
Weight	LTS150C 2.28 kg (5.03 lbs) LTS300C 3 kg (6.61 lbs)
USB Cable Length for LTS150C and LTS300C	1.5 m

Note

The max velocity and acceleration values quoted opposite are achievable with lighter loads. As the load is increased, the velocity and acceleration should be decreased accordingly. For the maximum 15 kg load, the velocity should be reduced to either 15 mm/s with 3 mm/s^2 acceleration or 12 mm/sec with 5 mm/s^2 acceleration, depending upon whether speed or acceleration is more important for the intended application.

9.2 Motor Specifications

Parameter	Value
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)

9.3 Parts List

Parameter	Value
LTS150C and LTS150C/M	Long Travel Stage with 150 mm travel
LTS300C and LTS300C /M	Long Travel Stage with 300 mm travel
LTSP1 and LTSP1/M	XY Mounting Adapter Plate
LTSP2 and LTSP2/M	Vertical (Z-axis) Mounting Plate for LTS150C
LTSP3 and LTSP3/M	Vertical (Z-axis) Mounting Plate for LTS300C
HA0203T	Handbook

Chapter 10 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 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 HW Serial Number 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 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 (deceleration) 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.

Chapter 11 Stepper Motor Operation

11.1 How a Stepper Motor Works

11.1.1 General Principle

Thorlabs' actuators use a stepper motor to drive a precision lead screw.

Stepper motors operate using the principle of magnetic attraction and repulsion to convert digital pulses into mechanical shaft rotation. The amount of rotation achieved is directly proportional to the number of input pulses generated and the speed is proportional to the frequency of these pulses. A basic stepper motor has a permanent magnet and/or an iron rotor, together with a stator. The torque required to rotate the stepper motor is generated by switching (commutating) the current in the stator coils as illustrated in Figure 33.

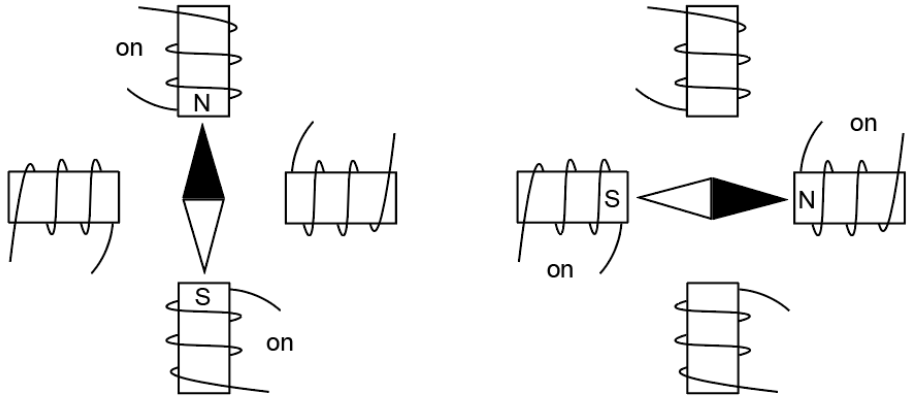

Figure 33 Simplified Concept of Stepper Motor Operation

Although only 4 stator poles are shown above, there are numerous tooth-like poles on both the rotor and stator. 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 practice, the mechanical resolution achieved by the system may be coarser than a single microstep, primarily because there may be a small difference between the orientation of the magnetic field generated by the stator and the orientation in which the rotor comes to rest.

11.1.2 Positive and Negative Modes

Positive and *negative* are used to describe the direction of a move. A positive move means a move from a smaller absolute position to a larger one, a negative move means the opposite.

In the case of a linear actuator, a positive move takes the platform of the stage further away from the motor.

In a rotational stage, a positive move turns the platform clockwise when viewed from above.

11.1.3 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 7.3.1.

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 Figure 34), the stage is ramped at acceleration '*a*' to a maximum velocity '*v*'. As the destination is approached, the stage is decelerated at '*a*' so that the final position is approached slowly in a controlled manner.

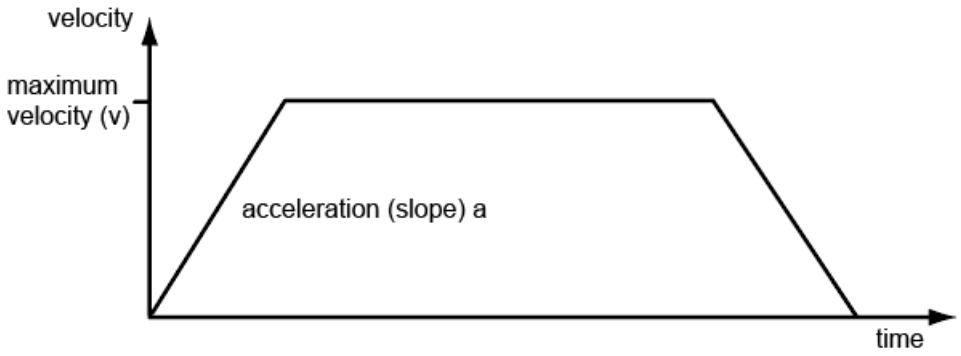

Figure 34 Graph of a Trapezoidal Velocity Profile

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

The *Bow Value* is applied in mm/s^3 and is derived from the Bow Index field as follows:

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

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

Example

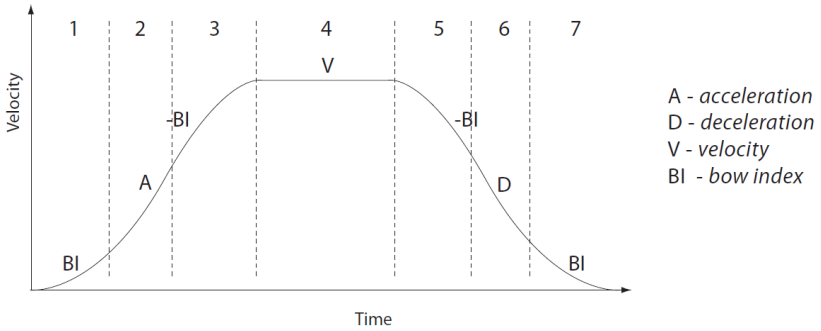

Figure 35 Typical S-Curve Profile

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.

11.2 Positioning a Stage

11.2.1 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 Fa 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.

11.2.2 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.

11.2.3 Limit Switches

A linear stage moves between two stops, and movement outside these limits is physically impossible. Linear stages can include stages that control the angle of a platform within a certain range, although the movement of the platform is not linear but angular. Rotary stages can rotate indefinitely, like a wheel.

Linear and rotary stages 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.

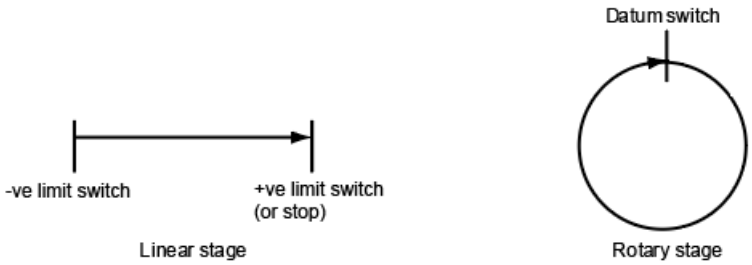

Figure 36 Stage Limit Switches

11.2.4 Minimum and Maximum Positions

These positions are dependent upon the stage or actuator to which the motors are fitted, and are defined as the minimum and maximum useful positions of the stage relative to the 'Home' position – see Figure 37.

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.

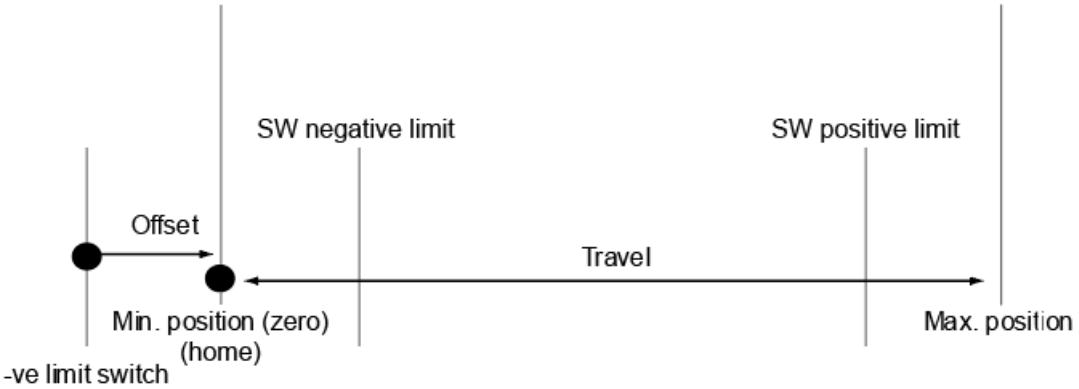

Figure 37 Minimum and Maximum Positions

11.2.5 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 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 7.3.3 for more details on these power settings.

11.3 Error Correction

Backlash Correction

The term *backlash* refers to the tendency of the stage to reach a different position depending on the direction of approach.

Backlash can be overcome by always making the last portion of a move in the same direction, conventionally the positive direction. Consider the situation in Figure 38, a *positive* move, from 10 to 20 mm, is carried out as one simple move, whereas a *negative* move, from 20 to 10 mm, first causes the stage to overshoot the target position and then move positively through a small amount.

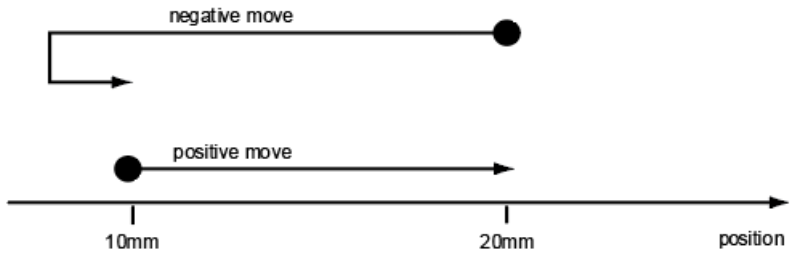

Figure 38 Backlash Correction

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 7.3.1 for details on setting the backlash correction.

Chapter 12 Certifications and Compliance

EU Declaration of Conformity

in accordance with EN ISO 17050-1:2010

We: Thorlabs Ltd.

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

in accordance with the following Directive(s):

2006/42/EC	Machinery Directive (MD)
2014/30/EU	Electromagnetic Compatibility (EMC) Directive
2011/65/EU + 2015/86	Restriction of Use of Certain Hazardous Substances (RoHS)

hereby declare that:

Model: ***LTS Series***

Equipment: ***Integrated 150 or 300 mm Long Travel Stage(Imperial or Metric)***

is/are 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
Authorised to compile the technical file:	Thorlabs GmBH Münchner Weg1, 85232 Bergkirchen, Deutschland	
EN 61326-1	Electrical Equipment for Measurement, Control and Laboratory Use - EMC Requirements	2013
EN 63000	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances	2018

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

contains no substances in excess of the maximum concentration values tolerated by weight in homogenous materials as listed in Annex II of the Directive

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

Signed: Keith Dhese *On:* 24 February 2023

Name: Keith Dhese

Position: General Manager

EDC - LTS Series -2023-02-24

CE

Chapter 13 Thorlabs Worldwide Contacts

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

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