



DDR05

Direct Drive Rotation Stage

User Guide



Original Instructions

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# Chapter 1 Safety

## 1.1 Safety Information

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

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



### Shock Warning



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



### Caution



Given when there is a risk of injury to users.



### Caution



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

### Note

Clarification of an instruction or additional information.

## 1.2 General Warnings



### Warnings



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

Spillage of fluid, such as sample solutions, should be avoided. If spillage does occur, clean up immediately using absorbant 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.

Keep clear of the moving world when the unit is in operation and rotating with equipment attached to the top plate.

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## Chapter 2 Overview

### 2.1 Introduction

The Thorlabs' DDR05 low-profile, direct-drive rotary stage provides continuous rotation of a load with inertia moment up to 70 kg.mm<sup>2</sup> with 2 µrad resolution and a maximum rotation speed of 5 Hz (300 rpm). A SM05 threaded central aperture allows an optical path to pass directly through the body of the stage.

It has a 3-phase, brushless DC motor integrated directly into the frame of the stage. This eliminates all forms of mechanical transmission providing high repeatability, rigidity and reliability. The winding design eliminates torque ripple due to magnetic cogging, enabling good velocity stability even at low speeds. The high resolution encoder mounted directly on the moving world provides high accuracy and repeatability, while the precision-engineered bearings and tight manufacturing tolerances produce very low axial wobble (400 µrad). An engraved graduated scale with 2° increments allows for coarse positioning.

The stage is designed to be mounted vertically on a cage system or post. The rotating plate features an SM05-threaded through hole to allow Ø0.5" optics and our SM05 product line to be mounted. The rotating front face also features four 4-40 tapped holes to integrate 16 mm cage assemblies and components. The non-rotating faces feature four 4-40 tapped holes to allow use with cage system components. The front face is compatible with 30 mm cages while the rear face can be used with 16 mm systems.

The stage is driven by the TBD001 brushless DC controller, giving very precise, fine, positioning and control through the stable closed-loop control system.

Its speed, precision, and stability make this unit suitable for applications requiring high speed rotation such as scanning, surface mapping and laser welding.



Fig. 2.1 DDR05 Direct Drive Rotation Stage Mounted on 1/2" Post

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## Chapter 3 Installation

### 3.1 Unpacking

#### Notes

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. The unit should only be handled by its base, not by any attachments to the moving platform.

The unit has fragile internal components that can be damaged if the staged is dropped.

### 3.2 Environmental Conditions



#### Caution



This unit is design for operation within normal operating conditions. It is not recommended to use this equipment outside the following limits

Location	Indoor use only
Maximum altitude	2000 m
Temperature range	5 to 40°C (41 to 104°F)
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



#### Warning



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



#### Cautions



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.

#### 3.3.1 Post Mounting

The stage can be mounted vertically on a 1/2" or 1" diameter post - see Fig. 3.1.

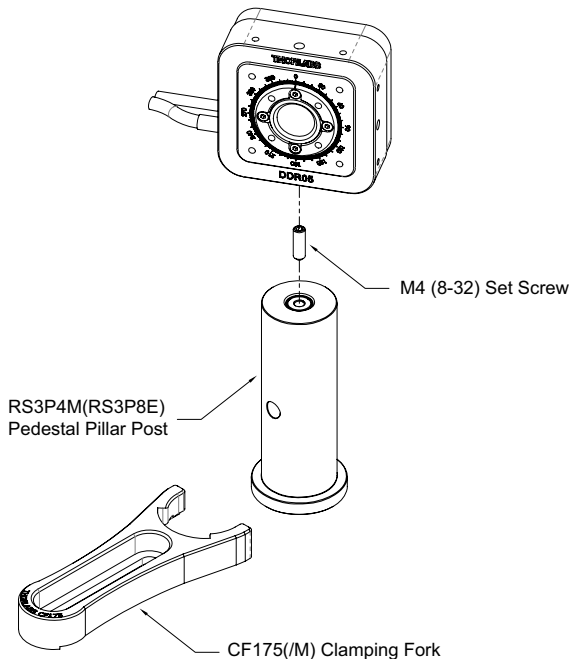
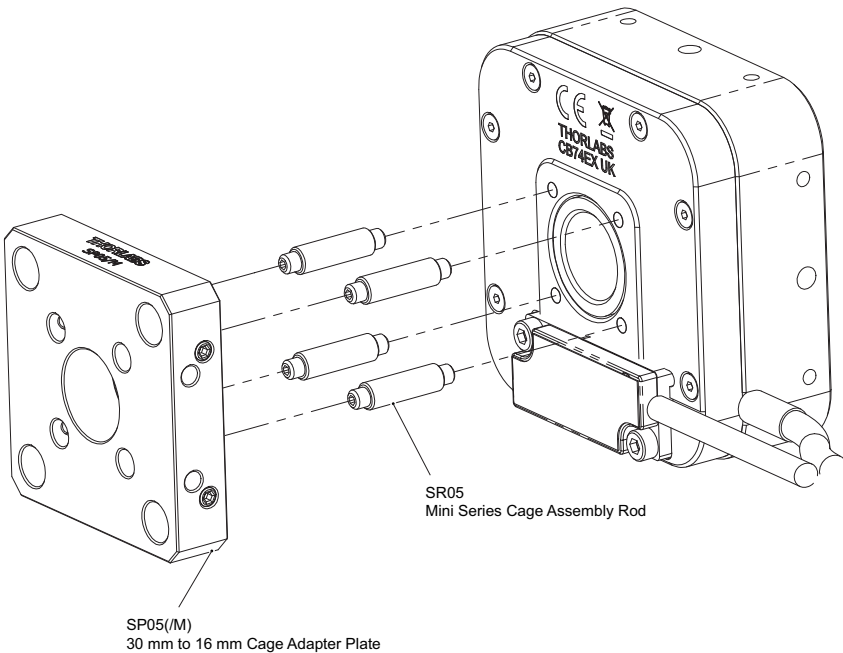


Fig. 3.1 Vertical mounting on post

### 3.3.2 Cage Mounting

An array of threaded holes in the rotating face allow 16 mm cage system components to be fitted.

The rear face is also fitted with an array of threaded holes compatible with 16 mm cage systems. By using these holes, the stage can be mounted within the cage system, and components can then be rotated within the cage. For compatibility with 30 mm cage systems, an adapter must be constructed by using our SP05(/M) 16 mm to 30 mm adapter plate, and four 16 mm cage rods (e.g. SR05 1/2" cage rod) as shown below and on the next page.





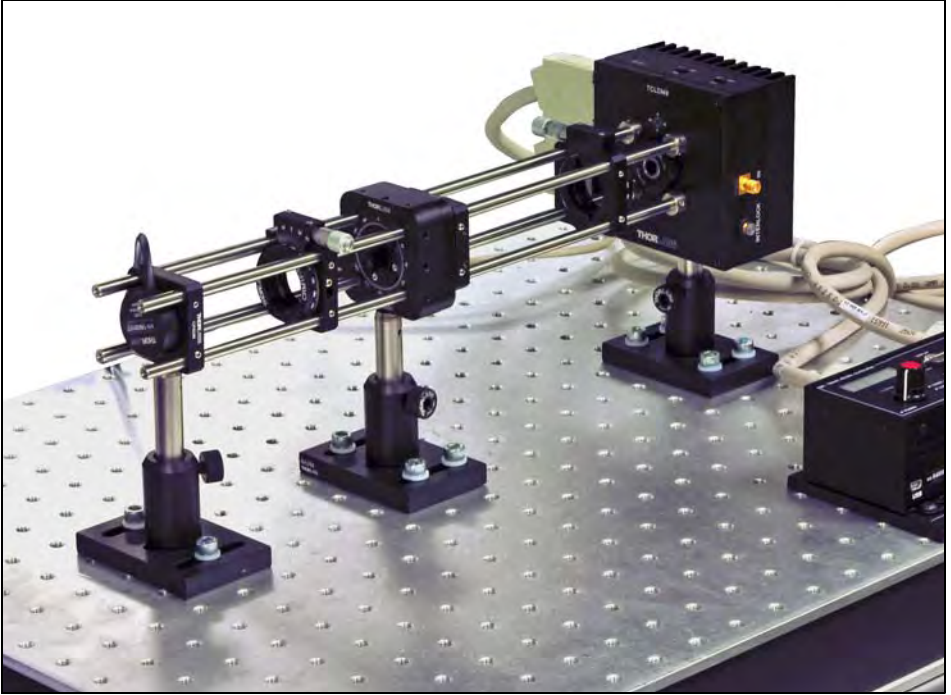
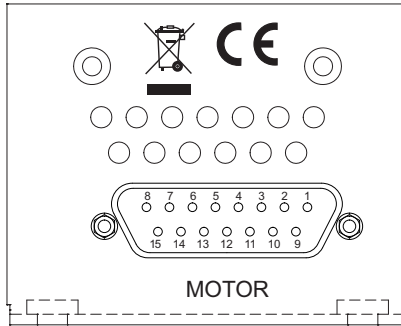


Fig. 3.2 DDR05 fitted with cage system components

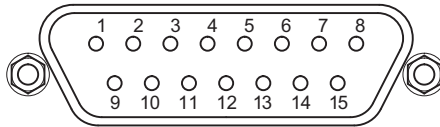
### 3.4 Electrical Connections

For optimum performance, the stage must be driven by a Thorlabs TBD001 controller. Connect the flying lead to the MOTOR connector on the rear of the unit.



**Fig. 3.3 Electrical connections**

Pin out information for the connector on the stage flying lead is detailed below..



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

**Fig. 3.4 MOTOR flying lead pin identification**

### 3.5 Dimensions

All dimensions in mm [in.]

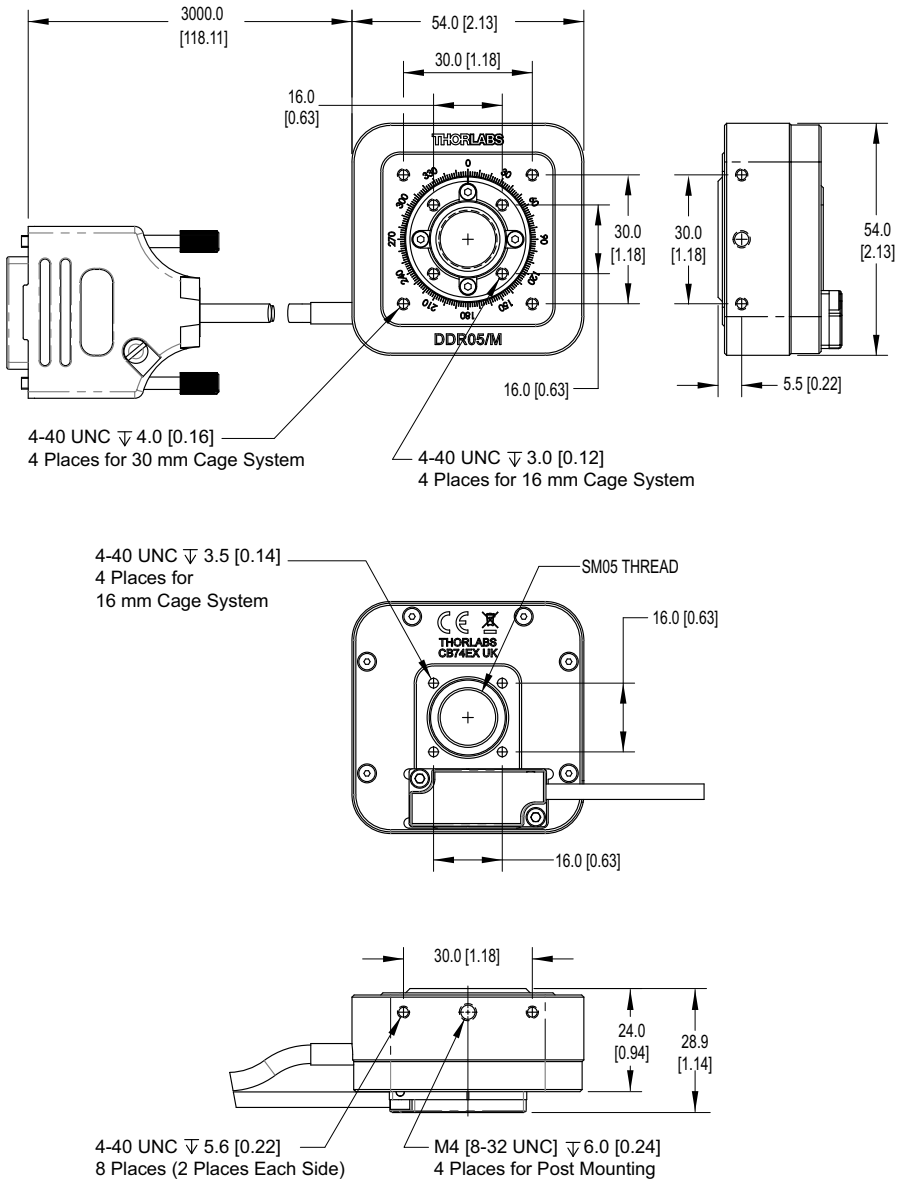


Fig. 3.5 Stage Dimensions

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## Chapter 4 Operation

### 4.1 General



#### Caution



**The DDR05 stage is designed to be driven by the Thorlabs TBD001 Brushless DC Motor Controller.**

**Keep clear of the moving world when the unit is in operation and rotating with equipment attached to the top plate.**

The stage is connected to the controller via a flying lead, terminated in D-type connector.



#### 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 unexpectedly. Operators should take care when working inside the moving envelope of the stage.**

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

- 1) Make electrical connections as detailed in Section 3.4.
- 2) Manually 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 energising 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 initialisation can only take place if the motor can move unobstructed during this time. Before powering up the TBD controller at item (3), ensure that the stage movement is unobstructed.**

- 3) Power up the TBD controller and wait until the Channel Enable LEDs start flashing (approx 3 seconds).
- 4) Run the APTUser utility and click the 'Home' button on each GUI panel. When homing is complete, the Channel Enable LEDs stop flashing.

**Note**

**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. The DDR05 stages use an optical reference marker for reference.**

- 5) The stage can now be moved using the GUI panel, or by setting commands to move each axis by relative and absolute amounts – see the handbook supplied with the TBD controller, and the helpfile supplied with the APT server for more information.

**Note**

**There are two position reporting modes. The displayed position is dependent on the mode selected - see Section 4.3. for more details.**

- 6) The stage is shipped already loaded with default parameter settings, which should give satisfactory performance for a typical load with inertia moment up to  $70\text{kg}\cdot\text{mm}^2$ . The maximum load will vary depending on the inertia moment and it needs to be calculated each time customers change the load and the mounting position, however, for an inertia moment of  $70\text{kg}\cdot\text{mm}^2$  it can be estimated that the maximum load would be around 0.25kg. Depending on the application and load, it may be necessary to adjust the PID loop parameter settings to fine tune the response - see the handbook supplied with the TBD controller for more information.
- 7) If it is not already running, start the APTUser utility - Start/Programs/Thorlabs/APT User/APT User  
The APT server reads in the stage and controller information on boot up and the GUI panel shown below is displayed.



Fig. 4.1 APTUser GUI screen

### Note

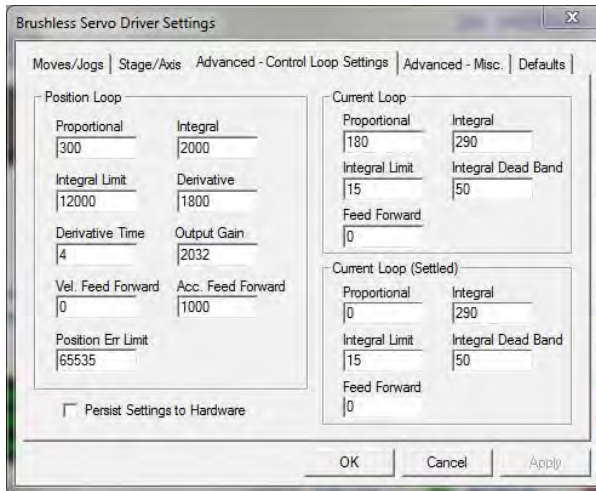
The MOTOR DRIVE connectors for each channel/axis contain an EEPROM, which stores the factory default settings for the set up parameters. When the stage is connected, these settings are loaded into the controller on start up, and are tuned for loads with an inertia moment of  $70\text{kg}\cdot\text{mm}^2$  maximum, at speeds up to 300 rpm.

However, depending on the inertia moment 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.

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



**Fig. 4.2 Advanced Control Loop Settings**

- 9) Adjust the PID settings to fine tune the control loop for your application. Refer to the handbook supplied with the TBD series control unit for more information.
- 10) 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.
- See the manual supplied with the TBD series controller unit for more information.

### Note

#### Position PID Settings Summary

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

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

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

***Stage sounds noisy*** - reduce the derivative term.

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

## 4.2 Minimum and Maximum Position Settings

There are no mechanical end stops on the DDR05 stage and theoretically, the total (accumulative) angle of the motion could be arbitrarily large. In practice, however, the integer arithmetic used for the position counter poses a restriction on the range of position values that can be represented. To avoid integer overflow and underflow problems, the target position is checked against the limits displayed in the Min Pos and Max Pos values. This check is done to ensure that the position counter always shows a correct value. For the DDR05 stage, the Min Pos and Max Pos limits are equivalent to  $\pm 536$  full rotations (193274 degrees).

In applications where continuous rotation is required, the Move At Velocity command can be used. This command does not constrain the angle to the Min Pos and Max Pos range and the continuity of the movement will not be interrupted until a Stop command is issued. However, when the integer representing the position counter overflows, the position value will flip sign and will no longer be correct. Any application commanding continuous moves for long period of times must take this into account and accept that once the Min Pos and Max Pos position is exceeded, the value displayed may no longer be correct.

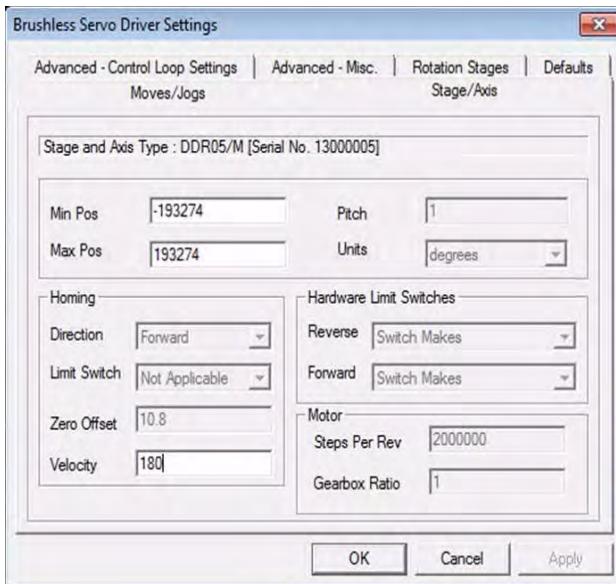
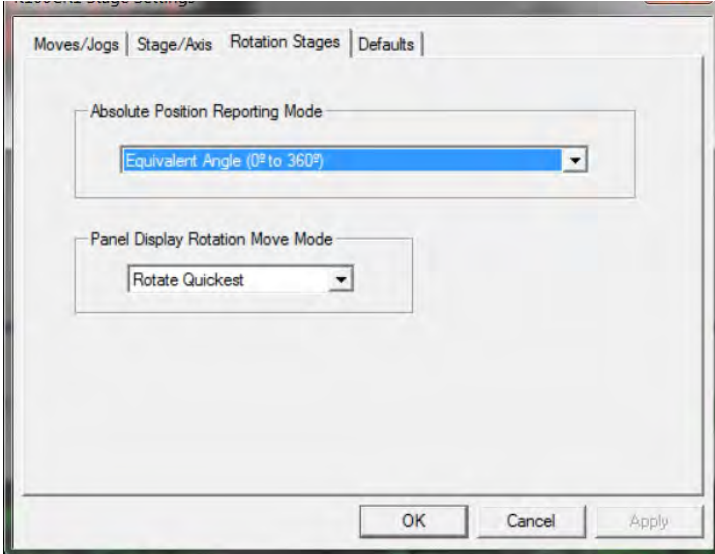


Fig. 4.3 DDR05 Stage/Axis Settings Tab



### 4.3 Rotational Stage Settings



#### Absolute Position Reporting Mode

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

*Equivalent Angle 0 to 360 degrees* – 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 (360 x Num Revs + Angular Offset)* – The total angular rotation is displayed, e.g. for a movement of two full rotations plus 10°, the display will show 730°.

**Note.** The following parameters are applicable only if the Absolute Position Reporting Mode is set to 'Equivalent Angle 0 to 360 degrees'.

#### Panel Display Rotation Move Mode

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

*Rotate Positive* – The move is performed in a positive direction

*Rotate Negative* - The move is performed in a negative direction

*Rotate Quickest* - The move is performed in the quickest direction

#### 4.4 Stopping the Stage

The drive channel is enabled and disabled by clicking the 'Enable' button on the GUI panel. The green indicator in the button center is lit when the drive channel is enabled. Disabling the channel removes the drive power.

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 APTUser GUI screen

#### 4.5 Position Error Messages



#### Caution



The maximum velocity at which the encoder can operate is 300 rpm. 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 TBD controller, the maximum velocity is limited to safe values. The TBD controller has fault monitoring to detect the loss of encoder pulses. If this fault occurs, an error message will be generated and the controller must be powered down and re-started so that correct phasing and commutation can be established.

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## 4.6 Maintenance

The product is maintenance free up to 8,000 hours of intermittent operation. If any problems occur, the user should contact the local Thorlabs tech support for more information. After 8,000 hours, the bearing may need to be re-lubricated. Contact your local Thorlabs tech support for more information.

## 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.**

**The unit has fragile internal components that can be damaged if the staged is dropped.**

## 4.8 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. Contact details are contained in Chapter 6.3.

# Chapter 5 Specifications

## 5.1 Specification

Parameter	Value
Travel Range	360° Continuous
Max Speed	5.0 Hz (1800°/s)
Max Acceleration <sup>1</sup>	29.1 Hz/s (10477°/s/s)
Repeatability	0.00054° (9.424778 µrad)
Backlash <sup>2</sup>	N/A
Encoder Resolution	2 x 10 <sup>6</sup> counts/rev (0.00018°)
Min Incremental Movement	0.00036°
Maximum Moment of Inertia of Load <sup>3</sup>	70 kg•mm <sup>2</sup>
<b>*Note</b>	
<b>The stage can carry higher loads at lower acceleration. The acceleration is limited by the motor force.</b>	
Min. Motor Holding Torque	1.8 N•m
Velocity Stability	± 2.0% (speed range 0.5 to 5 Hz)
Max Wobble (Axial)	500 µrad
Bearing Type	4-point Ball Bearing
Limit Switches	None
Central Aperture	SM05 Threaded
Operating Temperature Range <sup>4</sup>	5 to 40°C (41 to 104°F)
Motor Type	Brushless DC Rotary Motor
Cable Length	3 m (9.8')
Weight (Excluding cables)	0.39 kg (0.86 lb)
<b>Notes</b>	
<p><sup>1</sup> The acceleration is limited by the peak torque of the stage. Lighter loads can accelerate faster while heavier loads accelerate slower.</p> <p><sup>2</sup> The stage does not suffer from backlash because there is no transmission.</p> <p><sup>3</sup> Maximum load will vary depending on the moment of inertia. The estimated maximum load for 70 kg•mm<sup>2</sup> inertial moment is around 0.25kg.</p> <p><sup>4</sup> For operation at temperatures outside normal room temperature, the PID parameters may require optimization.</p>	

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# Chapter 6 Regulatory

## 6.1 Declarations Of Conformity

### 6.1.1 For Customers in Europe

See section Section 6.3.

### 6.1.2 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.

## 6.2 Waste Electrical and Electronic Equipment (WEEE) Directive

### 6.2.1 Compliance

As required by the Waste Electrical and Electronic Equipment (WEEE) Directive 2002/96/EC of the European Community and the corresponding national laws, we offer all end users in the EC the possibility to return "end of life" units without incurring disposal charges.

This offer is valid for electrical and electronic equipment

- sold after August 13th 2005
- marked correspondingly with the crossed out "wheelie bin" logo (see Fig. 1)
- sold to a company or institute within the EC
- currently owned by a company or institute within the EC
- still complete, not disassembled and not contaminated



**Fig. 6.1** Crossed out "wheelie bin" symbol

As the WEEE directive applies to self contained operational electrical and electronic products, this "end of life" take back service does not refer to other products, such as

- pure OEM products, that means assemblies to be built into a unit by the user (e. g. OEM laser driver cards)
- components
- mechanics and optics
- left over parts of units disassembled by the user (PCB's, housings etc.).

If you wish to return a unit for waste recovery, please contact Thorlabs or your nearest dealer for further information.

### **6.2.2 Waste treatment on your own responsibility**


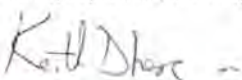

If you do not return an "end of life" unit to the company, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

### **6.2.3 Ecological background**

It is well known that WEEE pollutes the environment by releasing toxic products during decomposition. The aim of the European RoHS directive is to reduce the content of toxic substances in electronic products in the future.

The intent of the WEEE directive is to enforce the recycling of WEEE. A controlled recycling of end of life products will thereby avoid negative impacts on the environment

### 6.3 CE Declaration

	<b>THORLABS</b> www.thorlabs.com	
<b>EU Declaration of Conformity</b> <i>in accordance with EN ISO 17050-1:2010</i>		
We:	<input type="text" value="Thorlabs Ltd."/>	
Of:	1 St. Thomas Place, Ely, CB7 4EX, United Kingdom	
in accordance with the following Directive(s):		
2006/42/EC	Machinery Directive (MD)	
2004/108/EC	Electromagnetic Compatibility (EMC) Directive	
hereby declare that:		
Model:	<b>DDR05 Series</b>	
Equipment:	<b>Motorized 1/2" Waveplate Rotator</b>	
is in conformity with the applicable requirements of the following documents:		
EN ISO 12100	Safety of Machinery. General Principles for Design. Risk Assessment and Risk Reduction	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 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:		
does not contain 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: 17 July 2015
Name:	Keith Dhese	
Position:	General Manager	
		EDC - DDR05 Series -2015-07-17

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## Chapter 7 Thorlabs Worldwide Contacts

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



### USA, Canada, and South America

Thorlabs, Inc.  
[sales@thorlabs.com](mailto:sales@thorlabs.com)  
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### UK and Ireland

Thorlabs Ltd.  
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### Europe

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### Scandinavia

Thorlabs Sweden AB  
[scandinavia@thorlabs.com](mailto:scandinavia@thorlabs.com)

### France

Thorlabs SAS  
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