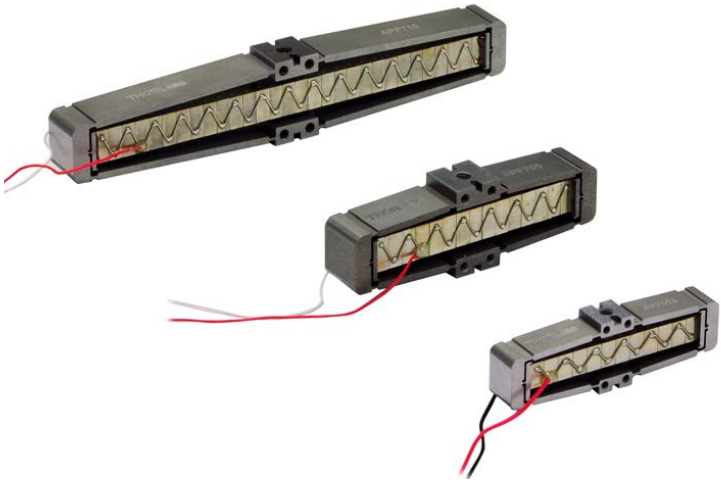
THORLABS

APF503, APF705 and APF710

Amplified Piezo Actuators

User Guide



Original Instructions

Contents

Chapter 1 Overview

1.1 Introduction

These piezo flexure amplifiers are open-loop, open-frame actuators for OEM applications, covering a travel range from 310 µm to 1150 µm when driven by 0 to 150V. The travel range can be extended by using a drive voltage in the range -30V to 150V - see Chapter 4 for more details. They are sold unhoused, as sub-assembly components, ready to be incorporated into third party stages and other equipment. The design features a standard ceramic piezoelectric stack within a hardened tool steel, precision flexure structure, which provides both preload for the piezo stack, and mechanical movement through lever amplification. The flexure structure also offers various options for fixing other components and integration into third party equipment.

The actuators offer flexibility in assembly and a minimised footprint.

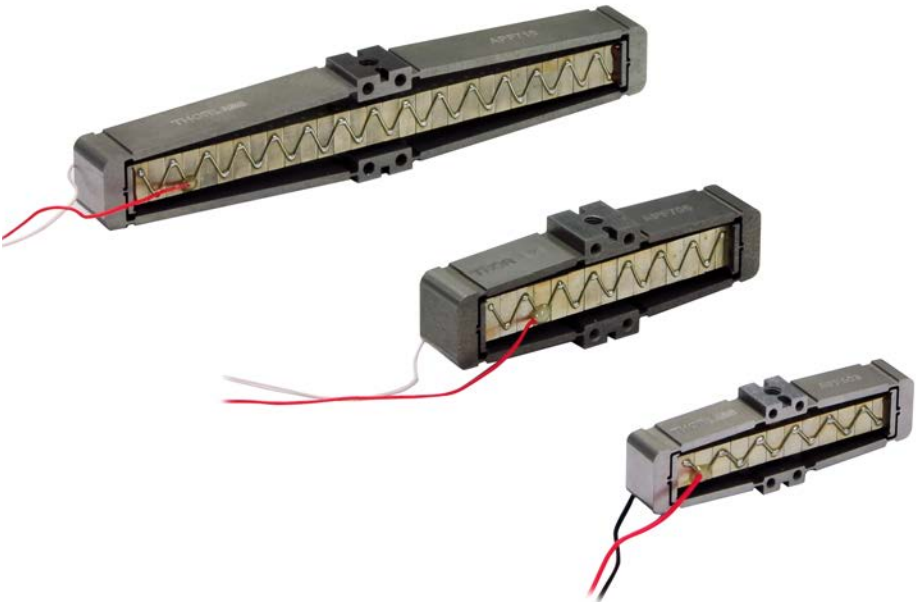


Fig. 1.1 APF503, APF705 and APF710 amplified piezo actuators

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

IIf 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.

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

Warning

Piezo actuators are driven by high voltages. Voltages up to 150V may be present at the 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 piezo actuator is connected or disconnected. Failure to switch the controller off may result in damage to either the controller, the piezo amplifier or both.

Caution

When removed from its packaging, the piezo assembly can be easily damaged by mishandling. In particular, do not squeeze the assembly, or apply compression to the mechanical flexure. Excessive compression could cause the piezo to become detached from the mechanical amplifier assembly (see Section 5.1. for limits).

Chapter 3 Installation

3.1 Storage Precautions

Warning

Piezos can store and release large amounts of energy and should be handled with caution. To prevent charge build up, piezos must be stored with the high voltage wires (red and white) joined together (short circuit).

3.2 Mechanical Installation

Caution

When removed from its packaging, the piezo assembly is easily damaged by mishandling. In particular, do not squeeze the assembly, or apply compression to the mechanical flexure. Doing so could cause the piezo to become detached from the mechanical amplifier assembly.

The APF series actuators have an open frame design, intended for incorporation into other third party equipment, and installation will depend on the specific application. Therefore, undertaking necessary assessments related to the use of the actuator in an assembly remains the responsibility of the end user. Detailed dimensional information is contained in the drawings available from www.thorlabs.com.

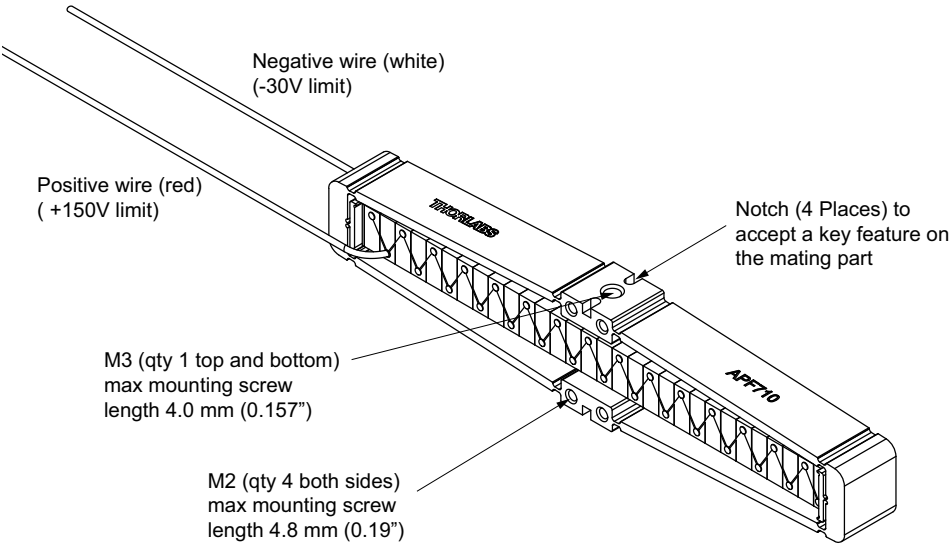


Fig. 3.1 Fitting the APF7 series piezo actuator

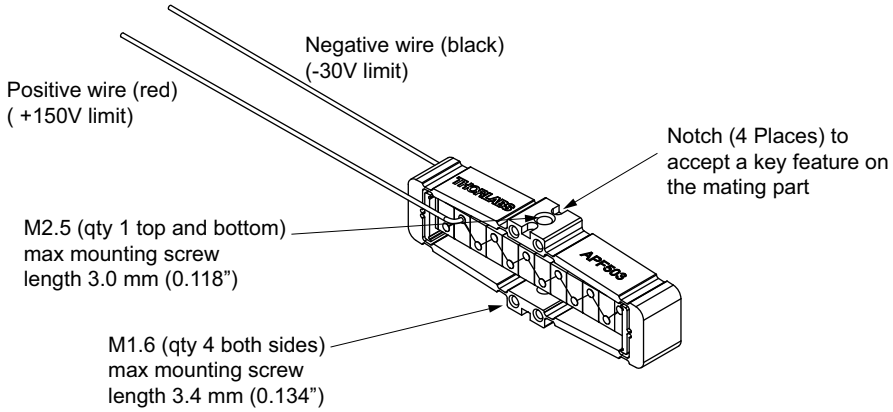


Fig. 3.2 Fitting the APF5 series piezo actuator

Caution

When tightening a screw into the top or bottom threads, the same face should be constrained (held). Holding the opposing face could cause damage to the actuator.

3.3 Electrical Connections

To achieve its full range of movement, the actuator drive voltage should be in the range -30 to 150 V. See Chapter 4 for movement direction when operating with positive and negative voltages. For typical performance data, see Chapter 5.

Connect the piezo actuator to the controller in accordance with the instructions supplied in the relevant controller handbook. The red wire should receive the drive

voltage and the white wire (APF7 series) or black wire (APF5 series) should be grounded.

Note

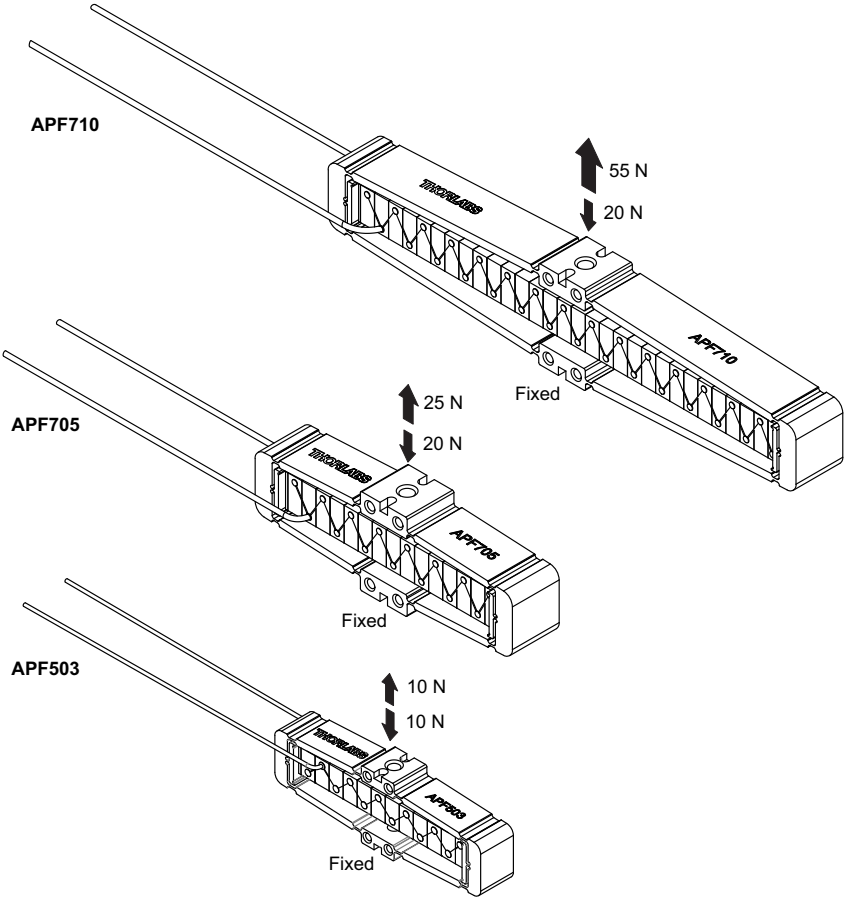
Typically, the black/white wire should be used as a ground reference (e.g. connecting to chassis of controller), and a bipolar power supply used to drive the red wire -30V to 150V.

However, given the commonly accepted description of voltage as a relative difference in the electrical field, the DC voltage applied to red wire and black/white wire should be at the range of -30V and 150V. Customers without a bipolar power supply can apply +30V to black/white wire, and 0V to red wire, to create a -30V difference, which would compress the piezo (and hence pushes up the amplifier). Alternatively, you can apply a +30V to black/white wire and +180V to red wire to achieve a +150V difference between the two electrodes of the piezo chips.

3.4 Maximum External Preload Inserted by the Application

In order for the piezo stack to function correctly, it must be under a preload. The piezo flexure assembly has a preset preload. When integrating into an assembly/ application, a maximum limit per direction of preload onto the actuator must be followed. This could be a total of gravitational forces plus reaction forces from a set of

compression springs (external preload) when the piezo is at 0V. The recommended external preload values are detailed in Fig. 3.3. .



Warning

Preloads in excess of the recommended values can damage the actuator.

Fig. 3.3 External preload values

Chapter 4 Operation

4.1 General

Warning

The piezo actuators in this product use high voltages. Voltages up to 150V may be present at the wire ends. This is hazardous and can cause serious injury. Appropriate care should be taken when using this device.

Persons integrating the device into an assembly 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 actuator is connected or disconnected. Failure to switch the controller off may result in damage to either the controller, the actuator or both. Any residual charge remaining in the piezo stack should be discharged.

For a complete tutorial on driving the actuator using the Thorlabs range of controllers, see the handbook for the appropriate controller. Basic steps in controlling the actuator using a Thorlabs controller are as follows:

1) Fit the actuator to the relevent stage or mount.
2) Make electrical connections using an appropriate type of connector, e.g. SMC, BNC etc.) as detailed in Section 3.3.
3) Run the APT or Kinesis software utility.
4) The actuator can now be moved using the controls on the controller unit, the GUI panel, or by setting commands to move each axis – see the handbook supplied with the controller, and the helpfile supplied with the APT server for more information.

Note

Typically, the black/white wire should be used as a ground reference (e.g. connecting to chassis of controller), and a bipolar power supply used to drive the red wire -30V to 150V.

However, given the commonly accepted description of voltage as a relative difference in the electrical field, the DC voltage applied to red wire and black/white wire should be at the range of -30V and 150V. Customers without a bipolar power supply can apply +30V to black/white wire, and 0V to red wire, to create a -30V difference, which would compress the piezo (and hence pushes up the amplifier). Alternatively, you can apply a +30V to black/white wire and +180V to red wire to achieve a +150V difference between the two electrodes of the piezo chips.

4.2 How the Actuator Moves with Voltage

One face of the actuator must be fixed, with all movement being realised by the opposing face, which moves down as the voltage is increased and up as the voltage is decreased as shown in Fig. 4.1.

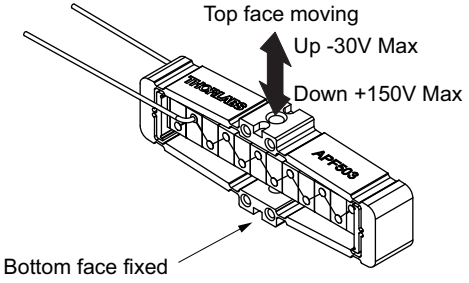


Fig. 4.1 APF503, APF705 and APF710 actuator movement

Furthermore, despite the very high resolution of piezoelectric actuators (the actual resolution achived will depend on the controller used), an inherent problem is the significant amount of hysteresis they exhibit, (i.e., the tendency of the actuator to reach a final position that lags behind the demand position).

If a cyclic voltage is applied to the actuator the positions reached on the upward sweep are smaller than those achieved on the downward sweep. This effect is called hysteresis and is based on molecular effect within the piezo crystals. Hysteresis could typically be up to 10% of full range in the APF series actuators. If position is plotted against voltage, the graph describes a hysteresis loop – see Fig. 4.2.

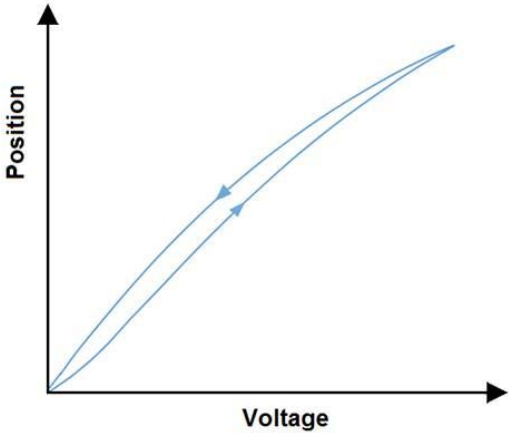


Fig. 4.2 Piezo-electric hysteresis

Therefore, to achieve positioning repeatability, a closed loop feedback system will be required.

Chapter 5 Specification

5.1 General Specifications

Parameter	APF503	APF705	APF710	Variance
Operating Voltage	-30V to 150V[a]			
Travel (0 to 150V)	310 µm	440 µm	1150 µm	±15%
Travel (-30V to 150V)	390 µm	560 µm	1500 µm	
Operating Temperature	0 to 50°C			
Capacitance	3.5 µF	8.0 µF	16.0 µF	
Max Pulling Force [b]	10 N	25 N	55 N	Max
Max Pushing Force [c, d]	10 N	20 N	20 N	Max
Hysteresis	<15%			
Stiffness	0.06 N/ µm	0.08 N/ µm	0.04 N/ µm	±15%
Loaded Resonant Frequency, Linear On-Axis 5g	385 Hz	315 Hz	185 Hz	±15%
Loaded Resonant Frequency, Linear On-Axis 50g	190 Hz	195 Hz	140 Hz	
Loaded Resonant Frequency, Angular Off-Axis 5g [e]	240 Hz	180 Hz	105 Hz	
Loaded Resonant Frequency, Angular Off-Axis 50g [e]	105 Hz	114 Hz	95 Hz	
Max Dynamic/Scanning Load	150 g	300 g	300 g	Max
Max Static Load	500 g	1000g	1000 g	Max
Height	14.0 mm	18.0 mm	18.0 mm	±0.2
Length	44.0 mm	55.0 mm	100.0 mm	±0.2
Width (excl wires)	7.0 mm	10.0 mm	10.0 mm	±0.1
Width (incl wires)	8.5 mm	11.2 mm	11.2 mm	Max
Top/Bottom Mounting Threads	M2.5 x 3.0 mm	M3 x 4.0 mm		
Side Mounting Threads	M1.6 x 3.4 mm	M2 x 4.8 mm		
Weight (inc. wires)	16 g	37g	66 g	±2 g

[a] See note Section 4.1.

[b] When increasing voltage

[c] When decreasing voltage

[d] Based on preload in piezo-flexure assembly. Equivalent of typ. 100V to avoid risk of damage.

[e] Off-axis (asymmetric) loading in relation to the top mounting hole axis will affect the resonant frequency (see Fig. 5.1 and Fig. 5.2).

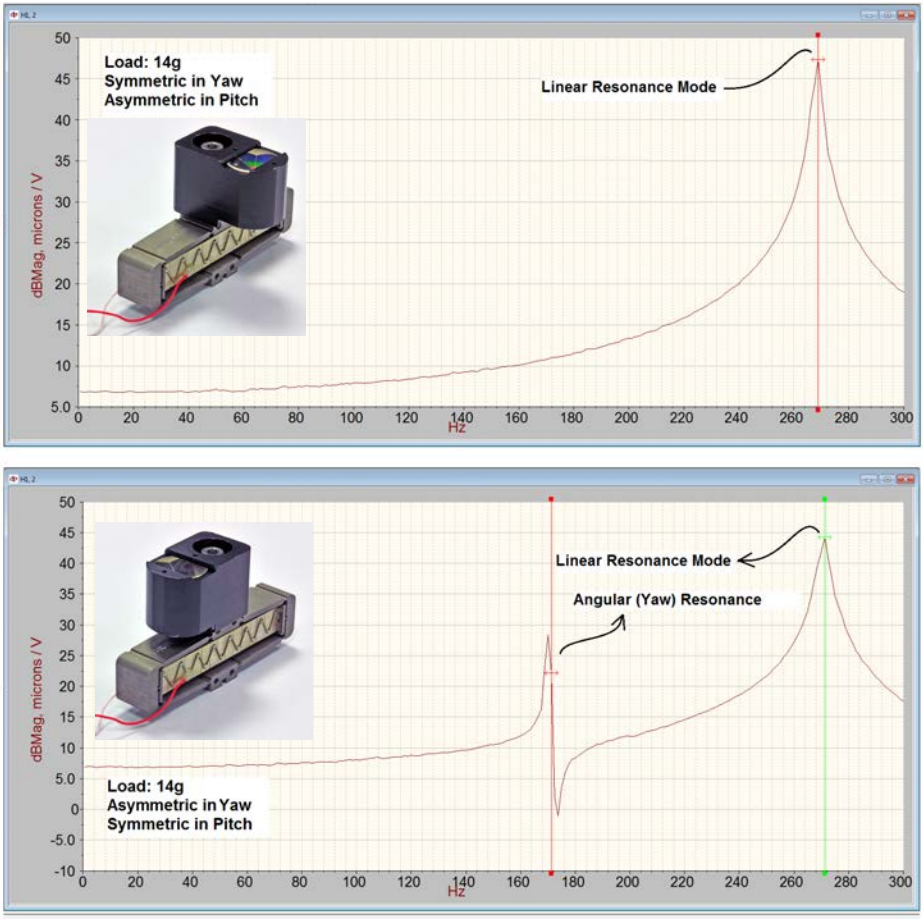


Fig. 5.1 Effect of assymetric loading on resonance mode, linear v angular

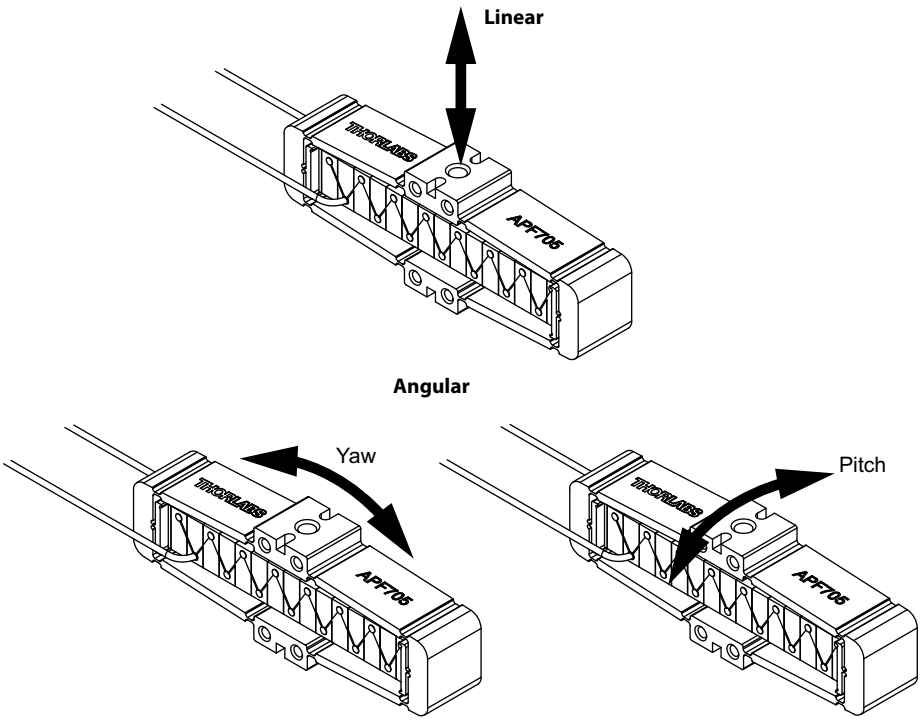
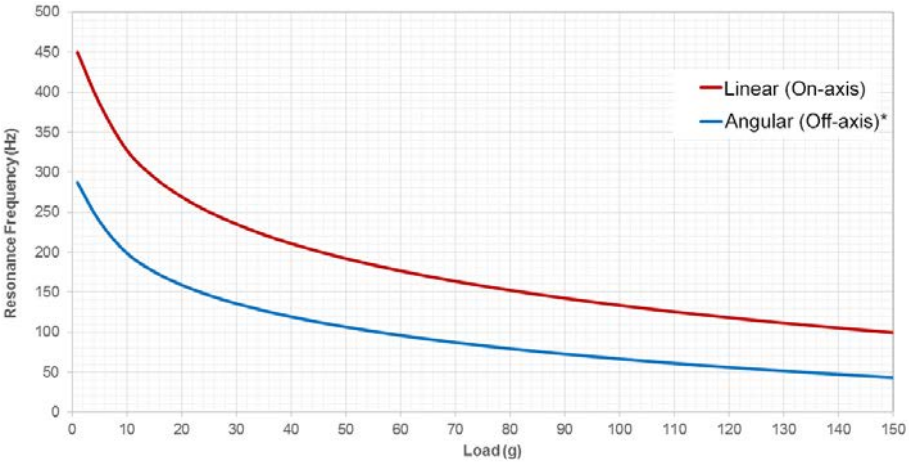
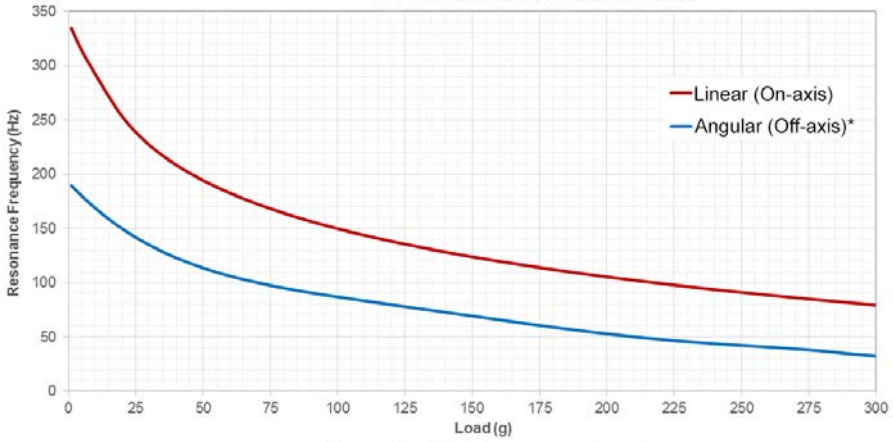


Fig. 5.2 Definition of linear and angular resonance modes



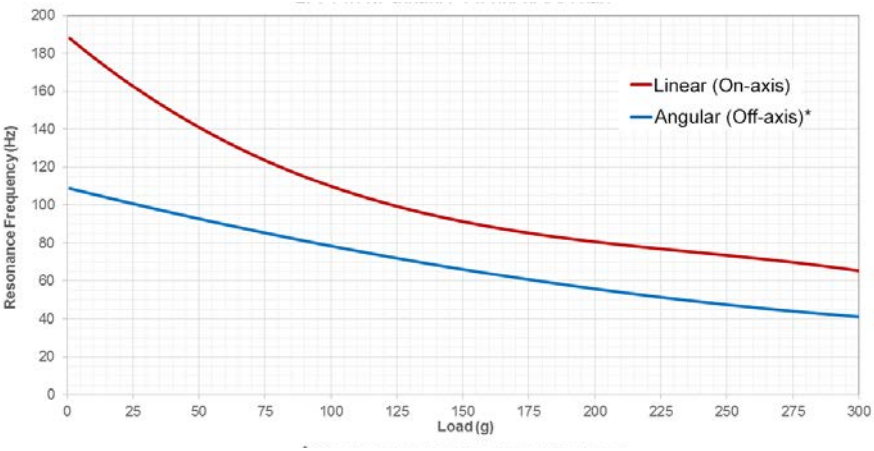
*with assymetric loading in relation to the top mounting hole axis

Fig. 5.3 APF503 resonant frequency v load



*with assymetric loading in relation to the top mounting hole axis

Fig. 5.4 APF705 resonant frequency v load



*with assymetric loading in relation to the top mounting hole axis

Fig. 5.5 APF710 resonant frequency v load

Chapter 6 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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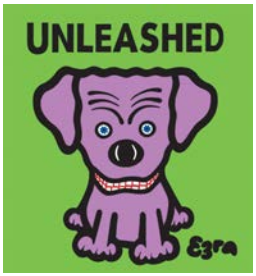

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