THORLABS

BSC103
Benchtop Stepper Motor Controller

User Guide

Contents

Continued......

Appendices

Chapter 1   Safety

1.1   Safety Information

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

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

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

Warning
Given when there is a risk of injury to users.

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

Note
Clarification of an instruction or additional information.

1.2   General Warnings

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

Chapter 2   Overview

2.1   Introduction

The new three channel APT Stepper Motor Controllers feature a card slot architecture, which also allows it to be offered configured for two or three channels of operation (BSC102). Furthermore it is perfectly feasable to add a third channel later by purchasing a single channel driver card (SCC101).

They are designed to drive larger framed 2-phase bipolar stepper motors, with and without encoder feedback, and can be used in a wide variety of applications. These high power units deliver up to 48V/50W peak (25W average) drive power per channel and are compatible with most stepper driven nano-positioning actuators & stages in the Thorlabs range.

To facilitate connection to third party actuators and motors, Thorlabs offers a breakout board (please see Appendix C   for details). The unit combines the latest high speed digital signal processors (DSP) with low-noise analog electronics and ActiveX® software technology for effortless high resolution microstepping (25,600 steps per revolution for a 200 full step motor) of up to three axes. Additional axes can be driven by connecting one or more benchtop units via a standard USB hub.The apt stepper motor controller is supplied with a full suite of software support tools. An intuitive graphical instrument panel allows immediate control and visualization of the operation of the stepper controllers, and any other controllers that are installed in the system. See Chapter 5 for a full description of the apt system software.

Fig. 2.1   APT Three Channel Stepper Motor Controller (BSC103)

Stepper motors give excellent low speed performance and positioning stability compared with DC servo motors. A wide range of 2-phase bipolar stepper motors and associated actuators are commercially available, each with its own characteristics, such as step resolution, peak phase current or voltage, and lead screw pitch. For this reason the apt™ stepper unit operation is fully configurable (parameterized) with key settings exposed through the associated graphical interface panels.

Motor step resolution, and lead screw pitch can be set for a particular motor/actuator combination, phase currents can be limited to suitable peak powers as required, and limit switch configuration is accommodated through a flexible set of limit switch logic settings. Moreover, relative and absolute moves can be initiated with move profiles set using velocity profile parameters. Similarly, home sequences have a full set of associated parameters that can be adjusted for a particular stage or actuator. For simplicity of operation, the apt™ software incorporates pre-configured settings for each of the Thorlabs stages and actuators, while still exposing all parameters individually for use with other stepper motor driven systems.

For convenience and ease of use, adjustment of many key parameters is possible through direct interaction with the graphical panel. For example a move to the next position can be initiated by clicking directly on the position display and entering a new value (see the tutorial in Chapter for further details). Furthermore, all such settings and parameters are also accessible through the ActiveX® programmable interfaces for automated alignment sequences.

The apt™ stepper unit also supports encoder feedback through dedicated quadrature encoded pulse (QEP) inputs, one for each channel of operation. Through conversion routines, the apt™ software is able to use this feedback signal to generate encoder position for access either through the GUI or via programmable interfaces for custom closed loop algorithms. A "built in" algorithm can be enabled to allow the stepper system to reach and maintain an encoded position through an iterative move sequence. Please see the APTServer online helpfile or the handbook supplied with your linear encoded stage for further details.

In the remainder of this handbook, the Tutorial section (Chapter) provides a good initial understanding on using the unit, and the reference sections (Chapter 5) covers all operating modes and parameters in detail.

2.2 APT PC Software Overview

2.2.1 Introduction

As a member of the APT range of controllers, the BSC102 and BSC103 stepper controllers share many of the associated software benefits. This includes USB connectivity (allowing multiple units to be used together on a single PC), fully featured Graphical User Interface (GUI) panels, and extensive software function libraries for custom application development.

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

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

Aside

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

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

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2.2.2 APTUser Utility

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

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

For many users, the APTUser application provides all of the functionality necessary to operate the APT hardware without the need to develop any further custom software. For those who do need to further customize and automate usage of the controller (e.g. to implement a positioning algorithm), the APTUser application illustrates how the various methods and properties of the APT ActiveX server can be exposed by a client application.

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

2.2.3   APT Config Utility

There are many system parameters and configuration settings associated with the operation of the APT Server. Most can be directly accessed using the various graphical panels, however there are several system wide settings that can be made 'off-line' before running the APT software. These settings have global effect; such as switching between simulator and real operating mode, associating mechanical stages to specific motor actuators and incorporation of calibration data.
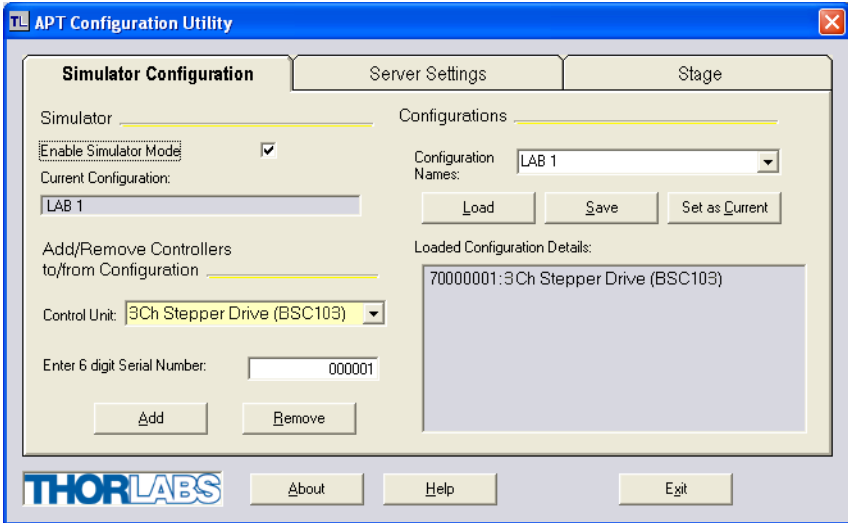
The APTConfig utility is provided as a convenient means for making these system wide settings and adjustments. Full details on using APTConfig are provided in the online help supplied with the utility.

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

2.2.4 APT Server (ActiveX Controls)

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

With the APT system, ActiveX Controls are deployed to allow direct control over (and also reflect the status of) the range of electronic controller units, including the BSC103 stepper motor controller. 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 a Stepper Motor Drive Card fitted to a BSC103 APT stepper controller unit (one panel is displayed for each channel (card) fitted.

This Control provides a complete user graphical instrument panel to allow the motor unit to be manually operated, as well as a complete set of software functions (often called methods) to allow all parameters to be set and motor operations to be automated by a client application. The instrument panel reflects the current operating state of the controller unit to which it is associated (e.g. such as motor position). Updates to the panel take place automatically when a user (client) application is

making software calls into the same Control. For example, if a client application instructs the associated stepper motor Control to move a motor, the progress of that move is reflected automatically by changing position readouts on the graphical interface, without the need for further programming intervention.

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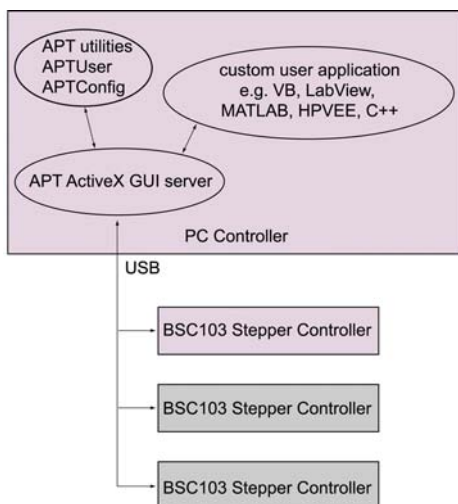
Fig. 2.2   System Architecture Diagram

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

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

Detailed instructions on installing upgrades are included on the APT Software CD ROM.

Chapter 3   Getting Started

3.1   Installing APT Software

Note
When operating via a PC, direct user interaction with the unit is accomplished through intuitive graphical user interface panels (GUIs), which expose all key operating parameters and modes. The user can select multiple panel views displaying different information about a particular hardware unit. The multitasking architecture ensures that the graphical control panels always remain live, showing all current hardware activity.

⚠️	Caution	⚠️
	Some PCs may have been configured to restrict the 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 CONTROLLER TO YOUR PC YET

1) Insert the CD into your PC.
2) The CD should run automatically. If your CD does not start, double click the file 'autorun.exe', found on the Software CD.
3) A Welcome dialogue screen is displayed. Before installing the software, you are strongly advised to read the Installation Guide. Click the associated link.
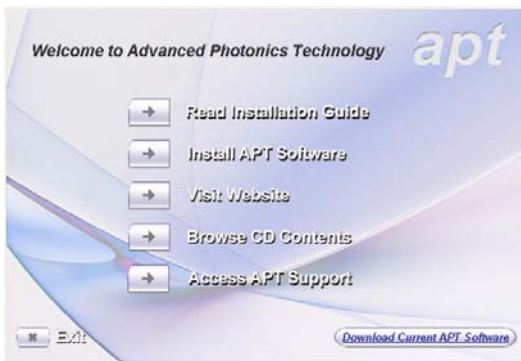
4) Once you are familiar with the installation procedure, click the 'Install APT Software' hyperlink displayed on the Welcome dialogue screen.
5) Follow the on-screen instructions - see the Installation Guide supplied for more information.

3.2 Mechanical Installation

3.2.1 Siting

The unit is designed to be mounted free standing on a shelf, benchtop or similar surface.

⚠	Caution	⚠
	When siting the unit, it should be positioned so as not to impede the operation of the rear panel power supply switch. **Ensure that proper airflow is maintained to the rear of the unit.**	

3.2.2 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.

3.3   Electrical Installation

3.3.1   Connecting To The Supply

⚠️ **Shock Warning** ⚠️

The unit must be connected only to an earthed fused supply of 110 to 230V.

Use only power supply cables supplied by Thorlabs, other cables 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

3.3.2   Fuses

Two T 3A/250V a.c. antisurge ceramic fuses are located on the back panel, one for the live feed and one for the neutral as follows:

Fuse	Rating	Type	Fused Line
F1	T 3.15A	ceramic; antisurge	Live feed
F2	T 3.15A	ceramic; antisurge	Neutral feed

When replacing fuses:

1) Switch off the power and disconnect the power cord before removing the fuse cover.

2) Always replace broken fuses with a fuse of the same rating and type.
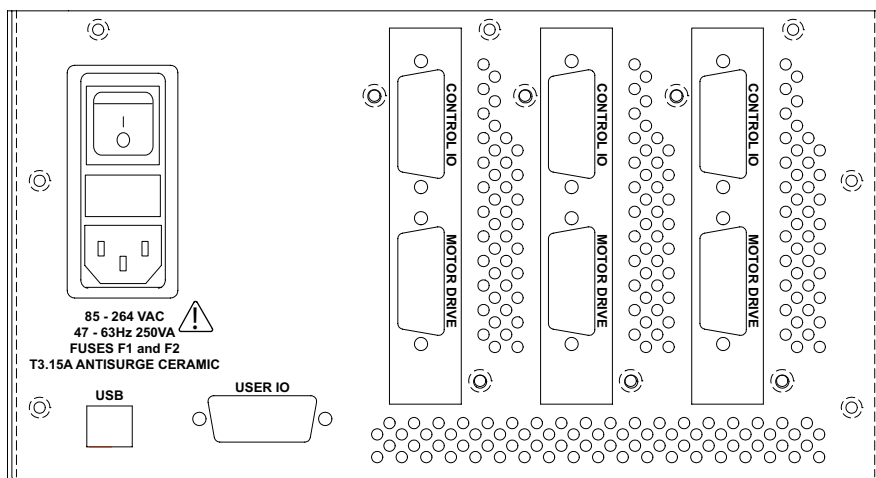
3.3.3   Rear Panel Connections

Fig. 3.1   Rear panel connections

MOTOR DRIVE - (15-Pin D-Type, Female) Provides connection to the actuator.

This connector provides all phase current drive and encoder feedback connections to drive a range of encoded and non-encoded stepper motors - see Section A.2.

CONTROL I/O - (15-Pin D-Type, Female) The 'CONTROL I/O' connector exposes a number of electrical signals useful for external control. It is possible to configure a particular controller to respond to trigger inputs, generate trigger outputs or both respond to and generate a trigger output - see Section 5.3.3. Motor jogging lines can be used to jog the motor in both forward and reverse directions from a remote handset (Jogging parameters (e.g. jog distance) are set via the GUI panel - see Section 5.3.1.).

USER I/O - (15-Pin D-Type, Female) The User I/O connector exposes a number of internal electrical signals. For convenience, a number of logic inputs and outputs are included, thereby negating the need for extra PC based IO hardware. Using the APT support software, these user programmable logic lines can be deployed in applications requireing control of external devices such a relays, light sources and other auxillairy equipment. - see Section A.3. for further details.

USB - USB port for system communications.

Note
The USB cable length should be no more than 3 metres unless a powered USB hub is being used.

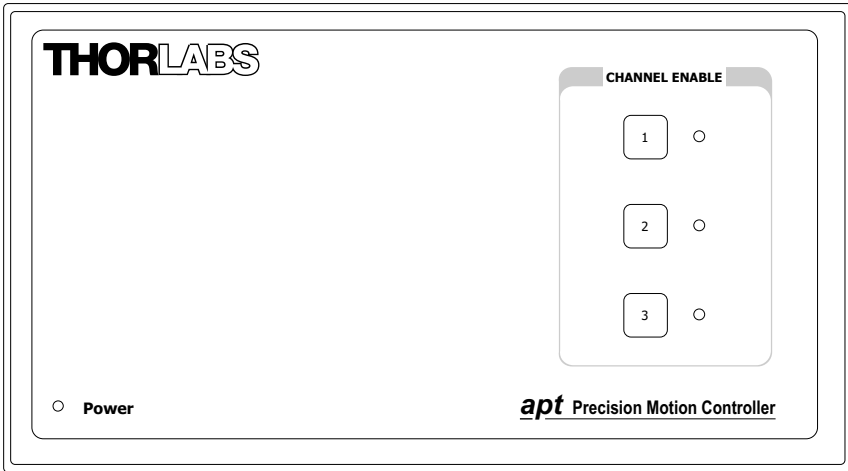## 3.4   Front Panel Controls and Indicators

Fig. 3.2   Front panel controls and indicators

Power LED – Indicates that power is applied to the unit.

CHANNEL ENABLE buttons – Used to enable/disable channel functionality. The associated LED is lit when the channel is enabled. Disabling the channel allows the motor actuator to be moved manually.

Note
On BSC102 units, the Channel 3 LED is not used. It becomes active if a third channel is added later by fitting an additional SCC101 card.

3.5   Connecting The Hardware

1) Perform the mechanical installation as detailed in Section 3.2.
2) Install the APT Software - see Section 3.1.
3) Connect the stepper motor actuator to the Controller unit - see Section 3.3.3.
4) Connect the Controller unit to the power supply - see Section 3.3.1.
5) Connect the PSU to the main supply and switch 'ON'.
6) Connect the Controller 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).

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

3.6   Select the Stage Type (Using APTConfig)

To ensure that a particular stage is driven properly by the system, a number of parameters must first be set. These parameters relate to the physical characteristics of the stage being driven (e.g. min and max positions, leadscrew pitch, homing direction etc.).

To assist in setting these parameters correctly, it is possible, using the APT Config utility, to associate a specific stage type and axis with a motor controller channel. Once this association has been made, the APT server applies automatically, suitable default parameter values on boot up of the software.

Even if a stage type and axis has been associated with a controller channel, it is still possible to alter these parameters if required, (e.g. for a custom stage type not selectable using the APT Config utility).

Note

The BSC103 APT stepper controller unit can be fitted with up to three SCC101 stepper motor drive cards. Each card behaves as a discrete unit with its own GUI control panel.

1) Shut down all applications using the APT server (e.g. APT User or your own custom application).

2) Run the APT Config utility - Start/All Programs/Thorlabs/APT Config/APT Config.

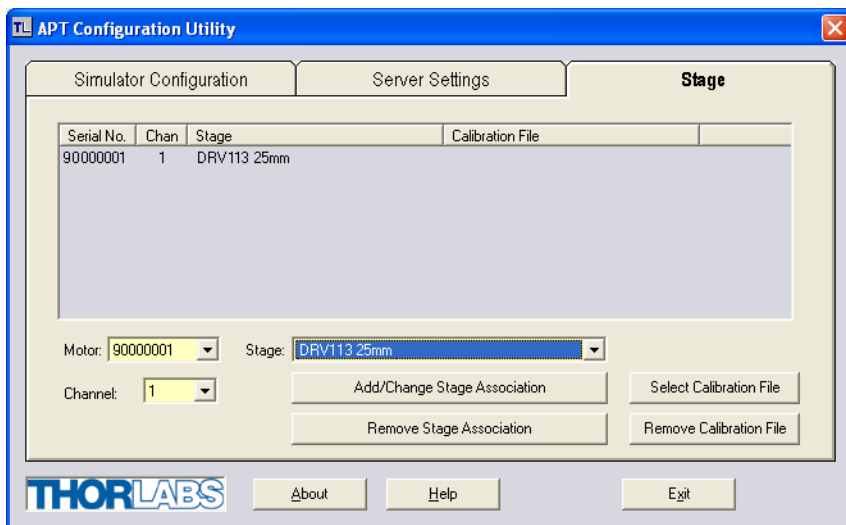3) From the 'APT Configuration Utility' window, click the 'Stage' tab.

Fig. 3.3   APT Configuration Utility - Stage Tab

Caution

The following items relate to the single channel SCC101 Drive Cards fitted to the controller, and not the parent 3-channel controller housing.

4) In the 'Motor' field, select the serial number of the SCC101 drive card to be configured.

5) For the SCC101 Cards, the 'Channel' field defaults to '1' and the 'Channel 2' option is greyed out.

6) In the 'Stage' field, select your actuator type from the list displayed (e.g. 25mm travel DRV113 actuator).

7) Click the 'Add Stage Association' button.

8) The server reads in the stage and controller information on start up.
   Shut down the APTConfig utility and proceed to Section 3.7. to verify the software operation.

See the APT Config utility on line help for further information.

3.7   Verifying Software Operation

3.7.1   Initial Setup

The APT Software should be installed (Section 3.1.) and the stage association performed (Section 3.6.) before software operation can be verified.

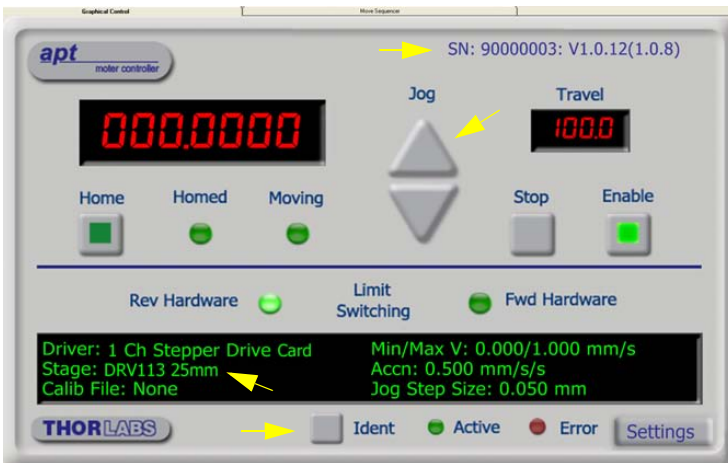1) Run the APTUser utility and check that the Graphical User Interface (GUI) panel appears and is active.

Fig. 3.4 Gui panel showing jog and ident buttons

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2) Check that the actuator type and serial number associated in Section 3.6. are displayed in the GUI panel.

3) Click the 'Ident' button. The associated channel LED on the front panel of the controller flashes. This is useful in multi-channel systems for identifying which channel is associated with which GUI.

4) Click the jog buttons on the GUI panel and check that the motor or axis connected to the controller moves. The position display for the associated GUI should increment and decrement accordingly.

Follow the tutorial steps described in Chapter 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 4.9. or the *APTConfig* helpfile for detailed instructions.

Chapter 4   Operation - Tutorial

4.1   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 shown in Section 3.3.3. and that the APT Software is already installed - see Section 3.1. For illustration purposes, it also assumes that a DRV113 motor is connected to a 'Motor' connector on the rear panel.

4.2   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.
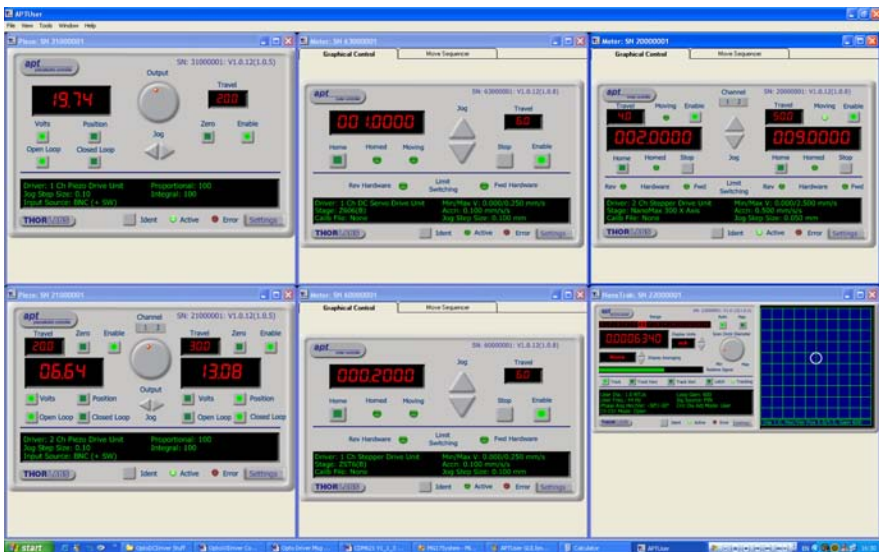

Fig. 4.1   Typical APT User Screen

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

<div style="background:red;color:white;text-align:center;font-weight:bold">Note</div>

The channel functionality of the BSC103 motor controller is accessed via a single channel GUI panel, one panel for each motor drive card fitted.

Notice how the DRV113 actuator type, selected in Section 3.6. is displayed in the 'Settings' window. See Section 4.10. and Section 5.3. for further details on the parameter values shown in the 'Settings' display.

4.3   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. 4.2   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 E   , Section E.2.2. for background information on the home position.

4.4 Moving to an Absolute Position

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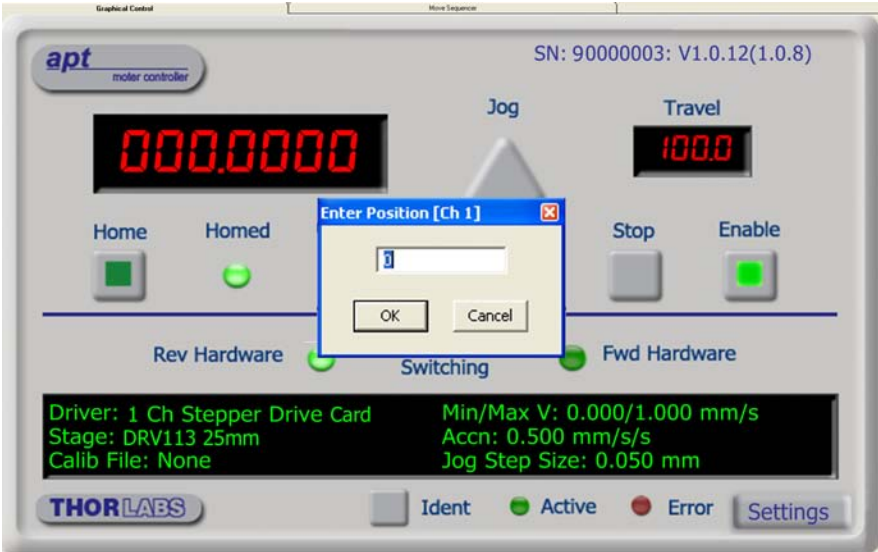
1) Click the position display.

Fig. 4.3   Absolute Position Popup Window

2) Enter 3.0 into the pop up window
3) Click 'OK'. Notice that the position display counts up to 003.000 to indicate a move to the absolute position 3.00mm.

4.5 Changing Motor Parameters

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

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

Fig. 4.4   Settings Panel - Move/Jogs Tab

2) Select the Move/Jogs tab as shown in Fig. 4.4.

3) In the 'Moves' field, 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 moves initiated on channel 1 will now be performed at a maximum velocity of 2.5mm per second, with an acceleration of 0.5mm/sec/sec.

4.6   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. 4.5. In 'Continuous' mode, the motor actuator will accelerate and move at the jog velocity while the button is held down.

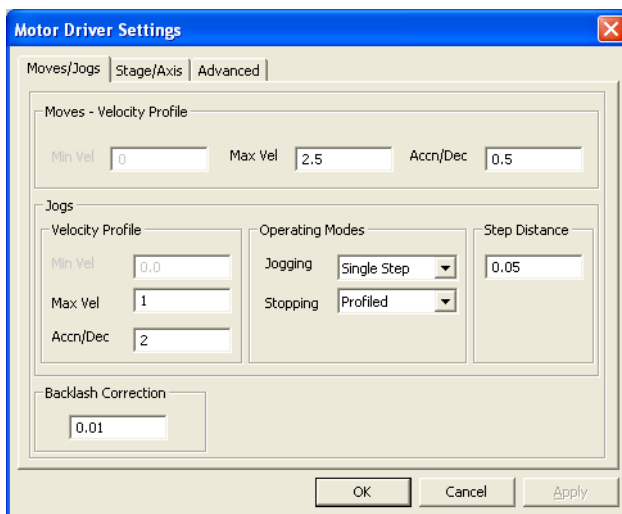1) On the GUI panel, click the 'Settings' button to display the Settings panel.
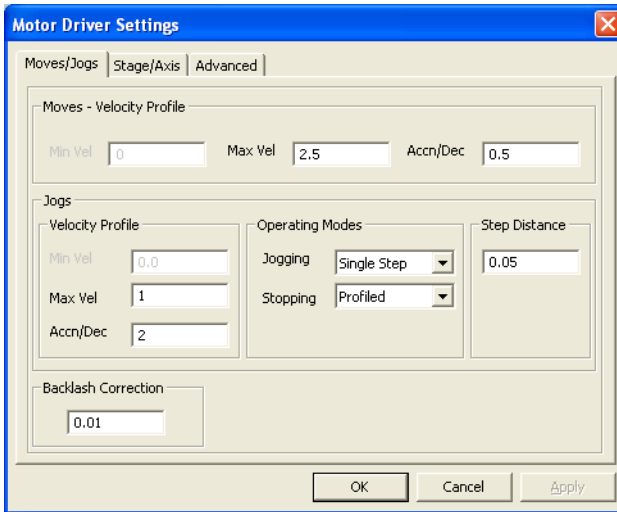
Fig. 4.5   Settings Panel - Move/Jogs Tab

2) Select the Move/Jogs tab as shown in Fig. 4.5.
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.

4.7   Graphical Control Of Motor Positions (Point and Move)

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

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

Fig. 4.6 Motor GUI Panel - Graphical View

Consider the display shown above for an SCC101 Stepper Motor Drive Card fitted to a BSC103 APT stepper controller unit.

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

Note
The channel functionality of the BSC103 motor controller is accessed via a single channel GUI panel, one panel for each SCC101 motor drive card fitted. The Channel 2 parameters are greyed out.

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

The vertical divisions relate to the travel of the stage/actuator associated with the controller (the stage/actuator is selected in the 'APT Config' utility). For example, the screen shot above shows the parameters for a 25mm travel DRV113 motor actuator. The graph shows 5 divisions in the X axis, which relates to 5mm of travel per division (25mm 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 5.3.

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'.

4.8   Setting Move Sequences

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

For details on moving to absolute positions initiated by a mouse click – see Section 4.9.

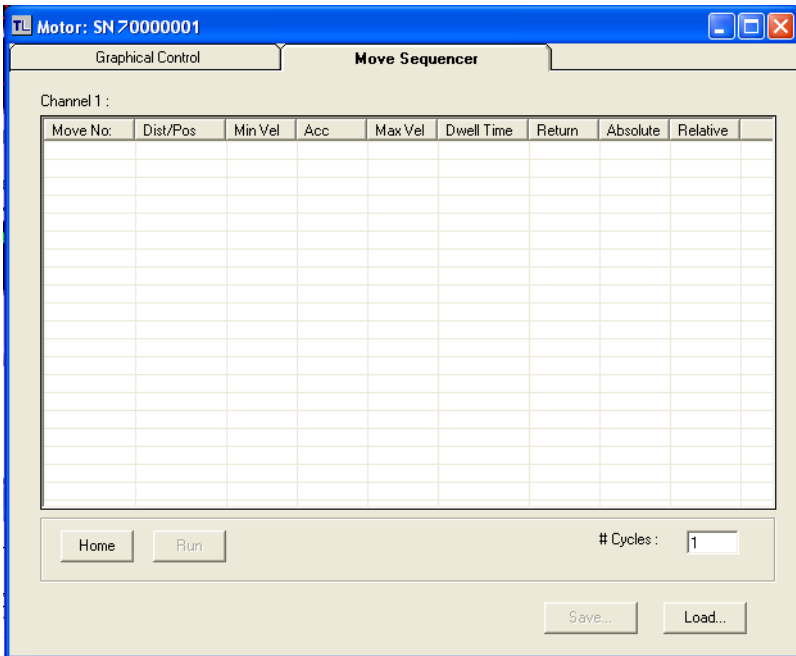1) From the Motor GUI Panel, select 'Move Sequencer' tab to display the Move Sequencer window.

Fig. 4.7 Move Sequencer Window

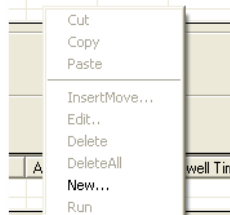2) Right click, in the move data field to display the pop up menu.

Fig. 4.8 Move Sequencer Pop Up Menu

3) Select 'New' to display the 'Move Editor' panel.
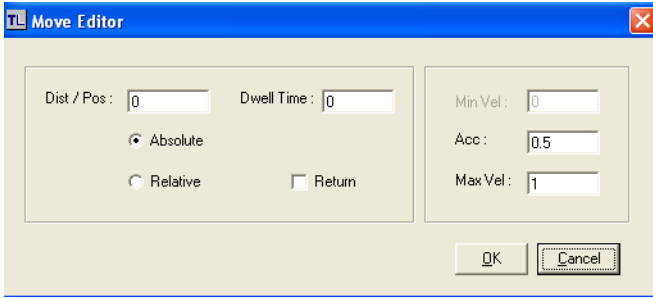
Fig. 4.9 Move Editor Window

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.

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

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.

4) Enter the required move data into the Move Editor and click OK. The move data is displayed in the main window as shown below.
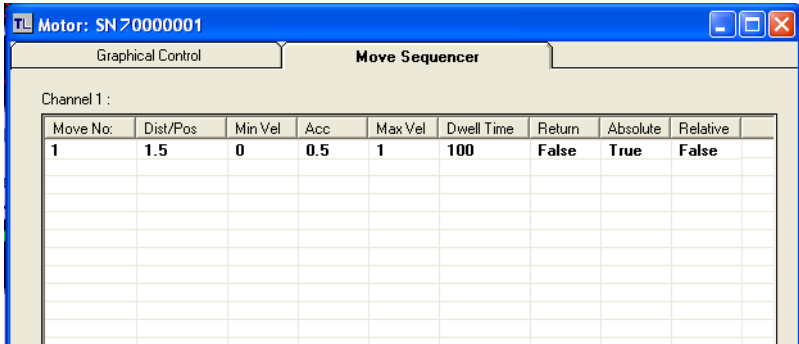
Fig. 4.10 Main Window with Move Data

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

Fig. 4.11 Pop Up Options

6) To run a single line of data, right click the appropriate data and select 'Run' from the pop up menu (shown above).

7) To run the entire sequence, click the 'Run' button (shown below). A Home move can also be performed from this panel by clicking the 'Home' button.
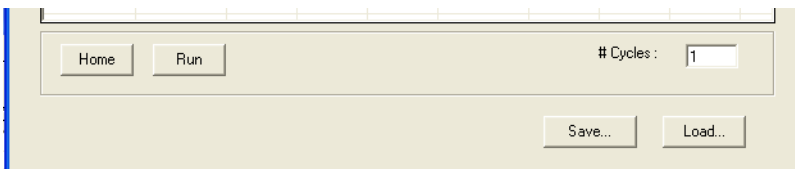
Fig. 4.12 Home and Run Buttons

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.

4.9   Creating a Simulated Configuration Using APT Config

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

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

To create a simulated configuration proceed as follows:

1) Run the APT Config utility - Start/All Programs/Thorlabs/APT/APT Config.

2) Click the 'Simulator Configuration' tab.

Fig. 4.13 APT Configuration Utility - Simulator Configuration Tab

3) Enter 'LAB1' in the Configuration Names field.

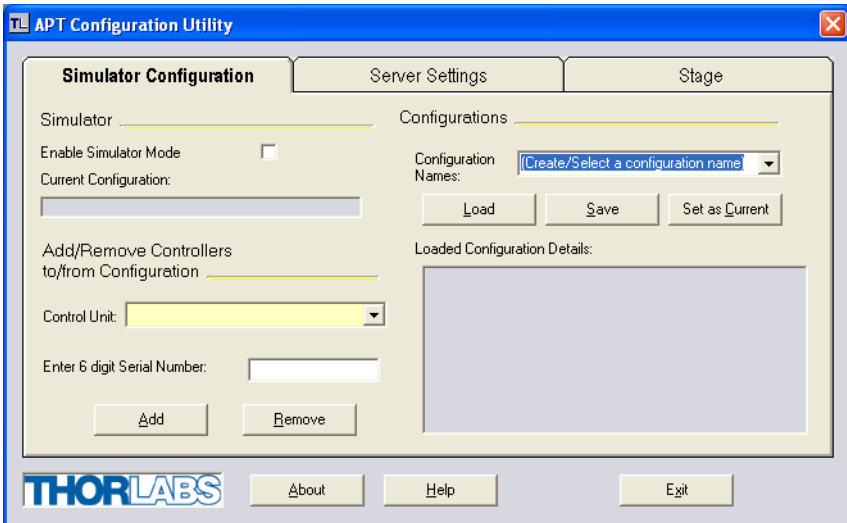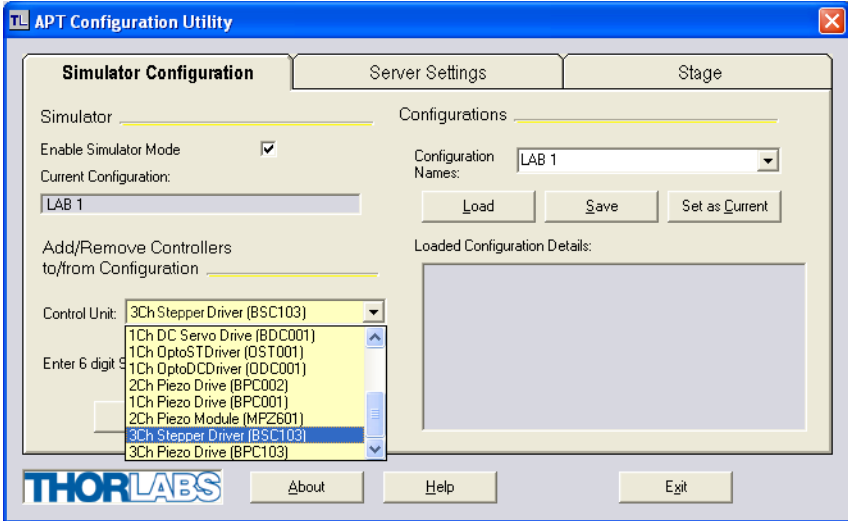4) In the 'Simulator' field, check the 'Enable Simulator Mode' box. The name of the most recently used configuration file is displayed in the 'Current Configuration' window.

5) In the 'Control Unit' field, select '3 Ch Stepper Driver (BSC103)'.
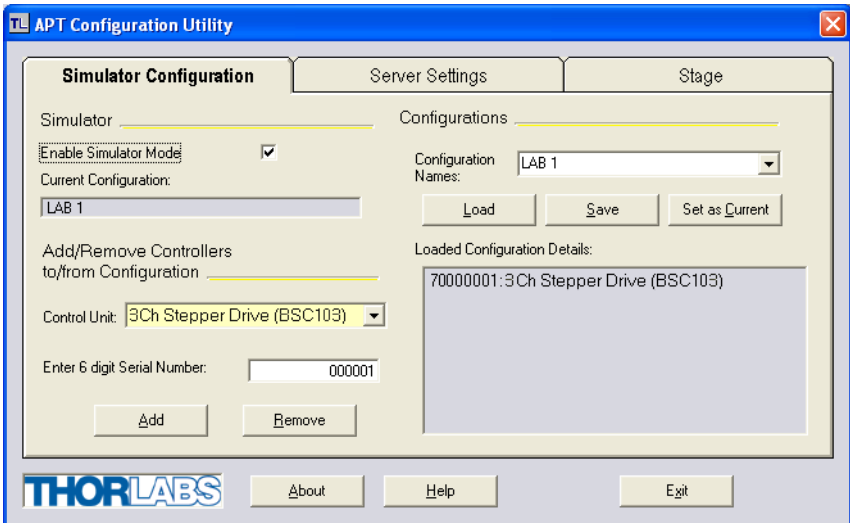
6) Enter a 6 digit serial number.

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 BSC103 stepper controller are:**   **70xxxxxx - Benchtop APT Three Channel Stepper Motor Controller**   **90xxxxxx - SCC101 Single Channel Stepper Motor Drive Card**

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

4.10   Stage/Axis Tab

This tab contains a number of parameters which are related to the physical characteristics of the particular stage or actuator being driven. They need to be set accordingly such that a particular stage is driven properly by the system.
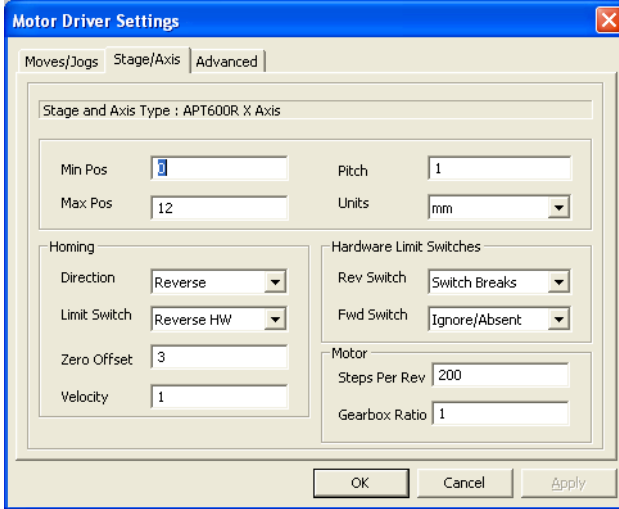
Fig. 4.14   Stage/Axis Tab

These parameters were set automatically when the DRV113 actuator was selected using the APTConfig utility in Section 3.6. The APT server automatically applied suitable defaults for the parameters on this tab during boot up of any client software such as APTUser. These parameters should not be altered for pre-defined Thorlabs stages and actuators selected using APT Config, as it may adversely affect the performance of the stage.

For custom stage types not available using the APT Config utility, the stage details must be entered manually.

Individual parameters are described in Section 5.3.

Chapter 5 Software Reference

5.1 Introduction

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

5.2 GUI Panel

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

Fig. 5.1   Motor Controller Software GUI

Note

The serial number of the SSC101 card 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 5.3.).

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

Moving - lit when the motor is in motion.

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

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

Home - sends the motor to its 'Home' position - see Appendix E   Section E.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 - halts the movement of the motor.

Limit switches - the LEDs are lit when the associated limit switch has been activated - see Appendix E   Section E.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 or degrees/s), and can be set via the 'Settings' panel (see Section 5.3.).

Accn - the rate at which the velocity climbs to, and slows from, maximum velocity, displayed in real world units (mm/s/s or degrees/s/s). The acceleration can be set via the 'Settings' panel (see Section 5.3.) and is used in conjunction with the Min/Max velocity settings to determine the velocity profile of a motor move. See Appendix E   Section E.1.3. for more information on velocity profiles.

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

Settings button - Displays the 'Settings' panel, which allows the motor drive's operating parameters to be entered - see Section 5.3.

Ident - when this button is pressed, the 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.

5.3 Settings Panel

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

5.3.1 Moves/Jogs tab
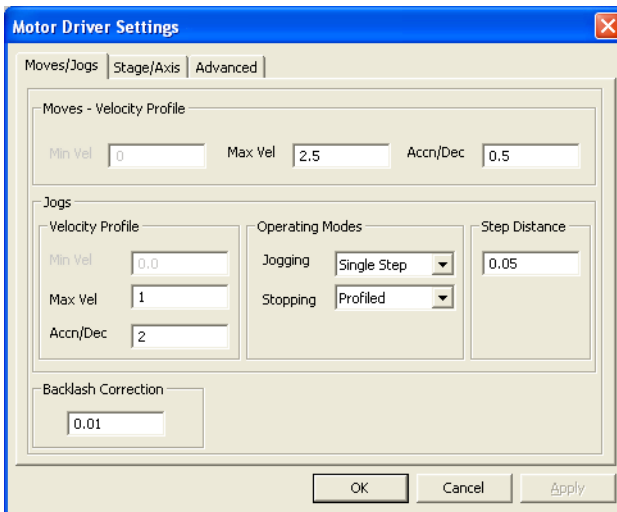
Fig. 5.2   Stepper Motor Controller - Move/Jog Settings

Moves

Moves can be initiated via the GUI panel by entering a position value after clicking on the position display box (see Section 4.4.) 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 or degrees.

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

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

MaxVel - the maximum velocity at which to perform a move.

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

<div align="center">

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).

</div>

Jogs

Jogs are initiated by using the 'Jog' keys on the GUI panel (see Section 4.6.), or via a jog handset connected to the unput logic pins exposed on the rear panel Control IO connector (see Appendix A   ).

Velocity Profile (specified in real world units, millimetres or degrees)

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

MaxVel - 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.

Operating Modes

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

There are two jogging modes available, 'Single Step' and 'Continuous'. In 'Single Step' mode, the motor moves by the step size specified in the Step Distance parameter. If the jog key is held down, single step jogging is repeated until the button is released - see Fig. 5.3. In 'Continuous' mode, the motor actuator will accelerate and move at the jog velocity while the button is held down..
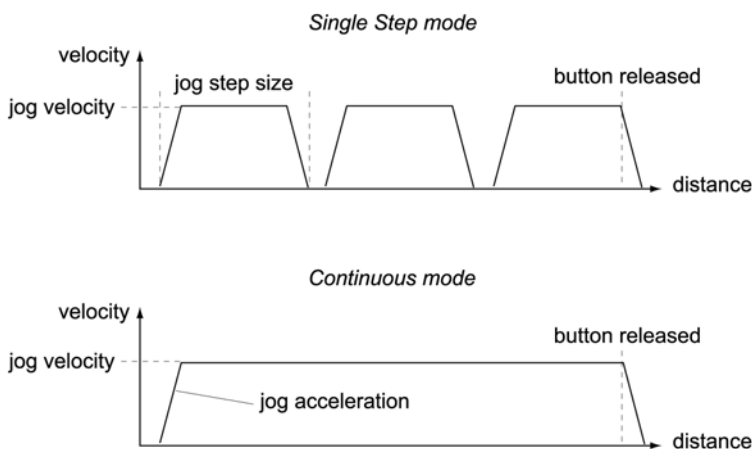
Fig. 5.3 Jog Modes

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

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

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

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

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

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

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 or degrees). To remove backlash correction, this value should be set to zero.

5.3.2 Stage/Axis tab

Fig. 5.4   Stepper Motor Controller - Stage/Axis Settings

Note
This tab contains a number of parameters which are related to the physical characteristics of the particular stage being driven. They need to be set accordingly such that a particular stage is driven properly by the system.
For Thorlabs stages, the APT Config utility can be used to associate a specific stage and axis type with the motor channel (refer to the APT Config helpfile for further details on how to associate a stage and axis). Once this association has been made, the APT server will automatically apply suitable defaults for the parameters on this tab during boot up of the software. These parameters should not be altered for pre-defined Thorlabs stages selected using APT Config, as it may adversely affect the performance of the stage.
For custom stage types not available using the APT Config utility, the stage details must be entered manually. Individual parameters are described in the following paragraphs.

Stage and Axis Type - For Thorlabs stages, the stage type is displayed automatically once the axis has been associated using the APTConfig utility. For third party stages, the display shows '*Unknown*'.

⚠️ 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 physical motor/stage combination being driven. Consult Thorlabs for advice on settings for stage/actuator types that are not selectable via the APTConfig utility.

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 or degrees) travelled per revolution of the leadscrew).

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

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 *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 E.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 Rev Switch or Fwd Switch 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 majority of Thorlabs stages/actuators have 200 full steps per rev and no gearbox fitted. For these motors 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 APTConfig.exe utility is used to associate a specific stage or actuator type with a motor channel. See the APTConfig helpfile and the tutorial Section 3.6. for more details.** |

5.3.3   Advanced Tab
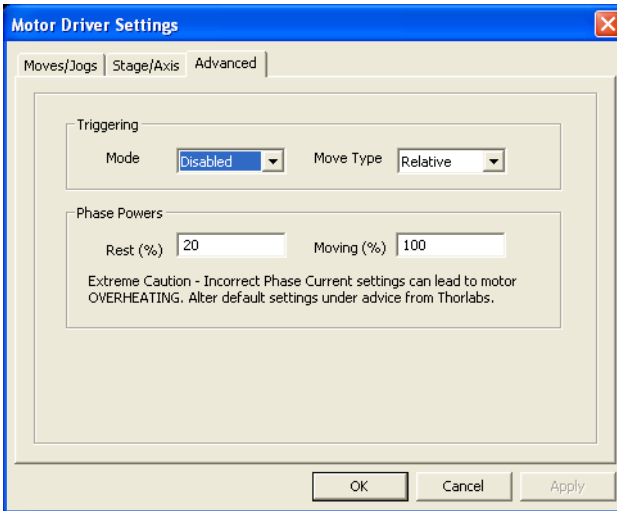
Fig. 5.5 Stepper Motor Controller - Advanced Settings

Triggering

It is possible to configure a particular controller to respond to trigger inputs, generate trigger outputs or both respond to and generate a trigger output. When a trigger input is received, the unit can be set to initiate a move (relative, absolute or home). Similarly the unit can be set to generate a trigger output signal when instructed to move via a software (USB) command. For those units configured for both input and output triggering, a move can be initiated via a trigger input while at the same time, a trigger output can be generated to initiate a move on another unit.

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

Mode

The *Mode* parameter sets the trigger mode for the associated channel.

Disabled - triggering operation is disabled

Trig In - a move (specified using the *Move Type* parameter below) is initiated on the specified channel when a trigger input signal (i.e. rising edge) is received on the Trig In pin of the rear panel CONTROL IO D-type connector - see Section A.1. for pin out details.

Trig In/Out - As for Trig In, but now a trigger output signal will also be generated on the Trig Output pin when the move begins - see Section A.1. for pin out details.

Trig Out - A trigger output signal is generated on the Trig Out pin when a move (relative, absolute or home) is initiated via software (either through the GUI panel or ActiveX method call).

Move Type

The *Move Type* parameter determines the type of move to be initiated on the associated channel when a trigger input signal is detected on the Trig In or Trig Out connector.

Relative - triggered relative move. Relative move distance and velocity profile parameters can be set prior to triggering using the SetRelMoveDist and SetVelParams methods respectively.

Absolute - triggered absolute move. Absolute move position and velocity profile parameters can be set prior to triggering using the SetAbsMovePos and SetVelParams methods respectively.

Home - triggered home sequence. Homing parameters can be set prior to triggering using the SetHomeParams method.

For example, consider the following diagram:
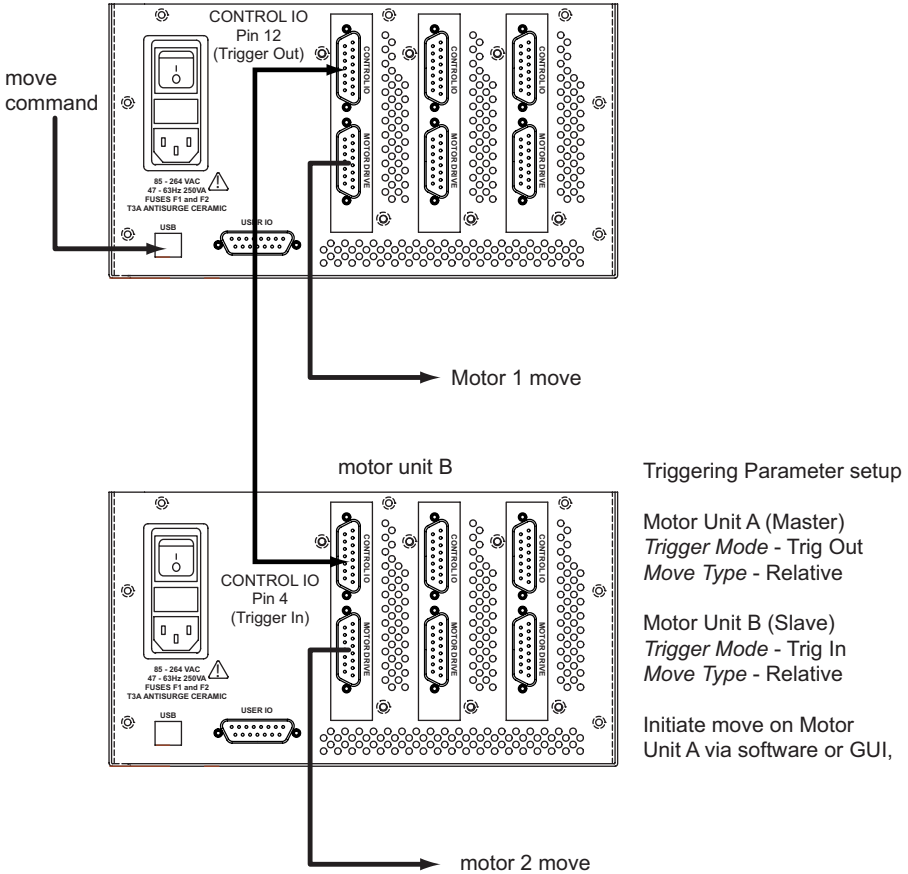
Fig. 5.6 Typical Triggering Set Up

When the move command is received via the USB link, the motor associated with unit A starts to move by the specified relative distance. Unit A also sends a trigger signal to Unit B. Unit B has been set to 'Trig In', so on receipt of the trigger from unit A, the associated motor also starts to move.

Phase Powers

The BSC stepper motor controller 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 values are 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 via the APTConfig utility. Modify these values with caution (particularly the rest power) as the risk of damage to the motor due to overheating is significant.

# Appendix A   Rear Panel Connector Pinout Details

A.1   Rear Panel CONTROL IO Connector

The 'CONTROL I/O' is a 15-Pin D-Type, Female connector that exposes a number of electrical signals useful for external control. It is possible to configure a particular controller to respond to trigger inputs, generate trigger outputs or both respond to and generate a trigger output - see Section 5.3.3. Motor jogging lines can be used to jog the motor in both forward and reverse directions from a remote handset (Jogging parameters (e.g. jog distance) are set via the GUI panel - see Section 5.3.1.).

The pin functions are detailed in Fig. A.1.
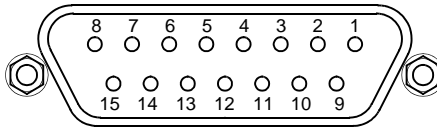
Pin	Description	Return	Pin	Description	Return
1	User 5V I/O	9	9	User 0V	–
2	* Jog forwards	9	10	* Jog backwards	9
3	Not Used	9	11	** Analog In	9
4	Tigger In	–	12	Trigger Out	4
5	Not Used	–	13	Not Used	–
6	Reserved for future use	–	14	Reserved for future use	6
7	Digital (User) In	–	15	Digital (User) Out	9
8	Keyed Pin	–			

Notes

*   Jog inputs must be short circuit to User 0V (pin 9) in order to function.

**   Analog In is 0 to 5V wrt 0V (pin 9). The input can be read by calling the LLGetADCInputs method in the APT software - see the *APTServer helpfile* for more details.

Fig. A.1 MOTOR I/O connector pin identification

A.1.1 Digital/User Outputs

All digital outputs are of the open-collector type, with a 330 Ohm series resistor. When the output is set to a logic zero (which is also the default state), it behaves as open circuit. When it is a logic one, it behaves as a 330 Ohm resistor connected to ground.
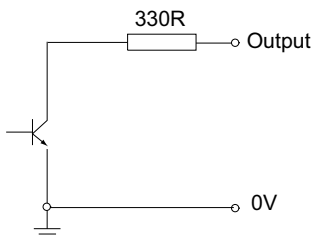
Fig. A.2 Digital Output Schematic

In some applications, the outputs may be required to control external equipment that has optocoupler type inputs (such as PLCs). The digital outputs used here can be used to directly drive most optocouplers and the +5V supply available on pins 14 and 15 can be used to provide power for the optocouplers.
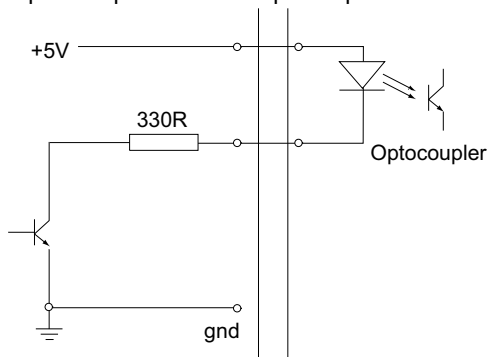
Fig. A.3 Application Example: Connection to Optocoupler Inputs

These outputs can also be used to interface to external logic circuitry (a pull-up resistor may be needed if the external logic does not contain it) or control other types of inputs.

⚠	Caution	⚠
	The voltage that external equipment applies to the digital outputs must be within the range 0 V and +5 V DC, or damage to the outputs may occur.	

Please see the LLSetGetDigOPs method in the APTServer helpfile for details on how to control these logic IO.

A.1.2   Digital/User Inputs

The digital inputs used in the controller are of the standard CMOS logic gate type with TTL compatible input levels and a built-in pull-up resistor (10 kOhm to +5V). They can be connected directly to mechanical switches, open-collector type outputs or most type of logic outputs.

Fig. A.4 Digital Input Schematic (protection circuitry not shown)

When connected to a switch, the inputs will read as logic LOW if the switch is open circuit and HIGH if the switch is closed. When connected to a logic output, or any other voltage source, the input is guaranteed to read LOW if the voltage is above 2.4V and HIGH when the output is below 0.8 V. Please see the LLGetStatusBits method in the APTServer helpfile for details on how to control these logic IO.

Caution

The voltage applied to the digital inputs must be within the range 0 V to +7V DC, or damage to the inputs may occur.

A.1.3   Trigger Output

The trigger output is different from the rest of the digital outputs in that it is a 5V CMOS logic gate with a series 1 kOhm resistor for protection. It behaves as +5V voltage source with 1 kOhm in series when the outputs is a logic HIGH, and 1 kOhm to ground when it is a logic LOW. The 1 kOhm resistor limits the current to 5 mA maximum for any load as long as the output is not connected to voltages outside the 0 V to +5V range.
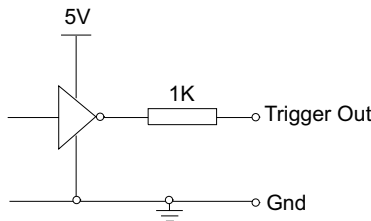
Fig. A.5 Trigger Output Schematic

As this output is actively driven, it can be connected, for example, to an oscilloscope without a need for an external pull-up resistor. It can also be used to drive most optocouplers.

A.1.4   Trigger Input

The Trigger inputs are ekectrically identical to the digital inputs (i.e. a standard CMOS logic gate type with TTL compatible input levels and a built-in pull-up resistor, 10 kOhm to +5V). They can be connected directly to mechanical switches, open-collector type outputs or most type of logic outputs.
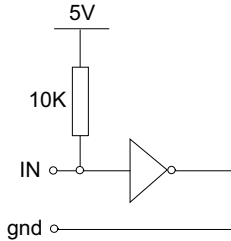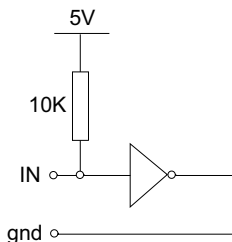

Fig. A.6 Trigger Input Schematic (protection circuitry not shown)

When connected to a switch, the inputs will read as logic LOW if the switch is open circuit and HIGH if the switch is closed. When connected to a logic output, or any other voltage source, the input is guaranteed to read LOW if the voltage is above 2.4V and HIGH when the output is below 0.8 V.

Caution
The voltage applied to the trigger inputs must be within the range 0 V to +7V DC, or damage to the outputs may occur.

A.1.5   +5 Volt Supply

A +5 V, 250 mA supply is provided for interfacing to external circuits that require a power source.

Caution
Do not exceed the 250 mA maximum output current. For applications requiring higher currents an external power supply must be used.

A.2   Rear Panel MOTOR DRIVE Connectors

The 'MOTOR DRIVE ' is a 15-Pin D-Type, Female connector that provides connection to the motors. The pin functions are detailed in Fig. A.7. In each case the signal must be referenced to the indicated return pin in order to be true.
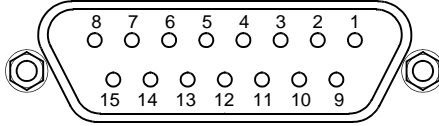
Pin	Description	Return	Pin	Description	Return
1	Encoder A +ve		9	CW Limit Stwitch	
2	Encoder A -ve		10	CCW Limit Switch	
3	Encoder B +ve		11	0V User	
4	Encoder B -ve	–	12	Not Used	
5	5V User	–	13	Not Used	
6	Not Used	–	14	Phase B +	
7	Phase B -	–	15	Phase A +	
8	Phase A -	–			

Fig. A.7 DRIVE CHANNEL Connector Pin Identification

A.3   Rear Panel User I/O Connector

A.3.1   Pin Identification

The User I/O is a 15-Pin D-Type, Female connector that exposes a number of internal electrical signals. For convenience, a number of logic inputs and outputs are included, thereby negating the need for extra PC based IO hardware. Using the APT support software, these user programmable logic lines can be deployed in applications requiring control of external devices such a relays, light sources and other auxilliary equipment.

The pin functions are detailed in in Fig. A.8 .

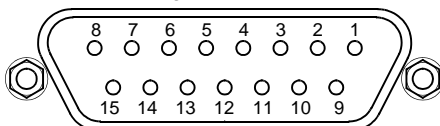| Pin	Description	Return	Pin	Description	Return
1	Digital O/P 1	5, 9, 10	9	Digital Ground	
2	Digital O/P 2	5, 9, 10	10	Digital Ground	
3	Digital O/P 3	5, 9, 10	11	For Future Use (Trigger Out)	5, 9, 10
4	Digital O/P 4	5, 9, 10	12	For Future Use (Trigger IN)	5, 9, 10
5	Digital Ground		13	Digital I/P 4	5, 9, 10
6	Digital I/P 1	5, 9, 10	14	5v Supply Output	5, 9, 10
7	Digital I/P 2	5, 9, 10	15	5v Supply Output	5, 9, 10
8	Digital I/P 3	5, 9, 10			

Warning

Do not, under any circumstances attempt to connect the digital I/O to any external equipment that is not galvanically isolated from the mains or is connected to a voltage higher than the limits specified in Section A.3.2. to Section A.3.6. In addition to the damage that may occur to the controller there is a risk of serious injury and fire hazard.

For applications requiring the capability to control higher voltages and currents, such as mains voltages, Thorlabs offers a relay box which provides 4 independent channels with galvanic isolation and a voltage and current capability of up to 230 Volts 5 Amps AC.

Fig. A.8 USER Connector Pin Identification

A.3.2   Digital Outputs

All digital outputs are of the open-collector type, with a 330 Ohm series resistor. When the output is set to a logic zero (which is also the default state), it behaves as open circuit. When it is a logic one, it behaves as a 330 Ohm resistor connected to ground.
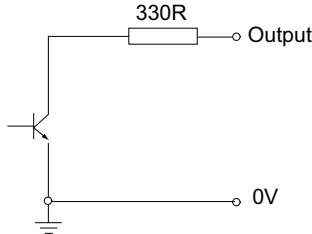
Fig. A.9 Digital Output Schematic

In some applications, the digital outputs may be required to control external equipment that has optocoupler type inputs (such as PLCs). The digital outputs used here can be used to directly drive most optocouplers and the +5V supply available on pins 14 and 15 can be used to provide power for the optocouplers.
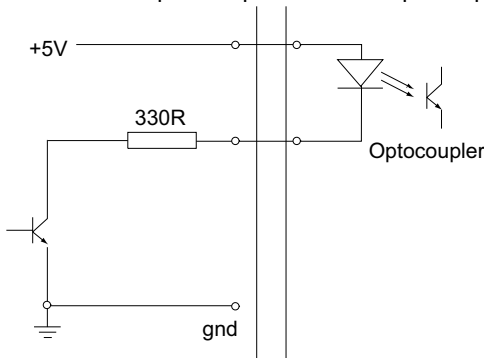
Fig. A.10 Application Example: Connection to Optocoupler Inputs

The digital outputs can also be used to interface to external logic circuitry (a pull-up resistor may be needed if the external logic does not contain it) or control other types of inputs.

Caution
The voltage that external equipment applies to the digital outputs must be within the range 0 V and +5 V DC, or damage to the outputs may occur.

Please see the LLSetGetHostDigOPs method in the APTServer helpfile for details on how to control these logic IO.

A.3.3 Digital Inputs

The digital inputs used in the controller are of the standard CMOS logic gate type with TTL compatible input levels and a built-in pull-up resistor (10 kOhm to +5V). They can be connected directly to mechanical switches, open-collector type outputs or most type of logic outputs.

Fig. A.11 Digital Input Schematic (protection circuitry not shown)

When connected to a switch, the inputs will read as logic LOW if the switch is open circuit and HIGH if the switch is closed. When connected to a logic output, or any other voltage source, the input is guaranteed to read LOW if the voltage is above 2.4V and HIGH when the output is below 0.8 V. Please see the LLGetHostStatusBits method in the APTServer helpfile for details on how to control these logic IO.

⚠️ **Caution** ⚠️
**The voltage applied to the digital inputs must be within the range
0 V to +7V DC, or damage to the inputs may occur.**

A.3.4 Trigger Output

The trigger output is different from the rest of the digital outputs in that it is a 5V CMOS logic gate with a series 1 kOhm resistor for protection. It behaves as +5V voltage source with 1 kOhm in series when the outputs is a logic HIGH, and 1 kOhm to ground when it is a logic LOW. The 1 kOhm resistor limits the current to 5 mA maximum for any load as long as the output is not connected to voltages outside the 0 V to +5V range.
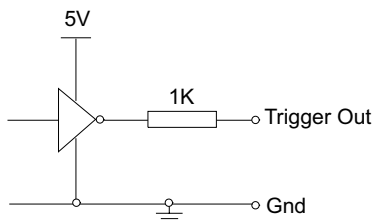
Fig. A.12 Trigger Output Schematic

As this output is actively driven, it can be connected, for example, to an oscilloscope without a need for an external pull-up resistor. It can also be used to drive most optocouplers.

A.3.5   Trigger Input

The Trigger inputs are ekectrically identical to the digital inputs (i.e. a standard CMOS logic gate type with TTL compatible input levels and a built-in pull-up resistor, 10 kOhm to +5V). They can be connected directly to mechanical switches, open-collector type outputs or most type of logic outputs.
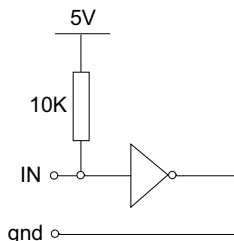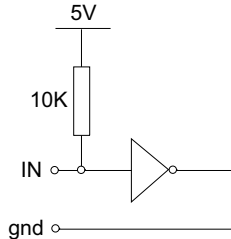

Fig. A.13 Trigger Input Schematic (protection circuitry not shown)

When connected to a switch, the inputs will read as logic LOW if the switch is open circuit and HIGH if the switch is closed. When connected to a logic output, or any other voltage source, the input is guaranteed to read LOW if the voltage is above 2.4V and HIGH when the output is below 0.8 V.

Caution

The voltage applied to the trigger inputs must be within the range 0 V to +7V DC, or damage to the outputs may occur.

A.3.6   +5 Volt Supply

A +5 V, 250 mA supply is provided for interfacing to external circuits that require a power source.

Caution

Do not exceed the 250 mA maximum output current. For applications requiring higher currents an external power supply must be used.

Appendix B   Preventive Maintenance

Shock Warning

The equipment contains no user servicable parts. There is a risk of severe 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.

B.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.

B.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.

Appendix C   Specifications and Associated Parts

C.1   Specifications

Parameter	Value
Input/Output	
Motor Drive (15-Pin D-type Female)	2-Phase Bipolar Motor Drive Output Differential Quadrature Encoder Interface Forward, Reverse Limit Switch Inputs
Control IO (15-Pin D-type Female)	Jog Forward Jog Back User Outputs/Inputs Single - ended analog input (0-10 Volt) Trigger In/Out (For Future Use)
User IO (15-Pin D-type Female)	Digital Output Digital Input Trigger Output (For Future Use) Trigger Input (For Future Use) +5V Output
Resolution	128 Microsteps per Full Step 200 Step Motor - 25,600 Microsteps per Rev 24 Step Motor - 3072 Microsteps per Rev
Motor Power	Up to 48 V/50 W (peak)
Input Power Requirements	
Voltage	85-264 VAC
Power	200 W
Fuse	3.15 A
Motor speeds	Up to 600 RPM (for 200 full step motor)
Encoder feedback bandwidth	500,000 counts/sec
General	
Housing Dimensions (W x D x H)	240 x 360 x 133 mm (9.5 x 14.2 x 5.2 in.)
Instrument Weight	6.7 kg (14.75 lbs)
Compatible Motors	
Peak Powers	5 to 50 W
Average Power	25 W Maximum
Step Angle Range	20° to 1.8°
Coil Resistance (nominal)	4 to 15 Ω¶
Coil Inductance (nominal)	4 to 15 mH
Rated Phase Currents (nominal)	100 mA to 1 A

C.2   Associated Products

Product Name	Part Number
Stepper Motor Actuator, 4mm travel	DRV001
Stepper Motor Actuator, 25mm (1") travel, trapezoidal leadscrew	DRV013
Stepper Motor Actuator, 50mm (2") travel, trapezoidal leadscrew	DRV014
Stepper Motor Drive Cable (1.25 Metres)	PAA 610
Stepper Motor Drive Cable (3.0 Metres)	PAA 611

Appendix D   Motor Control Method Summary

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

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

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

Methods

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

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

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

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

Properties

APTHelp	Specifies the help file that will be accessed when the user presses the F1 key. If APTHelp is set to 'True', the main server helpfile MG17Base will be launched.
DisplayMode	Allows the display mode of the virtual display panel to be set/read.
HWSerialNum	specifies the serial number of the hardware unit to be associated with an ActiveX control instance.

Appendix E   Stepper Motor Operation - Background

E.1   How A Stepper Motor Works

E.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. E.1.
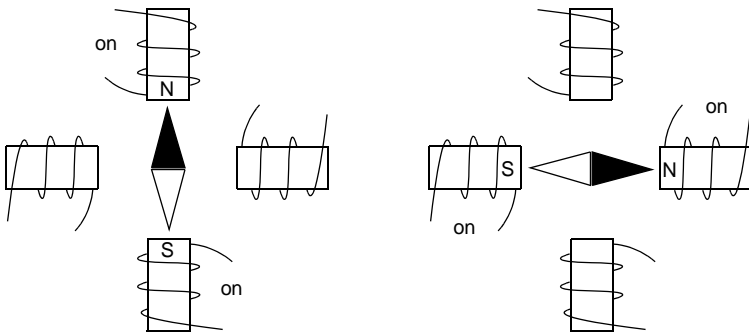

Fig. E.1 Simplified concept of stepper motor operation

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. When used with the Thorlabs BSC103 Stepper Motor Controller, the smallest angular adjustment is 0.014 degrees (i.e. 1.8/0.014 = 128 microsteps per full step), resulting in a resolution of 25,600 microsteps per revolution for a 200 full step 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.

E.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.

E.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. E.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.
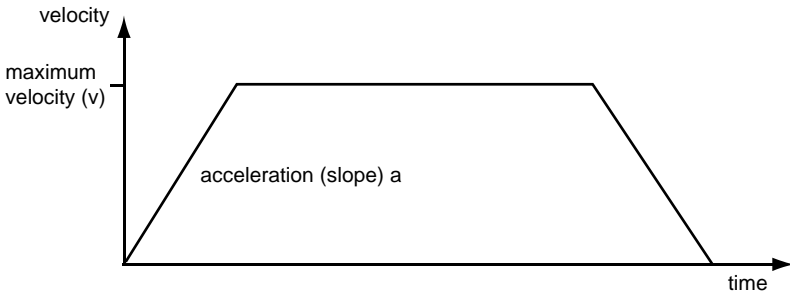

Fig. E.2 Graph of a trapezoidal velocity profile

E.2 Positioning a Stage

E.2.1 General

Whenever a command is received to move a stage, the movement is specified in motion units, (e.g. millimetres). This motion unit value is converted to microsteps before it is sent to the stage. If operating the unit by the front panel (local mode) this conversion is performed internally by the controller. If operating via a PC (remote mode) then the conversion is performed by the APT software.

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

E.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 4.3. for details on performing a Home move.

E.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.
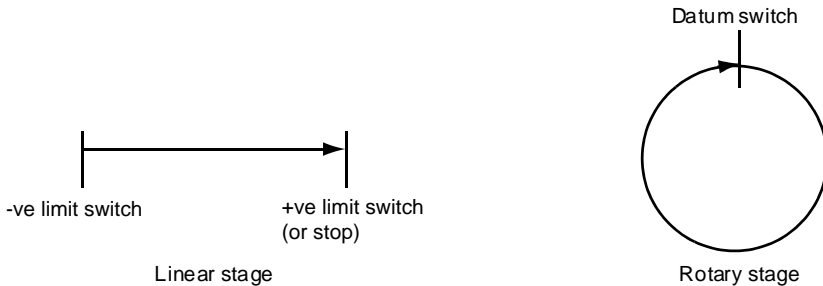
Datum switch

-ve limit switch   +ve limit switch
                          (or stop)

Linear stage   Rotary stage

Fig. E.3 Stage limit switches

E.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. E.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.
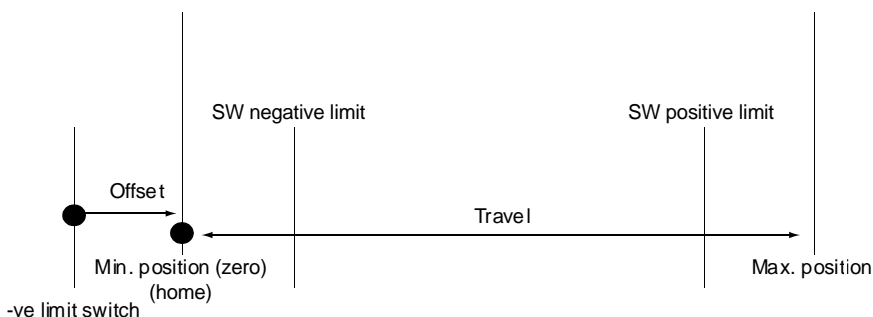
SW negative limit   SW positive limit

Offset

Travel

Min. position (zero)   Max. position
(home)

-ve limit switch

Fig. E.4 Minimum and Maximum Positions

E.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.

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 5.3.3. for more details on these power settings.

E.3 Error Correction

E.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. 5.5, 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.
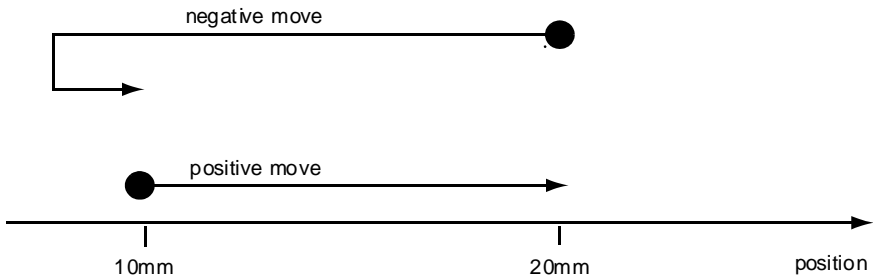

Fig. 5.5 Backlash correction

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 5 (PC Operation) for details on setting the backlash correction.

Appendix F   Regulatory

F.1   Declarations Of Conformity

F.1.1   For Customers in Europe

This equipment has been tested and found to comply with the EC Directives 89/336/EEC 'EMC Directive' and 73/23/EEC 'Low Voltage Directive' as amended by 93/68/EEC.

Compliance was demonstrated by conformance to the following specifications which have been listed in the Official Journal of the European Communities:

Safety   EN61010: 2001 Installation Category II, Polution Degree II.

EMC   EN61326: 1997

F.1.2   For Customers In The USA

This equipment has been tested and found to comply with the limits for a Class A digital device, persuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Changes or modifications not expressly approved by the company could void the user's authority to operate the equipment.

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

F.2.1   Compliance

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

This offer is valid for electrical and electronic equipment

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

Fig. 6.1   Crossed out "wheelie bin" symbol

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

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

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

F.2.2   Waste treatment on your own responsibility

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

F.2.3   Ecological background

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

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

Appendix G   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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