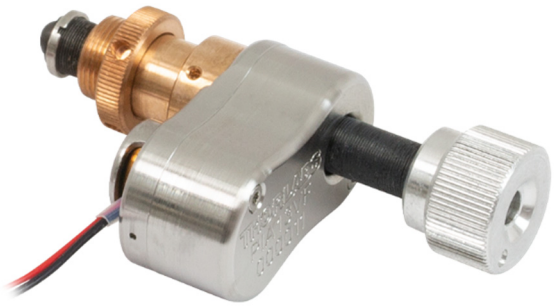
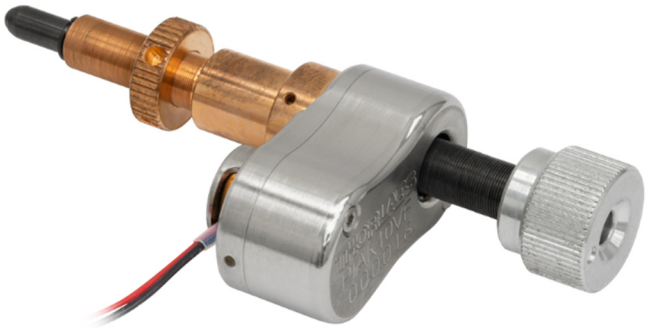
THORLABS

Vacuum-Compatible Piezo Inertia Actuators

User Guide





Original Instructions

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Chapter 1 Overview

1.1. 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. The PIA13VF features a Ø3/8" (Ø9.525 mm) mounting barrel with a 3/8"-40 threaded mount, whereas the PIAK10VF variant has a 1/4"-100 threaded mounting barrel, compatible with the KS1TV kinematic mirror mount. The PIA13VF and the PIAK10VF deliver 25 N and 30 N of pushing force, respectively, and are ideal for fine positioning using the fine-threaded 1/4"-80 drive screw for translational and angular adjustment. These actuators maintain their position with no power applied and have an adjustment knob for manual positioning.

The PIAK10VF actuator is not compatible with Polaris® mounts that use 1/4"-100 adjusters. These mounts require a specific actuator ball size and tip design to ensure that the ball contact is centered on the sapphire end stone and that there is proper screw clearance during full translation. In the case of the PIAK10VF actuator, the side of the screw, rather than the ball tip, will contact the sapphire end stone and, as a result, the actuator should not be used with Polaris mounts.

When driven by the KIM101 or KIM001 Inertial Piezo Controller, these actuators offer continuous long term stepping as well as periodic position and hold mode.

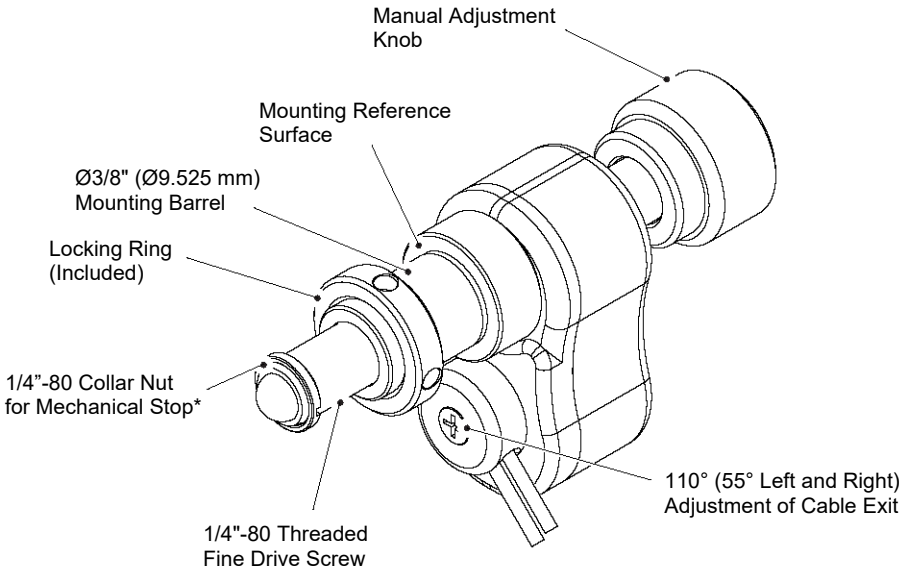


Figure 1 Features of PIA13VF Piezo Inertia Actuator

CAUTION

*** Removing the 1/4"-80 Collar Nut will invalidate the warranty.**

Removing the manual adjustment knob could affect performance and specification.

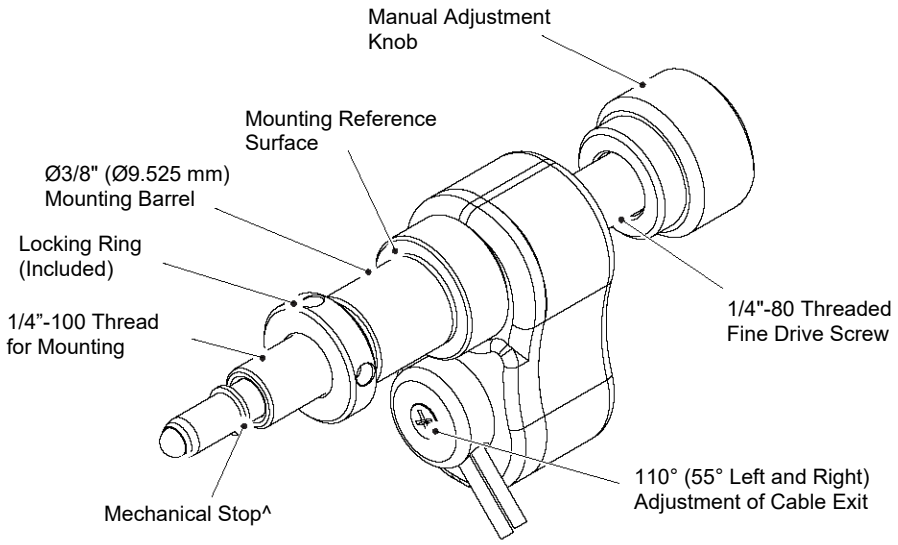


Figure 2 Features of PIAK10VF Piezo Inertia Actuator

CAUTION

^ Removing the Mechanical Stop will invalidate the warranty.

Removing the manual adjustment knob could affect performance and specification.

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.

SHOCK WARNING

Warning is given when there is danger of injury to users.

CAUTION

Caution is given when there is a possibility of damage to the product.

WARNING

Given when there is danger of injury to users.

Use either exclamation points or laser warning if laser.

2.2. General Warnings, Cautions, and Notes

2.2.1. 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.

2.2.2. General Cautions

CAUTION

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

The drive screw must not be obstructed.

Dust and debris can reduce the lifetime of the actuatot. 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.

2.2.3. 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 dependent 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 more than 20% and is not normally repeatable.

Chapter 3 Installation

3.1. Before Use

Although the unit is thoroughly cleaned after assembly, and is vacuum-packed before shipping, some impurities may still remain.

It is recommended that before the unit is installed in the vacuum chamber, it is pre-baked in order to remove volatile compounds and moisture from the unit, which could potentially spoil the vacuum.

CAUTION

During the 'bake out' process, the temperature must be limited to 130 °C max. Higher temperatures could damage the piezo.

3.2. Mounting

3.2.1. General

WARNING

The actuator is supplied with flying leads, for connection to the vacuum chamber bulkhead, and a dual core cable for connection from the bulkhead to the KIM controller.

Only personnel trained in the maintenance of electrical equipment should make any wiring connections.

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 finished with a tungsten carbide coating for 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 vacuum compatible 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.

Note: The actuator is supplied vacuum-sealed. Do not remove from this sealed packaging until ready for use.

3.2.2. 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.

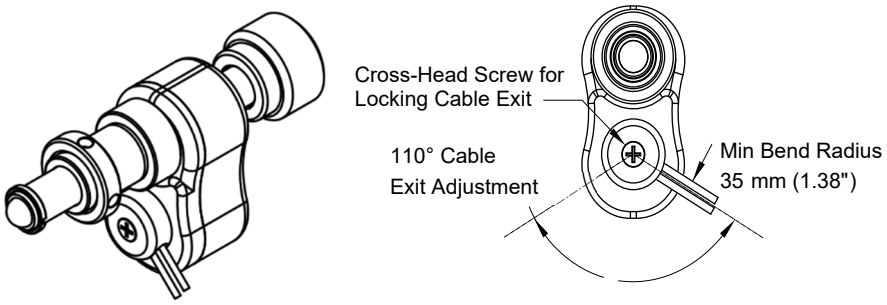


Figure 3 Adjusting the Cable Exit Position

3.2.3. 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 3.2.2.
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 orient 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.

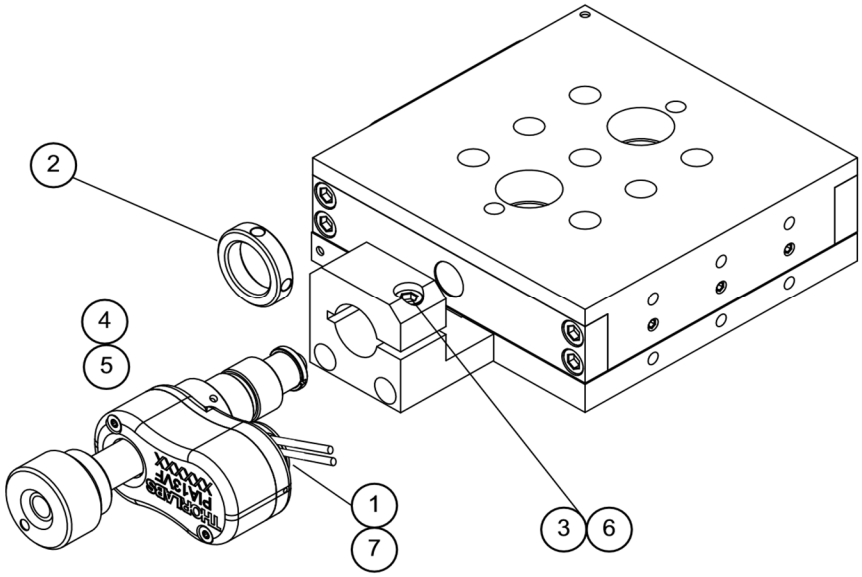


Figure 4 Adjusting the Cable Exit Position

3.2.4. Fitting to a Mirror Mount (PIAK10VF Only)

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.

Only fit an actuator onto a stage or mount with ¼"-100 internal threads.

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

The PIAK10VF actuator is not compatible with Polaris mounts that use 1/4"-100 adjusters. These mounts require a specific actuator ball size and tip design to ensure that the ball contact is centered on the sapphire end stone and that there is proper screw clearance during full translation. In the case of the PIAK10VF actuator, the side of the screw, rather than the ball tip, will contact the sapphire end stone and, as a result, the actuator should not be used with Polaris mounts.

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

1. Set the required actuator cable exit position - see Section 3.2.2.
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 3 mm 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.

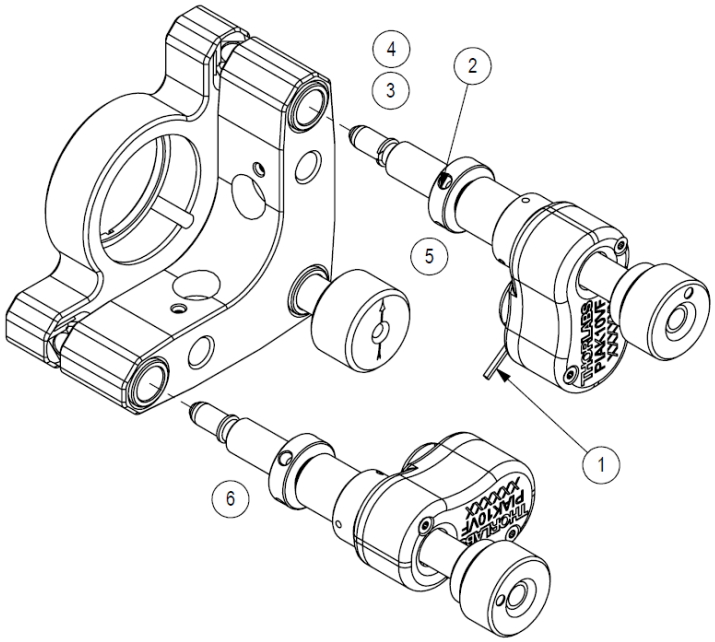


Figure 5 Fitting Two PIAK10VF Actuators onto a KS1TV Mount

3.3. Electrical Connections

The actuator must be driven by a Thorlabs KIM101 or KIM001 controller (or legacy TIM101).

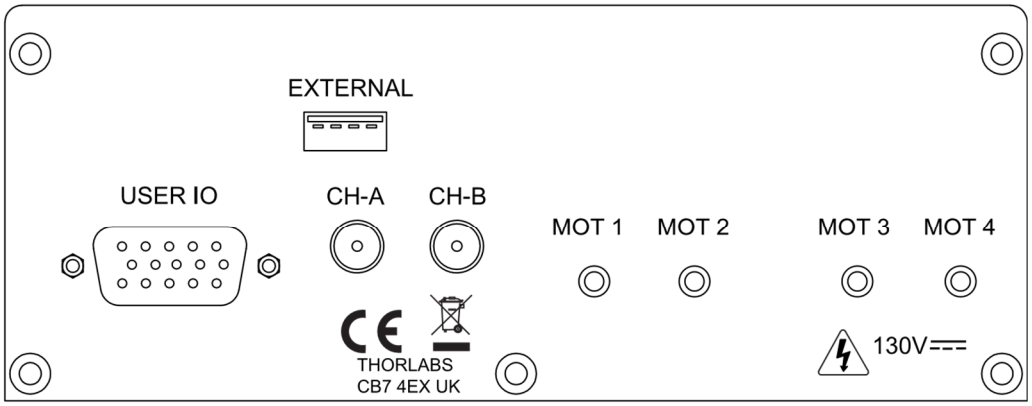
SHOCK WARNING

Only personnel trained in the maintenance of electrical equipment should make any wiring connections.

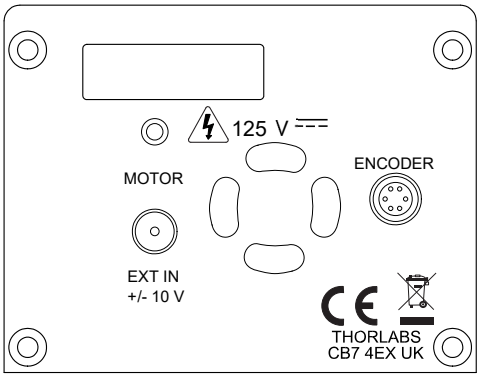
The actuator is supplied with vacuum compatible flying leads, for connecting the actuator to the vacuum chamber bulkhead, and a dual core cable for connection from the bulkhead to the KIM controller.

The combined length of both these cables is 1.75 m.

Due to the capacitance of the cables, do not use cables longer than 2.0 m in total.



KIM101 Rear Panel



KIM001 Rear Panel

Figure 6 Controller Electrical Connections

Wiring Identification

Actuator Flying Lead - red is positive, black is negative.
Dual Core Cable - inner core is positive, outer core is negative.

Chapter 4 Operation

4.1. General

WARNING

The piezo actuators in this product use high voltages. Voltages up to 130 V 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 KIM001 Controllers (or legacy TIM101 driver).

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

1. Mount the PIA actuator to the relevant stage or mount as detailed in Section 3.2.
2. Make electrical connections as detailed in Section 3.3.
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. Turn ON the controller and sure the PIA stage type is selected - see the manual for the associated controller.
5. 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.
6. The stage can now be moved using the controls on the top panel of the unit, the GUI panel, or by setting commands to move each axis – see the handbook supplied with the associated controller, and the helpfile supplied with the software for more information.

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.

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.

4.2. Maintenance

During ‘bake out’ procedures, the temperature must be limited to 130 °C max. Higher temperatures could damage the piezo.

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 Specifications

Parameter	PIA13VF	PIAK10VF
Travel Range	13 mm (0.51")	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	
Speed (Continuous Stepping)	2 mm/minute (Typical), <3.5 mm/minute (Maximum)	
Maximum Active Preload[3]	25 N	30 N
Typical Angular Resolution[4]	N/A	0.5 µrad
Recommended Maximum Active Load Capacity[5]	2.5 kg	
Mounting Feature (Auxiliary)	Ø3/8" (Ø9.525 mm) Barrel (3/8"-40 Thread with Lock Nut)	1/4"-100 Thread with Lock Nut (Ø3/8" (Ø9.525 mm) Barrel)
Drive Screw	1/4"-80 Thread, Hard PVD Coated	
Actuator Tip	Tungsten-Carbide-Coated Ball	
Lifetime	>1,000,000,000 Steps	
Connector Type	SMC Female	
Cable Length	0.75 m (2.48 ft) Flying Lead for Vacuum, 1.0 m (3.3 ft) of Cored Cable for Wiring Outside Chamber	
Cable Exit Adjustability	±55° for Left- or Right-Hand Exit	
Max Operating Voltage	125 V	
Piezo Capacitance	175 nF	
Piezo Resonant Frequency	125 kHz (No Load)	
Vacuum Rating	10^{-6} Torr	
Operating Temperature	5 to 130 °C	
Dimensions	59.4 x 31.5 x 17.0 mm (2.34" x 1.24" x 0.67")	77.7 x 31.5 x 17.0 mm (3.06" x 1.24" x 0.67")
Weight (Including Cable)	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 returns 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, resulting in residual rotation. This in turn is translated 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 dependent 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 0) 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 or KIM001 Inertia Piezo Driver.

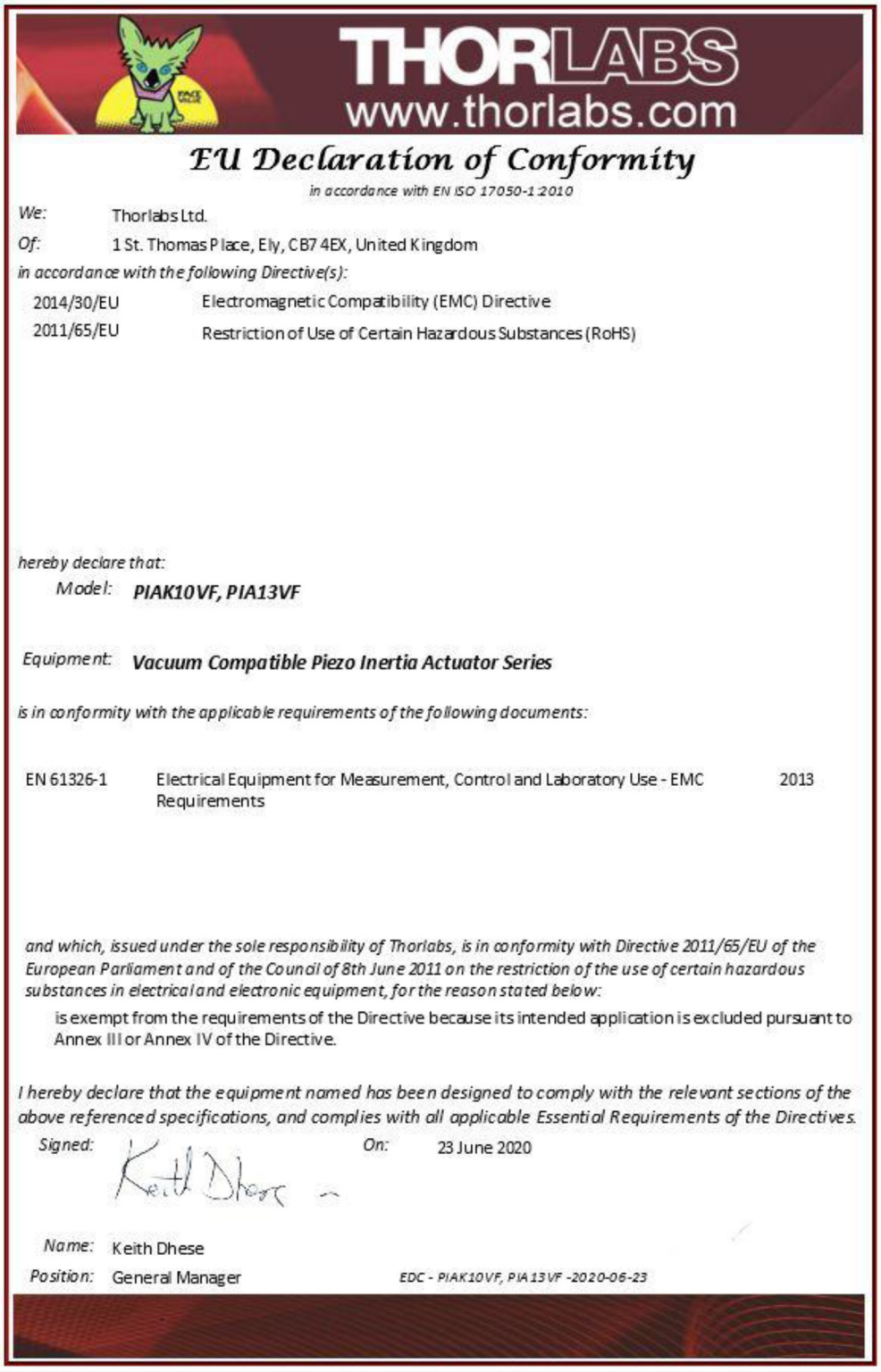
What is the maximum length of cable?

The actuators are shipped with a 0.75 m (2.48 ft) flying lead, plus 1.0 m (3.3 ft) of cored cable for wiring outside chamber. Due to the capacitance of the cables, do not use cables longer than 2.0 m in total.

Chapter 7 Regulatory

7.1. Declarations of Conformity

7.1.1. For Customers in Europe



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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):

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

hereby declare that:

Model: **PIAK10VF, PIA13VF**

Equipment: **Vacuum Compatible Piezo Inertia Actuator Series**

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

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.

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: 23 June 2020

Name: Keith Dhese

Position: General Manager

EDC - PIAK10VF, PIA13VF -2020-06-23

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.

Chapter 8 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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China
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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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