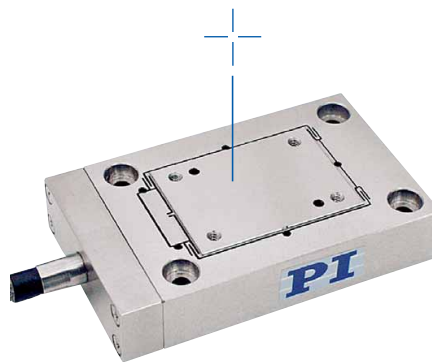


Miniature Nanopositioning Linear Stages

Flexure Drives, Closed Loop, Sub-Nanometer Precision

HIGH PRECISION



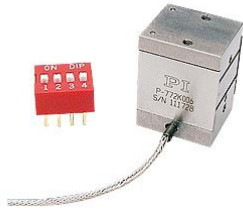
COMPACT



LARGE VARIETY

Click on the Images to Jump to Datasheet

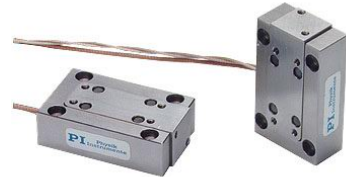
Miniature Piezo Linear Nanopositioning Stages



P-772.1CD miniature piezo nanopositioning / scanning stage (DIP switch for size comparison)



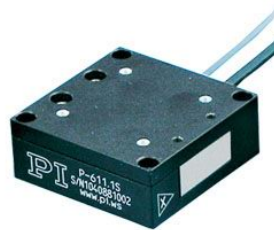
P-712 piezo scanner for imaging applications. Up to 40 µm travel range



P-753.11C LISA nano-precision linear actuator & positioning stage



P-752.11C provides ultra-straight motion with sub-nanometer precision



P-611.1 low-cost flexensional linear nanopositioning system, 100 µm



PIHera® flexure-guided piezo nanopositioning systems feature travel ranges from 50 to 1800µm



P-603 low-cost flexensional piezo actuators provide travel ranges to 0.5mm



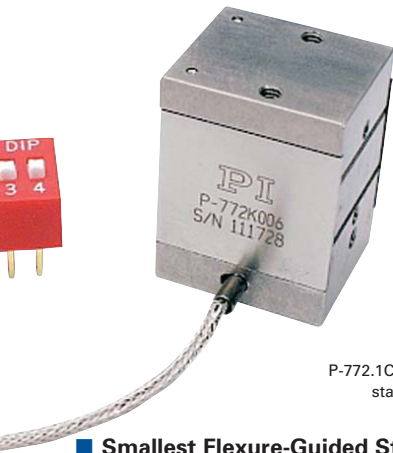
P-601 flexensional Z-actuator with optional position feedback. Fast response to sub-milliseconds feasible



P-602 flexure guided / I ever amplified nanopositioning actuators family provides travel ranges from 100µm to 1mm

P-772 Miniature Stage

Ultra-Compact Piezo NanoAutomation® Stage with Direct Metrology



P-772.1CD piezo nanopositioning / scanning stage (DIP switch for size comparison)

- Smallest Flexure-Guided Stage with Capacitive Feedback
- Ideal for Head/Media Test & Fiber Optics
- Resolution <0.1 nm
- Ultra-Fast Response (1.7 kHz Resonant Frequency)
- ID-Chip for Auto Calibrate Function
- Frictionless Precision Flexure Guiding System
- PICMA® High-Performance Piezo Drives

P-772 nanopositioning stages are the smallest flexure-guided, piezo-driven positioning systems with integrated capacitive sensors currently available. They provide a positioning and scanning range of up to 10 μm, sub-nanometer resolution and ultra-fast response.

Nanometer Precision in Milliseconds

Careful attention to mass minimization, results in significant reduction in inertial recoil forces applied to the supporting structures, enhancing overall system response, throughput and stability with settling times in the millisecond range. Furthermore our new digital control electronics with DDL (Dynamic Digital Linearization) can be used to increase linearity and effective bandwidth in scanning applications by up to 1000-fold (see p. 6-16).

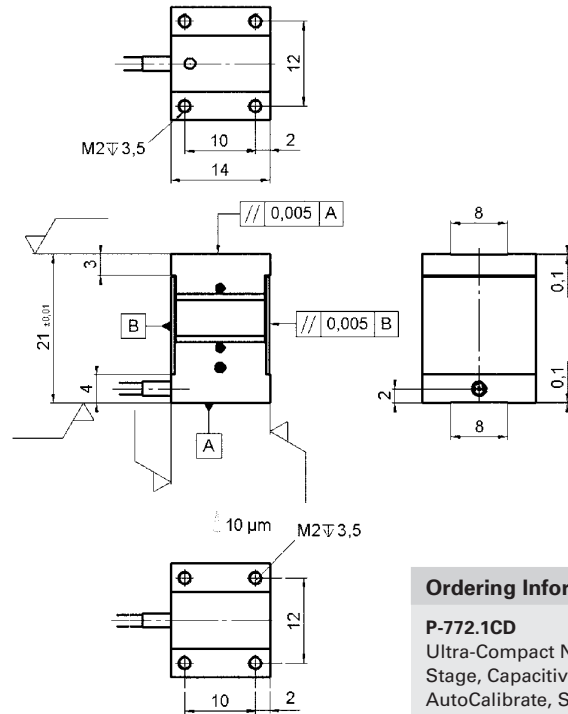
AutoCalibration

For optimized operation and interchangeability of nano-mechanisms and controllers,

model P-772.1CD is equipped with an ID-chip which holds all calibration data and sends it to the digital controller (e.g. E-750.CP). Model P-772.1CL can be used with either analog or digital controllers.

Superior Accuracy Through Direct-Motion Metrology with Capacitive Sensors

P-772 stages are equipped with absolute-measuring, direct-metrology capacitive sensors. These sensors make possible motion linearity to 0.03% with effective resolution in the sub-nanometer range. They boast high bandwidth and exhibit no periodic errors. Unlike conventional sensors, capacitive sensors measure the actual distance between the fixed frame and the moving part of the stage. This results in higher motion linearity, long-term stability, phase fidelity, and—because external disturbances are seen by the sensor immediately—a stiffer, faster-responding servo-loop. See p. 2-4 *ff.* and p. 5-2 *ff.* for more information.



Ordering Information

P-772.1CD
Ultra-Compact NanoAutomation® Stage, Capacitive Sensor, AutoCalibrate, Sub-D Connector

P-772.1CL
Ultra-Compact NanoAutomation® Stage, Capacitive Sensor, Lemo Connector

Ask about custom designs!

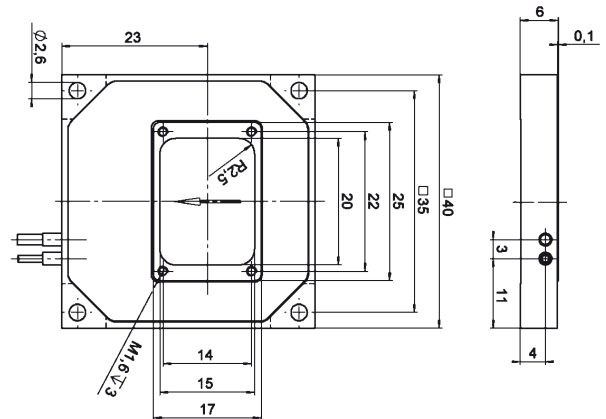
Models	P-772.1CD	P-772.1CL	Units
Active axes	X	X	
Open-loop travel @ 0 to 100 V	12	12	μm ±20%
Closed-loop travel	10	10	μm
Integrated feedback sensor	capacitive	capacitive	
* Closed-loop / open-loop resolution	0.05 / 0.05	0.05 / 0.05	nm
** Closed-loop linearity (typ.)	0.03	0.03	%
Full-range repeatability (typ.)	±1	±1	nm
Stiffness	7	7	N/μm ±20%
Push/pull force capacity (in operating direction)	50 / 5	50 / 5	N
Max. (±) normal load	5	5	N
Lateral force limit	10	10	N
Electrical capacitance	0.8	0.8	μF ±20%
*** Dynamic operating current coefficient (DOCC)	7.5	7.5	μA/(Hz x μm)
Unloaded resonant frequency	1700	1700	Hz ±20%
Operating temperature range	-20 to 80	-20 to 80	°C
Voltage connection	ID	VL	
Sensor connection	ID	2 x C	
Weight (w/o cables)	170	170	g ±5%
Body material	N-S	N-S	

P-712 Low-Profile Piezo Scanner

Compact OEM System



P-712 piezo scanner with up to 40 μm travel range



- High Dynamic, to 5 ms Settling Time
- Travel Range up to 40 μm
- Resolution to 0.2 nm
- Compact Design with Low Profile, 40 x 40 x 6 mm
- Clear Aperture 25 x 15 mm
- PICMA® High-Power Actuators

P-712 piezo scanners are ideal for applications where limited space requires small-sized equipment. The high resonant frequency allows for fast linear scanning with 30 μm travel in one axis and provides settling times of about 5 ms. The P-712 linear scanner is offered in two versions, one with SGS position sensors for closed-loop operation, and one without sensors for open-loop.

A similar XY version is available with product number P-713 / P-714

Excellent Guiding Accuracy

Flexures optimized with Finite Element Analysis (FEA) are used to guide the stage. FEA techniques are used to give the design the highest possible stiffness in, and perpendicular to, the direction of motion, and to minimize linear and angular runout. Flexures allow extremely high-precision motion, no matter how minute, as they are completely free of play and friction.

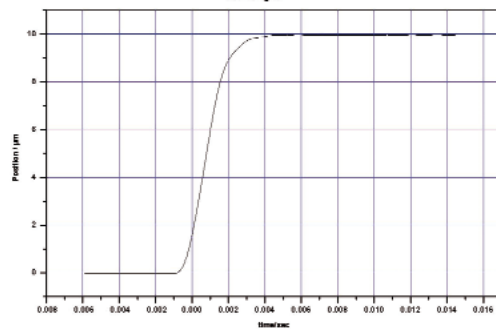
Electric discharge machining (EDM) with fine cutting wires is used to obtain the required precision for the flexures which make up the guidance system and determine the stiffness.

Optional Position Control

High-resolution, broadband, strain gauge sensors (SGS) are applied to appropriate locations on the drive train and measure the displacement of the moving part of the stage relative to the base indirectly. The SGS sensors assure optimum position stability in the nanometer range and fast response.

Ceramic Insulated Piezo Actuators Provide Long Lifetime

Highest possible reliability is assured by the use of award-winning PICMA® multilayer piezo actuators. PICMA® actuators are the only actuators on the market with ceramic-only insulation, which makes them resistant to ambient humidity and leakage-current failures. They are thus far superior to conventional actuators in reliability and lifetime.

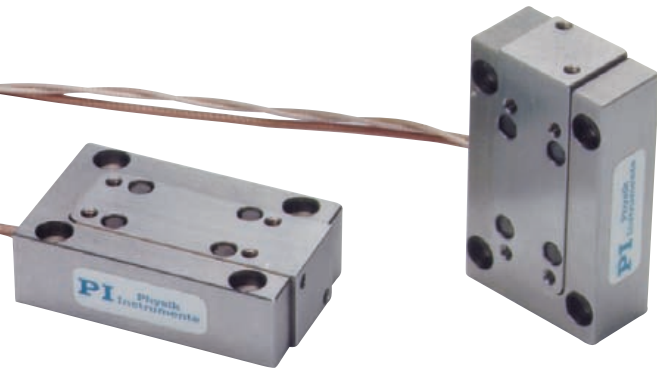


Settling time for the P-712 at 30 μm is in the 5 ms range

Model	P-712.1SL	Units
Active axes	X	
Motion and positioning		
Integrated sensor	SGS	
Open-loop travel, -20 to +120 V	40	μm
Closed-loop travel	30	μm
Closed-loop resolution	2	nm
Open-loop resolution	0.2	nm
Linearity, closed-loop	0.3	%
Repeatability	± 5	nm
Pitch	± 5	μrad
Yaw	± 20	μrad
Mechanical properties		
Stiffness in motion direction	0.6	N/ μm
Unloaded resonant frequency	1550	Hz
Resonant frequency under load	1090 (20 g)	Hz
Push/pull force capacity in motion direction	6	N
Load capacity	5	N
Lateral Force	6	N
Drive properties		
Ceramic type	PICMA® P-882	
Electrical capacitance	0.3	μF
Dynamic operating current coefficient	1.3	$\mu\text{A}/(\text{Hz} \cdot \mu\text{m})$
Miscellaneous		
Operating temperature range	-20 to 80	
Material	Stainless steel	
Dimensions	40 x 40 x 6	mm
Mass	0.095	kg
Cable length	1.5	m
Voltage connection	LEMO	
Sensor connector	LEMO	

P-753 LISA Linear Actuator & Stage

High-Dynamics, Very Stable Piezo Nanopositioner



P-753.11C LISA nano-precision actuators / positioning stages

- **Versatile Design: Flexure Stage or Actuator**
- **Resolution 0.05 nm, Rapid Response**
- **Capacitive Sensors for Highest Linearity**
- **Frictionless Precision Flexure Guidance for Frictionless, Ultra-Straight Motion**
- **Outstanding Lifetime Due to PICMA® Piezo Actuators**
- **Vacuum-Compatible and Nonmagnetic Versions Available**

The P-753 LISA (Linear Stage Actuators) high-speed nanopositioners can be used both as linear actuators or as translation stages. They are equipped with capacitive feedback sensors, frictionless, flexure guiding systems and high-performance piezo drives providing a positioning and scanning range of up to 38 µm

Application Examples

- Disc-drive-testing
- Metrology
- Nanopositioning
- Scanning microscopy
- Photonics / integrated optics
- Interferometry
- Biotechnology
- Micromanipulation

with very fast settling time and extremely low tip/tilt error.

Direct-Drive Design for Fastest Response

The direct-drive design, together with careful attention to mass minimization, results in significant reduction in inertial recoil forces applied to the supporting structures, enhancing overall system response, throughput and stability with settling times in the millisecond range.

PI's proprietary capacitive sensors measure position directly and without physical contact. They are free of friction and hysteresis, a fact which, in combination with the positioning resolution of well under 1 nm, makes it possible to achieve very high levels of linearity. A further advantage of direct metrology with capaci-

tive sensors is the high phase fidelity and the high bandwidth of up to 10 kHz.

Automatic Configuration

The „CD“ versions are equipped with an ID-chip that stores all individual stage data and servo-control parameters. This data is read out automatically by the AutoCalibration Function of PI's digital piezo controllers. Thus, digital controllers and nanopositioning stages with ID-chip can be operated in any combination.

High Reliability and Long Lifetime

The compact P-753 LISA systems are equipped with pre-loaded PICMA® high-performance piezo actuators which are integrated into a sophisticated, FEA-modeled, flexure guiding system. The PICMA® actuators feature cofired ceramic encapsulation and thus offer better performance and reliability than conventional piezo actuators. Actuators, guidance and sensors are maintenance-free and not subject to wear, and thus offer an extraordinary reliability.

Ordering Information

P-753.11C
LISA High-Dynamics Nanopositioning System, 12 µm, Direct Metrology, Capacitive Sensor, LEMO Connector

P-753.21C
LISA High-Dynamics Nanopositioning System, 25 µm, Direct Metrology, Capacitive Sensor, LEMO Connector

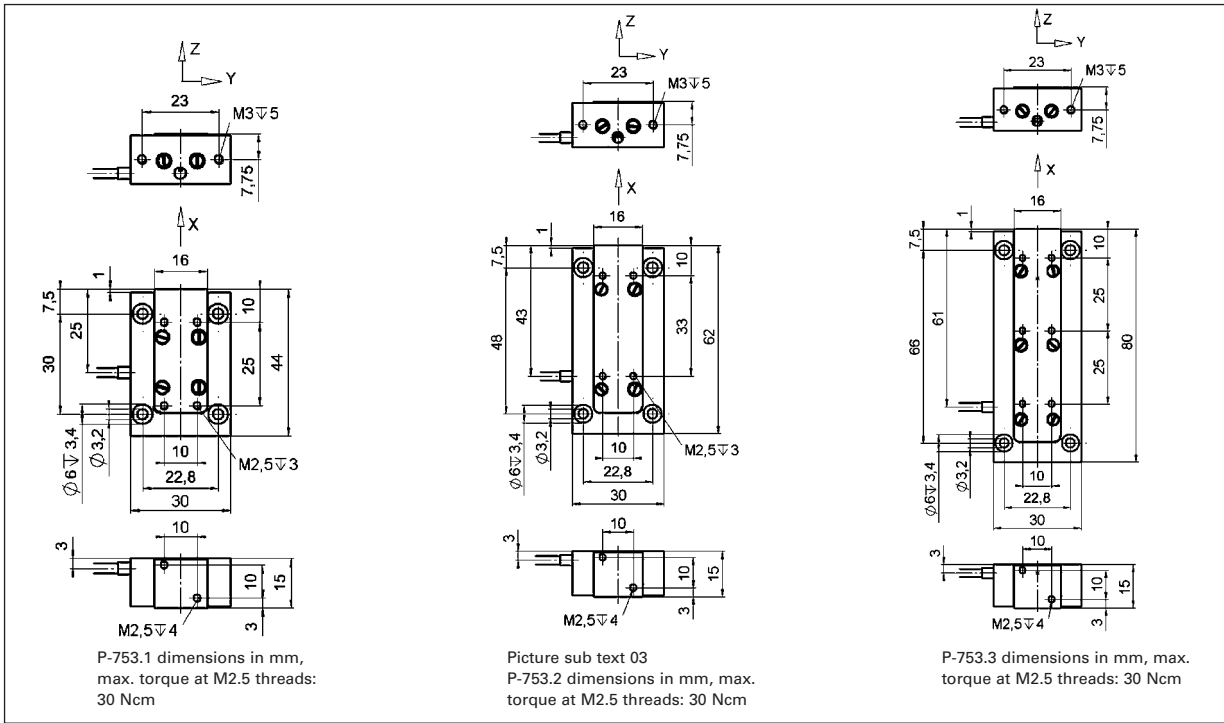
P-753.31C
LISA High-Dynamics Nanopositioning System, 38 µm, Direct Metrology, Capacitive Sensor, LEMO Connector

P-753.1CD*
LISA High-Dynamics Nanopositioning System, 12 µm, Direct Metrology, Capacitive Sensor, Sub-D Connector

P-753.2CD*
LISA High-Dynamics Nanopositioning System, 25 µm, Direct Metrology, Capacitive Sensor, Sub-D Connector

P-753.3CD*
LISA High-Dynamics Nanopositioning System, 38 µm, Direct Metrology, Capacitive Sensor, Sub-D Connector

*Vacuum versions to 10⁻⁹ hPa are available as P-753.xUD, non-magnetic vacuum versions can be ordered as P-753.xND.



Technical Data

Model	P-753.11C	P-753.21C	P-753.31C	P-753.1CD	P-753.2CD	P-753.3CD	Units	Tolerance
Active axes	X	X	X	X	X	X		
Motion and positioning								
Integrated sensor	Capacitive	Capacitive	Capacitive	Capacitive	Capacitive	Capacitive		
Closed-loop travel	12	25	38	12	25	38	µm	calibrated
Closed-loop / open-loop resolution	0.05	0.1	0.2	0.05	0.1	0.2	nm	typ., full travel
Linearity, closed-loop	0.03	0.03	0.03	0.03	0.03	0.03	%	typ.
Repeatability	±1	±2	±3	±1	±2	±3	nm	typ.
Pitch / yaw	±5	±7	±10	±5	±7	±10	µrad	typ.
Mechanical properties								
Stiffness in motion direction	45	24	16	45	24	16	N/µm	±20%
Unloaded resonant frequency	5.6	3.7	2.9	5.6	3.7	2.9	kHz	±20%
Resonant frequency @ 200 g	2.5	1.7	1.4	2.5	1.7	1.4	kHz	±20%
Push/pull force capacity in motion direction	100 / 20	100 / 20	100 / 20	100 / 20	100 / 20	100 / 20	N	Max.
Load capacity (vertical/horizontal mounting)	10 / 2	10 / 2	10 / 2	10 / 2	10 / 2	10 / 2	kg	Max.
Drive properties								
Ceramic type	PICMA® P-885	PICMA® P-885	PICMA® P-885	PICMA® P-885	PICMA® P-885	PICMA® P-885		
Electrical capacitance	1.5	3.1	4.6	1.5	3.1	4.6	µF	±20%
Dynamic operating current coefficient	12	15	15	12	15	15	µA/(Hz • µm)	±20%
Miscellaneous								
Operating temperature range	-20 to 80	-20 to 80	-20 to 80	-20 to 80	-20 to 80	-20 to 80	°C	
Material	Stainless steel	Stainless steel	Stainless steel	Stainless steel	Stainless steel	Stainless steel		
Dimensions	44 x 30 x 15	44 x 30 x 62	44 x 30 x 80	44 x 30 x 15	44 x 30 x 62	44 x 30 x 80	mm	
Mass	0.15	0.205	0.25	0.16	0.215	0.26	kg	±5%
Cable length	1.5	1.5	1.5	1.5	1.5	1.5	m	±10 mm
Sensor / voltage connection	LEMO	LEMO	LEMO	Sub-D Special	Sub-D Special	Sub-D Special		

Resolution of PI Piezo Nanopositioners is not limited by friction or stiction. Value given is noise equivalent motion with E-503 (p. 2-146) amplifier.

Recommended controller / amplifier

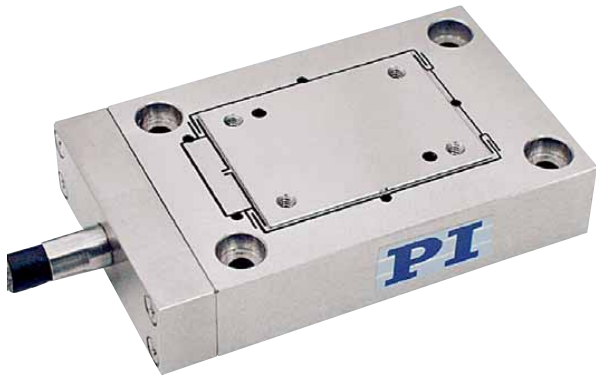
LEMO connector: E-500 (p. 2-142) piezo controller system with E-505 high-power amplifier (p. 2-147) and E-509 servo module (p. 2-152)

Sub-D special connector: E-610 servo controller / amplifier card (p. 2-110), E-625 servo controller, bench-top (p. 2-114), E-665 high-power display controller, bench-top (p. 2-116),

E-753 digital controller (p. 2-108)

P-752 High Precision Nanopositioning Stage

High-Dynamics, Very Stable Piezo Scanner with Extreme Guiding Accuracy



P-752.11C piezo nanopositioning system

- 0.1 nm Resolution, Fast Response
- Travel to 35 μm
- Capacitive Sensors for Highest Linearity
- Flexure Guidance for Frictionless, Ultra-Straight Motion
- Outstanding Lifetime Due to PICMA® Piezo Actuators

P-752 series high-speed nanopositioning stages are extremely precise devices, providing a positioning and scanning range up to 30 μm with very rapid settling and extremely low tip/tilt errors. These stages were specially designed for high-speed dithering and disk drive testing applications.

Direct-Drive Design for Fastest Response

The direct-drive design, together

Application Examples

- Disc-drive-testing
- Metrology
- Nanopositioning
- Scanning microscopy
- Photonics / integrated optics
- Interferometry
- Biotechnology
- Micromanipulation

her with careful attention to mass minimization, results in significant reduction in inertial recoil forces applied to the supporting structures, enhancing overall system response, throughput and stability. In combination with the E-500 controller system the P-752.11C stage with 300 g load settles to better than 1% with less 10 msec.

P-752 stages are equipped with capacitive sensors providing sub-nanometer resolution and stability. PI's proprietary capacitive sensors measure position directly and without physical contact. They are free of friction and hysteresis, a fact which, in combination with the positioning resolution of well under 1 nm, makes it possible to achieve very high levels of linearity. Further advantages of direct metrology with capacitive sensors are the high phase fidelity and the high bandwidth of up to 10 kHz.

Automatic Configuration

The ".CD" versions are equipped with an ID-chip that stores all individual stage data and servo-control parameters. This data is read out automatically by the AutoCalibration function of PI's digital piezo controllers. Thus, digital controllers and nanopositioning stages with ID-chip can be operated in any combination.

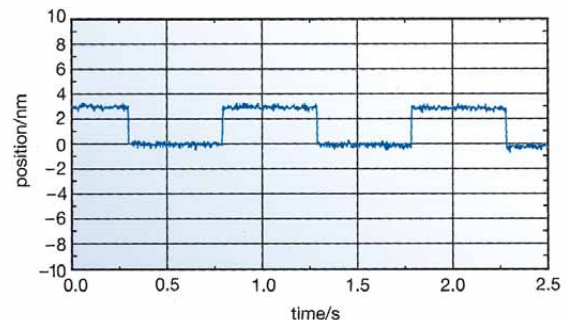
Higher Precision in Periodic Motion

The highest dynamic accuracy in scanning applications is made possible by the DDL algorithm, which is available in most of PI's modern digital controllers. DDL eliminates tracking errors, improving dynamic linearity and usable

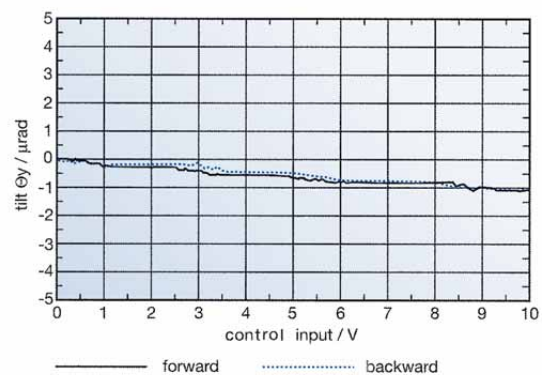
Ordering Information

- P-752.11C**
High-Dynamics Piezo Nanopositioning System, 15 μm , Direct Metrology, Capacitive Sensor, LEMO Connector
- P-752.21C**
High-Dynamics Piezo Nanopositioning System, 30 μm , Direct Metrology, Capacitive Sensor, LEMO Connector
- P-752.1CD**
High-Dynamics Piezo Nanopositioning System, 15 μm , Direct Metrology, Capacitive Sensor, Sub-D Connector
- P-752.2CD**
High-Dynamics Piezo Nanopositioning System, 30 μm , Direct Metrology, Capacitive Sensor, Sub-D Connector

bandwidth by up to three orders of magnitude!



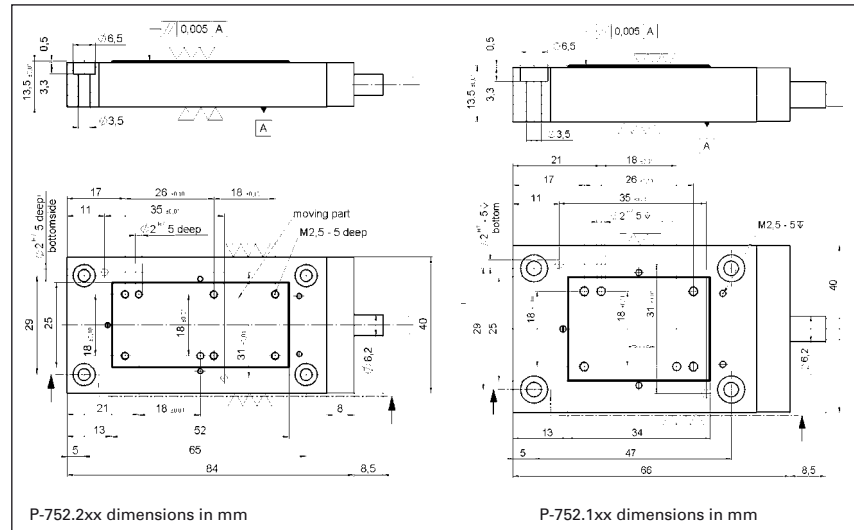
Response of a P-752.11C to a square wave control signal with 3 nm amplitude shows true sub-nm positional stability, incremental motion and bidirectional repeatability (measured with E-501 & E-503.00 & E-509.C1 controller, bandwidth set to 240 Hz)



Typical 0.5 μrad bidirectional trajectory repeatability (P-752.11C stage) means processes may be performed bidirectionally for twice the productivity

High Reliability and Long Lifetime

The compact P-752 systems are equipped with preloaded PICMA® high-performance piezo actuators which are integrated into a sophisticated, FEA-modeled, flexure guiding system. The PICMA® actuators feature cofired ceramic encapsulation and thus offer better performance and reliability than conventional piezo actuators. Actuators, guidance and sensors are maintenance-free and not subject to wear, and thus offer an extraordinary reliability.



Technical Data

Model	P-752.11C	P-752.1CD	P-752.21C	P-752.2CD	Units	Tolerance
Active axes	X	X	X	X		
Motion and positioning						
Integrated sensor	Capacitive	Capacitive	Capacitive	Capacitive		
Open-loop travel, -20 to +120 V	20	20	35	35	µm	min. (+20%/-0%)
Closed-loop travel	15	15	30	30	µm	calibrated
Closed-loop / open-loop resolution	0.1	0.1	0.2	0.2	nm	typ.
Linearity, closed-loop	0.03	0.03	0.03	0.03	%	typ.
Repeatability	±1	±1	±2	±2	nm	typ., full travel
Pitch / yaw	±1	±1	±1	±1	µrad	typ.
Mechanical properties						
Stiffness in motion direction	30	30	20	20	N/µm	±20%
Unloaded resonant frequency	3200	3200	2100	2100	Hz	±20%
Resonant frequency @ 300 g	980	980	600	600	Hz	±20%
Push/pull force capacity in motion direction	100 / 10	100 / 10	100 / 10	100 / 10	N	Max.
Load capacity	30	30	30	30	N	Max.
Drive properties						
Ceramic type	PICMA® P-885	PICMA® P-885	PICMA® P-885	PICMA® P-885		
Electrical capacitance	2.1	2.1	3.7	3.7	µF	±20%
Dynamic operating current coefficient	17	17	15	15	µA/(Hz • µm)	±20%
Miscellaneous						
Operating temperature range	-20 to 80	-20 to 80	-20 to 80	-20 to 80	°C	
Material	Stainless steel	Stainless steel	Stainless steel	Stainless steel		
Dimensions	66 x 40 x 13.5	66 x 40 x 13.5	84 x 40 x 13.5	84 x 40 x 13.5	mm	
Mass	0.25	0.25	0.35	0.35	kg	±5%
Cable length	1.5	1.5	1.5	1.5	m	±10 mm
Sensor / voltage connection	LEMO	Sub-D Special	LEMO	Sub-D Special		

Resolution of PI Piezo Nanopositioners is not limited by friction or stiction. Value given is noise equivalent motion with E-503 (p. 2-146) amplifier.

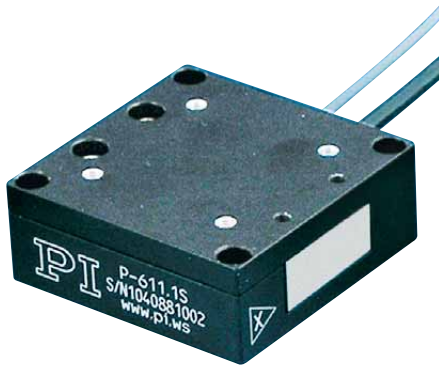
Recommended controller / amplifier

LEMO connector: E-500 piezo controller system (p. 2-142) with E-505 high-power amplifier (p. 2-147) and E-509 servo module (p. 2-152)

Sub-D special connector: E-610 servo controller / amplifier (p. 2-110), E-625 servo controller, bench-top (p. 2-114), E-665 high-power display controller, bench-top (p. 2-116), E-753 digital controller (p. 2-108)

P-611.1 Piezo Nanopositioner, 100 μm Low Cost

Cost-Effective, Compact Linear Positioning System



P-611.1 linear nanopositioning system, 100 μm travel, resolution of 0.2 nm

- **Compact Design: Footprint 44 x 44 mm**
- **Travel Range to 120 μm**
- **Resolution to 0.2 nm**
- **Cost-Effective Mechanics/Electronics System Configurations**
- **Outstanding Lifetime Due to PICMA® Piezo Actuators**
- **Z Stage, XY, XZ and XYZ Versions Available**

P-611.1 piezo stages are flexure-guided nanopositioning systems featuring a compact footprint of only 44 x 44 mm. The linear stages described here are part of the P-611 family of positioners available in 1 to 3 axis configurations. Despite their small dimensions, the systems provide up to 120 μm travel with sub-nanometer resolution. They are ideally suited for positioning tasks such as optical-path length correction in interferometry, sample positioning in microscopy or scanning applications. Equipped with ceramic-encapsulated piezo drives and a stiff zero-stiction, zero-friction flexure guiding

Application Examples

- **Micromachining**
- **Microscopy**
- **Micromanipulation**
- **Semiconductor testing**

system, all P-611 piezo stages combine millisecond responsiveness with nanometric precision and extreme reliability.

Closed-Loop and Open-Loop Versions

High-resolution, fast-responding, strain gauge sensors (SGS) are applied to appropriate locations on the drive train and provide a high-bandwidth, nanometer-precision position feedback signal to the controller. The sensors are connected in a full-bridge configuration to eliminate thermal drift, and assure optimal position stability in the nanometer range.

The open-loop models are ideal for applications where fast response and very high resolution are essential, but absolute positioning is not important. They can also be used when the position is controlled by an external feedback system such as an interferome-

ter, a PSD (position sensitive diode), CCD chip / image processing system, or the eyes and hands of an operator.

Versatility & Combination with Motorized Stages

The P-611 family of piezo stages comprises a variety of single- and multi-axis versions (X, XY, Z, XZ and XYZ) that can be easily combined with a number of very compact manual or motorized micropositioning systems to form coarse/fine positioners with longer travel ranges (see p. 2-36, 2-50 ff).

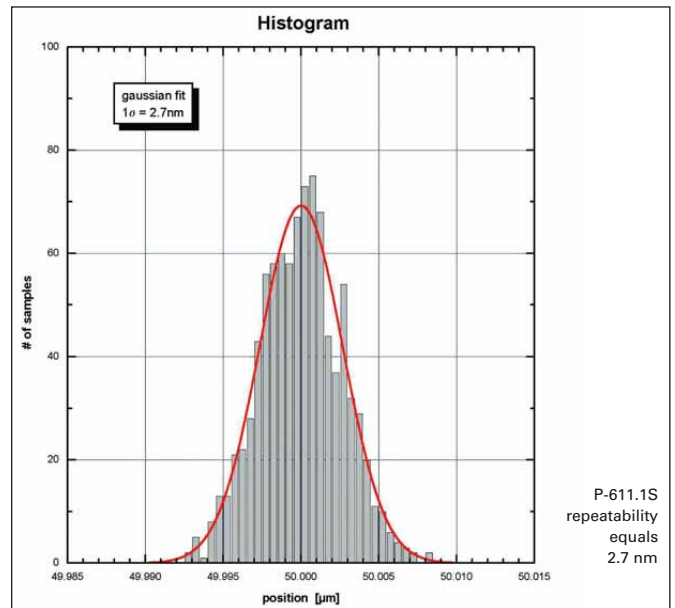
High Reliability and Long Lifetime

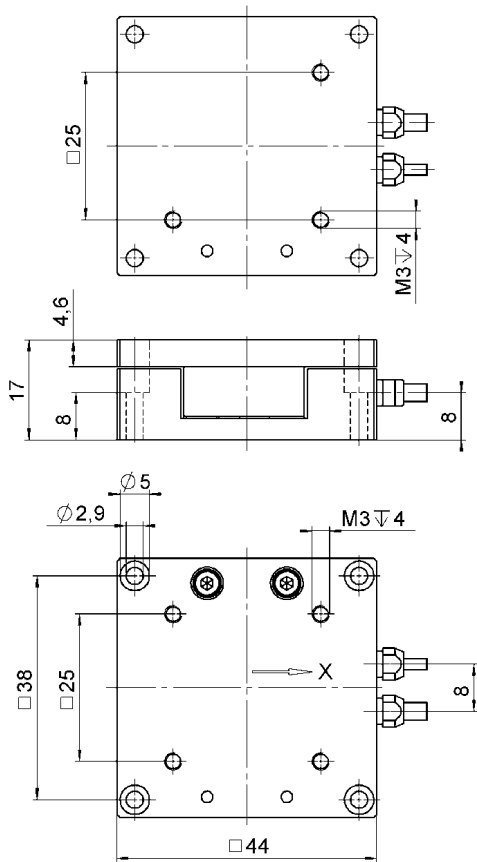
The compact P-611 systems are equipped with preloaded PICMA® high-performance piezo actuators which are inte-

Ordering Information

- P-611.10**
Linear Nanopositioning System, 120 μm , No Sensor
- P-611.1S**
Linear Nanopositioning System, 100 μm , SGS-Sensor

grated into a sophisticated, FEA-modeled, flexure guiding system. The PICMA® actuators feature cofired ceramic encapsulation and thus offer better performance and reliability than conventional piezo actuators. Actuators, guidance and sensors are maintenance-free and not subject to wear, and thus offer an extraordinary reliability.





Technical Data

Model	P-611.1S	P-611.10	Unit	Tolerance
Active axes	X	X		
Motion and positioning				
Integrated sensor	SGS	-		
Open-loop travel, -20 to 120 V	120	120	µm	min. (+20%/0%)
Closed-loop travel	100	-	µm	calibrated
Open-loop resolution	0.2	0.2	nm	typ.
Closed-loop resolution	2	-	nm	typ.
Linearity, closed-loop	0.1	-	%	typ.
Repeatability	<10	-	nm	typ.
Pitch	±5	±5	µrad	typ.
Yaw	±20	±20	µrad	typ.
Flatness	10	10	nm	typ.
Mechanical properties				
Stiffness in motion direction	0.2	0.2	N/µm	±20%
Unloaded resonant frequency	400	400	Hz	±20%
Resonant frequency @ 30 g	300	300	Hz	±20%
Resonant frequency @ 100 g	195	195	Hz	±20%
Push/pull force capacity in motion direction	15 / 10	15 / 10	N	Max.
Load capacity	15	15	N	Max.
Drive properties				
Ceramic type	PICMA® P-885	PICMA® P-885		
Electrical capacitance	1.5	1.5	µF	±20%
Dynamic operating current coefficient	1.9	1.9	µA/(Hz • µm)	±20%
Miscellaneous				
Operating temperature range	-20 to 80	-20 to 80	°C	
Material	Aluminum, steel	Aluminum, steel		
Dimensions	44 x 44 x 17	44 x 44 x 17	mm	
Mass	0.135	0.135	kg	±5%
Cable length	1.5	1.5	m	±10 mm
Voltage connection	LEMO	LEMO		
Sensor connector	LEMO	-		

Resolution of PI Piezo Nano-positioners is not limited by friction or stiction. Noise equivalent motion with E-503 amplifier (p. 2-146). Dynamic Operating Current Coefficient in µA per Hz and µm. Example: Sinusoidal scan of 50 µm at 10 Hz requires approximately 0.9 mA drive current.

Recommended controller / amplifier
 E-610 servo controller / amplifier (p. 2-110), E-625 servo controller, bench-top (p. 2-114), E-665 powerful servo controller, bench-top (p. 2-116), for open-loop systems:
 E-660 bench-top (p. 2-119) for multiple independent axes:
 E-621 controller module (p. 2-160)

PIHera® Piezo Linear Stage Family, to 1.8 mm, High Precision Compact Nanopositioning System Family with Long Travel Ranges



PIHera® piezo nanopositioning systems feature travel ranges from 50 to 1800 µm

- Travel Ranges 50 to 1800 µm
- High-Precision, Cost-Efficient
- Resolution to 0.1 nm
- Direct Metrology with Capacitive Sensors
- 0.02 % Positioning Accuracy
- Frictionless, High-Precision Flexure Guiding System
- Outstanding Lifetime Due to PICMA® Piezo Actuators
- X-, XY-, Z-, XYZ Versions
- Vacuum-Compatible Versions Available

Single-axis PIHera® systems are piezo-nanopositioning stages featuring travel ranges from 50 to 1800 µm. Despite the increased travel ranges, the units are extremely compact and provide rapid response and high guiding precision. This and the long travel range is achieved with a friction-free and extremely stiff flexure system.

The PIHera® piezo nanopositioning series also includes Z- and XY-stages (see p. 2-40, p. 2-54).

Nanometer Precision in Milliseconds

One of the advantages of PIHera® stages over motor-driven positioning stages is the rapid response to input changes and the fast and precise settling behavior. The P-622.1CD, for example, can settle to an accuracy of 10 nm in only 30 msec (other PI stages provide even faster response)!

Superior Accuracy With Direct-Metrology Capacitive Sensors

A choice of tasks such as optical path adjustment in interferometry, sample positioning in microscopy, precision alignment or optical tracking require

the relatively long scanning ranges and nanometer precision offered by PIHera® nanopositioning stages.

PI's proprietary capacitive sensors measure position directly and without physical contact. They are free of friction and hysteresis, a fact which, in combination with the positioning resolution of well under 1 nm, makes it possible to achieve very high levels of linearity. A further advantage of direct metrology with capacitive sensors is the high phase fidelity and the high bandwidth of up to 10 kHz.

Designed for Precision

High stiffness is achieved with the FEA-optimized design of the frictionless flexure elements, which assure excellent guiding accuracy and dynamics. A straightness and flatness in the nanometer range is achieved.

Ordering Information

P-620.1CD* / P-620.1CL*
PIHera® Precision Piezo Linear Nanopositioning System, 50 µm, Direct Metrology, Capacitive Sensor

P-621.1CD* / P-621.1CL*
PIHera® Precision Piezo Linear Nanopositioning System, 100 µm, Direct Metrology, Capacitive Sensor

P-622.1CD* / P-622.1CL*
PIHera® Precision Piezo Linear Nanopositioning System, 250 µm, Direct Metrology, Capacitive Sensor

P-625.1CD* / P-625.1CL*
PIHera® Precision Piezo Linear Nanopositioning System, 500 µm, Direct Metrology, Capacitive Sensor

P-628.1CD* / P-628.1CL*
PIHera® Precision Piezo Linear Nanopositioning System, 800 µm, Direct Metrology, Capacitive Sensor

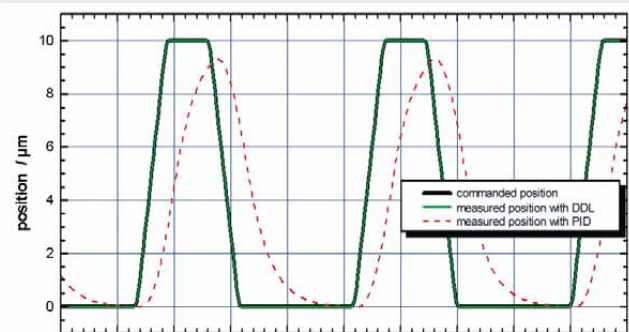
P-629.1CD* / P-629.1CL*
PIHera® Precision Piezo Linear Nanopositioning System, 1500 µm, Direct Metrology, Capacitive Sensor

*.1CD with Sub-D Connector
*.1CL with LEMO Connector

Open-loop versions are available as P-62x.10L.
Vacuum versions to 10⁻⁹ hPa are available as P-62x.1UD.

System properties

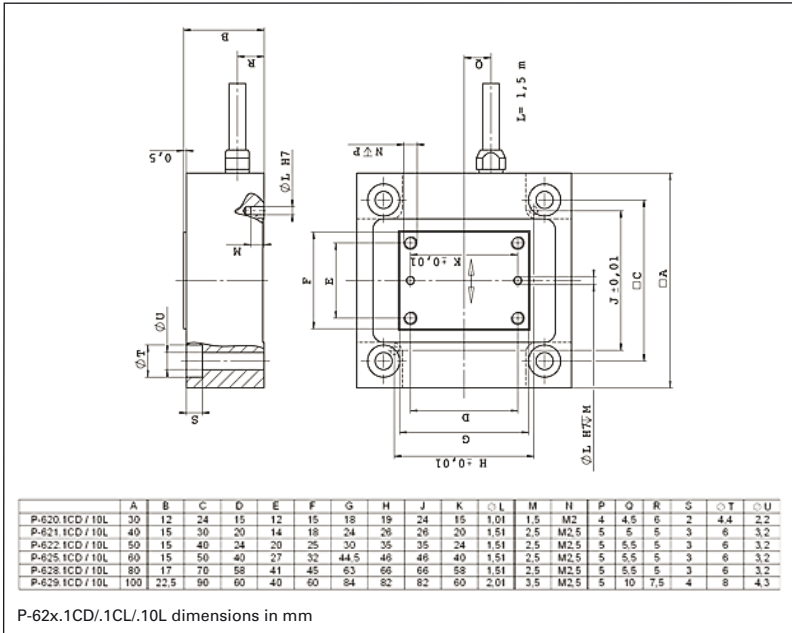
System configuration	P-625.1CD and E-500 modular piezo controller system with E-505.00F amplifier and E-509.C1A servo controller; 250 g load
Closed-loop amplifier bandwidth, large signal	30 Hz
Settling time (full travel)	31 ms



Rapid scanning motion of a P-621.1CD (commanded rise time 5 ms) with the E-710 controller ##600300 and Digital Dynamic Linearization (DDL) option. DDL virtually eliminates the tracking error (<20 nm) during the scan. The improvement over a classical PI controller is up to 3 orders of magnitude, and increases with the scanning frequency

Application Examples

- Interferometry
- Microscopy
- Nanopositioning
- Biotechnology
- Quality assurance testing
- Semiconductor technology



PIHera® XYZ combination,
P-62x.2 XY piezo stage (see
p. 2-54), P-62x.Z vertical
stage (see p. 2-40)

Technical Data

Model	P-620.1CD/ P-620.1CL	P-621.1CD/ P-621.1CL	P-622.1CD/ P-622.1CL	P-625.1CD/ P-625.1CL	P-628.1CD/ P-628.1CL	P-629.1CD/ P-629.1CL	P-62x.10L open-loop version	Units	Tolerance	
Active axes	X	X	X	X	X	X	X			
Motion and positioning										
Integrated sensor	Capacitive	Capacitive	Capacitive	Capacitive	Capacitive	Capacitive	–			
Open-loop travel, -20 to +120 V	60	120	300	600	950	1800	as P-62x.1CD	µm	min. (+20%/0%)	
Closed-loop travel	50	100	250	500	800	1500	–	µm	calibrated	
Closed-loop / open-loop resolution	0.2 / 0.1	0.4 / 0.2	0.7 / 0.4	1.4 / 0.5	1.8 / 0.5	3 / 2	as P-62x.1CD	nm	typ.	
Linearity, closed-loop	0.02	0.02	0.02	0.02	0.03*	0.03**	–	%	typ.	
Repeatability	±1	±1	±1	±5	±10	±14	–	nm	typ.	
Pitch / yaw	±3	±3	±3	±6	±6	±10	as P-62x.1CD	µrad	typ.	
Mechanical properties										
Stiffness in motion direction	0.42	0.35	0.2	0.1	0.12	0.13	as P-62x.1CD	N/µm	±20%	
Unloaded resonant frequency	1100	800	400	215	125	125	as P-62x.1CD	Hz	±20%	
Resonant frequency @ 20 g	550	520	340	180	115	120	as P-62x.1CD	Hz	±20%	
Resonant frequency @ 120 g	260	240	185	110	90	110	as P-62x.1CD	Hz	±20%	
Push/pull force capacity in motion direction	10	10	10	10	10	10	as P-62x.1CD	N	Max.	
Load capacity	10	10	10	10	10	10	as P-62x.1CD	N	Max.	
Lateral Force	10	10	10	10	10	8	as P-62x.1CD	N	Max.	
Drive properties										
Ceramic type	PICMA® P-883	PICMA® P-885	PICMA® P-885	PICMA® P-885	PICMA® P-887	PICMA® P-888	as P-62x.1CD			
Electrical capacitance	0.35	1.5	3.1	6.2	19	52	as P-62x.1CD	µF	±20%	
Dynamic operating current coefficient	0.9	1.9	1.9	1.6	3	4.3	as P-62x.1CD	µA/(Hz • µm)	±20%	
Miscellaneous										
Operating temperature range	-20 to 80	-20 to 80	-20 to 80	-20 to 80	-20 to 80	-20 to 80	-20 to 150	°C		
Material	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum			
Dimensions	30 x 30 x 12	40 x 40 x 15	50 x 50 x 15	60 x 60 x 15	80 x 80 x 17	100 x 100 x 22.5	as P-62x.1CD	mm		
Mass	0.11	0.16	0.2	0.24	0.38	0.72	as P-62x.1CD	kg	±5%	
Cable length	1.5	1.5	1.5	1.5	1.5	1.5	1.5 m		±10 mm	
Sensor / voltage connection	CD version: Sub-D special CL version: LEMO	CD version: Sub-D special CL version: LEMO	CD version: Sub-D special CL version: LEMO	CD version: Sub-D special CL version: LEMO	CD version: Sub-D special CL version: LEMO	CD version: Sub-D special CL version: LEMO	LEMO (no sensor)			

Resolution of PI Piezo Nanopositioners is not limited by friction or stiction. The value given is noise equivalent motion with E-710 controller (p. 2-128).

*With digital controller. For analog controller 0.05%.

**With digital controller. For analog controller 0.07%.

Recommended controller / amplifier

CD version: E-610 servo controller / amplifier (p. 2-110), E-625 servo controller, bench-top (p. 2-114), E-665 powerful servo controller, bench-top (p. 2-116)

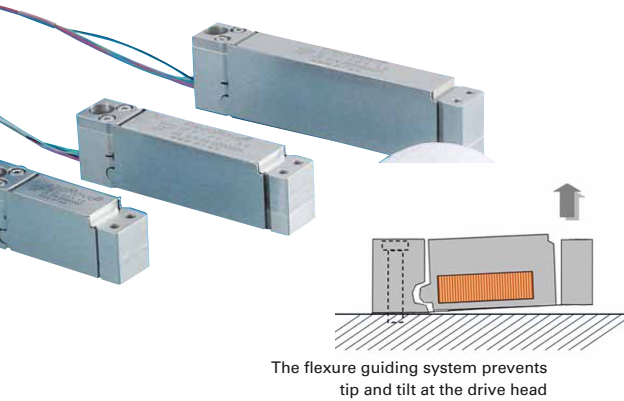
Single-channel digital controller: E-753 (bench-top) (p. 2-108)

CL version: E-500 modular piezo controller system (p. 2-142) with E-505 amplifier module (high power) p. 2-147 and E-509 controller (p. 2-152)

Open-loop version: E-500 modular piezo controller system (p. 2-142) with E-505 amplifier module (high power) (p. 2-147)

P-601 PiezoMove™ -Actuator

Flexure-Guided OEM Piezo Actuator with Long Stroke to 400 µm



- Flexure Guidance for Frictionless, Ultra-Straight Motion
- Travel Ranges to 400 µm
- Resolution to 0.2 nm
- High Dynamics and Stiffness
- Custom Designs with Longer Travel or Faster Response and Non-Magnetic Versions Feasible
- Outstanding Lifetime Due to PICMA® Piezo Actuators
- Choice of Closed-Loop and Open-Loop Models
- Ideal OEM Actuator for Precision Motion Control in Optics, Medical, Biotech and Microfluidics Applications

The flexure-guided, lever-amplified PiezoMove™ P-601 actuators provide large vertical travel ranges up to 400 µm, fast response and high positioning accuracy in a very small package. With settling times of only a few milliseconds and a resolution in the sub-nanometer range they are well suited for both static and dynamic applications.

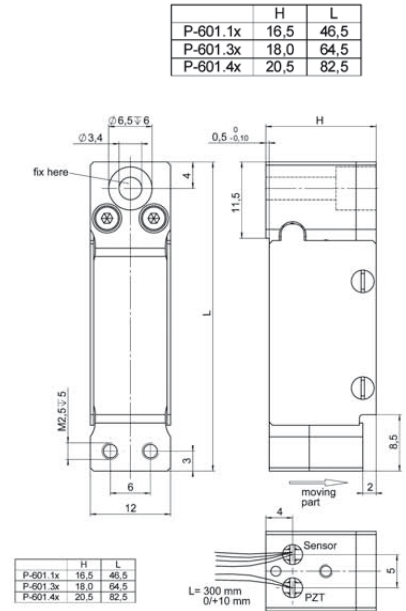
P-601 PiezoMove™ lever-amplified actuators cover the range between direct-driven pre-loaded piezo translators, such as the P-840 series (see p. 1-74) and single-axis nanopositioning stages, like the P-611 series (see p. 2-20). Compared to direct-driven piezo translators, lever-amplified actuators offer larger travel ranges and much higher lateral stiffness and guiding precision. Compared to single-axis nanopositioning stages, they offer significantly smaller sizes.

OEM Actuator with Integrated Guidance

With their highly precise, frictionless flexure guidance, a very high stiffness and excellent straightness of motion are achieved. Together with their small dimensions and the cost-effective design, the P-601 lever amplified actuators are especially suited for OEM applications. Versions with strain-gauge sensors (SGS) are equipped with a full bridge circuit that is insensitive to thermal drift. Versions without sensors are also available for open-loop applications such as in high-speed switches and pumps. In addition to the standard steel models, special invar and non-magnetic versions are available on request.

Ceramic Insulated Piezo Actuators Provide Long Lifetime

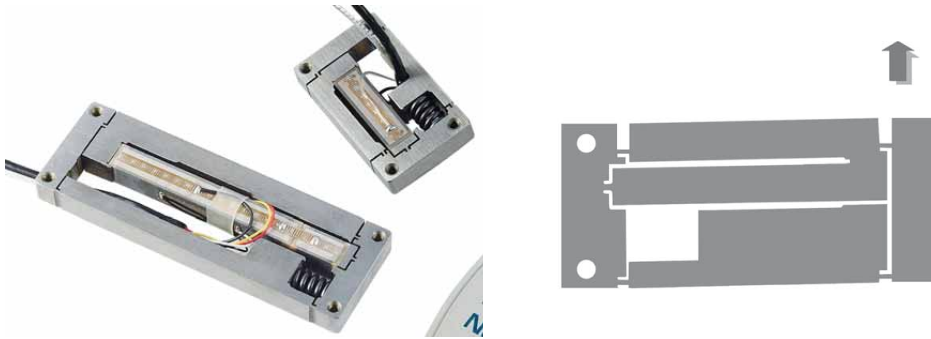
Highest possible reliability is assured by the use of award-winning PICMA® multilayer piezo actuators.



	P-601.1S P-601.1SL	P-601.4S P-601.4SL	Units
Active axes	Z	Z	s
Motion and positioning			
Integrated sensor	SGS	SGS	
Open-loop travel, -20 to +120 V	100	400	µm
Closed-loop travel	100	400	µm
Open-loop resolution	0.2	0.4	nm
Closed-loop resolution	2	12	nm
Linearity, closed-loop	0.1	0.3	%
Repeatability	8	30	nm
Runout θ_x, θ_y	20 / 10	20 / 10	µrad
Mechanical properties			
Stiffness in motion direction	0.8	0.28	N/µm
Unloaded resonant frequency	750	350	Hz
Resonant frequency @ 30 g	620	290	Hz
Push/pull force capacity in motion direction	30/10	15/10	N
Lateral force	30	30	N
Drive properties			
Ceramic type	PICMA® P-885	PICMA® P-885	
Electrical capacitance	1.5	4.6	µF
Miscellaneous			
Operating temperature range	-20 to 80	-20 to 80	°C
Material	Stainless steel	Stainless steel	
Mass without cables	0.05	0.11	kg
Cable length	S-version: 0.3 SL-version: 1.5	S-version: 0.3 SL-version: 1.5	m
Sensor / voltage connection	S-version: open leads SL-version: LEMO	S-version: open leads SL-version: LEMO	

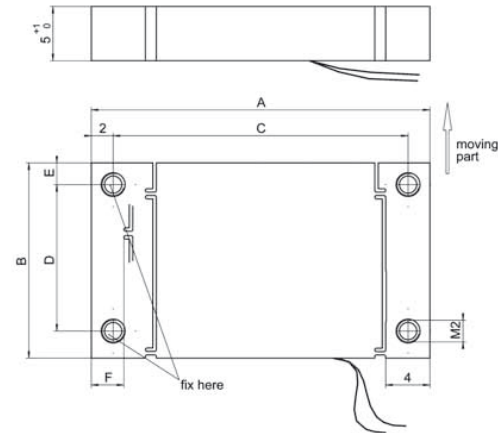
P-603 PiezoMove Linear Actuator

Low-cost and with Large Travel Ranges



P-603 linear actuators with 500 and 100 µm travel range (from left to right). CD for size comparison

- Frictionless, High-Precision Flexure Guiding System
- Travel Ranges to 500 µm
- Cost-Effective Design
- Outstanding Lifetime Due to PICMA® Piezo Actuators
- Available with Integrated Position Sensor
- Ideal OEM Actuators for Precision Motion Control in Optics, Medical, Biotech and Microfluidics Applications
- Custom Designs with Larger Travel or Faster Response and Non-Magnetic Versions Feasible



	A	B	C	D	E	F
P-603.1xx	31	18	27	13,5	2	3
P-603.3xx	51	20	47	13,5	3,25	3,5
P-603.5xx	60	20	56	16	2	3

P-603 PiezoMove flexure-guided piezo actuators integrate a frictionless high-efficiency motion amplifier to combine large travel ranges up to 500 µm with high stiffness and very fast response. The flexure guides reduce tip at the drive head to a minimum saving the cost for additional guiding systems when integrating these actuators in micro-dispensing devices, pumps or servo valves. The overall precision of 10s of nanometers also makes these devices ideal for nanomanipulation applications.

Options and Custom Versions

For OEM applications, PiezoMove actuators can be modified in various ways to suit the customer's requirements. The stiffness and force generation can be influenced via the lever design and the dimensions of the piezo ceramics used in the actuator.

Technical Data (preliminary)

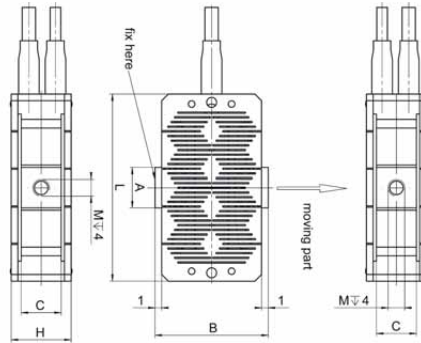
Model	P-603.1S0 P-603.1SL	P-603.3S0 P-603.3SL	P-603.5S0 P-603.5SL	P-603.x00 open-loop versions	Units
Active axes	X	X	X	X	
Motion and positioning					
Integrated sensor	SGS	SGS	SGS	–	
Open-loop travel, -20 to +120 V	100	300	550	as P-603.xS0	µm
Closed-loop travel	100	300	500	–	µm
Open-loop resolution	0.2	0.3	0.4	as P-603.xS0	nm
Closed-loop resolution	2	4	7.5	–	nm
Linearity, closed-loop	0.3	0.3	0.3	–	%
Repeatability	8	10	30	–	nm
Mechanical properties					
Stiffness in motion direction	0.25	0.14	0.06	as P-603.xS0	N/µm
Unloaded resonant frequency	900	450	300	as P-603.xS0	Hz
Blocking force	20	35	25	as P-603.xS0	N
Drive properties					
Ceramic type	PICMA® P-885	PICMA® P-885	PICMA® P-885	PICMA® P-885	
Electrical Capacitance	1.5	3.1	3.7	as P-603.xS0	µF
Dynamic operating current coefficient	1.9	1.3	1.6	as P-603.xS0	µA/(Hz*µm)
Miscellaneous					
Operating temperature range	-20 to 80	-20 to 80	-20 to 80	-20 to 80	°C
Material	Stainless steel	Stainless steel	Stainless steel	Stainless steel	
Dimensions	31x18x5	50x20x5	51x20x5	as P-603.xS0	mm
Mass	0.02 / 0.031	0.032 / 0.043	0.038 / 0.049	as P-603.xS0	kg
Cable length	0.5	0.5	0.5	0.5	m
Sensor / voltage connection	S-version: open leads SL-version: LEMO connector (SGS Sensor)	S-version: open leads SL-version: LEMO connector (SGS Sensor)	S-version: open leads SL-version: LEMO connector (SGS Sensor)	Open leads	

Recommended controller / amplifier
E-610 controller / amplifier see p. 2-110, E-625 bench-top controller see p. 2-114

P-602 High Stiffness Flexure Actuators, to 1000 μm Integrated Guiding System, High Force and Large Travel Ranges



P-602 linear actuator family featuring travel ranges of 100, 500, and 1000 μm (from left to right)



	L	B	H
P-602.1xx	28	17	9
P-602.3xx	46	19	9
P-602.5xx	85	26	9
P-602.8xx	126	34	14
P-602.1x8	28	22	14
P-602.3x8	46	24	14
P-602.5x8	85	31	14

	M	A	C
P-602.1xx	M2,5	6	6
P-602.3xx	M2,5	6	6
P-602.5xx	M2,5	6	6
P-602.8xx	M2,5	6	6
P-602.1x8	M4	10	11
P-602.3x8	M2,5	6	11
P-602.5x8	M2,5	6	11

- Frictionless Flexure Guiding System for Straight Motion
- Integrated Motion Amplifier for Travel Ranges to 1 mm
- High Dynamics and Stiffness, Forces to 400 N, Backlash-Free Construction
- Outstanding Lifetime Due to PICMA® Piezo Actuators
- Available with Integrated Position Sensor
- Custom Designs with Larger Travel or Faster Response and Non-Magnetic Versions Feasible

Model	P-602.100 P-602.1S0 P-602.1SL	P-602.300 P-602.3S0 P-602.3SL	P-602.500 P-602.5S0 P-602.5SL	P-602.108 P-602.1S8 P-602.1L8	P-602.308 P-602.3S8 P-602.3L8	P-602.508 P-602.5S8 P-602.5L8	P-602.800 P-602.8S0 P-602.8SL	Units	Tolerance
Active axes	X	X	X	X	X	X	X		
Motion and positioning									
Integrated sensor	- / SGS / SGS	- / SGS / SGS	- / SGS / SGS	- / SGS / SGS	- / SGS / SGS	- / SGS / SGS	- / SGS / SGS		
Open-loop travel, -20 to +120 V	120	300	600	100	300	500	1000	μm	min. (+20%/-0)
Closed-loop travel	- / 100 / 100	- / 300 / 300	- / 500 / 500	- / 100 / 100	- / 300 / 300	- / 500 / 500	- / 1000 / 1000	μm	
Open-loop resolution	0.2	0.3	0.4	0.2	0.3	0.4	0.5	nm	typ.
Closed-loop resolution	- / 2 / 2	- / 3 / 3	- / 3 / 3	- / 2 / 2	- / 3 / 3	- / 3 / 3	- / 7 / 7	nm	typ.
Linearity, closed-loop	- / 0.5 / 0.5	- / 0.5 / 0.5	- / 0.5 / 0.5	- / 0.5 / 0.5	- / 0.5 / 0.5	- / 0.5 / 0.5	- / 1.5 / 1.5	%	typ.
Repeatability	- / 10 / 10	- / 20 / 20	- / 35 / 35	- / 10 / 10	- / 20 / 20	- / 35 / 35	- / 60 / 60	nm	typ.
Mechanical properties									
Stiffness in motion direction	0.8	0.35	0.3	2.3	0.75	0.65	0.4	N/ μm	$\pm 20\%$
Unloaded resonant frequency	1000	450	230	1000	450	230	150	Hz	$\pm 20\%$
Blocking force	80	105	150	230	225	325	400	N	max.
Drive properties									
Ceramic type	PICMA® P-885	PICMA® P-885	PICMA® P-885	PICMA® P-888	PICMA® P-888	PICMA® P-888	PICMA® P-888		
Electrical Capacitance	1.5	3.1	6.2	6	13	26	39	μF	$\pm 20\%$
Dynamic operating current coefficient	1.9	1.3	1.6	7.5	5	6	4	$\mu\text{A}/(\text{Hz}\cdot\mu\text{m})$	$\pm 20\%$
Miscellaneous									
Operating temperature range	-20 to 80	-20 to 80	-20 to 80	-20 to 80	-20 to 80	-20 to 80	-20 to 80	$^{\circ}\text{C}$	
Material	Stainless steel	Stainless steel	Stainless steel	Stainless steel	Stainless steel	Stainless steel	Stainless steel		

Program Overview

- Piezo Ceramic Actuators & Motors
- Piezo Nanopositioning Systems and Scanners
- Active Optics / Tip-Tilt Platforms
- Capacitive Nanometrology Sensors
- Piezo Electronics: Amplifiers and Controllers
- Hexapod 6-Axis Positioners / Robots
- Micropositioning Stages & Actuators
- Photonics Alignment Systems, Solutions for Telecommunications
- Motor Controllers
- Ultrasonic Linear Motors

Request or download the complete PI Nanopositioning & Piezo Actuator Catalog



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