DDS220(/M)
Direct Drive Translation Stage

User Guide



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Chapter 1 Introduction

1.1 Introduction

The Thorlabs' DDS220 low-profile, direct-drive stage provides 220 mm of travel with 50 nm resolution and a maximum speed of 300 mm/s. The stage is ideal for applications that require high speeds and high positioning accuracy, including automated alignment, surface inspection, mapping, and probing.

An innovative low-profile design with integrated, brushless linear motors eliminates the external housings that create mechanical clash points and impede access to the moving platform. The direct-drive technology removes the need for a lead screw, eliminating backlash. Twin, precision-grooved linear bearings provide superior rigidity and linearity with excellent on-axis accuracy. This backlash-free operation coupled with high-resolution, closed-loop optical feedback ensures a minimal bidirectional repeatability of 0.25 µm. Furthermore, the stage features an integrated cable management system, thereby eliminating the need for any user side cabling. Along with the Thorlabs BBD controller or UMC series controller and the Thorlabs software interface, it forms a truely plug and play system.

The DDS220 stage has been designed for easy XY configuration. Two stages can be bolted together without the use of any additional brackets. The Thorlabs BBD302 or UMC series controllers can be used to control two stages simultaneously in the XY configuration.

Characterized by high-speed translation and high-positional accuracy, the DDS220 stage is well-suited for surface mapping and characterization applications where there is a need to move a camera or probe at constant velocity while simultaneously capturing data. Very precise, fine, positioning and control is easily achieved through the combination of the stable closed-loop control system and associated MJC2 joystick option.



Fig. 1.1 Typical XY Configuration

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 by the manufacturer, the protection provided by the equipment may be impaired. In particular, excessive moisture may impair operation.

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

When bolting the stage to the work surface and when fixing a load to the top platform, high tightening torque of the attachment bolts can result in an increased resistive force on the moving platform. This in turn can lead to degraded performance and may require the PID parameters to be adjusted. As a general guide, 70 N·cm is a recommended nominal torque when tightening the attachment bolts.

Chapter 3 Installation

3.1 Unpacking

Note

Retain the packing in which the unit was shipped, for use in future transportation.



Caution

Once removed from its packaging, the stage can be easily damaged by mishandling. When handling, the moving platform must be constrained to avoid sudden movement and damage to the bearings. The unit should only be handled by its base, not by any attachments to the moving platform.

3.2 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 °C to 40 °C
Maximum Humidity	Less than 80% RH (non-condensing) at 31 °C

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

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

The unit must not be used in an explosive environment.

3.3 Mounting

3.3.1 Vertical Mounting



Warning

The stage is not suitable for mounting in a vertical (Z-axis) configuration.

3.3.2 General

Caution

When mounting the stage close to other equipment, ensure that the travel of the moving platform is not obstructed. If equipment mounted on the moving platform is driven against a solid object, damage to the internal mechanism could occur. The range of travel is 220 mm (8.66“).

When considering the stage movement in the proximity of other objects or equipment, ensure that movement of cables connected to the moving carriage is not impeded.

Ensure that any devices and components attached to the moving platform are securely fastened. Incorrectly attached components could come loose when the stage is operated.

When bolting the stage to the work surface and when fixing a load to the top platform, high tightening torque of the attachment bolts can result in an increased resistive force on the moving platform. This in turn can lead to degraded performance and may require the PID parameters to be adjusted.

As a general guide, 70 N·cm is a recommended nominal torque when tightening the attachment bolts.

High drag forces can adversely affect phase initialization, homing, positioning accuracy and general reliability. Take care to minimize drag caused by attachments to the moving platform (cables, tubing, electrical wiring), especially when the stage is changing direction.

Warning

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

3.3.3 Cable Routing and Cable Extension

Caution

The D-Type shell of the motor connector houses an ID chip which could be damaged if the plug is opened. The encoder connector houses circuitry which could be easily damaged by static discharge. Under no circumstances should these plugs be opened or removed (e.g. to facilitate cable routing).

3.3.4 Mounting the Stage to the Work Surface

The DDS220 stage is mounted to the working surface by four M6 x 25mm (1/4-20 x 1") screws. The mounting holes are accessed from the top of the stage - see Fig. 3.1 on the following page.

Using a diagonal pattern, tighten all four mounting bolts.

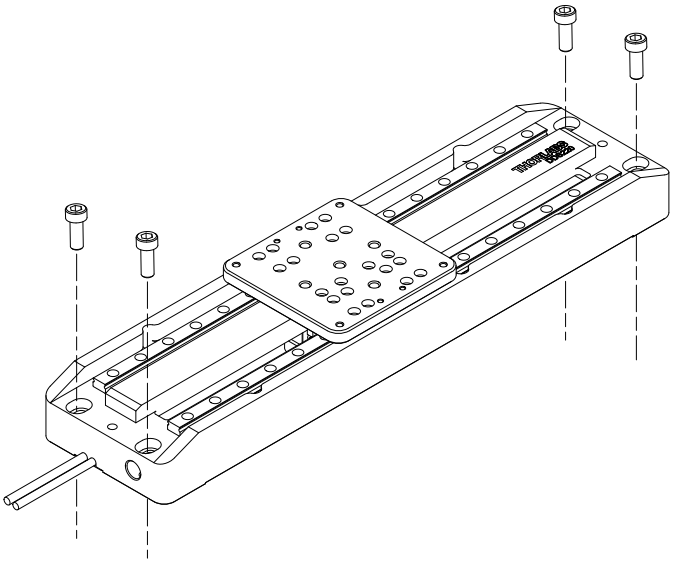


Fig. 3.1 Mounting

Caution

The performance of the stage could be affected if the mounting surface is not flat. Care should be taken when bolting the stage to the worksurface, to ensure that the base plate does not warp, which could cause stiffness to be experienced in the bearing rails. Shims should be fitted as necessary.

After mounting the stage to the work surface, if any increased resistance is experienced when moving the top platform, the likely cause is over tightening/ torquing of the mounting bolts. As a general guide, 70 N·cm is a recommended nominal torque when tightening the attachment bolts.

Please contact tech support for more information.

The stage can also be mounted on its side, using two VB01 or AP90RL brackets and four M6 x 25mm (1/4-20 x 1") screws - see Fig. 3.2.

Using a diagonal pattern, tighten all four mounting bolts.

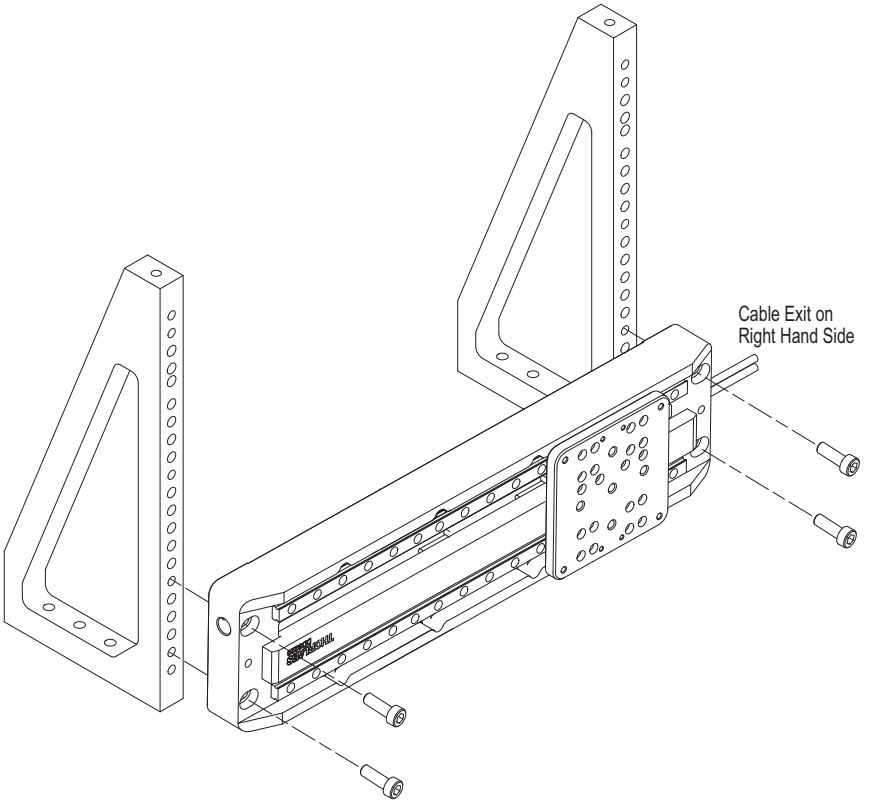


Fig. 3.2 Side Mounting

Caution

When mounting the stage on its side, ensure that the cable exit is on the right hand side as shown above. Mounting with the cables in the LHS could cause damage to the internal cable management system.

3.3.5 Mounting in Multi-Axis Configurations

For dual-axis applications, two DDS stages can be bolted together in an XY configuration, without the need for any adapter or spacer plates, keeping the vertical profile to a minimum. Four M4 x 20 mm (8-32 x 3/4") screws are used to secure one stage to the other. Cut outs in the chassis allow access to the mounting holes in the top stage as shown in Fig. 3.3.

The stage can be mounted in a centred or overhanging configuration by choosing the relevant mounting holes as shown below.

Using a diagonal pattern, tighten all four mounting bolts.

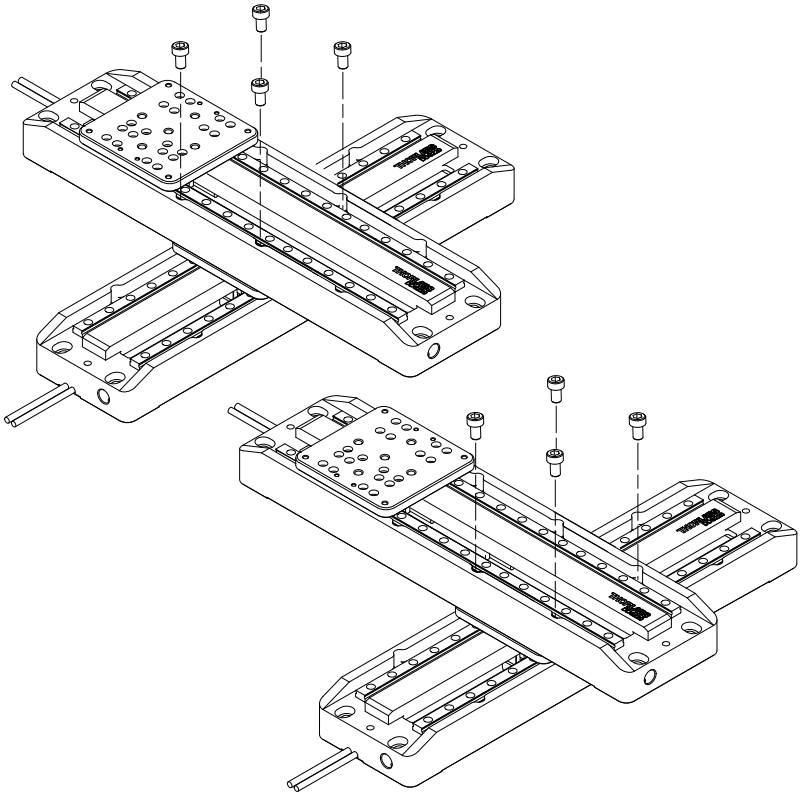


Fig. 3.3 Typical XY Configuration

Caution

After mounting the stages in the XY set up, if any increased resistance is experienced when moving the top platform, the likely cause is over tightening/ torquing of the mounting bolts.

Please contact tech support for more information.

3.4 Electrical Connections

The stage must be driven by a Thorlabs BBD or UMC series controller. Connect the motor leads to the MOTOR DRIVE connectors, and the encoder feedback leads to the FEEDBACK connectors. Ensure that the motor drive and feedback leads for each motor are connected to the correct channel.

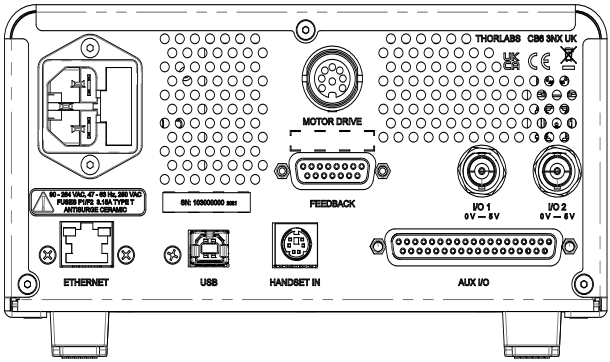
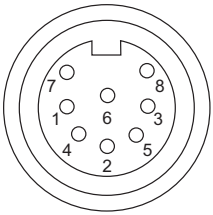


Fig. 3.4 Electrical Connections

Pin out information for the motor drive and encoder feedback connectors on the motor flying leads is detailed below.

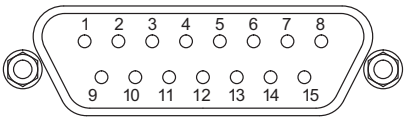


MOTOR DRIVE

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 signals present on pin 3 and 8 are not used by Brushless controllers

ENCODER FEEDBACK



1		9	GND†
2	GND†	10	Limit Switch +
3		11	Limit Switch -
4	Enc Index -	12	Enc Index +
5	QB -	13	QB +
6	QA -	14	QA +
7	5 V* ‡	15	x
8	5 V* ‡		

Notes.
* Pins 7 and 8 are shorted together.
† Pins 2 and 9 are shorted together
‡ The current draw for the encoder 5 V lines is 300 mA (pins 7/8 and 2/9).

Fig. 3.5 Motor Drive and Feedback Flying Lead Pin Out Details

3.5 Dimensions

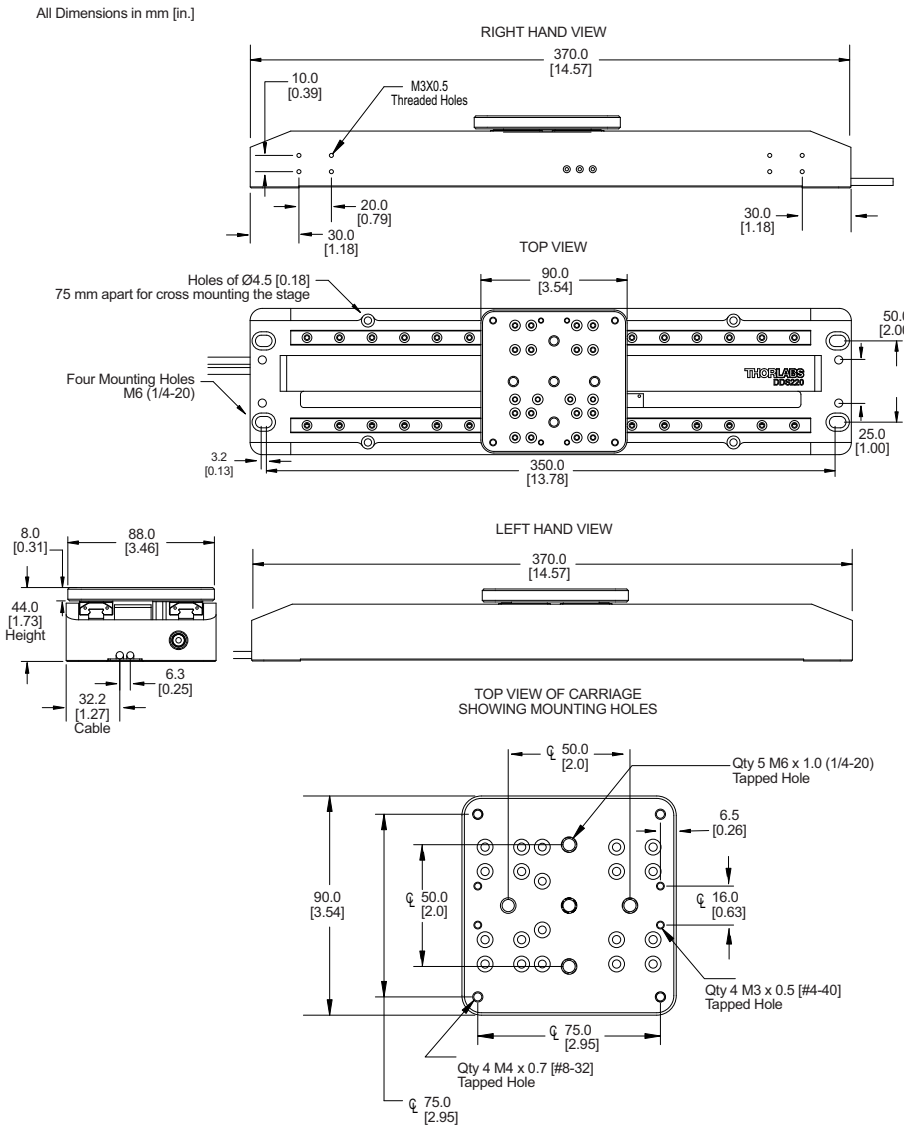


Fig. 3.6 Dimensions

Chapter 4 Operation

4.1 Getting Started

Caution

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

The DDS220 stage is designed to be driven by the Thorlabs BBD30x or UMC series controllers.

The stages are connected to the controller via 2 flying leads, one terminated in D-type connector (FEEDBACK) and one terminated in a round 8-Pin DIN Connector (MOTOR DRIVE).

Warning

The motor controller must be switched OFF before the stages are plugged in or unplugged. Failure to switch the controller off may result in damage to either the controller, the stage, or both.

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

For a complete tutorial on using the stage, see the manual supplied with the controller. Basic steps in controlling the stage are as follows:

1) Make electrical connections as detailed in Section 3.4.
2) Move the moving platform a few times over its full range of travel to overcome any storage resistance, then position the moving platform to be around its central position.

Warning

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 motor coil housing. On power up, the position of the coil housing 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) may make a slight buzzing noise and move slightly. Phase initialization can only take place if the motor can move unobstructed during this time. Before powering up the BBD or UMC series controller at item (2), ensure that the stage movement is unobstructed.

3) Power up the controller and wait for 10 secs until the Channel Enable LEDs start flashing.

4) If a joystick control is being used, press and hold the 'High/Low' button for 2 seconds, then release to home the stage. When homing is complete, the green LED stops flashing.
5) If no joystick is being used, run the software utility and click the 'Home' button on each GUI panel. When homing is complete, the Channel Enable LEDs stop flashing.

Note

The stage design incorporates several reference markers on the encoder scale, which are used to calibrate the position counter.

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 allow the encoder read head to scan through encoder scale's reference markers in search of the reference marker designated for homing. The position counter is then reset, and the software will show an absolute value once the homing move sequence is completed.

6) 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 handbook supplied with the BBD controller or UMC series controller, and the helpfile supplied with the software for more information.

4.2 General Operation

The following sections contain a brief overview the stage using the Kinesis® software. The BBD30x controller is also supported by Thorlabs' XA software application. For more detailed information see the manual for the associated controller (BBD30x or UMCx).

The stage is shipped already loaded with default parameter settings, which should give satisfactory performance in most cases. However, depending on the application, it may be necessary to adjust the PID loop parameter settings to fine tune the response. In the event that these settings need to be changed, the user can create a custom settings group - see the Kinesis Helpfile for more information.

1) If it is not already running, start the Kinesis software - Start/Programs/Thorlabs/ Kinesis/Kinesis.The server reads in the stage and controller information on boot up and the GUI panel shown below is displayed.

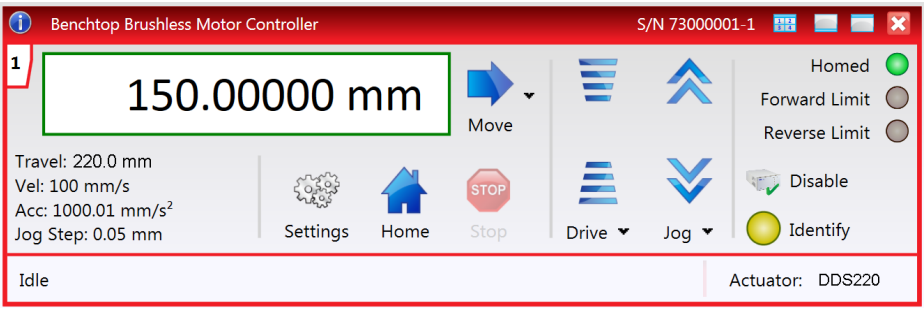


Fig. 4.1 Kinesis GUI Screen

Note

The MOTOR DRIVE connectors for each channel/axis contain an EEPROM, which stores the factory default settings for the set up parameters. When the stage is connected, these settings are loaded into the controller on start up, and are tuned for loads up to the 3.0 kg (6.6 lb) maximum, at speeds up to 100 mm/s.

However, depending on the load being driven and the speed/duty cycle of the particular application, it may be necessary to further optimize the Position PID loop settings.

If problems are encountered (e.g. stability of the closed loop position control, lost motion or incomplete moves) the position loop 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.

2) Click the Settings button on the GUI to display the Settings panel, then select the 'Advanced' tab.

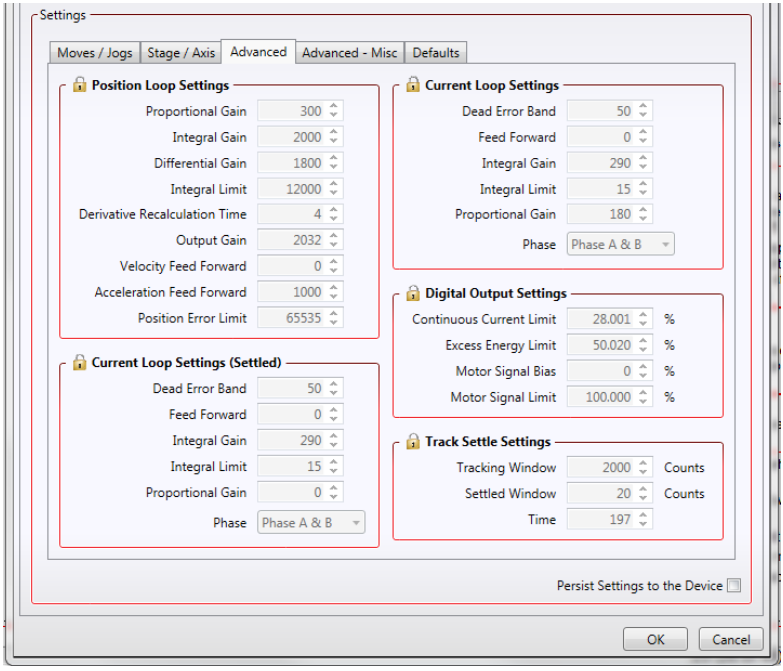


Fig. 4.2 Advanced Control Loop Settings

3) Create a Custom Settings Group (see the Kinesis helpfile for more information) and then adjust the PID settings to fine tune the control loop for your application.

Refer to the handbook supplied with the BBD301 control unit for more details on PID settings.

Caution

Default PID 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 can 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.

See Fig. 4.3 below for guidelines on recommended PID values for a given load when the top plate resistive force profile is 2 to 5 N. If the force is outside this range, please contact Tech Support.

When extracting values from the graph, take note of the scale in the legend box. On the graph, the Integral limit values have been divided by '10' and the derivative time values have been multiplied by '100'.

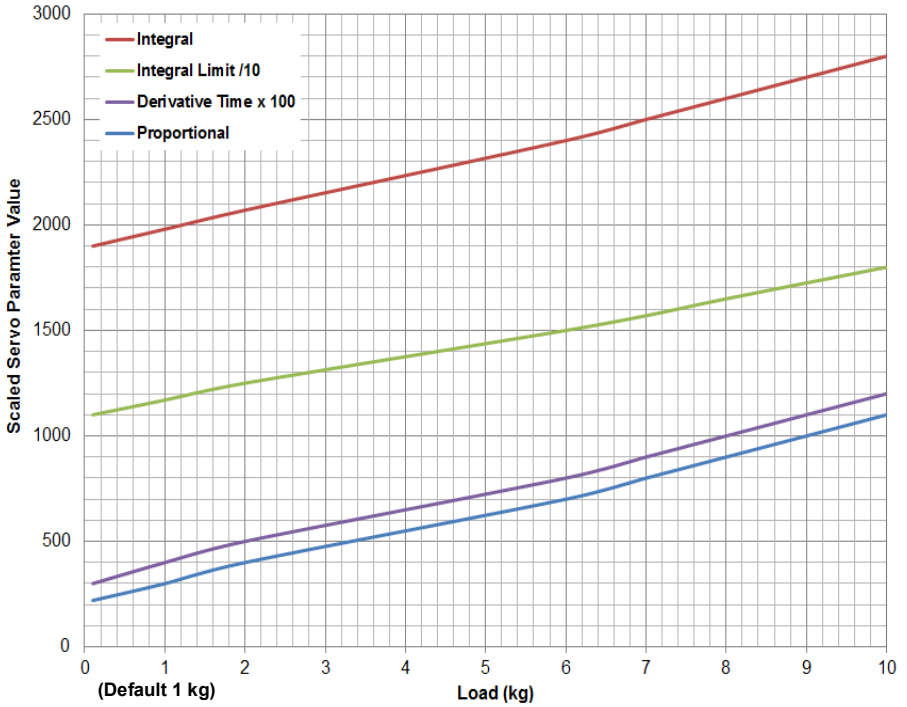


Fig. 4.3 Position Loop Settings v Load for a Top PLate Resistive Force Profile 2N to 5N

4) After the parameter changes have been performed, click the 'Persist Settings to Hardware' box, then click 'OK'. This will ensure that the same parameter settings will be loaded next time the unit is powered up - even in the absence of a PC.

Caution

If settings are persisted, then a stage is changed, further parameter adjustment may be required to achieve optimum performance with the new stage.

See the manual supplied with the controller unit for more information.

Note

For a given load, a deviation of typically ±10% from the values quoted in Fig. 4.3 may be necessary. To optimise parameters proceed as follows:

Stage struggles to reach final position - increase the values in 5% increments until satisfactory performance is achieved.

Stage overshoots or is unstable during move - reduce the values in 5% decrements until satisfactory performance is achieved.

Please see the handbook supplied with the controller, for more information on changing these settings

4.3 Stopping the Stage

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

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

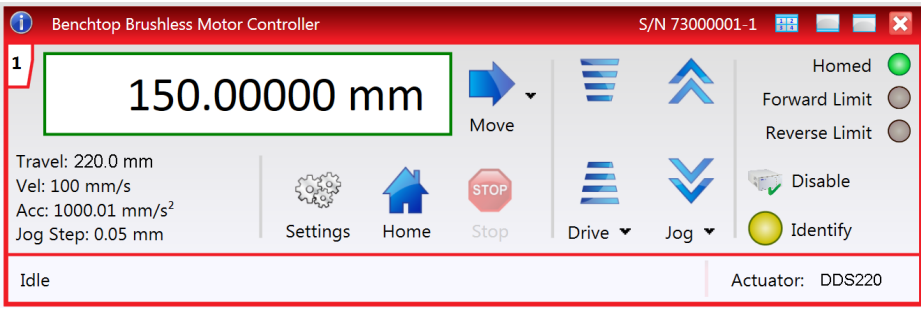


Fig. 4.4 Kinesis GUI Screen

4.4 Position Error Messages

Caution

The maximum velocity at which the encoder can operate is approximately 400 mm/sec. Above this speed, encoder pulses may be lost and, as a result, the position readout becomes incorrect. This renders normal operation impossible because phase commutation of the motor is also based on the encoder reading.

When the stage is controlled by the BBD30x or UMC series controller, the maximum velocity is limited to safe values. However, if the output is disabled (with the controller connected and monitoring the position) and the stage is moved manually at high speeds, it is possible to exceed this limit. If the BBD30x or UMCx 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 or UMC series 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 MJC2 joystick, in the absence of a PC, the red LED on the joystick console is lit, and all operation is suspended until the controller is shut down and rebooted.

4.5 Maintenance

Repetitive movement over long periods can result in build up of lubricant which can cause uneven motion. Periodically, the stage should be powered down and the top platform moved from one end of travel to the other several times to redistribute the bearing lubricant.

The product is maintenance free up to 5 million cycles. If any problems occur, the user should contact the local Thorlabs tech support for more information. After 5 million cycles, a replacement of the internal flexible cable, and a re-lubrication of the bearing carriers is recommended. Contact your local Thorlabs tech support for more information.

Warning

Prolong and repeated contact of the lubricant used on the linear rail bearing may cause skin irritation. Gloves should be worn when such contact is likely.



Caution

The coating on the bearing rails is easily damaged/removed by solvents (e.g. paint thinners) or similar aggressive substances. Do not allow such substances to contact the bearing rail.

The rails should be wiped gently with a lint free cloth lightly dampened with oil.

4.6 Troubleshooting

If an unexpected obstruction to the stage motion is encountered, the control system interface software disables the current to the associated drive channel, which may or may not result in the channel being disabled. After the obstruction to be removed, the associated channel of the controller should first be disabled to clear any fault codes, then re-enabled.

In the event of a breakdown, or malfunction of the product please contact Thorlabs Tech Support.

4.7 Transportation



Caution

When packing the unit for shipping, use the original packing. If this is not available, use a strong box and surround the unit with at least 100 mm of shock absorbent material.

In particular, the moving platform must be constrained to avoid damage during shipping.

Chapter 5 Specification

Parameter	Value
Travel Range	220 mm (8.6")
Maximum Speed	300 mm/s*
Acceleration	5000 mm/s^2*
Bidirectional Repeatability	±0.25 µm
Backlash	N/A (No Leadscrew)
Encoder Resolution	50 nm
Minimum Incremental Movement	0.1 µm
Home Location Accuracy (Unidirectional)	±0.25 µm
Load Capacity	3 kg (6.6 lbs)

Note*
The stage can carry higher loads at lower acceleration. The acceleration is limited by the motor force.

Absolute On-Axis Accuracy	±2.0 µm
Straightness/Flatness	±5.0 µm
Pitch	±175 µrad
Yaw	±175 µrad
Continuous Motor Force	7.0 N
Peak Motor Force (2 sec)	15.0 N
Bearing Type	High Rigidity Recirculating Precision Linear Bearing
Operating Temperature Range	5 to 40 °C (41 to 104 °F)
Motor Type	Brushless DC Linear Motor
Dimensions (Mid Travel)	370 mm x 90 mm x 44 mm (14.6" x 3.5"x 1.73")
Cable Length	2.6 m (8.5')
Weight (Excluding Cables)	2.1 kg (4.6 lbs)
Weight (Including Cables)	2.4 kg (5.3 lbs)

Note*
The default tuning parameters can be changed to optimize settling times for a specific loads.



Caution

The maximum speed and acceleration values quoted can be safely achieved with the maximum load and a high duty cycle. However in this case, some heating of the stage may occur and dimensional stability of the stage may be affected. This could result in less than optimal repeatability and accuracy. For cases were repeatability and accuracy are critical it is recommended that the stage temperature is allowed to reach a steady state before measurements are taken.

Alternatively the load, acceleration and duty cycle should be reduced from the maximum values. Some trial and error in setting these values may be necessary before the ideal settings are attained.

Appendix A Accessories

A.1 Accessories List

Thorlabs' MJC2 joystick console is designed for remote operation and enables intuitive, tactile, manual positioning of a stage. This highly reliable, Hall effect joystick features XY control, a speed adjustment for fast or high precision movement, and a high-quality, anodized aluminum casing.

Product Name	Part Number
MJC2	2-Axis USB HID Joystick

Appendix B Regulatory

B.1 Declarations of Conformity

B.1.1 For Customers in Europe

See Section B.2.

B.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.

B.2 CE Certificates



EU Declaration of Conformity

Manufacturer: Thorlabs LTD

Address: 204 Lancaster Way, Ely, CB6 3NX, UK

We hereby declare under our sole responsibility that:

Product: **DDS Series - DDS220(/M), DDS300(/M), DDS600(/M), DDS800(/M), DDS1000(/M)**

Product description: **Direct Drive Stage (Imperial & Metric)**

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

2014/30/EU	Electromagnetic Compatibility (EMC) Directive
2011/65/EU	Restriction of Use of Certain Hazardous Substances (RoHS), including 2015/863
2006/42/EC	Machinery Directive (MD)

and (harmonized) standards / technical specifications :

EN 61326-1	Electrical Equipment for Measurement, Control and Laboratory Use - EMC Requirements	2021
EN IEC 63000	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances	2018
EN ISO 12100	Safety of Machinery. General Principles for Design. Risk Assessment and Risk Reduction	2010

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

Signed: Keith Dhese

Name: Keith Dhese *On:* 6/2/2026

Position: General Manager

CE

Appendix C 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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techsupport@thorlabs.com

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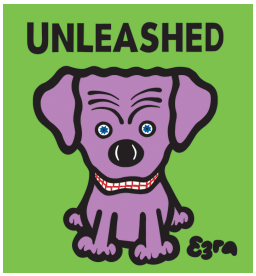
sales.de@thorlabs.com
europe@thorlabs.com

Product Manufacturer
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THORLABS
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