BBD301, BBD302, & BBD303 Brushless DC Motor Controllers

Kinesis User Guide

Original Instructions

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Chapter 1 Introduction and Overview

1.1. Introduction

The BBD30x is a family of three Brushless DC Motor Controllers that are ideal for motion control applications demanding high speed (100s of mm/s) and high encoder resolution (<100 nm) operation:

BBD301 Single Channel Controller

BBD302 Two Channel Controller

BBD303 Three Channel Controller

These controllers offer high-precision motion control in a wide range of applications, and in particular when used along with our DDS series fast translation stages, where speeds of up to 300 mm/sec can be achieved. Designed using the latest digital and analog techniques and with high-bandwidth high-power servo control circuitry, these new controllers are capable of driving a range of rotary and linear brushless 3-phase DC motors at 2.5 A continuous current (4 A peak) and up to 5 A maximum in total.

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

A new feature of the controller is its Ethernet connectivity, allowing full system control at significantly greater distances than available with USB and thus ideal for remote working environments.

Figure 1 BBD303 Three Channel Brushless DC Servo Motor Controller

Operation of the BBD30x Series Controllers is fully configurable (parameterized) with key settings (e.g. PID settings, min and max position values, and limit switch operation) exposed through the associated graphical interface panels.

For convenience and ease of use, movement of stages and adjustment of many key parameters is possible either through direct interaction with the front panel controls (see Chapter 4), or via a PC and virtual graphical panel (see Chapter 5). Furthermore, all such settings and parameters are also accessible through the Kinesis programmable interfaces for automated alignment sequences.

Using the Kinesis® software, PID control loop values can be adjusted for a particular application, minimum and maximum position values can be entered to suit different stages as required, and limit switch configuration is accommodated through a flexible set of limit switch logic settings. Moreover, relative and absolute moves can be initiated with move profiles set using velocity profile parameters. Similarly, home sequences have a full set of associated parameters that can be adjusted for a particular stage or actuator. For simplicity of operation, the Kinesis 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.

The reference section (Chapter 6) covers all operating modes and parameters in detail.

1.2. Kinesis Software Overview

1.2.1. Introduction

As a member of the Thorlabs range of controllers, the BBD30x series DC motor controllers share many of the associated software benefits. This includes USB connectivity (allowing multiple units to be used together on a single PC), fully featured Graphical User Interface (GUI) panels, and extensive software function libraries for custom application development. These features are also available when using the new Ethernet connectivity that is available with the BBD30x controllers.

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 'out-of-box' operation without the need to develop any further custom software. It provides 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 troubleshooting. The Kinesis Application Programming Interface (API) is also used by software developers to allow the creation of advanced automated positioning applications very rapidly and with great ease.

1.2.2. Kinesis Graphical User Interface

The Kinesis software suite includes a graphical user interface (GUI), Thorlabs.MotionControl.Kinesis.exe, which is an application capable of simultaneously controlling the BBD30x and other devices. When this application is run, each connected device can be controlled using a dedicated instrument panel. The instrument panel for the BBD30x, which is shown in Figure 2, can both operate and adjust many of the BBD30x's settings, including position, velocity, and PID parameters.

Consider the control supplied for the BBD30x Brushless DC Servo Controller unit:

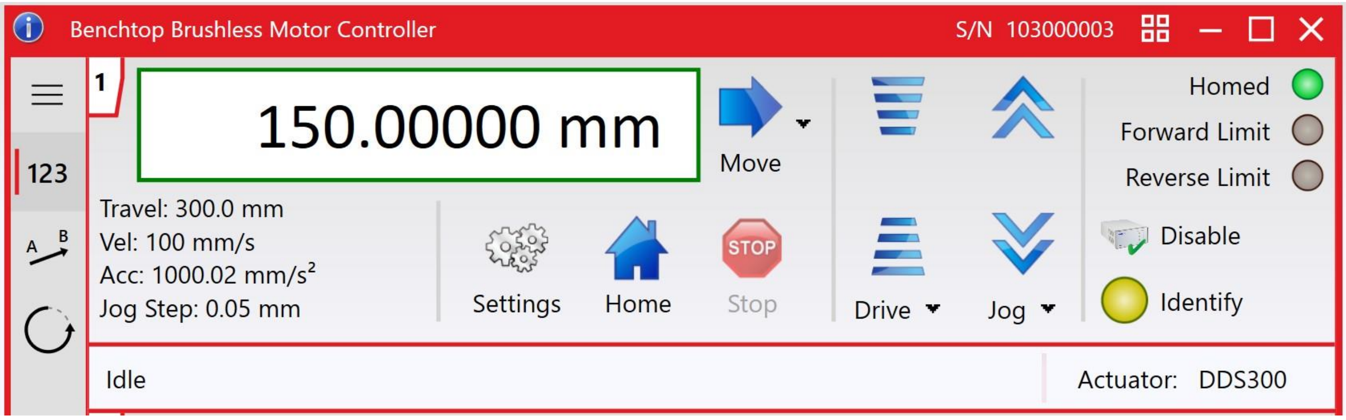


Figure 2 Standard PC GUI with Kinesis

Updates to the instrument panel take place automatically and provide information about the current operating state of the associated device. The operating state will update in the GUI regardless of whether the change was made by interacting with this panel, pressing buttons on the front panel of the controller, or by a different program based on the Kinesis API. For example, if a stage moves in response to pressing buttons on the BBD30x's front panel, the progress of the move is reflected automatically by position readout changes on the graphical user interface, without the need for further programming intervention.

See Chapters 5 and 6 for more information about the GUI. In addition, a help file that provides an overview of the GUI can be accessed by pressing Ctrl + F1 while running the application.

1.3. Kinesis Programmable Interface

The individual compiled software controls used to create the GUI are also available for Windows application development. Included are controls used to manipulate image files, connect to the Internet, or simply provide user interface components such as buttons and list boxes. In some cases, the functionality offered by these controls exceeds that provided by the GUI described in Section 1.2.2.

Within the Kinesis software suite, .Net controls are deployed to allow direct control over (and also reflect the status of) the range of electronic controller units, including the BBD30x series controllers. 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 Microsoft Office applications such as Excel and Word via VBA.

Each of the controllers has an associated GUI control, which is described in the following chapters. The relationship between the GUI, the underlying .Net messages, and custom applications created using the controls is illustrated in Figure 3.

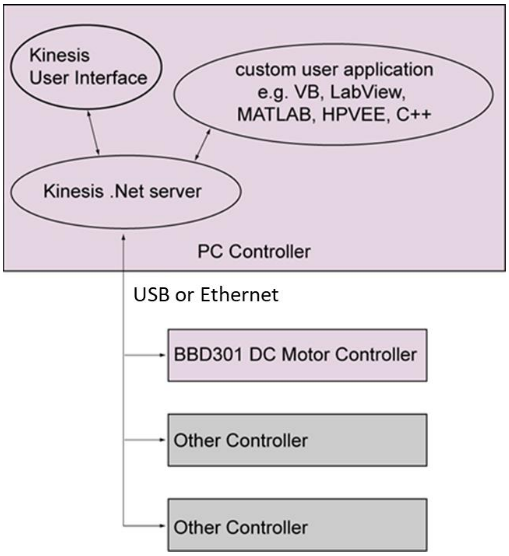


Figure 3 System Architecture Diagram

For more information, see Chapter 6, as well as the on-line help file and example applications. The available commands are also described in the programming reference available from the "Communications Protocol" tab in the Software Download section of the website (https://www.thorlabs.com/software_pages/ViewSoftwarePage.cfm?Code=Motion_Control)

1.4. Software Upgrades

Thorlabs operate a policy of continuous product development and may issue software upgrades as necessary. The latest software can be downloaded from the ‘Services’ section of www.thorlabs.com.

1.5. Ethernet Connectivity

The Ethernet interface on the BBD30x controllers supports communication via TCP/IP. All commands have the same format and the bytes exchanged between the controller and the control PC are the same regardless of whether the underlying physical interface is USB or TCP/IP (Ethernet).

The current implementation only supports DHCP (Dynamic Host Configuration Protocol) and uses Port number 40303. The local DHCP server assigns the controller IP address, and all IP addresses are IPv4 (rather than IPv6).

It may be useful to configure the DHCP server to reserve a particular IP address for the BBD30x unit; this will prevent scenarios where the device appears offline due to the DHCP server assigning a different IP address to the unit when the lease expires.

Chapter 2 Safety

2.1. 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.

Warning: Risk of Electrical Shock

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.

2.2. General Warnings

Warning

If this equipment is used in a manner not specified in the handbook, 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.

The equipment is for indoor use only.

When running custom move sequences, or under fault conditions, the stage may move unexpectedly. Operators should take care when working inside the moving envelope of the stage.

Chapter 3 Installation

3.1. Installing the Software

Caution

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

If you experience any problems when installing software, contact Thorlabs on

+44 (0)1353 654440 and ask for Technical Support.

DO NOT CONNECT THE STAGE TO YOUR PC YET

1) Download the Kinesis software. Thorlabs.com/Products/Software Downloads or https://www.thorlabs.com/software_pages/ViewSoftwarePage.cfm?Code=Motion_Control

2) Run the .exe file and follow the on-screen instructions.

3.2. Mechanical Installation

3.2.1. Siting

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

Caution

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

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

3.2.2. Environmental Conditions

Warning

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

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

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

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

The unit must not be used in an explosive environment.

3.3. Electrical Installation

Warning

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

3.3.1. Connecting the Supply

Warning: Risk of Electrical Shock

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

Use only power supply cables supplied by Thorlabs, other cables may not be rated to the same current. The unit is shipped with appropriate power cables for use in the UK, Europe and the USA. When shipped to other territories the appropriate power plug must be fitted by the user. Cable identification is as follows:

Brown Live

Blue Neutral

Green/Yellow Earth/Ground

3.3.2. Fuses

Two T 3.15A/250VAC anti-surge ceramic fuses are located in the fuse drawer on the mains inlet panel, one for the live feed and one for the neutral as follows:

Fuse	Rating	Type	Fused Line
F1	T 3.15 A	Ceramic; Antisurge	Live Feed
F2	T 3.15 A	Ceramic; Antisurge	Neutral Feed

When replacing fuses:

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

2) Always replace broken fuses with a fuse of the same rating and type. It is good practice to replace both fuses when a fuse blows.

3.3.3. Rear Panel Connections BBD301

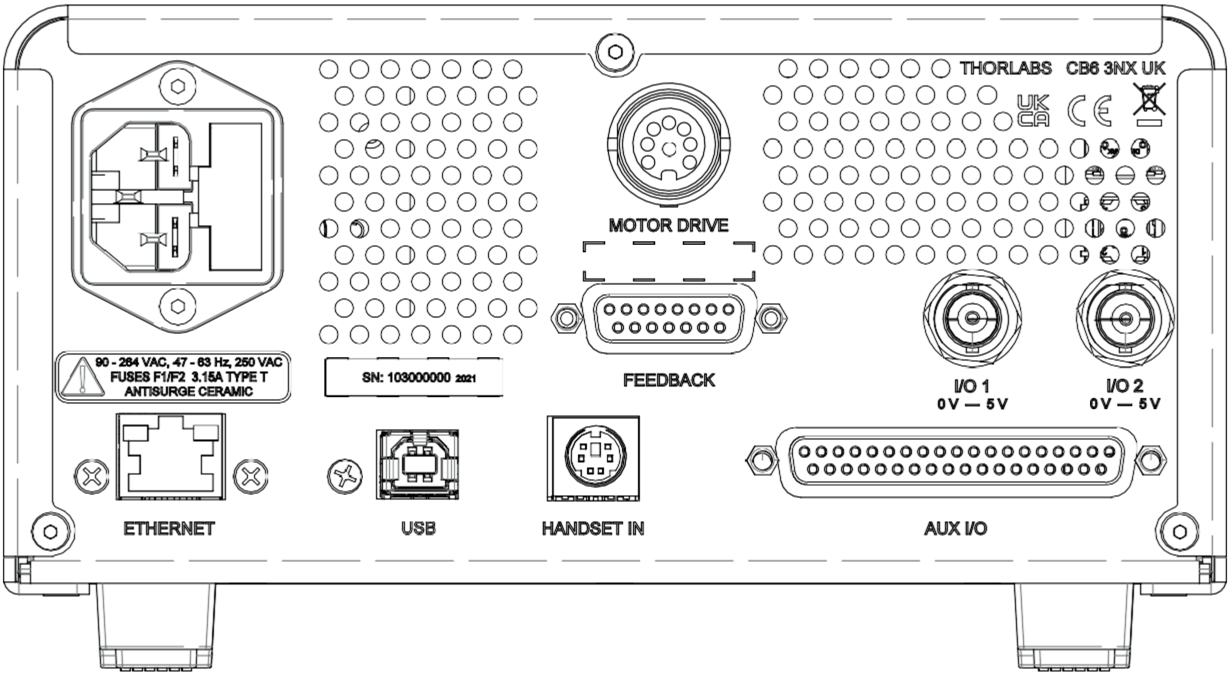


Figure 4 BBD301 Rear Panel Connections

MOTOR DRIVE - Provides all phase current drive connections to the DC motor actuators, via a female 8-pin DIN connector – see Section 8.1.

FEEDBACK - 15-pin female D Connector. Provides connection for the position encoder feedback signals - see Section 8.2.

I/O 1 and I/O 2 – BNC connectors for use with external trigger input signals (5V TTL levels) – see Section 3.3.5.

ETHERNET - For use in Ethernet communications.

USB - USB port for system communications.

Note

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

HANDSET IN - Provides connection, via a female Mini-DIN, for the MJC001 2-Axis Joystick - see Section 8.4.

AUX I/O - 37-pin female DIN Connector. The AUX I/O connector exposes a number of internal electrical signals. For convenience, a number of logic inputs and outputs are included, thereby negating the need for extra PC based IO hardware. Using the Kinesis support software, these user programmable logic lines can be deployed in applications requiring control of external devices such as relays, light sources and other auxiliary equipment. - see Section 8.3. for further details.

3.3.4. Rear Panel Connections BBD302 and BBD303

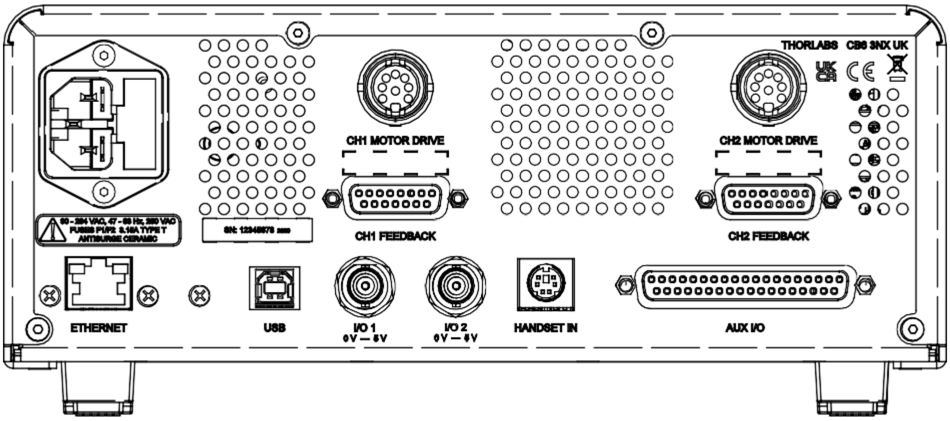


Figure 5 BBD302 Rear Panel Connections

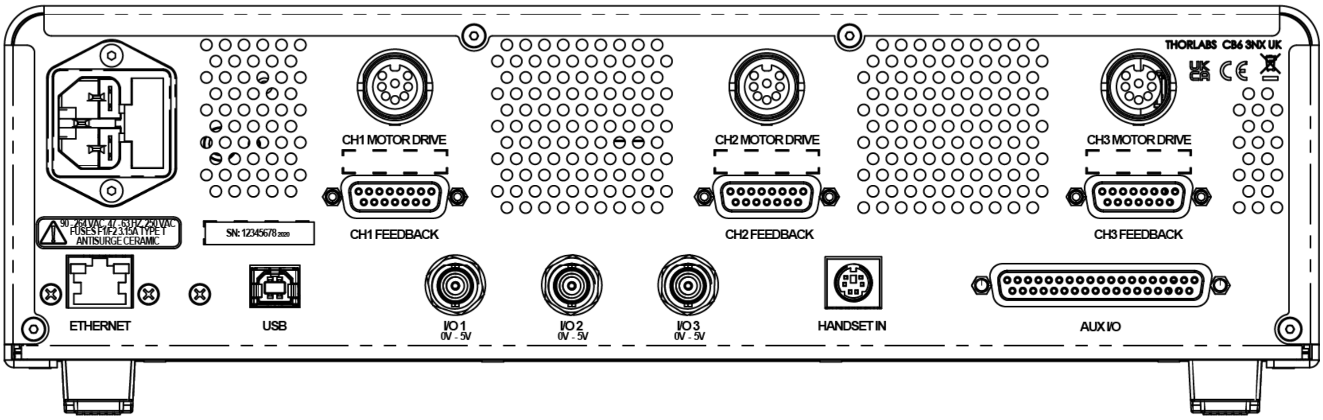


Figure 6 BBD303 Rear Panel Connections

3.3.5. Configuring the Rear Panel BNC I/O Connectors

The BBD30x brushless motor controllers offer additional triggering functions that expand the triggering capabilities of the legacy BBD20X controllers. In the legacy controller family, triggering is

(a) implemented on a per-channel basis, i.e. each motor channel had its own dedicated trigger input and output.

(b) for the inputs, hardware triggering can be used to trigger an absolute, relative and home moves.

(c) the outputs can be asserted when the stage is in motion or reaches its maximum velocity.

The BBD30x controllers expand this functionality and add the following features:

(a) For ease of connectivity, the main trigger features are brought out on BNC connectors. This allows the use of off-the-shelf BNC cables for connecting to external equipment rather than having to interface to D-type connectors.

(b) The trigger inputs and outputs are not hard wired to a particular I/O connector. In input mode, the same connector can be used to trigger multiple motor channels. In output mode, any I/O connector can be used to output a trigger signal from a motor channel.

(c) Low latency position triggering has been added. This operates at the speed of the hardware signals involved, offering delays measured in tens of nanoseconds.

(d) An analogue monitor feature has been added, allowing various system variables to be monitored using an external oscilloscope.

A block diagram of the BBD30x BNC trigger I/O is shown below:

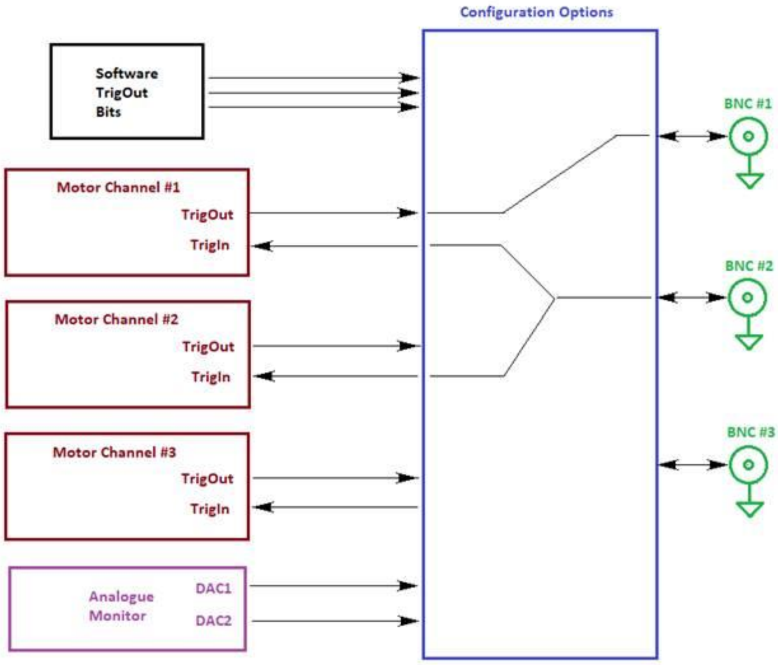


Figure 7 BBD30x BNC trigger I/O Schematic

Main features:

- Each BNC port can be configured to be a digital input, a digital output or an analogue monitor output (only on BNC #1 and BNC #2).
- Each motor channel also has a trigger input and a trigger output signal.
- When a BNC I/O port is configured as an input, its signal can be routed to any one or more motor channels. This, for example, as shown above, BNC #2 is routed to both Motor Channel #1 and Motor Channel #2.
- When configured as an output, the BNC I/O port can be driven by any of the motor channels (but only one, in order to avoid the possibility of conflicts between different motor channels driving the same output).
- When configured as an analogue monitor, the BNC I/O port can be used to output an analogue voltage in the range of 0 to +5V. This can be assigned to a number of system variables and provides a very low latency way of monitoring the state of the system as the signal follows any changes to the system variable at the speed of the hardware. For example, absolute position can be monitored to aid PID tuning.

The BBD301 and BBD302 controllers provide two BNC trigger I/O ports whereas the BBD303 provides three.

The configuration of the BNC I/O connectors and the associated motor channels is detailed in Section 6.4.1

3.4. Front Panel Controls and Indicators

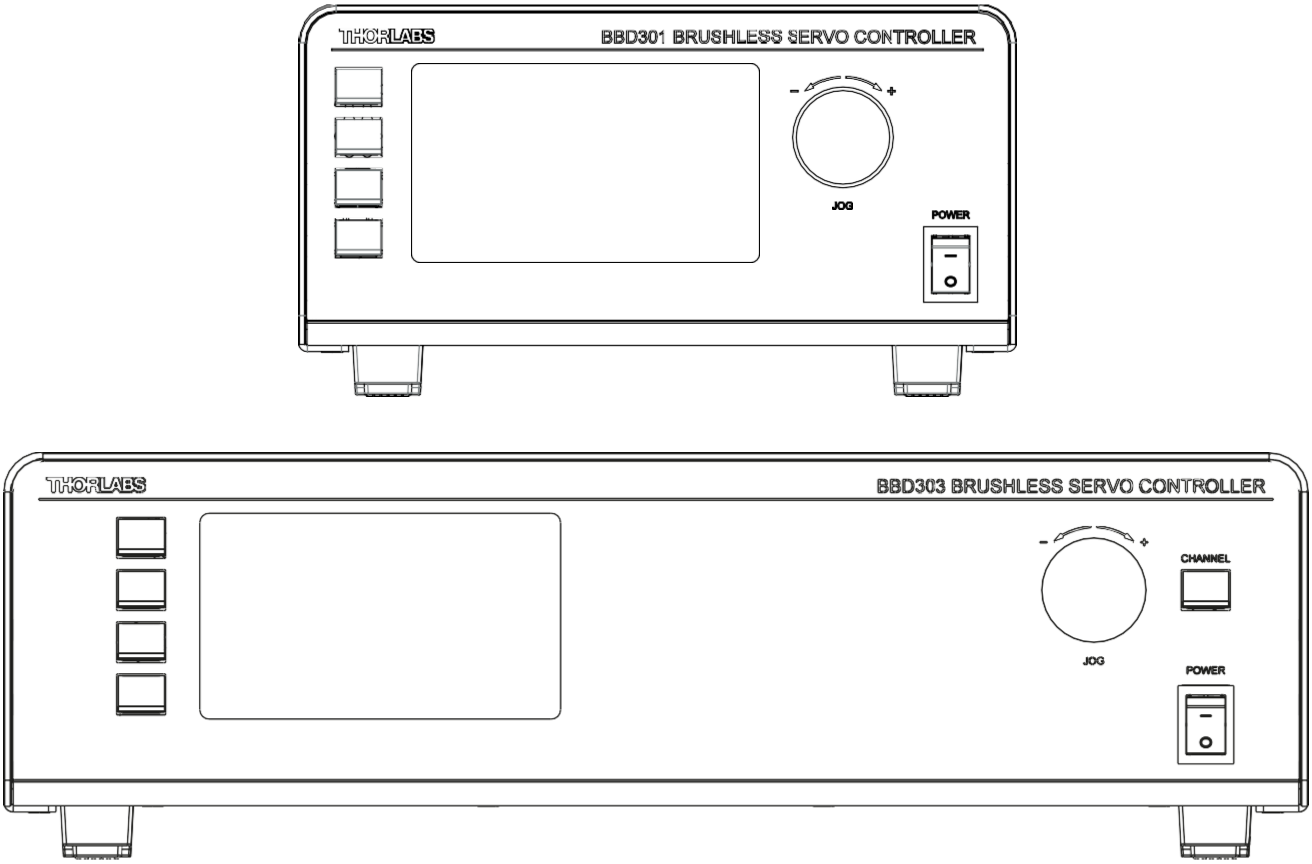


Figure 8 Front Panel Controls and Indicators

Power - Rocker switch to turn power ON and OFF.

Jog Knob - Used to initiate moves in normal operation.

Main Display - In normal operation the display shows channel information, such as axis position and stage type connected. In set-up mode the display allows various parameter settings to be changed - see Chapter 4.

Buttons – The buttons on the left are used to manually communicate with the BBD30x via information provided in the corresponding position on the screen - see Chapter 4.

Channel – BBD302 and BBD303 only; located above the power switch. Used to toggle between the various channels connected.

3.5. Connecting the Hardware and Powering Up

Follow the set procedure for powering up, as described below. Specifically, a stage must only be connected to and disconnected from a controller that is powered down.

1) Install the Software - see Section 3.1.

2) Connect the stage to the Controller unit using the Motor Drive and Feedback cables supplied.

3) Connect the Controller unit to your PC using the USB connection.

Note

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

4) Connect the Controller unit to the power supply and switch 'ON'.

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

5) Wait for around 10 seconds for the initialization phase to complete.

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.

If using USB connectivity, automatic recognition will allow the Kinesis GUI to be displayed – see steps 6 & 7. If using Ethernet connectivity, some extra steps need to be taken – see section 3.5.1.

6) (USB only). Run the software and first click "Enable" followed by the 'Home' button on each GUI panel. When homing is complete, the Channel Enable LEDs on the controller GUI front panel stop flashing.

7) The stage can now be moved using the GUI panel, or by sending commands to move each axis by relative and absolute amounts – see the help-file supplied with the Kinesis API for more information.

3.5.1. Extra steps needed for Ethernet Connectivity

If using Ethernet connectivity, the controller is not currently auto detected by Kinesis and the IP address, assigned by the local DHCP server, needs to be manually inserted before continuing.

Run Kinesis after connection and power up, then press the Connect button on the display that appears (top left, Figure 9a) followed by Find Device (bottom left, Figure 9a). The IP address of the controller can now be inserted (in this case, 10.26.11.24). The address is available directly from the front LCD display (Figure 9b) by pressing "Ch All" then "NEXT" on the front panel controls; for further details see Chapter 4.

Once the IP address has been input, the device will appear in the drop-down list of devices: check and then press "Connect". The Kinesis GUI screen for the controller now appears – see next section.

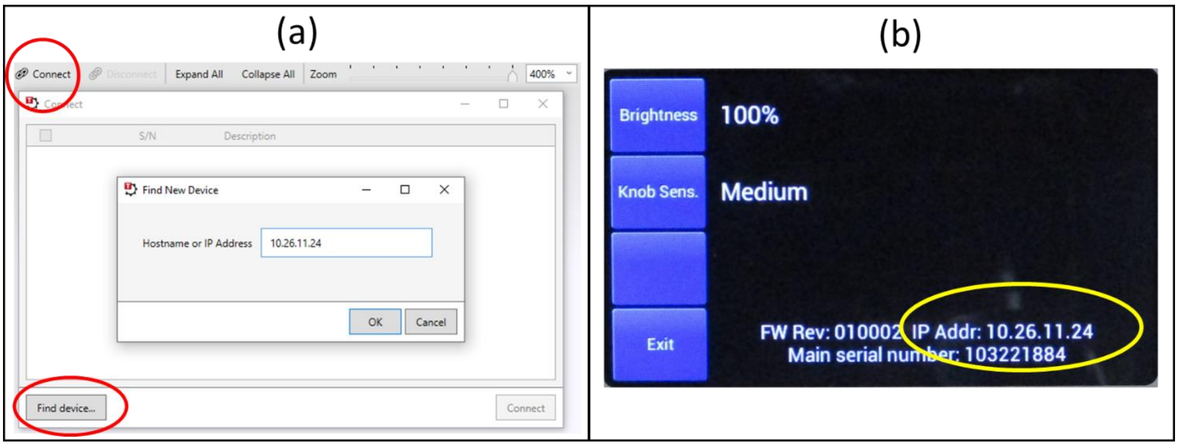


Figure 9 Manually inputting the IP address when connection is via Ethernet

3.6. Updating the Firmware

Caution

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

3.7. Verifying Software Operation

3.7.1. Initial Setup

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

1. Run the software and check that the Graphical User Interface (GUI) panel appears and is active. If needed 'Enable' the motor(s) on the button just above 'Identify'.

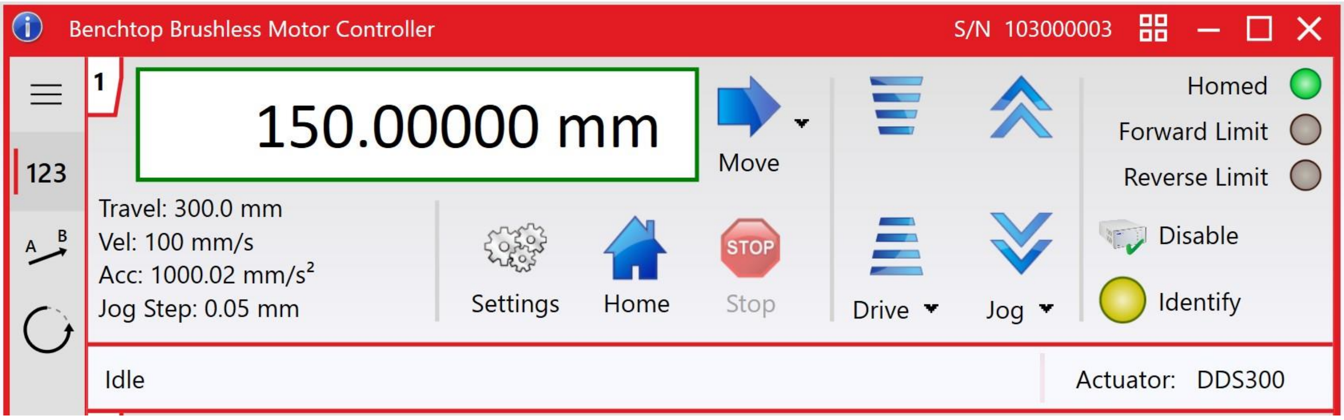


Figure 10 GUI Panel Showing Jog and Ident Buttons

2. Click the 'Identify' button. The display on the front panel of the associated controller flashes. This is useful in multi-channel systems for identifying which driver unit is associated with which GUI.
3. Home the stage.
4. Click the jog buttons on the GUI panel and check that the motor or axis connected to the controller moves. The position display for the associated GUI should increment and decrement accordingly. The default setting for the Jog mode is "Continuous" i.e., clicking the jog buttons will move the stage a distance dependent on the time that passes between clicking and releasing the mouse button. The Jog button behavior can be changed to "Single Step" in the Settings panel, which provides discrete changes in position when a jog button is pressed.

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

Chapter 4 Operation from the Front Panel

4.1. Introduction

The BBD30x can be used to drive attached stages directly via the front panel controls and display screen, without the specific need of a computer connection and its peripheral software; only a mains power connection is needed, together with electrical connections to each stage (15-pin D plug, and 8-pin DIN plug for each stage). However, the fullest functionality is available if the front panel is used in conjunction with Kinesis software - described in more detail in Chapter 5 - and this will need a USB connection to the computer.

This section describes the functionality and use of stage control via the front panel of the BBD30x controller. Throughout the chapter, examples are given assuming linear stages are being addressed. For rotary stages, the same functionality is available (so replace linear speed/acceleration/position with their angular counterparts). Any differences are specifically addressed in section 4.9.

Caution

There is maximum stage velocity at which the encoder can operate (which is motor-dependent). 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 BBD30x controller, the maximum velocity is limited to safe values. However, if the

Motor output is disabled (with the controller connected and monitoring the encoder position) and the stage is moved by hand at high speeds, it is possible to exceed this limit. If the controller is subsequently used again to move the stage, the incorrect encoder reading will cause incorrect operation, often resulting in sudden uncontrolled moves. It is therefore important not to move the stage excessively quickly when it is moved by hand.

The BBD controller has fault monitoring to detect the loss of encoder pulses. If this fault occurs, an error message will be generated, and the controller must be powered down and re-started so that correct phasing and commutation can be re-established.

4.2. Front Panel Menu Index

The front panel main page, active on startup, allows intuitive access to an array of sub-pages that provide information on the system status and parameters, the possibility to set and change parameters, and the ability to control the attached stages. Figure 11 below provides an index of these pages (and where they can be accessed). More details can be found in sections 4.3 to 4.8.

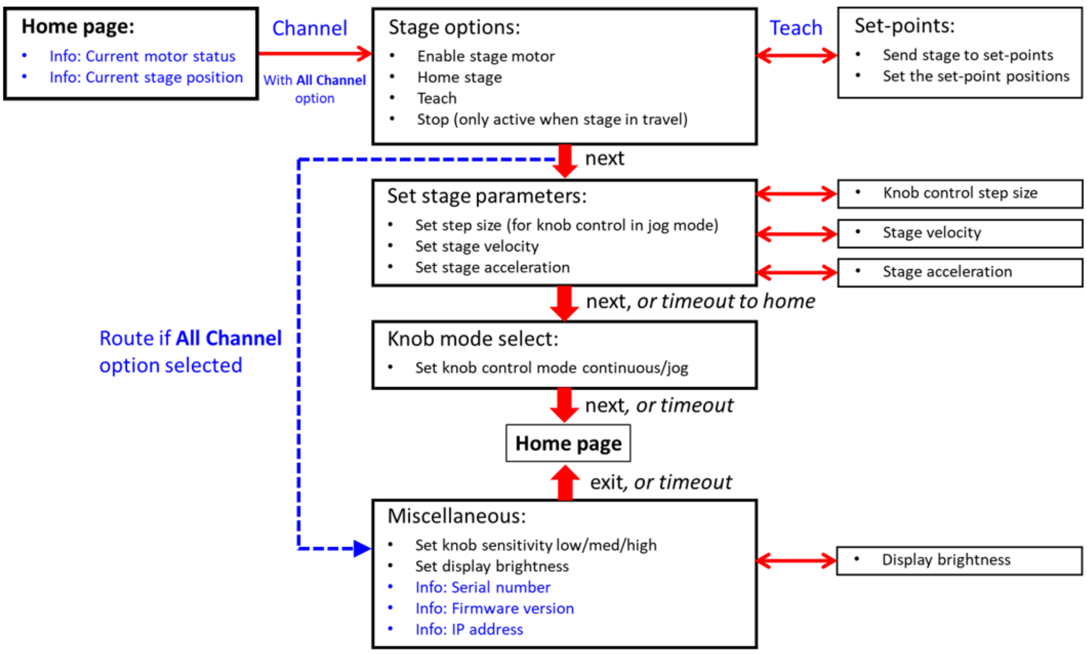


Figure 11 Front Panel Display Pages Map

4.3. System Startup

On powering up the controller for the first time, the BBD30x first initializes (Figure 12a) and retrieves information from the stages connected, which is then displayed in the appropriate channel on the front panel home page. An example is shown in Figure 12b for a Thorlabs DDS220 linear stage. Where more stages are attached (for example when using a BBD302 or BBD303), information is also displayed in the Ch 2 and Ch 3 spaces. Note that the stage is disabled after initialization, and it is necessary to enable and then home the stage before using it. To enable an individual connected stage, press the panel button adjacent to the stage's Channel label to select the stage and open its control screen (Figure 12c). Then press the button adjacent to the "Enable" label. The control screen of the enabled stage is shown in Figure 12d. The stage can be disabled again by pressing the button next to the "Disable" label.

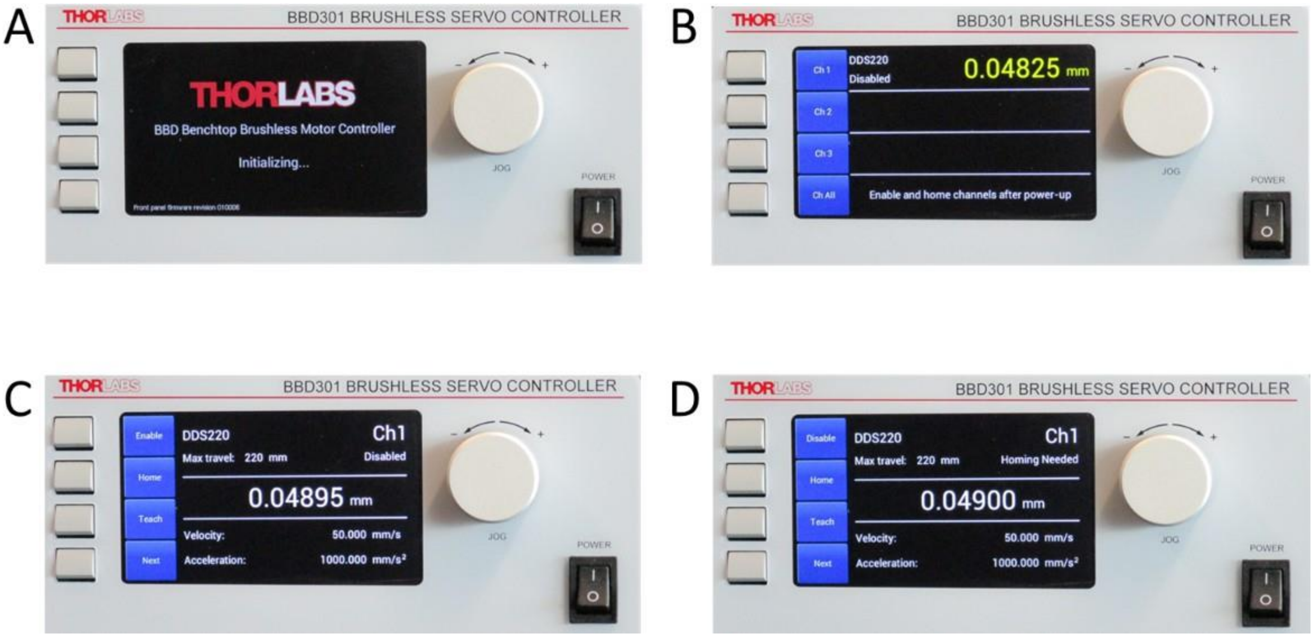


Figure 12 Startup Sequence for BBD301 under Front Panel Control

To home the stage, press the button next to the "Home" label (Figure 12d). During the homing process (Figure 13a), the stage first travels to its encoder calibration position, which is typically an end switch. This is followed by a move to the preset home position. At this point, the stage is ready for use (Figure 13b)."

Note that it is also possible to enable and then home all connected stages at the same time. To enable all at once, first press the panel button next to the "Ch All" label (Figure 12b), and then press the button next to the "Enable All" label. Similar to the case in which a single stage is enabled, all stages can be disabled by pressing the button next to the "Disable All" button. Press "Home All" to start the homing procedure for all connected stages at once."

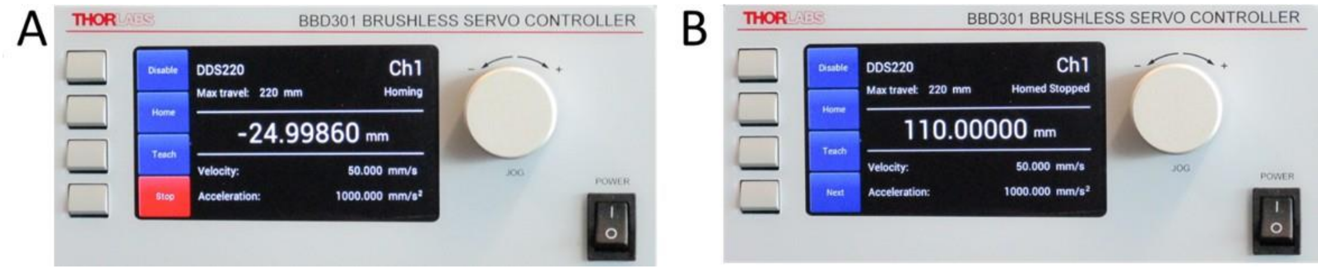


Figure 13 Homing in Operation

Note

During the homing process when the stage is in motion, a red "STOP" sign is illuminated on the display (Fig. 4.3a) and pressing the corresponding panel button will immediately stop the stage's motion; for example, this might be needed in case there is an observed obstruction to the stage's travel. The same applies whenever a motor is in motion. If there are 2 or more motors/axes, each axis must be selected and stopped separately.

Important: The stage stops traveling when the “STOP” button is released, not when it is depressed.

Additional information appears on the screen once a particular motor channel is selected, including: Maximum travel, Velocity and Acceleration.

These are default values read from the firmware. The maximum travel is factory set according to the stage being driven, but the velocity and acceleration can be changed via the controller front panel at any time: see Section 4.4.

4.4. Setting Motor Velocity and Acceleration

Individual motor speed and acceleration can be set by first selecting the appropriate channel (which produces a screen similar to Figure 13b) then scrolling to the next page by pressing the lowest control panel button adjacent to "Next". This brings up a screen similar to Figure 14a, where Step Size, Velocity and Acceleration can all be changed. Step Size relates to stage movement when the knob control is operating in jog mode - see Section 4.5. for further details. However, in all cases, the method of changing the parameters is the same: select what needs to be altered (e.g. Velocity in Figure 14b), then use "+/-" buttons to increment/decrement the number indicated by the cursor. The cursor position is changed by the Resolution button at the bottom. When finished, press Enter (top button).

Note: This page times out after 20 second of inactivity.

Note: The controller will prevent the inputting of parameters that are outside the permitted range of the device in question. If required, these parameters can be viewed via the PC GUI described in Chapter 5.

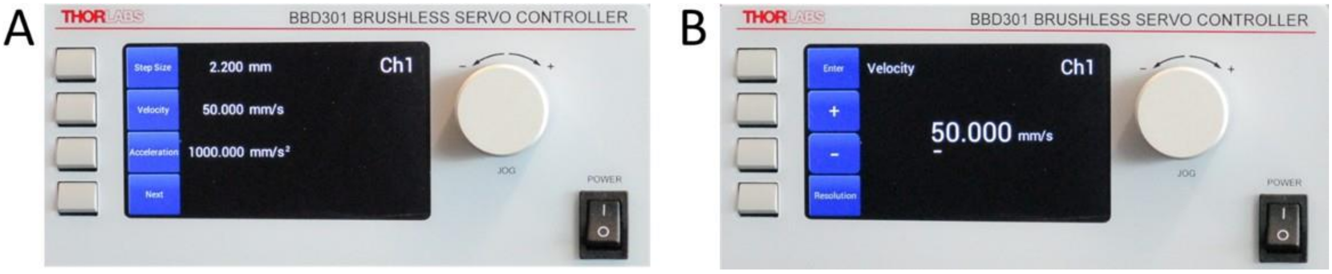


Figure 14 Changing Motor Parameters

4.5. Moving the Stage

Moving motorized stages using the BBD30x front panel buttons is simple, and can be done via two methods:

1) By using pre-selected positions (up to 3) found under the "Teach" tab. In this mode, the stage travels directly to the requested position at the speed/acceleration currently loaded into the firmware. Simply press the button corresponding to Position 1/2/3 to send the stage to that point. See Section 4.6. on how to change these set-points.

2) By using the control knob on the front panel to increment/decrement the stage position. There are two options for how this is done:

    - Jog Mode, whereby turning the control knob allows motion in either direction, one step at a time: keep turning the knob for further steps. Allow the knob to return to its zero potion, and twist again for more steps.
    - Continuous Mode, whereby turning the control knob allows motion in either direction, one step at a time. To initiate a jog, twist the knob in the desired direction. The stage will move as soon as torque is applied. Release the knob to allow it to return to its zero position and twist it again to initiate another jog step.

See Section 4.7. for how the control knob functionality can be changed.

4.6. The Teach Facility: Inputting Stage Set-Points

On the title page of any chosen motor channel, the Teach facility is directly available (3rd button down - see Figure 13b). Pressing this reveals a page similar to that shown in Figure 15a, where the current set-points are indicated. Pressing Pos1/Pos2/ Pos3 will send the stage to those points. The positions are reset to factory defaults when the controller is powered down.

However, if an alternative set-point position is required, move the stage into the desired position (the current position is indicated on the screen on the right-hand side, even when the stage is moving). Note that the control knob can be used to move the stage into position. Then hold down the button corresponding to the position that needs to be set. Wait for the white progress bar in the bottom right-hand corner to complete (see Figure 15b), and the button can now be released. The new set-point should then appear on the panel, and this will now have been loaded into the firmware for future use. When finished, press 'Exit'.

Note that if precise calibration positions are required, this may be better achieved through the Kinesis software control option, described in Chapters 5 and 6.

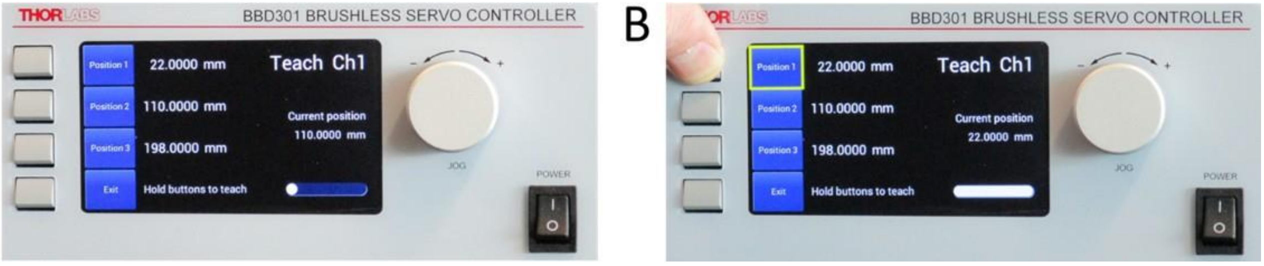
A B


Figure 15 Stage position Set-points and Changing them via Teach

4.7. The Knob Control: Setting Functionality

As noted in Section 4.5. the knob can control the motor stage position in either continuous-motion (default setting) or jog mode; speed is set in the Set Stage parameters page (Figure 14a). The choice of continuous vs. jog action is set via toggle action in the knob mode page (Figure 16a).

As seen from the page index overview (Figure 11), the knob function (continuous vs. jog mode) must be set for individual motors and cannot be set for all stages simultaneously.

Note: this page times out after 20 second of inactivity.

A B


Figure 16 Setting the Front Panel Knob Control Function

4.8. Miscellaneous: Screen Brightness, Knob Sensitivity, Firmware Version, IP Address, Serial Number

The final Miscellaneous screen (Figure 16b) (accessed by pressing CH All/Next/Miscellaneous) allows setting of the knob sensitivity (toggle between low, medium, and high); as this is applied to all stages, the page can only be accessed via the All Channels route (see page index in Figure 11).

The screen brightness (1-100%) control is also found on this page and is useful for operating the controller in a variety of lighting conditions. Selecting the button next to Brightness allows the change to be made in similar fashion to stage velocity (Figure 14b).

The screen also provides information on Firmware version currently uploaded, Controller Serial Number and IP address of the controller.

Note: this page times out after 20 second of inactivity.

4.9. Comments on Rotary Stages

For rotary sages, most of the functionality of the front panel resembles that of linear stages, except:

º replaces mm

º/s replaces mm/s

º/s^2 replaces mm/s^2

The final difference is that, if the knob control is used to move the stage, there is no upper/lower hardware limit to motion; the stages can freely rotate continuously. However, the recorded angle reverts to 0º once 360º is passed (i.e., 370º is read as 10º) and any setting (e.g., in Teach) must be between 0º and 360º.

Chapter 5 PC Operation - Quick Start Guide

5.1. Introduction

The Kinesis software suite includes a graphical user interface. The following provides a brief tutorial of the operation of the stage using the GUI controls, as well as an introduction to parameters that can be configured through the GUI. This chapter assumes that the stage, controller, and computer are connected and powered up as described in Section 3.5, and that the software is already installed (see Section 3.1). The DDS300 Direct Drive Translation stage was used to demonstrate operation.

Warning

The Kinesis 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 software, 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

There is maximum stage velocity at which the encoder can operate (which is motor-dependent). 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 BBD30x controller, the maximum velocity is limited to safe values. However, if the motor output is disabled (with the controller connected and monitoring the position) and the stage is moved by hand at high speeds, it is possible to exceed this limit. If the controller is subsequently used again to move the stage, the incorrect encoder reading will cause incorrect operation, often resulting in sudden uncontrolled moves. It is therefore important not to move the stage excessively quickly when it is moved manually.

The BBD controller has fault monitoring to detect the loss of encoder pulses. If this fault occurs, an error message will be generated and the controller must be powered down and re-started so that correct phasing and commutation can be established.

If this fault occurs when the stage is being controlled via the MJC001 joystick, in the absence of a PC, the red LED on the joystick console is lit, and all operation is suspended until the controller is shut down and rebooted.

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

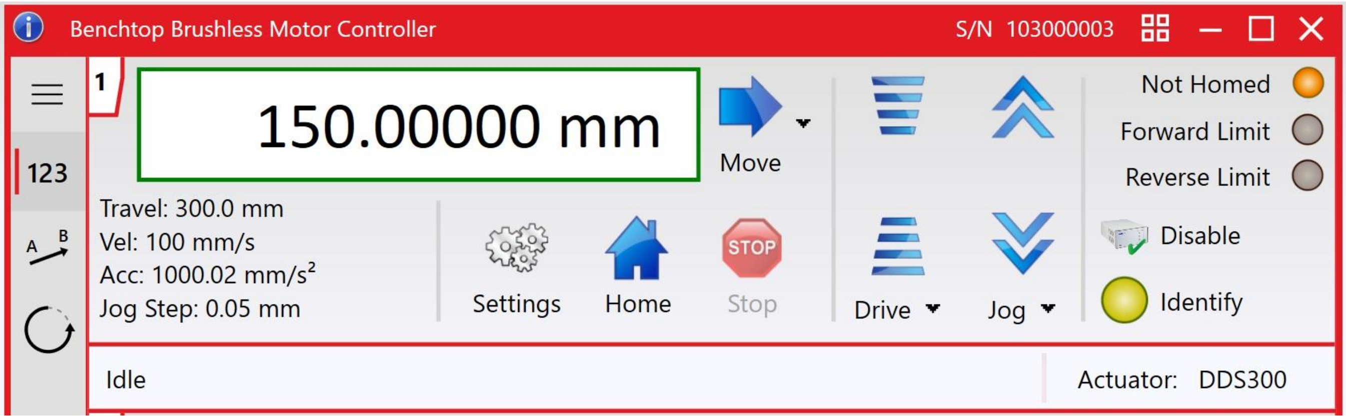


Figure 17 Motor Controller Software GUI

1) If the stage is not enabled, click the 'Enable' button (see Section 5.4).

2) After clicking on ‘Enable’ for first time use (to enable the motor), click the ‘Home’ button. Notice that the ‘Not Homed’ LED changes to ‘Homing’ and flashes green to indicate that homing is in progress.

3) When homing is complete, the ‘Homed’ LED is lit green.

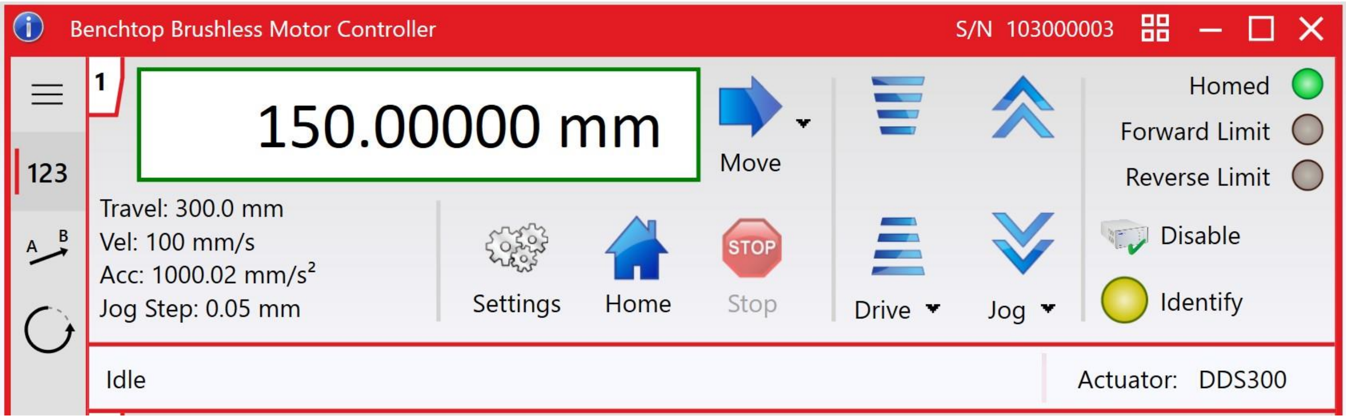


Figure 18 BBD30x GUI - Homed

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.

Note that the Homing function may not work correctly if non-optimal PID settings are active. In this case, it is necessary to disable the stage and adjust the PID settings (Section 5.7)..

5.3. 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.

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

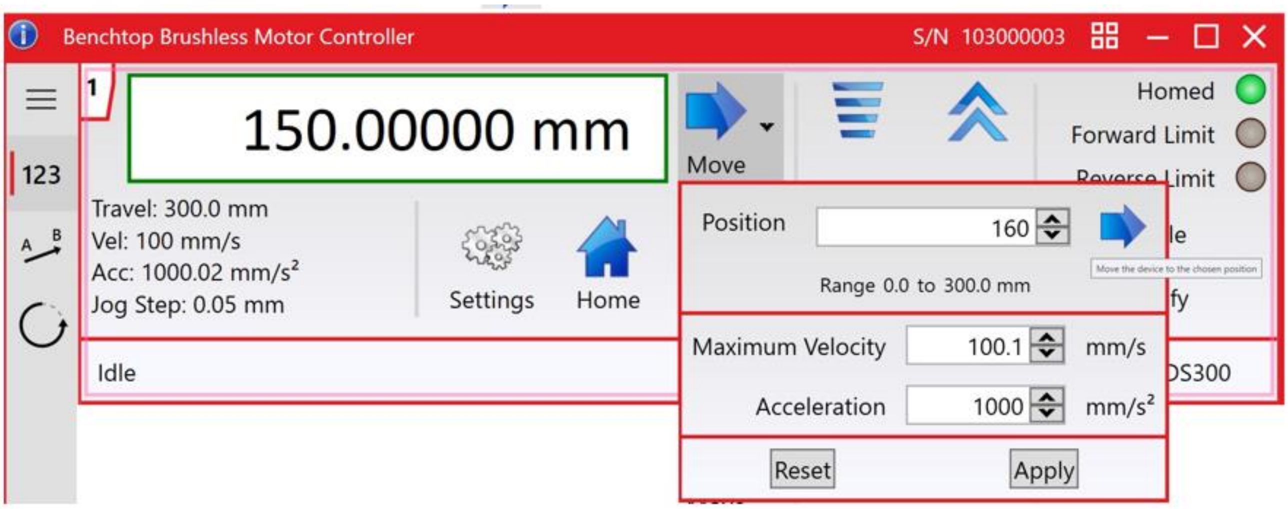


Figure 19 Absolute Position Popup Window

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.

5.4. Disabling, Enabling and Stopping the Stage

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

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

Note that the stop function will not work correctly during a failed Homing operation, if non-optimal PID settings are active. In this case, it is necessary to disable the stage and adjust the PID settings (Section 5.7).

5.5. Jogging and Driving

During PC operation, the motor actuators are jogged using the GUI panel arrow keys. There are two jogging modes available, ‘Single Step’ and ‘Continuous’ (default). In ‘Single Step’ mode, the motor moves by the step size specified in the Step Distance parameter each time the key is pressed. In ‘Continuous’ mode, the motor actuator will accelerate and move at the jog velocity while the button is held down.

Note

There is a range of allowable Jog step sizes, and this range is smaller than the stage's range of travel. If a step size is entered that is larger than the maximum allowed, the border surrounding the step size data entry field will turn red.

If an over-limit step size value is entered, it is important to overwrite this value with a value within acceptable limits. Clicking outside this dialog, without overwriting the over-value limit, will not clear the value and will lead to unpredictable behavior.

Changes made to these parameters in the Kinesis GUI do not update the corresponding parameters used to control Jog movement when the knob on the front panel of the BBD30x box is twisted.

The settings on the front panel of the BBD30x box can be changed within the Kinesis GUI via the "Advanced - Misc." tab in the "Settings" menu, as described in Section 6.4.4.

1) On the GUI panel, click the word ‘Jog’ to display the Settings panel

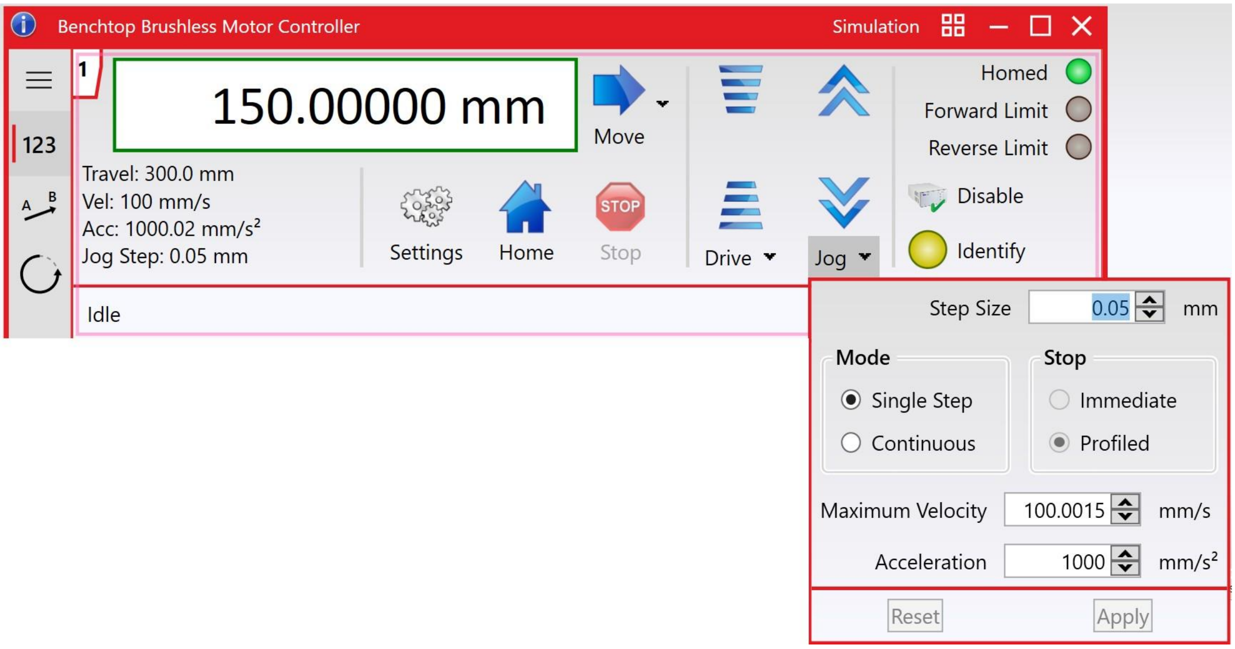


Figure 20 Settings Panel - Move/Jogs Tab

2) Make parameter changes as required.

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

The Drive buttons function similarly to the Jog button, when continuous Jog mode is active. There are eight Drive buttons, in which four move the stage in one direction while the other four move the stage in the opposite direction. The length of the bar corresponds to the velocity of the stage while the button is pressed.

5.6. Setting Move Sequences

The Kinesis GUI 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 Help-file.

Note that the Kinesis help-file can be access from within the GUI by clicking "Help" in the title bar and then selecting "Show Help", or alternatively by Clicking Ctrl+F1

There is a "Sequences" menu in the title bar, and that clicking the "Sequences" button on the right edge of the GUI will open a "Sequences" panel on the right side of the GUI.

5.7. Changing and Saving Parameter Settings

The BBD30x controller's firmware includes default parameter settings for each compatible stage. These default parameter settings are applied when a stage is first connected to the BBD30x. These default values have been chosen to provide safe performance under general operating conditions. However, it is sometimes necessary to optimize parameter values. The majority of these parameters, including velocities, accelerations, and PID parameters, can be changed from within the Kinesis GUI application. To access these parameters, click the Settings button. These settings are described in Chapter 6. Note that it is possible to make most altered settings persist in the Controller, so that these will be applied after power cycling the controller. The Default settings can be restored by clicking the Settings button, selecting the Defaults tab and following instructions.

5.8. Using A Joystick Console

The MJC001 joystick console has been designed for microscope users, to provide intuitive, tactile, manual positioning of the stage. The console features a two axis joystick for XY control, and if the parameter settings are persisted to the controller (see Section 6.4.) the controller need not be connected to a host PC, thereby allowing remote operation.

1) Connect the stage to the Controller unit.

2) Connect the joystick console to the HANDSET IN connector of the controller.

3) Switch ON the controller.

4) Wait until the red led on the joystick console stops flashing (~3 s) and for the controller phase initialization to complete.

5) Press and hold the 'High/Low' button for 2 seconds to home the stage. When homing is complete, the green LED stops flashing.

In order to establish control over a particular axis, the joystick axes must be associated with the corresponding channels of the related controller. This is achieved by setting the joystick ID switch, located on the underside of the joystick console to '0'.

> **Note**
>
> The other settings 1 to F are not required for operation with the BBD30x series, and are reserved for use with earlier, legacy BBD units.

Figure 21 ID switch settings

6) Set the joystick console ID switch to '0' as shown above.

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

Chapter 6 Software Reference: Kinesis GUI Application

6.1. Introduction

The Kinesis software suite includes the Kinesis GUI application, Kinesis API with a library of DLL functions, a simulator, and stand-alone help files for both the GUI and simulator. The Kinesis API , which is discussed in Chapter 7, was used to build the Kinesis GUI. In Chapter 6, the commands and settings available in the Kinesis GUI are discussed in detail.

6.2. GUI Panel

The following screen shot shows the graphical user interface (GUI) panel provided by the Kinesis GUI when a DDS300 stage is connected to the BBD30x controller. This panel will be used to describe the different features of the Kinesis GUI.

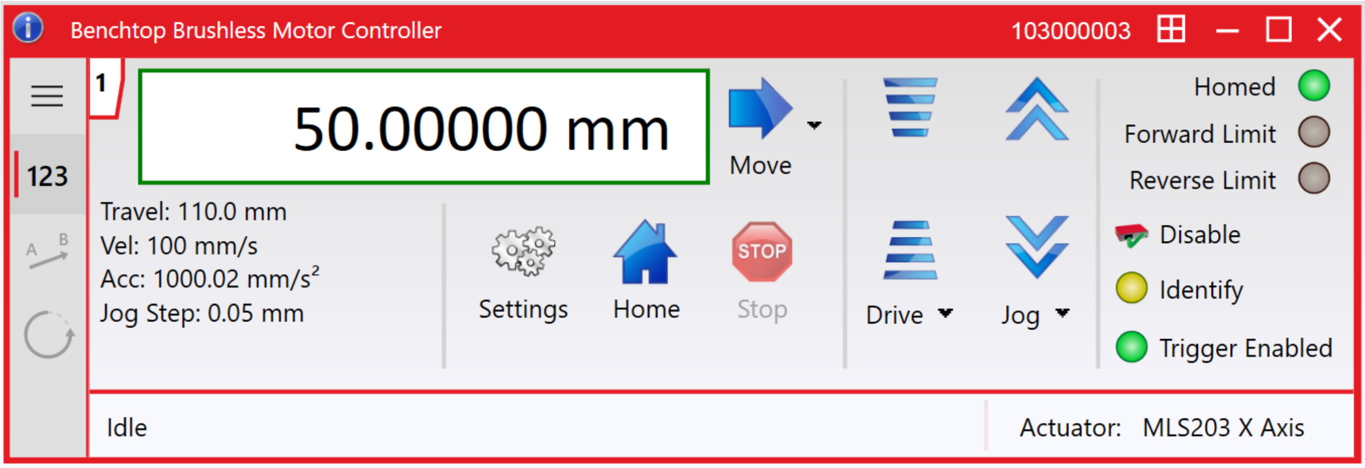
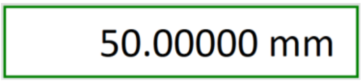


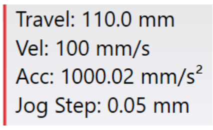
Figure 22 Motor Controller Software GUI

Note

The serial number of the driver card 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 length or angular units) of the motor. The position will not be meaningful until after the stage is homed. After homing, the stage's position is reported relative to a fixed, physical reference point.



Displayed Key Parameters - The four parameters displayed under the left edge of the Position window are the total travel range of the stage, the maximum velocity and acceleration of the stage during a "Move" operation, and the Jog step size. Note that the Jog step size parameter does not apply when the Jog mode is set to "Continuous," which is the default setting.

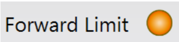
Move - Opens the move settings window. Enter the target position and make any desired modifications to velocity and acceleration parameters. To move to the specified position, click the blue arrow to the right of the position entry field. The current values of the Move function's velocity and acceleration parameters are also shown below the left corner of the Position window.

Drive Controls - Used to increment or decrement motor position. These eight controls are arranged as a bar graph. The controls in the top and bottom groupings increment and decrement the stage position, respectively. Clicking each bar in a group moves the stage at a different velocity, the speed of which is related to the length of the bar. To change any of the four velocity settings, click the button labeled with "Drive" and a down arrow. Note that the velocities can be entered in any order. However, they will be automatically reordered from largest to smallest before being assigned to the controls

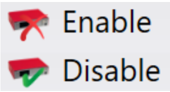
Jog Controls - Used to increment or decrement motor position. The Jog controls are a set of two arrows. The stage position is incremented or decremented by clicking the top or bottom arrow, respectively. There are two Jog modes, "Continuous" and "Single Step," and Continuous mode is the default. When operating in Continuous jog mode, clicking an arrow will move the stage in the indicated direction until the button is released. When operating in Single Step mode, clicking an arrow will move the stage in the indicated direction by an amount specified by the step size parameter.

To adjust any Jog parameter (step size, operating mode, stop profile, maximum velocity, or acceleration) in the Kinesis GUI, click the button labeled with "Jog" and the down arrow. Note that if the entered step size value exceeds acceptable limits, the box surrounding the entry field will turn red. It is important to enter a valid number before dismissing the setting dialog, otherwise the stage can exhibit unexpected behavior when a jog button is clicked. Note also that changes to these Kinesis GUI Jog parameters do not update the corresponding Jog parameters used control stage movement when the control knob on the front panel of the BBD30x is twisted. To update the BBD30x's front panel settings using the Kinesis GUI, please see Section 6.4.4's discussion of the "Advanced - Misc" tab of the "Settings" menu.

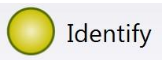
Homed/Not Homed - lit orange when the motor has not been 'Homed' since power up. When the home button is clicked, the caption changes to 'Homed' and the LED flashes while the home move is being performed. The LED is lit green once the move is complete. Under rare circumstances, the homing procedure cannot conclude. In this situation, it is necessary to Disable the stage to exit the homing procedure. Failure to home is a rare problem that is typically resolved by optimizing the PID parameters (see Section 6.4.3).



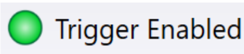
Limit Switch - lit when a Forward or Reverse limit switch is activated, i.e. the motor is at its end stop.



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 display on the front panel of the associated hardware unit will flash for a short period.

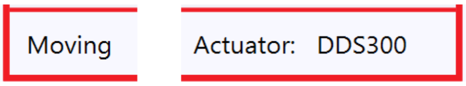


Trigger Enabled – Enables and disables the position trigger function. When the LED is lit, the position trigger is enabled – see Section 6.4.8.

Settings - Displays the 'Settings' panel, which allows the operating parameters to be entered for the motor drive - see Section 6.4.

Home - sends the motor to its 'Home' position - see Section 5.2.

Stop - halts the movement of the motor. Under the rare circumstance when the stage fails to home, "Stop" cannot be used to exit the homing procedure. Instead, the stage should be disabled and the PID parameters adjusted (see Section 6.4.3).



Lower Display - Shows the present state of the motor, e.g. Idle, Moving, or Homing.

Also shows the part number of the associated actuator or stage.

6.3. Synchronized Moves

On BBD302 2-Axis and BBD303 3-Axis controllers, it is possible to perform synchronized moves by clicking the button to 'group' the channels. When this button is clicked, the Vector button and the path button become active.

6.3.1. Entering Positions for a Synchronized Vector Move

The Vector button displays the channels in a vector window, allowing multi-channel moves to be performed simultaneously in a synchronized fashion.

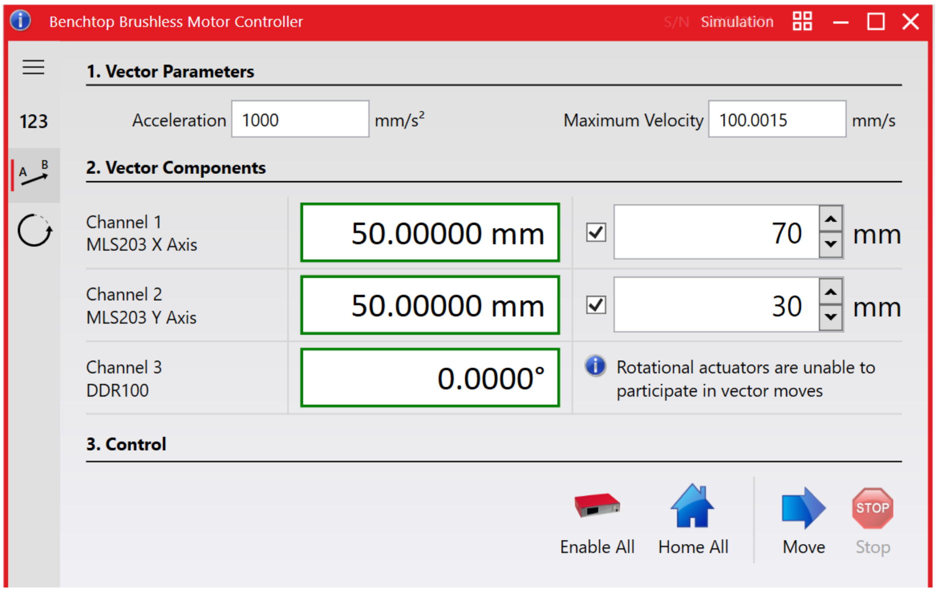


Figure 23 Vector Window

1. Click the 'Home All' button at the bottom right of the window to home each motor channel associated with the move.
2. For each required channel, check the channel box to activate the position window, then enter the absolute positions to move (in mm).
3. Click the Move arrow.

Note how the motors move simultaneously to the required positions.

6.3.2. Path Designer Synchronized Moves

Path designers allow the rapid design and execution of synchronized motion across multiple axes of the same controller.

Several designers are provided: Circle, Circular Arc, Line and Raster Scan.

Each provides user-configurable parameters and a graphic to demonstrate the contribution of each parameter to the move.

The path button  displays a window which allows the user to select from different basic path types or upload a saved path in the form of a time position array saved as a .csv file.

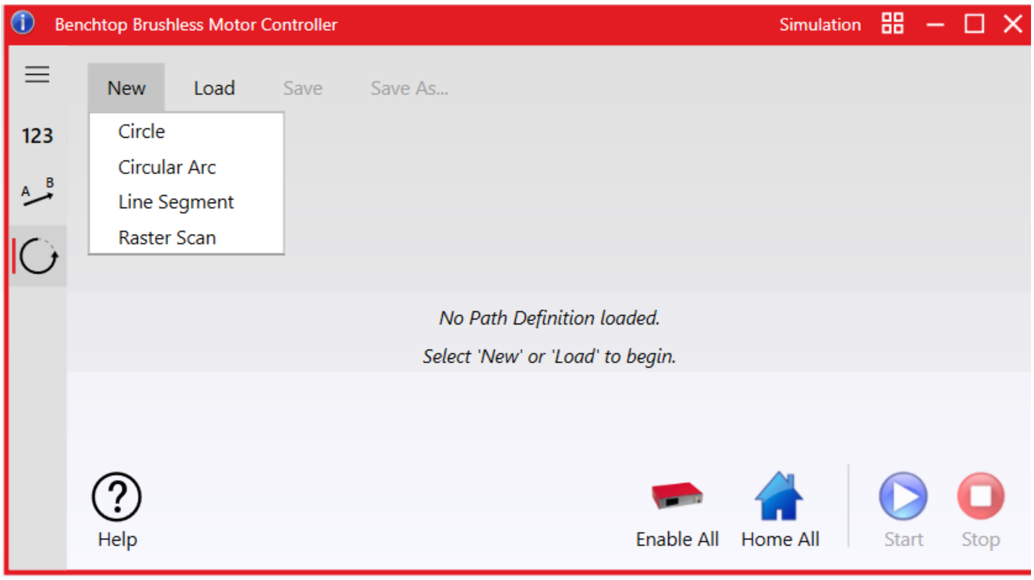


Figure 24 Path Designer Window

A time-position array contains a Lead-in Section, a Repeatable Section and a Lead-out Section and the Path window allows these parameters to be entered. Thus the time-position array will be output with the repeatable section beginning at Start Index, and finishing at End Index. In the case of the circle path designer, if the path is loaded from a CSV file or KPD-type data. the repeatable section is repeated the number of times entered in the Repetitions parameter – see Section 12.3 for more information.

Normally the time-position array leading and trailing sections contain a smooth transition from stationary to moving state and then back to stationary again, as the multi-axis synchronized move is assumed to describe a complete move sequence. However, if the path is loaded from a CSV file or KPD-type data and the move needs to be interrupted and stopped, the parameter Deceleration Time will be applied to bring the various moving axes to standstill.

Note

The Path designers describe motion in physical units and save output as device units, so if the path data is uploaded from a saved CSV file, the data will be in device units. Conversion from device units to physical units is different for each stage and is detailed in the protocol document, available from www.thorlabs.com.

The following sections describe the various path options available.

6.3.3. Circle

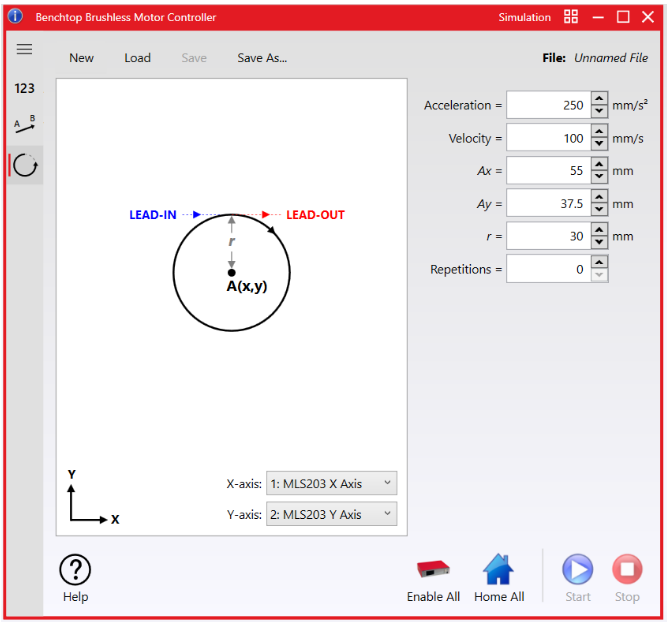
The circle path designer produces a synchronized circular motion on 2 axes of the same controller. The entire motion consists of 3 distinct phases:

Lead-in (acceleration) - This phase increases the velocity from zero to the specified value. This is performed horizontally, along the X-axis, towards the apex of the circle.

Constant velocity circular motion - This part of the motion starts and ends at the apex of the circle and is performed in a clockwise direction. It is repeated the specified number of times.

Lead-out (deceleration) - This phase reduces the velocity to zero. This is performed horizontally, along the X-axis, away from the apex of the circle after the specified number of repetitions have been performed.

From the 'New' drop down menu, select Circle



Acceleration: The acceleration up to the move velocity below.

Velocity: The velocity at which the move is performed.

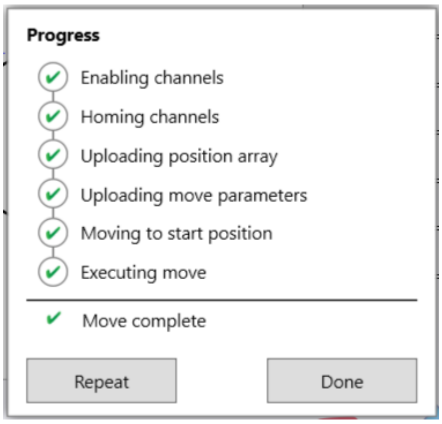
Ax: The centre of the circular move in the X-axis.

Ay: The centre of the circular move in the Y-axis.

r: The radius of the circular path to move.

Repetitions: The number of times the move is repeated.

1. Click 'Enable All' to enable the required motor channels.
2. Click 'Home All' to home the required motor channels.
3. Enter the required parameter values as described above.
4. Click 'Start' to start the move. The progress window to the right is displayed.



Note: The lengths of the Lead in (shown in blue) and Lead out (shown in red) are dependent upon the velocity and acceleration values entered, and movement may not start and finish at the positions expected. The constant velocity section of the move (shown in black) will always start and end as designed.

For an introduction to multi-axis synchronized moves, please see Appendix E.

6.3.4. Circular Arc

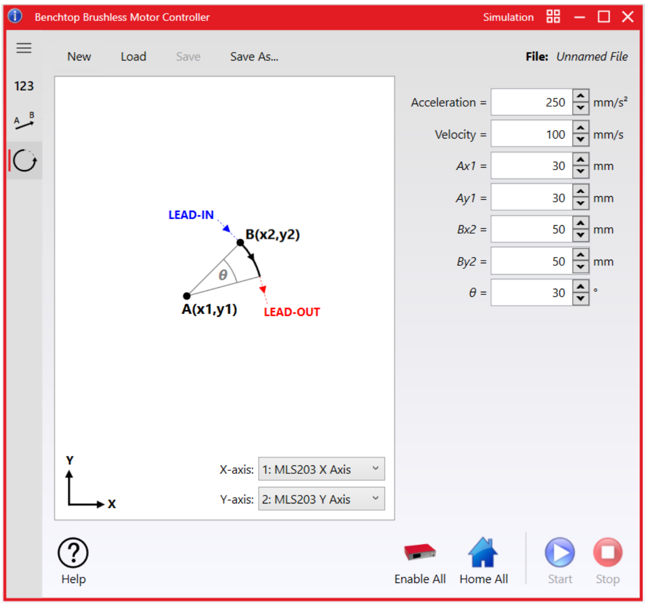
The Circular Arc path designer produces a synchronized circular arc motion on 2 axes of the same controller. The entire motion consists of 3 distinct phases:

Lead-in (acceleration) - This phase increases the velocity from zero to the specified value and is performed in a straight line towards point B. The gradient of the line will be the same as the gradient of the tangent to the circular arc at point B.

Constant velocity circular arc motion - This part of the motion starts at point B. Point B lies on the circumference of a circle with centre point A. The motion continues in a clockwise direction along the circumference at the specified constant velocity until the angle (θ) is reached.

Lead-out (deceleration) - This phase reduces the velocity to zero in a straight line. The gradient of the line is the same as the gradient of the circular arc tangent at the end of the previous phase of motion.

From the 'New' drop down menu, select Circular Arc



Acceleration: The acceleration up to the move velocity below.

Velocity: The velocity at which the move is performed.

Ax1: The pivot point of the arc move in the X-axis.

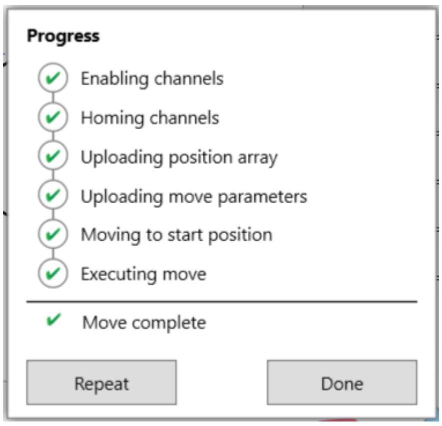
Ay1: The pivot point of the arc move in the Y-axis.

Bx2: The start point of the arc move in the X-axis.

By2: The start point of the arc move in the Y-axis.

Θ: The angle subtended at the centre by the arc move.

1. Click 'Enable All' to enable the required motor channels.
2. Click 'Home All' to home the required motor channels.
3. Enter the required parameter values as described above.
4. Click 'Start' to start the move. The progress window to the right is displayed.



Note: The lengths of the Lead in (shown in blue) and Lead out (shown in red) are dependent upon the velocity and acceleration values entered, and movement may not start and finish at the positions expected. The constant velocity section of the move (shown in black) will always start and end as designed.

For an introduction to multi-axis synchronized moves, please see Appendix E.

6.3.5. Line Segment

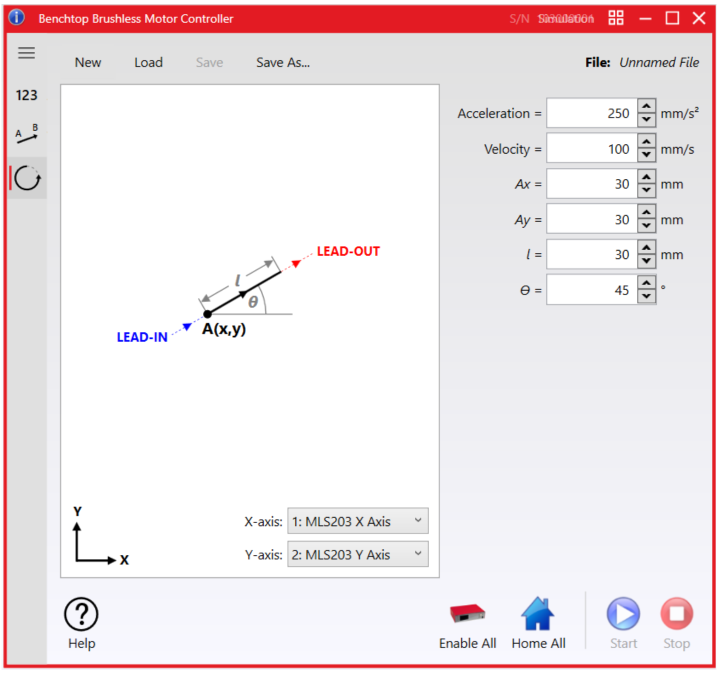
The line designer produces a synchronized line segment motion on 2 axes of the same controller. The entire motion consists of 3 distinct phases:

Lead-in (acceleration) - This phase increases the velocity from zero to the specified value and is performed in a straight line towards point A. The gradient is the same along the entire length of motion as dictated by the angle θ.

Constant velocity line segment - This part of the motion starts at point A and continues for l mm at the specified constant velocity. The gradient is the same along the entire length of motion as dictated by the angle θ.

Lead-out (deceleration) - This phase reduces the velocity to zero in a straight line. The gradient is the same along the entire length of motion as dictated by the angle θ.

From the 'New' drop down menu, select Line Segment



Acceleration: The acceleration up to the move velocity below.

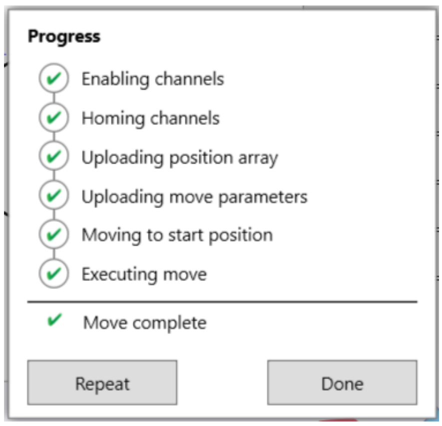
Velocity: The velocity at which the move is performed.

Ax: The start point of the move in the X-axis.

Ay: The start point of the move in the Y-axis.

l: The length (distance) of the move.

Θ: The angle of the move from the horizontal (Y) axis.



1. Click 'Enable All' to enable the required motor channels.
2. Click 'Home All' to home the required motor channels.
3. Enter the required parameter values as described above.
4. Click 'Start' to start the move. The progress window to the right is displayed.

Note: The lengths of the Lead in (shown in blue) and Lead out (shown in red) are dependent upon the velocity and acceleration values entered, and movement may not start and finish at the positions expected. The constant velocity section of the move (shown in black) will always start and end as designed.

For an introduction to multi-axis synchronized moves, please see Appendix E.

6.3.6. Raster Scan

The raster scan designer produces a synchronized raster scan motion on 2 axes of the same controller. Per scan-line, the motion consists of several distinct phases:

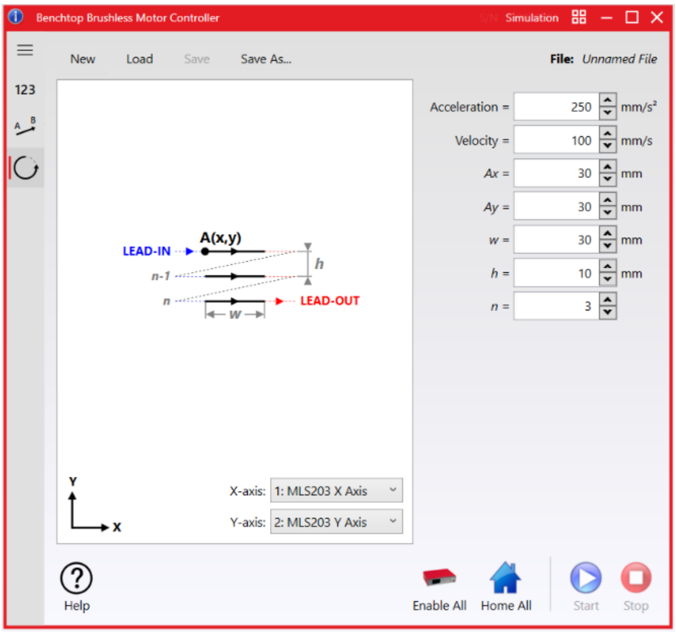
Lead-in (acceleration) - This phase increases the velocity from zero to the specified value and is performed in a straight line along the x-axis towards Ax.

Constant velocity line segment - This part of the motion begins at Ax and ends after w mm of constant velocity travel along the x-axis in a straight line.

Lead-out (deceleration) - This phase reduces the velocity to zero in a straight line along the x-axis.

Retrace (except final scan-line) - This phase prepares for the next scan by decrementing the y-axis position by h mm and retracing along the x-axis to the start position of the next lead-in phase. This will be performed such that the motion will have a trapezoidal velocity profile. The acceleration, deceleration and constant velocity phases will use the values specified.

From the 'New' drop down menu, select Raster Scan



Acceleration: The acceleration up to the move velocity below.

Velocity: The velocity at which the move is performed.

Ax: The start point of the move in the X-axis.

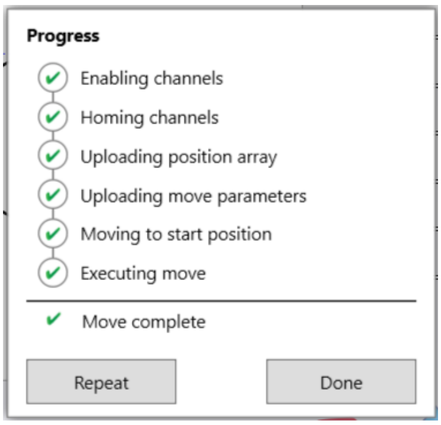
Ay: The start point of the move in the Y-axis.

w: The relative distance to move between points in the X axis.

h: The relative distance to move between points in the Y axis.

n: The number of times the scan is performed.

1. Click 'Enable All' to enable the required motor channels.
2. Click 'Home All' to home the required motor channels.
3. Enter the required parameter values as described above.
4. Click 'Start' to start the move. The progress window to the right is displayed.



Note: The lengths of the Lead in (shown in blue) and Lead out (shown in red) are dependent upon the velocity and acceleration values entered, and movement may not start and finish at the positions expected. The constant velocity section of the move (shown in black) will always start and end as designed.

For an introduction to multi-axis synchronized moves, please see Appendix E.

6.3.7. Loading a Saved File

Previous scans can be loaded from two formats:

Kinesis Path Definition (KPD) files

This is the prefered/primary file format. A KPD file contains all information required to describe a move. As a convenience, they also contain the raw path array data. Loading and saving this format is provided across all path designers.

Comma-Separated Values (CSV) files

CSV files are unable to store all information required to describe the move. They only contain the channel numbers, time deltas and positional data. Due to this limitation, only CSV file loading is supported. This is provided to maintain compatibility with files created for the previous generation of path designer. When a CSV file is loaded, a special designer is presented which allows the missing parameters to be entered. Saving a move loaded from a CSV file will always produce a file in the new KPD format.

Here is the top section of an CSV file as viewed in a spreadsheet application:

	A	B	C
1	time	1	3
2	0	1100000	1150000
3	250	1119781	1149511

Column A holds time deltas. All other columns store positional data for a single channel in the move.

The channel numbers are held in row 1. The rows that follow hold the positions that must be attained at that point in the move.

Cell A1 is unused and may be any text or just left empty.

The move described by this file is:

At time delta 0 (cell A2)

- Channel 1 (cell B1) must be at position 1100000 (cell B2)

- Channel 3 (cell C1) must be at position 1150000 (cell C2)

After 250 device time units (cell A3)

- Channel 1 must be at position 1119781 (cell B3)

- Channel 3 must be at position 1149511 (cell C3)

Channel 2 is not present on row 1 and is therefore not involved in the move.

The time deltas are measured in device time units and the positions are measured in device positional units.

These are dependent on the type of controller and stage being used. For more detailed information on this, please consult the Host-Controller Communications Protocol document, available from www.thorlabs.com.

To load a scan file, click the LOAD button and choose the required file from the list displayed.

6.4. Settings Panel

When the 'Settings' button on the GUI panel is clicked, the 'Settings' window is displayed. This panel allows motor operation parameters such as move/jog velocities, and stage/axis information to be modified. Note that each of these settings also can be read and updated using the Kinesis API. Chapter 7 provides more information about the Kinesis API, including a table that associates Kinesis API commands with the Kinesis GUI functionality described in this chapter.

The settings are presented in three groups, one for the base unit, and one for each of the motor channels present on the base unit.

6.4.1. Base Unit - LCD Display Tab

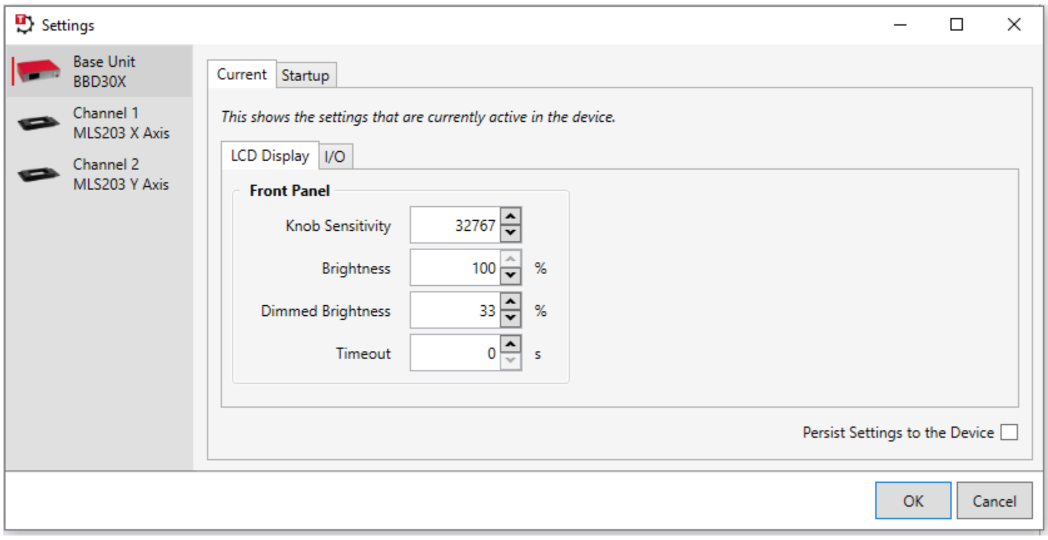


Figure 25 Base Unit LCD Display Setting

Front Panel

Knob Sensitivity – the adjustment sensitivity of the knob on the front panel of the unit, in the range 0 to 65535.

Brightness – The brightness of the LCD display as a percentage of full brightness, 0 to 100%.

Dimmed Brightness – After a certain time (entered in the Time Out parameter below) the display will dim to avoid burn out. This parameter sets the dim level as a percentage of full brightness, 0 to 100%.

Time Out – The time period before the display dims.

6.4.2. Base Unit - I/O Tab

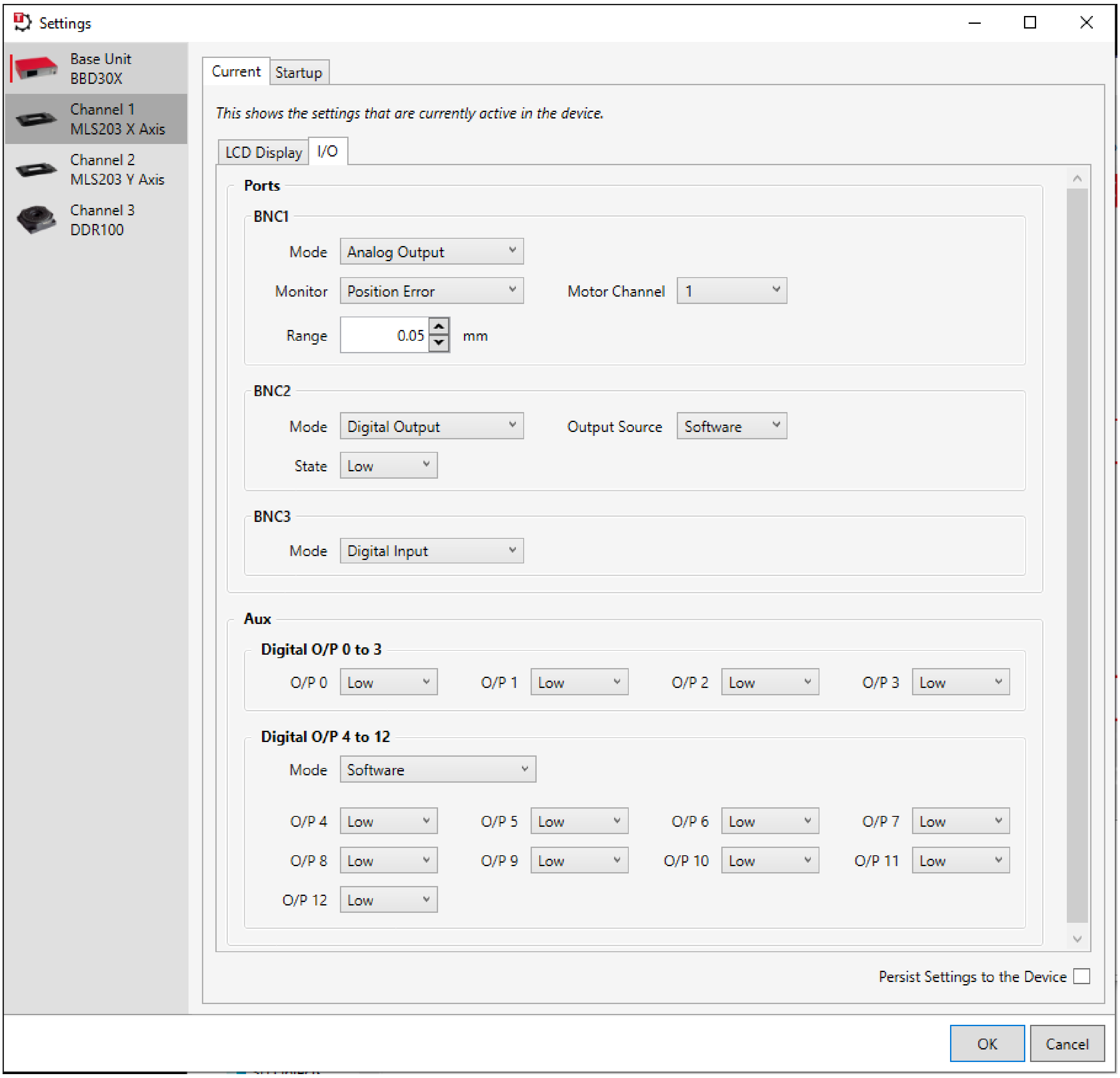


Figure 26 Base Unit I/O Settings

Ports – The BNC connectors on the rear panel of the unit (1 for each motor channel) can be configured to be a Digital Input, a Digital Output or an Analog Output. This is explained in Section 3.3.5.

If the BNC is an input, it is not associated with any particular motor channel, as in input mode the signal can be routed to any or more motor channels.

If the BNC is an output (either analog monitor or digital), a “Motor Channel” pull-down menu appears and the Output Source must be assigned to a particular motor channel. The output is then set using the MGMSG_MOD_SET_DIGOUTPUTS software message.

If the BNC is a digital output, the associated logic state, Low or High, is set in the *State* parameter. The actual motor-channel related function must also be configured under the motor channel trigger settings – see Section 6.4.8.

If the BNC is an analog monitor, for some monitored variables (e.g. Actual Position) a “scale” and “offset” value may also be entered. This is because while for some system variables (such as motor current, for example) a natural scaling factor and offset is provided by the system, for other variables (such as position) the user must define these.

For example, motor current is always restricted to the range provided by the hardware (approximately ±4 Amps), so this can be scaled to a 0…+5V range. In contrast, system variables such as position can take a wide range of values (a move can be made between 0… 0.01 mm or 10..70 mm), so in order to map these to the 0…+5V range, an offset and scale factor must be provided.

Aux - In addition to the functionality provided by the BNC connectors, the AUX I/O connector (37-way D-type) on the rear panel provides further flexible options for connecting external digital I/O signals.

The connector provides

- 4 single ended input ports
- 4 single ended output ports
- 2 differential input ports
- One RS-232 port (Rx and Tx)
- 12 differential output ports (

The 12 differential output ports offer the user the choice to expose a buffered version of the 3 encoder signals or drive them to a software defined state.

The logic state of O/P0 to O/P3 can assigned individually. If the *Mode* is set to *Software*, O/P4-O/P12 can also be assigned individually, however if the *Mode* is set to *Motor Channel Encoder*, then Channel 1 is routed to O/P4, O/P5 and O/P6, Channel 2 is routed to O/P7, O/P8 and O/P9, and Channel 3 is routed to O/P10, O/P11 and O/P12.”.

6.4.3. Channel Settings

The settings for the motor channels are entered on dedicated panels, one set for each motor channel. These are identical to each other and are accessed by clicking Channel 1 or Channel 2 on the left hand side of the Settings window.

6.4.4. Moves/Jogs tab

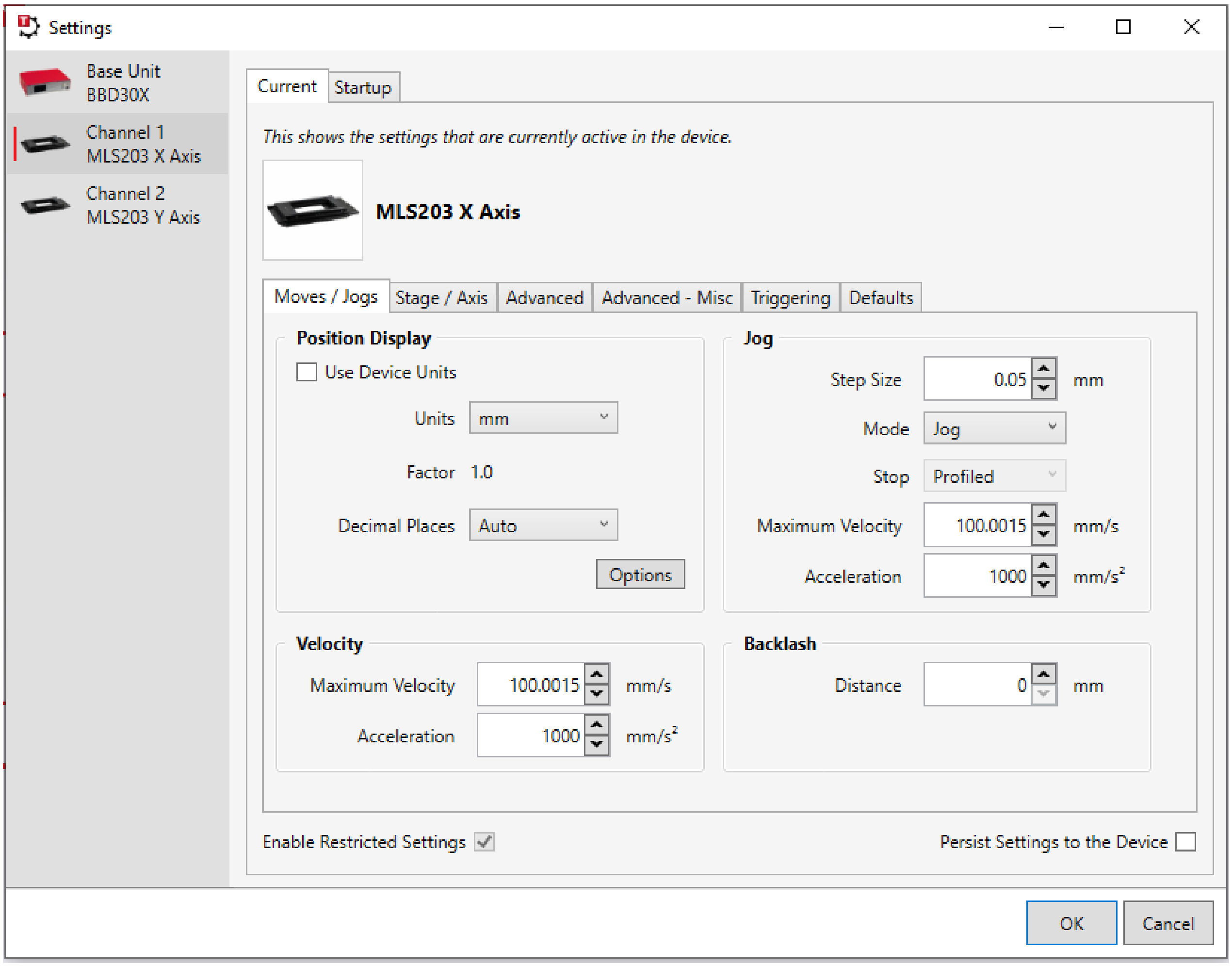


Figure 27 Move/Jog Settings

Position Display Parameters

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

Use Device Units – If this box is checked, the display on the GUI panel shows position in encoder counts rather than real world units (e.g. mm).

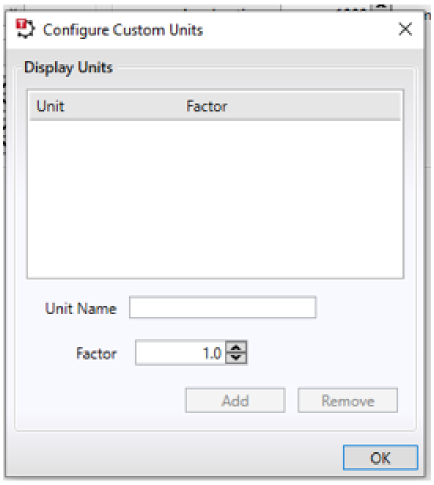
Units - the positioning units used on the GUI display.

Factor - the scaling factor associated with the selected units.

Decimal Places - the number of decimal places to show on the GUI display.

Custom units can be added to the drop-down "Units" menu. To do this, click the "Options" button to open the "Configure Custom Units" window. Enter the name of the custom unit in the "Unit Name" field, and adjust the factor to the value necessary to convert from millimeters to the new custom unit. Then click add. When finished click OK. The new custom unit can now be selected from the Units drop-down menu. window.

Enter a name for the new units, and a factor for conversion from millimetres, then click Add.



The new units are added to the list and can now be selected in the Units parameter described previously. Once selected, click the Apply button to apply the new units.

Jog Parameters

These parameters affect the Jogs initiated by clicking the jog buttons in the Kinesis GUI. Updating these parameters does not update the corresponding Jog parameters that control movement of the stage when the control knob on the front panel of the BBD30x is twisted. To update the BBD30x's front panel settings using the Kinesis GUI, please see Section 6.4.4's discussion of the "Advanced - Misc" tab of the "Settings" menu.

Step Size - The distance to move when a Jog command is initiated and the Jog mode is set to Jog / Single Step.

Mode - Can be set to Jog / Single Step or Continuous and determines the response of the stage to the receipt of a Jog command. A Jog command can be sent to the stage by clicking one of the two Jog buttons in the Kinesis GUI.

Continuous mode is the default. In continuous mode, the stage will accelerate and move at the maximum jog velocity while until the button in the Kinesis GUI is released. In Jog / Single Step mode, the stage will advance by one step size, as specified by the Step Size parameter, each time one of the Kinesis GUI Jog buttons is clicked. The stage moves only after the button is released.

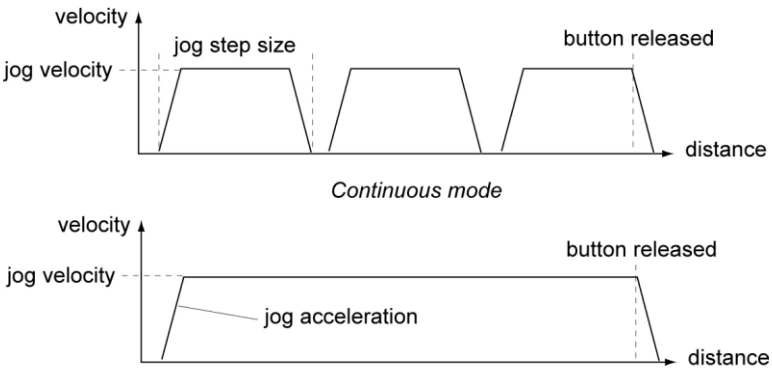


Figure 28 Jog Modes

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 Velocity Profile parameters set above.

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

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

Velocity Parameters

The two commands in the Velocity parameter grouping affect stage movement when the Move function in the Kinesis GUI is used to move the stage to an absolute position. The parameters in this Velocity group do not affect the velocity or acceleration of the stage when the Drive or Jog buttons are clicked.

- *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

Distance - The system compensates for lead screw backlash during reverse direction moves, by moving passed the demanded position by a specified amount, and then reversing. This ensures that positions are always approached in a forward direction. The Backlash Distance is specified in millimeters. To remove backlash correction, this value should be set to zero.

Enable Restricted Settings - This checkbox enables settings that should not be changed unless the user fully understands the impact of the changes. Under normal circumstances, this box should remain unchecked, and the default values should offer satisfactory performance in most cases.

Persist Settings to the Device - Many of the parameters that can be set for the BBD30x series drivers can be stored (persisted) within the unit itself, such that when the unit is next powered up these settings are applied automatically. This is particularly important when the driver is being used manually via a joystick, in the absence of a PC and USB link.

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

6.4.5. Stage/Axis tab

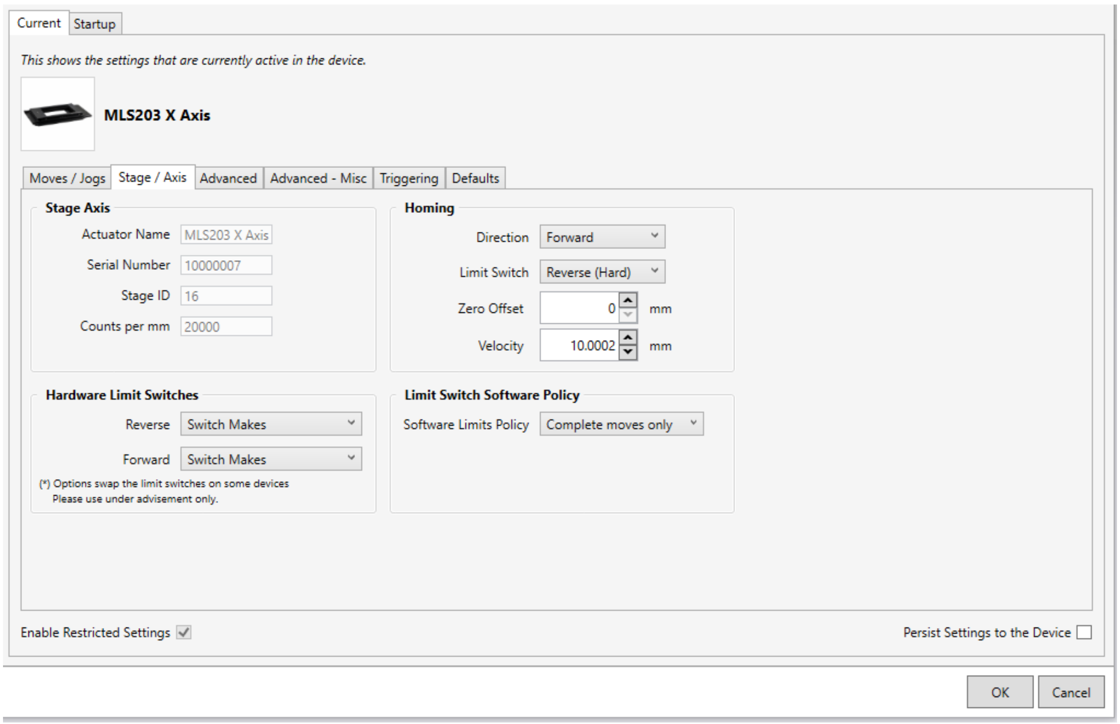


Figure 29 Stage/Axis Settings

Note

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

Stage Axis Settings

Caution

Extreme care must be taken when modifying the stage related settings that follow. Some settings are self-consistent with respect to each other, and illegal combinations of settings can result in incorrect operation of the physical motor/ stage combination being driven.

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 Settings

Note

For Thorlabs brushless motor-driven stages, the Homing, Limit Switch and Motor parameters described on the next two pages are not applicable for the DDS220 and MLS203 stages because the stage does not use a limit switch as a reference point for homing. Instead, it uses a special reference marker pulse from the encoder. Homing on these stages involves a search for this reference marker. Initially, the stage moves in the forward direction and if the reference marker is found before the stage hits the forward limit switch, then homing is completed. If not, the stage reverses direction and continues to search for the reference marker. Due to the different method used, only the Homing Velocity parameter can be adjusted, although normally the default value is suitable for nearly all applications. All other parameters are restricted (grayed out), but clicking "Enable Restricted Settings" will allow these parameters to be modified.

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.

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

Limit Switch - The hardware limit switch associated with the home position, either Ignore, Forward (Hard) or Reverse (Hard).

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

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

Hardware Limit Switches

Note

The operation of the limit switches is inherent in the design of the associated stage or actuator. These settings are read in on start up and should not normally be changed. Extreme cation must be used when changing these settings.

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.

Ignore/Absent - The switch is missing, or should be ignored.

Switch Makes - The switch closes on contact

Switch Breaks - The switch opens on contact

Switch Makes (Home) – Used only for HOME moves. The switch closes on contact

Switch Breaks (Home) - Used only for HOME moves. The switch opens on contact

PMD Indexing - For PMD based brushless servo controllers only - uses index mark for homing.

Note

Under certain conditions, usually involving OEM applications, it may be required to swap over the forward and reverse limit switches. This is achieved through software by selecting the appropriate option marked with a (*).

Limit Switch Software Policy

These settings allow or prohibit moves to be initiated that are outside the range of the limit switches.

Complete moves only – The software allows moves only if the move can be completed within the range of the limit switches.

Clip move to limit – The software allows a move to start but the move stops when a limit switch is reached.

Ignore – The software is ignored and any move is restricted only by the hardware limit switches.

Enable Restricted Settings - This checkbox enables settings that should not be changed unless the user fully understands the impact of the changes. Under normal circumstances, this box should remain unchecked, and the default values should offer satisfactory performance in most cases.

Persist Settings to the Device - Many of the parameters that can be set for the BBD30x series drivers can be stored (persisted) within the unit itself, such that when the unit is next powered up these settings are applied automatically. This is particularly important when the driver is being used manually via a joystick, in the absence of a PC and USB link.

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

6.4.6. Advanced Tab

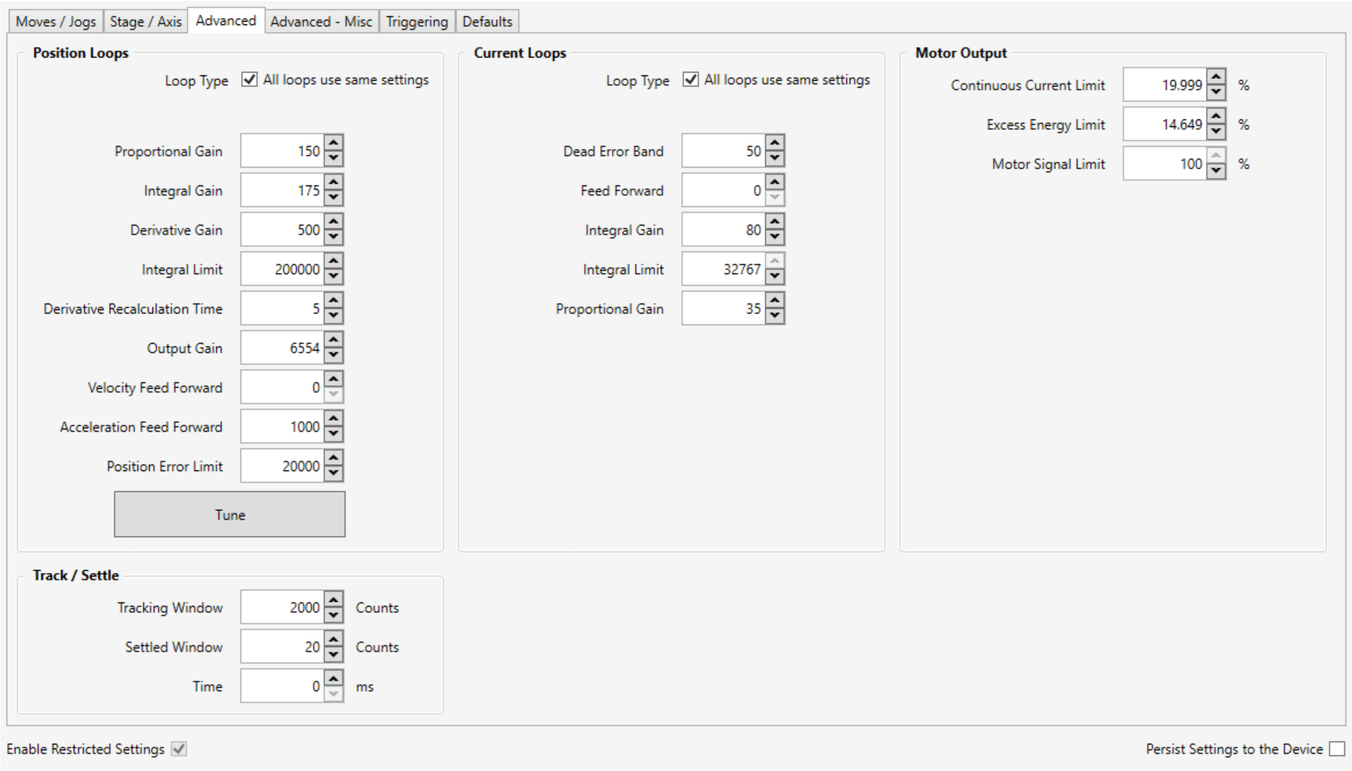


Figure 30 Advanced Control Loop Settings

Position Loop (Stationary, Accelerating, and Constant Velocity)

There are 3 sets of PID parameters, one for each stated move type, stationary, accelerating and constant velocity. This is an advanced feature for users who want to refine and optimize the controller's behavior in very sensitive applications. 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.

Once restricted settings have been enabled the user can modify the PID values in Position Loop.

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.

It is recommended that the user always installs the latest version of Kinesis software.

Loop Type – If this box is unchecked, the user must select the position loop type (Stationary, Accelerating or Constant Velocity) using the parameter settings that follow, and each loop type must be set separately. If this box is checked then all position loops use the same settings.

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. stiction, 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 Deriv is too high, it can become sensitive to noise from the measured position error; if 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 it is set as low as possible, but high enough that with the given integral term, the final position can be reached. It accepts values in the range 0 to 2,147,483,647. 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.

Velocity Feed Forward - Feed-forward term 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.

Acceleration Feed Forward – Feed-forward term 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 2,147,483,647. The actual position error is continuously compared against the limit entered, and if exceeded the associated axis is stopped.

Tune Buttons - These buttons open a window with slider controls, to allow the parameter to be adjusted graphically, rather than by entering numbers.

Positioning Problems Arising from PID Settings: Summary

If the PID parameters are set such that the stage cannot settle (See the following "Track Settle" section, the move will not complete and the stage will stall.

Stage overshoots the intended position - reduce Integral and increase Derivative and Proportional terms.

Stage doesn't attain final position - increase the Integral and Proportional terms.

Motion is unstable - reduce Proportional and Integral, increase Derivative.

Stage sounds noisy - reduce Derivative.

Excessive sensitivity to noise - reduce Derivative time

Current Loop

The current loop parameters provide digital control of the alternating current (AC) sent to the stage's electric motor. The current drives the motor, and the current loop parameters can be used to improve response times and increase motor efficiency as the stage moves to the target position. The current is supplied to several different coils of wire within the motor. These coils are often called phase windings, since the phase of the AC in each coil differs by a controlled amount.

The current supplied to the stage is controlled by monitoring a current error value, which is the difference between the required current and the actual current. A PI-type filter, whose parameters are adjustable, processes the error value. The output of the filter is used to specify an output voltage for each motor coil.

Once restricted settings have been enabled the user can modify the PID values in the current Loop.

> **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.

Loop Type – If this box is unchecked, the user must select the current loop type (Default or Settled) using the parmeter settings that follow, and each loop type must be set separately. If this box is checked then all current loops use the same 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 accepts values in the range 0 to

> **Note**
>
> The Dead Error Band and Feed Forward 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.

32767.

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

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 2,147,483,647.

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 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 either a trapezoidal or s-curve trajectory (see Section 6.4.4.). A move is considered complete when the profile generator has completed the calculated move and the axis has 'settled' at the demanded position. 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, however 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 set in the range 0 to 65535 counts. 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.

Tracking Window- Specifies the maximum allowed position error between the target and actual motor trajectory.

Settle Window- Specifies the maximum allowed position error between the target and actual motor positions.

Time - The minimum time duration over which the axis must be within the settle window for the stage to be recognized as settled.

The system incorporates a monitoring function, which continuously indicates whether or not the axis has 'settled'.

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 6.4.3.) are set such that the settle window cannot be reached, the first move in the sequence will never complete, and the sequence will stall. The Settle Window and 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.

*Enable Restricted Setting*s - This checkbox enables settings that should not be changed unless the user fully understands the impact of the changes. Under normal circumstances, this box should remain unchecked, and the default values should offer satisfactory performance in most cases.

Persist Settings to Hardware - Many of the parameters that can be set for the BBD30x series drivers can be stored (persisted) within the unit itself, such that when the unit is next powered up these settings are applied automatically. This is particularly important when the driver is being used manually via a joystick, in the absence of a PC and USB link.

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

6.4.7. Advanced - Misc. Tab

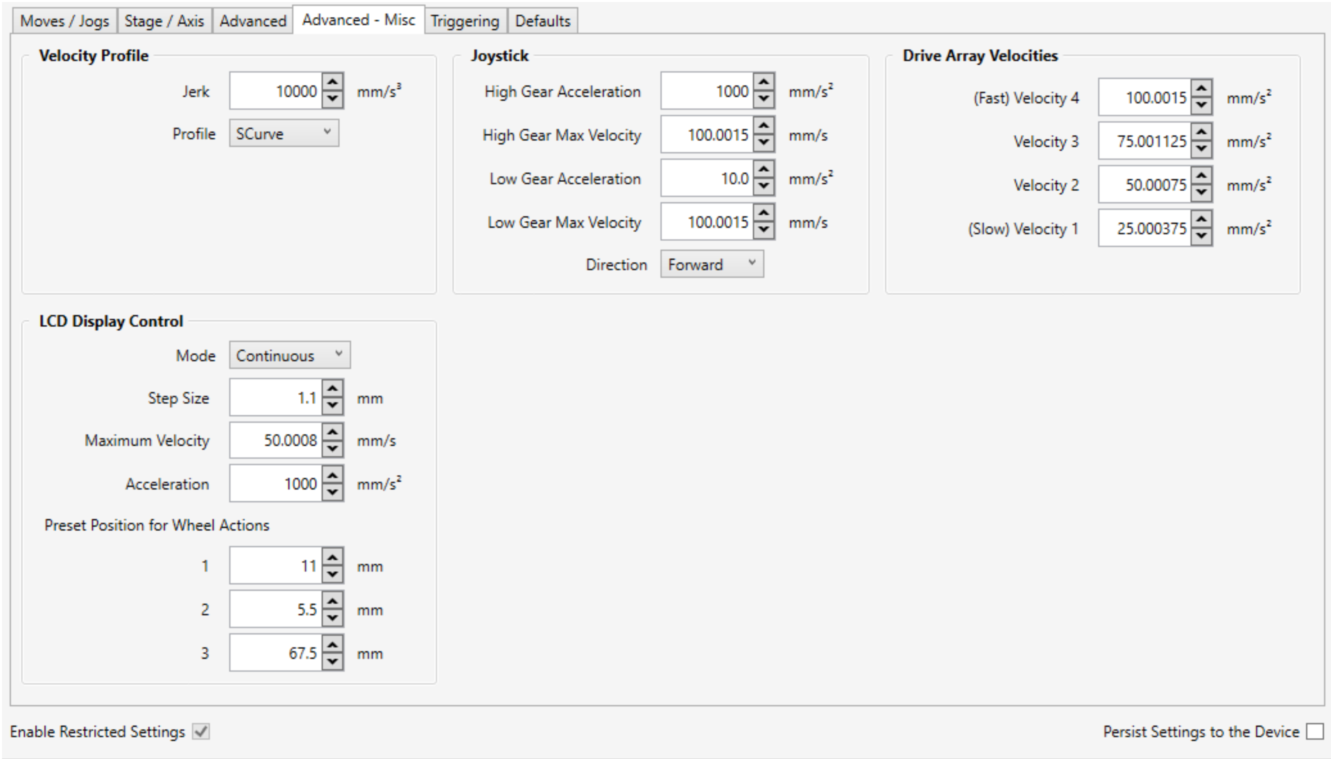


Figure 31 Advanced Miscellaneous Settings

Velocity Profile Settings

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

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

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

There are two available profiles, S-curve and Trapezoidal.

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

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

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

Example

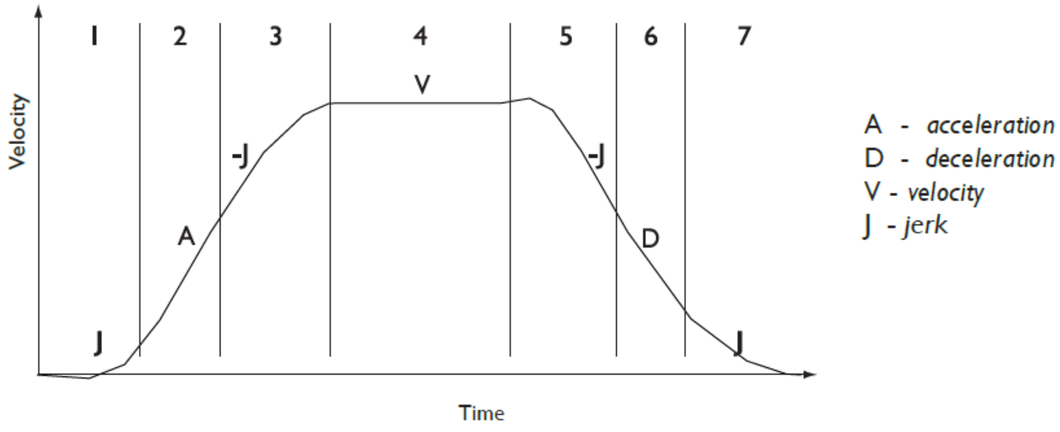


Figure 32 Typical S-Curve Profile

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

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

In the trapezoidal profile (see Figure 33), the stage velocity is increased with acceleration (a) towards the maximum velocity (v). The stage may or may not reach the maximum velocity. Near the target postion, the stage velocity is decreased with decelleration (-a). The stage approaches its final position slowly in a controlled manner.

Note that since the trapezoidal curve is the S-curve profile with the 'Jerk' transitions removed, the movement of a stage following a trapezoidal profile is generally less smooth than a stage following an S-curve profile.

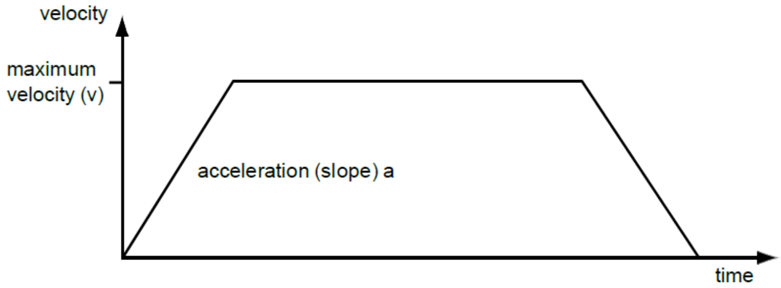


Figure 33 Graph of a trapezoidal velocity profile

Joystick Settings

If the optional Thorlabs joystick console is being used (MJC001) the following parameters are used to set the velocity and acceleration limits and the direction sense of any moves initiated from the joystick - see Section 5.8 for more details on joystick use.

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

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

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

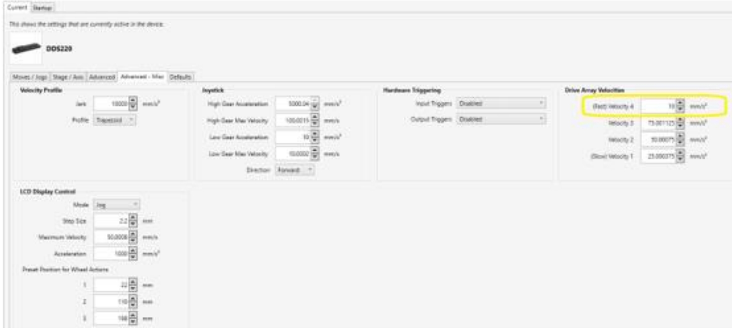
Low Gear Max Velocity – The max velocity of a move when low gear mode is selected.

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

Drive Array Velocities

These parameters are the velocity settings programmed into the different Drive buttons on the GUI panel (see section 6.2). Each velocity setting in this tab is tied directly to a specific bar in the Drive bar graph (bottom, left). The velocity entered into the Velocity 1 field corresponds to the shortest Drive bar, the velocity entered into the Velocity 2 field corresponds to the next-shortest bar, and so on.

Note that it is possible to enter a velocity value into the Velocity 4 field that is not the fastest, and this value will be applied to the longest Drive bar (bottom, right). This is in contrast to when entering values via the panel control, in which the values are automatically arranged highest-to-lowest, regardless of the order in which they were entered.



LCD Display Control

These settings affect the values programmed into the buttons and knob located on the front panel of the BBD30x units (see Section 3.4). Note that changing these settings does not affect the Jog and Move settings of the buttons on the GUI panel (Section 6.2). The Jog and Move settings on the BBD30x front panel are changed independently of the Jog and Move setting provide in the Kinesis GUI.

Mode - Selects whether the stage will move while there is torque on the knob (Continuous mode), or by a discrete, pre-determined amount (Jog/ Single Step mode) each time the knob is rotated away from its zero position. There are two Jog modes, "Continuous" and "Single Step," and Continuous mode is the default.

> *Jog* - When operating in Jog mode, twisting the a knob away from its center position will result in the stage moving a distance of one jog step size. The stage begins to move when torque is applied, but maintaining torque on the knob will not result in subsequent steps. To initiate an additional step, release the knob, let it return to its zero position, and twist the knob again.

> *Continuous* - When operating in Continuous jog mode, twisting the knob will cause the state to move in the indicated direction until the knob is released. When the knob is released, it returns to its zero position..

Step Size - The distance to move when a Jog command is initiated and the Jog mode is set to Jog / Single Step.

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.

Enable Restricted Settings - This checkbox enables settings that should not be changed unless the user fully understands the impact of the changes. Under normal circumstances, this box should remain unchecked, and the default values should offer satisfactory performance in most cases.

Persist Settings to Hardware - Many of the parameters that can be set for the BBD30x series drivers can be stored (persisted) within the unit itself, such that when the unit is next powered up these settings are applied automatically. This is particularly important when the driver is being used manually via a joystick, in the absence of a PC and USB link.

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

6.4.8. Triggering Tab

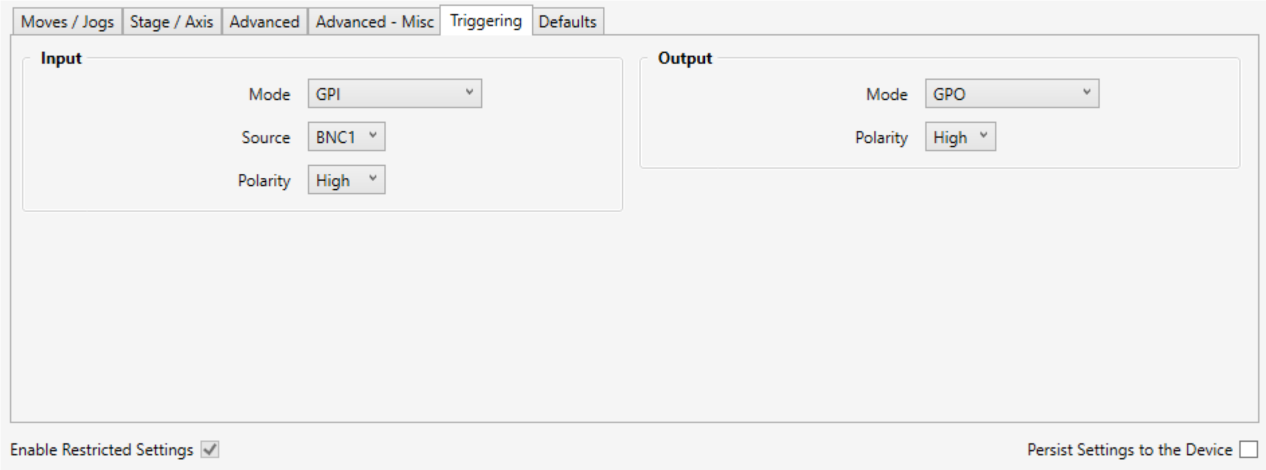


Figure 34 BBD30x Triggering Tab

The BBD30x series controllers can be configured to respond to trigger inputs, generate trigger outputs, or perform both functions simultaneously. For example, a controller configured for both input and output triggering can initiate a move in response to a trigger input, while at the same time generating a trigger output. Both input and output triggers are TTL compatible signals.

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

Input triggers are coupled to the BBD30x controllers via any of the BNC connectors on the rear panel. See BNC configuration section 3.3.5 and I/O Tab 6.4.2 for details of configuring the connector for input triggering.

Input Triggers

The controller can be configured so that it responds to the Trigger In signal, provided via the BNC port, by homing the stage, moving the stage by a relative amount, or moving the stage to a specified absolute position. The rising or falling edge of a Trigger In signal initiates the action. The rising edge refers to a transition from logic LOW to HIGH, and the falling edge refers to a transition from logic HIGH to LOW. Since a move already in progress will not be interrupted, the stage will not respond to an external Trigger In signal if in the process of executing a move.

The trigger settings can be used to specify whether Trigger In is disabled or will respond to the rising or falling edge of a Trigger In signal. When an absolute move is specified, a field is provided to specify the target position (Figure 35). If the signal is specified to initiate a relative move, both the direction of the move and the relative distance can be specified (Figure 36). In order to avoid unexpended moves being executed on start-up, the trigger input settings are not retained in memory and will default to the input being disabled on power-up. Also be aware that transients generated when powering off a function generator connected to the Trigger In port can also be interpreted as a Trigger In signal.

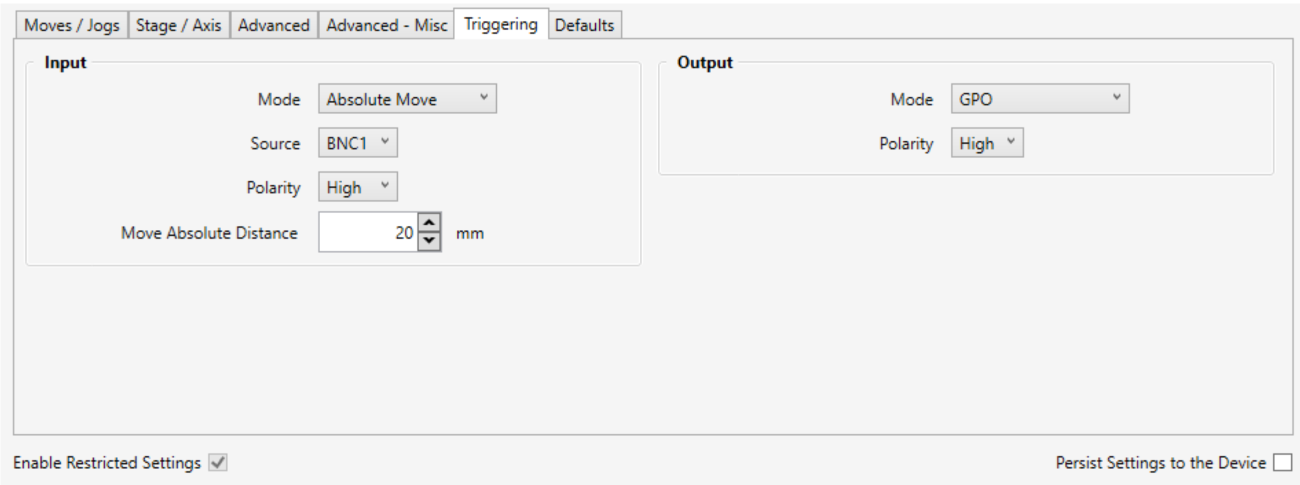


Figure 35 Absolute move settings example

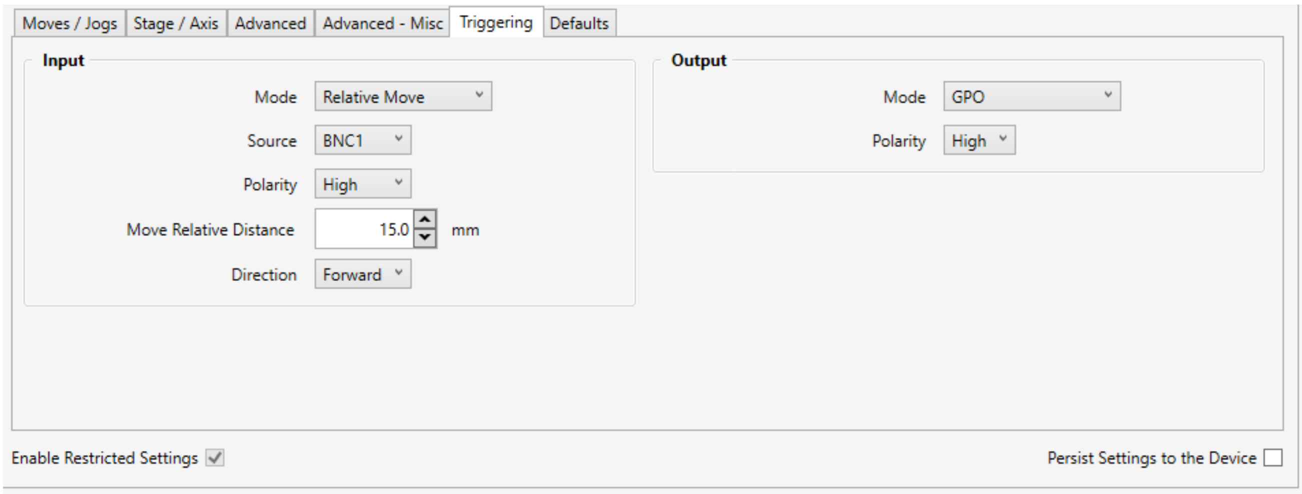


Figure 36 Relative Move Settings Example

Input Trigger options are set as follows:

Disabled – triggering operation is disabled.

GPI – General purpose input.

Relative Move – a relative move (specified using the latest GUI panel settings) is initiated on the selected channel when an input signal is received. The Input Source (BNC1, BNC2 etc.), the Polarity (High or Low) of the trigger signal, the relative distance to move and the direction of travel are specified in their associated parameter fields.

Absolute Move – an absolute move (specified using the latest GUI panel settings) is initiated on the selected channel when an input signal is received. The Input Source (BNC1, BNC2 etc.), the Polarity (High or Low) of the trigger signal and the absolute distance to move are specified in their associated parameter fields.

Home Move – a home move (specified using the latest GUI panel settings) is initiated on the selected channel when an input signal is received. The Input Source (BNC1, BNC2 etc.), and the Polarity (High or Low) of the trigger signal are specified in their associated parameter fields.

Stop - a stop command is initiated on the selected channel when an input signal is received. The Input Source (BNC1, BNC2 etc.), and the Polarity (High or Low) of the trigger signal are specified in their associated parameter fields.

Output Triggers

The channel's output trigger signal can be routed to any of the BNC connectors on the rear panel. . For output triggering to work, the associated BNC connector must be configured as an output - see BNC configuration section 3.3.5 and I/O Tab section 6.4.2 for details of configuring the connector for output triggering. The individual motor channel trigger outputs are also available on the rear panel Aux IO connector (see Figure 43). This output signal is either logic High or Low, and it is set LOW by default. The Trigger Out signal level can be set to a desired level in response to the stage movement, as described in the following. In addition, the Trigger Out signal level can also be changed in response to a command included in a Sequence programmed in the Kinesis GUI. Sequences are described in the Kinesis GUI help file.

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

Output Trigger options are set as follows:

Disabled – triggering operation is disabled

GPO – General purpose logic output.

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

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

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 below for further details.

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 below for further details.

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 below for further details.

At Forward Limit – Trigger output active (pulsed) when the forward limit switch is made.

At Reverse Limit – Trigger output active (pulsed) when the reverse limit switch is made.

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.

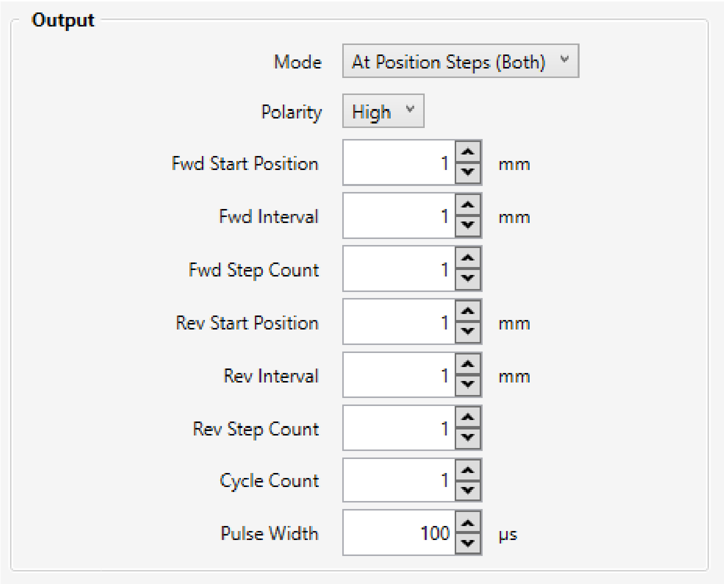
In the non position trigger modes (In Motion, At Maximum Velocity, At Forward Limit, At Reverse Limit), configuring the trigger settings automatically enables the generation of the trigger signal.

In the position trigger modes, the configuration settings only arm the trigger engine and in order to activate it, the main GUI "Trigger Enabled" button must be clicked. When position trigger is enabled, this button will turn green.

When the position trigger engine completes the specified trigger sequence and all trigger pulses have been generated, the button turns grey again, indicating that triggering is no longer active.

An active trigger (indicated by the green button) can be cancelled by clicking on the button. Once this is done, a subsequent activation will reset the trigger sequence to the beginning, regardless of how many trigger pulses have already been generated.

The Trigger Enabled button (see section 6.2) is only employed in "Trigger Out Position Steps" triggering modes. Please note if the step parameters are changed when the position trigger is enabled a reset to the enabled state should be performed by turning the trigger enabled button off an on again.



As soon as a position triggering mode is selected on any of the BNC ports, the port will assert the inactive logic state, set in the Trigger *Polarity* parameter.

As the stage moves in its travel range and the actual position matches the position set in the *Fwd Start Position* parameter, the BNC 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 *Fwd Interval* parameter.

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

When the number of pulses set in the *Cycle Count* parameter has been generated, the trigger engine will schedule the next position to occur at the position specified in the *Rev 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 *Cycle Count* parameter. This means that the total number of pulses output will be *Trigger Cycle Counts x (Forward Trigger Count + Reverse Trigger Count)*.

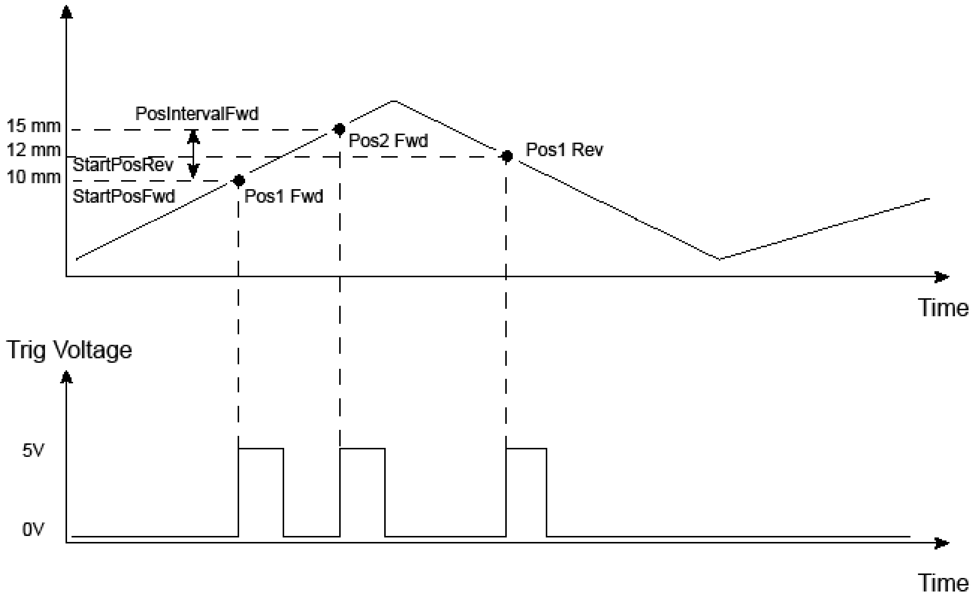


Figure 37 Position Steps Triggering

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.

Trigger Polarity

The polarity of the trigger pulse is specified in the Trigger 1 Polarity and Trigger 2 Polarity parameters as follows:

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

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

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.

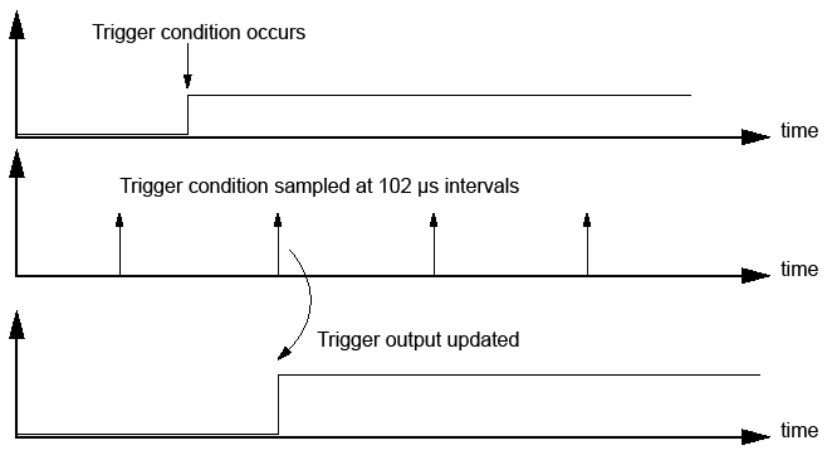


Figure 38 Triggering Latency

6.4.9. Defaults Tab

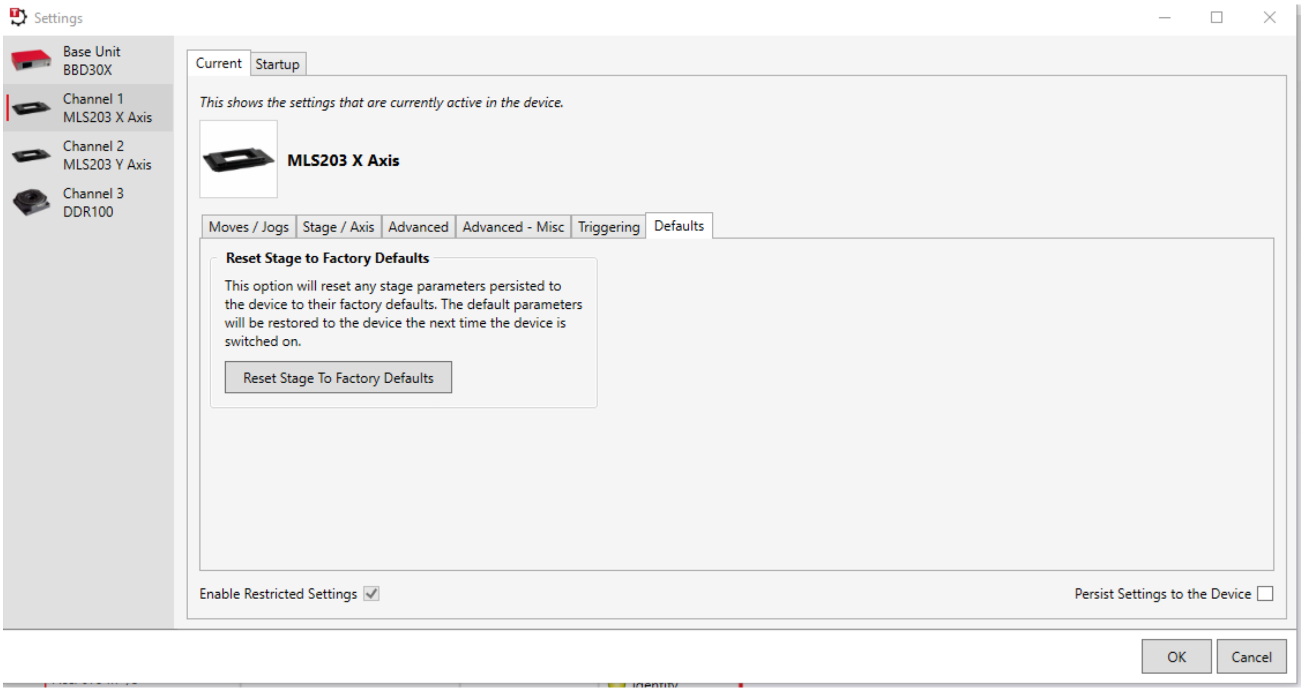


Figure 39 BBD30x - Defaults Tab

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

To restore the default values, click the ‘Reset Stage to Factory Defaults’ Button, then click OK. The controller must then be power cycled before the default values can take effect.

6.4.10. Troubleshooting and Restoring Default Parameters

If the PID parameters are set such that the stage cannot settle (See the following "Track Settle" section, the move will not complete and the stage will stall.

Positioning problems arising from PID Settings: Summary

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

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

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

Stage sounds noisy - reduce the derivative term.

Excessive sensitivity to noise - reduce derivative time.

See Section 6.4.3. for further information.

6.4.11. Rotation Stages Tab

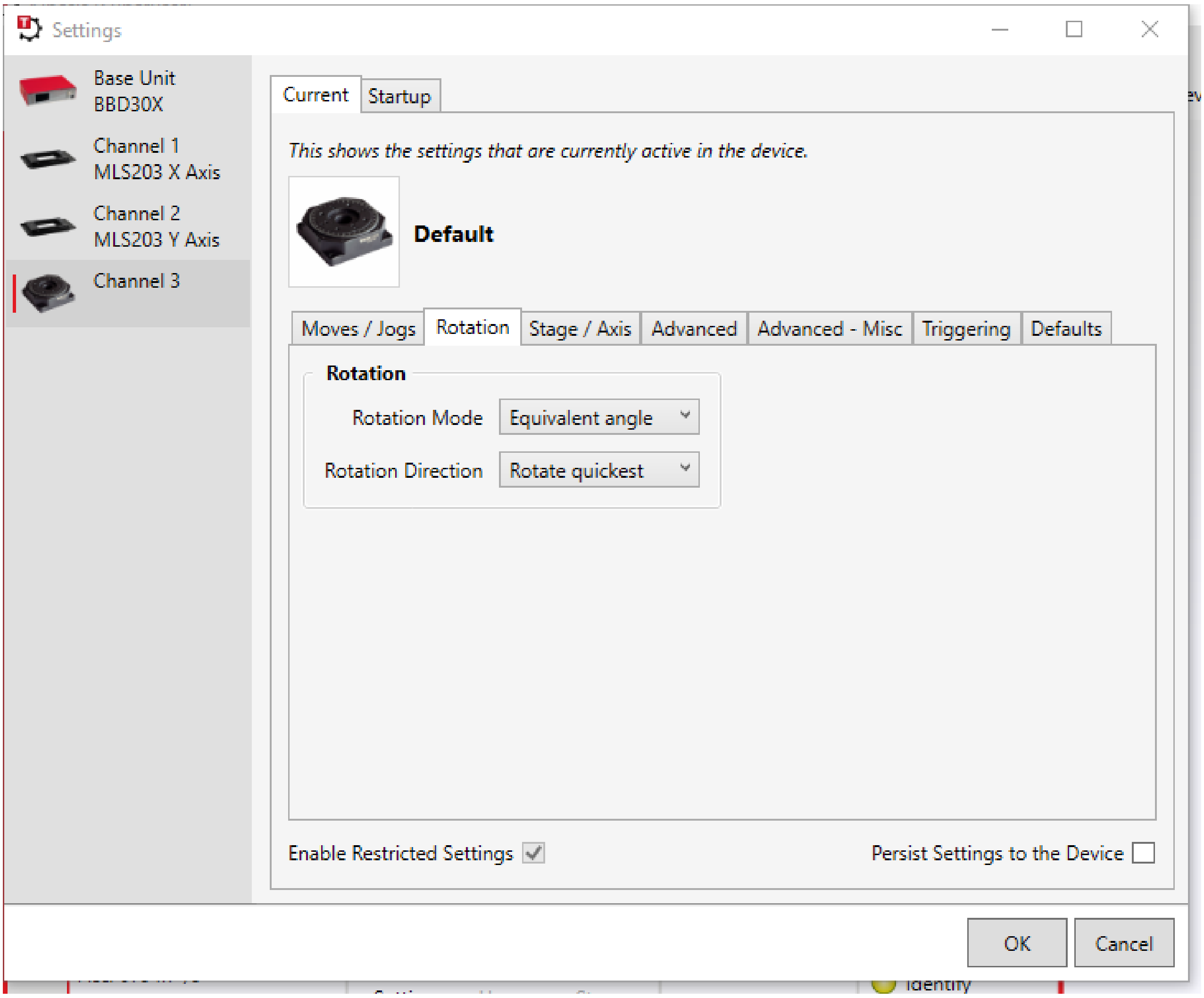


Figure 40 Rotation Stages Tab

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°.

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

Chapter 7 Kinesis API Reference

Using the Kinesis API, it is possible to build programs that can be used to operate the BBD30x series controllers, in addition to other devices. The Kinesis GUI is one example of a program built using the Kinesis API, and Section 7.2 provides a guide that associates the different commands in the API with the functionality implanted in the GUI. For additional information about the GUI's implemented functionality, please see Chapter 6.

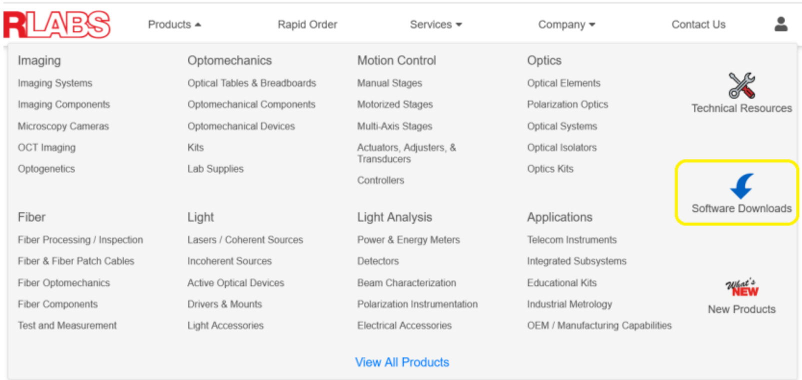
7.1. Available References

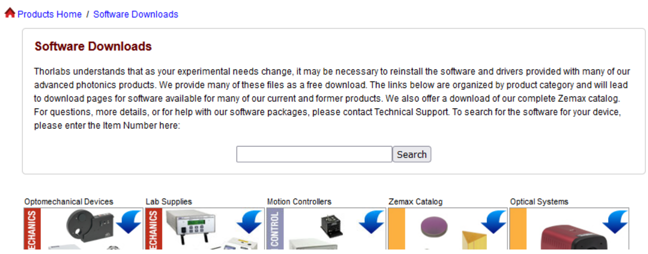
When developing a custom application using the Kinesis API, there are help files and example applications that can be referenced. Some stand-alone help files

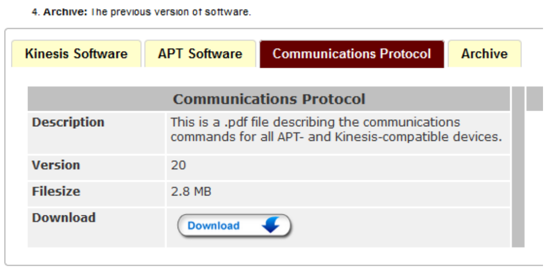
- Thorlabs.MotionControl.C_API.chm
- Thorlabs.MotionControl.DotNet_API.chm

are located in the Thorlabs\Kinesis folder. Double click on a file to open it.

The API command set is also described in the "APT_Communications_Protocol.pdf" reference available by visiting Thorlabs.com. , clicking on the Products menu, clicking on Software Downloads, Entering BBD301 in the search field, and then clicking on the "Download" button in the "Communications Protocol" Tab, as show in the following figures.







7.2. API Commands and Related Kinesis GUI Functionality

The commands and settings available in the Kinesis GUI are discussed in detail in Chapter 6. The following table relates the Kinesis API commands to the functionality described in Chapter 6.

Associated Communications Protocol Commands, as Described in APT_Communications_Protocol.pdf

Actions	APT Commands	Manual Section
Position and other Status Updates	MGMSG_HW_START_UPDATEMSGS MGMSG_HW_STOP_UPDATEMSGS	6.2
Set Relative Move Parameters	MGMSG_MOT_SET_MOVERELPARAMS MGMSG_MOT_REQ_MOVERELPARAMS MGMSG_MOT_GET_MOVERELPARAMS	5.6, 6.4.8
Initiate Relative Move	MGMSG_MOT_MOVE_RELATIVE	5.6
Set Absolute Move Parameters	MGMSG_MOT_SET_MOVEABSPARAMS MGMSG_MOT_REQ_MOVEABSPARAMS MGMSG_MOT_GET_MOVEABSPARAMS	5.6, 6.4.4, 6.4.8
Initiate Absolute Move	MGMSG_MOT_MOVE_ABSOLUTE	6.4.4
Initiate Continuous Move	MGMSG_MOT_MOVE_VELOCITY	6.4.4
Request to Stop Movement	MGMSG_MOT_MOVE_STOP	6.4.4
Request Movement Stopped Notice	MGMSG_MOT_MOVE_STOPPED	N/A
Request Move Complete Notice	MGMSG_MOT_MOVE_COMPLETED	N/A
Set Velocity Parameters	MGMSG_MOT_SET_VELPARAMS MGMSG_MOT_REQ_VELPARAMS MGMSG_MOT_GET_VELPARAMS	6.4.4
Initiate Jog Movement	MGMSG_MOT_MOVE_JOG	6.2
Set Jog Parameters	MGMSG_MOT_SET_JOGPARAMS MGMSG_MOT_REQ_JOGPARAMS MGMSG_MOT_GET_JOGPARAMS	6.4.4
Backlash Settings	MGMSG_MOT_SET_GENMOVEPARAMS MGMSG_MOT_REQ_GENMOVEPARAMS	6.4.4

	MGMSG_MOT_GET_GENMOVEPARAMS	
Set Homing Parameters	MGMSG_MOT_SET_HOMEPARAMS MGMSG_MOT_REQ_HOMEPARAMS MGMSG_MOT_GET_HOMEPARAMS	6.4.5
Initiate Homing	MGMSG_MOT_MOVE_HOME	6.2
Homing Completed Inquiry	MGMSG_MOT_MOVE_HOMED	6.2
Set Limit Switch Parameters	MGMSG_MOT_SET_LIMSWITCHPARAMS MGMSG_MOT_REQ_LIMSWITCHPARAMS MGMSG_MOT_GET_LIMSWITCHPARAMS	6.4.5
Set Jog and Move Parameters	MGMSG_MOT_SET_LCDMOVEPARAMS MGMSG_MOT_SET_LCDMOVEPARAMS MGMSG_MOT_SET_LCDMOVEPARAMS	6.4.7
Enable / Disable	MGMSG_MOD_SET_CHANENABLESTATE MGMSG_MOD_REQ_CHANENABLESTATE MGMSG_MOD_GET_CHANENABLESTATE	6.2
Identify	MGMSG_MOD_IDENTIFY	6.2
Create Time-Position Array for Synchronized Moves	MGMSG_MOT_SET_MOVESYNCHARRAY	6.3
Output Time-Position Array for Synchronized Moves	MGMSG_MOT_SET_MOVESYNCHPARAMS	6.3
Begin Multi-Axis Synchronized Move	MGMSG_MOT_MOVE_SYNCHSTART	6.3
Position Loop Parameters	MGMSG_MOT_SET_POSITIONLOOPPARAMS MGMSG_MOT_REQ_POSITIONLOOPPARAMS MGMSG_MOT_GET_POSITIONLOOPPARAMS	6.4.6
Current Loop Parameters	MGMSG_MOT_SET_CURRENTLOOPPARAMS MGMSG_MOT_REQ_CURRENTLOOPPARAMS MGMSG_MOT_GET_CURRENTLOOPPARAMS	6.4.6
Current Loop Parameters	MGMSG_MOT_SET_SETTLEDCURRENTLOOPPARAMS	6.4.6

	MGMSG_MOT_REQ_SETTLEDCURRENTLOOPPARAMS MGMSG_MOT_GET_SETTLEDCURRENTLOOPPARAMS	
Track / Settle	MGMSG_MOT_SET_TRACKSETTLEPARAMS MGMSG_MOT_REQ_TRACKSETTLEPARAMS MGMSG_MOT_GET_TRACKSETTLEPARAMS	6.4.6 see footnote
Motor Output	MGMSG_MOT_SET_MOTOROUTPUTPARAMS MGMSG_MOT_REQ_MOTOROUTPUTPARAMS MGMSG_MOT_GET_MOTOROUTPUTPARAMS	6.4.6
Velocity Profile	MGMSG_MOT_SET_PROFILEMODEPARAMS MGMSG_MOT_REQ_PROFILEMODEPARAMS MGMSG_MOT_GET_PROFILEMODEPARAMS	6.4.7
Front Panel Knob Parameters	MGMSG_MOT_SET_LCDMOVEPARAMS MGMSG_MOT_REQ_LCDMOVEPARAMS MGMSG_MOT_GET_LCDMOVEPARAMS	6.47
Hardware Triggering	MGMSG_MOT_SET_TRIGGER MGMSG_MOT_REQ_TRIGGER MGMSG_MOT_GET_TRIGGER	6.4.8 see footnote
Hardware Information	MGMSG_HW_REQ_INFO MGMSG_HW_GET_INFO	6.4.2
Stage Axis Parameters	MGMSG_MOT_SET_STAGEAXISPARAMS MGMSG_MOT_REQ_STAGEAXISPARAMS MGMSG_MOT_GET_STAGEAXISPARAMS	See Footnote
Configure I/O Connector Outputs	MGMSG_MOD_SET_DIGOUTPUTS MGMSG_MOD_REQ_DIGOUTPUTS MGMSG_MOD_GET_DIGOUTPUTS	6.4.2, 6.4.8
Front Panel Display Parameters	MGMSG_MOT_SET_LCDDISPLAYPARAMS MGMSG_MOT_REQ_LCDDISPLAYPARAMS MGMSG_MOT_GET_LCDDISPLAYPARAMS	6.4.1
Disconnect Hardware	MGMSG_HW_DISCONNECT	N/A

Notification of Fault Condition Needing Response	MGMSG_HW_RESPONSE MGMSG_HW_RICHRESPONSE	N/A
Determine Occupancy of Controller's Bay	MGMSG_RACK_REQ_BAYUSED MGMSG_RACK_GET_BAYUSED	N/A
Set Controller's Position Counter	MGMSG_MOT_SET_POSCOUNTER MGMSG_MOT_REQ_POSCOUNTER MGMSG_MOT_GET_POSCOUNTER	N/A
Set Controller's Encoder Counter	MGMSG_MOT_SET_ENCCOUNTER MGMSG_MOT_REQ_ENCCOUNTER MGMSG_MOT_GET_ENCCOUNTER	N/A
Motor Channel Status Update	MGMSG_MOT_GET_USTATUSUPDATE MGMSG_MOT_GET_USTATUSUPDATE MGMSG_MOT_GET_USTATUSUPDATE MGMSG_ MOT_REQ_STATUSBITS	N/A
Suspend or Resume Certain Messages from Controller	MGMSG_ MOT_SUSPEND_ENDOFMOVEMSGS MGMSG_ MOT_RESUME_ENDOFMOVEMSGS	N/A
Save Parameter Settings for Specified Message	MGMSG_MOT_SET_EEPROMPARAMS	N/A

Track / Settle:

The Kinesis API command set provides a 'Tracking Window", which is not implemented in the Kinesis GUI . The tracking window is used to monitor servo performance outside the context of motion error. The tracking window is a programable position error limit within which the axis must remain, but unlike the "Position Error Limit" parameter, the axis is not stopped if it moves outside the specified tracking window.

This function is useful for process 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.

Triggering:

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

It is possible to set or clear the Trigger Out output under software-only control. As with the Trigger In input, this allows application software to use the Trigger Out output as a general-purpose digital output. To use this option, set the Trigger Out option to Disabled and use software messages to control the state of the output directly.

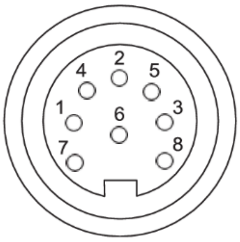
Stage Axis Parameters:

These parameters provide more detailed information about the stages than is provided using the Kinesis GUI. In addition, this command allows some parameters to be set.

Chapter 8 Rear Panel Connector Pin-out Details

8.1. Rear Panel MOTOR DRIVE Connectors

The ‘MOTOR DRIVE’ connector is a female, round, 8-pin DIN type and provides drive connection to the motors. The pin functions are detailed in Figure 41.



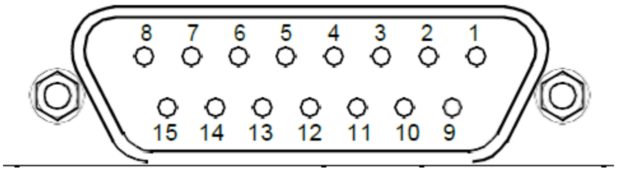
Pin	Description	Pin	Description
1	Motor Phase B	5	Stage ID
2	GND	6	Enable
3	Unused (Motor Phase D)*	7	Motor Phase C
4	Motor Phase A	8	+5 V*

* The signal present on Pins 3 and 8 are not used by brushless controllers

Figure 41 MOTOR DRIVE connector pin identification

8.2. Rear Panel FEEDBACK Connector

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



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

* Pins 7 and 8 are short circuited internally

Figure 42 FEEDBACK connector pin identification

8.3. Rear Panel AUX I/O Connector and BNC connectors

8.3.1. Pin Identification

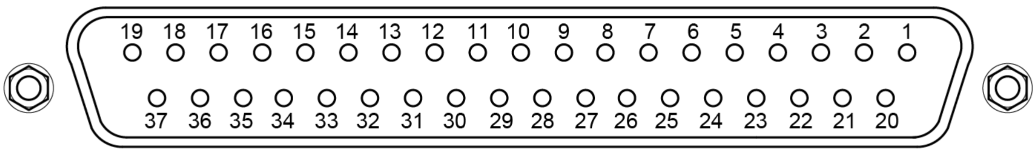


Figure 43 AUX I/O Connector Pin Identification

The AUX I/O connector is a female, 37 pin D-Type exposes a number of internal electrical signals. For convenience, a number of logic inputs and outputs are included, thereby negating the need for extra PC based IO hardware. Using the Kinesis support software, these user programmable logic lines can be deployed in applications requiring control of external devices such as relays, light sources and other auxiliary equipment. The state of digital outputs 0 to 3 are always controlled by software. The function of digital outputs 4 to 12 is user selectable. They can either output the buffered encoder signals of the motor channels or they can be controlled by software.

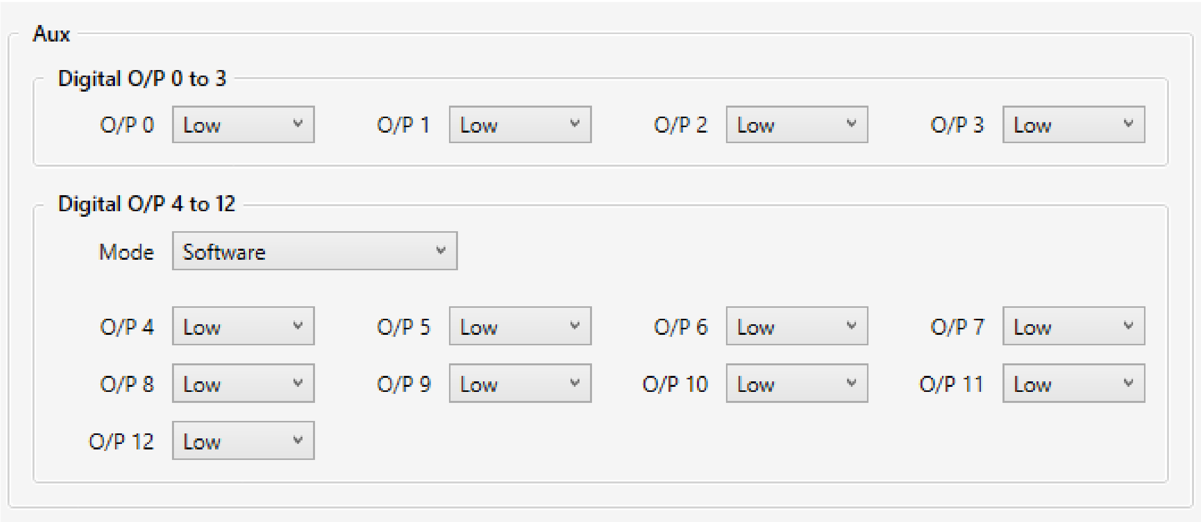


Figure 44 Digital Output 0 to 3 and 4 to 12 In Kinesis GUI

The AUX I/O pins are given in Figure 43, with the function details provided in the table below.

Pin Assignment with digital outputs 4 to 12 in “Motor Channel Encoder” mode:

37-way D-type pin	Signal	BBD301	BBD302	BBD303	Comments
1	RS232 TX	Serial RS - 232 comunication port			Used for communication via RS - 232
2	RS232 TX	Serial RS - 232 comunication port			
3	Ground	Ground			
4	Differential I/P 2+	Reserved For Future Use			
5	Differential I/P 2-	Reserved For Future Use			
6	Differential I/P 1-	Reserved For Future Use			
7	Differential I/P 1+	Reserved For Future Use			
8	User Digital O/P 12-			Motor #3 Encoder A-	Buffered encoder outputs, these can be used to monitor the state of Motor #3 encoder inputs
9	User Digital O/P 12+			Motor #3 Encoder A+	
10	User Digital O/P 11-			Motor #3 Encoder B-	
11	User Digital O/P 11+			Motor #3 Encoder B+	
12	User Digital O/P 10-			Motor #3 Encoder IX-	
13	User Digital O/P 10+			Motor #3 Encoder IX+	

14	User Digital O/P 9-	Motor #2 Encoder A-	Buffered encoder outputs, these can be used to monitor the state of Motor #2 encoder inputs
15	User Digital O/P 9+	Motor #2 Encoder A+	
16	User Digital O/P 8-	Motor #2 Encoder B-	
17	User Digital O/P 8+	Motor #2 Encoder B+	
18	User Digital O/P 7-	Motor #2 Encoder IX-	
19	User Digital O/P 7+	Motor #2 Encoder IX+	
20	+5V	+5V	
21	+5V	+5V	
22	User Digital I/P 3		
23	User Digital I/P 2		
24	User Digital I/P 1		
25	User Digital I/P 0		
26	User Digital O/P 0		
27	User Digital O/P 1		
28	User Digital O/P 2		
29	User Digital O/P 3		
30	Ground	Ground	
31	User Digital O/P 4+	Motor #1 Encoder IX+	Buffered encoder outputs, these can be used to monitor the state of Motor #1 encoder inputs
32	User Digital O/P 4-	Motor #1 Encoder IX-	
33	User Digital O/P 5+	Motor #1 Encoder B+	
34	User Digital O/P 5-	Motor #1 Encoder B-	
35	User Digital O/P 6+	Motor #1 Encoder A+	
36	User Digital O/P 6-	Motor #1 Encoder A-	
37	Ground	Ground	

BNC#1	I/O #1	Trigger input and output are configurable via software	Trigger I/O. These can trigger motion related actions (e.g., absolute move). Status of these ports returned in the status update messages.
BNC#2	I/O #2		
BNC#3	I/O #3		

Notes:

Pins 1 & 2 are used for RS232 communications. This allows control of the device using the low level communications protocol, or other software environments such as micromanager.

Pins 22-29 are single ended inputs and outputs .

Pins 8-19 are differential outputs.

Pin 20-21 is a +5 V supply.

Pins 4-7 are currently not useable; a firmware/software update will allow for future use.

Warning

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

8.3.2. Differential Outputs

All differential outputs (QA, QB and IX/Ref) are driven by an AM26C31 line driver, with a 130 Ω resistor between the output of the line driver and the connector pin as shown in Figure 45. When the stage is being controlled by a joystick, in the absence of a PC, these outputs could be connected to an oscilloscope or custom circuit to facilitate monitoring of the position output.

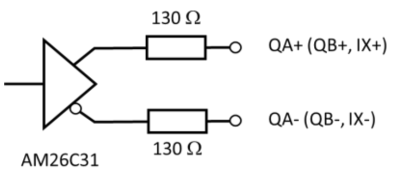


Figure 45 Differential Output Schematic

8.3.3. Digital Outputs

The digital outputs are via a 5V CMOS logic gate with a 330 Ω series resistor for protection (see Figure 46). They behave as +5 V voltage sources with 330 Ω in series when the outputs are logic HIGH, and 330 Ω to ground when logic LOW. The resistor limits the current to a 15 mA maximum for any load, provided the output is not connected to voltages outside the 0 to +5 V range.

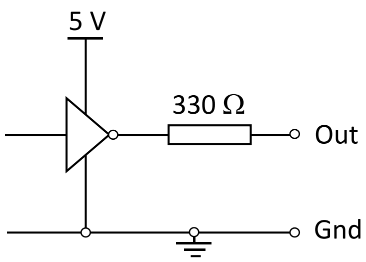


Figure 46 Digital Output Schematic

In some applications, the digital outputs may be required to control external equipment that has optocoupler type inputs (such as PLCs). As the outputs are actively driven, they can be used here to directly drive most optocouplers and the +5 V supply available on pins 20 and 21 can be used to provide power for these.

Caution

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

Please see the Kinesis Server help-file for details on software calls used to control these logic IO.

A.3.4 Digital Inputs

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

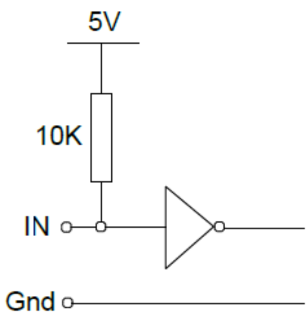


Figure 47 Digital Input Schematic (protection circuitry not shown)

When connected to a switch, the inputs will read as logic LOW if the switch is open circuit and HIGH if the switch is closed. When connected to a logic output, or any other voltage source, the input is guaranteed to read LOW if the voltage is above 2.4 V and HIGH when the output is below 0.8 V. Please see the Kinesis Server help-file for details on software calls used to control these logic IO.

Caution

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

8.3.4. +5 V Supply

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

Caution

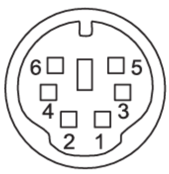
Do not exceed the 250 mA maximum output current. For applications requiring higher currents an external power supply must be used.

8.4. Rear Panel HANDSET Connector

8.4.1. Pin Identification

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

The pin functions are detailed in Figure 48.



Pin	Description
1	RX (controller input)
2	Ground
3	Ground
4	Supply Voltage for Handset 5 V
5	TX (controller output)
6	Ground

Figure 48 HANDSET Connector Pin Identification

Note

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

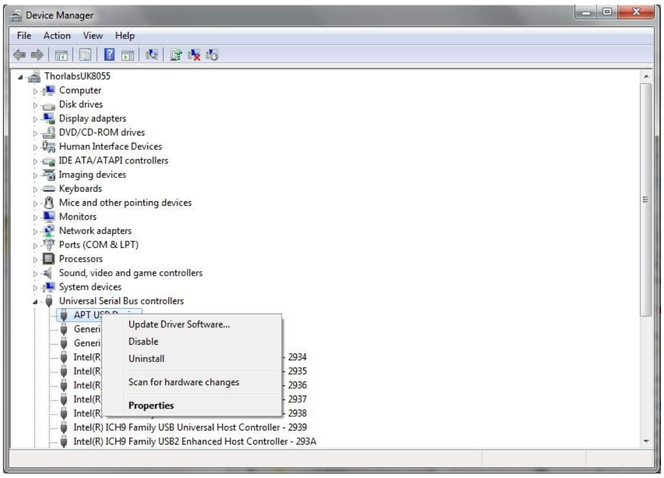
Pin 4 is for use only with Thorlabs joystick MJC001. It should not be used to power any other device.

Chapter 9 Using the RS232 or Virtual Comm Port

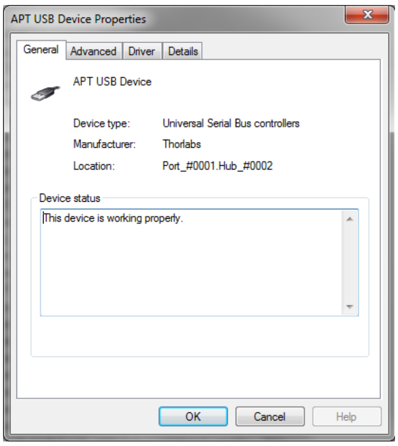
When using the low level communications protocol messages to develop client applications outside of the Kinesis software, communication with the device is facilitated by using the RS232 comms pins on the rear panel AUX I/O connector – see Section 8.3. Alternatively, a virtual comms port can be configured as follows:

1) Open the device manager by selecting Start/Control Panel/Device Manager

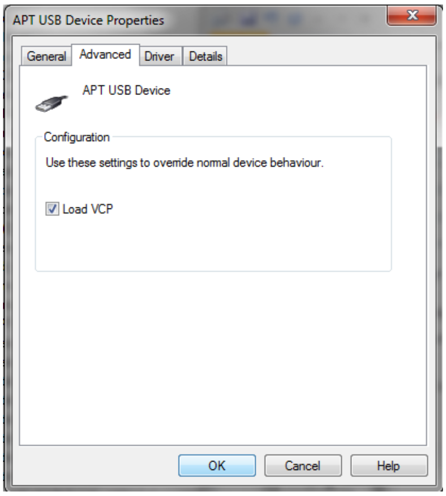
2) Click 'USB Serial Bus Controllers' and select the USB Device to be configured, then right click and select 'Properties'.



3) The 'USB Device Properties' window is displayed.

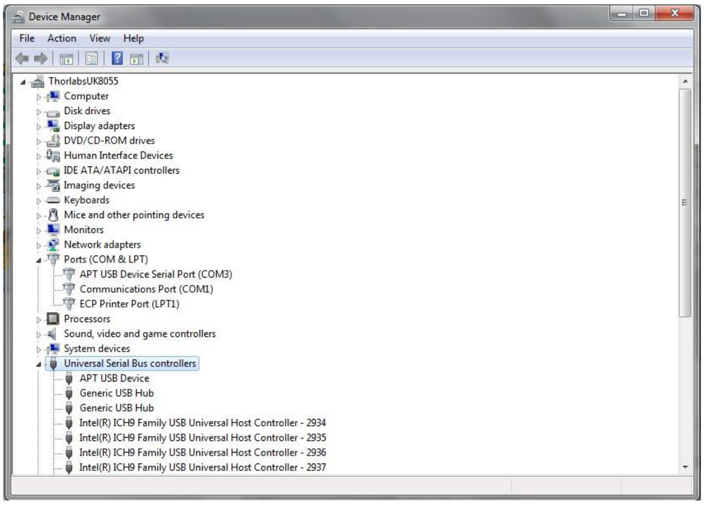


5. Select the ‘Advanced’ tab, and check the ‘Load VCP’ box.



5) Click OK, then power cycle the device being configured.

6) In the device manager, click ‘Ports (COM & LPT)’, and note the ‘USB Device Serial Port’ COM port number (e.g. COM3).



This COM port can then be used by the client application to communicate with the device using the low level protocol messages.

Chapter 10 Preventive Maintenance

10.1. Safety Testing

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

10.2. Fuses

Two T 3.15A/250V a.c. Antisurge Ceramic fuses are located on the back panel, one for the live feed and one for the neutral as follows:

Fuse	Rating	Type	Fused Line
F1	T 3.15 A	Ceramic; Anti-surge; 20 mm	Live Feed
F2	T 3.15 A	Ceramic; Anti-surge; 20 mm	Neutral Feed

When replacing fuses:

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

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

10.3. 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.

Chapter 11 Specifications

11.1. Specifications

Item #	Value
Drive Connector	8-Pin DIN-Type, Female (Motor Phase Outputs, Stage ID Input)
Feedback Connector	15-Pin D-Type, Female
AUX Control Connector	37-Pin D-Type Female (User Digital IO, 5 V O/P)
Brushless Continuous Output	2.5 A per channel (5 A max. total output)
Brushless Peak Output	4.0 A per channel (5 A max. total output)
PWM Frequency	40 kHz
Operating Modes	Position, Velocity
Control Algorithm	16-bit Digital PID Servo Loop with Velocity and Acceleration Feedforward
Velocity Profile	Trapezoidal/S-Curve
Position Count	32 Bit
Position Feedback	Incremental Encoder
Encoder Bandwidth	2.5 MHz/ 10 M Counts/sec
Encoder Supply	5 V
Front Panel Display	Full colour LCD display, 4.3”, 480 x 272 pixels
Input Power Requirements	
Voltage	100 to 240 V AC
Power	250 VA
Frequency	47 to 63 Hz
General	
Housing Dimensions **(W x D x H)**	BBD301: 199.8 x 229.1 x 108.8 mm (7.87" x 9.02" x 4.28") BBD302: 250.0 x 279.1 x 108.8 mm (9.84" x 10.99" x 4.28") BBD303: 350.0 x 279.1 x 108.8 mm (13.78" x 10.99" x 4.28")
Weight	BBD301: 1.20 kg (2.65 lbs) BBD302: 1.70 kg (3.75 lbs) BBD303: 2.20 kg (4.85 lbs)
Compatible Motors	3-Phase DC Brushless Motors Peak Powers: 100 W Coil Resistance: 0.1 to 100 Ω Coil Inductance (Nominal): 1 to 100 mH Rated Phase Currents (Nominal): 100 mA to 5 A

Chapter 12 An Introduction to Multi-Axis Synchronized Moves

12.1. Introduction

This section describes the implementation of multi-axis synchronized moves on the Thorlabs BBD30x series controllers.

In order to give developers a better understanding of the underlying principles of multi-axis synchronized moves, the relevant building blocks of the BMC10X controller are shown below:

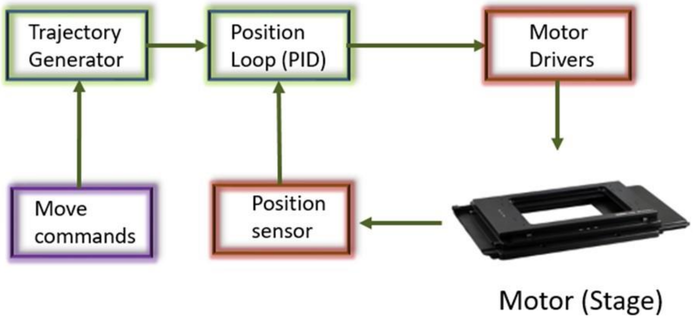


Figure 49 Multi-Axis Synchronized Moves Schematic

At the heart of nearly all motion control algorithms a trajectory generator is used to generate the position points where the motor is required to be at any one time. The trajectory (position target) values output by the trajectory generator are fed to the position loop controller which compares the target position to the actual position and adjusts the motor current, always trying to maintain the target position. Thus when a move is commanded, the corresponding parameters are sent to the trajectory generator, which then calculates the position target values required to execute the move.

12.2. Trapezoidal Move Profiles

Simple linear point-to-point moves (which are also the most commonly used moves) are conveniently described by the end position, acceleration and maximum velocity values.

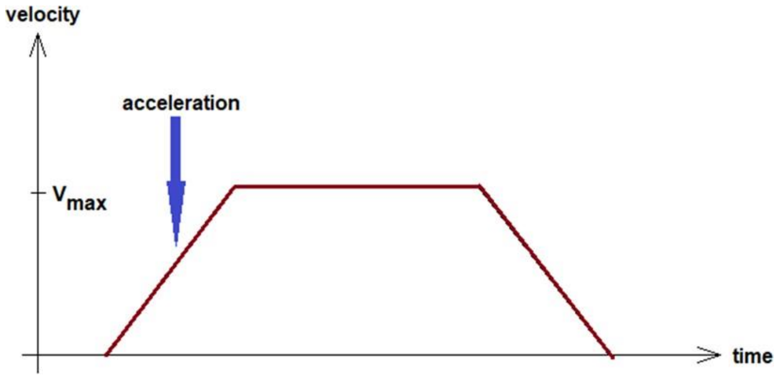


Figure 50 Trapezoidal Move Trajectory

At the start of the move, the motor accelerates to the specified maximum velocity, travels at that velocity and then decelerates to zero velocity and reaches that at exactly the target position.

For simple multi-axis moves, the trapezoidal move scheme can easily be extended to two or more dimensions.

If we want to move from position (x1, y1) to position (x2, y2) with acceleration Acc and velocity Vel, then the moves for the individual axes will be effectively the vector projections of the overall 2-D move.

Thus from the 2-D move parameters we can calculate the move parameters for each axis by simply multiplying Acc and Vel with the scaling factors:

$$Scale_x = \frac{x_2 - x_1}{\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}}$$

and

$$Scale_y = \frac{y_2 - y_1}{\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}}$$

Thus:

$Acc^x = Acc * Scale^x$ and $Acc^y = Acc * Scale^y$ $Vel^x = Vel * Scale^x$ and $Vel^y = Vel * Scale^y$

12.3. Complex Move Shapes

The trapezoidal move profile is impractical for describing more complex move shapes, such as an arc or circle. For these, a different approach is used and the move is described as a time-position array that defines the position targets the trajectory has to output at the predefined time points. For the time points in-between the specified points the trajectory generator uses linear interpolation.

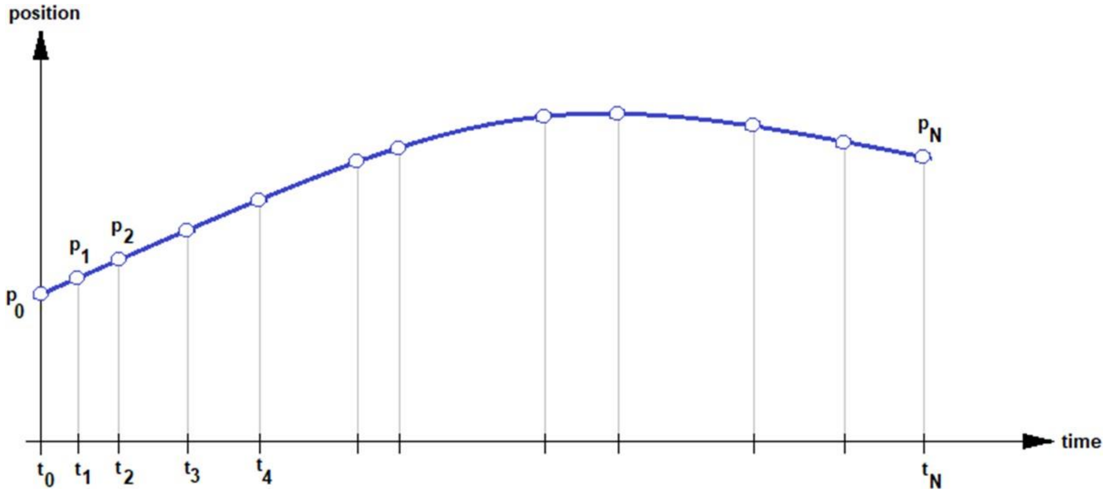


Figure 51 Curved Move Trajectory

The figure above shows the approach: the shape of the curve is described as a time-position array (t0, p0), (t1, p1) … (tN, pN)

The interval between the time points does not need to be equal. In fact, as linear interpolation is used between adjacent points,

the algorithm effectively moves in a straight line between points, so more linear sections of the shape do not need to be described with the same frequency as more curved sections.

With this definition of the move trajectory the acceleration and velocity values are no longer predefined parameters but instead are implicit in the time-position difference between adjacent points. This also means that the user must pay attention to the velocity and acceleration limitations of the controller and the stage. With simple trapezoidal move profiles, the acceleration and velocity are normally set to values that are supported by the controller and with reasonable values they result in smooth motion. The time-position array, on the other hand, allows the user more freedom but as a result also opens up the possibility of move definitions that the controller cannot execute. For example, a large position change in a very short time can translate into excessive velocity and/or acceleration values.

Whilst the approach can be used to define single axis moves, it is more useful for multi-axis synchronized moves. For these the time-position array contains the position points for each axis. Thus, the array defines the position of all axes involved in the move at the same time points. Assuming 2 dimensional (x, y) coordinates, the array becomes:

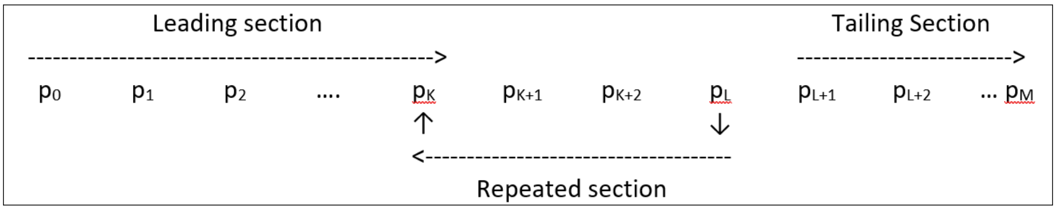
(t0, x0, y0), (t1, x1, y1) … (tN, xN, yN)

Obviously, the scheme can be extended to any number of axes that the controller supports.

12.4. Repeated Patterns

To make the scheme more flexible, a section of the curve can also be repeated for a number of times. With this extension, the array can be considered as having a leading, a repeated and a tailing section. This is useful for applications where, for example, the repeated pattern needs to be preceded by an acceleration phase and then completed by deceleration to standstill.

In the illustration below the section pK to pL is repeated.



12.5. Starting a Synchronized Trajectory

The user must take into account the initial position of the stage when the trajectory is started. In almost all usage scenarios the stage will be at standstill when the synchronous move is started and immediately afterwards there will be a move to the first point in the time-position array. This can result in a large jump. The easiest way of avoiding this is by moving the stage to the first point defined in the time-position array prior to starting the synchronized trajectory.

To define the multi-axis synchronized moves, the time-position array and the corresponding parameters must be loaded into the controller. This is achieved by uploading a .CSV file via the GUI panel - see Section 6.3.2.

Chapter 13 Regulatory

13.1. Declarations of Conformity

13.1.1. For Customers in Europe

THORLABS
www.thorlabs.com

EU Declaration of Conformity

in accordance with EN ISO 17050-1:2010

We: Thorlabs Ltd.

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

in accordance with the following Directive(s):

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

hereby declare that:

Model: ***BBD30X***

Equipment: ***Benchtop Brushless Motor Controller***

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

EN 61010-1	Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use.	2010
EN 61326-1	Electrical Equipment for Measurement, Control and Laboratory Use - EMC Requirements	2013

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

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

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

Signed: *On:* 12 May 2021

Name: Keith Dhese

Position: General Manager

EDC - BBD30X -2021-05-12

CE

13.1.2. 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.

Chapter 14 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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Thorlabs, Inc.
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brasil@thorlabs.com

China
Thorlabs China
chinasales@thorlabs.com

Thorlabs verifies our compliance with the WEEE (Waste Electrical and Electronic Equipment) directive of the European Community and the corresponding national laws. Accordingly, all end users in the EC may return "end of life" Annex I category electrical and electronic equipment sold after August 13, 2005 to Thorlabs, without incurring disposal charges. Eligible units are marked with the crossed out "wheelie bin" logo (see right), were sold to and are currently owned by a company or institute within the EC and are not dissembled or contaminated. Contact Thorlabs for more information. Waste treatment is your own responsibility. "End of life" units must be returned to Thorlabs or handed to a company specializing in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

Annex I

www.thorlabs.com