THORLABS

BBD201
Brushless DC Servo Controller

User Guide

Original Instructions

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 absorbent tissue. Do not allow spilled fluid to enter the internal mechanism.

Chapter 2   Overview and Setup

2.1   Introduction

The BBD201 Brushless DC Motor Controllers are ideal for motion control applications demanding high speed (100s of mm/s) and   high encoder resolution (<100 nm) operation. These single channel controllers offer high-precision motion control in a wide range of applications, and in particular when used along with our DDS220 fast translation stage where speeds of up to 300 mm/sec can be achi eved. Designed using latest digital and analog techniques and with high-bandwidth high-power servo control circuitry, these new controllers are capable of driving a range of rotary and linear brushless 3-phase DC motors of up to 2.5 Amp peak coil current.

Integrated into the apt famil y of pro ducts, it offe rs Thorlabs standard control and programming interface, allowing easy integration into the customer's own automated motion control applications. These units are cable of being reprogrammed in-field, allowing the option of upgrading the units with future firmware releases as soon as new programming interfaces (such as microscopy standard command sets) a re added..

Fig. 2.1   APT Single Channel Brushless DC Servo Motor Controller (BBD201)

Operation of the BBD series brushless DC mo tor unit is fully configurable (parameterized) with key settings (e.g. PID settings, min and max position values, and limit switch operation) exposed through the associated graphical interface panels.

PID control loop values can be adjusted for a particular application, minimum and maximum position values can be entered to suit different stages as required, and limit switch configuration is accommodated through a flexible set of l imit switch l ogic 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 b e adjusted for a particular stage or actuator. Fo r simplicity of operation, the apt™ software incorporates pre-configured settings for each of th e Thorlabs stages an d actuators, while still exp osing all parameters individually for use with other DC 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 n ext position can be initiated by clicking directly on the position display and entering a new value (see the tutorial in Chapter 4 for further details). Furthermore, all such settings and parameters are also accessible through the ActiveX® programmable interfaces for automated alignment sequences.

In the remainder of this handbook, the Tutorial section (Chapter 4) 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 BBD201 DC motor 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 f unction libraries for custom application development.

The APT software suite supplied with all APT con trollers, including the BBD201 DC Servo 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 d evelop any further cu stom 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 pan els, communications handling for multiple USB units, and logging of all system activity to assist in hardware trouble shooting. It is this APT server 'engine' that is used by software developers to allow the creation of advanced automated positioning applications very rapidly and with great ease. The APT server is described in more detail in Section 2.2.4.

Aside

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

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

2.2.2 APTUser Utility

The APTUser application allows the user to interact with a number of APT hardware control units connected to the ho st PC. This program displays multiple graphical instrument panels to allow multiple APT units to be controlled from the same screen.
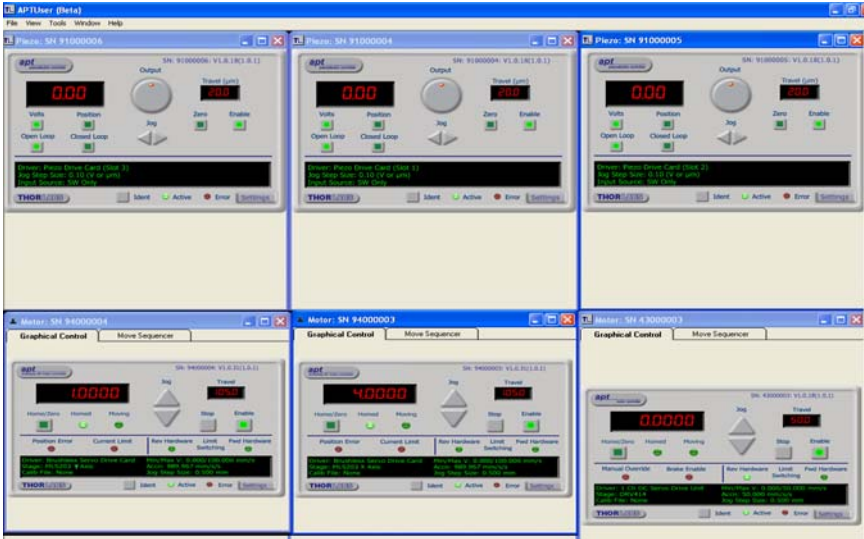
All basic operating parameters can be altered and, similarly, all operations (such as motor moves) can be initiated. Settings and parameter changes can be saved and loaded to allow multiple operating configurations to be created and easily applied.

For many users, the APTUser application provides all of the functionality necessary to operate the APT hardware without the need to deve lop any further custom software. For those wh o do need to further customise and automate u sage of the controller (e.g. to implement a positioning algorithm), this application illustrates how the rich fun ctionality provided by the APT ActiveX server is e xposed by a client application.

Use of the APT User utility is covered in the PC tu torial (Chapter 4) 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 par ameters 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, and associating third party mechanical stages to specific motor actuators.
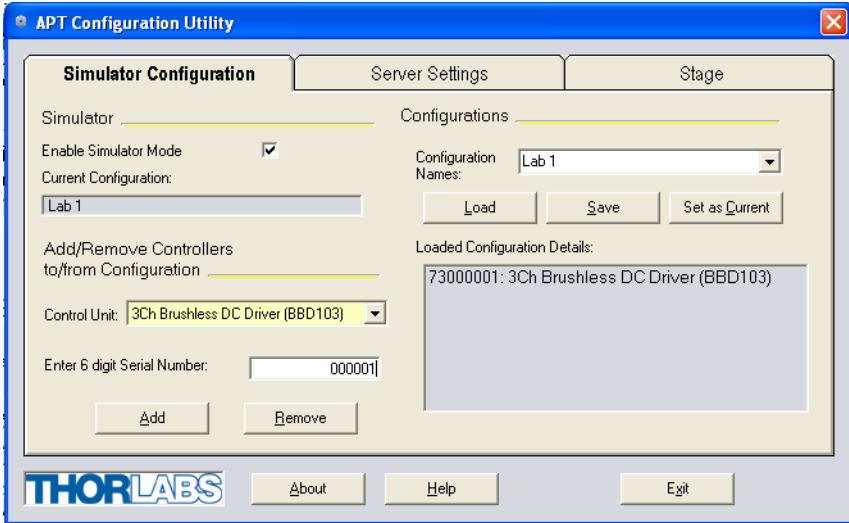
If a BBD series controller is used with the DDS220 Direct Drive Translation stage, all stage-associated settings are made automatically when the stage is connected to the controller.

The APTConfig utility is provided as a convenient means for making these system wide settings and adjustments for third party brushless DC motor driven stages. An overview of APTConfig is provided in Section 2.2.3. Full details are contained in the online help supplied with the utility.

2.2.4   APT Server (ActiveX Controls)

ActiveX Controls are re-usable compiled software components that sup ply both a graphical user interface an d a p rogrammable interface. Many such Controls a re available for Windows applications development, providing a large range of re-usable functionality. For example, there are C ontrols available that can be used to manipulate image files, connect to the in ternet or si mply 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 BBD201 DC motor controllers. Software applications that use ActiveX C ontrols are often referred to as 'client applications'. Based on Active X interfacing technology, an

ActiveX Control is a l anguage independent software component. Consequently ActiveX Controls can be in corporated into a wide range of softwa re development environments for u se by clie nt application developers. Development environments supported include Visual Basic, Labview, Visual C++, C++ Builder, HPVEE, Matlab, VB.NET, C#.NET and, via VBA, Microsoft Office applications such as Excel and Word.

Consider the ActiveX Control supplied for the BBD201 APT Brushless DC Servo Controller unit.
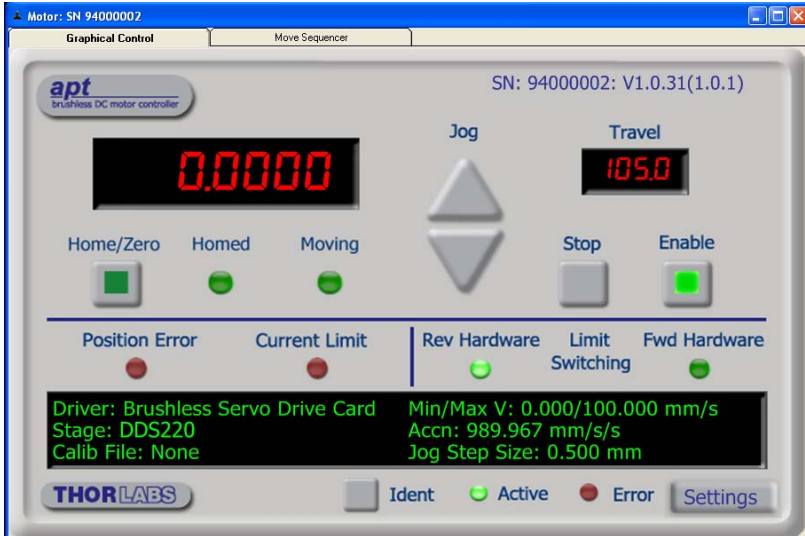
This Control provides a complete user graphical instrument panel to allow the motor unit to be manually operated, as well as a complete set of software functions (often called methods) to allow all parameters to be set a nd motor operations to be automated by a client application. The instrument panel reflects the current operating state of the controller unit to which it is associated (e.g. such as motor position). Updates to the p anel take place automatically when a user (client) application is making software calls into the sa me Control. For example, if a client application instructs the associated DC 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).
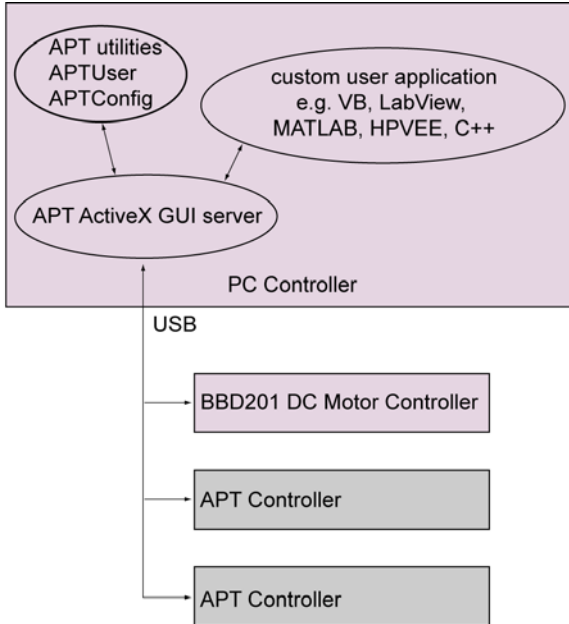
Fig. 2.2   System Architecture Diagram

Refer to the main APT Software onl ine help file, APTServer.hlp, for a comple te programmers guide and reference material on using the APT ActiveX Controls collection. Additional software developer support is provided by the APT Support CD supplied with every APT controller. This CD con tains a comple te range of tutorial samples and coding hints and tips, together with ha ndbooks 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

<table>
<tr><td align="center">Note</td></tr>
<tr><td>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.</td></tr>
</table>

<table>
<tr><td align="center">⚠️ Caution ⚠️</td></tr>
<tr><td>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.</td></tr>
<tr><td align="center">If you experience any problems when installing software, contact Thorlabs on +44 (0)1353 654440 and ask for Technical Support.</td></tr>
</table>

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 or the control panel buttons. **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^oC to 40^oC
Maximum Humidity	Less than 80% RH (non-condensing) at 31°C

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

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

The unit must not be used in an explosive environment.

3.3   Electrical Installation

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

3.3.1   Connecting To The Supply

⚡ **Shock Warning** ⚡
**The unit must be connected only to an earthed fused supply of 100 to
240V.**

**Use only power supply cables supplied by Thorlabs, other cables may not
be rated to the same current. The unit is shipped with appropriate power
cables for use in the UK, Europe and the USA. 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 3.15A/250V a.c. antisurge ceramic fuses are located in the fuse drawer on the
mains inlet 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. It is good
   practise to replace both fuses when a fuse blows.

3.3.3 Rear Panel Connections
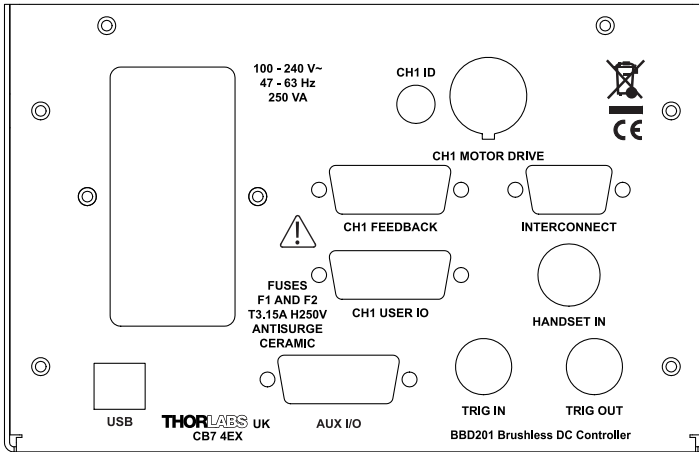
Fig. 3.1   Rear panel connections

CH ID - For channel selection when using the MJC001 joystick - see Section 4.10.

MOTOR DRIVE - Provides all phase current drive connections to the DC motor actuators - see Section A.1.

FEEDBACK - Provides connection for the position encoder feedback signals - see Section A.2.

USER I/O - The 'USER I/O' connector exposes a number of electrical signals useful for external control and monitoring - see Section A.3. for more 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.

HANDSET IN - Provides connection for the Thorlabs Joystick, MJC001 - see Section A.5.

INTERCONNECT - For use in RS232 communications - see Section A.6.

TRIG IN – For Future Use.

TRIG OUT – For Future Use.

AUX I/O - The AUX 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 requiring control of external devices such a relays, light sources and other auxillairy equipment. - see Section A.4. for further details.

3.4 Front Panel Controls and Indicators

Fig. 3.2 Front panel controls and indicators
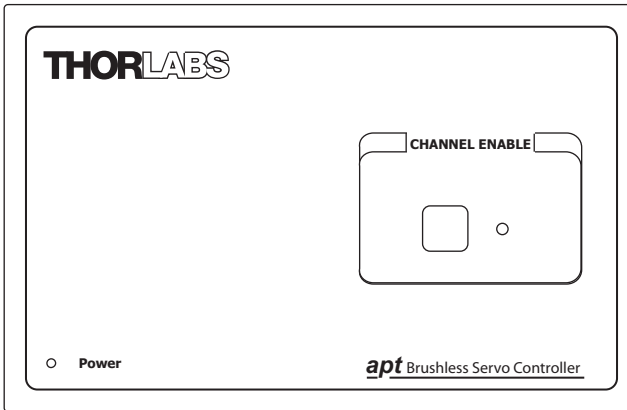
Power LED – Indicates that power is applied to the unit.

Enable button – Used to enable/disable channel functionality. The associated LED is lit when the channel is enabled. Disabling the channel removes the drive power and allows the motor actuator to be operated manually.

3.5 Connecting The Hardware and Powering Up

1) Install the APT Software - see Section 3.1.
2) Connect the stage to the Controller unit.
3) Connect the Controller unit to your PC.

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

4) Connect the Controller unit to the power supply and switch 'ON'. 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
5) Wait for 10 seconds until the Channel Enable LEDs stop flashing. This indicates that phase initialisation is complete.

Note
3-phase brushless DC motors are commutated electronically, i.e. the controller drives the coils with a precisely controller waveform, that depends on the position of the rotor (or, with linear motors, the position of the coil housing). On power up, the position of the rotor is not known. The controller establishes this by energising the coils and measuring the resulting movement. This is why on power up, the stage (motor) makes a slight buzzing noise and moves about slightly for a few seconds. Phase initialisation can only take place if the motor can move unobstructed during this time.

6) Run the APT User utility and click the 'Home' button on each GUI panel. When homing is complete, the Channel Enable LEDs on the controller front panel stop flashing.
7) The stage can now be moved using the GUI panel, or by sending commands to move each axis by relative and absolute amounts – see the helpfile supplied with the APT server for more information.
8) See the Getting Started Guide supplied with the controller, or Chapter 4 of this manual, for a brief tutorial on operation of the unit.

3.6   Verifying Software Operation

3.6.1   Initial Setup

The APT Software should be installed (Section 3.1.) and the power up procedure performed (Section 3.5.) before software operation can be verified.

1) Run the APTUser utility and check that the Graphical User Interface (GUI) panel appears and is active.
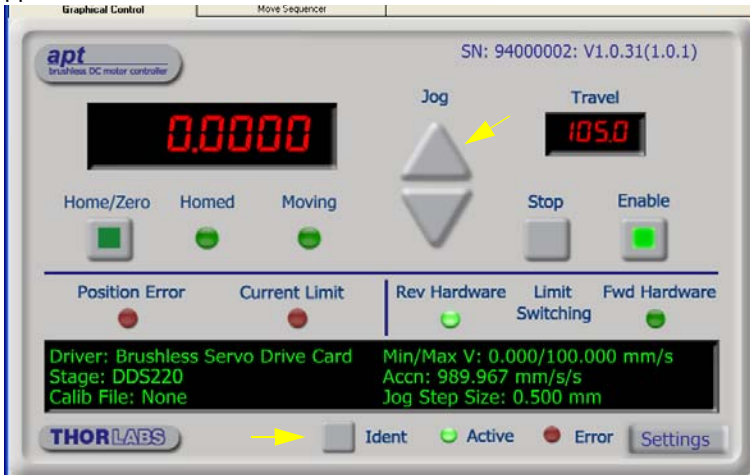
Fig. 3.3 Gui panel showing jog and ident buttons

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

3) Click the jog buttons on the GUI panel and check that the 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 4 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 4.12. or the *APTConfig* helpfile for detailed instructions.

Chapter 4   Operation - Tutorial

4.1   Introduction

The following brief tutorial guides the user thro ugh a typical series o f 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. that the APT Software is already installed - see Section 3.1. and that the stage being driven is the T horlabs DDS220 Direct Drive Translation stage.

Warning
The APTServer includes built in safety features which prevent the user from performing a move before the actuators being driven have been 'homed'. If a custom software application, which operates outside of the APTServer, is being used to position the actuator, then these safety features will not be implemented. In this case, it is the responsibility of the user to home the motors before performing any further moves. Failure to home the motors will cause an error in positional information which could result in damage to the unit and possible injury to personnel operating the equipment.

Caution
The maximum velocity at which the encoder can operate is approximately 400 mm/sec. Above this speed, encoder pulses may be lost and, as a result, the position readout becomes incorrect. This renders normal operation impossible because phase commutation of the motor is also based on the encoder reading.
When the stage is controlled by the BBD201 controller, the maximum velocity is limited to safe values. However, if the output is disabled (with the controller connected and monitoring the position) and the stage is moved manually at high speeds, it is possible to exceed this limit. If the BBD201 controller is subsequently used again to move the stage, the incorrect encoder reading will cause incorrect operation, often resulting in sudden uncontrolled moves. It is therefore important not to move the stage excessively quickly when it is moved manually.
The BBD controller has fault monitoring to detect the loss of encoder pulses. If this fault occurs, an error message will be generated and the controller must be powered down and re-started so that correct phasing and commutation can be established.
If this fault occurs when the stage is being controlled via the MJC001 joystick, in the absence of a PC, the red LED on the joystick console is lit, and all operation is suspended until the controller is shut down and rebooted.

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.
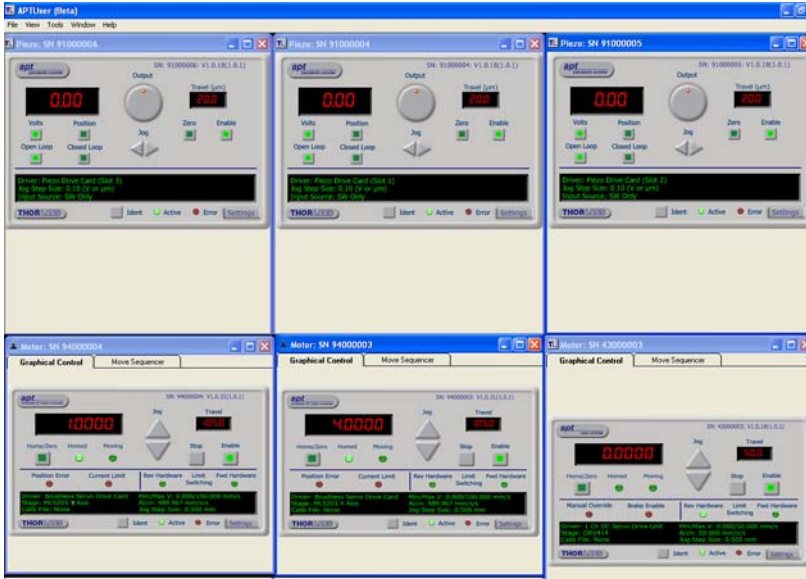
Fig. 4.1   Typical APT User Screen

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

4.3   Homing Motors

The need for homing comes from the fact that on power up the motor (stage) is at a random position, so the value of the position counter is meaningless. Homing involves moving the motor to a known reference marker and resetting the position counter to the associated absolute value. This reference marker can be one of the limit switches or can be provided by some other signal. The MLS series stages use an electronic reference marker and therefore the limit switches are not used for reference.
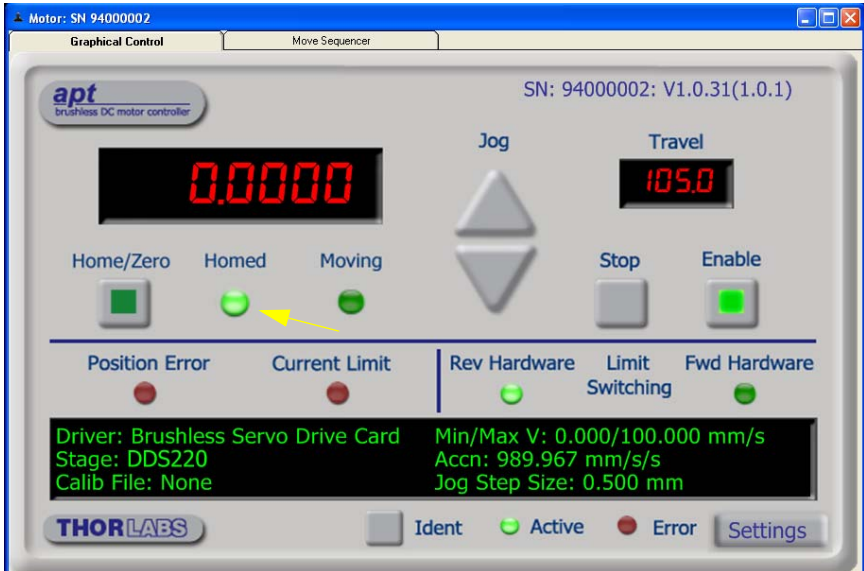
Fig. 4.2   Motor Controller Software GUI

1) Click the 'Home' button. Notice that the led in the button lights to indicate that homing is in progress.
2) When homing is complete, the 'Homed' LED is lit as shown above.

Note
If a move is demanded on a particular axis, before the axis has been 'Homed' then a Windows 'Event Information' panel is displayed, telling the user that the axis must be homed before operation.

4.4   Moving to an Absolute Position

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

1) Click the position display.
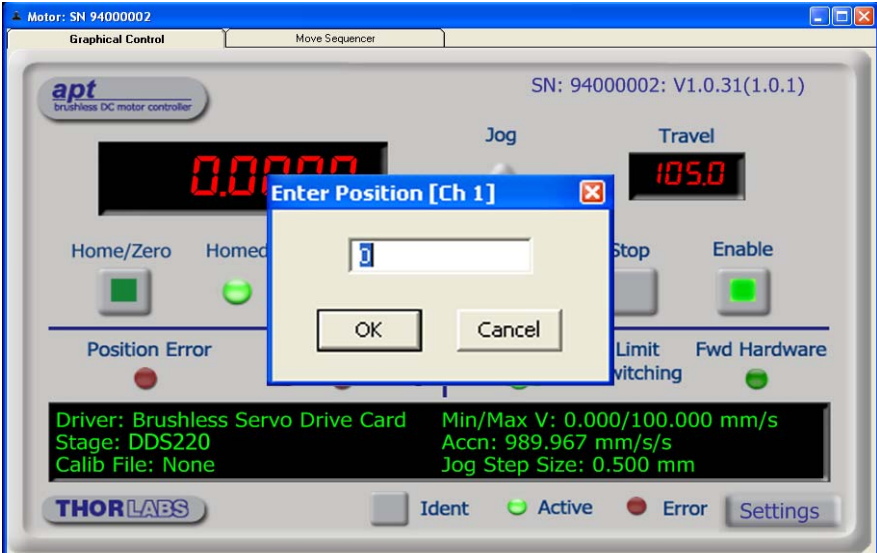
Fig. 4.3   Absolute Position Popup Window

2) Enter 3.0 into the pop up window
3) Click 'OK'. Notice that the position display counts up to 3.000 to indicate a move to the absolute position 3.00mm.

4.5   Stopping the Stage

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

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

4.6   Changing Motor Parameters

Note

Moves are performed using a Trapezoidal or S-Curve velocity profile (see Section 5.3.4.). 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.
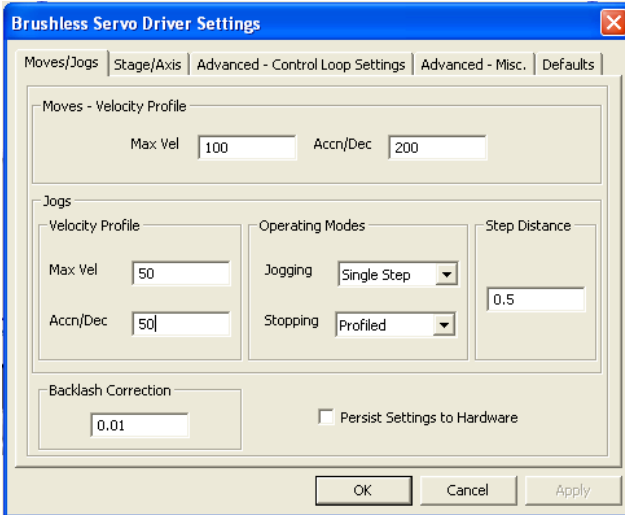
Fig. 4.4   Settings Panel - Move/Jogs Tab

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

3) In the 'Moves' field, change the parameters as follows:
   'Max. Vel' - '100'
   'Accn/Dec' - '200'

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 100 mm per second, with an acceleration of 200 mm/sec/sec.

4.7   Jogging

During PC operation, the motor actuators are jogged using the GUI panel arrow keys. There are two jogging modes available, 'Single Step' and 'Continuous'. In 'Single Step' mode, the motor moves by the step size specified in the Step Distance parameter each time the key is pressed. 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.
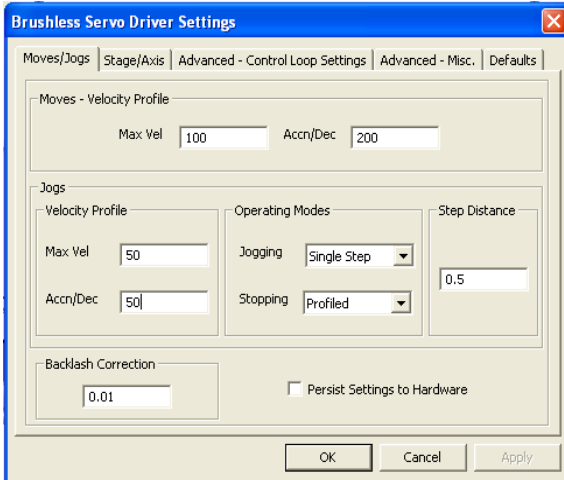
Fig. 4.5   Settings Panel - Move/Jogs Tab

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

3) In the 'Jogs' field, enter parameters as follows: (see Section 5.3.1. for details of these parameters).
   'Max. Vel' - '50'
   'Accn/Dec' - '50'

   Operating Modes
   'Jogging' - 'Single Step'
   'Stopping' - 'Profiled'

   'Step Distance' - '0.5'

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 0.5 mm every time the button is clicked.

4.8   Graphical Control Of Motor Positions (Point and Move)

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

To change the panel view to graph ical view, right click in the screen and select 'Graphical View'.
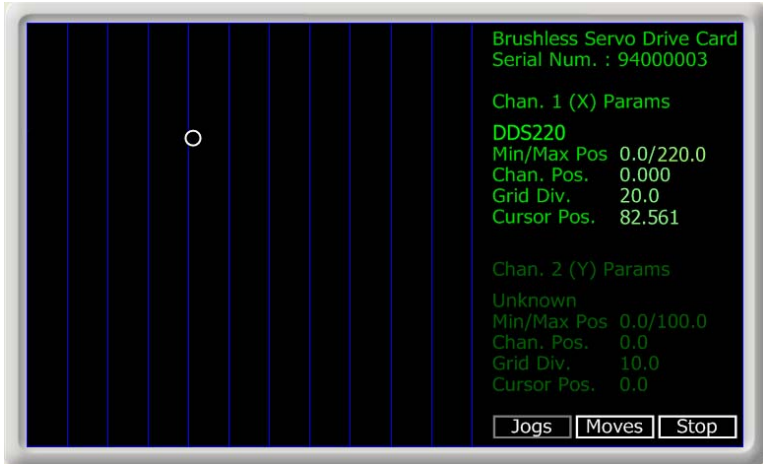
Fig. 4.6 DC Controller GUI Panel - Graphical View

Consider the display shown above for a DC Motor Drive Card.

The right hand display shows the channel and motor unit parameters; i.e. controller unit type and se rial number, associated stage and actuator type, min imum 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 BBD201 controller is accessed via a single channel GUI panel.

The left h and 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 stag e/actuator being driven by the controller. For example, the screen shot above shows the parameters for a DDS220 stage. The graph shows 11 divisions in the X axis, which rel ates to 220mm of total travel (20 mm per division).

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

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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'.

4.9   Setting Move Sequences

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

For details on moving to absolute positions initiated by a mouse click – see Section 4.12.

1) From the Motor GUI Panel, select 'Move Sequencer' tab to display the Move Sequencer window.
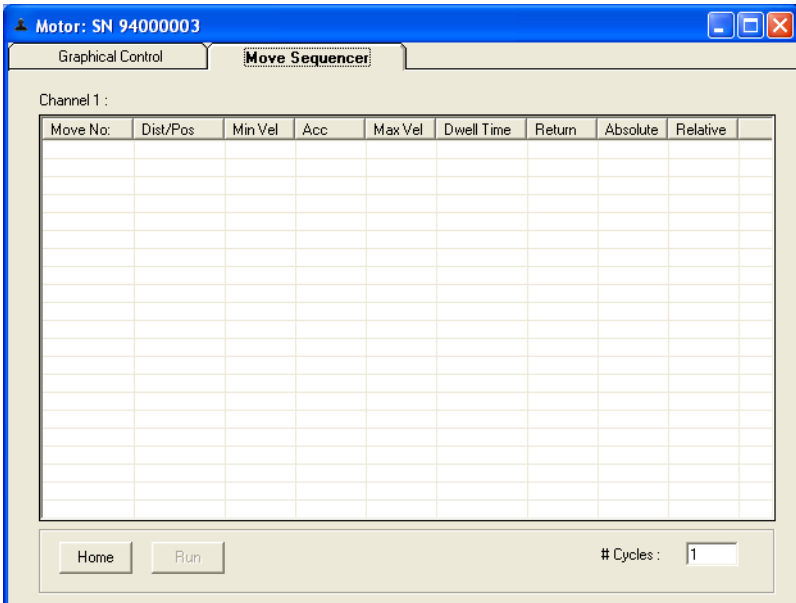
Fig. 4.7 Move Sequencer Window

2) Right click, in the move data field to display the pop up menu.
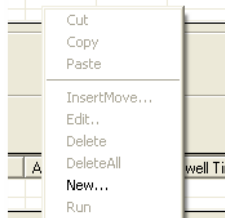
Fig. 4.8 Move Sequencer Pop Up Menu

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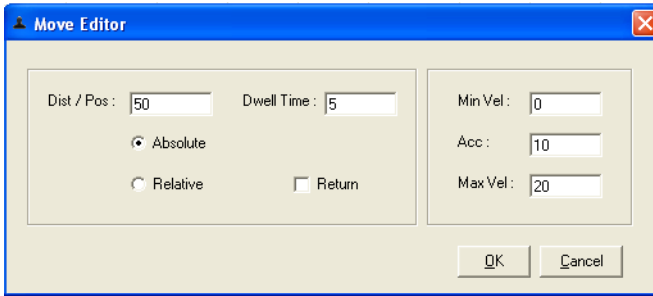
Fig. 4.9 Move Editor Window

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) (values entered in mm).

Dwell Time: - after the move is performed, th e 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 (velocity parameters are entered in mm/sec, acceleration in mm/sec/sec).

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.

4.10   Using A Joystick Console

The MJC001 joystick console has been designed for microscope users, to provide intuitive, tactile, manual positioning of the stage. The console features a two axis joystick for XY control. Up to 3 joysticks can be connected to each other, interfacing neatly into a multi-channel control application. Furthermore, if the parameter settings are persisted to the controller (see Section 5.3.) the controller need not be connected to a host PC, thereby allowing remote operation.

Note
The default parameter values loaded at the factory should be acceptable for most applications, and in this case, it is not necessary to connect the controller to a PC running the APT software. If these parameter values subsequently require adjustment, this can only be perfromed by running the APT software - see Section 3.1. and Section 5.3. for more information.

1) Connect the stage to the Controller unit.
2) Connect the joystick console to the HANDSET IN connector of the controller.
3) Switch ON the controller.
4) Wait until the red led on the joystick console and the Channel Enable LEDs on the controller front panel stop flashing (~3s). This indicates that phase initialisation is complete.
5) Press and hold the 'High/Low' button for 2 seconds to home the stage. When homing is complete, the green LED stops flashing.

In order to establish control over a particular axis, the joystick axes must be associated with the corresponding channels of the related controller. This is achieved by setting the joystick ID switch, located on the underside of the joystick console, and the channel ident switches on the rear panel of the BBD controller.

The joystick ID switch assigns the selected number to the X axis of the joystick and the next sequential number to the Y axis. The channel ident switches on the controller unit(s) must then be set to match these joystick axis numbers.

For example, if the joystick switch is set to '1', then the channel ID switch on the controller must also be set to '1' as shown in Fig. 4.1. If two single channels are being used, the Y-Axis controller unit must be set to '2'.

Fig. 4.1 ID switch settings

6) Set the joystick console ID switch and the controller channel ID switches as described in the preceding paragraph.


Caution

Do not set the switches to identical numbers as this may result in lack of joystick control. Also, do not set the channel ID switches to 'E' or 'F' as this is reserved for factory use and testing.

---

7) The stage can now be moved using the joystick, GUI panel, or by setting commands to move each axis by relative and absolute amounts – see the helpfile supplied with the APT server for more information.

4.11 External Triggering

External triggering is facilitated by the Trigger In and Trigger Out pins (pins 2 and 3) of the USER IO connector on the rear panel of the unit.
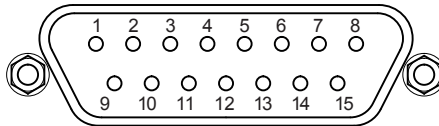
These connectors provide a 5V logic level input and output that can be configured to support triggering from and to external devices - see Section 5.3.4. Section A.4. for further details.

4.12 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.

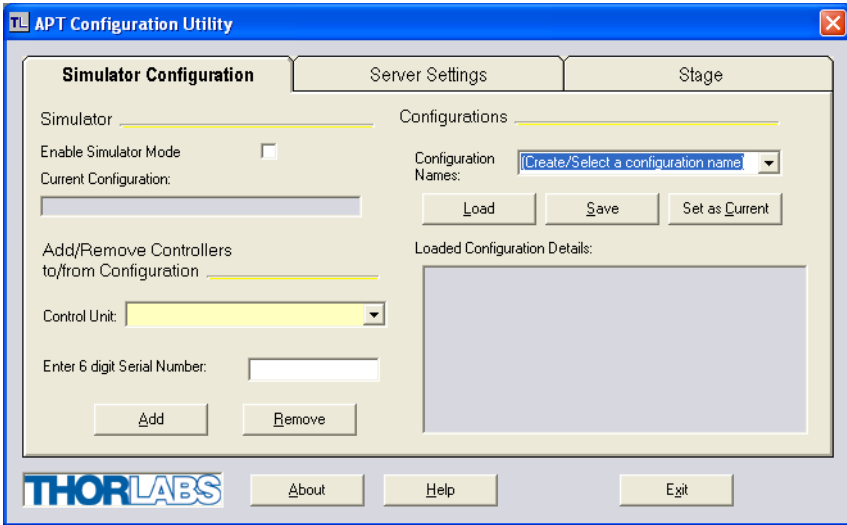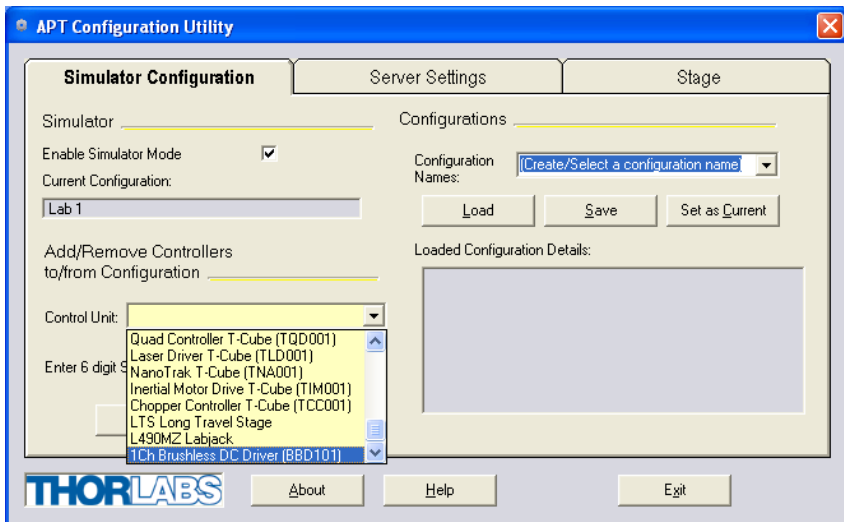2) Click the 'Simulator Configuration' tab.

Fig. 4.13 APT Configuration Utility - Simulator Configuration Tab

3) Enter a name (e.g. 'LAB1') in the Configuration Names field.

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

Note
Each physical APT hardware base 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.
During sub-item (5), the system recognises the BBD201 controller as a multi-channel unit (i.e. BBD103), fitted with only one driver card. The prefixed digits relating to the BBD103 stepper controller are:
73xxxxxx - 3 Channel Brushless DC Driver (BBD103)
Note. The '73' prefix described above is applicable only to the base units. The serial number of the individual driver cards is prefixed by '94' - see Section 5.2.

5) In the 'Control Unit' field, select '3 Ch Brushless DC Driver (BBD103)'.
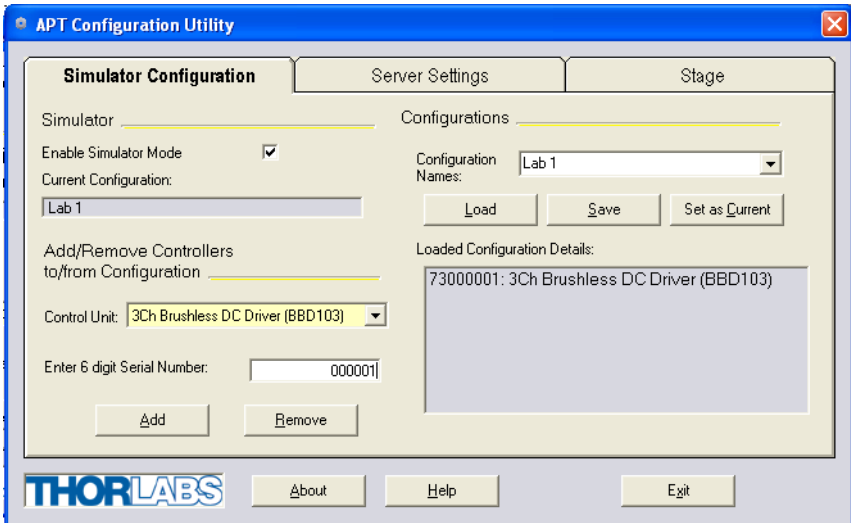
6) Enter a 6 digit serial number.
7) Click the 'Add' button.

8) Repeat items (1) to (7) to build the required system. (A unit can be removed from the configuration by selecting it in the 'Loaded Configuration Details' window and clicking the 'Remove' button or by right clicking it and selecting the 'Remove' option from the pop up window).

9) Enter a name into the 'Configuration Names' field.

10) Click 'Save'.

11) Click 'Set As Current' to use the configuration.

Chapter 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 E   .

5.2   GUI Panel

The following screen shot shows the graphical user interface (GUI) displayed when accessing the DC controller using the APTUser utility.
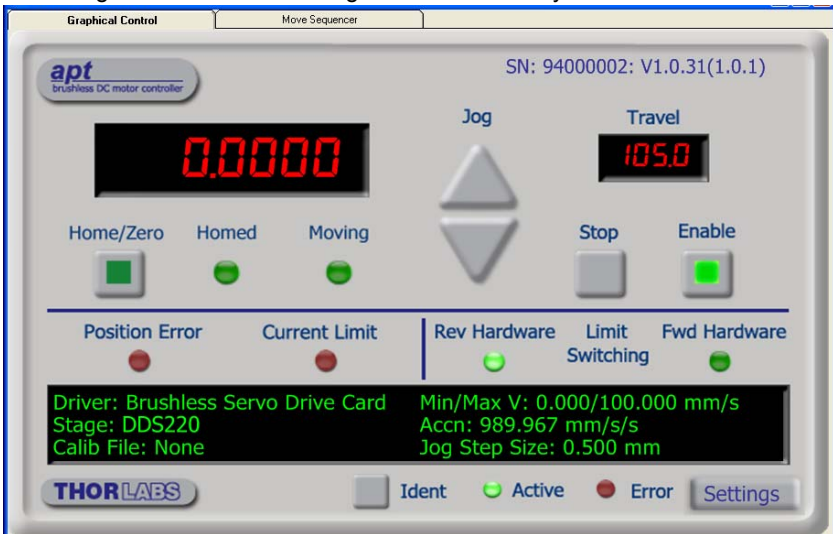
Fig. 5.1   Motor Controller Software GUI

Note
The serial number of the single channel driver cards is derived from the base unit serial number, with the '73' prefix being replaced with '94' and the subsequent 6 digit number incremented by '1' for each card in the system, e.g. a 1-channel BBD201 unit with a base serial number 73123456 will have card serial numbers 94123457.
The serial number of the driver 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 - the travel (in mm or degs) of the actuator associated with the GUI panel.

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/Zero - sends the motor to its 'Home' position - The LED in the button is lit while the motor is homing.

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

Moving - lit when the motor is in motion.

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

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

Position Error - lit when the associated axis has exceeded the position error limit setting - see Section 5.3.3.

Current Limit - lit when an 'current foldback' condition exists - Section 5.3.4.

Limit switches - the LEDs are lit when the associated limit switch has been activated.

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.

Note
The software automatically associates the stage/actuator type on bootup.

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

Note
Calibration files are not applicable for the Thorlabs Brushless DC motor stages such as the DDS220.

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.

Jog Step Size - the size of step (mm or degs) 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 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
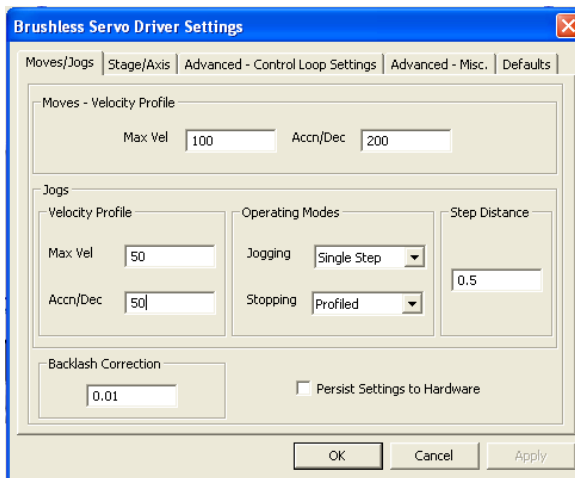
Fig. 5.2   Move/Jog Settings

Moves - Velocity Profile

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.

MaxVel - the maximum velocity (in mm/sec) 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 (in mm/sec^2).

Note
Under certain velocity parameter and move distance conditions, the maximum velocity may never be reached (i.e. the move comprises an acceleration and deceleration phase only).
The limits for the max velocity or acceleration parameters are dependent on the stage being driven. They can be obtained by calling the *GetVelParamLimits* method.
The move is also affected by the 'Profile' and 'Jerk' settings in the Advanced - Misc. tab.

Jogs

Jogs are initiated by using the 'Jog' buttons on the GUI panel (see Section 4.7.).

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

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

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

Note
The limits for the max velocity or acceleration parameters are dependent on the stage being driven. They can be obtained by calling the *GetVelParamLimits* method.

Operating Modes

Jogging - The way in which the motor moves when a jog command is received (i.e. 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, each time the jog key is pressed - see Fig. 5.3. In 'Continuous' mode, the

motor actuator will accelerate and move at the jog velocity while the button is held down..
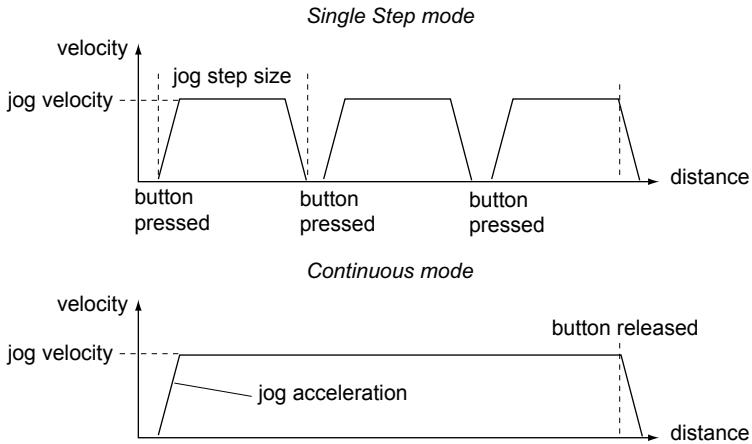

Fig. 5.3 Jog Modes

Single Step - the motor moves by the step size specified in the Step Distan ce 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 - th e motor stops in a profile d manner using the jog Velocity Profile parameters set above.

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

Backlash Correction - Backla sh is a te rm used to d escribe the errors inh erent in motors which use a leadscrew. Brushless linear DC motors that have no leadscrew and therefore this parameter is normally set to 0.

For motors which do incorporate a leadscrew,W en this parameter is set, the system will overshoot the demanded set point by the specified amount, and then reverse.

This ensures that durin g absolute or rel ative moves, the target position is alwa ys approached in a forward direction. The Backlash Correction Distance is specified in real world units (millimeters).

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

Note. Setting a negative value for backlash correction also results in zero correction.

Persist Settings to Hardware - Many of the parameters that can be set for the BBD201 series drivers can be stored (persisted) within the unit itself, such that when the unit is next powered up these settings are applied automatically. This is particularly important when the driver is being used manually via a joystick, in the absence of a PC and USB li nk. The *Move and Jog* parameters described previously are good examples of settings that can be altered and then persisted in the driver for later use.

To save the settings to hardware, check the 'Persist Settings to Hardware' checkbox before clicking the 'OK button.

5.3.2 Stage/Axis tab
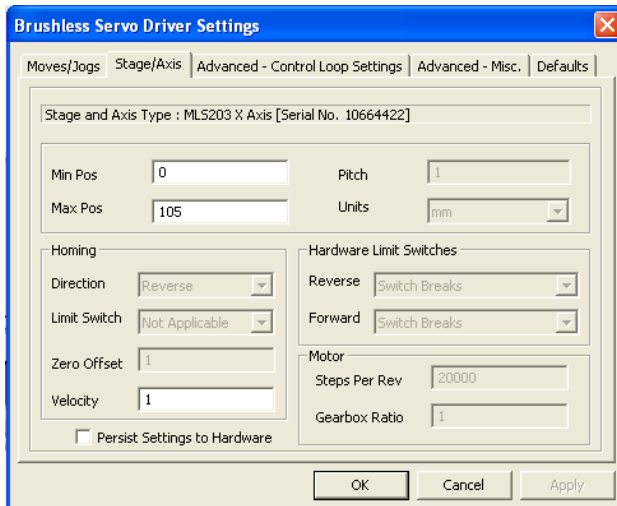
Fig. 5.4   Stage/Axis Settings

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 server will automatically apply suitable defaults for the parameters on this tab during boot up of the software. Most of these parameters cannot subsequently be altered as it may adversely affect the performance of the stage and they are greyed out. Description of these parameters is included for information only.

Stage and Axis Type - The stage type, serial number, and axis are displayed. This information should always be quoted when requesting technical support.

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.

Note

The *Min Pos* and *Max Pos* parameters can be used to restrict the working range of the stage to a particular area of interest.

Pitch - the pitch of the motor lead screw (i.e. the distance (in mm or degrees) travelled per revolution of the leadscrew). Not applicable to MLS203 and DDS220 stages and preset to '1'.

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

Note

For DDS220 and MLS203 users. **The Homing, Limit Switch and Motor parameters described on the next two pages are not applicable for the DDS220 and MLS203 stages because the stage does not use a limit switch as a reference point for homing. Instead, it uses a special reference marker pulse from the encoder. Homing on these stages involves a search for this reference marker. Initially, the stage moves in the forward direction and if the reference marker is found before the stage hits the forward limit switch, then homing is completed. If not, the stage reverses direction and continues to search for the reference marker. Due to the different method used, only the Homing Velocity parameter can be adjusted, although normally the default value is suitable for nearly all applications. All other parameters are greyed out.**

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.

Note

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

Hardware Limit Switches

The operation of the limit switches is inherent in the design of the associated stage or actuator. The following parameters notify the system to the action of the switches when contact is made. Select 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.
Not Applicable - Limit switches are not applicable.

Motor

These parameters are used to set the ' resolution' characteristics of the DC motor connected to the selected channel. The resolution of the motor, combined with other characteristics (such as ge arbox ratio) of the associated actuator or stag e, determines the overall resolution.

Steps Per Rev - The number of encoder counts per revolution of the DC servo motor (minimum '1', maximum '10,000').

For linear driven stages (e.g. DDS220) this parameter is set to '1' and cannot be adjusted.

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').

For linear driven stages with no gearbox (e.g. DDS220) this parameter is set to '1' and cannot be adjusted.

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 encoder counts.
The correct default values for Steps Per Rev and Gearbox Ratio are applied automatically when the software is booted up.

Persist Settings to Hardware - Many of the par ameters that can be set for the BBD201 series drivers can be stored (persisted) within the unit itself, such that when the unit is next powered up these settings are applied automatically. This is particularly important when the driver is being used manually via a joystick, in the absence of a PC and USB link. The *Min Pos, Max Pos, and Velocity* parameters described previously are good examples of settings that can be altered and then persisted in the driver for later use.

To save the settings to hardware, check the 'Persist Settings to Hardware' checkbox before clicking the 'OK button.
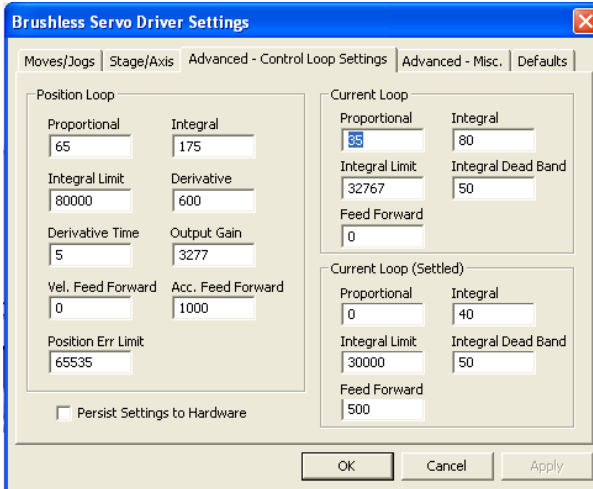
5.3.3   Advanced - Control Loop SettingsTab

Fig. 5.5 Advanced Control Loop Settings

Position Loop Control Settings

The motion processors within the BBD series controllers use a position control loop to determine the motor command output. The purpose of the position loop is to match the actual motor position and the demanded position. This is achieved by comparing the demanded position with the actual encoder position to create a position error, which is then passed through a digital PID-type filter. The filtered value is the motor command output.

Caution
The PID and other closed loop parameters must be set according to the stage or actuator type associated with the driver, the load being positioned and the speed/duty cycle of operation. Default values have already been optimized and stored within the stage, and these are loaded into the controller on power up. If problems are encountered (e.g. stability of the closed loop position control, lost motion or incomplete moves) the position PID parameters should be adjusted to tune the stage for the given application. Normally, only minor adjustment of the Proportional, Integral and Derivative parameters should be necessary, and some trial and error will be required before the ideal settings for a specific application are achieved. In cases where further adjustment of the control loop parameters is required, the following guidelines are provided in order to assist in the tuning process.

Proportional term - Increasing the proportional (Prop) term will increase the amount of effective torque used to correct a given position error. Typically this is used to minimise the amount of position error when an impulse event affects current target

position during motion. i.e. sticksion, vibration…etc .If the proportional term is too high this can lead to overshoot and general instability. If this is too low it can result in a sloppy response. It accepts values in the range 0 to 32767.

Integral term - Increasing the integral (Int) term minimises following error and final position error. If Integral is too high this will typically lead to motion overshoot during and at end of move. If the integral term is too low final position may take a long time to reach, if at all. It accepts values in the range 0 to 32767.

Integral limit - Limits the wind up limit for the integral term such that excessive overshoots are prevented. Typically used to prevent runaway integral calculations due to stiction and other such physical forms of random forces. Normally set as low as possible, but high enough that with the given integral term final position can be reached. It accepts values in the range 0 to 32767. If set to 0 then the integration term in the PID loop is ignored.

Derivative term - Increasing the derivative (Deriv) term decreases the rate of change of controller output. Typically this is used to reduce the overshoot from a given motion. If derivative is too high it can become sensitive to noise from the measured position error. If derivative is too low, velocity fluctuations may arise during motion. It accepts values in the range 0 to 32767.

Derivative Time – Time over which derivative is calculated. Under normal circumstances, the derivative term of the PID loop is recalculated at every servo cycle. However, it may be desirable to increase the sampling rate to a higher value, in order to increase stability. The *Derivative Time* parameter is used to set the sampling rate. For example if set to 10, the derivative term is calculated every 10 servo cycles. The value is set in cycles, in the range 1 to 32767 (1 cycle = 102.4 μs). Typically increasing the derivative time increases sensitivity to noise.

Output Gain – This parameter is a scaling factor applied to the output of the PID loop. It accepts values in the range 0 to 65535, where 0 is 0% and 65535 is 100%. Typically used to tighten a control loop for increased positional performance at the expense of stability.

Vel. Feed Forward and *Acc. Feed Forward* – These parameters are velocity and acceleration feed-forward terms that are added to the output of the PID filter to assist in tuning the motor drive signal. They accept values in the range 0 to 32767.

Position Err. Limit – Under certain circumstances, the actual encoder position may differ from the demanded position by an excessive amount. Such a large position error is often indicative of a potentially dangerous condition such as motor failure, encoder failure or excessive mechanical friction. To warn of, and guard against this condition, a maximum position error can be set in the *Position Err. Limit* parameter, in the range 0 to 65535. The actual position error is continuously compared against the limit entered, and if exceeded, the Motion Error bit (bit 15) of the Status Register is set, the associated axis is stopped and the GUI panel Position Error LED is lit.

Position PID Settings Summary

Stage overshoots the intended position - reduce Int and increase Deriv and Prop terms.

Stage doesn't attain final position - increase the Int and Prop terms.

Motion is unstable - reduce Prop and Int, increase Deriv.

Stage sounds noisy - reduce Deriv.

Current Loop Control Settings

The motion processors within the BBD series controllers use digital current control as a technique to control the current through each phase winding of the motors. In this way, response times are improved and motor efficiency is increased. This is achieved by comparing the required current with the actual current to create a current error, which is then passed through a digital PI-type filter. The filtered current value is used to develop an output voltage for each motor coil. The following parameters allow this signal to be tuned for a fast response and low error when moving to the demanded position.

Note
These parameters are specific to the motor within the stage. Default values are set at the factory and under normal circumstances do not need to be changed.

Proportional – This term drives the motor current to the demand value, reducing the current error. It accepts values in the range 0 to 32767.

Integral – This term provides the 'restoring force' that grows with time, ensuring that the current error is zero under a constant torque loading. It accepts values in the range 0 to 32767.

Integral Limit – This term is used to cap the value of the Integrator to prevent an excessive build up over time of the 'restoring force', thereby causing runaway of the integral sum at the output. It accepts values in the range 0 to 32767. If set to 0 then the integration term in the PI loop is ignored.

Note
The following two parameters assist in fine tuning the motor drive current and help reduce audible noise and/or oscillation when the stage is in motion. A certain amount of trial and error may be experienced in order to obtain the optimum settings.

Integral Dead Band – This parameter allows an integral dead band to be set, such that when the error is within this dead band, the integral action stops, and the move is completed using the proportional term only. It accept values in the range 0 to 32767.

Feed Forward – This parameter is a feed-forward term that is added to the output of the PI filter. It accept values in the range 0 to 32767.

Current Loop (Settled) Control Settings

The following parameters are designed to assist in maintaining stable operation and redusing noise at the demanded position. They allow the system to be tuned such that errors caused by external vibration and manual handling (e.g. loading of samples) are minimized, and are applicable only when the stage is settled, i.e. the Axis Settled status bit (bit 14) is set - see Section 5.3.4.

Proportional – This term drives the motor current to the demand value, reducing the current error. It accepts values in the range 0 to 32767.

Integral – This term provides the 'restoring force' that grows with time, ensuring that the current error is zero under a constant torque loading. It accepts values in the range 0 to 32767.

Integral Limit – This term is used to cap the value of the Integrator to prevent an excessive build up over time of the 'restoring force', thereby causing runaway of the integral sum at the output. It accepts values in the range 0 to 32767. If set to 0 then the integration term in the PI loop is ignored.

Note
The following two parameters assist in fine tuning the motor drive current and help reduce audible noise and/or oscillation when the stage is near the target position. A certain amount of trial and error may be experienced in order to obtain the optimum settings.

Integral Dead Band – This parameter allows an integral dead band to be set, such that when the error is within this dead band, the integral action stops, and the move is completed using the proportional term only. It accept values in the range 0 to 32767.

Feed Forward – This parameter is a feed-forward term that is added to the output of the PI filter. It accept values in the range 0 to 32767.

Persist Settings to Hardware - Many of the parameters that can be set for the BBD201 series drivers can be stored (persisted) within the unit itself, such that when the unit is next powered up these settings are applied automatically. This is particularly important when the driver is being used manually via a joystick, in the absence of a PC and USB link. The *Position and Current Loop* parameters described previously are good examples of settings that can be altered and then persisted in the driver for later use.

To save the settings to hardware, check the 'Persist Settings to Hardware' checkbox before clicking the 'OK button.
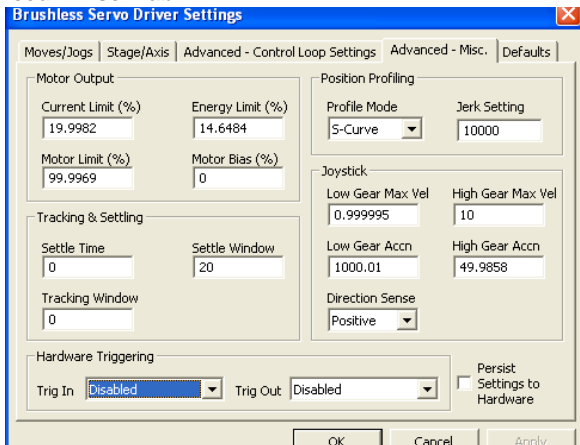
THORLABS

5.3.4   Advanced - Misc. Tab

Fig. 5.6 Advanced Miscellaneous Settings

Motor Output Settings

Caution
The default values programmed into the APT software will give acceptable performance in most cases. The following parameters are set according to the stage or actuator type associated with the driver and have already been optimized. Changing these parameters can result in control instability and possible damage. Use extreme caution if adjusting these parameters.

Current Limit – The system incorporates a cu rrent 'foldback' facility, whereby the continuous current level can be capped. The *Current Limit* parameter, accepts values as a percentage of maximum peak current, in the range 0% to 100%, which is the default maximum level set at the factory (this maximum value cannot be altered).

Energy Limit – When the current output of the drive exceeds the limit set in the *Current Limit* parameter, accumulation of the exc ess current energy begins. The *Energy Limit* parameter specifies a limit for this accumulated energy, as a percentage of the factory set default maximum, in the range 0% to 100%. When the accumulated energy exceeds the value specified in the *Energy Limit* parameter, a 'current foldback' condition is said to exist, and the comma nded current is limite d to the value spec ified in the *Current Limit* parameter. When this occurs, the Current Foldback status bit (bit 25) is set in the Status Register and the 'Current Limit' LED on the GUI panel is lit. When the acc umulated energy above the *Current Limit* value falls to 0, the limit is removed and the status bit is cleared.

Motor Limit – This parameter sets a limit for the motor drive signal and accepts values in the range 0 to 100% (32767). If the system produc es a value greater than the limit set, the motor command takes the limiting value. For example, if the *Motor Limit* is set to 30000 (91.6%), then signals greater than 30000 will be output as 30000 and values less than -30000 will be output as -30000.

Motor Bias – When an axis is subject to a constant external force in one direction (such as a vertical axis pulled downwards by gravity) the servo filter can compensate by adding a constant DC bias to the output. This bias is set in the *Motor Bias* parameter, which accepts values in the range -32768 to 32767. The default value is 0. Once set, the motor bias is applied while the position loop is enabled.

Tracking & Settling Settings

Moves are generated by an internal profile generator, and are based on either a trapezoidal or s-curve trajectory (see Section 5.3.3.). A move is considered complete when the profile generator has completed the calculated move and the axis has 'settled' at the demanded position.

The system incorporates a monitoring function, which continuously indicates whether or not the axis has 'settled'. The 'Settled' indicator is bit 14 in the Status Register and is set when the associated axis is settled. Note that the status bit is controlled by the processor, and cannot be set or cleared manually.

The axis is considered to be 'settled' when the following conditions are met:

- the axis is at rest (i.e. not performing a move),
- the error between the demanded position and the actual motor position is less than or equal to the specified number of encoder counts (0 to 65535) set in the *Settle Window* field,
- the above two conditions have been met for a specified number of cycles (1 cycle = 102.4 µs), set in the *Settle Time* field (range 0 to 32767).

The above settings are particularly important when performing a sequence of moves. If the PID parameters (see Section 5.3.3.) are set such that the settle window cannot be reached, the first move in the sequence will never complete, and the sequence will stall. The settle window and settle time values should be specified carefully, based on the required positional accuracy of the application. If positional accuracy is not a major concern, the settle time should be set to '0'. In this case, a move will complete when the motion calculated by the profile generator is completed, irrespective of the actual position attained, and the settle parameters described above will be ignored.

The processor also provides a 'tracking window' which is used to monitor servo performance outside the context of motion error. The tracking window is a programmable position error limit within which the axis must remain, but unlike the *Position Err Limit* parameter set in the *Advanced - Control Loop Settings* tab, the axis is not stopped if it moves outside the specified tracking window.

This function is useful for processes that rely on the motor's correct tracking of a set trajectory within a specific range. The tracking window may also be used as an early warning for performance problems that do not yet qualify as motion error.

The size of the tracking window (i.e. the maximum allowable position error while remaining within the tracking window) is specified in the *Tracking Window* field, in the range 0 to 65535. If the position error of the axis exceeds this value, the Tracking Indicator status bit (bit 13) is set to 0 in the Status Register. When the position error returns to within the window boundary, the status bit is set to 1.

Position Profiling

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

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

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

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

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

In a typical trapezoidal velocity profile, (see Fig. 5.7.), the sta ge 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.
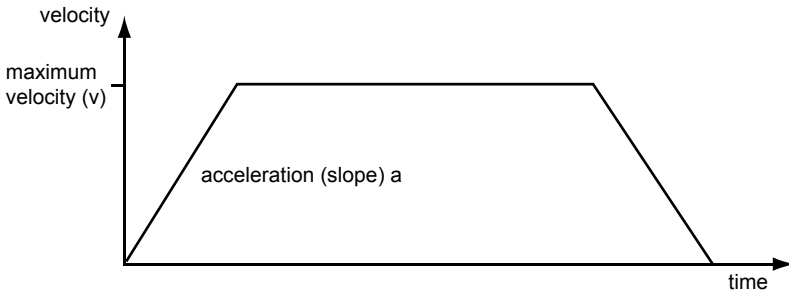
Fig. 5.7   Graph of a trapezoidal velocity profile

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

Jerk Setting – This parameter is specified in mm/s^3 and accepts values in the range 0 to 46566139. It is used to specify the maximum rate of change in acceleration in a single cycle of the basic trapezoidal curve.

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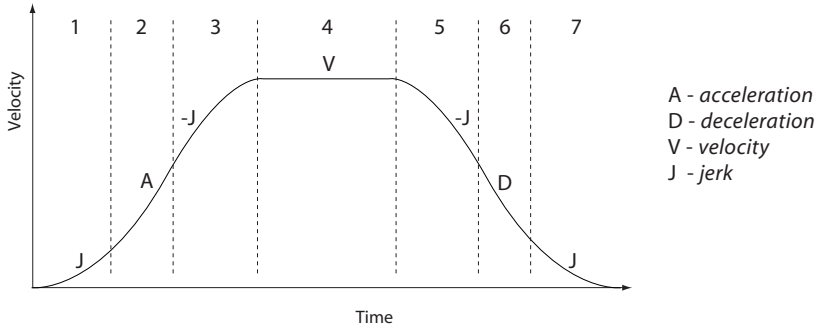

Fig. 5.8   Typical S-Curve Profile

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

Joystick

If the optional Thorlabs joystick console is being used (MJC001) the following parameters are used to set the velocity and acceleration limits and the direction sense of any moves initiated from the joystick.- see Section 4.10. for more details on joystick use.

Low Gear Max Vel – The max velocity of a move when low gear mode is selected.

High Gear Max Vel – The max velocity of a move when high gear mode is selected.

Low Gear Accn – The acceleration of a move when low gear mode is selected.

High Gear Accn – The acceleration of a move when high gear mode is selected.

Direction Sense – The actual direction sense of any joystick initiated moves is dependent upon the application. This parameter can be used to reverse the sense of direction for a particular application and is useful when matching joystick direction sense to actual stage direction sense.

Note
Joystick controlled moves always use a trapezoidal velocity profile.

Persist Settings to Hardware - Many of the parameters that can be set for the BBD201 series drivers can be stored (persisted) within the unit itself, such that when the unit is next powered up these settings are applied automatically. This is particularly important when the driver is being used manually via a joystick, in the absence of a PC and USB link. The *Motor Output, Position Profiling Tracking & Settling, and Joystick* parameters described previously are good examples of settings that can be altered and then persisted in the driver for later use.

To save the settings to hardware, check the 'Persist Settings to Hardware' checkbox before clicking the 'OK button.

Triggering

External triggering is facilitated by the Trigger In and Trigger Out pins (pins 2 and 3) of the USER IO connector on the rear panel of the unit - see Section A.4.

These connectors allow the connection of external TTL compatible signals to initiate moves (Trigger In) and generate a hardware signal when certain motion related conditions are met (Trigger Out). They provide a 5V logic level input and output that can be configured to support triggering from and to external devices.

It is possible to configure a particular controller to respond to trigger inputs, generate trigger outputs or both simultaneously. For those units configured for both input and output triggering, a move can be initiated via a trigger input while at the same time, a trigger output can be generated to initiate a move on another unit.

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

Trigger In

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

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

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

Trigger In options are set as follows:

Disabled – triggering operation is disabled

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

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

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

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

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

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

Trigger Out

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

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

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

Trigger Out options are set as follows:

Disabled – triggering operation is disabled

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

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

Move Complete (Trig HI)

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

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

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

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

5.4   Troubleshooting and Restoring Default Parameters

⚠️ **Caution** ⚠️

The PID and other closed loop parameters must be set according to the stage or actuator type associated with the driver, the load being positioned and the speed/duty cycle of operation. Default values have already been optimized and stored within the stage, and these are loaded into the controller on power up.

If problems are encountered (e.g. stability of the closed loop position control, lost motion or incomplete moves) the position PID parameters should be adjusted to tune the stage for the given application. Normally, only minor adjustment of the Proportional, Integral and Derivative parameters should be necessary, and some trial and error will be required before the ideal settings for a specific application are achieved. In cases where further adjustment of the control loop parameters is required, the following guidelines are provided in order to assist in the tuning process.

Position PID Settings Summary

Stage overshoots the intended position - reduce the integral term, and increase the derivative and proportional terms.

Stage fails to attain final position - increase the integral and proportional terms.

Motion is unstable - reduce the proportional and integral terms, in crease the derivative term.

Stage sounds noisy - reduce the derivative term.

See Section 5.3.3. for further information.

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

To restore the default values:

1) Select the 'Defaults' tab.
2) Click the 'Reset Parameter Defaults in the Controller' check box,
3) Click OK.
4) The controller must then be power cycled before the default values can take effect
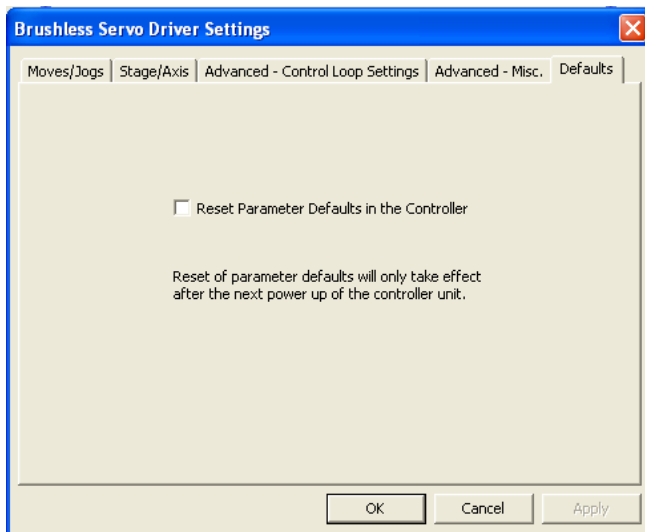

Fig. 5.9   Defaults tab

Changing the parameters under the "Advanced" tabs can cause the motor to become unstable or uncontrollable. If these settings are persisted, the unit may not be able to phase initialise the axis correctly the next time it powers up and, as a result, APT will not display some or any of the panels. If this occurs, the unit can be set to a special mode where the persisted settin gs are ignored and the default (safe) operating parameters are loaded after power-up.

To enter this mode, power down the unit and set the rear panel 'CH1 ID' switch to 'D'. When the unit is powered up, it will load the default set of operating parameters for all channels. In this mode parameters can still be persisted but they will not be loaded on start-up as long as the "CH1 ID" switch is set to ' D'. Moving the switch back to its normal position will re-enable the operating parameters that were last persisted.

Appendix A   Rear Panel Connector Pinout Details

A.1   Rear Panel MOTOR DRIVE Connectors

The 'MOTOR DRIVE' connector is a female, round, 8-pin DIN type and provides drive connection to the motors. The pin functions are detailed in Fig. A.1..
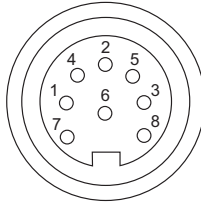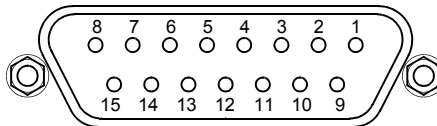

Pin	Description	Pin	Description
1	Motor Phase V	5	Stage ID
2	GND	6	GND
3	Temp Sensor (Not Used)	7	Motor Phase W
4	Motor Phase U	8	Enable

Fig. A.1 MOTOR DRIVE **connector pin identification**

A.2   Rear Panel FEEDBACK Connector

The 'FEEDBACK' connector is a female, 15 pin D-Type and supplies connection for the motor encoder feedback lines.

Pin	Description	Pin	Description
1	Not Connected	9	GND
2	GND	10	Limit Switch +
3	Not Connected	11	Limit Switch -
4	Index -	12	Index +
5	QB -	13	QB +
6	QA -	14	QA +
7	* 5 V	15	Not Connected
8	* 5 V		

* Pins 7 and 8 are short circuit internally

Fig. A.2 FEEDBACK connector pin identification

A.3 Rear Panel USER IO Connector

The 'USER I/O' connector is a male, 15 pin D-Type that exposes a number of electrical signals useful for monitoring purposes or fault diagnosis.
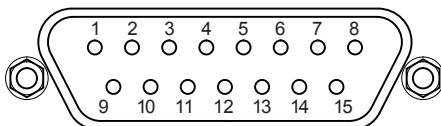
Pin	Description	Pin	Description
1	5V	9	(iii) QA+
2	(i) Trigger In	10	(iii) QA-
3	(ii) Trigger Out	11	(iii) QB+
4	Ground	12	(iii) QB-
5	Ground	13	(iv) Index/Ref+
6	For Future Use	14	(iv) Index/Ref-
7	For Future Use	15	Ground
8	For Future Use		

Notes.

(i)   Or general purpose digital input - see Section A.3.2.

(ii) Or general purpose digital output (open collector) - see Section A.3.1.

(iii) Buffered versions of Encoder Quadrature signal for monitoring purposes

(iv) Encoder index (or reference) signal for monitoring purposes

Fig. A.3 USER I/O connector pin identification

A.3.1   Trigger Out (Digital Output)

The digital output (AxisOut) is driven by the non-inverting output of an AM26C31 line driver, with a 100R resistor between the output of the line driver and the connector pin. The output voltage levels are compatible with most logic families (approx. 4V for logic High and 0V for logic Low unloaded).
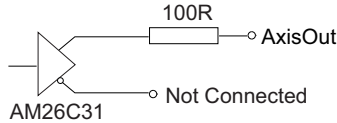

Fig. A.4 Digital Output Schematic

Please see the APTServer helpfile for details on software calls used to control these logic IO.

A.3.2   Trigger In (Digital Input)

The digital input (AxisIn) circuit accepts signals in the range 0 to 10 V and has TTL compatible, Schmidt trigger thresholds. It has a pull up to 5V to allow direct interfacing to open collector souces without the need for an external pull up resistor and a 16 kHz R-C low pass filter to reject noise.
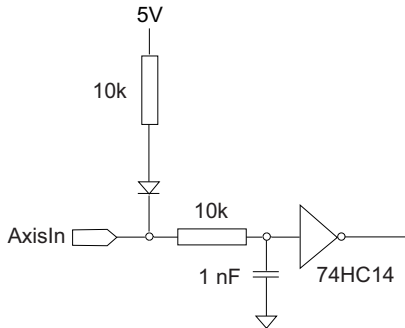

Fig. A.5 Digital Input Schematic

A.3.3   Differential Outputs

All differential outputs (QA, QB and IX/Ref) are driven by an AM26C31 line driver, with a 100 Ohm resistor between the output of the line driver and the connector pin. When the stage is being controlled by a joystick, in the absence of a PC, these outputs could be connected to an oscill oscope or custome circuit to fa cilitate monitoring of the position output.
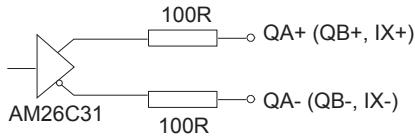

Fig. A.6 Differential Output Schematic

A.3.4   +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.4 Rear Panel AUX I/O Connector

A.4.1 Pin Identification

The AUX I/O connector is a female, 15 pin D-Type 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.7 .
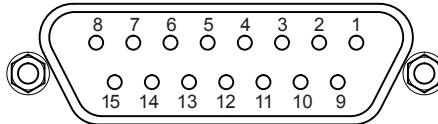
Pin	Description	Return	Pin	Description	Return
1	Digital O/P 1	5, 9, 10	9	Digital Ground	
2	Digital O/P 2	5, 9, 10	10	Digital Ground	
3	Digital O/P 3	5, 9, 10	11	For Future Use	5, 9, 10
4	Digital O/P 4	5, 9, 10	12	For Future Use	5, 9, 10
5	Digital Ground		13	Digital I/P 4	5, 9, 10
6	Digital I/P 1	5, 9, 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.4.2. to Section A.4.4. In addition to the damage that may occur to the controller there is a risk of serious injury and fire hazard.

Fig. A.7 AUX IO Connector Pin Identification

A.4.2   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.
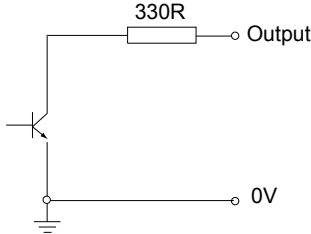

Fig. A.8 Digital Output Schematic

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.
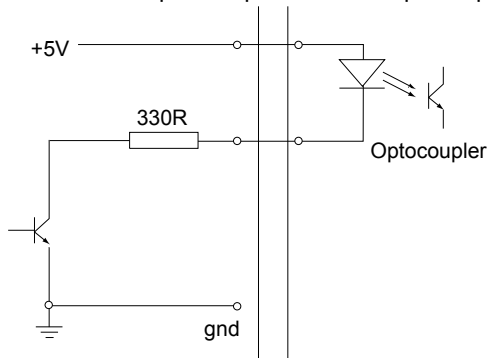
Fig. A.9 Application Example: Connection to Optocoupler Inputs

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 APTServer helpfile for details on software calls used to control these logic IO.

A.4.3 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.
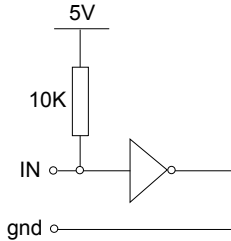
Fig. A.10 Digital Input Schematic (protection circuitry not shown)

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 APTServer helpfile for details on software calls used 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 outputs may occur.	

A.4.4 +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.5   Rear Panel HANDSET Connector

A.5.1   Pin Identification

The HANDSET connector is a female, 6 pin mini- DIN connector that exposes internal electrical signals for use with the external remote control handset (MJC001).

The pin functions are detailed in in Fig. A.11 .
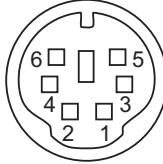
Pin	Description
1	RX (controller input)
2	Ground
3	Ground
4	Supply Voltage for Handset 5V
5	TX (controller output)
6	Ground

Note

Pins 2, 3 and 6 are common (connected) ground connections.

Pin 4 is for use only with Thorlabs joystick MJC001. It should not be used to power any other device.

Fig. A.11 HANDSET Connector Pin Identification

A.6   Rear Panel INTERCONNECT Connector (RS232)

A.6.1   Pin Identification

The INTERCONNECT terminal is a male, 9 pin D-Type that exposes electrical signals for use in RS232 communications. This allows control of the device using the low level communications protocol, or other software environments such as micromanager. A 9-way D-type female to female crossover (null modem) cable is required for connecting to the host PC.

The pin functions are detailed in Fig. A.11 .
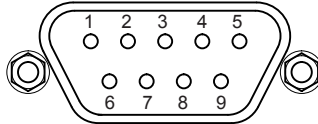
Pin	Description
1	Not Connected
2	RX (controller input)
3	TX (controller output)
4	Not Connected
5	Ground
6	Not Connected
7	Not Connected
8	Not Connected
9	Not Connected

Fig. A.12 INTERCONNECT Connector Pin Identification

Appendix B   Using the RS232 or Virtual Comm Port

When using the low level communications   protocol messages to develop client applications outside of the APT software, communication with the device is facilitated by using the RS232 comms pins on the rear panel INTERCONNECT connector - see Section A.6. Alternatively, a virtual comms port can be configured as follows:

1) Open the device manager by selecting Start/Control Panel/Device Manager/
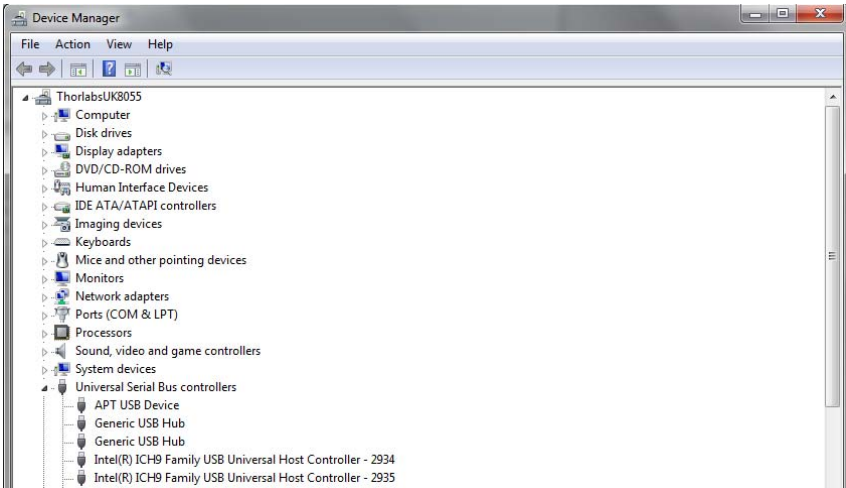
2) Click 'USB Seria l Bus Controll ers' and sel ect the APT   USB Device to be configured, then right click and select 'Properties'.
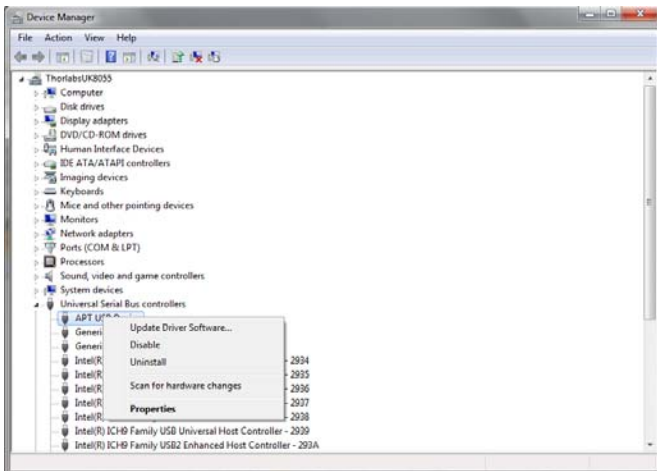
3) The 'USB Device Properties' window is displayed.
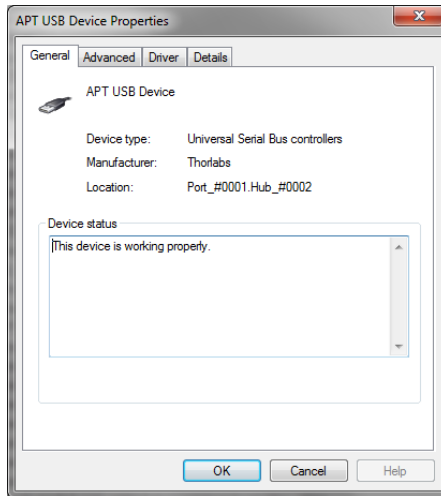
4) Select the 'Advanced' tab, and check the 'Load VCP' box.
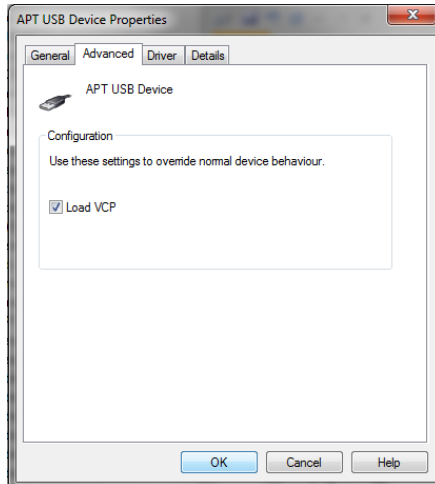
5) Click OK, then power cycle the device being configured.

6) In the device manager, click 'Ports (COM & LPT)', and note the 'APT USB Device Serial Port' COM port number (e.g. COM3).
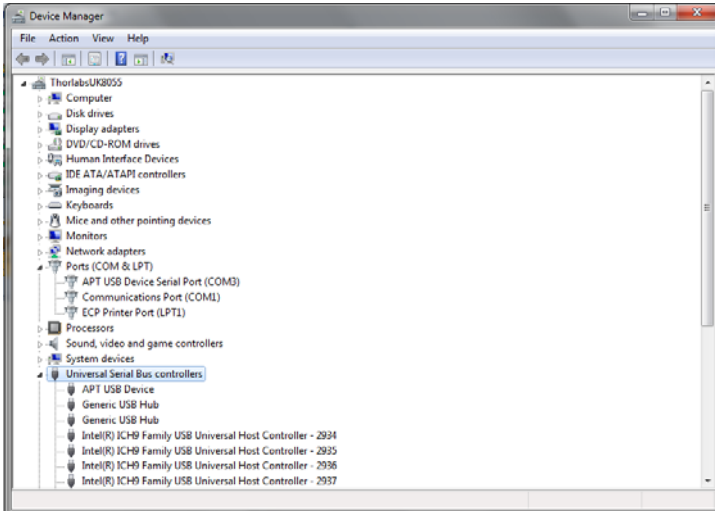
This COM port can then be used by the client application to communicate with the device using the low level protocol messages.

Appendix C   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.	

C.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. Repeated application of 'flash' test may damaage the insulation.	

C.2   Fuses

Two T 3.15A/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; 20mm	Live feed
F2	T 3.15A	ceramic; antisurge; 20mm	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.

C.3   Cleaning

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

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

Appendix D   Specifications and Associated Parts

D.1   Specifications

Drive Connector: 8-Pin DIN, Round, Female

(Motor Phase Outputs, Stage ID Input)

FEEDBACK Connector: 15-Pin D-Type

Brushless Continuous Output: 2.5A

PWM Frequency: 40 kHz

Operating Modes: Position, Velocity

Control Algorithm: 16-bit Digital PID Servo Loop with Velocity and Acceleration Feedforward

Velocity Profile: Trapezoidal/S-Curve

Position Count: 32 Bit

Position Feedback: Incremental Encoder

Encoder Bandwidth: 2.5 MHz/ 10 M Counts/sec

Encoder Supply: 5V

AUX Control Connector: 15-Pin D-Type Female

(User Digital IO, 5 V O/P)

Input Power Requirements:

• Volts: 100 to 240V AC

• Power: 250 VA

• Frequency: 47 to 63 Hz

• Fuse: 3.15A

General

• Dimensions: 174 x 245 x 126 mm (6.85" x 9.65" x 4.96")

• Weight: 3.46 kg (7.6 lbs)

Compatible Motors

• 3-Phase DC Brushless Motors

• Peak Powers: 100W

• Coil Resistance: 0.1 to 100Ω

• Coil Inductance (Nominal): 1 to 100mH

• Rated Phase Currents (Nominal): 100mA to 5A

Appendix E   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 serial number of the single channel driver cards is derived from the base unit serial number, with the '73' prefix being replaced with '94' and the subsequent 6 digit number incremented by '1' for each card in the system, e.g. a 2-channel unit with a base serial number 73123456 will have card serial numbers 94123457 and 94123458.

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

Methods

DeleteParamSet	Deletes stored settings for specific controller.
DisableHWChannel	Disables the drive output.
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.
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.
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 j ogging maximum velocity parameter (returned by value).
GetMotorParams	Gets the motor gearing parameters.
GetParentHWInfo ;	Gets the identification information of the host controller.
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 contro ller status bits encoded in 32 bit integer (returned by value).
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 mo ve 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 bi ts 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 m ove with specified positions for encoder equipped stages.
MoveAbsoluteEx	Initiates an absoloute move with specified positions.
MoveAbsoluteRot	Initiates an absolute m ove 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.
SetDispMode	Sets the GUI display mode.
SetHomeParams	Sets the homing sequence parameters.
SetJogMode	Sets the jogging button operating modes.
SetJogStepSize	Sets the jogging step size.
SetJogVelParams	Sets the jogging velocity profile parameters.
SetPositionOffset	Sets the motor position offset.
SetRelMoveDist	Sets the relative move distance.
SetStageAxisInfo	Sets the stage axis parameters.
SetVelParams	Sets the velocity profile parameters.
ShowSettingsDlg	Display the GUI Settings panel.
StartCtrl	Starts the ActiveX Cont rol (starts communication with controller)

StopCtrl	Stops the ActiveX Control (stops co mmunication with controller)
StopImmediate	Stops a motor move immediately.
StopProfiled	Stops a mo tor move in a p rofiled (decelleration) manner.
GetDCCurrentLoopParams	Gets the Current servo loop PID parameter settings applied when the unit is moving
GetDCPositionLoopParams	Gets the Position servo loop PID parameter settings
GetDCMotorOutputParams	Gets the limits that are a pplied to the motor dri ve signal
GetDCTrackSettleParams	Gets the settings for the Track and Settle windows
GetDCProfileModeParams	Gets the settings for the profile mode
GetDCJoystickParams	Gets the settings for the joystick max velocity and acceleration
GetDCSettledCurrentLoopParams	
	Gets the Current servo loop PID parameter settings applied when the unit is 'settled'.
SetDCCurrentLoopParams	Sets the Current servo loop PID parame ter values applied when the unit is moving
SetDCPositionLoopParams	Sets the Position servo loop PID parameter values
SetDCMotorOutputParams	Sets the limits that are ap plied to the motor dri ve signal
SetDCTrackSettleParams	Sets the pa rameters for the Tra ck and Settle windows
SetDCProfileModeParams	Sets the parameters for the profile mode
SetDCJoystickParams	Sets the values for the joys tick max velocity and acceleration
SetDCSettledCurrentLoopParams	
	Sets the Current servo loop PID parameter settings applied when the unit is 'settled'.

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 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 2004/108/EC 'EMC Directive' and 2006/95/EC 'Low Voltage Directive'.

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

Safety   EN61010-1: 2010 Safety requirements for electrical equipment for measurement, control and laboratory use.

EMC   EN61326-1: 2006 Electrical equipment for measurement, control and laboratory use - EMC requirements.

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.

6.3   CE Certificate

THORLABS

EU Declaration of Conformity

in accordance with EN ISO 17050-1:2010

We   Thorlabs Ltd

Of   1 Saint Thomas Place, Ely, Cambridgeshire, CB7 4EX

in accordance with the following Directive(s):

2006/95/EC	Low Voltage (LVD)
2004/108/EC	Electromagnetic Compatibility (EMC)
2011/65/EU	Restriction of use of certain hazardous substances (RoHS)

hereby declare that:

Equipment   Single Channel Brushless DC Motor Controller

Model Number   BBD201

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

EN61010 -1	Safety requirements for electrical equipment for measurement, control and laboratory use.	2010
EN61326-1	Electrical Equipment for measurement, control and laboratory use - EMC requirements	2006

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

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

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

Signed:

Keith Dhese

Name: Keith Dhese

Position: General Manager

On: 21 August 2013

CE 13

EDC - 2013-09-02 - Sin -BBD201

THORLABS

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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