

# P-733.2 · P-733.3 XY(Z) Piezo-Nanopositioning Stage

## High-Precision XY(Z) Scanner Family with Aperture



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  $\mu\text{m}$  in X,Y & to 10  $\mu\text{m}$  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 and Dynamics**
- **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 nanopositioning and scanning systems. They provide a positioning and scanning range of 100 x 100 (x10)  $\mu\text{m}$  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.

### 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 nanopositioning 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)  $\mu\text{m}$ . P-733 nanopositioning 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

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 nanopositioning 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.

### Large Variety of Models for a Broad Range of Applications

For Z-axis scanning applications, the P-733.ZCD (see

### Ordering Information

#### P-733.2DD

High-Dynamics High-Precision XY Nanopositioning System, 30 x 30  $\mu\text{m}$ , Direct Drive, Capacitive Sensors, Parallel Metrology, Sub-D Connector

#### P-733.3DD

High-Dynamics Precision XYZ Nanopositioning System, 30 x 30 x 10  $\mu\text{m}$ , Direct Drive, Capacitive Sensors, Parallel Metrology, Sub-D Connector

#### P-733.2CD\* / P-733.2CL\*

High-Precision XY Nanopositioning System, 100 x 100  $\mu\text{m}$ , Capacitive Sensors, Parallel Metrology

#### P-733.3CD\* / P-733.3CL\*

Precision XYZ Nanopositioning System, 100 x 100 x 10  $\mu\text{m}$ , Capacitive Sensors, Parallel Metrology

#### P-733.2VL\* / P-733.2VD\*

High-Precision XY Nanopositioning System, 100 x 100  $\mu\text{m}$ , Capacitive Sensors, Parallel Metrology, Vacuum Compatible to 10-6 hPa

#### P-733.2UD

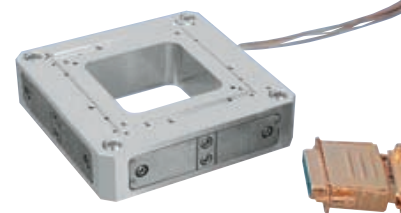
High-Precision XY Nanopositioning System, 100 x 100  $\mu\text{m}$ , Capacitive Sensors, parallel metrology, Sub-D Connector, Vacuum Compatible to 10-9 hPa

\*.xxD with Sub-D Connector

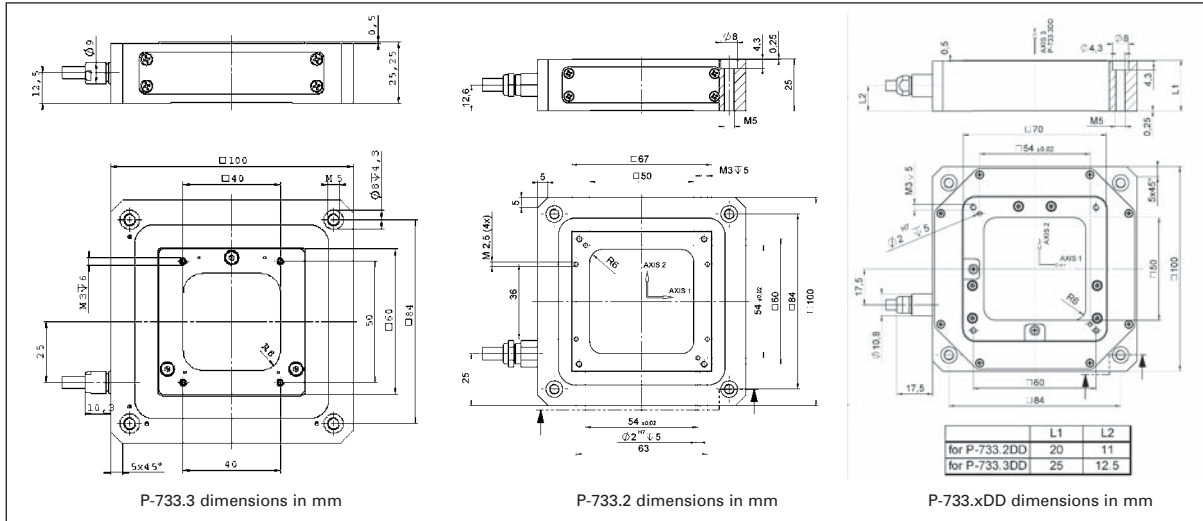
\*.xxL with LEMO Connector

**Ask about custom designs**

p. 2-42) version is available with a travel range of 100  $\mu\text{m}$ . For ultra-high-vacuum applications down to 10<sup>-9</sup> hPa, nanopositioning systems as well as comprehensive accessories, such as suitable feedthroughs, are available.



P-733.2UD non-magnetic XY scanning stage for UHV to 10<sup>-9</sup> hPa



## Linear Actuators &amp; Motors

## Nanopositioning / Piezoelectrics

## Piezo Flexure Stages / High-Speed Scanning Systems

Linear  
Vertical & Tip/Tilt

2- and 3-Axis

6-Axis

Fast Steering Mirrors / Active Optics

Piezo Drivers / Servo Controllers

Single-Channel

Multi-Channel

Modular

Accessories

## Piezoelectrics in Positioning

## Nanometrology

## Micropositioning

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## 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		
<b>Motion and positioning</b>						
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.
<b>Mechanical properties</b>						
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.
<b>Drive properties</b>						
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%
<b>Miscellaneous</b>						
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)

# P-733.Z High-Dynamics Z-Nanopositioner / Scanner

## Direct Position Metrology and Clear Aperture



P-733.ZCD Piezo Z-Stage

- Travel Range 100  $\mu\text{m}$
- Direct Metrology with Capacitive Sensors
- Resolution to 0.3 nm, Closed-Loop
- Clear Aperture 50 x 50 mm
- Versions with Additional Degrees of Freedom Available
- XY and XYZ Versions Also Available
- Vacuum-Compatible Versions Available

P-733.Z piezo vertical stages offer a positioning and scanning range of 100  $\mu\text{m}$  with sub-nanometer resolution. The 50 x 50 mm clear aperture is ideal for applications such as scanning or confocal microscopy. Their fast settling time of less than 10 ms allows high throughput rates.

### Application Examples

- Scanning microscopy
- Confocal microscopy
- Mask / wafer positioning
- Surface measurement technique
- Nano-imprinting
- Micromanipulation
- Image processing / stabilization
- Nanopositioning with high flatness & straightness

### Capacitive Sensors for Highest Accuracy

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 resolution of the P-733.Z is better than 0.3 nm.

Because of the direct measurement of the actual distance between the fixed frame and the moving part of the stage, errors in the drive train, actuator, lever arm or in guiding system do not influence the measuring accuracy. The result is exceptional motion linearity, higher long-term stability and a stiffer, more-responsive control loop, because external influ-

ences are immediately recognized by the sensor. The capacitive sensor non-linearity is typically less than 0.03%, the repeatability of the P-733.Z is better than 2 nm.

### Ceramic Insulated Piezo Actuators Provide Long Lifetime

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

### Large Variety of Models for a Broad Range of Applications

For scanning and positioning tasks in XY, the P-733.2CD and .3CD versions are available with a travel range of 100 x 100  $\mu\text{m}$ . For high-dynamics applications, the P-733.2DD

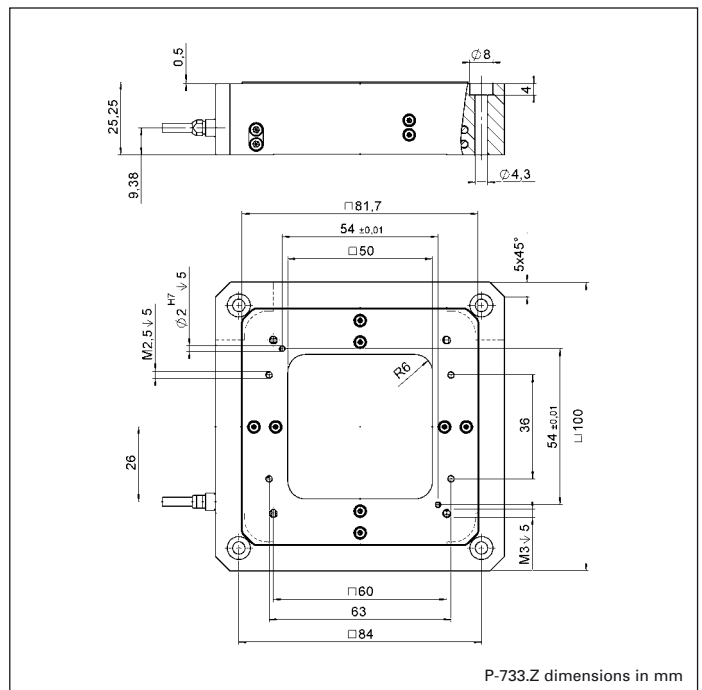
### Ordering Information

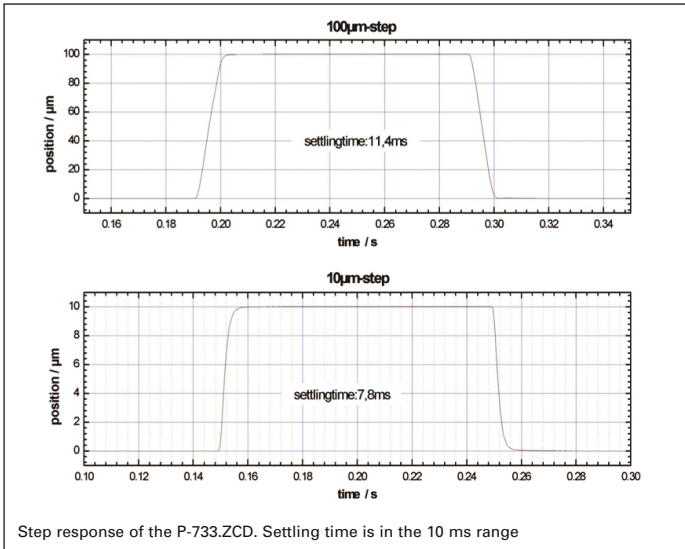
**P-733.ZCD**  
Compact Precision Nanopositioning Vertical Stage, 100  $\mu\text{m}$ , Capacitive Sensor, Sub-D Connector

**P-733.ZCL**  
Compact Precision Nanopositioning Vertical Stage, 100  $\mu\text{m}$ , Capacitive Sensor, LEMO Connector

and P-733.3DD models can be offered with direct drive and reduced travel range (see p. 2-62).

For ultra-high-vacuum applications down to 10<sup>-9</sup> hPa, nanopositioning systems as well as comprehensive accessories, such as suitable feedthroughs, are available.





#### System properties

System configuration	E-500 modular system with E-503 amplifier and E-509 sensor module; 20 g load
Amplifier bandwidth, small signal	96 Hz
Settling time (10% step width)	8 ms

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#### Nanopositioning / Piezoelectrics

#### Piezo Flexure Stages / High-Speed Scanning Systems

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#### Technical Data

Model	P-733.ZCD P-733.ZCL	Tolerance
Active axes	Z	
<b>Motion and positioning</b>		
Integrated sensor	Capacitive	
Open-loop travel, -20 to +120 V	115 µm	min. (+20%/-0%)
Closed-loop travel	100 µm	
Open-loop resolution	0.2 nm	typ.
Closed-loop resolution	0.3 nm	typ.
Linearity	0.03%	typ.
Repeatability	<2 nm	typ.
Rotation around Z	<10 µrad	typ.
Rotation around X	<5 µrad	typ.
Rotation around Y	<5 µrad	typ.
<b>Mechanical properties</b>		
Stiffness	2.5 N/µm	±20%
Unloaded resonant frequency	700 Hz	±20%
Resonant frequency @ 120 g	530 Hz	±20%
Resonant frequency @ 200 g	415 Hz	±20%
Push/pull force capacity	50 / 20 N	Max.
<b>Drive properties</b>		
Ceramic type	PICMA® P-885	
Electrical capacitance	6 µF	±20%
Dynamic operating current coefficient	7.5 µA/(Hz • µm)	±20%
<b>Miscellaneous</b>		
Operating temperature range	20 to 80 °C	
Material	Aluminum	
Dimensions	100 x 100 x 25 mm	
Mass	580 g	±5%
Cable length	1,5 m	±10 mm
Sensor connection	Sub-D special (CD-version); 2x LEMO (CL-version)	
Voltage connection	Sub-D special (CD-version); 1 x LEMO (CL-version)	

Dynamic Operating Current Coefficient in µA per Hz and mrad. Example: Sinusoidal scan of 10 µm at 10 Hz requires approximately 3 mA drive current.

Recommended controller

One channel: E-610 controller / amplifier (p. 2-110), E-625 bench-top controller (p. 2-114), E-621 modular controller (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)

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