TBD001
T-Cube Brushless DC Servo Driver

User Guide
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Continued...
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.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>!</td>
<td>Shock Warning</td>
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<tr>
<td>!</td>
<td>Given when there is a risk of injury from electrical shock.</td>
</tr>
<tr>
<td>!</td>
<td>Warning</td>
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<tr>
<td>!</td>
<td>Given when there is a risk of injury to users.</td>
</tr>
<tr>
<td>!</td>
<td>Caution</td>
</tr>
<tr>
<td>!</td>
<td>Given when there is a risk of damage to the product.</td>
</tr>
<tr>
<td>!</td>
<td>Note</td>
</tr>
<tr>
<td>!</td>
<td>Clarification of an instruction or additional information.</td>
</tr>
</tbody>
</table>

1.2  General Warnings

**Warnings**

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

Spillage of fluid, such as sample solutions, should be avoided. If spillage does occur, clean up immediately using absorbant tissue. Do not allow spilled fluid to enter the internal mechanism.

**Caution**

If your PC becomes unresponsive (e.g. due to an operating system problem, entering a sleep state condition, or screen saver operation) for a prolonged period, this will interrupt communication between the APT Software and the hardware, and a communications error may be generated. To minimize the possibility of this happening it is strongly recommended that any such modes that result in prolonged unresponsiveness be disabled before the APT software is run. Please consult your system administrator or contact Thorlabs technical support for more details.
Chapter 2  Overview and Setup

2.1  Introduction

The TBD001 Brushless DC Motor T-Cubes 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 DDSM100 fast translation stage where speeds of up to 500 mm/sec can be achieved. 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 Amp peak coil current.

Integrated into the apt family of products, it offers Thorlabs standard control and programming interface, allowing easy integration into the customer’s own automated motion control applications. These units are capable 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) are added.
Operation of the TBD001 brushless DC motor unit is fully configurable (parameterized) with key settings (e.g. PID settings, min and max position values, and joystick response) 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 the response of the key pad joystick can be adjusted for speed or precision. Moreover, relative and absolute moves can be initiated with move profiles set using velocity profile parameters. Similarly, home sequences have a full set of associated parameters that can be adjusted for a particular stage or actuator. For simplicity of operation, the apt™ software incorporates pre-configured settings for each of the Thorlabs stages and actuators, while still exposing all parameters individually for use with other 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 next position can be initiated by clicking directly on the position display and entering a new value (see the tutorial in Chapter 5 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 5) provides a good initial understanding on using the unit, and the reference sections (Chapter 6) 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 TBD001 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 function libraries for custom application development.

The APT software suite supplied with all APT controllers, including the TBD001 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 develop any further custom software. Both utilities are built on top of a sophisticated, multi-threaded ActiveX ‘engine’ (called the APT server) which provides all of the necessary APT system software services such as generation of GUI panels, communications handling for multiple USB units, and logging of all system activity to assist in hardware trouble shooting. It is this APT server ‘engine’ that is used by software developers to allow the creation of advanced automated positioning applications very rapidly and with great ease. The APT server is described in more detail in Section 2.2.4.

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

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

Caution
On start up, wait until the top panel POWER led is lit bright green and the ENABLE led stops flashing, before running the APT software.
2.2.2 APTUser Utility

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

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

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

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

Caution

On start up, wait until the top panel POWER led is lit bright green and the ENABLE led stops flashing, before running the APT software.
2.2.3 APT Config Utility

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

If a TBD001 controller is used with the DDSM100 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 supply both a graphical user interface and a programmable interface. Many such Controls are available for Windows applications development, providing a large range of re-usable functionality. For example, there are Controls available that can be used to manipulate image files, connect to the internet or simply provide user interface components such as buttons and list boxes.

With the APT system, ActiveX Controls are deployed to allow direct control over (and also reflect the status of) the range of electronic controller units, including the TBD001 DC motor controllers. Software applications that use ActiveX Controls are often referred to as 'client applications'. Based on ActiveX interfacing technology, an
Chapter 2

ActiveX Control is a language independent software component. Consequently ActiveX Controls can be incorporated into a wide range of software development environments for use by client application developers. Development environments supported include Visual Basic, Labview, Visual C++, C++ Builder, HPVEE, Matlab, VB.NET, C#.NET and, via VBA, Microsoft Office applications such as Excel and Word.

Consider the ActiveX Control supplied for the TBD001 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 and motor operations to be automated by a client application. The instrument panel reflects the current operating state of the controller unit to which it is associated (e.g. such as motor position). Updates to the panel take place automatically when a user (client) application is making software calls into the same Control. For example, if a client application instructs the associated 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).

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

2.2.5 Software Upgrades
Thorlabs operate a policy of continuous product development and may issue software upgrades as necessary.
Detailed instructions on installing upgrades are included on the APT Software CD ROM.
Chapter 3  Getting Started

3.1 Installing APT Software

**Caution**
If your PC becomes unresponsive (e.g. due to an operating system problem, entering a sleep state condition, or screen saver operation) for a prolonged period, this will interrupt communication between the APT Software and the hardware, and a communications error may be generated. To minimize the possibility of this happening it is strongly recommended that any such modes that result in prolonged unresponsiveness be disabled before the APT software is run. Please consult your system administrator or contact Thorlabs technical support for more details.

**Caution**
Some PCs may have been configured to restrict the users ability to load software, and on these systems the software may not install/run. If you are in any doubt about your rights to install/run software, please consult your system administrator before attempting to install. If you experience any problems when installing software, contact Thorlabs on +44 (0)1353 654440 and ask for Technical Support.

3.2 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.
3.3 Mechanical Installation

3.3.1 Environmental Conditions

**Warning**

Operation outside the following environmental limits may adversely affect operator safety.

- **Location**: Indoor use only
- **Maximum altitude**: 2000 m
- **Temperature range**: 5°C to 40°C
- **Maximum Humidity**: Less than 80% RH (non-condensing) at 31°C

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

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

3.3.2 Mounting Options

The T-Cube Brushless DC Servo Driver is shipped with a baseplate fitted, ready to be bolted to a breadboard, optical table or similar surface.

If desired, the baseplate can be removed and the unit can be stood on rubber feet - see Section 3.3.3.

For multiple cube systems, a USB controller hub (TCH002) is available - see Section 3.4.2. for further details. Full instructions on the fitting and use of the controller hub are contained in handbook **ha0146 T-Cube Controller Hub**, shipped with the product.

**Caution**

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

Ensure that proper airflow is maintained to the rear of the unit.
3.3.3 Removing the Baseplate

The baseplate must be removed before the rubber feet (supplied) can be fitted, or the unit is connected to the USB controller hub.

Using a hexagon key, remove the bolts securing the unit to the baseplate. Retain the bolts for future use if the baseplate is refitted.

1) Invert the unit.
2) Remove the backing paper from the rubber feet (supplied) taking care not to touch the exposed adhesive surface.
3) Position the feet as desired, then press and hold for a few seconds until the adhesive has bonded.
4) The unit may now be used freestanding, sitting on its rubber feet.
3.4 Electrical Installation

3.4.1 Connecting a Motor

The unit is supplied with a female 15 pin D-type connector as shown above, which is compatible with the DDSM100 brushless DC driven translation stage (refer to Appendix A for details of pin outs).

3.4.2 Using The TCH002 Controller Hub

The TCH002 USB Controller Hub provides power distribution for up to six T-Cubes, and requires only a single power connection (from a separate supply unit TPS006 supplied by Thorlabs). Further details are contained in handbook ha0146T, T-Cube Controller Hub, supplied with the unit.

**Warning**

DO NOT PLUG A POWERED UP T-CUBE INTO THE TCH002 USB CONTROLLER HUB. Always ensure that all power is disconnected from the Brushless DC Driver T-Cube AND the hub before the T-Cube is plugged into the hub. Failure to observe this precaution will seriously damage the T-Cube unit and could result in personal injury.
3.4.3 Connecting To A Standalone Power Supply

![Front Panel Power Supply Connector](image)

1) Perform the mechanical installation as detailed in Section 3.3.
2) Using the front panel connector as shown above, connect the unit to a regulated DC power supply of 15 V, 2A.

Thorlabs offers a compact, multi-way power supply unit (TPS008), allowing up to eight Driver T-Cubes to be powered from a single mains outlet. A single way wall plug supply (TPS003) for powering a single Driver T-Cube is also available.

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**Shock Warning**

The unit must be connected only to a DC supply of 15V, 2A regulated. Connection to a supply of a different rating may cause damage to the unit and could result in injury to the operator.

3) Install the APT Software.

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**Caution**

During items (3) to (6) the instructions should be followed strictly in the order stated. Problems may occur if the process is not performed in the correct sequence.

4) Connect the Controller unit to your PC.

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

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**Caution**

During item (4) ensure the power supply unit is isolated from the mains before connecting to the T-Cube unit. Always power up the T-Cube unit by connecting its power supply to the mains. DO NOT connect the T-Cube unit to a 'live' external power supply. Doing so (i.e. “hot plugging”) carries the risk of PERMANENT damage to the unit. Similarly, to power down the unit, disconnect the power supply from the mains before disconnecting the T-Cube unit.
5) Connect the DC servo motor actuator to the Controller unit - see Section 3.4.1.
6) Connect the Controller unit to the power supply - see Section 3.4.3.
7) Connect the PSU to the main supply and switch ‘ON’.
   Windows™ should detect the new hardware. Wait while Windows™ installs the
   drivers for the new hardware - see the Getting Started guide for more information
8) Wait until the Enable LED stop flashing (~3s). This indicates that phase
   initialisation is complete.

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<th>Note</th>
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<tr>
<td>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.</td>
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Press and hold the ENABLE button for 3 secs to home the stage.
The ‘Active LED flashes while the motor is homing. The homing move is complete, when the LED stops flashing and is extinguished...

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<th>Note</th>
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<tbody>
<tr>
<td>If any problems are encountered during the connection and power up process, power cycle the unit, which should clear the error.</td>
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</table>
Chapter 4  Standalone Operation

4.1 Introduction

The Brushless DC Driver T-Cube has been designed specifically to operate with the range of Thorlabs Brushless DC motorised opto-mechanical products. The unit offers a fully featured motion control capability including velocity profile settings, limit switch handling, homing sequences and, for more advanced operation, adjustment of PID settings, allowing support for many different actuator configurations. These parameters can be set via the APT Server software - see Chapter 5. Furthermore, many of these parameters are automatically set to allow “out of the box” operation with no further “tuning” required.

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

4.2 Control Panel Buttons and Indicators

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

VELOCITY Joystick - Used to drive the motor at a varying speed in either forward or reverse directions for full and easy motor control - see Section 4.3.

HIGH/LOW - Used to control the gain (responsiveness) of the VELOCITY joystick. When set to HIGH, the HIGH LED is lit - see Section 4.3. for more details.

ENABLE - Used to connect and disconnect the drive power to the motor. The LED is lit when the drive power is enabled. When the motor is disabled (ENABLE led not lit), it is possible to move the motor manually. In this mode the feedback mechanism is inactive and will not attempt to maintain motor position.
Active LED - The Active LED flashes when the Ident button is pressed in the GUI panel. It can also be lit when the motor is moving. - see Section 6.3.3. for further details.

POWER LED - Lit when power is applied to the unit.

4.3 Joystick Operation

The VELOCITY joystick is a sprung potentiometer, such that when released it returns to its central position. In this central position the motor is stationary. As the slider is moved away from the centre, the motor begins to move. Bidirectional control of the motor is possible by moving the slider in both directions. The speed of the motor increases by discrete amounts as a function of slider deflection.

The gain of the velocity control can be switched between HIGH and LOW by pressing the associated button. When HIGH is selected, the LED is lit.

These speed settings are entered in real world units (mm or degrees) in the ‘Joystick’ parameter in the ‘Advanced’ settings tab - see Section 6.3.3.

4.4 Homing

A ‘Home’ move is performed to establish a datum from which subsequent absolute position moves can be measured (see Section 5.4. for further information).

To initiate a ‘Home’ move, press and hold the ENABLE button for 3 seconds.

The ‘Active LED flashes while the motor is homing. The homing move is complete, when the LED stops flashing and is extinguished.

4.4.1 External Triggering

External triggering is facilitated by the ‘TRIG IN’ and ‘TRIG OUT’ connectors on the front panel of the unit as shown above. These connectors provide a 5V logic level input and output that can be configured to support triggering from and to external devices.
4.4.2 Trigger In

The TRIG IN input contains a pull up resistor to an internal +5V supply, allowing it to be operated by passive devices (e.g. a switch or relay contact) as well as standard logic outputs. The protection circuit also allows the external signal to be in the ±10 V voltage range.

The input logic threshold levels are compatible with most TTL and CMOS logic circuits (input <0.8V is low and >2.4 V is high). Do not exceed the maximum voltage range of -10V to 10V.

4.4.3 Trigger Out

The TRIG OUT output is the output of a standard 5V CMOS logic gate in series with a 470 Ω resistor. The resistor provides protection against accidentally short circuiting to ground by limiting the current to approx 10 mA maximum.

Do not connect the output to any voltage level outside the 0 to 5V range. It is recommended that the output is only used to drive external devices or equipment that has a high input resistance (>10 kΩ).
Chapter 5  PC Operation - Tutorial

5.1 Introduction

The following brief tutorial guides the user through a typical series of moves and parameter adjustments performed using the PC based APT software. It assumes that the unit is electrically connected as shown in Section 3.4.1. that the APT Software is already installed - see Section 3.1. and that the stage being driven is the Thorlabs DDSM100 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 600 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 TBD001 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 TBD001 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 TBD 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.
Chapter 5

5.2 Verifying Software Operation

5.2.1 Initial Setup

The APT Software should be installed (Section 3.1.) and the power up procedure performed (Section 3.4.) before software operation can be verified.

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

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

3) Click the 'Home/Zero button on the GUI panel and check that the motor or axis connected to the controller moves. See Section 5.4. for further details on homing.

Follow the tutorial steps described in Chapter 5 for further verification of operation.

Note

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

Any number of 'virtual' control units are combined to build a model of the real system, which can then be used to test the application software offline.

If using real hardware, ensure that Simulator Mode is disabled. If using a simulated setup, enable Simulator Mode and set up a 'Simulated Configuration' - see Section 5.12. or the APTConfig helpfile for detailed instructions.
5.3 Using the APT User Utility

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

Fig. 5.2 Typical APT User Screen

1) Run the APT User program - Start/All Programs/Thorlabs/APT User/APT User.
Chapter 5

5.4 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 DDSM series stages use an electronic reference marker and therefore the limit switches are not used for reference.

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.
5.5 Moving to an Absolute Position

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

1) Click the position display.

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 3.00 mm.
5.6 Changing Motor Parameters

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

2) Select the Move/Jogs tab as shown in Fig. 5.5.

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 will now be performed at a maximum velocity of 100 mm per second, with an acceleration of 200 mm/sec/sec.
5.7 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. 5.6 Settings Panel - Move/Jogs Tab](image)

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

3) In the ‘Jogs’ field, enter parameters as follows: (see Section 6.3.1. for details of these parameters).
   - ‘Max. Vel’ - ‘50’
   - ‘Accn/Dec’ - ‘50’

**Operating Modes**

- ‘Jogging’ - ‘Single Step’
- ‘Stopping’ - ‘Profiled’

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.
5.8 Graphical Control Of Motor Positions (Point and Move)

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

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

Consider the display shown above for a TBD001 Motor Driver.

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

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

The vertical divisions relate to the travel of the stage/actuator being driven by the controller. For example, the screen shot above shows the parameters for a DDSM100 stage. The graph shows 10 divisions in the X axis, which relates to 100 mm of total travel (10 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.

---

**Note**

The channel functionality of the TBD001 controller is accessed via a single channel GUI panel, so the settings for channel 2 are greyed out.
Move Mode
When ‘Move’ is selected, the motors move to an absolute position which corresponds to the position of the cursor within the screen.
To specify a move:
1) Position the mouse within the window. For reference, the absolute motor position values associated with the mouse position is displayed in the ‘Cursor Position field.
2) Click the left hand mouse button to initiate the move.

Jog Mode
When ‘Jogging’ mode is selected, the motors are jogged each time the left mouse button is clicked.
The Jog direction corresponds to the position of the cursor relative to the circle (current motor position), e.g. if the cursor is to the left of the circle the motor will jog left. The Jog Step size is that selected in the Settings panel - see Section 6.3.

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

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

5.9 Loading Parameter Settings
Normally, when the APTServer is run up, the default settings for the system (e.g. move velocity, phase currents etc) are loaded. These values have been chosen to be suitable for the majority of applications. However, for applications where these settings need to be changed, the values can be saved to a ‘Settings Group’, which can be uploaded on subsequent start up. This is achieved via the APTUser utility, please see Section 5.11. for more details.
5.10 Setting Move Sequences

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

For details on moving to absolute positions initiated by a mouse click – see Section 5.8.

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

Fig. 5.8 Move Sequencer Window

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

Fig. 5.9 Move Sequencer Pop Up Menu
3) Select ‘New’ to display the ‘Move Editor’ panel.

![Fig. 5.10 Move Editor Window](image)

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

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

**Min Vel: Acc: and Max Vel:** - the velocity profile parameters for the move (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. 5.11 Main Window with Move Data](image)

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

![Fig. 5.12 Pop Up Options](image)

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

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

![Fig. 5.13 Home and Run Buttons](image)

8) To save data to a file, or load data from a previously saved file, click the ‘Save’ or ‘Load’ button and browse to the required location.
5.11 Creating/Loading a Settings File

5.11.1 Introduction
APTUser can be used either to control the physical hardware connected via the USB bus, or to interact with a simulated hardware configuration set up using the APTConfig utility (see Section 5.12.). Normally, when the APTServer is run up, the default settings (e.g. move velocity, phase currents etc) for the system are loaded and these values have been chosen to provide safe performance in the majority of applications. However, for applications where these settings need to be changed, the values can be saved to a ‘Settings Group’, which can then be uploaded on subsequent start up. When saving, only those settings applicable to the graphical panels displayed will be saved. For example, if two motor panels are displayed, then the settings for both panels will be saved together in a single set with a single name. Settings are saved by association with the serial numbers of the hardware units connected.

A brief tutorial follows, but for complete details, please see the help file supplied with the APTUser utility.

5.11.2 Creating a New Settings Group
1) From the ‘View’ menu, select ‘Graphical Panels’, then select a unit type as required.

2) Choose a serial number (or series of serial numbers) from the list displayed.

3) Click ‘OK’. The GUI panel(s) for the selected unit is added to the display.
4) Repeat items (1) to (3) as necessary until all required APT unit GUI panels are displayed.

5) Adjust the settings as necessary, using the ‘Settings’ button on each GUI panel.

6) From the ‘File’ menu, select ‘Save’.

Any previously saved settings are listed in the main display.
To save the current settings under a new name, enter a file name into the upper display area and click ‘Save’.
To save the settings under an existing name, select a filename from the main display, then click ‘Save’.
5.11.3 Automatically Loading a Settings Group on Start Up

1) From the ‘Tools’ menu, select ‘Options’. The Options window is displayed.

2) Select the ‘Automatically load settings on Startup’ box, then click ‘OK’.
3) On boot up, the system will now load the most recently used settings group.

**Warning**
Settings should only be loaded automatically when the same hardware set up is being used for prolonged periods of time. The 'Automatically load settings on Startup' box must be unchecked before the system configuration can be changed, e.g. to drive a different stage/actuator. This is particularly important when the system has previously been used in simulator mode, or when the phase powers have been adjusted - see Section 6.3.3. for more details.

5.12 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.

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.
In the 'Control Unit' field, select '1 Ch Brushless Drive T-Cube (TBD001)'.

Enter a 6 digit serial number.

Click the 'Add' button.

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).

Enter a name into the 'Configuration Names' field.

Click 'Save'.

Click 'Set As Current' to use the configuration.

**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.

The Prefixed digits for the TBD001 Brushless DC Motor T-Cube are 67xxxxxx.
Chapter 6  Software Reference

6.1  Introduction

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

6.2  GUI Panel

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

![Motor Controller Software GUI](image)

**Fig. 6.1  Motor Controller Software GUI**

**Note**

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

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

- **Travel** - the travel (in mm or degs) of the actuator associated with the GUI panel.
**Digital display** - shows the position of the stage in millimetres (or degrees in the case of a rotation stage). 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).

**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** - halts the movement of the motor.

**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 6.3.3.

**Current Limit** - lit when an 'current foldback' condition exists - Section 6.3.4.

**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 DDSM100.

**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 6.3.).

**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 6.3.) 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 6.3.

**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.
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6.3 Settings Panel

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

6.3.1 Moves/Jogs tab

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 5.5.) 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).
Jogs are initiated by using the ‘Jog’ buttons on the GUI panel (see Section 5.7.).

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.

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

**Single Step mode**

**Continuous mode**

**Fig. 6.3 Jog Modes**

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

*Continuous* - the motor continues to move until the jog signal is removed (i.e. jog button is released).
**Brushless DC Servo Driver T-Cube**

**Stopping** - the way in which the jog motion stops when the demand is removed.
- **Immediate** - the motor stops quickly, in a non-profiled manner
- **Profiled** - the motor stops in a profiled manner using the jog Velocity Profile parameters set above.

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

**Backlash Correction** - Backlash is a term used to describe the errors inherent in motors which use a leadscrew. Brushless linear DC motors have no leadscrew and therefore this parameter is normally set to 0.

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

This ensures that during absolute or relative moves, the target position is always approached in a forward direction. The Backlash Correction Distance is specified in real world units (millimeters).

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

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 TBD001 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 the top panel, in the absence of a PC and USB link. 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.'
6.3.2 Stage/Axis tab

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

**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.

**Caution**
Extreme care must be taken when modifying the stage related settings that follow. Some settings are self consistent with respect to each other, and illegal combinations of settings can result in incorrect operation of the physical motor/stage combination being driven. Consult Thorlabs for advice on settings for stage/actuator types that are not selectable via the APTConfig utility.

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

*Max Pos* - the stage/actuator maximum position.
Pitch - the pitch of the motor lead screw (i.e. the distance (in mm or degrees) travelled per revolution of the leadscrew). Not applicable to DDSM100 stages and preset to ‘1’.

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

Note

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

Note

For DDSM100 users. The Homing, Limit Switch and Motor parameters described on the next two pages are not applicable for the DDSM100 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.
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Hardware Limit Switches

These parameters are inherent in the design of the associated stage or actuator. Default values are loaded on boot up and are not adjustable. The parameters notify the system to the action of the switches when contact is made, i.e. Rev Switch or Fwd Switch as required.

- **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 gearbox ratio) of the associated actuator or stage, 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 stages (e.g. DDSM100) 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. DDSM100) 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 parameters that can be set for the TBD001 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.'
6.3.3 Advanced - Control Loop Settings Tab

Fig. 6.5 Advanced Control Loop Settings

Position Loop Control Settings
The motion processors within the TBD001 controller uses 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.

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. sticktion, vibration…etc. If the proportional term is too high...
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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.

<table>
<thead>
<tr>
<th>Note</th>
</tr>
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<tbody>
<tr>
<td>The position error limit is monitored only when the motor is enabled (i.e. the feedback loop is active).</td>
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</table>

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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 processor within the TBD controller uses 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.
- **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 accepts 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 accepts values in the range 0 to 32767.

**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 accepts 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 accepts values in the range 0 to 32767.
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Current Loop (Settled) Control Settings

The following parameters are designed to assist in maintaining stable operation and reducing 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 6.3.4.

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.

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 TBD001 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.

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.
6.3.4 Advanced - Misc. Tab

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 current ‘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 excess 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 commanded current is limited to the value specified 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 accumulated 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 produces 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.
Chapter 6

**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 6.3.3.). 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 6.3.3.) 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 - see the APTServer helpfile for details on accessing the status register.

**Position Profiling**

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

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

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

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

![Fig. 6.7 Graph of a trapezoidal velocity profile](image)

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.

**Example**

![Fig. 6.8 Typical S-Curve Profile](image)

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**

When the unit is operated by the top panel VELOCITY joystick, 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 6.3.3. 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.

**Persist Settings to Hardware** - Many of the parameters that can be set for the TBD001 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**

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

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

**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 relevant 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

---

**Note**

Joystick controlled moves always use a trapezoidal velocity profile.
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)** – 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).

6.4 Troubleshooting and Restoring Default Parameters

<table>
<thead>
<tr>
<th>Caution</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

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, increase the derivative term.

*Stage sounds noisy* - reduce the derivative term.

See Section 6.3.3. 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. 6.9  Defaults tab
Appendix A  Rear Panel Connector Pinout Details

A.1 Rear Panel MOTOR Connectors

The 'MOTOR DRIVE' connector is a female, 15-pin D-Type and provides drive connection to the motors. The pin functions are detailed in Fig. A.1.

![MOTOR DRIVE connector pin identification](image)

<table>
<thead>
<tr>
<th>Pin</th>
<th>Description</th>
<th>Pin</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Quadrature A-</td>
<td>9</td>
<td>GND</td>
</tr>
<tr>
<td>2</td>
<td>Quadrature A+</td>
<td>10</td>
<td>Motor Phase C</td>
</tr>
<tr>
<td>3</td>
<td>Quadrature B+</td>
<td>11</td>
<td>Motor Phase A</td>
</tr>
<tr>
<td>4</td>
<td>Quadrature B-</td>
<td>12</td>
<td>Motor Phase B</td>
</tr>
<tr>
<td>5</td>
<td>Encoder Index I-</td>
<td>13</td>
<td>+5 V</td>
</tr>
<tr>
<td>6</td>
<td>Encoder Index I+</td>
<td>14</td>
<td>GND</td>
</tr>
<tr>
<td>7</td>
<td>Negative Limit</td>
<td>15</td>
<td>Stage ID</td>
</tr>
<tr>
<td>8</td>
<td>Positive Limit</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes

- Quadrature X+/-: Differential quadrature pulses of the encoder
- Encoder Index I -/+: The differential Index pulse used for homing
- Limit -/+: Positive and negative limit switch signals
- Stage ID: Unique Thorlabs communication interface signal used to identify the stage connected.

*Fig. A.1 MOTOR DRIVE connector pin identification*
Appendix B    Preventive Maintenance

B.1 Safety Testing

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

B.2 Cleaning

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

Shock Warning

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

Warning

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

### C.1 Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drive Connector</strong></td>
<td>15-Pin D-Type, Female (Motor Phase Outputs, Stage ID Input)</td>
</tr>
<tr>
<td><strong>Peak Current Output</strong></td>
<td>2A</td>
</tr>
<tr>
<td><strong>PWM Frequency</strong></td>
<td>40 kHz</td>
</tr>
<tr>
<td><strong>Operating Modes</strong></td>
<td>Position, Velocity</td>
</tr>
<tr>
<td><strong>Control Algorithm</strong></td>
<td>16-bit Digital PID Servo Loop with Velocity and Acceleration Feedforward</td>
</tr>
<tr>
<td><strong>Velocity Profile</strong></td>
<td>Trapezoidal/S-Curve</td>
</tr>
<tr>
<td><strong>Position Count</strong></td>
<td>32 Bit</td>
</tr>
<tr>
<td><strong>Position Feedback</strong></td>
<td>Incremental Encoder</td>
</tr>
<tr>
<td><strong>Encoder Bandwidth</strong></td>
<td>2.5 MHz/10 M Counts/sec</td>
</tr>
<tr>
<td><strong>Encoder Supply</strong></td>
<td>5V</td>
</tr>
<tr>
<td><strong>Input Power Requirements</strong></td>
<td>Voltage: 14.5 - 15.5 V Regulated DC</td>
</tr>
<tr>
<td></td>
<td>Current: 2A Peak</td>
</tr>
<tr>
<td><strong>General</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Housing Dimensions (W x D x H)</strong></td>
<td>60 x 60 x 47 mm (2.4&quot; x 2.4&quot; x 1.8&quot;)</td>
</tr>
<tr>
<td><strong>Instrument Weight</strong></td>
<td>160 g (5.5 oz)</td>
</tr>
<tr>
<td><strong>Compatible Motors</strong></td>
<td>• 3-Phase DC Brushless Motors</td>
</tr>
<tr>
<td><strong>Rated Phase Currents (Nominal)</strong></td>
<td>100mA to 2A</td>
</tr>
</tbody>
</table>
Appendix D  Motor Control Method Summary

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

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

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

**Methods**

**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** Gets the jogging button operating mode (returned by value).
<table>
<thead>
<tr>
<th>Function Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GetJogMode_StopMode</td>
<td>Gets the jogging button stopping mode (returned by value).</td>
</tr>
<tr>
<td>GetJogStepSize</td>
<td>Gets the jogging step size.</td>
</tr>
<tr>
<td>GetJogStepSize_StepSize</td>
<td>Gets the jogging step size (returned by value).</td>
</tr>
<tr>
<td>GetJogVelParams</td>
<td>Gets the jogging velocity profile parameters.</td>
</tr>
<tr>
<td>GetJogVelParams_Accn</td>
<td>Gets the jogging acceleration parameter (returned by value).</td>
</tr>
<tr>
<td>GetJogVelParams_MaxVel</td>
<td>Gets the jogging maximum velocity parameter (returned by value).</td>
</tr>
<tr>
<td>GetMotorParams</td>
<td>Gets the motor gearing parameters.</td>
</tr>
<tr>
<td>GetParentHWInfo ;</td>
<td>Gets the identification information of the host controller.</td>
</tr>
<tr>
<td>GetPosition</td>
<td>Gets the current motor position.</td>
</tr>
<tr>
<td>GetPosition_Position</td>
<td>Gets the current motor position (returned by value).</td>
</tr>
<tr>
<td>GetPositionEx</td>
<td>Gets the current motor position.</td>
</tr>
<tr>
<td>GetPositionEx_UncalibPosition</td>
<td>Gets the current uncalibrated motor position (returned by value).</td>
</tr>
<tr>
<td>GetPositionOffset</td>
<td>Gets the motor position offset.</td>
</tr>
<tr>
<td>GetRelMoveDist</td>
<td>Gets the relative move distance.</td>
</tr>
<tr>
<td>GetRelMoveDist_RelDist</td>
<td>Gets the relative move distance (returned by reference).</td>
</tr>
<tr>
<td>GetStageAxis</td>
<td>Gets the stage type information associated with the motor under control.</td>
</tr>
<tr>
<td>GetStageAxisInfo</td>
<td>Gets the stage axis parameters.</td>
</tr>
<tr>
<td>GetStageAxisInfo_MaxPos</td>
<td>Gets the stage maximum position (returned by value).</td>
</tr>
<tr>
<td>GetStageAxisInfo_MinPos</td>
<td>Gets the stage minimum position (returned by value).</td>
</tr>
<tr>
<td>GetStatusBits_Bits</td>
<td>Gets the controller status bits encoded in 32 bit integer (returned by value).</td>
</tr>
<tr>
<td>GetVelParamLimits</td>
<td>Gets the maximum velocity profile parameter limits.</td>
</tr>
<tr>
<td>GetVelParams</td>
<td>Gets the velocity profile parameters.</td>
</tr>
<tr>
<td>GetVelParams_Accn</td>
<td>Gets the move acceleration (returned by value).</td>
</tr>
<tr>
<td>GetVelParams_MaxVel</td>
<td>Gets the move maximum velocity (returned by value).</td>
</tr>
<tr>
<td>Identify</td>
<td>Identifies the controller by flashing unit LEDs.</td>
</tr>
<tr>
<td>LLGetDigIPs</td>
<td>Gets digital input states encoded in 32 bit integer.</td>
</tr>
</tbody>
</table>
### Appendix D

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LLGetStatusBits</td>
<td>Gets the controller status bits encoded in 32 bit integer.</td>
</tr>
<tr>
<td>LLSetGetDigOPs</td>
<td>Sets or Gets the user digital output bits encoded in 32 bit integer.</td>
</tr>
<tr>
<td>LoadParamSet</td>
<td>Loads stored settings for specific controller.</td>
</tr>
<tr>
<td>MoveAbsolute</td>
<td>Initiates an absolute move.</td>
</tr>
<tr>
<td>MoveAbsoluteEnc</td>
<td>Initiates an absolute move with specified positions for encoder equipped stages.</td>
</tr>
<tr>
<td>MoveAbsoluteEx</td>
<td>Initiates an absolute move with specified positions.</td>
</tr>
<tr>
<td>MoveAbsoluteRot</td>
<td>Initiates an absolute move with specified positions for rotary stages.</td>
</tr>
<tr>
<td>MoveHome</td>
<td>Initiates a homing sequence.</td>
</tr>
<tr>
<td>MoveJog</td>
<td>Initiates a jog move.</td>
</tr>
<tr>
<td>MoveRelative</td>
<td>Initiates a relative move.</td>
</tr>
<tr>
<td>MoveRelativeEnc</td>
<td>Initiates a relative move with specified distances for encoder equipped stages.</td>
</tr>
<tr>
<td>MoveRelativeEx</td>
<td>Initiates a relative move with specified distances.</td>
</tr>
<tr>
<td>MoveVelocity</td>
<td>Initiates a move at constant velocity with no end point.</td>
</tr>
<tr>
<td>SaveParamSet</td>
<td>Saves settings for a specific controller.</td>
</tr>
<tr>
<td>SetAbsMovePos</td>
<td>Sets the absolute move position.</td>
</tr>
<tr>
<td>SetBLashDist</td>
<td>Sets the backlash distance.</td>
</tr>
<tr>
<td>SetDispMode</td>
<td>Sets the GUI display mode.</td>
</tr>
<tr>
<td>SetHomeParams</td>
<td>Sets the homing sequence parameters.</td>
</tr>
<tr>
<td>SetJogMode</td>
<td>Sets the jogging button operating modes.</td>
</tr>
<tr>
<td>SetJogStepSize</td>
<td>Sets the jogging step size.</td>
</tr>
<tr>
<td>SetJogVelParams</td>
<td>Sets the jogging velocity profile parameters.</td>
</tr>
<tr>
<td>SetPositionOffset</td>
<td>Sets the motor position offset.</td>
</tr>
<tr>
<td>SetRelMoveDist</td>
<td>Sets the relative move distance.</td>
</tr>
<tr>
<td>SetStageAxisInfo</td>
<td>Sets the stage axis parameters.</td>
</tr>
<tr>
<td>SetVelParams</td>
<td>Sets the velocity profile parameters.</td>
</tr>
<tr>
<td>ShowSettingsDlg</td>
<td>Displays the GUI Settings panel.</td>
</tr>
<tr>
<td>StartCtrl</td>
<td>Starts the ActiveX Control (starts communication with controller)</td>
</tr>
<tr>
<td>StopCtrl</td>
<td>Stops the ActiveX Control (stops communication with controller)</td>
</tr>
<tr>
<td>StopImmediate</td>
<td>Stops a motor move immediately.</td>
</tr>
</tbody>
</table>
**Brushless DC Servo Driver T-Cube**

<table>
<thead>
<tr>
<th>Method Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>StopProfiled</td>
<td>Stops a motor move in a profiled (decelleration) manner.</td>
</tr>
<tr>
<td>GetDCCurrentLoopParams</td>
<td>Gets the Current servo loop PID parameter settings applied when the unit is moving</td>
</tr>
<tr>
<td>GetDCPositionLoopParams</td>
<td>Gets the Position servo loop PID parameter settings</td>
</tr>
<tr>
<td>GetDCMotorOutputParams</td>
<td>Gets the limits that are applied to the motor drive signal</td>
</tr>
<tr>
<td>GetDCTrackSettleParams</td>
<td>Gets the settings for the Track and Settle windows</td>
</tr>
<tr>
<td>GetDCProfileModeParams</td>
<td>Gets the settings for the profile mode</td>
</tr>
<tr>
<td>GetDCJoystickParams</td>
<td>Gets the settings for the joystick max velocity and acceleration</td>
</tr>
<tr>
<td>GetDCSettledCurrentLoopParams</td>
<td>Gets the Current servo loop PID parameter settings applied when the unit is 'settled'.</td>
</tr>
<tr>
<td>SetDCCurrentLoopParams</td>
<td>Sets the Current servo loop PID parameter values applied when the unit is moving</td>
</tr>
<tr>
<td>SetDCPositionLoopParams</td>
<td>Sets the Position servo loop PID parameter values</td>
</tr>
<tr>
<td>SetDCMotorOutputParams</td>
<td>Sets the limits that are applied to the motor drive signal</td>
</tr>
<tr>
<td>SetDCTrackSettleParams</td>
<td>Sets the parameters for the Track and Settle windows</td>
</tr>
<tr>
<td>SetDCProfileModeParams</td>
<td>Sets the parameters for the profile mode</td>
</tr>
<tr>
<td>SetDCJoystickParams</td>
<td>Sets the values for the joystick max velocity and acceleration</td>
</tr>
<tr>
<td>SetDCSettledCurrentLoopParams</td>
<td>Sets the Current servo loop PID parameter settings applied when the unit is 'settled'.</td>
</tr>
</tbody>
</table>

**Properties**

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>APTHelp</td>
<td>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.</td>
</tr>
<tr>
<td>DisplayMode</td>
<td>Allows the display mode of the virtual display panel to be set/read.</td>
</tr>
<tr>
<td>HWSerialNum</td>
<td>specifies the serial number of the hardware unit to be associated with an ActiveX control instance.</td>
</tr>
</tbody>
</table>
Appendix E  Regulatory

E.1  Declarations Of Conformity

E.1.1  For Customers in Europe
This equipment has been tested and found to comply with the EC Directives 89/336/EEC ‘EMC Directive’ and 73/23/EEC ‘Low Voltage Directive’ as amended by 93/68/EEC.
Compliance was demonstrated by conformance to the following specifications which have been listed in the Official Journal of the European Communities:

<table>
<thead>
<tr>
<th>Specification</th>
<th>EN Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>EN61010: 2001</td>
</tr>
<tr>
<td>EMC</td>
<td>EN61326: 1997</td>
</tr>
</tbody>
</table>

E.1.2  For Customers In The USA
This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.
Changes or modifications not expressly approved by the company could void the user’s authority to operate the equipment.

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

E.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
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.

E.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.

E.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.
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