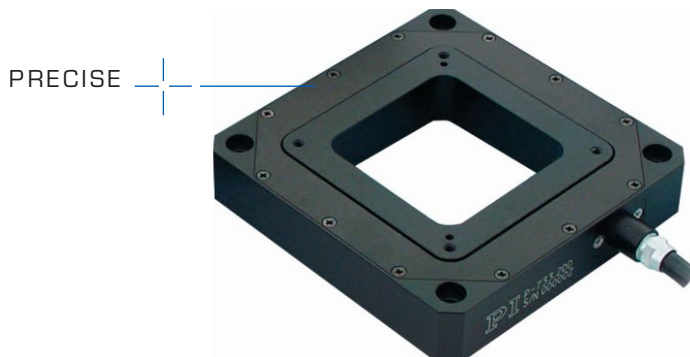


Super Resolution Microscope Stages

Nanometer and Picometer Resolution, High Speed & Stability



P-545 PInano™ Capacitive: Super-Stability XY / XYZ Piezo Stages

Capacitive Feedback for Highest Stability & Linearity: Ideal for SR-Microscopy



PInano™ series nanopositioning stages feature a very low profile of 0.8" (20mm) and use a full slide mounted at the bottom. They deliver very fast and highly accurate motion to 200µm with sub-nanometer resolution in up to 3 axes. PInano™ systems come complete with a high performance USB controller and software.

- **Capacitive Direct Metrology Sensors: Higher Linearity, Stability and Accuracy than PR-Sensor Versions**
- **Closed Loop USB Controller (24 Bit Resolution) & Software Included**
- **Low Profile for Easy Integration: 20 mm (0.8")**
- **Bottom Slide Mount: No Interference with Turret Rotation**
- **200 µm Travel Range per Axis**
- **10X Longer Lifetime with Proprietary Piezo Technology**
- **Compatible w/ Leading Image Acquisition Software**
- **Sub-Nanometer Resolution and Millisecond Step Time,**
- **Ideal for Super-Resolution Microscopy**
- **Optional Long Travel Piezomotor / Manual Stage**

High Stability and Linearity Optimized for High-Resolution Microscopes

The new PInano™ Cap XY and XYZ capacitive sensor piezo stages are optimized for easy integration into high resolution optical microscopes. They feature a very low profile of 0.8" (20 mm), a large aperture, and extremely fast response with subnanometer closed-loop resolution—ideal for leading-edge microscopy and imaging applications. The stage design permits a full slide to be mounted at bottom allowing the turret to be rotated without moving the objective in and out. Longest lifetime is guaranteed by the integrated ceramic encapsulated PICMA® piezo actuators. Due to the significantly higher humidity resistance, the patented PICMA® design provides up to 10 times longer life than conventional piezo actuators.

High Performance, Yet Cost Effective

PInano™ Cap series piezo stages provide even higher performance than their piezoresistive (PR) sensor equipped cousins. Systems consist of the piezo mechanics, an advanced controller optimized for capacitive feedback and software. For the highest linearity and stability, these stages are based on direct measuring, non-contact capacitive sensors, a principle free of Johnson noise. RF excitation circuitry in the controller further reduces sensitivity to external noise sources or DC voltage drift of electronic components that can limit the long term stability of DC signal excited sensors such as film and PR strain gauges. The proprietary servo design improves the motion linearity compared to conventional piezo controllers.

Stage Working Principle / Reliability

Flexures optimized with Finite Element Analysis (FEA) are employed to guide the PI nano™ series stages. FEA techniques 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. The award-winning PICMA® piezo drives are more robust than conventional piezo actuators, featuring superior lifetime and performance in both dynamic and static applications. Because guidance, actuators and sensors are all maintenance-free, these nanopositioning systems achieve outstanding levels of reliability:

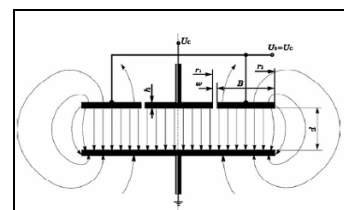
Ordering Information

P-545.2C7
PInano™ Cap XY Piezo Stage with large Aperture, 200x200µm, Capacitive direct Metrology Sensors, with USB Controller

P-545.3C7
PInano™ Cap XYZ Piezo Stage with large Aperture, 200x200x200µm, Capacitive direct Metrology Sensors, with USB Controller

Application Examples

- Biotechnology
- SR-Microscopy
- Scanning microscopy
- Confocal microscopy
- Sample Positioning



Non-contact capacitive position sensors measure directly and provide higher linearity and long term stability compared to piezoresistive or film sensors that infer position information from strain.

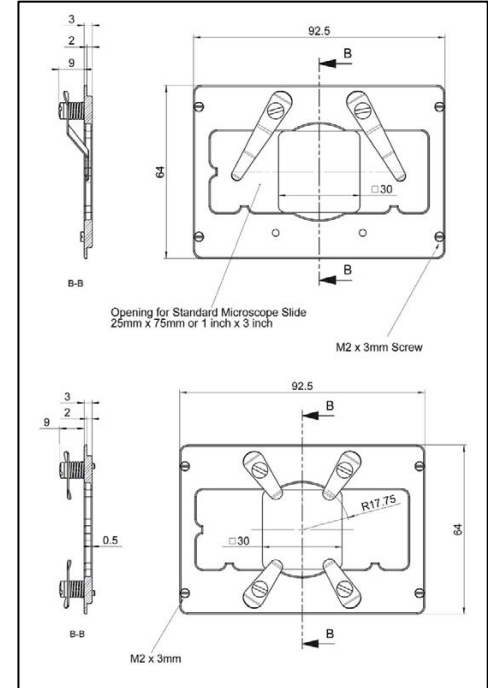
Long Travel XY Microscope Tables, 25x25 mm



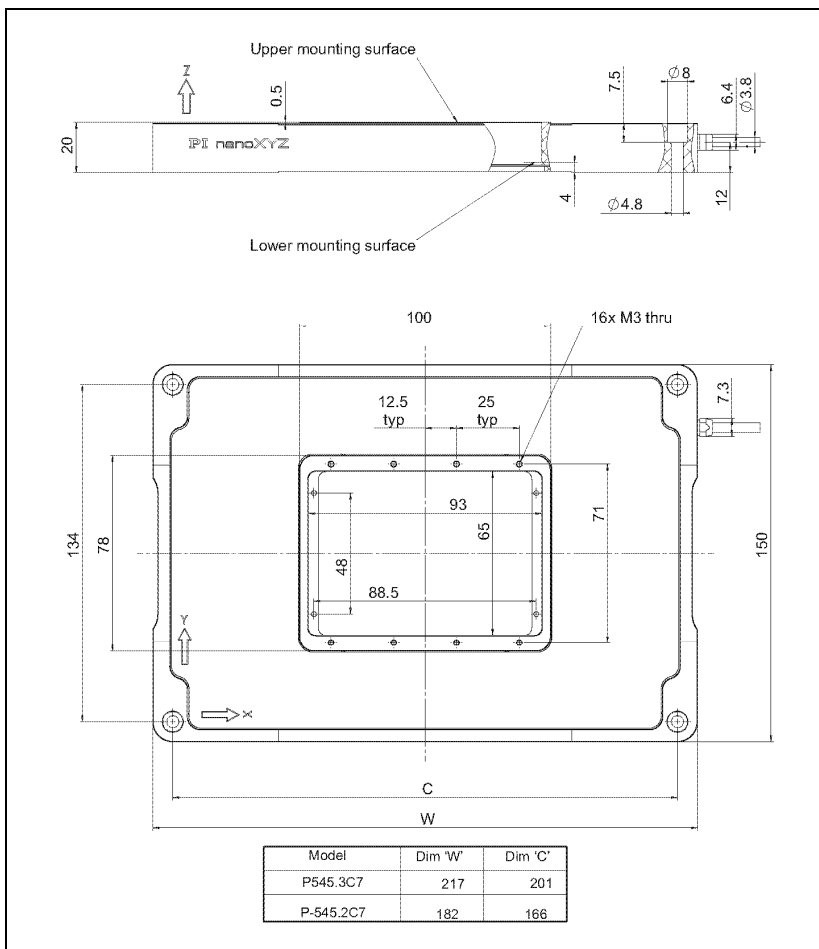
PI also offers manual and motorized long-travel microscope stages. These high-stability designs are ideal mounting platforms for the fast PInano™ piezo scanning stages. **Motorized stages** are available for Nikon and Olympus microscopes **Manual stages** are available for Nikon, Olympus, Zeiss & Leica microscopes

Models	Plnano™ XY	Plnano™ XYZ	Units	Tolerance
Active axes	X,Y	X,Y,Z		
Integrated sensor	Capacitive	Capacitive		
Closed-loop travel	200x200	200x200x200	µm	
*Resolution <1		<1	nm	1 σ
Linearity +/-	-0.05	+/-0.05	%	typ.
Repeatability	<5	<5	nm	typ.
Push/pull force capacity in motion direction	100 / 30	100 / 30		max.
Max. payload	500	500	g	max.
Ceramic type	PICMA®	PICMA®		
Recommended operating temperature range	20 to 30	20 to 30	°C	
Material	Aluminum	Aluminum		
Mass 1		1.2	kg	±5%
Cable length	2	2	m	±10 mm

*Resolution of PI Piezo Nanopositioners is not limited by friction or stiction. Value given is noise equivalent motion measured with interferometer



Accessories: P-545.SH3 Slide holder (above) and P-545.PD3 petri dish holder (below), dimensions in mm



P-545, Plnano™ piezo stage, dimensions in mm



A powerful 24 bit resolution controller with USB, TCP/IP and analog interfaces and software are included.

PI nano™ XYZ & XY SR-Microscope Piezo Positioning Stages

Low-Cost with Piezo Resistive Sensors



PI nano™ series nanopositioning stages feature a very low profile of 20 mm (0.8), a large aperture for 3 x 1" slides and deliver highly accurate motion with sub-nanometer resolution in up to 3 axes. Slide / petri dish holders optional

- **Low Profile for Easy Integration: 20 mm (0.8")**
- **Up to 200 x 200 x 200 μ m Travel Ranges**
- **Large Clear Aperture for 3 x 1" Slides**
- **Recessed Sample Holders for Maximized Utility Available**
- **Outstanding Lifetime Due to PICMA® Piezo Actuators**
- **Cost-Effective Design due to Piezoresistive Sensors**
- **Compatible w/ Leading Image Acquisition Software Package**
- **Closed-Loop Control for High Repeatability and Accuracy**
- **Millisecond Step Time, Ideal for Super-Resolution Microscopy**
- **24-Bit Controller w/ USB, Ethernet, RS-232 Interface and Analog Control**
- **Available Manual Long-Travel Stage with Motor Upgrade Option**

Long Travel, Low Profile, Optimized for Microscopy
 PI nano™ XY and XYZ low-profile piezo scanning stages are optimized for easy integration into high-resolution micro-

scopes. They feature a very low profile of 20 mm (0.8") and a large aperture designed to hold Petri dishes and standard slide holders. The long travel ranges of up to 200 x 200 x 200 μ m with nanometer closed-loop resolution are ideal for leading-edge

microscopy and imaging applications.

Cost Effective Design, High Performance

PI nano™ series piezo positioning stages are designed to provide high performance at minimum cost. For highly-stable, closed loop operation, piezoresistive sensors are applied directly to the moving structure and precisely measure the displacement of the stage platform. The very high sensitivity of these sensors provides optimum position stability and responsiveness as well as nanometer resolution. A proprietary servo controller significantly improves the motion linearity compared to conventional piezoresistive sensor controllers.

High Reliability and Long Lifetime

The compact P-545 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 provide better performance and reliability than conventional piezo actuators. Actuators, guidance and sensors are maintenance-free, not subject to wear and offer extraordinary reliability.

Ordering Information

P-545.2R7
 Plnano™ XY Piezo Stage, Slide-Size Aperture, 200 x 200 μ m, Piezoresistive Sensors, with USB Controller

P-545.3R7
 Plnano™ XYZ Piezo Stage, Slide-Size Aperture, 200 x 200 x 200 μ m, Piezoresistive Sensors, with USB Controller

Controller included

E-545.3RD
 Plnano™ Multi-Channel Piezo Controller with High-Speed Digital Interface, 3 Channels, Piezoresistive Sensors, Sub-D Connectors

Accessories

M-545.2MO
 XY Microscope Stage, 25 x 25 mm, Micrometer-Driven, High Stability, Compatible with PI® Piezo Stages, for Olympus Microscopes

M-545.2MN
 XY Microscope Stage, 25 x 25 mm, Micrometer-Driven, High Stability, Compatible with PI® Piezo Stages, for Nikon Microscopes

M-545.2ML
 XY Microscope Stage, 25 x 25 mm, Micrometer-Driven, High Stability, Compatible with PI® Piezo Stages, for Leica Microscopes

M-545.2MZ
 XY Microscope Stage, 25 x 25 mm, Micrometer-Driven, High Stability, Compatible with PI® Piezo Stages, for Zeiss Microscope

P-545.PD3
 35mm Petri Dish Holder for P-545 Plnano™ Piezo Stages

P-545.SH3
 Microscope Slide Holder for Plnano™ Piezo Stages

P-545.PP3
 Plain Plate for Accessories for Plnano™ Piezo Stages

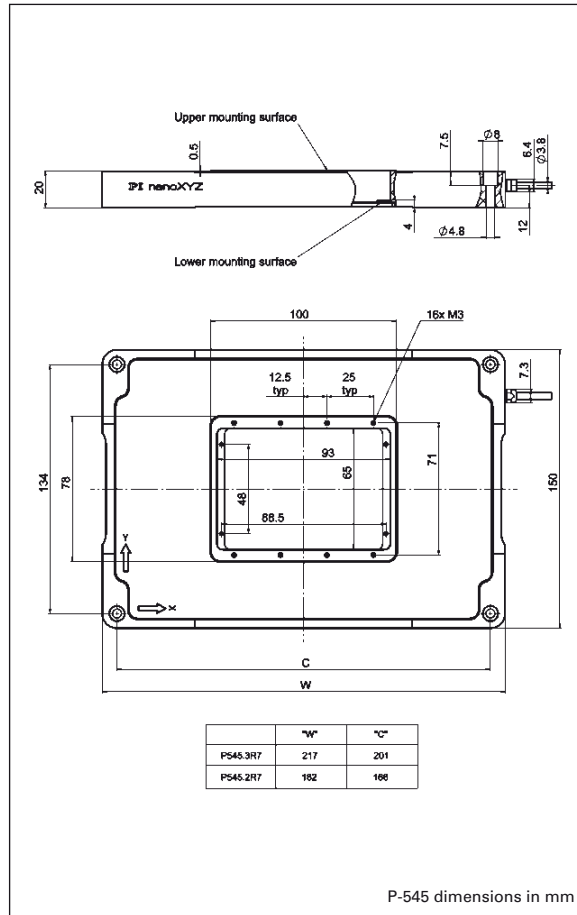
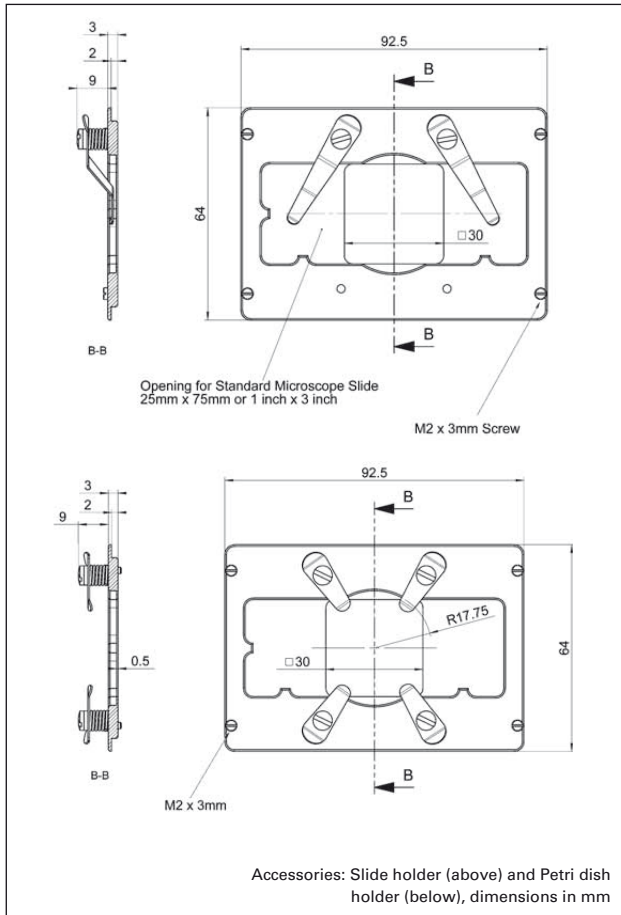
Additional accessories on request.

Application Examples

- Super-resolution microscopy
- 3D Imaging
- Laser technology
- Interferometry
- Metrology
- Biotechnology
- Screening
- Micromanipulation



Background: the piezo controller is included and comes with a 24-bit resolution USB port as well as ethernet, RS-232 and analog interface. Foreground: The optional M-545 manual XY stage provides a stable piezo platform for the PI nano™ piezo stages. Custom stage version shown



Technical Data

Model	P-545.2R7	P-545.3R7	Unit	Tolerance
Active axes	X, Y	X, Y, Z		
Motion and positioning				
Integrated sensor	piezoresistive	piezoresistive		
Closed-loop travel	200 x 200	200 x 200 x 200	µm	
Closed-loop resolution*	1	1	nm	typ.
Linearity	±0.1	±0.1	%	typ.
Repeatability	< 5	< 5	nm	typ.
Mechanical properties				
Push/pull force capacity	100 / 30	100 / 30	N	max.
Load	50	50	N	max.
Drive properties				
Ceramic type	PICMA® P-885	PICMA® P-885		
Electrical capacitance	6	6 (X, Y), 12 (Z)	µF	±20%
Miscellaneous				
Operating temperature range	-20 to 80	-20 to 80	°C	
Material	Aluminum	Aluminum		
Mass	1	1.2	kg	±5%
Cable length	1.5	1.5	m	±10 mm
Sensor / voltage connection	Sub-D, 25 pin	Sub-D, 25 pin		
Piezo controller (included in delivery)	E-545	E-545		

* Resolution of PI Piezo Nanopositioners is not limited by friction or stiction. Value given is noise equivalent motion measured with interferometer.

P-545 Plnano™ Trak High-Speed Piezo Tracking Stage

Fastest XY(Z) Microscope Stage to Enable Use of Full Turret Motion



The low profile of 20 mm and special design to allow for a full slide to be mounted at the bottom set Plnano™ piezo microscope stages apart. The Plnano™ Trak version shown above is optimized for extremely fast motion and provides sub-nanometer resolution in up to three axes

- **Fast Response < 5 ms: Ideal for Tracking**
- **Sub-Nanometer Resolution**
- **Low Profile for Easy Integration: 20 mm (0.8")**
- **Countersunk Insertion Frame: Ideal for Inverted Microscopy**
- **Revolving Nosepiece Freely Rotatable Without Additional Z Motion**
- **Travel Ranges up to 70 x 70 x 50 μm**
- **Cost-Effective Design due to Piezoresistive Sensors**
- **Compatible w/ Leading Image Acquisition Software Package**
- **Position Servo-Control for Repeatable Sub-Nanometer Resolution**
- **Ideal for Super-Resolution Microscopy**
- **Controller Included**
- **Available Long-Travel Stage**

Cost Effective Design, High Performance

Plnano™ series piezo positioning stages are designed to provide high performance at minimum cost. For highly-stable, closed-loop operation, piezoresistive sensors are applied directly to the moving structure and precisely measure the displacement of the stage platform. The very high sensitivity of these sensors provides optimum position stability and responsiveness as well as sub-nanometer resolution. A proprietary servo controller significantly improves the motion linearity compared to conventional piezoresistive sensor controllers.

High Reliability and Long Lifetime

The compact P-545 systems are equipped with preloaded piezo actuators which are integrated into a sophisticated, FEA-modeled, flexure guiding system. The PICMA® actuators feature cofired ceramic encapsulation and provide better performance and reliability than conventional piezo actuators. Actuators, guidance and sensors are maintenance-free, not subject to wear and offer extraordinary reliability.

Ordering Information

P-545.2D7
Plnano™ High-Dynamics XY Piezo Stage System, Slide-Size Aperture, 70 x 70 μm, Direct Drive, Piezoresistive Sensors, with Controller

P-545.3D7
Plnano™ High-Dynamics XYZ Piezo Stage System, Slide-Size Aperture, 70 x 70 x 50 μm, Direct Drive, Piezoresistive Sensors, with Controller

Accessories

M-545.2MO
XY Microscope Stage, 25 x 25 mm, Micrometer Drive, High Stability, Compatible with PI Piezo Stages, for Olympus Microscopes

M-545.2MN
XY Microscope Stage, 25 x 25 mm, Micrometer Drive, High Stability, Compatible with PI Piezo Stages, for Nikon Microscopes

M-545.2ML
XY Microscope Stage, 25 x 25 mm, Micrometer Drive, High Stability, Compatible with PI Piezo Stages, for Leica Microscopes

M-545.2MZ
XY Microscope Stage, 25 x 25 mm, Micrometer Drive, High Stability, Compatible with PI Piezo Stages, for Zeiss Microscopes

P-545.PD3
35 mm Petri Dish Holder for Plnano™ Piezo Stages

P-545.SH3
Microscope Slide Holder for Plnano™ Piezo Stages

P-545.PP3
Plain Plate for Accessories for Plnano™ Piezo Stages

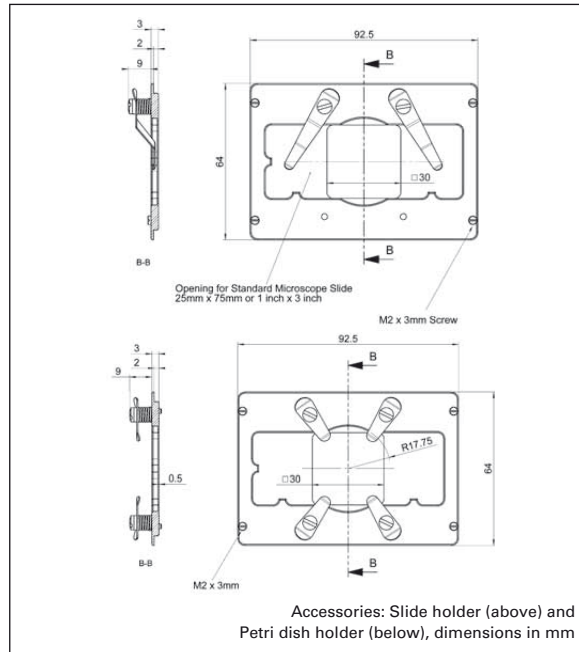
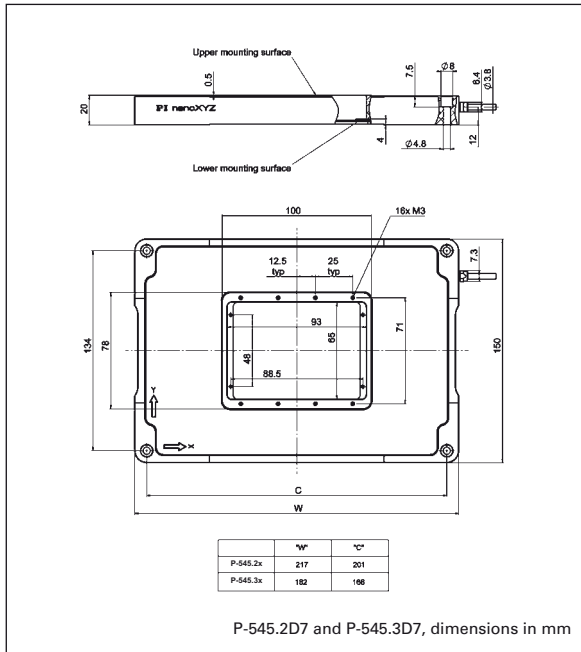
Additional accessories on request. Ask about custom designs!

Application Examples

- Super-resolution microscopy
- 3D Imaging
- Laser technology
- Interferometry
- Metrology
- Biotechnology
- Screening
- Micromanipulation

High Speed, Long Travel, Low Profile, Ideal for Single Molecule Tracking

The new Plnano™ Trak XY and XYZ high-speed piezo scanners are designed for extremely fast response such as required for single molecule tracking applications. The special low-profile design with a large aperture and recessed full size slide mount at the bottom of the stage allows easy integration into high-resolution inverted microscopes.



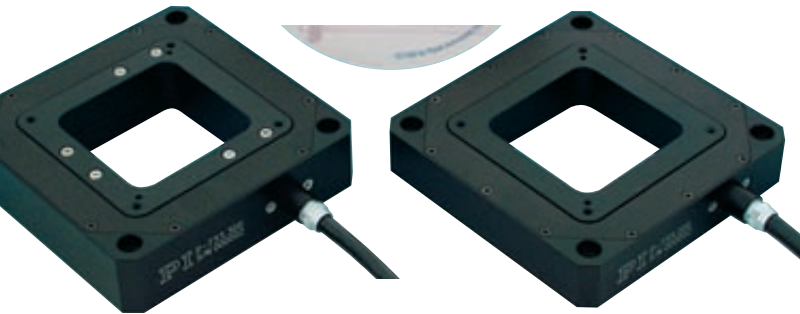
Technical Data

Model	P-545.2D7 for two axes P-545.3D7 for three axes	Unit	Tolerance
Active axes	X, Y, (Z)		
Motion and positioning			
Integrated sensor	Piezoresistive		
Closed-loop travel	70 x 70 (x 50)	µm	
Closed-loop resolution*	<1	nm	typ.
Mechanical properties			
Unloaded resonant frequency	1 (X), 1 (Y), 0.8 (Z)	kHz	
Push/pull force capacity	100 / 30	N	max.
Recommended load**	0,5	kg	max.
Drive properties			
Ceramic type	PICMA® P-885		
Electrical capacitance	6 (X, Y), 12 (Z)	µF	± 20%
Miscellaneous			
Operating temperature range	-20 to 80	°C	
Material	Aluminum		
Mass	1	kg	± 5%
Cable length	1.5	m	± 10 mm
Sensor / voltage connection	Sub-D, 25 pin		
Piezo controller			
Piezo controller	E-545 (included in delivery)		
Piezo connector	Sub-D, 25-pin		
Communication interfaces	Ethernet (TCP/IP) USB, RS-232		
Analog control input connector	BNC		
Command set	PI General Command Set (GCS)		
User software	PIMikroMove, NanoCapture		
Software drivers	Lab VIEW drivers, Windows and Linux Libraries (DLL) compatible with MetaMorph, µManager, MATLAB		
Supported functionality	Wave generator, data recorder, auto zero, trigger I/O		
Dimensions	450 x 88 x 343 + mounting rails		

* Resolution of PI Piezo Nanopositioners is not limited by friction or stiction. Value given is noise equivalent motion measured with interferometer.
** for optimum dynamics. Less load = higher dynamics.

P-733 XY / XYZ Piezo-Stage for Super-Resolution Microscopes

Parallel Kinematics & Parallel Metrology = Highest Performance for STED Microscopy



P -733.3 DD (left) and P -733.2 DD, high-speed, direct drive XY(Z) scanning stages are the fastest scanning stages with large aperture currently available (2.2 kHz resonant frequency!). Both units feature a footprint of only 100 x 100 mm. CD for size comparison.

- Travel Ranges to 100 x 100 µm in X,Y & to 10 µm in Z
- Resolution to 0.1 nm with Capacitive Sensors
- High-Speed Versions with Direct Drive
- Vacuum and Non-Magnetic Versions
- Parallel Kinematics for Better Multi-Axis Accuracy /Dynamics
- The Standard in STED Microscopy
- Parallel Metrology for Active Trajectory Control
- Frictionless, High-Precision Flexure Guiding System
- Clear Aperture 50 x 50 mm for Transmitted-Light Applications

P-733 XY and XYZ piezo driven stages are fast and highly accurate nan positioning and scanning systems. They provide a positioning and scanning range of 100 x 100 (x10) µm together with sub-nanometer resolution and are equipped with parallel-metrology capaci-

tive position feedback for superior multi-axis linearity and repeatability. The guiding accuracy minimizes runout to under 10 nm over the whole travel range. In addition, the high-speed Z-axis of the P-733.3CD can actively compensate any out-of-plane Z-axis deviation during XY motion.

other comparable systems), enabling millisecond scanning rates with sub-nanometer resolution.

Parallel-Kinematics / Metrology for Enhanced Responsiveness

In a parallel kinematics multi-axis system, all actuators act directly on one moving platform. This means that all axes move the same minimized mass and can be designed with identical dynamic properties. Multi-axis nan positioning systems equipped with both parallel kinematics and parallel, direct metrology are able to measure platform position in all degrees of freedom against one 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.

Capacitive Sensors for Subnanometer Resolution

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. The closed-loop resolution is 0.3 nm for the X and Y axes and 0.2 nm for the optional Z-axis. The direct drive versions are rated to 0.1 nm resolution for every axis.

Ordering Information

P-733.2DD
High-Dynamics High-Precision XY Nanopositioning System, 30 x 30 µm, Direct Drive, Capacitive Sensors, Parallel Metrology, Sub-D Connector

P-733.3DD
High-Dynamics Precision XYZ Nanopositioning System, 30 x 30 x 10 µm, Direct Drive, Capacitive Sensors, Parallel Metrology, Sub-D Connector

P-733.2CD* / P-733.2CL*
High-Precision XY Nanopositioning System, 100 x 100 µm, Capacitive Sensors, Parallel Metrology

P-733.3CD* / P-733.3CL*
Precision XYZ Nanopositioning System, 100 x 100 x 10 µm, Capacitive Sensors, Parallel Metrology

P-733.2VL* / P-733.2VD*
High-Precision XY Nanopositioning System, 100 x 100 µm, Capacitive Sensors, Parallel Metrology, Vacuum Compatible to 10-6 hPa

P-733.2UD
High-Precision XY Nanopositioning System, 100 x 100 µm, Capacitive Sensors, parallel metrology, Sub-D Connector, Vacuum Compatible to 10-9 hPa

*.xxD with Sub-D Connector

*.xxL with LEMO Connector

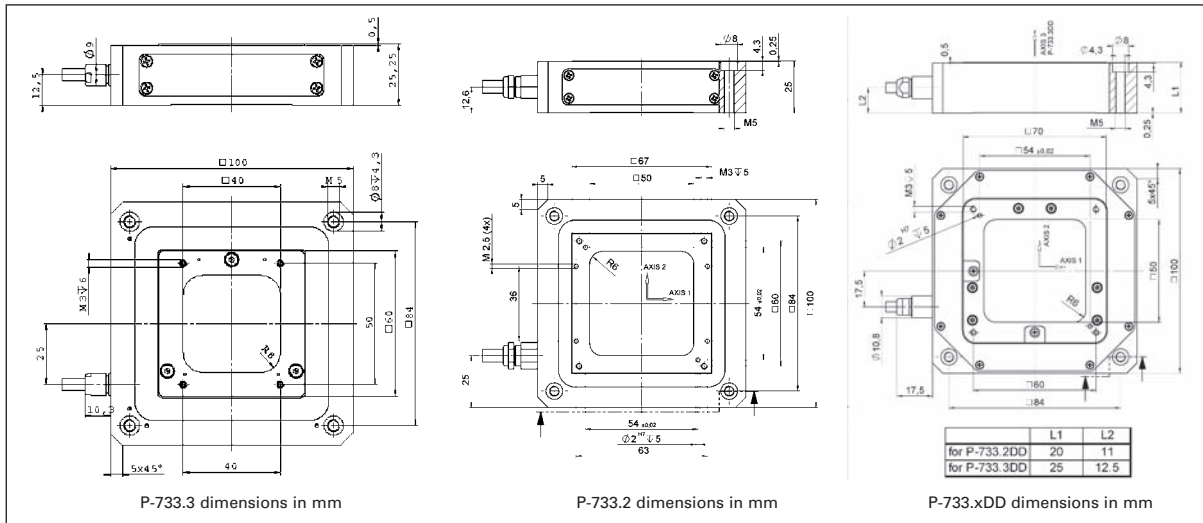
Ask about custom designs

Application Examples

- Image processing / stabilization
- Scanning microscopy
- Surface inspection
- Metrology / interferometry
- Biotechnology
- Semiconductor testing
- Mask / wafer positioning
- Micromanipulation
- Nanopositioning with high flatness & straightness

Fastest Multi-Axis Systems / Direct Drive, Low Profile and Large Apertures

P-733.2DD / .3DD multi-axis piezo nan positioning systems are the fastest ultra-high-precision, open-frame stages for scanning microscopy. They provide a positioning and scanning range of 30 x 30 (x10) µm. P-733 nan positioning and scanning stages feature very low profiles, as low as 20 mm (0.8 inch). The novel, high-stiffness direct drive gives the systems resonant frequencies as high as 2.2 kHz (4 x that of



Technical Data

Model	P-733.2CD P-733.2CL	P-733.3CD P-733.3CL	P-733.2DD	P-733.3DD	Units	Tolerance
Active axes	X, Y	X, Y, Z	X, Y	X, Y, Z		
Motion and positioning						
Integrated sensor	Capacitive	Capacitive	Capacitive	Capacitive		
Open-loop travel, -20 to +120 V	115 x 115	115 x 115 x 12	33 x 33	33 x 33 x 14	µm	min. (+20%/-0 %)
Closed-loop travel	100 x 100	100 x 100 x 10	30 x 30	30 x 30 x 10	µm	
Open-loop resolution	0.2	0.2 (0.1 in Z)	0.1	0.1	nm	typ.
Closed-loop resolution	0.3	0.3 (0.2 in Z)	0.1	0.1	nm	typ.
Linearity (X, Y)	0.03	0.03	0.03*	0.03*	%	typ.
Linearity (Z)	-	0.03	-	0.03*	%	typ.
Repeatability (X, Y)	<2	<2	<2	<2	nm	typ.
Repeatability (Z)	-	<1	-	<1	nm	typ.
Pitch (X,Y)	<±3	<±3	<±5	<±5	µrad	typ.
Yaw (X, Y)	<±10	<±10	<±10	<±10	µrad	typ.
Runout θZ (motion in Z)		<±5		<±5	µrad	typ.
Mechanical properties						
Stiffness	1.5	1.4 (9 in Z)	20	4 (10 in Z)	N/µm	±20 %
Unloaded resonant frequency	500	460 (1400 in Z)	2230	1200 (1100 in Z)	Hz	±20 %
Resonant frequency @ 120 g	370	340 (1060 in Z)	-	-	Hz	±20 %
Resonant frequency @ 200 g	340	295 (650 in Z)	1550	530 (635 in Z)	Hz	±20 %
Push/pull force capacity in motion direction	50/20	50/20	50/20	50/20	N	Max.
Drive properties						
Ceramic type	PICMA® P-885	PICMA® P-885	PICMA® P-885	PICMA® P-885		
Electrical capacitance	6	6 (2.4 in Z)	6.2	6.2 (3.3 in Z)	µF	±20 %
Dynamic operating current coefficient	7.5	7.5 (30 in Z)	25	25 (41 in Z)	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	0.58	0.675	0.58	0.675	kg	±5 %
Cable length	1.5	1.5	1.5	1.5	m	±10 mm
Sensor/ voltage connection	Sub-D special (CD-version) LEMO (CL-version)	Sub-D special (CD-version) LEMO (CL-version)	Sub-D special	Sub-D special		

*With digital controller. Non-linearity of direct drive stages measured with analog controllers is up to 0.1 % typ.

Recommended controller: Single-channel (1 per axis): E-610 servo controller / amplifier (p. 2-110), E -625 servo controller, bench-top (p. 2-114), E-621 controller module (p. 2-160)

Multi-channel: modular piezo controller system E-500 (p. 2-142) with amplifier module E-503 (three channels) (p. 2-146) or E-505 (1 per axis, high-power) (p. 2-147) and E-509 controller (p. 2-152)

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)