THORLABS

XA Motion Control Software

User Guide

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Chapter 1 Introduction

1.1 Intended Use

The purpose of this guide is to provide an overview of the XA GUI.

1.2 Description

XA is a motion control software application that allows both programmed and live control of the Thorlabs range of motion controllers for driving stages and actuators based on different motor types, including brushless, stepper, brushed, and piezo technologies. Software developers can use the C library or its associated language bindings included in the installation package and should refer to the developer documentation therein.

The XA library is designed to run under 32-bit and 64-bit Windows® operating systems and requires approximately 15 MB of disk space and around 250 MB of RAM.

This guide provides the initial steps required to install the supplied GUI application and connect to a controller to control a stage. The XA GUI application is built on the .NET language bindings that are supplied in the software development kit (SDK). Therefore, any functionality that it provides can be recreated in a custom application using the library. The SDK itself consists of a single dynamic link library (DLL) packaged within the installer, and the .NET library contains the native (C/C++) library internally. The XA application will eventually replace Thorlabs' Kinesis® software for existing and newly developed products. Thorlabs is committed to supporting the XA platform until at least 2040.

1.3 Supported Motion Control Devices

XA currently supports the following devices:

Stepper Motor Stages and Actuators:

BSC202 (controller), BSC203 (controller), KST201 (controller), DRV225, DRV250, FW103(/M), LTS150C(/M), LTS300C(/M), LTS450C(/M), MVSN1(/M), ZFS06, ZFS13, ZFS13B, ZFS25B, ZST206, ZST213, ZST213B, ZST225B

DC Brushed Stages and Actuators:

KDC101 (controller), CR1-Z6, CR1-Z7, MTS25-Z8, MTS25/M-Z8, MTS50/M-Z8, MTS50-Z8, MTS100-Z8, MTS100/M-Z8, PRM1Z8, PRM1/MZ8, Z606[a], Z606V[a], Z612[a], Z612B[a], Z612BV[a], Z612V[a], Z625B[a], Z625BV[a], Z806[a], Z806V[a], Z812[a], Z812B[a], Z812BV[a], Z812V[a], Z825[a], Z825B[a], Z825BV[a], Z906, Z906V, Z912, Z912B, Z912BV, Z912V, Z925B, Z925BV

Brushless Stages and Actuators:

BBD301 (controller), BBD302 (controller), BBD303 (controller), KBD101 (controller), TBD001[a] (controller), DDR25(/M), DDR100(/M), DDS050(/M), DDS100(/M), DDS220(/M), DDS300(/M), DDS600(/M), M150XY(/M), MLS203-1, MLS203-2

Piezo Actuators and Stages:

BPC303 (controller), APF503, APF705, APF710, APFH720, DRV120, DRV517, NF15AP25(/M), NFL5D(/M), NFL5DP20(/M), NFL5DP20S(/M), PAS009, PAZ005, PAZ009, PK2FSF1, PK2FVF1

a. This is a previous-generation item.

Chapter 2 Getting Started

The XA application and library can be installed using the Windows Install Shield installer, which can be downloaded from the Thorlabs website.

Double-click the installation file and follow the below process:

1. After installing XA, run the XA application from the start menu, which will open the XA main window.
2. The XA application automatically scans for USB motion controllers plugged into the PC, so plug in the controller and power it up.
3. Click 'Connect' in the main XA application window to see a list of detected devices.

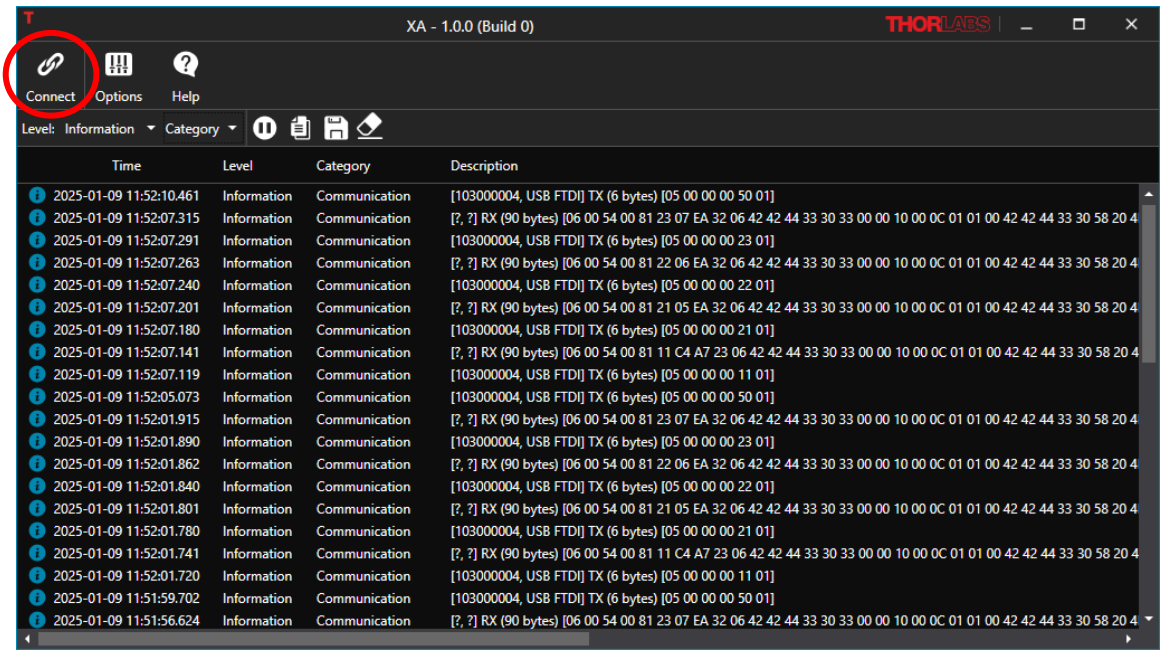


Figure 1 Connect the Hardware

4. The connection window displays that the controller (KDC101 in this case) is detected. Select and click 'OK' to initiate the connection.

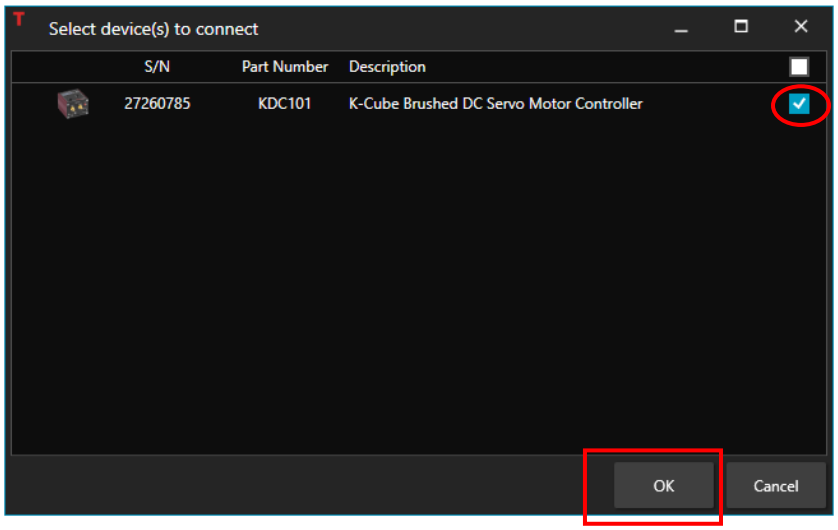


Figure 2 Connection Window

After connecting to each controller, a device control window will appear for each channel (on multi-channel controllers) or a single window on single-channel controllers. The window shows information about the

controller and stage, such as position and status, and controls the user can use to home, change settings, move, and perform other operations on the connected controller and stage.

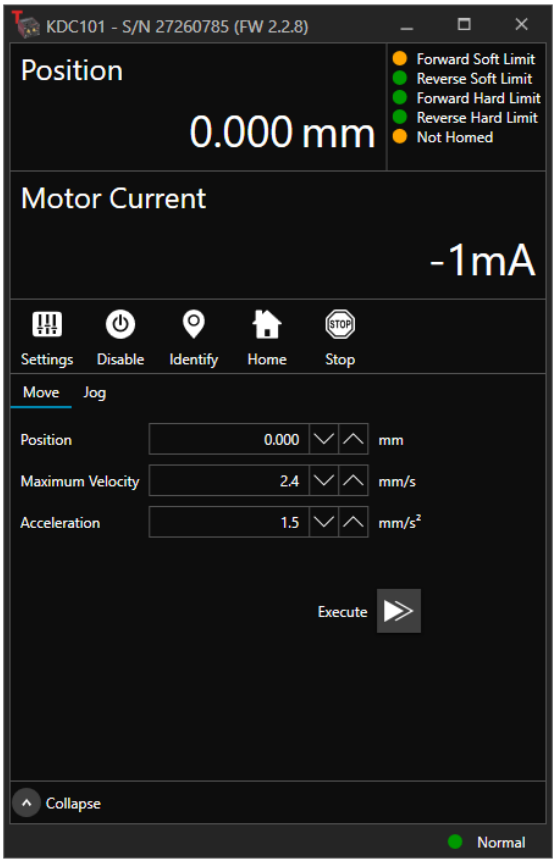


Figure 3 KDC101 GUI

Chapter 3 Basic Operation

3.1 Homing

Some stages or actuators require a homing procedure to be initiated so that all subsequent moves can be started from a known position. Prior to homing the status is indicated by an amber color Not Homed. Pressing the 'Home' button moves the stage or actuator toward its homed position. When homing is complete, the status indicator is green.

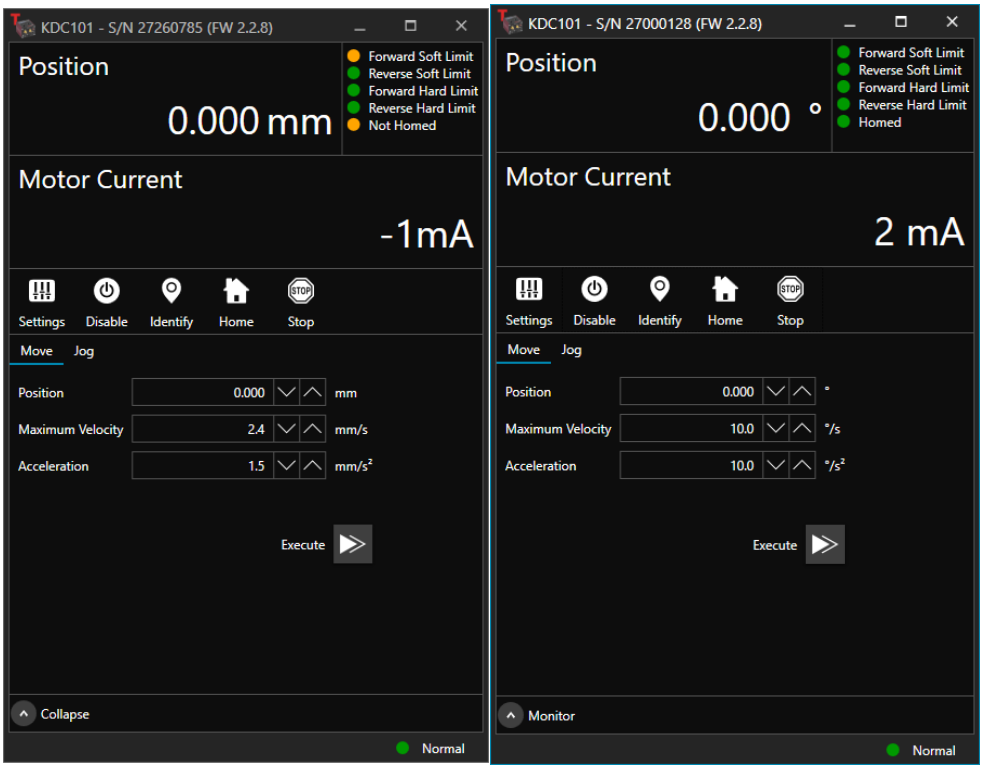


Figure 4 Homing

3.2 Moving to a Position

After homing the stage or actuator, the user can move it to a given position along its travel. Click the 'Move' tab on the device control window and enter the desired position. Once the 'Execute' button is clicked, the position dynamically updates as the stage or actuator moves to the requested position. For details about the information available in this window see section 4.2.

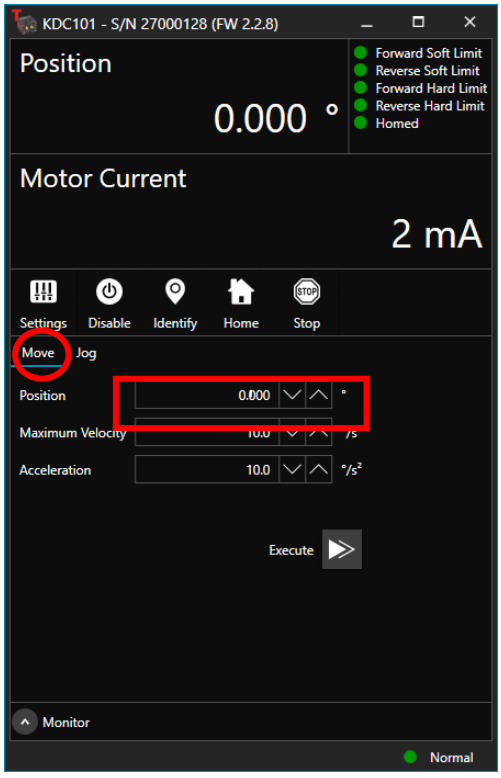


Figure 5 Moving to a Position

3.3 Jog by a Specified Distance

Jogs are initiated by using the 'Jog' keys on the GUI panel or the Jog Buttons on the front panel of the unit.

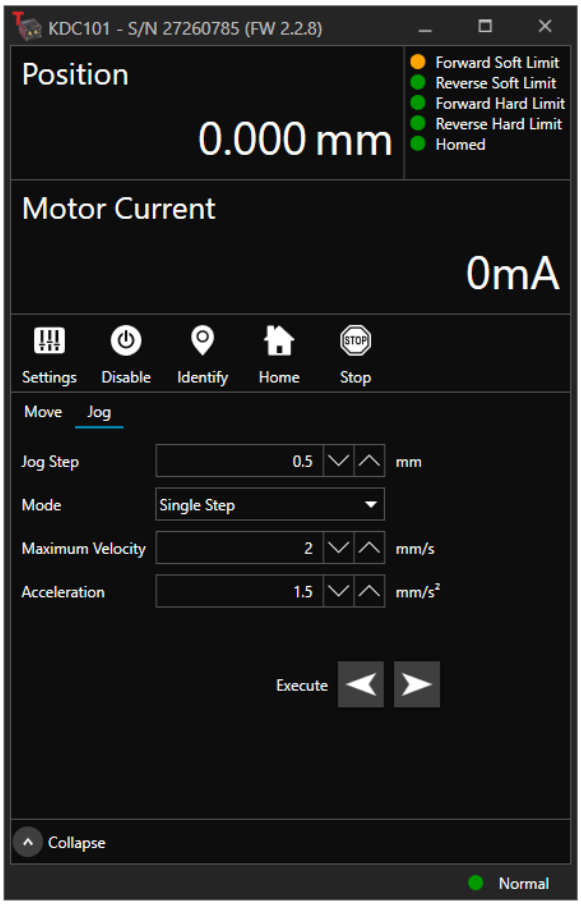


Figure 6 Jog Modes

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

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

There are two jogging modes available, 'Single Step' and 'Continuous'. In 'Single Step' mode, the motor moves by the distance specified in the 'Jog Step' parameter. If the jog key is held down, single step jogging is repeated until the button is released – see Figure 6. In 'Continuous' mode, the motor actuator accelerates and moves at the jog velocity while the button is held down.

Single Step – The motor moves by the distance specified in the Jog Step parameter.

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

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.

3.4 Changing Parameters

Certain performance parameters may require optimization based on equipment and application. These can be accessed in the 'Settings' window for each device. All settings can be saved and loaded from within the device's 'Settings' window to allow fast configuration of the stage or actuator in the future and bring it back to its current state. For details about the settings options available, please refer to Chapter 4.

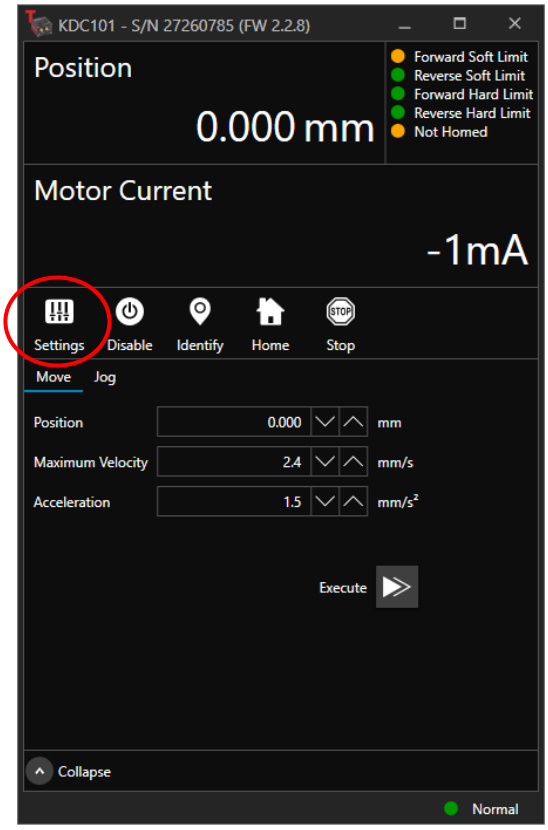


Figure 7 Changing Parameters

Chapter 4 Software Reference

4.1 Main Menu

Upon launch, as displayed by the following screenshot, the graphical user interface (GUI) opens to show a live, time-stamped set of logs indicating the various actions of the software.

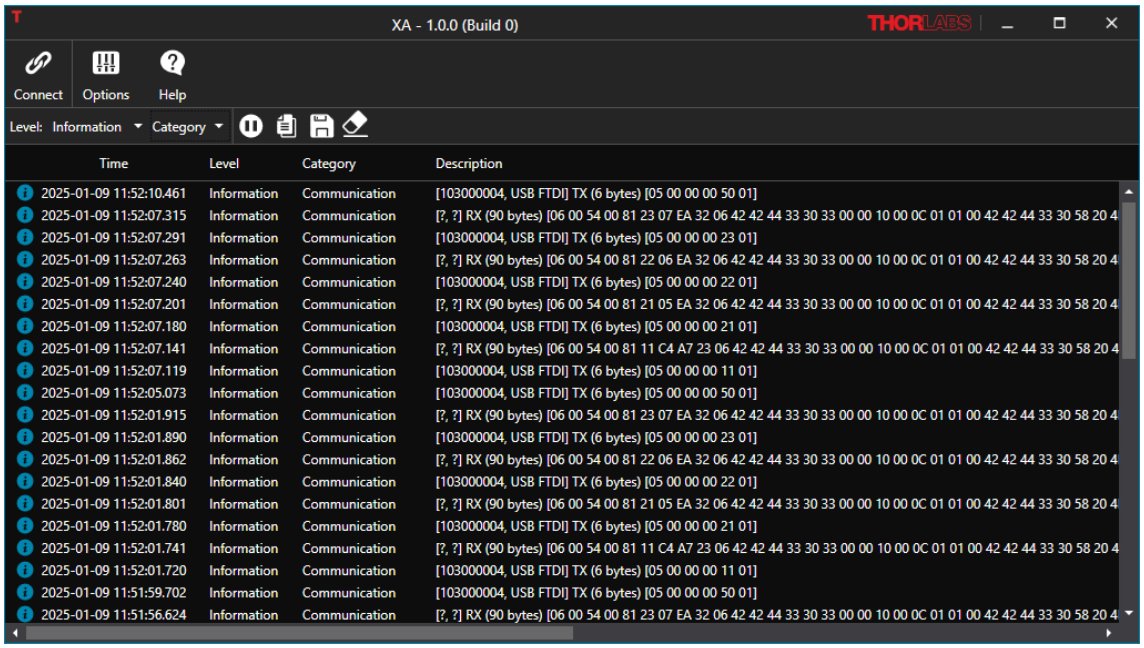
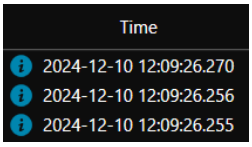


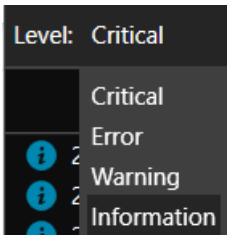
Figure 8 XA GUI

Below are the descriptions of the information and available options on the initial XA window:

Time Column – It records the time and date of the log message.



Level Column – It specifies the recorded log level. There are four different levels:



a) Critical

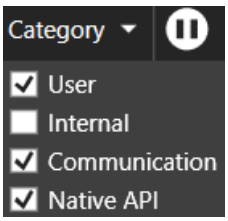
b) Error

c) Warning

d) Information

The levels range from Critical, the most severe level, to Information, the least severe. Selecting a particular level will allow log messages of that level and all more severe levels to be displayed. Changing the level controls the filtering of all subsequent messages. For example, if the level changes from Warning to Error, subsequent log messages will include only Error and Critical messages.

Category Column – It relates to the source of the log message. These can be turned on or off depending on the requirements of the log lists. There are four categories that can be selected:



a) Internal – The core of XA and its various subsystems.

b) Native API – The layer that exposes the core through the API surface.

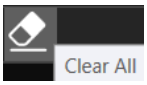
c) User – The logging system contains a user-accessible API so that customer applications can inject log messages into the system logs.

d) Communication – Protocol messages between XA and the device.

Copy Selected – All log entries are selectable from the main window and can be copied into the Windows clipboard as plain text for further editing, such as inserting into emails or a text editor. This is particularly useful for reporting issues discovered within the software to technical support.

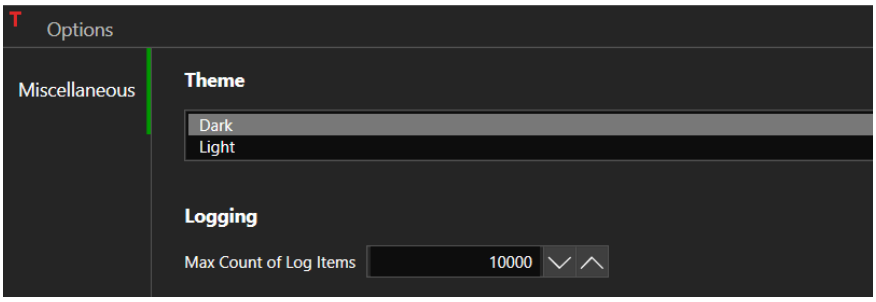
Play/Pause – This button will stop and resume the information logs.

Clear All – This button will remove the currently recorded logs.



Help – This button will show the build number and other information.

Options – This button displays various application-related options. Here, users can select a Dark or Light display and set the maximum number of recorded log messages. Device-specific settings are accessed through the device control window that appears once a connection is made.



4.2 Controller Menu

Once the XA software has connected to a controller, various parameters are displayed in the Controller GUI. The KDC101 controller is used as an example in the GUI shown below:

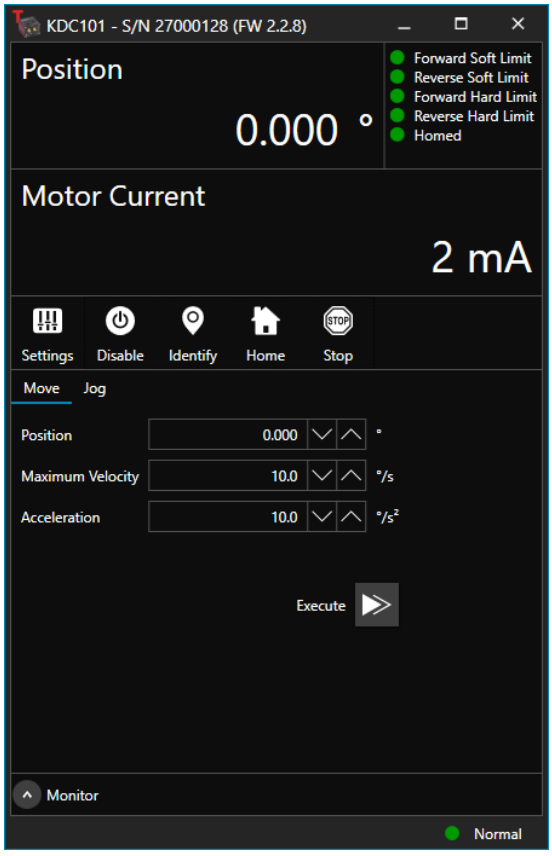


Figure 9 Controller GUI

Position window – Shows the position (in millimeters or degrees) of the motor. The motor must be 'Homed' before the display will show a meaningful value, (i.e. the displayed position is relative to a physical datum, the limit switch). Voltage will be displayed instead of position for Piezo devices.

Motor Current – Displays the current being sent to the motor.

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

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

Stop – Halts the movement of the motor.

Settings – Displays the 'Settings' panel, which allows the operating parameters to be entered for the motor drive. Refer to section 4.3 for details on the available parameters.

Forward Soft Limit – When linear stages or actuators are used, a physical limit switch inside the stage or actuator is activated at the forward travel limit. Forward hard limit switches are often not installed on rotation stages; however, some filter wheels may have them, and they may activate at each filter position.

Reverse Soft Limit – Physical limit switches are used to indicate the home, or zero distance, position to which all other distances are relative. In the case of linear stages or actuators, these switches are activated at the end of the travel range. When this switch is turned on, rotation stages will normally use this for homing but won't stop rotation after this point.

Forward Hard Limit – A user definable limit switch position in the forward travel direction settable on some controllers.

Reverse Hard Limit – A user definable limit switch position in the reverse travel direction settable on some controllers.

Move/Jog – Move changes the absolute position of a stage or actuator. Jog moves the stage or actuator a discrete distance in the specified direction as described in section 3.3.

4.3 Settings Menu

The parameters in the Settings GUI depend on the controller, but this section describes the common parameters available in the Settings window for the four types of motion controllers.

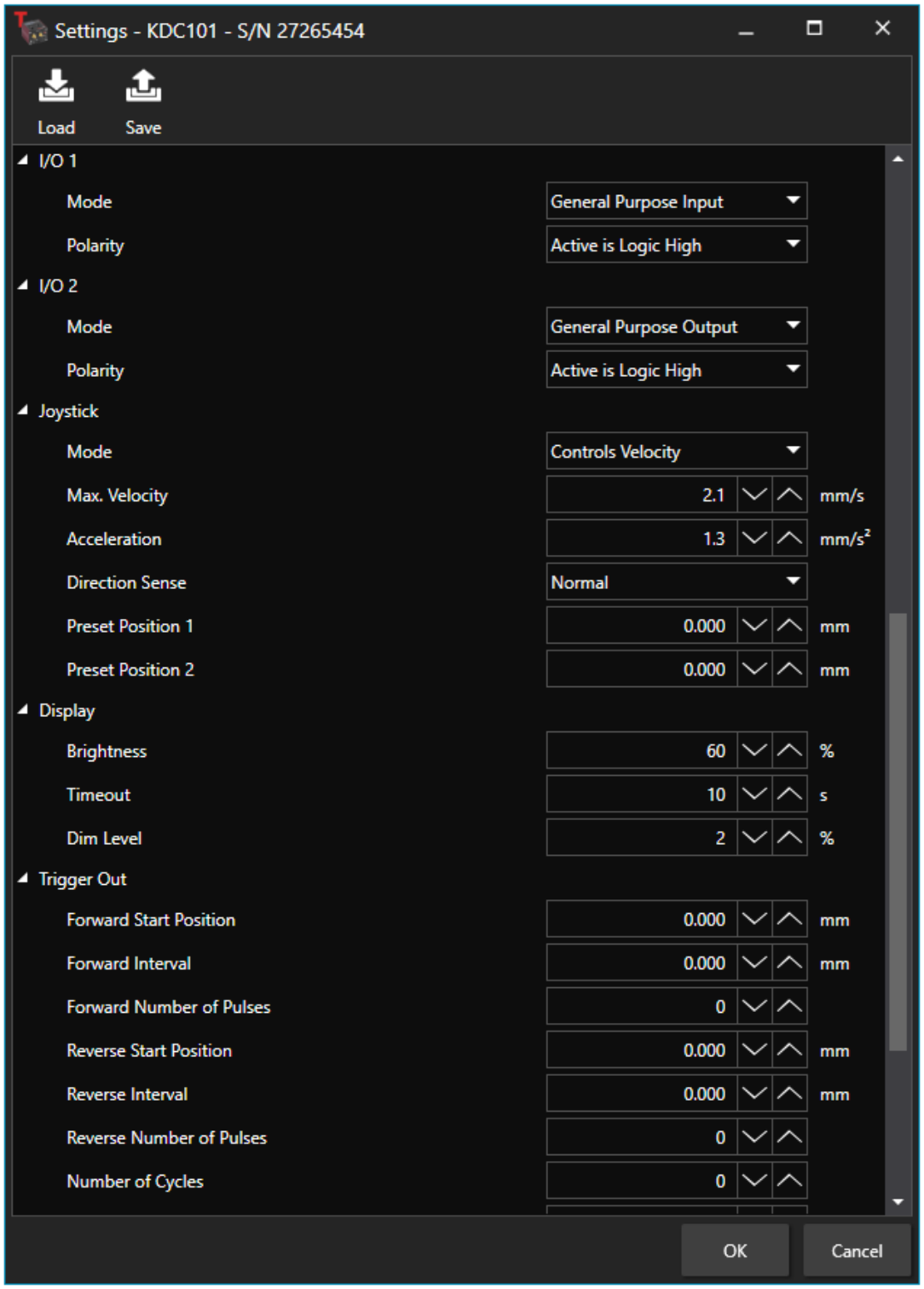
4.3.1 DC Brushed Stages

This section details the settings available for the KDC101 Brushed DC Motor Controller. This example is provided to familiarize the user with the expected settings. Other hardware configurations will have similar settings.

(a)


Settings - KDC101 - S/N 27265454
Load
Save
Control Loops
Position
Proportional 435
Integral 195
Derivative 993
Integral Limit 195
Move
Backlash Distance 0.007 mm
Preset Absolute Position 0.000 mm
Preset Relative Distance 0.000 mm
Min. Velocity 0.0 mm/s
Acceleration 0.6 mm/s²
Max. Velocity 0.4 mm/s
Home
Direction Reverse
Limit Switch Reverse
Offset Distance 0.711 mm
Velocity 0.4 mm/s
Jog
Mode Single Step
Step Size 0.071 mm
Min. Velocity 0.0 mm/s
Acceleration 0.6 mm/s²
Max. Velocity 0.4 mm/s
Stop Mode Profiled
OK
Cancel

(b)


Settings - KDC101 - S/N 27265454
Load
Save
I/O 1
Mode
General Purpose Input
Polarity
Active is Logic High
I/O 2
Mode
General Purpose Output
Polarity
Active is Logic High
Joystick
Mode
Controls Velocity
Max. Velocity
2.1
mm/s
Acceleration
1.3
mm/s²
Direction Sense
Normal
Preset Position 1
0.000
mm
Preset Position 2
0.000
mm
Display
Brightness
60
%
Timeout
10
s
Dim Level
2
%
Trigger Out
Forward Start Position
0.000
mm
Forward Interval
0.000
mm
Forward Number of Pulses
0
Reverse Start Position
0.000
mm
Reverse Interval
0.000
mm
Reverse Number of Pulses
0
Number of Cycles
0
OK
Cancel

(c)

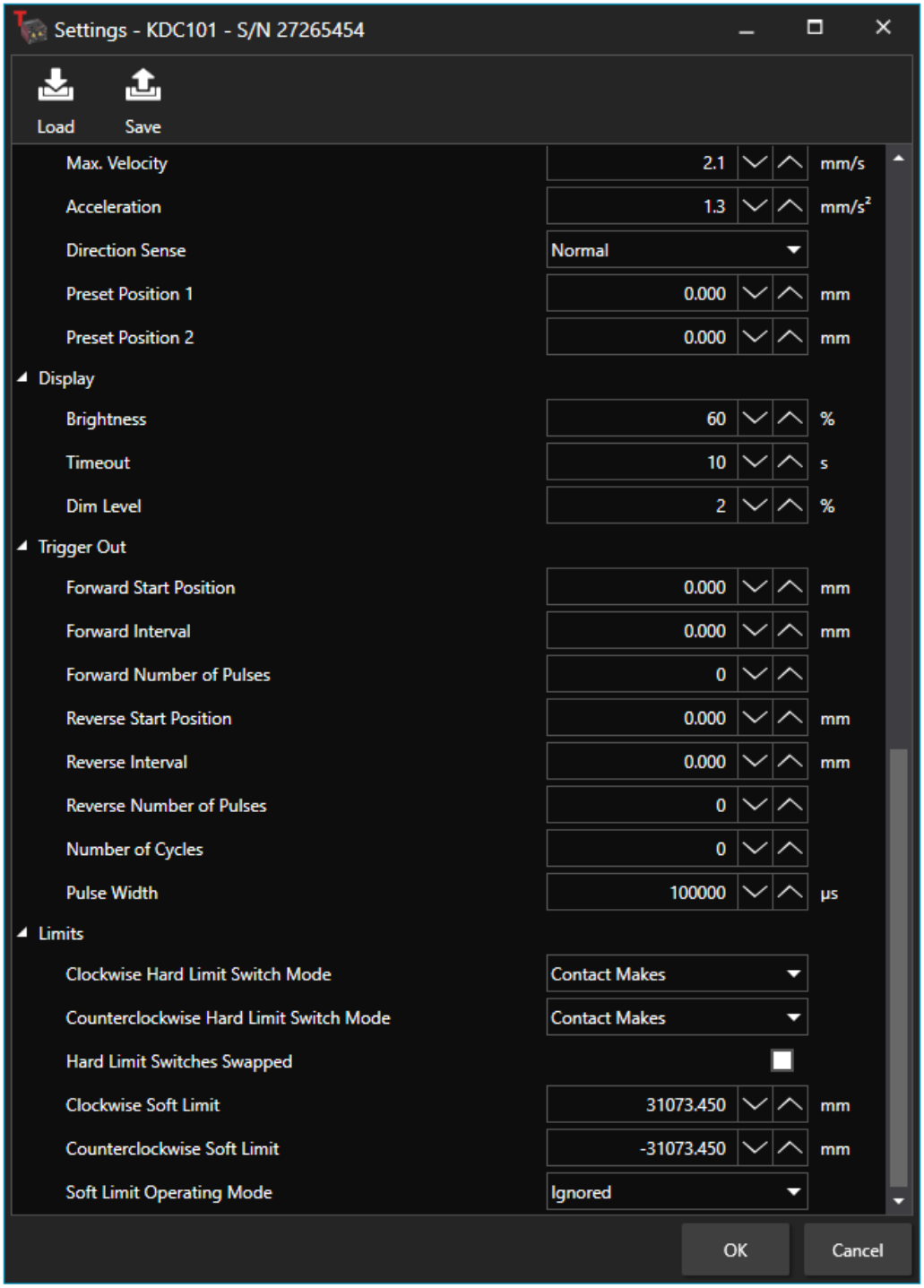


Figure 10 Screenshots (a), (b), and (c) show available settings for the KDC101 Brushed DC Controller.

Control Loops

The DC Driver K-Cube® implements a full servo control loop for motor velocity and position control. The loop response to demanded position moves is determined via Proportional, Integration and Derivative settings. These settings can be altered using the 'Servo Loop (PID) Control Settings' parameters.

Proportional – This parameter makes a change to the output which is proportional to the positional error value. A high proportional gain results in a large change in the output for a given error. It accepts values in the range 0 to 32767.

Integral – This parameter accelerates the process towards the demanded position, ensuring that the positional error is eventually reduced to zero. If set too high, the output can overshoot the demand value. Under a constant torque loading, the static position error is zero. It accepts values in the range 0 to 32767.

Derivative – This term provides the 'damping' force proportional to the rate of change of the position error, thereby decreasing the overshoot which may be caused by the integral term. However, the differential term also slows down system response. It accepts values in the range 0 to 32767.

Integral Limit – This term sets a maximum limit for the integration term to prevent an excessive build up over time of the restoring force. It accepts values in the range 0 to 32767

Move

Backlash Distance – The system compensates for lead screw backlash during reverse direction moves by moving past 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 real world units (millimeters or degrees). To remove backlash correction, this value should be set to zero.

Preset Absolute Position – The absolute position to move to when a trigger is configured.

Preset Relative Distance – The relative distance to move by when a trigger is configured.

Minimum Velocity – Starting velocity of the motion profile.

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

Maximum Velocity – The maximum velocity at which to perform a move.

Home

Direction – The direction to move when homing, either Forward or Reverse.

Limit Switch – The hardware limit switch associated with the home position, either Forward HW or Reverse HW.

Offset Distance – 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.

Jog

Mode – The way in which the motor moves when a jog command is received. There are two jogging modes available, 'Jog' and 'Continuous'. In 'Jog' mode, the motor moves by the distance specified in the Step Size parameter. If the jog key is held down, single-step jogging is repeated until the button is released. In 'Continuous' mode, the motor actuator will accelerate and move at the jog velocity while the button is held down

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

Minimum Velocity – Starting velocity of the motion profile.

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

Maximum Velocity – The maximum velocity at which to perform a move.

Stop Mode – 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.

I/O 1

Mode – I/O ports can be configured for several uses. If enabled as digital inputs, then they can be configured to trigger either relative or absolute movements when activated or they could initiate a homing procedure.

Alternatively, when configured as outputs, they can activate to indicate motion in progress or that maximum velocity has been reached during movement. They may also produce a pulsed output where they activate recurrently at pre-defined positions. Finally, the I/O ports can be configured for software control so that the client can read or set them arbitrarily.

Polarity – The Voltage level at which the I/O port is considered active. This could be nominally 0 V or 5 V.

I/O 2

Mode – The I/O mode of the second I/O port

Polarity – The polarity of the second I/O port.

Joystick

Mode – Deflecting the wheel starts a move with the velocity proportional to the deflection.

Maximum Velocity – The velocity corresponding to the full deflection of the joystick wheel.

Acceleration – The rate at which the velocity climbs from zero to maximum and slows from maximum to zero.

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

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

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

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

Preset position 1 – The motor moves to position 1 when the jog wheel is moved down.

Preset Position 2 – The motor moves to position 1 when the wheel is moved up.

Display

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

Timeout – 'Burn In' of the display can occur if it remains static for a long time. To prevent this, the display is automatically dimmed after the time interval specified in the Display Timeout parameter has elapsed.

Dim Level – The time interval is specified in minutes in the range 1 to 480. The dim level is set in the Dimmed Intensity parameter, as a percentage of full brightness from 0 (Off) to 10 (brightest) but is also limited by the Display Intensity parameter if this is lower.

Trigger Out

Forward Start Position – Trigger output active (pulsed) at pre-defined positions moving forward. Only one Trigger port at a time can be set to this mode.

Forward Interval – When a pulsed I/O mode is selected, this setting is the distance between the start of pulses in the forward direction.

Forward Number of Pulses – When a pulsed I/O mode is selected, this is the number of pulses that can be created in the forward direction.

Reverse Start Position – Trigger output active (pulsed) at pre-defined positions moving backwards. Only one Trigger port at a time can be set to this mode.

Reverse Interval – When a pulsed I/O mode is selected, this setting is the distance between the start of pulses in the reverse direction.

Reverse Number of Pulses – When a pulsed I/O mode is selected, this setting is the distance between the start of pulses in the reverse direction.

Number of Cycles – When a pulsed I/O mode is selected, this is the number forward/reverse move cycles.

Pulse Width – This is the trigger output pulse width.

Limits

Clockwise Hard Limit Switch Mode – Configures the hardware limit switch behavior in the forward or clockwise direction of travel.

Counterclockwise Hard Limit Switch Mode – Configures the hardware limit switch behavior in the reverse or counterclockwise direction of travel.

Hard Limit Switches Swapped – Defines whether the clockwise and counterclockwise limit switches have been physically swapped.

Clockwise Soft Limit – Software defined limit switch in the forward or clockwise direction of travel.

Counterclockwise Soft Limit – Software defined limit switch in the reverse or counterclockwise direction of travel.

Soft Limit Operating Mode – The operation of the stage or actuator when the software defined limit switch is triggered.

4.3.2 Stepper Motor Stages and Actuators

This section details the settings available for the BSC203 Stepper Motor Controller. This example is provided to familiarize the user with the expected settings. Other hardware configurations will have similar settings.

(a)


Settings - BSC203 - S/N 90458715
Load
Save
Move
Bow Index
S-Curve 2
Backlash Distance
0.010
mm
Preset Absolute Position
0.000
mm
Preset Relative Distance
0.100
mm
Min. Velocity
0.0
mm/s
Acceleration
4.0
mm/s²
Max. Velocity
2.0
mm/s
Home
Direction
Reverse
Limit Switch
Reverse
Offset Distance
0.500
mm
Velocity
1.0
mm/s
Jog
Mode
Single Step
Step Size
0.500
mm
Min. Velocity
0.0
mm/s
Acceleration
0.5
mm/s²
Max. Velocity
1.0
mm/s
Stop Mode
Profiled
Joystick
Low Gear Max Velocity
1.2
mm/s
High Gear Max Velocity
2.5
mm/s
Low Gear Acceleration
1.2
mm/s²
High Gear Acceleration
2.5
mm/s²
Direction Sense
Positive
OK
Cancel

(b)

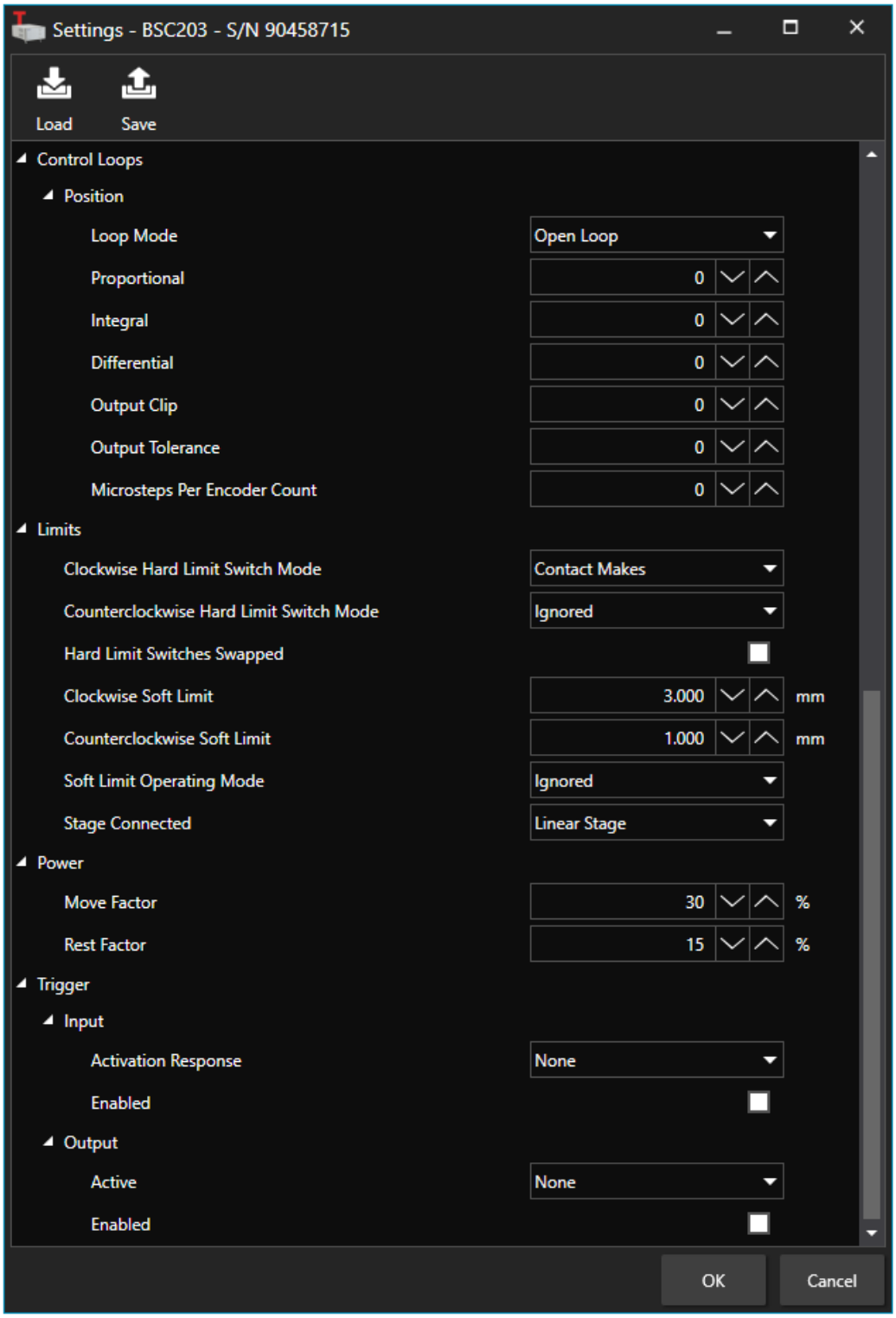


Figure 11 Screenshots (a) and (b) show available settings for the BSC203 Stepper Controller.

Move

Bow Index – Selects between trapezoidal or S-Curve motion profiles when executing a movement.

Backlash Distance – The system compensates for lead screw backlash during reverse direction moves by moving past 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 real-world units (millimeters or degrees). To remove backlash correction, this value should be set to zero

Preset Absolute Position – The absolute position to move to when a trigger is configured.

Preset Relative Distance – The relative distance to move by when a trigger is configured.

Minimum Velocity – The starting velocity when initiating a move.

Acceleration – The rate at which the velocity climbs from zero to maximum and slows from maximum to zero.

Maximum Velocity – The maximum velocity at which to perform a move.

Home

Direction – The direction to move when homing, either Forward or Reverse.

Limit Switch – The hardware limit switch associated with the home position, either Forward HW or Reverse HW.

Offset Distance – 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.

Jog

Mode – The way in which the motor moves when a jog command is received. There are two jogging modes available, 'Jog' and 'Continuous'. In 'Jog' mode, the motor moves by the distance specified in the Step Size parameter. If the jog key is held down, single step jogging is repeated until the button is released. In 'Continuous' mode, the motor actuator will accelerate and move at the jog velocity while the button is held down

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

Minimum Velocity – The starting velocity when initiating a jog.

Acceleration – The rate at which the velocity climbs from zero to maximum and slows from maximum to zero.

Maximum Velocity – The maximum velocity at which to perform a move.

Stop Mode – 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.

Joystick

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

High Gear Maximum 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.

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

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

Control Loops

Position

Loop Mode – Whether the movement is being performed in open-loop or closed-loop mode (only possible whilst an encoder is connected).

Proportional – This parameter makes a change to the output which is proportional to the positional error value. A high proportional gain results in a large change in the output for a given error. It accepts values in the range 0 to 32767.

Integral – This parameter accelerates the process towards the demanded position, ensuring that the positional error is eventually reduced to zero. If set too high, the output can overshoot the demand value. Under a constant torque loading, the static position error is zero. It accepts values in the range 0 to 32767.

Differential – The differential term in a PID loop has the effect of damping acceleration.

Output Clip – Clips the value of the PID loop to ensure that the value doesn't run away.

Output Tolerance – A dead-band value below which the output of PID generator is effectively deemed to be zero to avoid continual cycling about the set point.

Microsteps Per Encoder Count – The size of the microstep depends on the resolution of the driver electronics. When used with the Thorlabs BSC203 Stepper Motor Controller, the smallest angular adjustment is 0.000879° (i.e. 1.8/0.000879 = 2048 microsteps per full step).

Limits

Clockwise Hard Limit Switch Mode – Configures the hardware limit switch behavior in the forward or clockwise direction of travel.

Counterclockwise Hard Limit Switch Mode – Configures the hardware limit switch behavior in the reverse or counterclockwise direction of travel.

Hard Limit Switches Swapped – Defines whether the clockwise and counterclockwise limit switches have been physically swapped.

Clockwise Soft Limit – Software defined limit switch in the forward or clockwise direction of travel.

Counterclockwise Soft Limit – Software defined limit switch in the reverse or counterclockwise direction of travel.

Soft Limit Operating Mode – The operation of the stage or actuator when the software defined limit switch is triggered.

Stage Connected – The type of movement that the connected stage performs.

Power

Move Factor – Percentage of maximum power to drive the motor during a movement.

Rest Factor – Percentage of maximum power to drive the motor when holding its position.

Trigger

Input

Activation Response – Determine the effect of an input trigger. This could initiate a homing procedure or a relative or absolute move.

Enabled – Whether the trigger is enabled or not.

Output

Active – Outputs can be activated in the event of an input trigger and can either mirror the input trigger signal exactly or remain active for the period of the move.

Enabled – Whether or not the output is active.

4.3.3 Piezo Stages and Actuators

This section details the settings available for the BPC303 Piezo Controller. This example is provided to familiarize the user with the expected settings. Other hardware configurations will have similar settings.

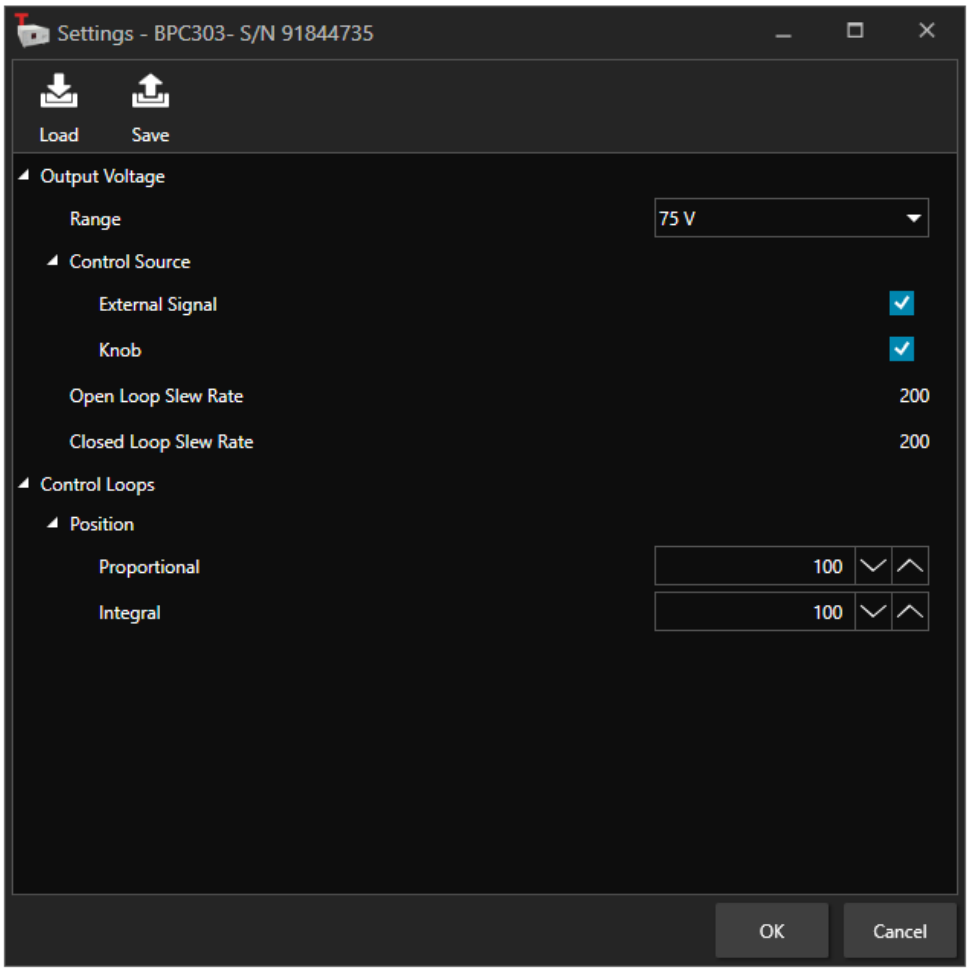


Figure 12 BPC303 Piezo Controller Settings

Output Voltage

Range – Maximum Voltage used to set the maximum output voltage of the piezo controller. This must be set up to suit the maximum specified operating voltage of the piezo actuator connected to the unit. Most Thorlabs piezo actuators are specified for either 75 V or 150 V maximum operation. In general, the maximum voltage should not be exceeded because it can cause damage to the piezo actuator.

Control Source

External Signal – Allows the output voltage to be controlled proportionally to the differential voltage applied to the EXT IN - and EXT IN + connectors.

Knob – Allows control of the output voltage by either the front panel knob or a potentiometer connected to the User I/O D-Type connector.

Open Loop Slew Rate – The maximum slew rate when operating in open loop mode. Slew Rate = Value x Max Voltage / 19000, where Max Voltage is 75, 100, or 150 V.

Closed Loop Slew Rate – The maximum slew rate when operating in closed loop mode. Calculated as for Open Loop Slew Rate.

Control Loops

Position

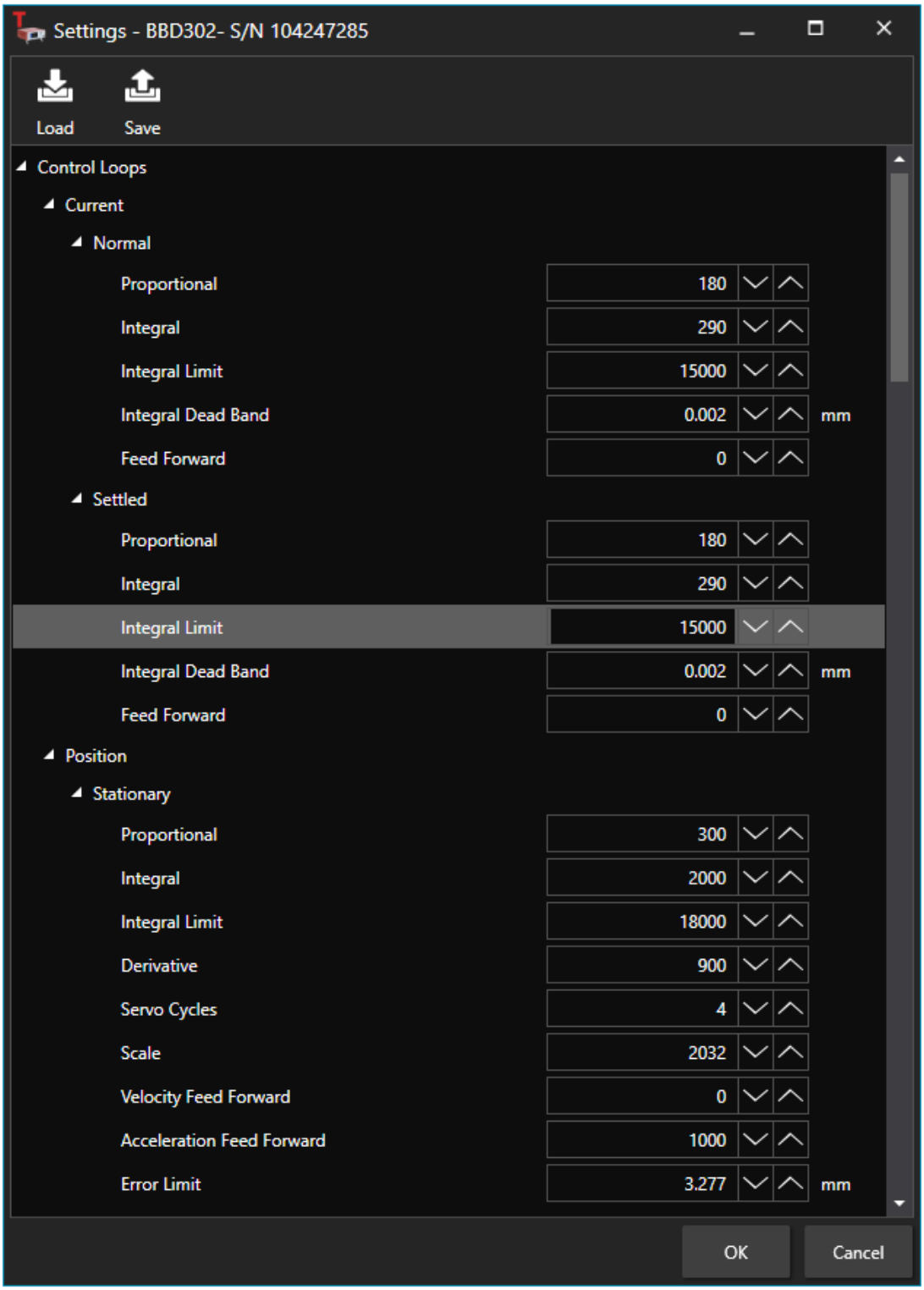
Proportional – Proportional term of the PID control loop. This value is proportional to error between the current and set point.

Integral – Integral term of the PID control loop.

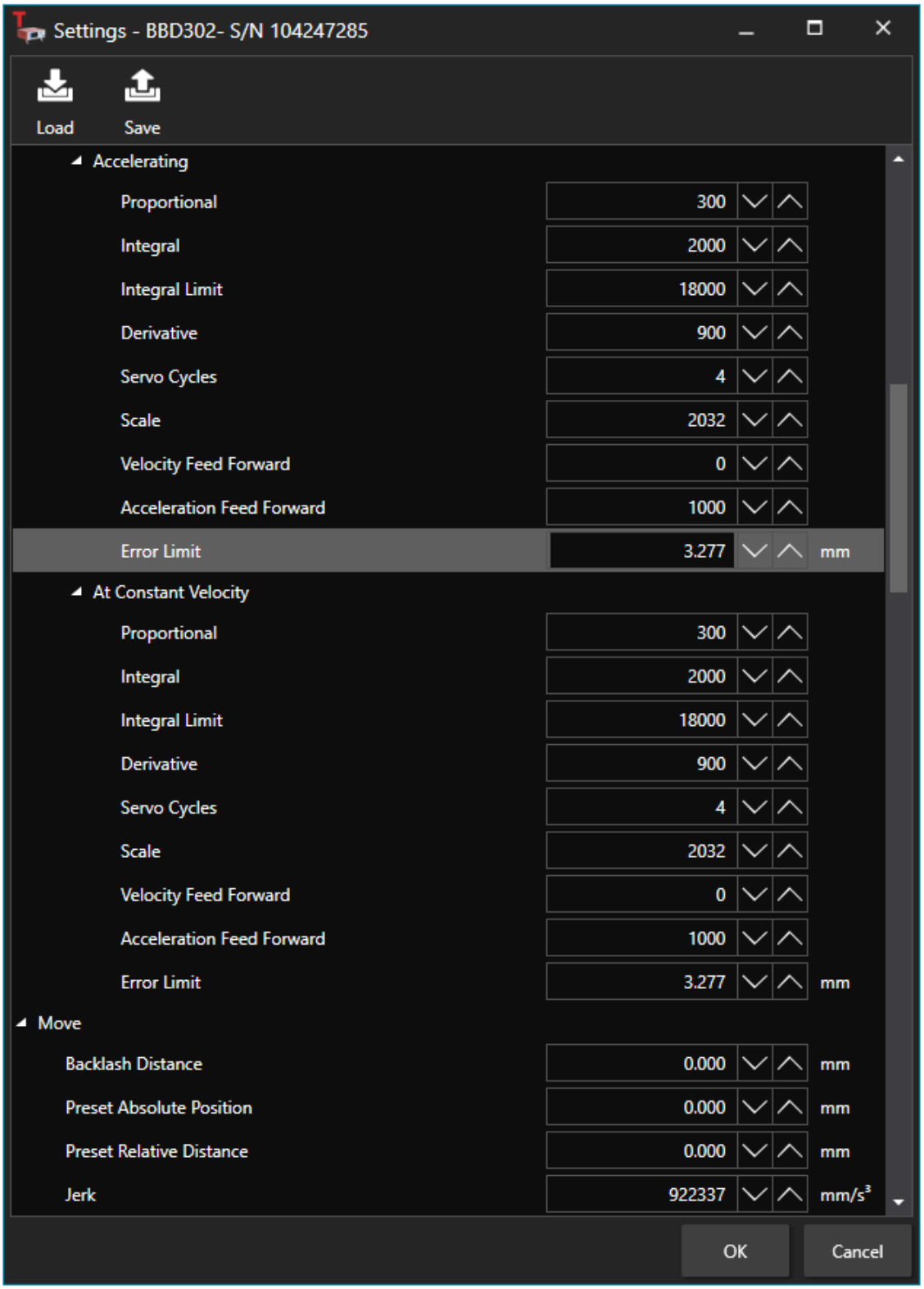
4.3.4 Brushless Stages and Actuators

This section details the settings available for the BBD302 Brushless Motor Controller. This example is provided to familiarize the user with the expected settings. Other hardware configurations will have similar settings.

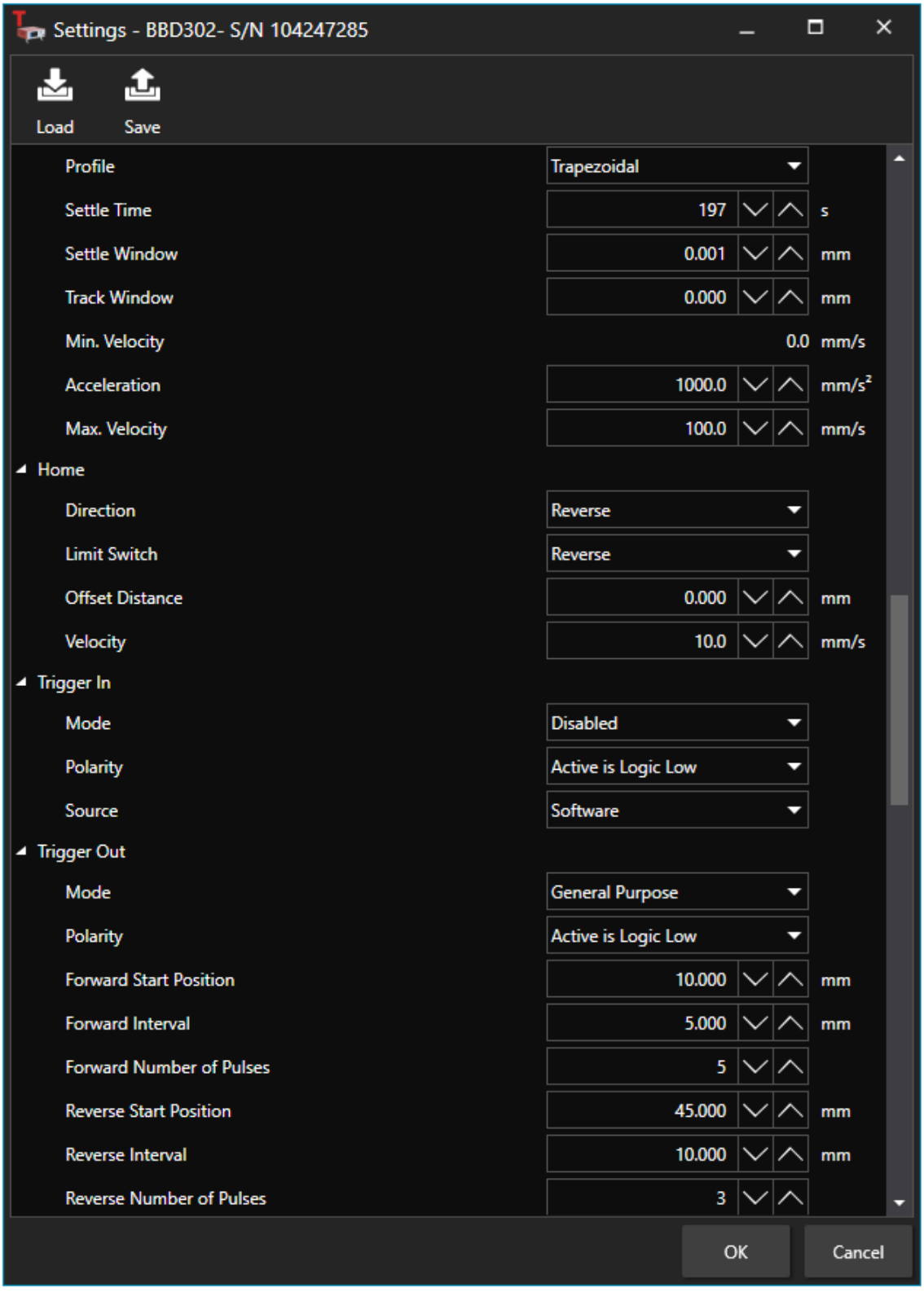
(a)



(b)


Settings - BBD302- S/N 104247285
Load
Save
Accelerating
Proportional 300
Integral 2000
Integral Limit 18000
Derivative 900
Servo Cycles 4
Scale 2032
Velocity Feed Forward 0
Acceleration Feed Forward 1000
Error Limit 3.277 mm
At Constant Velocity
Proportional 300
Integral 2000
Integral Limit 18000
Derivative 900
Servo Cycles 4
Scale 2032
Velocity Feed Forward 0
Acceleration Feed Forward 1000
Error Limit 3.277 mm
Move
Backlash Distance 0.000 mm
Preset Absolute Position 0.000 mm
Preset Relative Distance 0.000 mm
Jerk 922337 mm/s³
OK
Cancel

(c)


Settings - BBD302- S/N 104247285
Load
Save
Profile
Trapezoidal
Settle Time
197
s
Settle Window
0.001
mm
Track Window
0.000
mm
Min. Velocity
0.0
mm/s
Acceleration
1000.0
mm/s²
Max. Velocity
100.0
mm/s
Home
Direction
Reverse
Limit Switch
Reverse
Offset Distance
0.000
mm
Velocity
10.0
mm/s
Trigger In
Mode
Disabled
Polarity
Active is Logic Low
Source
Software
Trigger Out
Mode
General Purpose
Polarity
Active is Logic Low
Forward Start Position
10.000
mm
Forward Interval
5.000
mm
Forward Number of Pulses
5
Reverse Start Position
45.000
mm
Reverse Interval
10.000
mm
Reverse Number of Pulses
3
OK
Cancel

(d)


Settings - BBD302- S/N 104247285
Load
Save
Number of Cycles 4
Pulse Width 100000 µs
Jog
Mode Continuous
Step Size 6.000 mm
Min. Velocity 0.0 mm/s
Acceleration 1000.0 mm/s²
Max. Velocity 100.0 mm/s
Stop Mode Profiled
Joystick
Low Gear Max Velocity 10.0 mm/s
High Gear Max Velocity 100.0 mm/s
Low Gear Acceleration 10.0 mm/s²
High Gear Acceleration 1000.0 mm/s²
Direction Sense Positive
Knob
Acceleration 0.0 mm/s²
Jog Step Size 6.000 mm
Jog Stop Mode Profiled
Mode Velocity
Max. Velocity 50.0 mm/s
Preset Position 1 60.000 mm
Preset Position 2 0.000 mm
Preset Position 3 0.000 mm
Limits
OK
Cancel

(e)

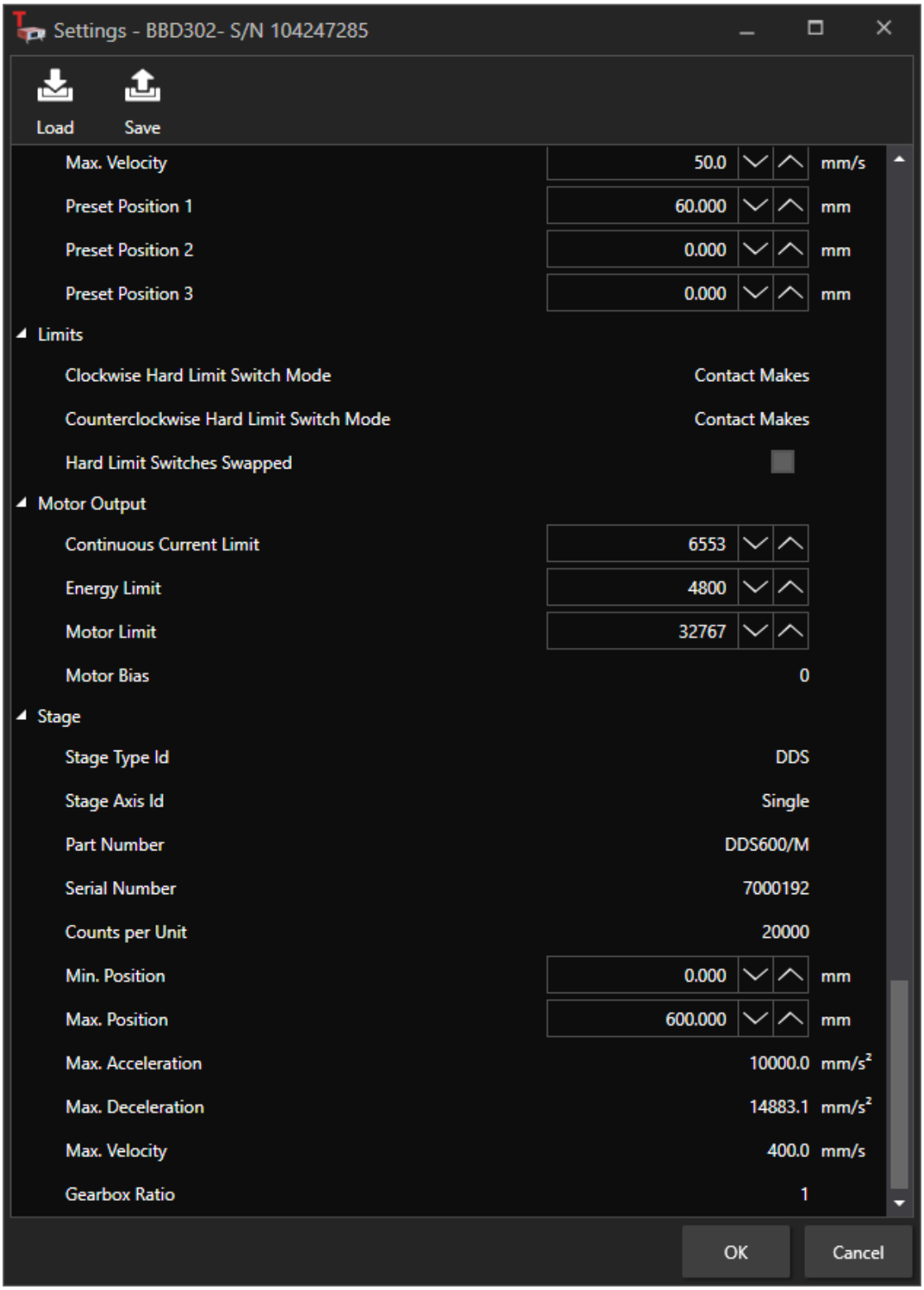


Figure 13 Screenshots (a), (b), (c), (d), and (e) show available settings for the BBD302 Brushless DC Controller.

Control Loops – 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

Current

Normal

Proportional – 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.

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

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

Integral Dead Band – 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.

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.

Settled

Proportional – 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.

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

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

Integral Dead Band – 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.

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.

Position

Stationary

Proportional – 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 – 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.

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 – 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.

Servo Cycles – Number of servo cycles to wait between calculating the derivative term.

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.

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.

Accelerating

Proportional – 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 – 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.

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 – 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.

Servo Cycles – Number of servo cycles to wait between calculating the derivative term.

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.

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.

At Constant Velocity

Proportional – 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 – 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.

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 – 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.

Servo Cycles – Number of servo cycles to wait between calculating the derivative term.

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.

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.

Move

Backlash Distance – The system compensates for lead screw backlash during reverse direction moves by moving past 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.

Preset Absolute Position – The absolute position to move to when a trigger is configured.

Preset Relative Distance – The relative position to move by when a trigger is configured.

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.

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.

Settle Time – The time that the associated axis must be settled before the settled status is sent.

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

Track Window – Specifies the maximum allowed position error between the target and actual motor trajectory.

Minimum Velocity – The starting velocity when a move is initiated.

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

Maximum Velocity – The maximum velocity at which to perform a move.

Home

Direction – The direction to move when homing, either Forward or Reverse.

Limit Switch – The hardware limit switch associated with the home position, either Forward HW or Reverse HW.

Offset Distance – 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.

Trigger In

Mode – I/O ports can be configured for several uses. If enabled as digital inputs, then they can be configured to trigger either relative or absolute movements when activated or they could initiate a homing procedure. Alternatively, when configured as outputs, they can activate to indicate motion in progress or that maximum velocity has been reached during movement. They may also produce a pulsed output where they activate recurrently at pre-defined positions. Finally, the I/O ports can be configured for software control so that the client can read or set them arbitrarily.

Polarity – The polarity of the trigger pulse is specified in the Trigger 1 Polarity and Trigger 2 Polarity.

Source – The source that activates the trigger. This can be Software if it's activated via. the SDK, or one of the electronic hardware inputs on the AUX I/O connector.

Trigger Out

Mode – The trigger output can be set either for the complete period that the stage or actuator is in motion, after motion has completed or after the stage has reached its target velocity.

Polarity – The Voltage level at which the I/O port is considered active. This could be nominally 0 V or 5 V.

Forward Start Position – Trigger output active (pulsed) at pre-defined positions moving forward. Only one Trigger port at a time can be set to this mode.

Forward Interval – When a pulsed I/O mode is selected, this setting is the distance between the start of pulses in the forward direction.

Forward Number of Pulses – When a pulsed I/O mode is selected, this is the number of pulses that can be created in the forward direction.

Reverse Start Position – Trigger output active (pulsed) at pre-defined positions moving backward. Only one Trigger port at a time can be set to this mode.

Reverse Interval – When a pulsed I/O mode is selected, this setting is the distance between the start of pulses in the reverse direction.

Reverse Number of Pulses – When a pulsed I/O mode is selected, this setting is the distance between the start of pulses in the reverse direction.

Number of Cycles – When a pulsed I/O mode is selected, this is the number forward/reverse move cycles.

Pulse Width – This is the trigger output pulse width.

Jog

Mode – The way in which the motor moves when a jog command is received. There are two jogging modes available, 'Jog' and 'Continuous'. In 'Jog' mode, the motor moves by the distance specified in the Step Size parameter. If the jog key is held down, single step jogging is repeated until the button is released. In 'Continuous' mode, the motor actuator will accelerate and move at the jog velocity while the button is held down

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

Minimum Velocity – Starting velocity of the motion profile.

Acceleration – The rate at which the velocity climbs from zero to maximum and slows from maximum to zero.

Maximum Velocity – The maximum velocity at which to perform a move.

Stop Mode – 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.

Joystick

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

High Gear Maximum 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.

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

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

Knob

Acceleration – The maximum acceleration of a move initiated by the control wheel.

Jog Step Size – Size of step that's initiated by the control wheel when configured to jog.

Jog Step Mode – Behavior of the control wheel. Can be moving with a velocity proportional to the deflection of the wheel, a jog motion when the wheel's deflected or moving between preset positions.

Mode – The way in which the motor moves when a jog command is received.

Maximum Velocity – The maximum velocity achievable under manual control using the wheel.

Preset Position 1 – The first of 3 preset positions that can be cycled through using the control wheel.

Preset position 2 – The second of 3 preset positions that can be cycled through using the control wheel.

Preset position 3 – The third of 3 preset positions that can be cycled through using the control wheel.

Limits

Clockwise Hard Limit Switch Mode – The hardware limit switch associated with the home position, either Ignore, Forward (Hard).

Counterclockwise Hard Limit Switch Mode – The hardware limit switch associated with the home position, Reverse (Hard).

Hard Limit Switches Swapped – Whether the clockwise (or forward) and counterclockwise (or reverse) limit switches have been physically swapped.

Motor Output

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).

Energy Limit – When the current output of the drive exceeds the limit set in the Current Limit parameter, accumulation of the excess current energy begins. The Energy Limit parameter specifies a limit for this accumulated energy, as a percentage of the factory set default maximum, in the range 0% to 100%. When the accumulated energy exceeds the value specified in the Energy Limit parameter, a 'current foldback' condition is said to exist, and the commanded current is limited to the value specified in the Current Limit parameter. When this occurs, the Current Foldback status bit (bit 25) is set in the Status Register and the 'Current Limit'

LED on the GUI panel is lit. When the accumulated energy above the Current Limit value falls to 0, the limit is removed and the status bit is cleared.

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

Motor Bias – Not currently implemented.

Stage

Stage Type 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.

Stage Axis – Identifies the axis on a multi-axis stage.

Part Number – The part number of the stage or actuator connected.

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

Counts Per Unit – The number of encoder counts per millimeter of travel of the DC servo motor.

Minimum Position – The minimum allowable travel of the stage.

Maximum Position – The maximum allowable travel of the stage.

Maximum Acceleration – The maximum allowable acceleration of the stage.

Maximum Deceleration – The maximum allowable deceleration of the stage.

Maximum Velocity – The maximum allowable velocity of the stage.

Gearbox Ratio – The number of encoder counts per real-world units.

Chapter 5 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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