KBD101

K-Cube® Brushless DC Servo Driver

User Guide



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Chapter 1 Safety

1.1 Safety Information

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

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

Shock Warning

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

Warning

Given when there is a risk of injury to users.

Caution

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

Note

Clarification of an instruction or additional information.

1.2 General Warnings

Warnings

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

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

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 Kinesis Software and the hardware, and a communications error may be generated. To minimize the possibility of this happening it is strongly recommended that any such modes that result in prolonged unresponsiveness be disabled before the software is run. Please consult your system administrator or contact Thorlabs technical support for more details.

Chapter 2 Overview and Setup

2.1 Introduction

The KBD101 Brushless DC Motor K-Cubes® are ideal for motion control applications demanding high speed (100s of mm/s) and high encoder resolution (<100 nm) operation. These single channel drivers 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 drivers are capable of driving a range of rotary and linear brushless 3-phase DC motors of up to 2 Amp peak coil current.

The KBD101 controller offers a standard control and programming interface, allowing easy integration into the customer's own automated motion control applications. These units are cable of being reprogrammed in-field, allowing the option of upgrading the units with future firmware releases as soon as new programming interfaces (such as microscopy standard command sets) are added.



Fig. 2.1 K-Cube Brushless DC Servo Motor driver (KBD101)

Operation of the KBD101 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 motion 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 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.

The KBD101 Controller can be operated from the front panel (see Chapter 4) or from a PC (see Chapter 5). It is fully compatible with Thorlabs' Kinesis® and XA software applications. This manual describes the use of KBD101 controller with Thorlabs' Kinesis software. For more information about operation using Thorlabs' XA software please refer to the XA User Guide.

2.2 Power Options

A single wall plug KPS201* supply for powering a single K-Cube Driver is available.

* The previous-generation KPS101 power supply is also compatible and can be used to power a single K-Cube Driver.

For multiple cube systems, a 3-channel (KEH3) or 6-channel (KEH6) K-Cube Controller Hub are offered. Previous generation 3- and 6-channel controllers (KCH301 and KCH601, respectively) may also be used, but are no longer available for individual purchase. These products have been designed specifically with multiple K-Cube operation in mind in order to simplify issues such as cable management, power supply routing, multiple USB device communications and different optical table mounting scenarios.

The K-Cube Controller Hub comprises a slim base-plate type carrier with electrical connections located on the upper surface to accept the K-Cubes.

Internally the Controller Hub contains a fully compliant USB 2.0 hub circuit to provide communications for all K-Cubes – a single USB connection to the Controller Hub is all that is required for PC control. The Controller Hub also provides power distribution for the K-Cubes, requiring only a single power connection.

2.3 PC Software Overview

The KBD101 Controller is fully compatible with Thorlabs' Kinesis and XA software applications. The remainder of this manual describes the use of the controller with Kinesis software. For information about operation using Thorlabs' XA software, please refer the XA User Guide.

2.3.1 Introduction

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

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

The User Interface allows full control of all settings and operating modes enabling complete 'out-of-box' operation without the need to develop any further custom software. It provides all of the necessary system software services such as generation of GUI panels, communications handling for multiple USB units, and logging of all system activity to assist in hardware trouble shooting. The Kinesis server is also used by software developers to allow the creation of advanced automated positioning applications very rapidly and with great ease. The Kinesis server is described in more detail in Section 2.3.2

Caution

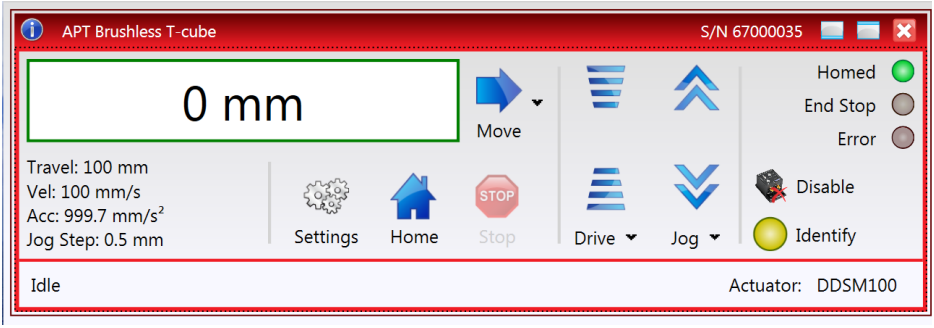
On start up, wait until the initialization sequence is completed before running the Kinesis software - see Section 3.4

2.3.2 Kinesis Server

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

With the Kinesis system, .Net Controls are deployed to allow direct control over (and also reflect the status of) the range of electronic controller units, including the Brushless Motor Driver K-Cube. Software applications that use .Net Controls are often referred to as 'client applications'. A .Net Control is a language independent software component. Consequently the controls can be incorporated into a wide range of software development environments for use by client application developers. Development environments supported include Visual Basic, Labview, Visual C++, C++ Builder, HPVEE, Matlab, VB.NET, C#.NET and, via VBA, Microsoft Office applications such as Excel and Word.

Consider the control supplied for the KBD101 Brushless DC Servo driver 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 driver 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 Kinesis Controls collection provides a rich set of graphical user panels and programmable interfaces allowing users and client application developers to interact seamlessly with the Kinesis hardware. Each of the Kinesis controllers has an associated .Net Control and these are described fully in the handbooks associated with the controllers.

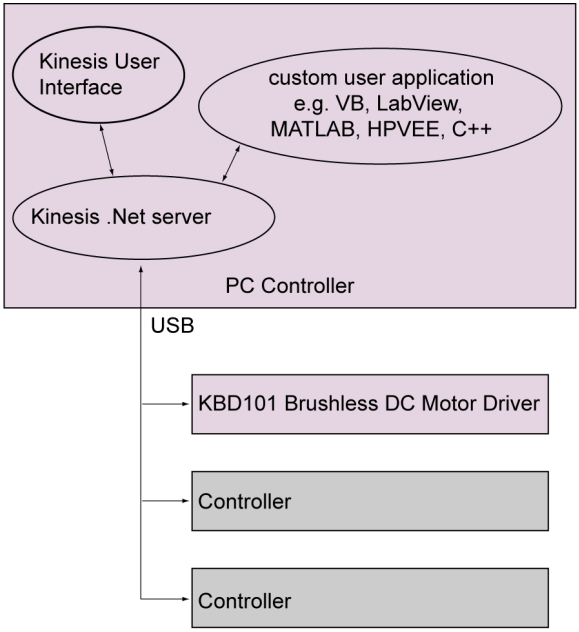


Fig. 2.2 System Architecture Diagram

Refer to the main Kinesis Software online help file, for a complete programmers guide and reference material on using the Kinesis Controls collection. This is available either by pressing the F1 key when running the Kinesis server, or via the Start menu, Start\Programs\Thorlabs\Kinesis\Kinesis Help.

2.3.3 Software Upgrades

Thorlabs often releases updated firmware for bug fixes and support for new features. We recommend all users to download the latest version of software and use the included firmware update utility. Failure to do this could result in stages not being recognized by the latest controllers.

Chapter 3 Getting Started

3.1 Installing the 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 Software and the hardware, and a communications error may be generated. To minimize the possibility of this happening it is strongly recommended that any such modes that result in prolonged unresponsiveness be disabled before the software is run. Please consult your system administrator or contact Thorlabs technical support for more details.

Caution

Some PCs may have been configure 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 885291 and ask for Technical Support.

DO NOT CONNECT THE CONTROLLER TO YOUR PC YET

1) Download the software from www.thorlabs.com.
2) Locate the downloaded setup.exe file and move to a suitable file location.
3) Double-click the setup.exe file and follow the on-screen instructions.

3.2 Mechanical Installation

3.2.1 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.

3.2.2 Mounting Options

The K-Cube Brushless DC Driver is shipped with a baseplate, for use when fitting the unit to a breadboard, optical table or similar surface.

For multiple cube systems, a 3-channel (KEH3) or 6-channel (KEH6) K-Cube Controller Hub are offered. Previous generation 3- and 6-channel controllers (KCH301 and KCH601, respectively) may also be used, but are no longer available for individual purchase. See Section 2.2 for further details. Full instructions on the fitting and use of the controller hub are contained in the handbook available at www.thorlabs.com

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.

3.2.3 Using the Baseplate

The baseplate must be bolted to the worksurface before the K-Cube is fitted, as shown below. The K-cube is then located on two dowels in the baseplate and secured by two clips.

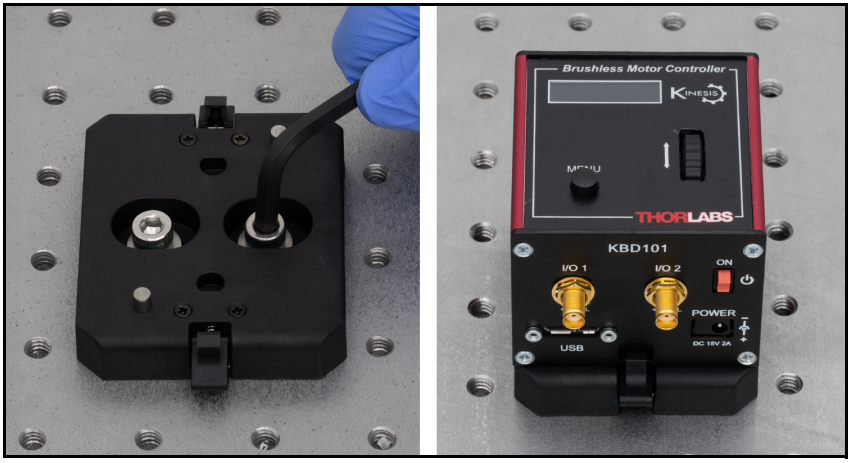


Fig. 3.1 Using The Baseplate

3.3 Electrical Installation

3.3.1 Rear Panel

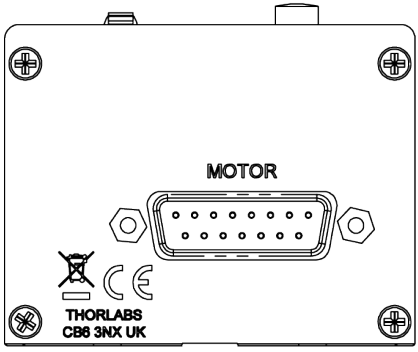


Fig. 3.2 Rear Panel Connections

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).

3.3.2 Front Panel

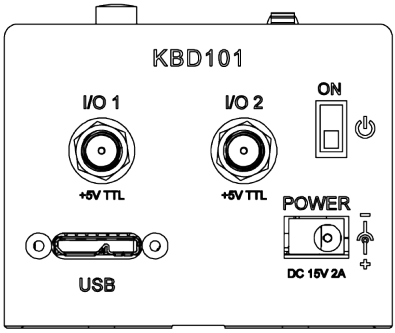


Fig. 3.3 Front Panel Connections

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.

POWER - A Standard 3.5 mm front panel jack connector for connecting the unit to a regulated DC power supply of 15 V, 2 A- 2.66 A.

A single way wall plug KPS201* supply for powering a single Driver K-Cube is available.

*The previous-generation KPS101 power supply is also compatible.

USB - USB port for system communications.

Note

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

ON - Power ON/Standby switch. When in the ON position, the unit is fully powered up. When the switch is turned to the Standby position, the unit initiates a controlled power down sequence, saving all user-adjustable parameters to non-volatile memory before turning off the power. For the first few seconds, the shutdown can be cancelled by turning the switch on again, in which case the unit will save the parameters but will remain powered up. In a powered down (Standby) state, the logic circuits are powered off and the unit will draw only a small quiescent current. The switch should always be used to power down the unit.

I/O 1 and I/O 2 - SMA connectors for use with external trigger input and output signals (5 V TTL levels). The function is set to trigger IN or OUT via the settings panel - see Section 4.5 and Section 6.3.6

3.4 Connect the Hardware

1) Perform the mechanical installation as detailed in Section 3.2
2) Install the software.

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.

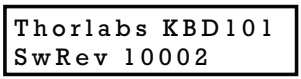
3) Connect the Controller unit to your PC.
   (**Note**. The USB cable should be no more than 3 metres in length. Communication lengths in excess of 3 metres can be achieved by using a powered USB hub).
4) Connect the DC servo motor actuator to the driver unit - see Section 3.3.1

Caution

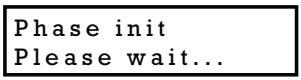
During item (5) ensure the power switch on the front panel of the unit is switched off before connecting power to the K-Cube. Always power up the K-Cube unit by its ON switch. DO NOT connect the K-Cube unit to a 'live' external power supply. Doing so (i.e. "hot plugging") carries the risk of PERMANENT damage to the unit. Similarly, to power down the unit, turn the power switch off before disconnecting the power supply.

5) Connect the driver unit to the power supply - see Section 3.3.2
6) Connect the PSU to the main supply.
7) Switch 'ON' the unit using the switch on the front panel.

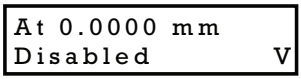
The unit takes about 5 seconds from power application until warm up is finished, and phase initialization is complete. During this time the following screens are displayed.











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Note

If any problems are encountered during the connection and power up process, power cycle the unit, which should clear the error.

Note

3-phase brushless DC motors are commutated electronically, i.e. the controller drives the coils with a precisely controlled 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 energizing 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 initialization can only take place if the motor can move unobstructed during this time.

8) Windows® should detect the new hardware. Wait while Windows® installs the drivers for the new hardware.

Note

After initial start up, the drive channel must be enabled before the stage can be driven - see Section 4.4.2

3.5 Stage Selection

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

To assist in setting these parameters correctly, a specific stage type and axis must be associated with the motor controller. Once this association has been made, the Kinesis server applies automatically, suitable default parameter values on boot up of the software.

For Thorlabs stages, the association is performed automatically when the stage is connected and suitable default parameter values are loaded when the controller is first powered up.

Note

After initial start up, the drive channel must be enabled before the stage can be driven - see Section 4.4.2

Chapter 4 Standalone Operation

4.1 Introduction

The Brushless DC Driver K-Cube has been designed specifically to operate with the range of Thorlabs Brushless DC motorized opto-mechanical products. The unit offers a fully featured motion control capability including 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 Kinesis 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

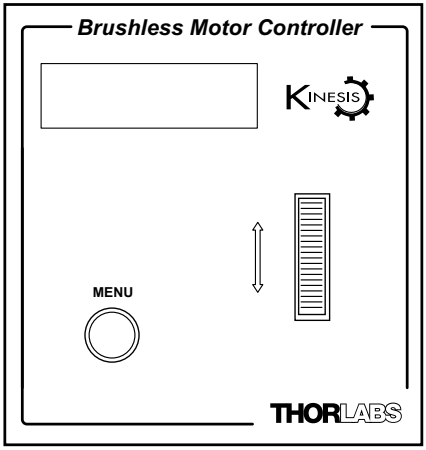


Fig. 4.1 Panel Controls and Indicators

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

Velocity Wheel - 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

Digital Display - The display shows the menu options and settings, accessed via the menu button - see Section 4.4 When the Ident button on the associated GUI panel is clicked, the display will flash for a short period.

MENU - used to access the settings menu - see Section 4.4 Also used to stop a move when the stage is in motion.

4.2.1 Digital Display - Operating Mode

During normal operation, the digital display shows the current position (in millimeters or degrees) and the current state of the motor (Stopped or Moving). If the stage being driven has been homed, the display will also show ‘Homed’.

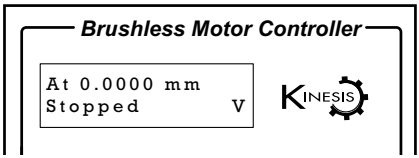


Fig. 4.2 Digital Display - Normal Operation

For rotation stages, the position display will be restricted to the "Equivalent Angle" display mode (see Section 6.3.9 for more details), so the position displayed will always be a positive number between 0 and 360 degrees. If set to Total Angle in the settings panel, the LED display will still show the equivalent 0 to 360° value but the GUI screen will show the total rotation.

4.3 Velocity Wheel Operation

The velocity wheel is a sprung potentiometer, such that when released it returns to its central position. In this central position the motor is stationary. Different types of move can be initiated by the wheel, depending on its mode setting. The mode can be set either via the GUI Settings panel, see Section 6.3.4 or via the top panel display menu, see Section 4.4 The various operating modes are described in Section 4.3.1 to Section 4.3.3

4.3.1 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 on the home position).

To initiate a ‘Home’ see Section 4.4.4

4.3.2 Go to Position

In ‘Go To Position’ mode, two preset position values can be specified, such that the motor moves to position 1 when the wheel is moved down, and to position 2 when it is moved up. These ‘taught’ positions can be set through the software GUI - see Section 6.3.4 or via the display menu, see Section 4.4.8

This mode of operation is enabled by setting the 'Wheel Mode' to 'Go To Position' through the software GUI - see Section 6.3.4 or via the display menu, see Section 4.4.6

Note for Rotation Stage Users

If the current absolute position is outside the 0 to 360 degree range, then "go to position" will result in a move to the correct angular position within the same 0..360 degree full turn "segment". This means that the move will always stay in the current full turn segment, and from this point of view it is not always the quickest position move. For example, if you are at 350 degrees and you enter a "go to" position of 10 degrees, the stage will rotate anticlockwise 340 degrees and not clockwise 20 degrees.

4.3.3 Jogging

The top panel wheel can also be configured to 'jog' the motor. This mode of operation is enabled by setting the 'Wheel Mode' parameter to 'Jogging' through the software GUI - see Section 6.3.4 or via the display menu, see Section 4.4.6

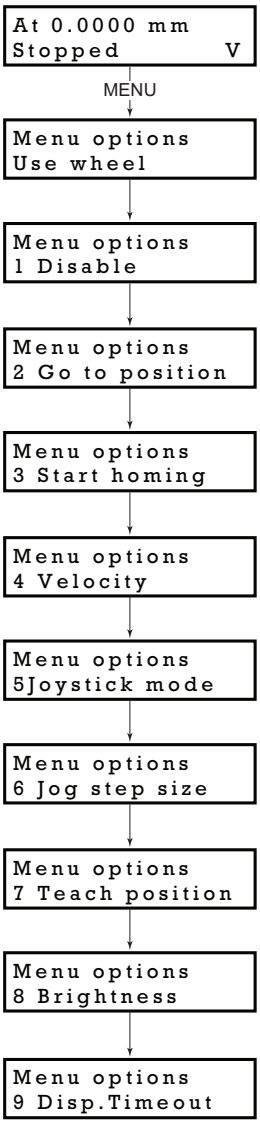
Once set to this mode, the jogging parameters for the wheels are taken from the 'Jog' parameters on the 'Move/Jogs' settings tab - see Section 6.3.2 or via the display menu, see Section 4.4.7

4.3.4 Velocity Moves

The wheel can also be used to initiate a move at a specified velocity. As the wheel is moved away from the centre, the motor begins to move. Bidirectional control of the motor is possible by moving the wheel in both directions. The speed of the motor increases by discrete amounts as a function of wheel deflection, up to a maximum as set in through the software GUI - see Section 6.3.4 or via the display menu, see Section 4.4.5 The move stops when the wheel is returned to its centre position.

4.4 Settings Menu

4.4.1 Overview



Press the MENU button

Use the wheel to scroll through the menu options
Press the MENU button to enter a particular option

Disable the stage - see Section 4.4.2

Move the stage to an absolute position - see Section 4.4.3

Move the stage to the Home position - see Section 4.4.4

Set the Max Velocity - see Section 4.4.5

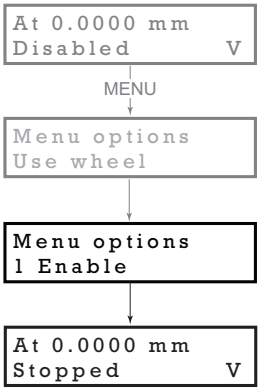
Set the joystick wheel mode - see Section 4.4.6

Set the Jog Step Size - see Section 4.4.7

Set the teach positions - see Section 4.4.8

Set the display brightness - see Section 4.4.9

Set the display time out period - see Section 4.4.10



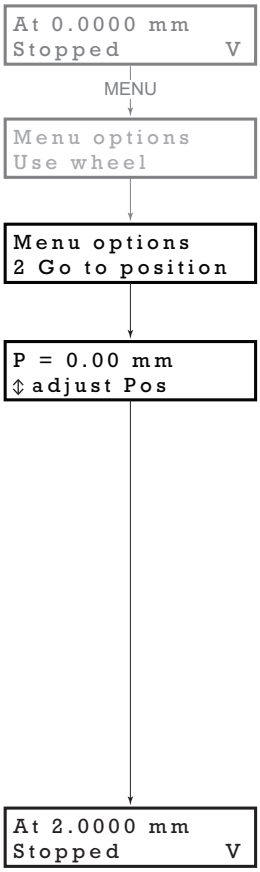
4.4.2 Menu Option - Enable/Disable

After initial start up the drive channel is disabled, and must be enabled before the stage can be driven.

Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the Enable option.

Press the MENU button to store the selection and return to the main display.



4.4.3 Menu Option - Go to position

This mode is used to move to an absolute position.

Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the Go to position option.

Use the wheel to adjust the position value, (within the travel range for linear stages, or 0 to 360 ° for rotation stages) then press the MENU button to store the selection.

Note for rotation stages. If the current absolute position is outside the 0 to 360 degree range, then "go to position" will result in a move to the correct angular position within the same 0..360 degree full turn "segment". This means that the move will always stay in the current full turn segment, and from this point of view it is not always the quickest position move. For example, if the stage is at 350 degrees and you enter a "go to" position of 10 degrees, the stage will rotate anticlockwise 340 degrees and not clockwise 20 degrees.

The stage moves to the position entered, and the display shows the change in position.

To stop the move, press the MENU button.

4.4.4 Menu Option - Start homing

This mode is used to home the stage.

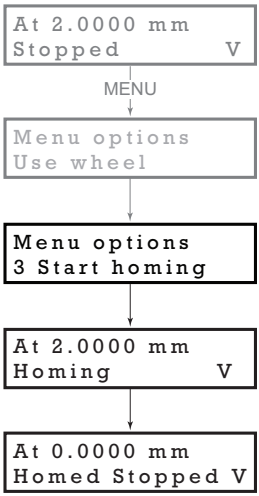
Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the Start Homing option.

The display shows a decreasing position count while the stage is homing.

Once homing is complete, the display shows the position at 0.0000 mm and 'Homed' is displayed.

To stop the move, press the MENU button.



4.4.5 Menu Option - Velocity

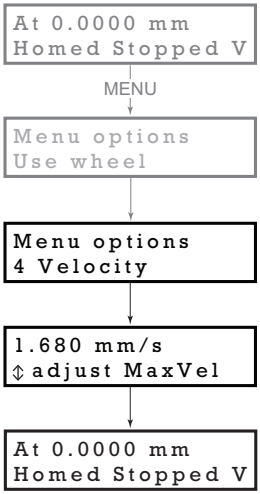
This mode is used to move to set the max velocity.

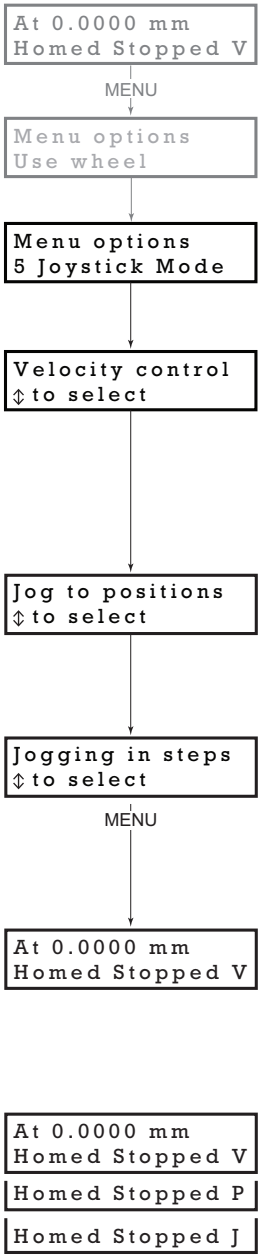
Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the Velocity option.

Use the wheel to adjust the max velocity, e.g. 1.68 mm/s, then press the MENU button to store the setting.

Subsequent moves will be performed at the velocity entered.





4.4.6 Menu Option - Joystick Mode

This mode is used to set the operating mode of the joystick wheel.

Press the MENU button, then use the wheel to scroll through the menu options

Press the MENU button to enter the Joystick mode option. Use the wheel to scroll through the options, then press MENU when the required option is displayed.

In *Velocity control mode*, deflecting the wheel starts a move with the velocity proportional to the deflection. The maximum velocity (i.e. velocity corresponding to the full deflection of the joystick wheel) is set in the preceding *3 Velocity* option. The move will stop when the wheel is released.

In *Jog to positions mode*, deflecting the wheel starts a move from the current position to one of the two predefined “teach” positions. The teach positions are specified in option *6 Teach Position*.

In *Jog in steps mode*, deflecting the wheel initiates a jog move, using the parameters specified by the *3 Velocity* and *5 Jog step size* options. Keeping the wheel deflected repeats the move automatically after the current move has completed.

Use the wheel to display the required option, then press MENU to store the selection and return to the main display.

The selected mode is indicated at the right hand side of the bottom line:

V = Velocity mode

P = Jog to position mode

J = Jog in steps mode

4.4.7 Menu Option - Jog Step Size

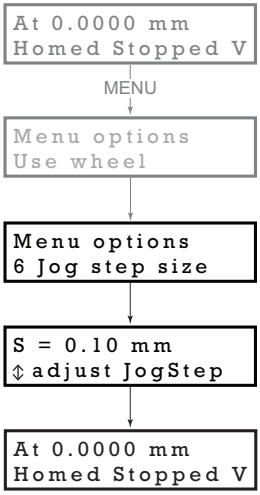
This mode is used to set the jog step size.

Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the Jog step size option.

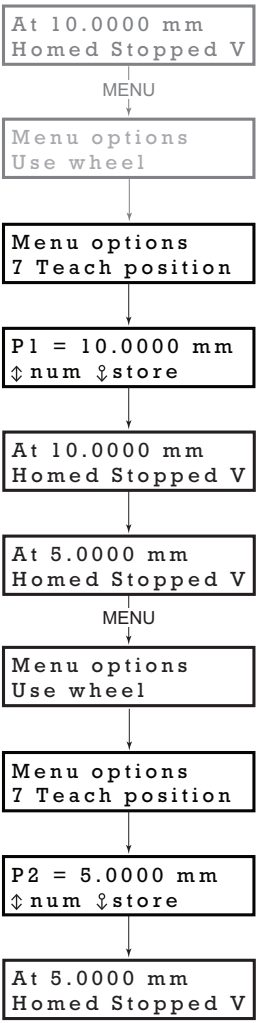
Use the wheel to adjust the step size, e.g. 0.10 mm, then press the MENU button to store the selection.

When *Jog in steps* mode is selected in the *Joystick mode* option (see Section 4.4.6), subsequent moves will be performed at the step size entered.



4.4.8 Menu Option - Teach Position

This mode is used to set the teach positions, used when the *Joystick mode* option is set to *Jog to positions* mode - see Section 4.4.6



To set Teach Position 1...

Move the stage to the position to use as teach position 1.

Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the Teach position option.

Use the wheel to select P1, then press the MENU button to store the current position as teach position 1 and return to the main display.

To set Teach Position 2...

Move the stage to the position to use as teach position 2.

Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the Teach position option.

Use the wheel to select P2, then press the MENU button to store the current position as teach position 2 and return to the main display.

When *Jog to position* mode is selected in the *Joystick mode* option (see Section 4.4.6), a downwards deflection of the wheel moves the stage to position 1, and an upwards deflection moves to position 2.

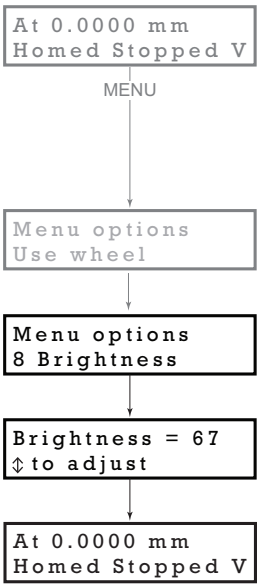
4.4.9 Menu Option - Brightness

In certain applications, it may be necessary to adjust the brightness of the LED display. The brightness is set as a value from 0 (Off) to 100 (brightest). The display can be turned off completely by entering a setting of zero, however, pressing the MENU button on the top panel will temporarily illuminate the display at its lowest brightness setting to allow adjustments. When the display returns to its default position display mode, it will turn off again.

Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the Brightness option.

Use the wheel to adjust the brightness, then press the MENU button to store the selection and return to the main display.



4.4.10 Menu Option - Disp.Timeout

'Burn In' of the display can occur if it remains static for a long time. To prevent this, the display is automatically dimmed after a specified time interval.

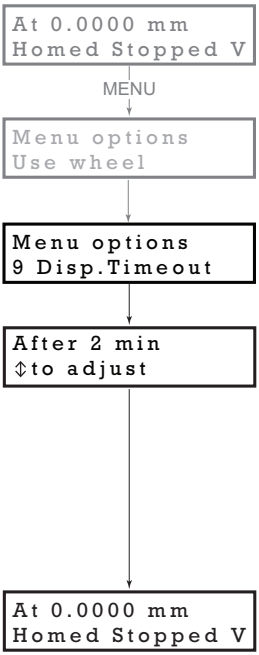
Press the MENU button, then use the wheel to scroll through the menu options.

Press the MENU button to enter the Disp.Timeout option.

The time out interval is specified in minutes in the range 1 to 480. The adjustment is done in steps of 1 minute if the timeout is between 1 to 10 minutes, 10 minute steps between 10 minutes and 1 hour, and 30 minute steps above, up to a maximum of 480 minutes. After 480 minutes there is an option for Never.

The dim level can only be adjusted via the Settings panel - see Section 6.3.5

Press the MENU button to store the selection and return to the main display.



4.5 External Triggering

External triggering is facilitated by the 'I/O 1' and 'I/O 2 connectors on the front panel of the unit - see Section 3.3.2. These connectors are controlled via the Kinesis software (see Section 6.3.5) and provide a 5 V logic level input/output that can be configured to support triggering from and to external devices.

4.5.1 Trigger In

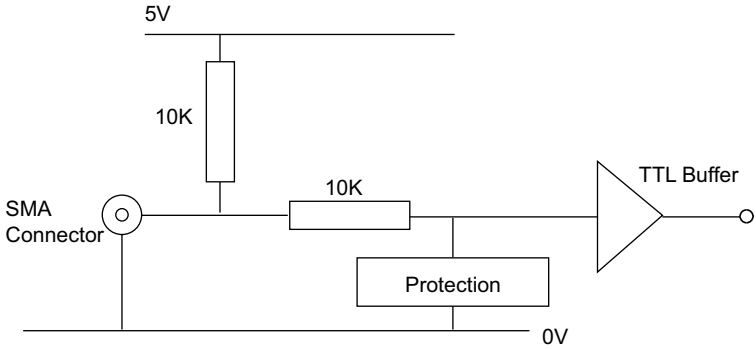


Fig. 4.3 TRIG IN Connection Detail

The TRIG Input contains a pull up resistor to an internal +5 V 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 <0.8 V is low and >2.4 V is high). Do not exceed the maximum voltage range of -10 V to 10 V.

4.5.2 Trigger In Latency

The trigger input will not accept another trigger request until the current move has completed, which imposes a restriction on how frequently moves can be triggered. In addition, there is a communications latency between the micro controller and the motion processor of up to 100 msec. This means that the maximum frequency at which triggered moves can be commanded is approximately 100 msec plus the duration of the move itself.

4.5.3 Trigger Out

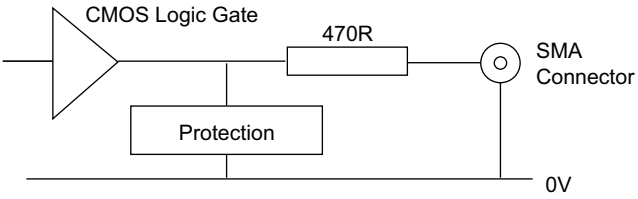


Fig. 4.4 TRIG OUT Connection Detail

The TRIG output is the output of a standard 5V CMOS logic gate in series with a 470Ω 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 5 V range. It is recommended that the output is only used to drive external devices or equipment that has a high input resistance (>10 kΩ).

4.5.4 Trigger Out Latency

The detection of whether a trigger condition has occurred is carried out periodically at 102 µs intervals. As a result, there is a maximum 102 µs delay between the condition occurring and the trigger output being updated. The following timing diagram illustrates this latency:

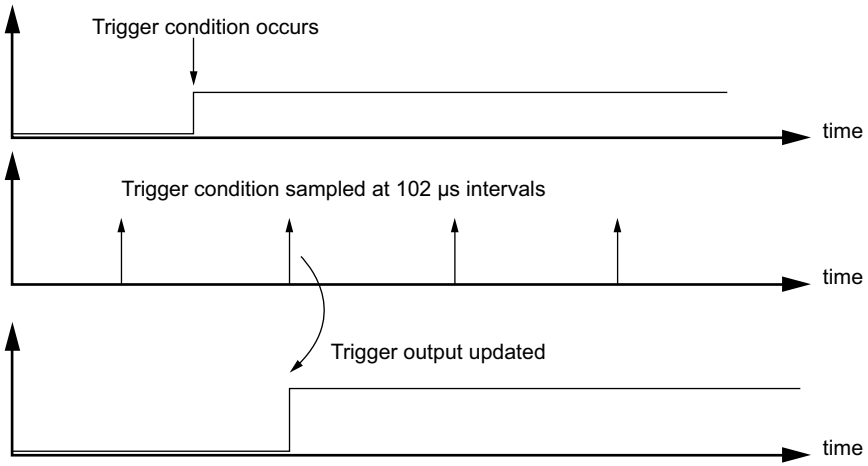


Fig. 4.5 Triggering Latency

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 Kinesis software. It assumes that the unit is electrically connected as shown in Section 3.3.1, that the software is already installed - see Section 3.1 and that the stage being driven is the Thorlabs DDSM100 Direct Drive Translation stage.

Warning

The software 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 Kinesis Server, 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 KBD101 driver, the maximum velocity is limited to safe values. However, if the output is disabled (with the driver connected and monitoring the position) and the stage is moved manually at high speeds, it is possible to exceed this limit. If the KBD101 driver 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 driver has fault monitoring to detect the loss of encoder pulses. If this fault occurs, an error message will be generated and the driver must be powered down and re-started so that correct phasing and commutation can be established.

For information about operation using Thorlabs' XA software, please refer to the XA User Guide.

5.2 Using the Kinesis Software

The Kinesis software application allows the user to interact with any number of hardware control units connected to the PC USB Bus. This program allows multiple graphical instrument panels to be displayed so that multiple units can be controlled. All basic operating parameters can be set through this program, and all basic operations (such as motor moves) can be initiated. A set of default parameter settings is loaded on start up, which should be satisfactory for most applications. However parameter values can be changed and saved to file if required. Move sequences can also be created and saved for later use.

5.3 Verifying Software Operation

5.3.1 Initial Setup

The Software should be installed (Section 3.1) and the power up procedure performed (Section 3.3) before software operation can be verified.

1) Run the Kinesis software - Start/All Programs/Thorlabs/Kinesis/Kinesis.
1) Notice how the DDSM100 stage type, selected at start up, is displayed in the window. See Section 5.8 and Section 6.3 for further details on the parameter values shown in the 'Settings' display



Fig. 5.1 GUI Panel Showing Jog and Ident Buttons

2) Click the Enable button.
3) Click the 'Ident' button. The ENABLE LED on the front panel of the associated driver flashes. This is useful in multi-channel systems for identifying which driver unit is associated with which GUI.
4) Click the 'Home/Zero button on the GUI panel and check that the motor or axis connected to the driver moves. See Section 5.4 for further details on homing.

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.

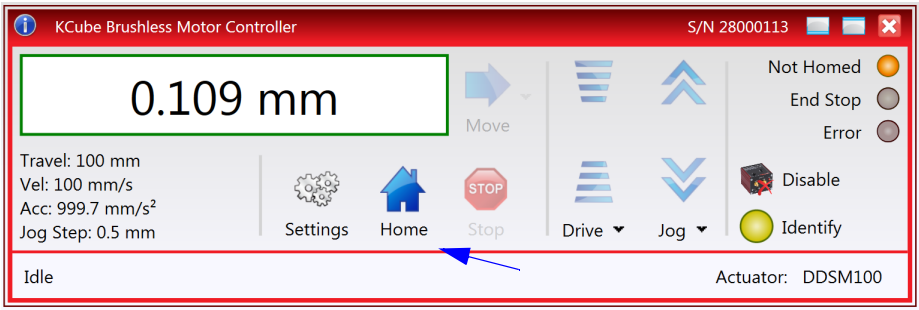


Fig. 5.2 Motor Controller Software GUI

1) Click the 'Home' button. Notice that the 'Not Homed' LED changes to 'Homed', and that the LED flashes to indicate that homing is in progress. The displayed position counts down to 0, i.e the home position.
2) When homing is complete, the 'Homed' LED is lit.

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 Changing Motor Parameters and Moving to an Absolute Position

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

Moves are performed using a trapezoidal profile (see Section 6.3.5). The velocity settings relate to the maximum velocities at which a move is performed, and the acceleration at which the motor speeds up from zero to maximum velocity.

1) On the GUI panel, click the Move arrow to show the Settings panel.

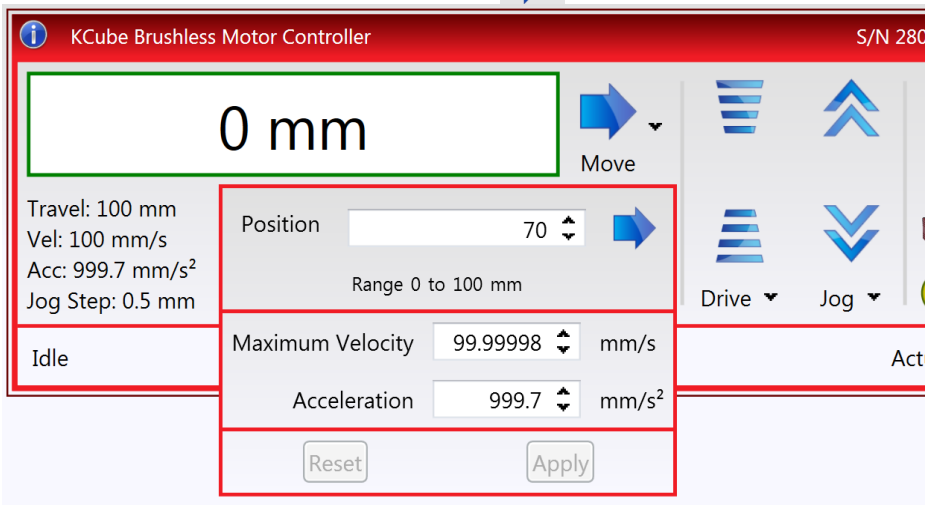


Fig. 5.3 Move Settings Panel

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

5.6 Jogging

During PC operation, the motor actuators are jogged using the GUI panel arrow keys. There are two jogging modes available, 'Single Step' and 'Continuous'. In 'Single Step' mode, the motor moves by the step size specified in the Step Distance parameter. If the jog key is held down, single step jogging is repeated until the button is released - see Fig. 6.3. In 'Continuous' mode, the motor actuator will accelerate and move at the jog velocity while the button is held down.

1) On the GUI panel, click the word 'Jog'  to display the Settings panel.

Fig. 5.4 Jog Settings Panel

2) Make parameter changes as required.

Note

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

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

5.7 Setting Move Sequences

The Kinesis software allows move sequences to be programmed, allowing several positions to be visited without user intervention. For more details and instructions on setting move sequences, please see the *Kinesis Helpfile*.

5.8 Changing and Saving Parameter Settings

During operation, certain settings (e.g. move velocity, jog step size etc) can be changed as required. Other settings (e.g. PID parameter values) cannot be changed so easily. When the Kinesis Server is run up and the stage/acuator association made, suitable default settings are loaded and these values have been chosen to proved safe performance in the majority of applications. However, for applications where these settings need to be changed, a new set of Device Start Up settings', must be created which can then be applied and/or uploaded on subsequent start up. See the *Kinesis Helpfile* for more details.

Chapter 6 Software Reference

6.1 Introduction

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

6.2 GUI Panel

The following screen shot shows the graphical user interface (GUI) displayed when accessing the Brushless DC driver using the Kinesis software.

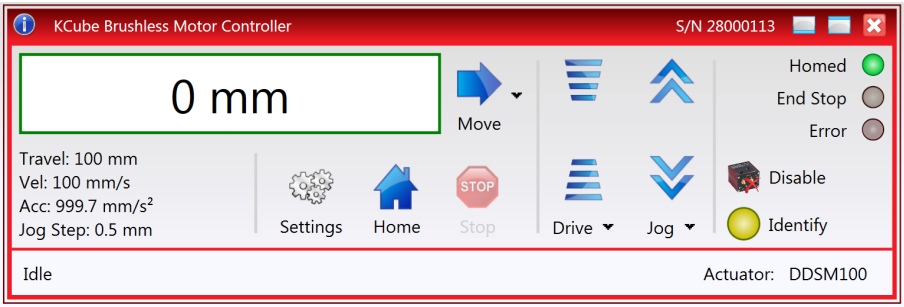


Fig. 6.1 Brushless DC Motor Driver Software GUI

Note

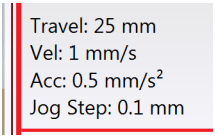
The serial number of the driver unit associated with the GUI panel is displayed in the top right hand corner. This information should always be provided when requesting customer support.

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





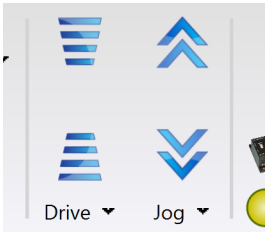
Move - Opens the settings window, so that position data and velocity parameters can be entered - see Section 5.5 Moves are performed using the current velocity parameters which can be changed in the same panel. The present settings are displayed below the window.



Velocity Parameters - the present setting for the move velocity parameters and the jog step size. The travel range of the associated stage/actuator is also displayed.

These settings can be adjusted as described previously, or by clicking the Settings button to display the settings window, see Section 6.3.2

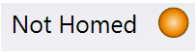
Jog Controls - used to increment or decrement the motor position. The controls comprise a bar graph and a set of jog arrows.



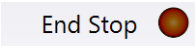
Each division of the bar graph represents a different velocity. The velocities are entered in the settings panel which is displayed by clicking 'Drive' or the small down arrow.

When the arrows are clicked, the motor is driven in the selected direction at the jog velocity, one step per click. The step size and jog velocity parameters can be changed by clicking 'Jog' or the small down arrow to display the settings panel.

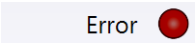
Homed/Not Homed - lit when the motor has not been 'Homed' since power up. When the home button is clicked, the caption changes to 'Homed' and the LED flashes while the home move is being performed. The LED is lit green once the move is complete.



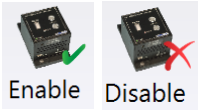
End Stop - lit when a limit switch is activated, i.e. the motor is at its end stop.



Error - lit when a fault condition occurs.



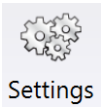
Enable/Disable - applies and removes power to the motor. With the motor enabled, only the Disable button is visible, and with the motor disabled only the Enable button is visible.



Identify - when this button is pressed, the front panel of the associated hardware unit will flash for a short period.



Settings - Displays the 'Settings' panel, which allows the operating parameters to be entered for the motor drive - see Section 6.3

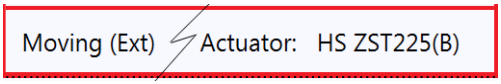


Home - sends the motor to its 'Home' position.





Stop - halts the movement of the motor.



Lower Display - Shows the present state of the motor, e.g. Idle, Moving, Moving EXT or Homing. Also shows the part number of the associated actuator or stage.

6.2.1 Keyboard Shortcuts

Certain functionality can also be accessed via PC keyboard shortcuts as follows:

Jog Forwards	'Ctrl' + 'F', 'Ctrl' + '+'
Jog Backwards	'Ctrl' + 'B', 'Ctrl' + '-'
Home	'Ctrl' + 'H', 'Ctrl' + 'Home'
Stop	'Ctrl' + '0'
Jog Forward1	'LeftCtrl' + '1' (Hold to move)
Forward2	'LeftCtrl' + '2' (Hold to move)
Forward3	'LeftCtrl' + '3' (Hold to move)
Forward4	'LeftCtrl' + '4' (Hold to move)
Backward1	'RightCtrl' + '1' (Hold to move)
Backward2	'RightCtrl' + '2' (Hold to move)
Backward3	'RightCtrl' + '3' (Hold to move)
Backward4	'RightCtrl' + '4' (Hold to move)
GoTo	'Enter' (On target position box)

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.

There are two settings tabs, 'Current Device Setting' and Device Startup Settings'.

The Current Device settings option shows the settings currently active in the device. If the settings are modified by using the GUI panel controls, then the changes will be reflected on this tab. Current Device Settings are never stored, instead they are created from existing Device Startup Settings either when the device loads or the Device Startup Settings for the device are changed in the Settings editor.

Device Startup Settings option shows the settings which are used to initialize the device on start up and are stored in a file on the PC. There may be one or more sets of Device Startup Settings available for any device and these fall into two catagories:

Default Device Startup Settings. These settings are supplied with the software and cannot be modified. There may be multiple sets of these settings, for example for different Actuator types.

Custom Device Startup Settings. These settings can be copied from existing Default Device Startup Settings and can be fully edited.

See the *Kinesis Helpfile* for more information

6.3.1 Persisting Settings to Hardware

Many of the parameters that can be set for the Brushless Driver K-Cube can be stored (persisted) within the unit itself, such that when the unit is next powered up these settings are applied automatically. This is particularly important when the driver is being used manually in the absence of a PC and USB link. The Jogging parameters described previously are good examples of settings that can be altered and then persisted in the driver for use in absence of a PC. To save the settings to hardware, check the '*Persist Settings to the Device'* checkbox before clicking the 'OK' button.

Caution

The 'Persist Settings' functionality is provided to simplify use of the unit in the absence of a PC. When the unit is connected to a PC and is operated via the Kinesis software, the default Server settings will be loaded at boot up, even if the 'Persist Settings' option has been checked.

6.3.2 Moves/Jogs tab

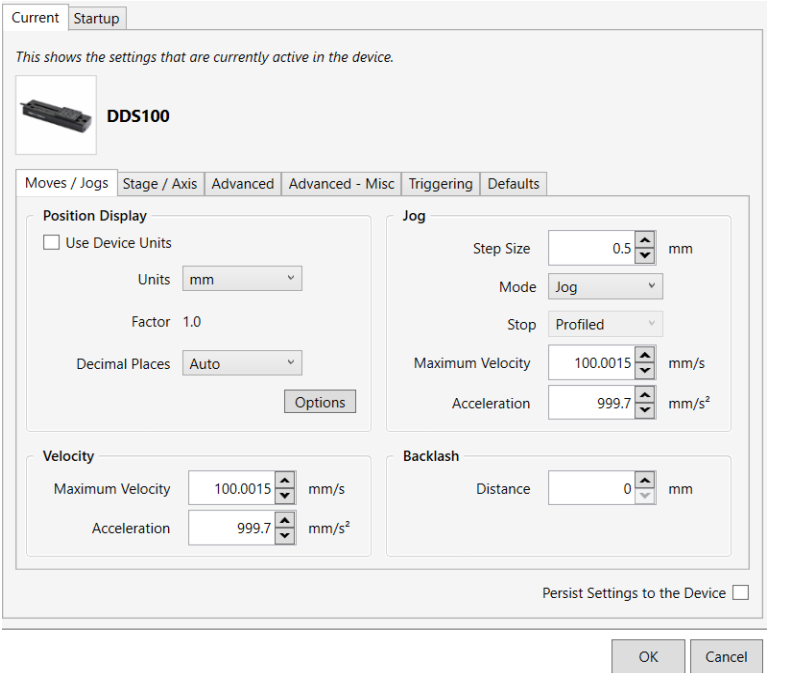


Fig. 6.2 Move/Jog Settings

Position Display

By default, the unit will display position in real world units (mm or degrees). If required, the units can be changed to so that the display shows other positional units (cm, µm, µrad etc).

Units - the positioning units used on the GUI display.

Factor - the scaling factor associated with the selected units.

Jog Parameters

Note

Under certain velocity parameter and move distance conditions, the maximum velocity may never be reached (i.e. the move comprises an acceleration and deceleration phase only).

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

Jogs are initiated by using the 'Jog' keys on the GUI panel (see Section 5.6), or the Jog Buttons on the front panel of the unit.

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

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

There are two jogging modes available, 'Jog' and 'Continuous'. In 'Jog' mode, the motor moves by the distance specified in the Step Size parameter. If the jog key is held down, single step jogging is repeated until the button is released - see Fig. 6.3. In 'Continuous' mode, the motor actuator will accelerate and move at the jog velocity while the button is held down.

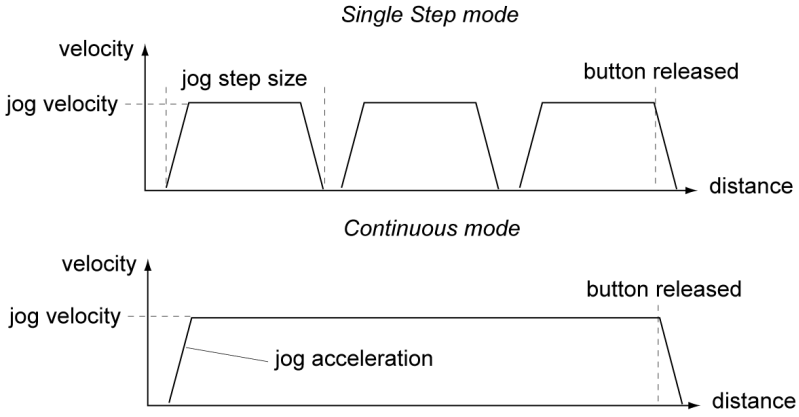


Fig. 6.3 Jog Modes

Jog - the motor moves by the distance specified in the Step Size parameter.

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

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

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

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

Maximum Velocity - the maximum velocity at which to perform a move.

Note

Under certain velocity parameter and move distance conditions, the maximum velocity may never be reached (i.e. the move comprises an acceleration and deceleration phase only).

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

Acceleration - the rate at which the velocity climbs from zero to maximum, and slows from maximum to zero.

Note

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

Velocity

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 *Kinesis API helpfile*). The following settings determine the profile of such moves, and are specified in real world units, millimetres or degrees.

Maximum Velocity - the maximum velocity at which to perform a move.

Acceleration - the rate at which the velocity climbs from zero to maximum, and slows from maximum to zero.

Note

Under certain velocity parameter and move distance conditions, the maximum velocity may never be reached (i.e. the move comprises an acceleration and deceleration phase only).

Backlash

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.

6.3.3 Stage/Axis Tab

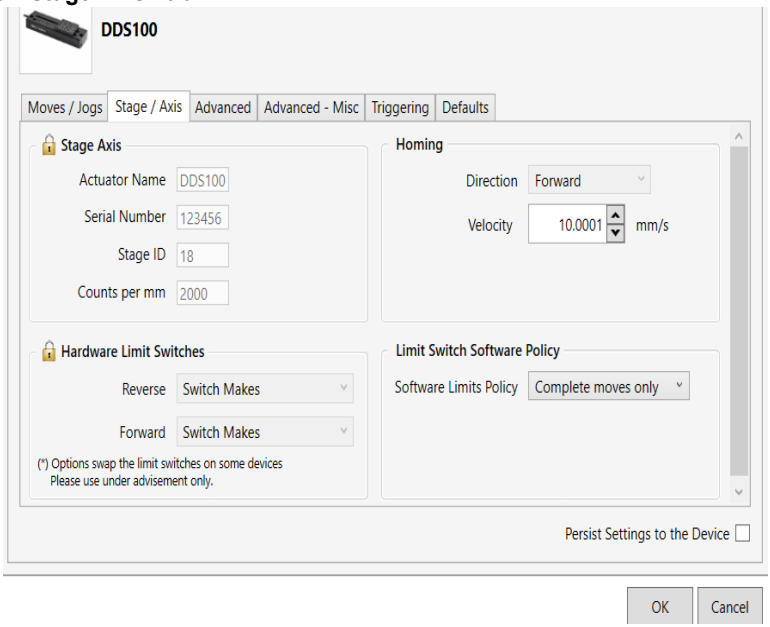


Fig. 6.4 Stage/Axis Settings

Note

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

For Thorlabs stages, the Kinesis 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.

In the event that these settings need to be changed, the user can create a custom settings group - see the Kinesis Helpfile for more information.

Stage Axis

These parameters are read automatically when the actuator/stage was associated at start up - see Section 3.5 These settings are provided for information only and cannot be adjusted. They should always be quoted when requesting technical support.

Actuator Name - The name (part number) of the stage or actuator connected.

Serial Number - The serial number of the stage or actuator connected.

Stage ID - The ID number of the stage or actuator connected. This number is used by the server to assign stage specific parameter values at start up.

Counts per mm - The number of encoder counts per millimeter of travel of the DC servo motor (minimum '1', maximum '10,000').

Homing

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.**

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

Note

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

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

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

Hardware Limit Switches

Note

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

The operation of the limit switches is inherent in the design of the associated stage or actuator. The following parameters notify the system to the action of the switches when contact is made. Select Reverse or Forward as required, then select the relevant operation.

Switch Makes - The switch closes on contact
Switch Breaks - The switch opens on contact
Ignore/Absent - The switch is missing, or should be ignored.

6.3.4 Advanced Settings Tab

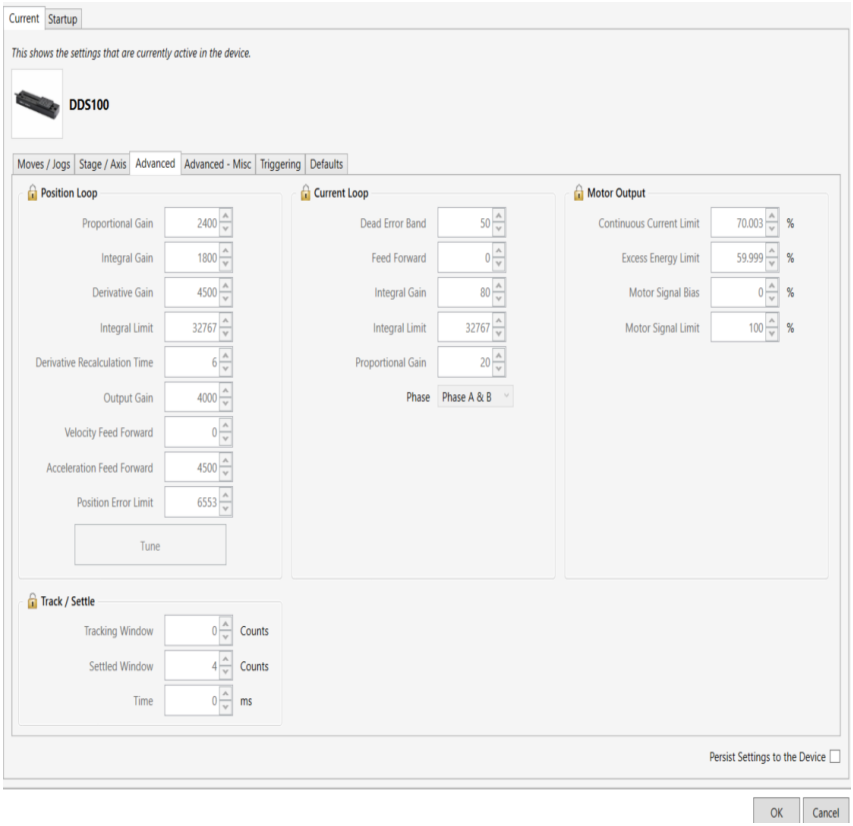


Fig. 6.5 Advanced Settings

Position Loop

The motion processors within the KBD101 driver 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.

Caution

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

Proportional Gain - Increasing the proportional (Prop) term will increase the amount of effective torque used to correct a given position error. Typically this is used to minimize the amount of position error when an impulse event affects current target position during motion. i.e. sticksion, vibration etc .If the proportional term is too high this can lead to overshoot and general instability. If this is too low it can result in a sloppy response. It accepts values in the range 0 to 32767.

Integral Gain - Increasing the integral (Int) term minimizes 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.

Derivative Gain - Increasing the derivative (Deriv) term decreases the rate of change of driver 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.

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 Recalculation 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 Error 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 Error 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.

Note

The position error limit is monitored only when the motor is enabled (i.e. the feedback loop is active).

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

The motion processor within the TBD driver 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.

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.

Dead Error 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.

Integral Gain – 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.

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

Current Loop (Settled)

The following parameters are designed to assist in maintaining stable operation and redusing noise at the demanded position. They allow the system to be tuned such that errors caused by external vibration and manual handling (e.g. loading of samples) are minimized, and are applicable only when the stage is settled, i.e. the Axis Settled status bit (bit 14) is set - see Section 6.3.5

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.

Dead Error 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.

Integral Gain – 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.

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

Motor Output

Caution

The default values programmed into the Kinesis 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.

Continuous 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).

Excess 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 Signal 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.

Motor Signal 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.

Track Settle

Moves are generated by an internal profile generator, and are based on a trapezoidal trajectory (see Section 6.3.5). 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 6.3.4) 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 *Time* parameter 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 Error Limit* parameter set in the *Position Loop Settings* group, 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.

6.3.5 Advanced - Misc. Tab

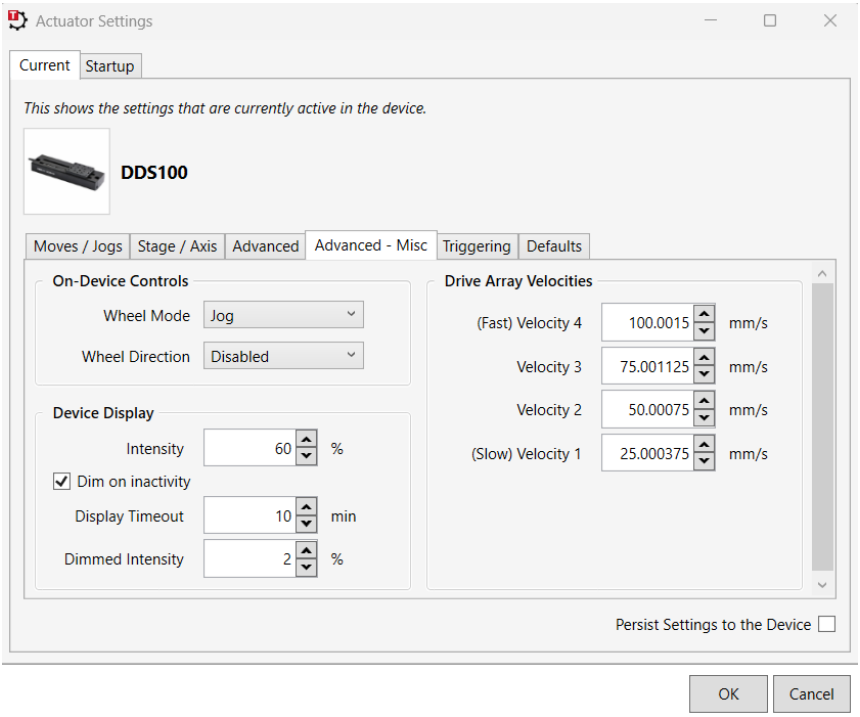


Fig. 6.6 Advanced Miscellaneous Settings

On Device Controls

The velocity wheel is sprung such that when released it returns to it's central position. In this central position the motor is stationary. As the wheel is moved away from the center, the motor begins to move; the speed of this movement increases as the wheel

deflection is increased. Bidirectional control of motor moves is possible by moving the wheel in both directions.

Joystick Mode

Velocity Control - Deflecting the wheel starts a move with the velocity proportional to the deflection. The maximum velocity (i.e. velocity corresponding to the full deflection of the joystick wheel) and acceleration are set in the *Max Velocity* and *Acceleration*. parameters.

Jog - Deflecting the wheel initiates a jog move, using the parameters specified by the Move/Jogs tab. Keeping the wheel deflected repeats the move automatically after the current move has completed.

Move To Position - Deflecting the wheel starts a move from the current position to one of the two predefined “teach” positions. The teach positions are specified in the *Preset Position 1* and *Preset Position 2* parameters, and are measured in number of steps from the home position.

Joystick Direction

The direction of a move initiated by the velocity wheel is specified as follows:

Forwards - Upwards rotation of the wheel results in a positive motion (i.e. increased position count).

Note. The following option applies only when the Wheel Mode is set to Velocity Control. If set to Position Jogging or Go to Position Mode, the following option is ignored.

Backwards - Upwards rotation of the wheel results in a negative motion (i.e. decreased position count).

Device Display

In certain applications, it may be necessary to adjust the brightness of the LED display on the top of the unit. The brightness is set in the *Display Intensity* parameter, as a value from 0 (Off) to 100 (brightest). The display can be turned off completely by entering a setting of zero, however, pressing the MENU button on the top panel will temporarily illuminate the display at its lowest brightness setting to allow adjustments. When the display returns to its default position display mode, it will turn off again.

Furthermore, 'Burn In' of the display can occur if it remains static for a long time. To prevent this, the display is automatically dimmed after the time interval specified in the *Display Timeout* parameter has elapsed. The time interval is specified in minutes in the range 1 to 480. The dim level is set in the *Dimmed Intensity* parameter, as a percentage of full brightness from 0 (Off) to 10 (brightest) but is also limited by the *Display Intensity* parameter if this is lower. These settings are only visible and active if the *Dim device display on inactivity* box is checked.

Drive Array Velocities

These parameters relate to the velocity for moves initiated by the DRIVE bar graph. Each specifies a velocity to apply when the associated bar is clicked. These settings are applicable in either direction of pot deflection, i.e. 4 possible velocity settings in the forward or reverse motion directions.

Note

It is acceptable to set velocities equal to each other to reduce the number of speeds.

6.3.6 Triggering

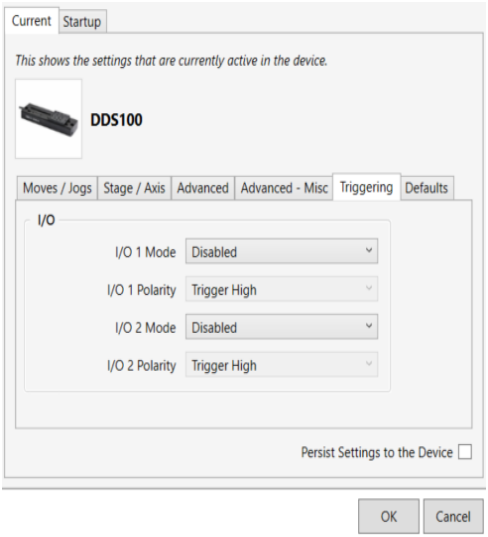


Fig. 6.7 Triggering Tab

Triggering Introduction

The K-Cube motor controllers have two bidirectional trigger ports (I/O 1 and I/O 2) that can be used to read an external logic signal or output a logic level to control external equipment. Either of them can be independently configured as an input or an output and the active logic state can be selected High or Low to suit the requirements of the application. Electrically the ports output 5 Volt logic signals and are designed to be driven from a 5 Volt logic.

When the port is used in the input mode, the logic levels are TTL compatible, i.e. a voltage level less than 0.8 Volt will be recognized as a logic LOW and a level greater than 2.4 Volt as a logic HIGH. The input contains a weak pull-up, so the state of the input with nothing connected will default to a logic HIGH. The weak pull-up feature allows a passive device, such as a mechanical switch to be connected directly to the input.

When the port is used as an output it provides a push-pull drive of 5 Volts, with the maximum current limited to approximately 8 mA. The current limit prevents damage when the output is accidentally shorted to ground or driven to the opposite logic state by external circuity.

Warning: do not drive the I/O ports from any voltage source that can produce an output in excess of the normal 0 to 5 Volt logic level range. In any case the voltage at the I/O ports must be limited to -0.25 to +5.25 Volts.

Input Trigger Modes

When configured as an input, the I/O ports can be used as a general purpose digital input, or for triggering a relative, absolute or home move. When used for triggering a move, the port is edge sensitive. In other words, it has to see a transition from the inactive to the active logic state (Low->High or High->Low) for the trigger input to be recognized. For the same reason a sustained logic level will not trigger repeated moves. The trigger input has to return to its inactive state first in order to start the next trigger. The mode is set in the *I/O 1 Mode* and *I/O 2 Mode* parameters as follows:

Disabled - The trigger IO is disabled

IN - GPI - General purpose logic input (read through status bits using the LLGetStatusBits method).

IN - Relative Move - Input trigger for relative move.

IN - Absolute Move - Input trigger for absolute move.

IN - Homed - Input trigger for home move.

Output Trigger Modes

When the *I/O 1 Mode* and *I/O 2 Mode* parameters are configured as outputs, the I/O ports can be used as a general purpose digital output, or to indicate motion status or to produce a trigger pulse at configurable positions as follows:

OUT GPO - General purpose logic output.

OUT - In Motion - Trigger output active (level) when motor 'in motion'. The output trigger goes high (5 V) or low (0 V) (as set in the I/O 1. Polarity and I/O. 2 Polarity parameters) when the stage is in motion.

OUT - At Max Velocity - Trigger output active (level) when motor at 'max velocity'.

OUT - At Position Steps Fwd - Trigger output active (pulsed) at pre-defined positions moving forward. Only one Trigger port at a time can be set to this mode. See Trigger Out Position Steps for further details.

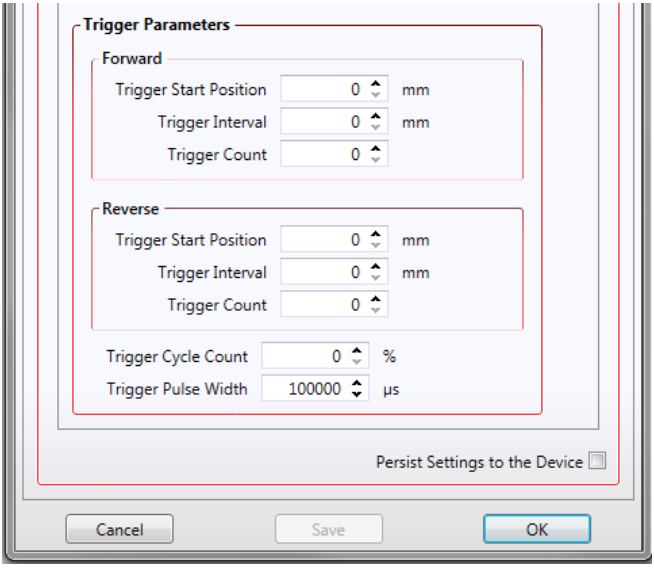
OUT - At Position Steps Rev - Trigger output active (pulsed) at pre-defined positions moving backwards. Only one Trigger port at a time can be set to this mode. See Trigger Out Position Steps for further details.

OUT - At Position Steps Both - Trigger output active (pulsed) at pre-defined positions moving forwards and backward. Only one Trigger port at a time can be set to this mode. See Trigger Out Position Steps for further details.

Trigger Out Position Steps

Note

If the trigger mode is not set to one of the three position modes described previously, then the following parameters are not applicable and will be hidden.



As soon as a position triggering mode is selected on either of the I/O ports, the port will assert the inactive logic state, set in the Trigger Polarity parameters.

As the stage moves in its travel range and the actual position matches the position set in the Trigger Start Position parameter, the TRIG port will output its active logic state. The active state will be output for the length of time specified by the Trigger Pulse Width parameter, then return to its inactive state and schedule the next position trigger point at the Trigger Start Position value plus the value set in Trigger Interval parameter.

Thus when this second position is reached, the TRIG output will be asserted to its active state again. The sequence is repeated the number of times set in the Trigger Count parameter.

When the number of pulses set in the Trigger Count parameter has been generated, the trigger engine will schedule the next position to occur at the position specified in the Reverse Trigger Start Position parameter. The same sequence as the forward direction is now repeated in reverse, except that the Reverse setting parameters apply. When the number of pulses has been output, the entire forward-reverse sequence will repeat the number of times specified by Trigger Cycle Count

parameter. This means that the total number of pulses output will be Trigger Cycle Counts x (Forward Trigger Count + Reverse Trigger Count).

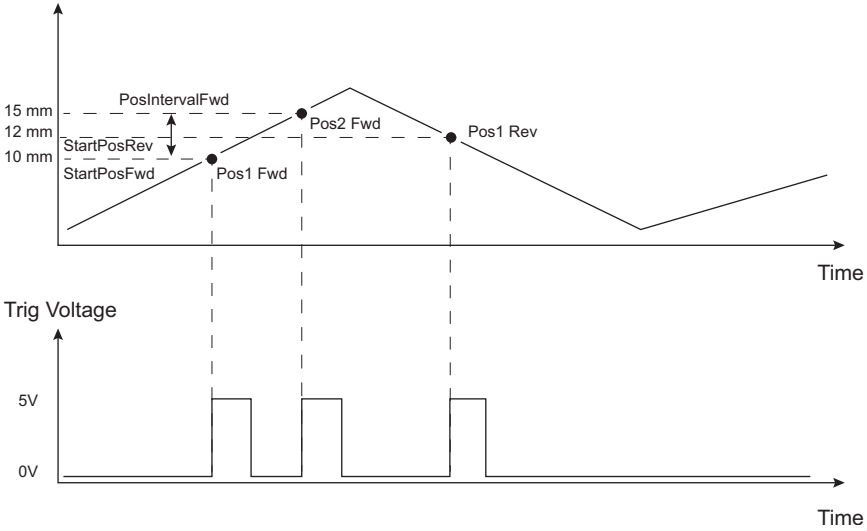


Fig. 6.8 Position Steps Triggering

Example for a move from 0 to 20 mm and back.

In forward direction: The first trigger pulse occurs at 10 mm (StartPosFwd), the next trigger pulse occurs after another 5 mm (PosIntervalFwd), the stage then moves to 20 mm.

In reverse direction: The next trigger occurs when the stage gets to 12 mm.

Note that position triggering can only be used on one TRIG port at a time, as there is only one set of position trigger parameters.

I/O Polarity

The polarity of the trigger pulse is specified in the *I/O 1 Polarity* and *I/O 2 Polarity* parameters as follows:

Trigger High - The active state of the trigger port is logic HIGH 5 V (trigger input and output on a rising edge).

Trigger Low - The active state of the trigger port is logic LOW 0 V (trigger input and output on a falling edge).

6.3.7 Triggering Latency

The detection of whether a trigger condition has occurred is carried out periodically at 102 µs intervals. As a result, there is a maximum 102 µs delay between the condition occurring and the trigger output being updated. The following timing diagram illustrates this latency:

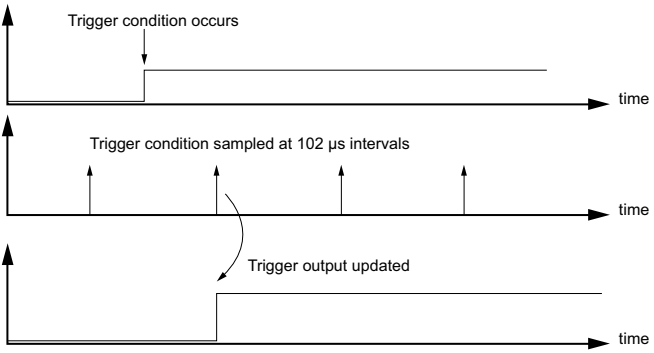


Fig. 6.9 Triggering Latency

6.3.8 Defaults

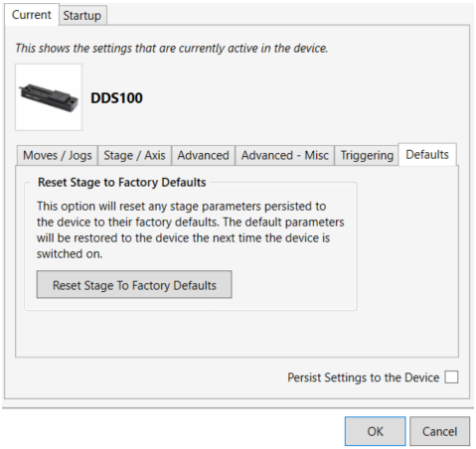
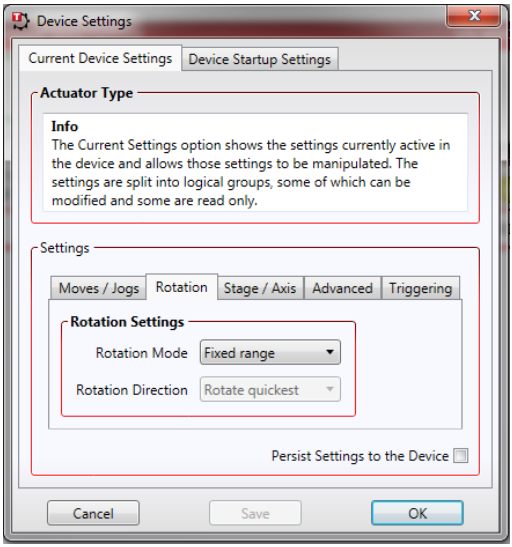


Fig. 6.10 Defaults Tab

This option will reset any device parameters persisted to the device to their factory defaults. The default parameters will be restored to the device the next time the device is switched on.

6.3.9 Rotation StagesTab



Rotation Mode

This setting relates to the way in which the angular position is displayed on the GUI panel. There are three options:

Fixed Range - The angular rotation is limited to 360° i.e. one revolution.

Equivalent Angle – The maximum displayed position is 359.99°. If a stage is driven past the 360° rotation point, the display reverts back to zero and counts up to 360° again.

Total Angle – The total angular rotation is displayed, e.g. for a movement of two full rotations plus 10°, the display will show 730°.

Note. The following parameters are applicable only if the Rotation Mode is set to 'Equivalent Angle'.

Rotation Direction

This setting specifies the move direction. There are three options:

Rotate Forwards – The move is performed in a positive direction

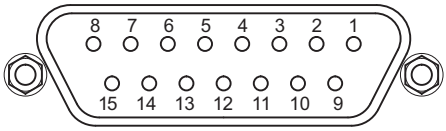
Rotate Reverse - The move is performed in a negative direction

Rotate Quickest - The move is performed in the quickest direction

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.



Pin	Description	Pin	Description
1	Quadrature A-	9	GND
2	Quadrature A+	10	Motor Phase C
3	Quadrature B+	11	Motor Phase A
4	Quadrature B-	12	Motor Phase B
5	Encoder Index I-	13	+5 V
6	Encoder Index I+	14	GND
7	Negative Limit	15	Stage ID
8	Positive Limit		

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

Shock Warning

The equipment contains no user serviceable 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.

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

Warning

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

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

Appendix C Specifications

C.1 Specifications

Parameter	Value
Drive Connector	15-Pin D-Type, Female (Motor Phase Outputs, Stage ID Input)
Peak Current Output	2 A
PWM Frequency	40 kHz
Operating Modes	Position, Velocity
Control Algorithm	16-bit Digital PID Servo Loop with Velocity and Acceleration Feedforward
Motion Profile	Trapezoidal
Position Count	32 Bit
Position Feedback	Incremental Encoder
Encoder Bandwidth	2.5 MHz/ 10 M Counts/sec
Encoder Supply	5V
Input Power Requirements	
Voltage	14.5 - 15.5 V Regulated DC
Current	2 A Peak
General	
Housing Dimensions (W x D x H) (excluding buttons and baseplate)	60 mm x 60 mm x 47 mm (2.36" x 2.36" x 1.85")
USB Connector Type	USB 3.0
USB Connection Speed	USB 1.1 Full Speed (12 Mbps)
Instrument Weight	160 g (5.5 oz)
Compatible Motors	
Type	• 3-Phase DC Brushless Motors
Rated Phase Currents (Nominal)	100 mA to 2 A

Appendix D Regulatory

D.1 Declarations of Conformity

D.1.1 For Customers in Europe

See Section D.2

D.1.2 For Customers in the USA

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

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

D.2 CE Certificate



EU Declaration of Conformity

Manufacturer: Thorlabs LTD

Address: 204 Lancaster Way, Ely, CB6 3NX

We hereby declare under our sole responsibility that:

Product: **KBD101**

Product description: **K-Cube Brushless DC Servo Driver**

is/are in conformity with the following directive(s):

2014/30/EU	Electromagnetic Compatibility (EMC) Directive
2014/35/EU	Low Voltage Directive (LVD)
2011/65/EU	Restriction of Use of Certain Hazardous Substances (RoHS), including 2015/863

and (harmonized) standards / technical specifications :

EN 61326-1	Electrical Equipment for Measurement, Control and Laboratory Use - EMC Requirements	2013
EN 61010-1	Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use.	2010 + A1:2019 + AC:2019
EN IEC 63000	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances	2018

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

Signed: Keith Dhese

Name: Keith Dhese *On:* 1/8/2025

Position: General Manager

CE

Appendix E Thorlabs Worldwide Contacts

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



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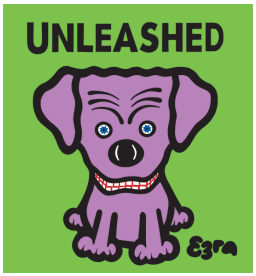
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