THORLABS

PIA Series
Piezo Inertia Actuators

User Guide

Original Instructions

Contents

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.

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.

1.2 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 and/or dust may impair operation.

The equipment is for indoor use only.

The equipment is not designed for use in an explosive atmosphere.

1.2.1 General Cautions

Caution

Damage to the threads of the drive screw can cause significant inconsistency of stepping behaviour.

The drive screw must not be obstructed.

Dust and debris can reduce the lifetime of the actuator. If left running unattended for periods of time, the application should be covered where possible.

If the clamping force onto the barrel is too high, this can cause reduced stepping performance and possible stalling of the drive screw.

The actuators are fitted with a collar nut which acts as a mechanical end stop. Removing this locking nut will invalidate the warranty.

1.2.2 General Notes

Note

The stick-slip nature of the mechanism uses a very short pulse width. Continuous stepping of the actuator results in an audible noise at a typical level of 60 to 70 dB.

The step size is defined as the distance moved in one step or pulse. This distance can be adjusted up to about 30% by changing the piezo drive voltage. The actual step size achieved for a given drive voltage will be dependant on application. Due to the open loop design, piezo hysteresis, component variance and application conditions, the achieved step size of the system may vary by over 20% and is not normally repeatable.

Chapter 2 Overview

2.1 Introduction

A piezo inertia motor uses inertia and friction to move a slider. The actuator's linear stepping is based on micro-rotation of the finely threaded drive screw circumference. In each single step, a clockwise or counterclockwise rotation is created with a voltage pulse to a piezo stack within the mechanism. This in turn creates a reciprocating linear displacement of the screw tip. Using different rise and fall voltage rates depending on the load, a typical step size of 20 nm can be achieved.

Thorlabs Piezo Inertia Actuators have been designed for use with our range of small positioning stages and optical mounts, and feature a 9.5 mm (3/8”) mounting barrel. The 13 mm (0.51”), 25 mm (0.98”) and 50 mm (1.97”) travel variants also feature a 3/8”-40 threaded mount option, whereas the 10 mm (0.39”) travel PIAK variant has a 1/4”-80 threaded mounting barrel, compatible with certain KM and KS series kinematic mirror mounts. They deliver a 25 N pushing force, and are ideal for fine positioning using the fine-threaded 1/4”-80 drive screw for transitional and angular adjustment. These actuators maintain their position with no power applied and have an adjustment knob for manual positioning.

When driven by the KIM101 Inertial Piezo Controller, the PIA series offers continuous long term stepping as well as periodical position and hold mode.

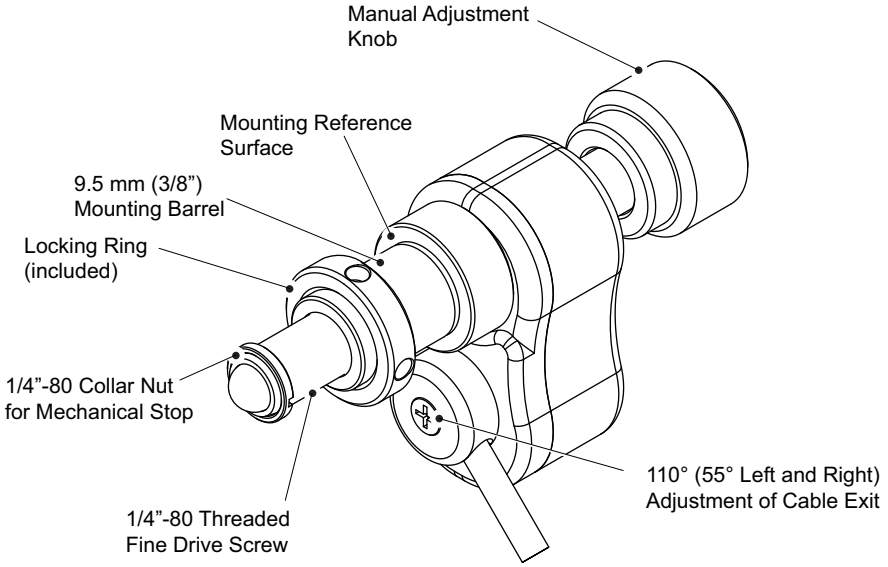

Fig. 2.1 PIA Series Piezo Inertia Actuator - Features

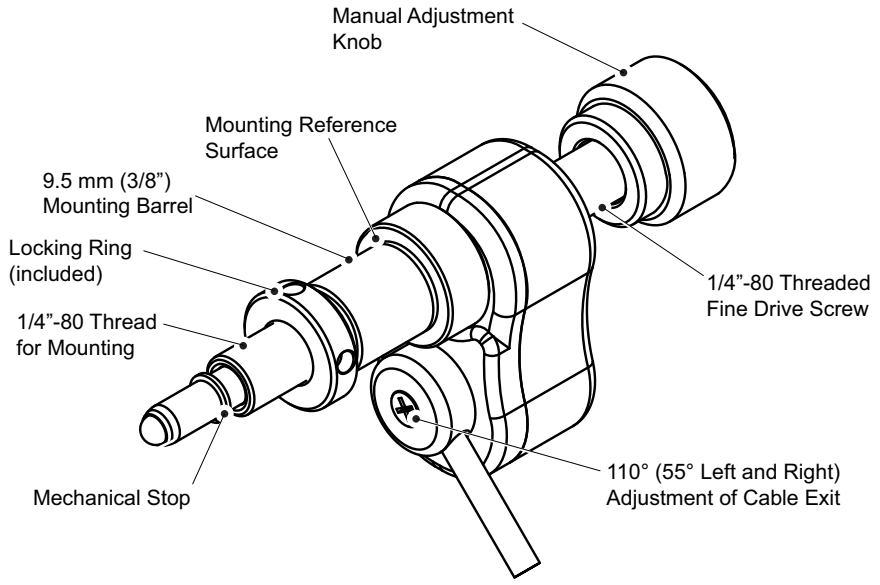

Fig. 2.2 PIAK10 Piezo Inertia Actuator - Features

Chapter 3 Installation

3.1 Mounting

3.1.1 General

Caution

When mounting close to other equipment, ensure that the travel of the platform being driven is not obstructed. If movement is obstructed the actuator will stall, which could cause premature wear failure of the drive screw coating.

The actuator tip is a tungsten carbide ball with a superior finish and wear resistance. Where possible, the contact area and torsional resistance of the actuator should be minimized by using a flat, smooth, hard surface (e.g. hardened steel or ceramic) for the ball to push against. Avoid pushing against soft material, e.g. aluminum or brass.

Use grease as required between the ball and the contact area. If the pushing surface is not hard enough, or there is excessive friction at the ball contact point, this could result in significant wearing of the contact pad and consequently increased torsional resistance against the drive screw.

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.

3.1.2 Adjusting the Cable Exit Position

Caution

The cable exit adjustment feature is for static use only, to set the appropriate cable exit angle. It is not for use in dynamic applications to achieve continuous flexing. The actuator should only be driven when the screw is locked.

The drive cable exit position can be adjusted to exit left or right as required, with an adjustment angle of 110° and a minimum bend radius of 35 mm (1.38”).

Simply loosen the locking screw as shown, rotate the cable to the required position and then tighten the screw gently.

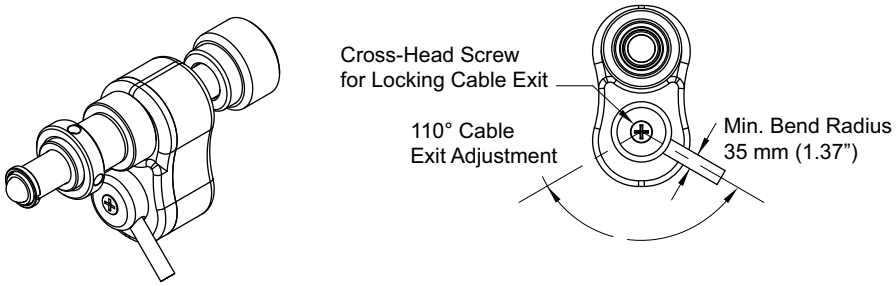

Fig. 3.1 Adjusting the Cable Exit Position

3.1.3 Fitting to a Barrel Mount

Caution

Only fit an actuator with the same travel as the stage. Fitting actuators with a longer travel will cause excessive axial preload. Do not exceed the preload values specified in Chapter 5.

1) Set the required actuator cable exit position - see Section 3.1.2.
2) Remove the barrel locking ring from the actuator.
3) Loosen the pinch bolt in the actuator clamp.
4) Fit the actuator into the clamp, ensuring that the mounting barrel is fully located in the clamp and reference surface is located flush against the clamp housing.
5) Rotate the actuator to orientate the housing as required.

Caution

During item (6), excessive clamping force onto the brass barrel mount may result in damage to the drive screw and reduced stepping performance.

6) Tighten the pinch bolt. Take care not to apply excessive clamping forces by overtightening. Tighten until the actuator is just held, then tighten by another 1/8 to 1/4 turn as necessary. Do not overtighten the pinch bolt.
7) Readjust the cable exit position as required.

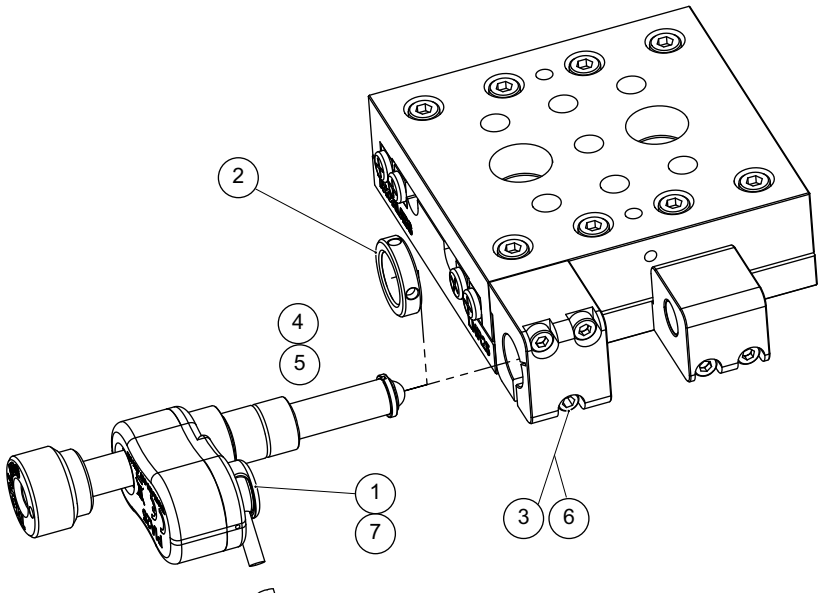

Fig. 3.2 Fitting a PIA25 to a LNR25 Stage

3.1.4 Fitting to a Threaded Mount

Caution

Only fit an actuator with the same travel as the stage. Fitting actuators with a longer travel will cause excessive axial preload. Do not exceed the preload values specified in Chapter 5.

When adjusting the locking ring at items (2) and (5), take care to avoid damaging the threads by cross threading the ring.

If fitted, remove the existing actuators from the mount, then proceed as follows:

1) Set the required actuator cable exit position - see Section 3.1.2.
2) Back off the locking ring until it is against the mounting barrel. Take care to avoid cross threading the ring.

Caution

During item (3), take care to ensure that the cable does not become damaged or tangled during rotation of the actuator.

3) Insert the threaded shaft into the actuator mounting hole, and screw in as required. A minimum of 3mm thread engagement is recommended.
4) Unscrew until the required orientation of the actuator housing is achieved.
5) Tighten the locking ring against the mount. Take care to avoid cross threading the ring.
6) Repeat items (1) to (5) for the remaining actuator.

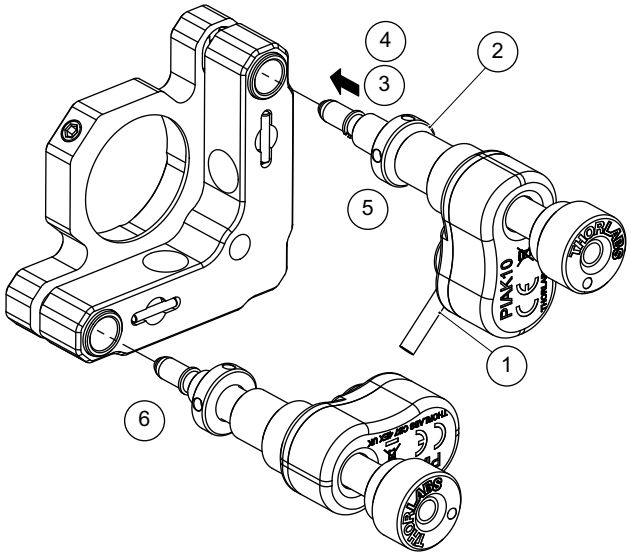

Fig. 3.3 Fitting the PIA10K to a KM100 Mirror Mount

3.2 Electrical Connections

The stage must be driven by a Thorlabs KIM101 controller (or legacy TIM101).

The PIA series actuators are shipped with a 1 m (3.3') cable, terminated in an SMC connector. Connect the PIA actuator to one of the MOT terminals on the rear panel of the KIM101 controller - see the KIM101 Controller handbook for pin out details.

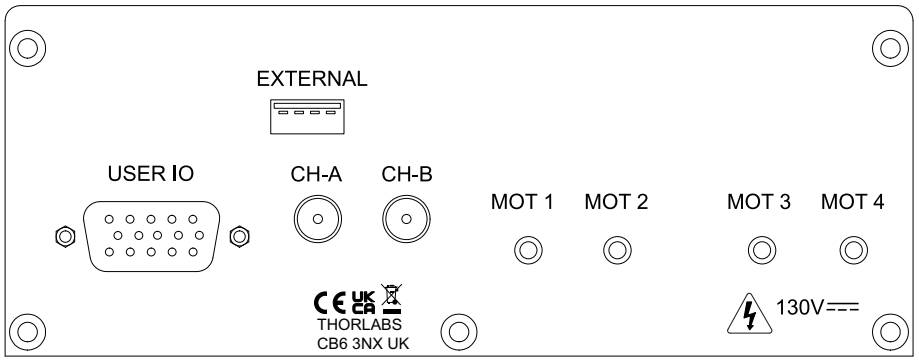

Fig. 3.4 Electrical connections

Chapter 4 Operation

4.1 General

Warning

The piezo actuators in this product use high voltages. Voltages up to 130V may be present at the SMC connector. This is hazardous and can cause serious injury. Appropriate care should be taken when using this device.

Persons using the device must understand the hazards associated with using high voltages and the steps necessary to avoid risk of electrical shock.

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

Caution

The PIA series actuators can only be driven by the Thorlabs KIM101 or legacy TIM101 Controllers.

For a complete tutorial on driving the actuator, see the manual supplied with the KIM101 controller. Basic steps in controlling the actuator are as follows:

1) Mount the PIA actuator to the relevent stage or mount as detailed in Section 3.1.
2) Make electrical connections as detailed in Section 3.2.
3) Turn the knob on the actuator to manually position the device being driven to the required start position.

Note

During operation, the actuator makes a high pitch whistling noise, and may generate some heat. This is normal behavior in the performance of the device and does not indicate a fault condition.

4) Run the software and click the 'zero' button on the GUI panel. This establishes a datum at the current position, from which subsequent positional moves can be measured.
5) The stage can now be moved using the controls on the KIM101 unit, the GUI panel, or by setting commands to move each axis – see the handbook supplied with the KIM101 controller, and the helpfile supplied with the software for more information.

Note

The PIA series actuators are open loop devices that have been designed to offer relative positioning which can be commanded via the number of steps.

Caution

If the actuator is driven into its end stops, the motor may stick and may not respond to subsequent motion demands. If this is the case, turn the adjustment knob of the actuator manually to move the device away from its end stop, then the motor should move normally.

4.2 Maintenance

Periodically, the manual knob should be used to move the drive screw from one end of travel to the other, in order to redistribute the grease. The periodicity will depend on usage. In applications involving continuous use or where a small travel range is used at high duty cycle, the grease should be redistributed often to ensure optimal performance of the actuator.

Due to frictional-inertia nature of the mechanism, wear of the screw coating occurs during its lifetime. Periodic maintenance helps to increase the optimum stepping performance during its lifetime.

4.3 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 20 mm of shock absorbent material.

Chapter 5 Specification

Parameter	PIA13	PIA25	PIA50	PIAK10
Travel Range	13 mm (0.51")	25 mm (0.98")	50 mm (1.97")	10 mm (0.39")
Typical Step Size[1, 2]	20 nm			
Maximum Step Size	<30 nm			
Step Size Adjustability[2]	Up to 30%			
Maximum Step Frequency	2000 Hz			
Velocity (Cont. Stepping)	2 mm/min (Typ), <3.5 mm/min (Max)			
Max Active Preload[3]	25 N			30 N
Typical Angular Resolution[4]	N/A			1" Mounts: 0.5µrad 2" Mounts: 0.3 µrad
Recommended Max Active Load Capacity[5]	2.5 Kg			
Mounting	9.5 mm (3/8") Barrel and 3/8-40 Thread			9.5 mm (3/8") Barrel and 1/4-80 Thread
Drive Screw	1/4-80 Thread, Hard PVD Coated			
Actuator Tip	Tungsten Carbide Ball			
Lifetime	>1 Billion Steps			
Connector Type	SMC Female			
Cable Length	1 m (3.3 ft) Cable Wrap Included			
Cable Exit Adjustability	±55 Deg for Left- or Right-hand Exit			
Piezo Capacitance	175 nF			
Max Operating Voltage	130 V			
Operating Temperature	10 to 40 °C			
Dimensions	59.5 x 31.5 x 17.0 mm (2.34" x 1.24" x 0.67")	71.4 x 31.5 x 17.0 mm (2.81" x 1.24" x 0.67")	96.6 x 31.5 x 17.0 mm (3.80" x 1.24" x 0.67")	72.9 x 31.5 x 17.0 mm (2.87" x 1.24" x 0.67")
Weight (inc. Cable)	55 g (1.94 oz)	60 g (2.12 oz)	65 g (2.29 oz)	55 g (1.94 oz)

Note. All specifications are measured using the KIM101 controller.

[1] Can vary by up to 20% due to component variance, change of direction and application conditions.

[2] Adjusted by changing the piezo drive voltage - see the controller handbook for more details.

[3] Axial force applied onto drive screw tip (ball). A minimum of 5 N active preload is recommended to enhance stepping behavior.

[4] The angular resolution when a PIAK10VF Actuator is fitted to a KS1TV Ø1" Mirror Mount. This does not apply to the PIA13VF Actuator.

[5] A higher horizontal load is possible but this may decrease the typical step size.

Chapter 6 FAQ

How does a piezo inertia motor work?

A piezo inertia actuator uses friction and inertia (stick/slip) to rotate a fine mechanical drive screw. The piezo is driven by a saw tooth voltage waveform. As the voltage is ramped up, the piezo will extend and turn the screw (stick). When the voltage is dropped to zero, the piezo returnes to its original length. By using different rates of voltage rise and fall, the drive screw rotates more in one direction than the other due to inertia and different frictional coefficients, reulting in residual rotation. This in turn is tranlated to a linear displacement of the screw which is transferred to the application via the tip of the screw.

What applications can they be used for?

Any 'set-and forget' application, particularly where space is tight. The primary function of the PIA series actuators is relative position and hold, whereby switching the controller off will result in the same drift as a 1/4-80 fine drive screw.

The step size is dependant upon drive screw preload, and will differ between actuators and applications. They are not suitable where repeatable step size is required.

What is the lifetime of the typical piezo inertial motor?

The piezo stack of the actuator is rated for a service life of over a billion steps. With proper maintenance (see Section 4.2.) the wear performance of the hard coating on the drive screw should endure for this life time, however up to a 30% drop in step size may be experienced.

What driver can I use?

The piezo inertia actuators are designed to be driven by the Thorlabs KIM101 Inertia Piezo Driver.

What is the maximum length of cable?

The actuators are shipped with 1m (3.3') of cable. Thorlabs offer 1.5m (PAA101) extension cables and male adapters (T5026) to extend this length to 2.5m, see www.thorlabs.com. Due to the capacitance of the cables, do not use cables longer than 2.5 m in total.

Chapter 7 Regulatory

7.1 Declarations Of Conformity

7.1.1 For Customers in Europe

See Section 7.2.

7.1.2 For Customers In The USA

This equipment has been tested and found to comply with the limits for a Class A digital device, persuant 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.

7.2 CE Certificates

THORLABS
www.thorlabs.com

EU Declaration of Conformity

in accordance with EN ISO 17050-1:2010

We: 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)
2014/30/EU	Electromagnetic Compatibility (EMC) Directive
2011/65/EU	Restriction of Use of Certain Hazardous Substances (RoHS)

hereby declare that:

Model: ***PIA Series***

Equipment: ***10, 13, 25 and 50mm Travel Piezo Actuator including Kinematic Mount Version***

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:

is exempt from the requirements of the Directive because its intended application is excluded pursuant to Annex III or Annex IV of the Directive. (Exemption 7c(1) applies).

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 *On:* 16 August 2018

Name: Keith Dhese

Position: General Manager

EDC - PIA Series -2018-08-16

CE

Chapter 8 Thorlabs Worldwide Contacts

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

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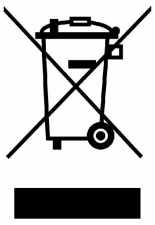
Thorlabs verifies our compliance with the WEEE (Waste Electrical and Electronic Equipment) directive of the European Community and the corresponding national laws. Accordingly, all end users in the EC may return "end of life" Annex I category electrical and electronic equipment sold after August 13,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



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