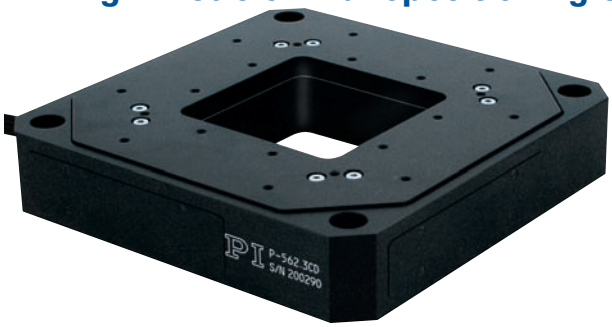
P-561 · P-562 · P-563 PIMars™ XYZ Piezo System

High-Precision Nanopositioning Stage, 3 to 6 Axes



P-562 PIMars™ multi-axis, parallel-kinematics nanopositioning stages are available with up to 340 µm travel per axis. Custom versions to 6 DOF are available

- **Parallel-Kinematics / Metrology for Enhanced Responsiveness / Multi-Axis Precision**
- **Travel Ranges to 340 x 340 x 340 µm**
- **Capacitive Sensors for Highest Linearity**
- **Frictionless, High-Precision Flexure Guiding System**
- **Excellent Scanning Flatness**
- **High-Dynamics XYZ Version Available; Custom Versions to 6-DOF**
- **Clear Aperture 66 x 66 mm**
- **Outstanding Lifetime Due to PICMA® Piezo Actuators**
- **UHV Versions to 10^{-9} hPa**

PIMars™ open-frame piezo stages are fast and highly accurate multi-axis scanning and nanopositioning systems with flatness and straightness in the nanometer range.

The 66 x 66 mm clear aperture is ideal for transmitted-light applications such as near-field scanning or confocal microscopy and mask positioning.

Large Variety of Models

PIMars™ multi-axis nanopositioners are offered in a large variety of configurations. Standard models include long-travel systems (to 300 x 300 x 300 µm), high-speed and vacuum versions. Custom six-axis designs with rotation to 6 mrad are available on request.

PI offers versions specially designed for applications in ultra-high vacuum with vacuum-qualified components only. The integrated ceramic-encapsulated PICMA® actuators allow high bakeout temperatures and assure minimal outgassing rates. A non-magnetizable version is available on request.

Application Examples

- Scanning microscopy
- Mask/wafer positioning
- Interferometry
- Metrology
- Biotechnology
- Micromanipulation

Direct Drive for Ultra-Fast Scanning and Positioning

The P-561.3DD versions have resonant frequencies to 1.0 kHz, enabling millisecond scanning rates with sub-nanometer resolution.

Capacitive Sensors for Highest Accuracy and Position 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. A further advantage of direct metrology with capacitive sensors is the high phase fidelity and the high bandwidth of up to 10 kHz.

Active and Passive Guidance for Nanometer Flatness and Straightness

Wire-cut flexures optimized with Finite Element Analysis (FEA) are used to guide the stage. The FEA techniques give the design the highest possible stiffness and minimize linear and angular runout. Further enhancement is achieved by active trajectory control: multi

Ordering Information

P-561.3CD
PIMars™ XYZ Piezo-Nanopositioning System, 100 x 100 x 100 µm, Parallel Metrology

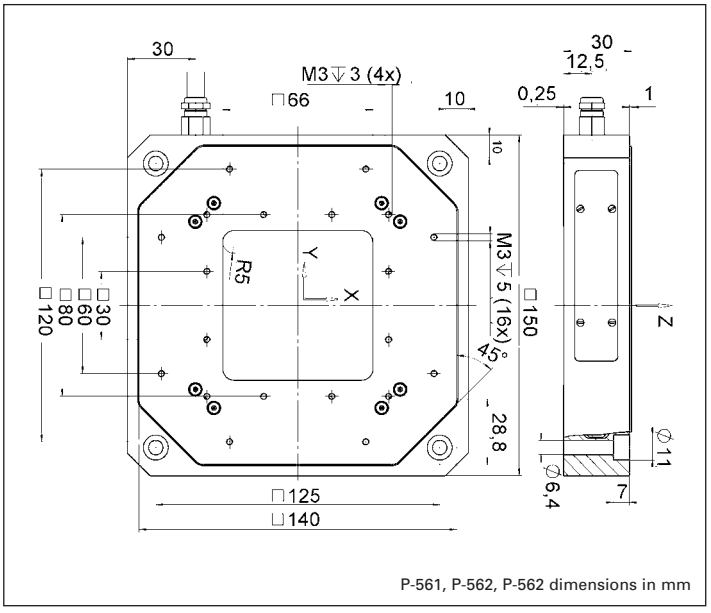
P-562.3CD
PIMars™ XYZ Piezo-Nanopositioning System, 200 x 200 x 200 µm, Parallel Metrology

P-563.3CD
PIMars™ XYZ Piezo-Nanopositioning System, 300 x 300 x 300 µm, Parallel Metrology

P-561.3DD
PIMars™ High-Dynamics XYZ Nanopositioning System, 45 x 45 x 15 µm, Parallel Metrology, Direct Drive

Vacuum-compatible versions to 10^{-6} hPa for the P-561.3CD, P-562.3CD and P-563.3CD models are available as P-561.3VD, P-562.3VD and P-563.3VD; versions to 10^{-9} hPa as P-561.3UD, P-562.3UD and P-563.3UD.

Super-invar & titanium versions are available, 6-DOF versions on request.



P-561, P-562, P-562 dimensions in mm

System properties

System Configuration	P-561.3CD with E-710 digital controller, 330 g load
Amplifier bandwidth, small signal	25 Hz in X, Y; 35 Hz in Z
Settling time (10 % step)	20 ms

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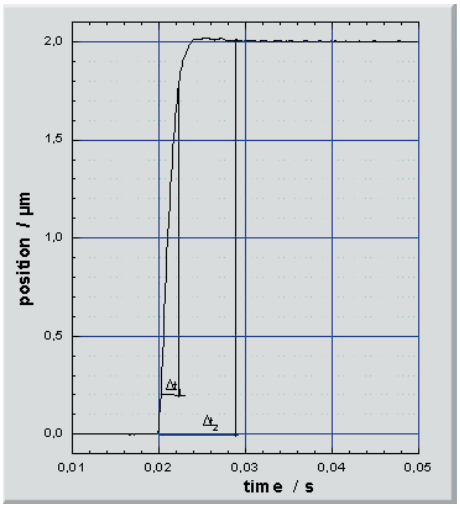
axis nanopositioning systems equipped with parallel metrology are able to measure platform position in all degrees of freedom against a common, fixed reference. In such systems, undesirable motion from one actuator in the direction of another (cross-talk) is detected immediately and actively compensated by the servo-loops. This can keep deviation from a trajectory to under a few nanometers, even in dynamic operation.



P-562.3CD (unloaded) step and settle is faster than 10 ms in X, Y and Z

Technical Data

Model	P-561.3CD	P-562.3CD	P-563.3CD	P-561.3DD	Units	Tolerance
Active axes	X, Y, Z	X, Y, Z	X, Y, Z	X, Y, Z		
Motion and positioning						
Integrated sensor	Capacitive	Capacitive	Capacitive	Capacitive		
Open-loop travel, -20 to +120 V	150 x 150 x 150	300 x 300 x 300	340 x 340 x 340	58 x 58 x 18	µm	min. (+20 %/0 %)
Closed-loop travel	100 x 100 x 100	200 x 200 x 200	300 x 300 x 300	45 x 45 x 15	µm	
Open-loop resolution	0.2	0.4	0.5	0.1	nm	typ.
Closed-loop resolution	0.8	1	2	0.2	nm	typ.
Linearity	0.03	0.03	0.03	0.01*	%	typ.
Repeatability in X, Y, Z	2 / 2 / 2	2 / 2 / 4	2 / 2 / 4	2 / 2 / 2	nm	typ.
Pitch in X,Y	±1	±2	±2	±3	µrad	typ.
Runout θ_x, θ_y (Z motion)	±15	±20	±25	±3	µrad	typ.
Yaw in X, Y	±6	±10	±10	±3	µrad	typ.
Flatness in X, Y	±15	±20	±25	±10	nm	typ.
Crosstalk X, Y (Z motion)	±30	±50	±50	±20	nm	typ.
Mechanical properties						
Unloaded resonant frequency in X / Y / Z	190 / 190 / 380	160 / 160 / 315	140 / 140 / 250	920 / 920 / 1050**	Hz	±20 %
Resonant frequency @ 100 g in X / Y / Z	–	145 / 145 / 275	120 / 120 / 215	860 / 860 / 950	Hz	±20 %
Resonant frequency @ 330 g in X / Y / Z	140 / 140 / 300	130 / 130 / 195	110 / 110 / 170	500 / 500 / 470	Hz	±20 %
Push force capacity in motion direction in X / Y / Z	200 / 200 / 50	120 / 120 / 50	100 / 100 / 50	200 / 200 / 50	N	Max.
Pull force capacity in motion direction in X / Y / Z	30 / 30 / 30	30 / 30 / 30	30 / 30 / 30	30 / 30 / 30		
Load capacity	50	50	50	50	N	Max.
Drive properties						
Ceramic type	PICMA® P-885	PICMA® P-885	PICMA® P-885	PICMA® P-885 in Z, P-888 in XY		
Electrical capacitance in X / Y / Z	5.2 / 5.2 / 10.4	7.4 / 7.4 / 14.8	7.4 / 7.4 / 14.8	38 / 38 / 6	µF	±20 %
Dynamic operating current coefficient (DOCC) in X / Y / Z	6.5 / 6.5 / 13	4.6 / 4.6 / 9.25	3.1 / 3.1 / 6.1	106 / 106 / 50	µA/ (Hz • µm)	±20 %
Miscellaneous						
Operating temperature range	-20 to 80	-20 to 80	-20 to 80	-20 to 80	°C	
Material	Aluminum	Aluminum	Aluminum	Aluminum		
Mass	1.45	1.45	1.45	1.55	kg	±5 %
Cable length	1.5	1.5	1.5	1.5	m	±10 mm
Sensor / voltage connection	Sub-D Special	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-710 (p. 2-128) controller.
*With digital controller. Non-linearity of direct drive stages measured with analog controllers is typically up to 0.1 %.

Recommended controller
Multi-channel digital controllers: E-710 bench-top (p. 2-128), E-712 modular (p. 2-140), E-725 high-power (p. 2-126), E-761 PCI board (p. 2-130)

P-562.6CD PIMars 6-Axis Piezo Stage System

High-Precision Nanopositioning System with 6 Degrees of Freedom

P-562.6CD PIMars six-axis parallel-kinematics nanoposi

- **6 Motion Axes: 3 x Linear, 3 x Rotation**
- **Travel Ranges to 200 µm Linear and 1 mrad Tilt Angle**
- **Enhanced Responsiveness & Multi-Axis Precision: Parallel Kinematics / Metrology**
- **Highest Linearity and Stability with Capacitive Sensors**
- **Frictionless, High-Precision Flexure Guiding System**
- **Excellent Scan-Flatness**
- **Clear Aperture 66 x 66 mm**
- **Outstanding Lifetime Due to PICMA® Piezo Actuators**
- **UHV Versions to 10^{-9} hPa**

PIMars open-frame piezo stages are fast and highly accurate multi-axis scanning and nanopositioning systems with flatness and straightness in the nanometer range. Thanks to the parallel-kinematic design, where all piezo drives act on the same moving platform, and sophisticated digital control algorithms it is possible to achieve highly precise motion in all degrees of freedom: three linear axes and three rotary axes. The travel ranges amount to 200 µm in X, Y and Z, and the tilt angles are ±0.5 mrad about the respective axis. Systems with larger travel ranges or faster response are available on request. A six-axis system with 800 µm travel range in the X and Y axis is available as the P-587.6CD s. p. 2-76.

PIMars systems feature a large 66 x 66 mm clear aperture for transmitted-light applications such as near-field scanning or confocal microscopy and mask positioning. PIMars stages for ultra-high vacuum applications are also available. These versions contain vacuum-qualified components only. The integrated ceramic-encapsulated PICMA® actuators allow high bakeout temperatures and assure minimal outgassing rates. A non-magnetizable version is available on request.

Application Examples

- Scanning microscopy (SPM)
- Mask/wafer positioning
- Interferometry
- Metrology
- Biotechnology
- Micromanipulation

Ordering Information

P-562.6CD
PIMars 6-Axis Nanopositioning System, 200 µm, 1 mrad, Parallel Metrology

Other travel ranges on request!

Capacitive Sensors for Highest Accuracy 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 excellent long-term stability, high phase fidelity and the high bandwidth of up to 10 kHz.

Active and Passive Guidance for Nanometer Flatness and Straightness

Wire-cut flexures optimized with Finite Element Analysis (FEA) are used to guide the stage. The FEA techniques give the design the highest possible stiffness and minimize linear and angular runout. Further enhancement is achieved by active trajectory control: multiaxis nanopositioning systems equipped with parallel metrology are able to measure platform position in all degrees of freedom against a common, fixed reference. In such systems, undesirable motion from one actuator in the direction of another (crosstalk) is detected immediately and actively compensated by the servo-loops. This can keep deviation from a trajectory to under a few nanometers, even in dynamic operation.

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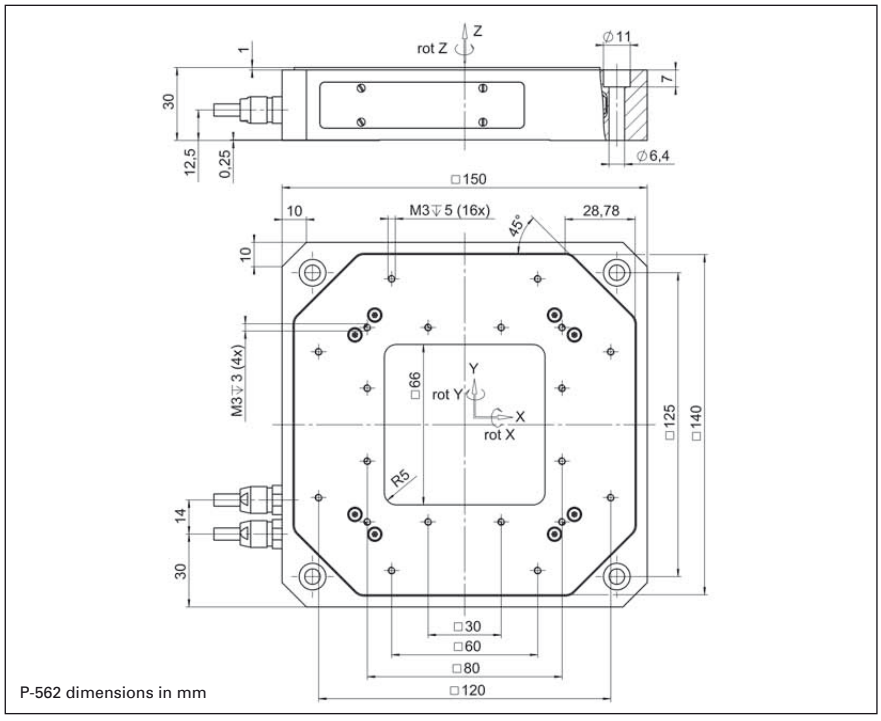

P-562 dimensions in mm

Technical Data

Model	P-562.6CD	Tolerance
Active axes	X, Y, Z, θX, θY, θZ	
Motion and Positioning		
Integrated sensor	Capacitive	
Closed-loop travel X, Y, Z	200 µm	
Closed-loop tip/tilt angle	±0.5 mrad	
Closed-loop resolution X, Y, Z	1 nm	typ.
Closed-loop tip/tilt resolution	0.1 µrad	typ.
Linearity X, Y, Z	0.01 %	typ.
Linearity θX, θY, θZ	0.1 %	typ.
Repeatability in X, Y, Z	±2 / ±2 / ±3 nm	typ.
Repeatability θX / θY / θZ	±0.1 / ±0.1 / ±0.15 µrad	typ.
Flatness	< 15 nm	typ.
Unloaded resonant frequency in X / Y / Z	110 / 110 / 190 Hz	±20%
Load capacity	50 N	max.
Push/pull force capacity in motion direction	120 / 30 N	max.
Drive properties		
Ceramic type	PICMA®	
Electrical capacitance in X / Y / Z	7.4 / 7.4 / 14.8 µF	±20%
Dynamic operating current coefficient in X, Y, Z	4.6 / 4.6 / 9.2 µA/(Hz • µm)	±20%
Miscellaneous		
Operating temperature range	-20 to 80 °C	
Material	Aluminium	
Mass	1.45 kg	±5%
Cable length	1.5 m	±10 mm
Sensor / voltage connection	2 x Sub-D Special	

Recommended controller / amplifier
E-710.6CD s. p. 2-128 or E-712.6CD digital controller s. p. 2-140