

P-313 High-Linearity PicoCube XYZ Positioning and Scanning System

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Product Description

The P-313.30L/.30D (hereinafter referred to as “P-313”) is an open-loop XYZ piezo scanner with picometer precision which can be used for scanning probe microscopy.

Intended Use

The P-313 is a laboratory device as defined by DIN EN 61010-1. It is intended to be used in interior spaces and in an environment which is free of dirt, oil and lubricants.

Based on its design and realization, the P-313 is intended for fine positioning as well as the fast and precise motion of small objects. The specifications of the P-313 apply to horizontal mounting. The motion is performed in two axes horizontally (X, Y) and in one axis vertically (Z). The P-313 is not intended to be mounted vertically.

The intended use of the P-313 is only possible in combination with suitable electronics (p. 10) that are available from PI. The electronics are not included in the scope of delivery of the P-313.

The electronics must provide the required operating voltages.

Symbols and Typographic Conventions

The following symbols and typographic conventions are used in this user manual:

DANGER



Imminently hazardous situation

If not avoided, the hazardous situation will result in death or serious injury.



- Actions to take to avoid the situation.

NOTICE



Dangerous situation

If not avoided, the dangerous situation will result in damage to the equipment.

- Actions to take to avoid the situation.

INFORMATION

Information for easier handling, tricks, tips, etc.

Symbol/Label	Meaning
1. 2.	Action consisting of several steps whose sequential order must be observed
➤	Action consisting of one or several steps whose sequential order is irrelevant
▪	List item
p. 5	Cross-reference to page 5
RS-232	Labeling of an operating element on the product (example: socket of the RS-232 interface)
 	Warning signs on the product which refer to detailed information in this user manual

Other Applicable Documents

The devices which are mentioned in this user manual are described in their own manuals. The latest versions of the user manuals are available for download on our website (www.pi.ws).

Product	Document
E-536.30 PicoCube piezo controller, 3 channels, open-loop	PZ173E user manual

Safety Precautions

Electrical Dangers

DANGER



Risk of electric shock if the protective earth conductor is not connected!

If a protective earth conductor is not or not properly connected, dangerous touch voltages can occur on the P-313 in the case of malfunction or failure of the system. If touch voltages exist, touching the P-313 can result in serious injury or death from electric shock.

- Connect the P-313 to a protective earth conductor (p. 10) before start-up.
- Do **not** remove the protective earth conductor during operation.
- If the protective earth conductor has to be removed temporarily (e.g., in the case of modifications), reconnect the P-313 to the protective earth conductor before starting it up again.

DANGER**Dangerous voltage and residual charge on piezo actuators!**

The P-313 is driven by piezo actuators. Temperature changes and compressive stresses can induce charges in piezo actuators. After being disconnected from the electronics, piezo actuators can also stay charged for several hours. Touching or short-circuiting the contacts in the connector of the P-313 can result in serious injury or death from electric shock. In addition, the piezo actuators can be destroyed by an abrupt contraction.

- Do **not** open the P-313.
- Discharge the piezo actuators of the stage before installation:
Connect the stage to the switched-off PI controller, which is equipped with an internal discharge resistor.
- Do **not** pull out the connector from the electronics during operation.



Touching the contacts in the connector can result in serious injury or death from electric shock (max. 250 V DC).

- Do **not** touch the contacts in the connector.

Only for P-313.30D:

- Secure the Sub-D connector of the stage with screws against being pulled out of the controller.

Only for P-313.30L:

- Ensure that the Sub-D connector of the stage is connected to the P-893.2DPL adapter cable (p. 10).
- Take suitable measures to prevent the P-893.2DPL adapter cable from being accidentally disconnected from the Sub-D connector of the stage.

NOTICE**Damage from unsuitable cables!**

Unsuitable cables can damage the stage and the electronics.

- Only use cables provided by PI for connecting the P-313 to the electronics.

NOTICE**Destruction of the piezo actuator by electric flashovers!**

The use of the P-313 in environments that increase the electrical conductivity can lead to the destruction of the piezo actuator by electric flashovers. Electric flashovers can be caused by moisture, high humidity, liquids and conductive materials such as metal dust. In addition, electric flashovers can also occur in certain air pressure ranges due to the increased conductivity of the air.

- Avoid operating the P-313 in environments that can increase the electric conductivity.
- Only operate the P-313 within the permissible ambient conditions and classifications (p. 17).

NOTICE**Reduced lifetime of the piezo actuator due to permanently high voltage!**

The permanent application of a high static voltage to piezo actuators leads to a considerable reduction in the lifetime of the piezo ceramics of the actuator.

- When the P-313 is not used but the controller remains switched on to ensure temperature stability, discharge the P-313 (p. 14).

NOTICE**Operating voltage too high or incorrectly connected!**

Operating voltages that are too high or incorrectly connected can cause damage to the P-313.

- Only operate the P-313 with controllers/drivers and original accessories from PI.
- Do **not** exceed the operating voltage range (p. 16) for which the P-313 is specified.
- Only operate the P-313 when the operating voltage is properly connected; see "Pin Assignment" (p. 19).

NOTICE**Uncontrolled oscillation!**

Oscillations can cause irreparable damage to the stage. Oscillations are indicated by a humming and can result from operation of the stage near its resonant frequency.

- If you notice oscillations, immediately stop the stage.

Mechanical Dangers

NOTICE



Mechanical overload from incorrect handling!

Impermissible mechanical loading of the motion platform as well as certain surfaces of the P-313 can lead to damage to the piezo actuators and flexure joints of the P-313 as well as to loss of accuracy. In addition, the P-313 can be damaged from tensile forces on the cable exit and bending of the connecting cable.

- Only hold the P-313 on the edges of its base body.
- Avoid tensile forces on the cable exit and do not bend the cable.

NOTICE



Damage from incorrect mounting!

Incorrect mounting of the P-313 or incorrectly mounted parts can damage the P-313.

- Only mount the P-313 and the loads on the mounting fixtures (holes) intended for this purpose.

NOTICE



Damage due to incorrectly tightened screws!

Incorrectly tightened screws can cause damage.

- Observe the torque range (p. 19) given for the screws used during installation.

NOTICE



Mechanical overload due to high torques and high loads!

When affixing the load, high torques and high loads can overload the motion platform of the P-313. Mechanical overload can cause damage to the piezo actuators and flexure joints of the P-313 and lead to losses in accuracy.

- Observe the torque range (p. 19) given for the screws used during installation.
- Avoid torques >20 Ncm on the motion platform.
- Do **not** exceed the maximum permissible stress and load capacities according to the specifications (p. 16).

NOTICE**Warping of the P-313 due to affixing of loads with uneven contact surface!**

Affixing loads with an uneven contact surface can warp the P-313. Warping reduces the accuracy.

- Only affix loads on the P-313 whose contact surface with the motion platform of the stage has an evenness of at least 20 µm.
- For applications with great temperature changes:
Only affix loads on the P-313 that have the same or similar thermal expansion properties as the P-313.

NOTICE**Center of load at unsuitable position!**

If the center of load is located far outside of the motion platform (e.g., high set-ups and long levers), the P-313 can be damaged from high strain on the flexure guides, high torques and oscillations.

- If the center of the load to be affixed is far above or to the side of the motion platform, adjust the controller settings before start-up or contact our customer service department (p. 15).

NOTICE**Screws that are too long!**

The P-313 can be damaged by screws that are too long.

- Note the depth of the mounting holes in the motion platform (p. 18).
- Only use screws of the correct length for the respective mounting holes.

Model Overview

The following standard versions of the P-313 are available:

Model	Description
P-313.30L	High-linearity PicoCube XYZ positioning and scanning system, 1 µm × 1 µm × 0.6 µm, open-loop, LEMO connectors
P-313.30D	High-linearity PicoCube XYZ positioning and scanning system, 1 µm × 1 µm × 0.6 µm, open-loop, Sub-D connector

Product View

The figure serves as an example and can differ from your stage model.

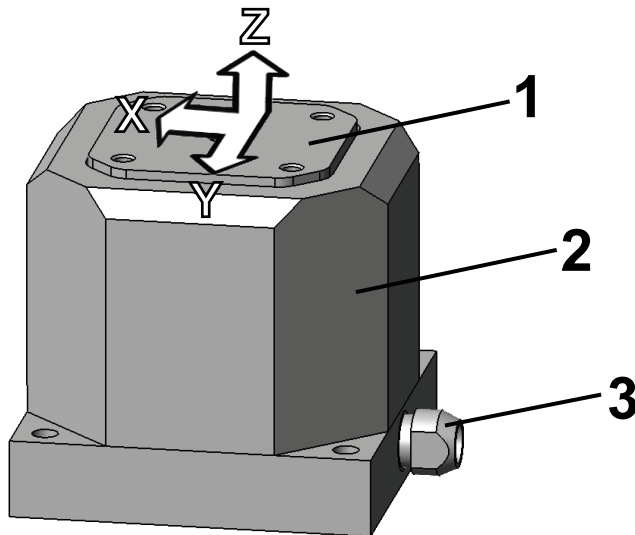


Figure 1: P-313 (example view)

- 1 Motion platform
- 2 Base body
- 3 Cable exit
- X, Y, Z: Positive directions of motion of the stage

Product Labeling

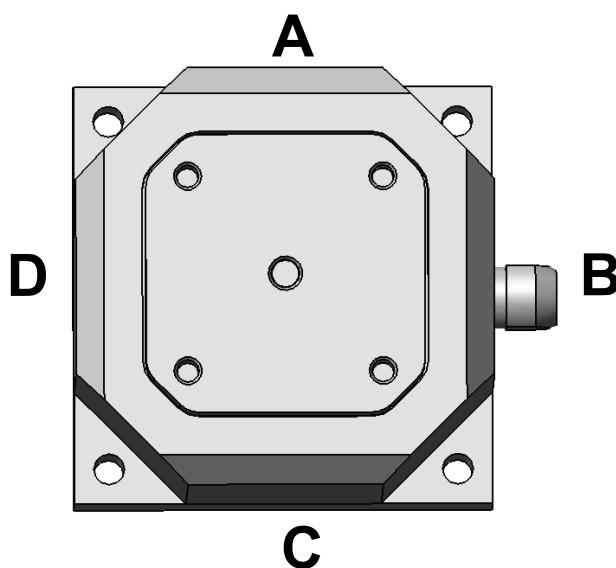


Figure 2: P-313: Position of the product labeling (example view from above)

Labeling	Description	Position
Triangular arrow with the letter X	Positive direction of motion of the X axis	A
Triangular arrow with the letter Y	Positive direction of motion of the Y axis	D
Triangular arrow with the letter Z	Positive direction of motion of the Z axis	C
	Manufacturer's logo	B
WWW.PI.WS	Manufacturer's address (website)	B
P-313.30	Product name (example), the places after the point refer to the model	B
117031266	Serial number (example), individual for each P-313 Meaning of the places (counting from left): 1 = internal information 2 and 3 = manufacturing year 4 to 9 = consecutive numbers	B
Country of origin: Germany	Country of origin	B
	Warning sign "Observe manual!"	B
	Old equipment disposal (p. 20)	B
	CE conformity mark	B
	Symbol for the protective earth conductor, marks the mounting holes to be used for connecting the P-313 to the protective earth conductor (p. 10)	B, D



Figure 3: P-313: "Residual voltage" warning sign on connector

Warning sign "Residual voltage": Notice of risk of electric shock (p. 3)

Scope of Delivery

Product number	Quantity	Items
P-313.30L or P-313.30D	1	High-linearity PicoCube XYZ positioning and scanning system according to order (p. 7)
P313T0001	1	User manual for P-313.30L and P-313.30D (this document)
Only for P-313.30L:		
P-893.2DPL	1	Adapter cable Sub-D to LEMO, 3 × HV LEMO, 1 m

Suitable Electronics

Product number	Description
E-536.30	PicoCube piezo controller, 3 channels, open-loop

Installation

Mounting the P-313 onto a Surface and Connecting it to the Protective Earth Conductor

INFORMATION

The contact of the P-313 with the protective earth conductor is made as follows:

- Four mounting holes in the base body of the P-313, marked with the  symbol for the protective earth conductor
- Suitable electrically conductive screws (p. 18)
- Protective earth conductor connected to the surface on which the P-313 is mounted

INFORMATION

- Observe the applicable standards for mounting the protective earth conductor.

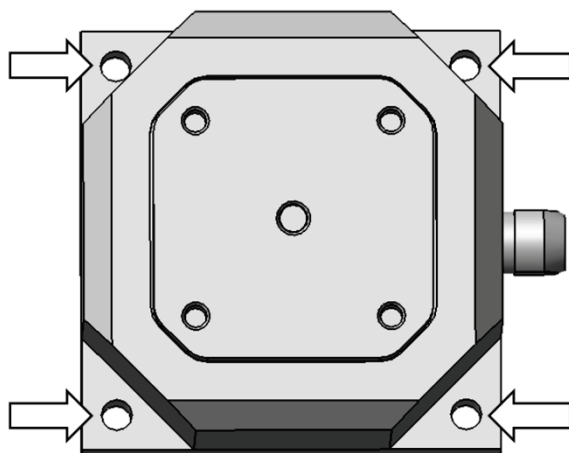


Figure 4: P-313: Mounting holes in the base body (see arrows)

Requirements

- ✓ You have read and understood the safety precautions (p. 3).
- ✓ You have provided a suitable surface (for the required position and depth of the holes for accommodating the screws, see "Dimensions", p. 18):
 - The surface must be connected to the protective earth conductor.
 - Four M2 holes are present.
 - The holes for accommodating the screws have to be sufficiently conductive to ensure the proper functioning of the protective earth conductor.
 - The recommended evenness of the surface is $\leq 10 \mu\text{m}$.
 - For applications with great temperature changes: The surface should have the same or similar thermal expansion properties as the P-313 (e.g., surface made of aluminum).
- ✓ You accounted for the space required for cable routing free of kinks and in accordance with regulations.
- ✓ The P-313 is **not** connected to the controller.

Tools and accessories

- Suitable protective earth conductor: Cross-sectional area of the cable $\geq 0.75 \text{ mm}^2$
- Four M2 screws of suitable length (p. 18)
- Suitable screwdriver

Mounting the P-313 onto a surface and connecting it to the protective earth conductor

1. Align the P-313 on the surface so that the corresponding holes in the P-313 and the surface overlap.
2. Introduce the four screws into the mounting holes in the base body of the P-313.
3. Tighten the screws crosswise with a torque of 20 Ncm each.
4. Make sure that the contact resistance is $<0.1 \Omega$ at 25 A at all connection points relevant for mounting the protective earth conductor.
5. Check that the P-313 fits on the surface without backlash.
6. If necessary, secure the screws with a thread-locking adhesive.

Affixing the Load to the P-313**INFORMATION**

The positive direction of motion of the axes is given in the product view (p. 8).

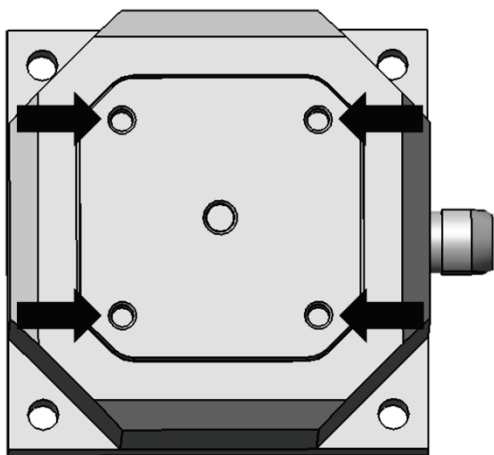


Figure 5: P-313: Mounting holes in the motion platform (see arrows)

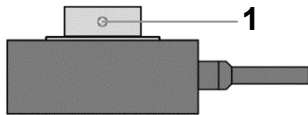
Center of load at the optimum position:

Figure 6: Example of an optimally placed load (1: center of load)

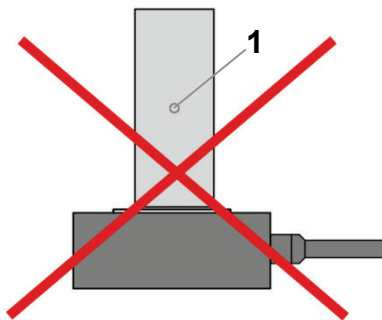
Center of load at an unsuitable position:

Figure 7: High set-up and center of load (1) far above the motion platform

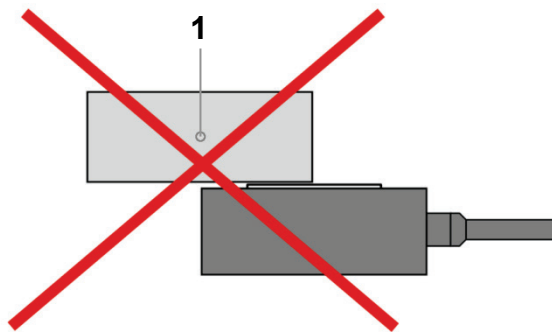


Figure 8: Long lever and center of load (1) on the side of the motion platform

Requirements

- ✓ You have read and understood the safety precautions (p. 3).

Tools and accessories

- Four M2 screws of suitable length (p. 18)
- Suitable tools

Affixing the load

- Only affix loads to the mounting holes (see arrows in Figure 5 on p. 12) intended for this purpose and with suitable screws. While doing so, observe the following:
 - Specified torque range for the mounting screws (p. 19)
 - Maximum permissible stress and load capacities according to the specifications (p. 16)
- Affix the load so that it is centered and that the center of load is on the motion platform.

Start-Up and Operation

Requirements

- ✓ You have read and understood the safety precautions (p. 3).

Start-up and operation

- Follow the instructions in the manual of the electronics used for start-up and operation of the P-313.

Discharging the P-313

The P-313 must be discharged in the following cases:

- Before installation
- If the P-313 is not used but the controller remains switched on to ensure temperature stability
- Before demounting (e.g., before cleaning and transporting the P-313 and for modifications)

The P-313 is discharged through the internal discharge resistor of the controller from PI.

Discharging a P-313 that is connected to the controller

- Set the piezo voltage to 0 V on the controller.

Discharging a P-313 that is not connected to the controller

- Connect the stage to the switched-off controller from PI.

Maintenance

NOTICE



Misalignment from loosening screws!

The P-313 is maintenance-free and achieves its positioning accuracy as a result of the optimum alignment of mechanical components and piezo actuators. Loosened screws cause a loss in positioning accuracy.

- Only loosen screws according to the instructions in this user manual.
- Do **not** open the P-313.

Cleaning the P-313

Requirements

- ✓ You have discharged the piezo actuators of the P-313 (p. 14).
- ✓ You have disconnected the P-313 from the controller.

Cleaning the P-313

- Clean the surfaces of the P-313 with a cloth that is dampened with a mild cleanser or disinfectant (e.g., ethanol or isopropyl alcohol).
- Do **not** do any ultrasonic cleaning.
- Do **not** use any organic solvents.

Customer Service

For inquiries and orders, contact your PI sales engineer or send us an email (service@pi.de).

If you have questions concerning your system, have the following information ready:

- Product and serial numbers of all products in the system
- Firmware version of the controller (if present)
- Version of the driver or the software (if present)
- Operating system on the PC (if present)

The latest versions of the user manuals are available for download on our website (www.pi.ws).

Specifications

	P-313 PicoCube XYZ scanner	Unit
Motion and positioning		
Active axes	X, Y, Z	
Travel range X,Y (± 250 V)	1	μm
Travel range Z (± 250 V)	0.6	μm
Resolution in X, Y	0.02	nm
Resolution in Z	0.14	nm
Mechanical properties		
Resonant frequency in X,Y	4	kHz
Resonant frequency in Z	11	kHz
Push / pull force capacity in motion direction	± 10	N
Load capacity	± 10	N
Miscellaneous		
Operating temperature range	5 to 40	$^{\circ}\text{C}$
Mass	80	g
Cable length	1.5	m
Voltage connection	Sub-D 24W7 (m)	

Maximum Ratings

P-313 stages are designed for the following operating data:

Maximum operating voltage 	Maximum operating frequency (unloaded) 	Maximum power consumption 
-250 to +250 V	2 kHz (in X) 2 kHz (in Y) 4 kHz (in Z)	3 W (in X) 3 W (in Y) 12 W (in Z)

Ambient Conditions and Classifications

The following ambient conditions and classifications must be observed for the P-313:

Area of application	For indoor use only
Maximum altitude	2000 m
Air pressure	1100 hPa to 0.1 hPa
Relative humidity	Highest relative humidity 80 % for temperatures up to 31 °C Decreasing linearly to 50 % relative humidity at 40 °C
Operating temperature	5 °C to 40 °C
Storage temperature	–25 °C to 85 °C
Transport temperature	–25 °C to 85 °C
Overvoltage category	II
Protection class	I
Degree of pollution	1
Degree of protection according to IEC 60529	IP20

Torque for Stainless Steel Screws (A2-70)

Screw size	Minimum torque	Maximum torque
M6	4 Nm	6 Nm
M5	2.5 Nm	3.5 Nm
M4	1.5 Nm	2.5 Nm
M3	0.8 Nm	1.1 Nm
M2.5	0.3 Nm	0.4 Nm
M2	0.15 Nm	0.2 Nm
M1.6	0.06 Nm	0.12 Nm

Pin Assignment

Connector: Sub-D 24W7 (m)

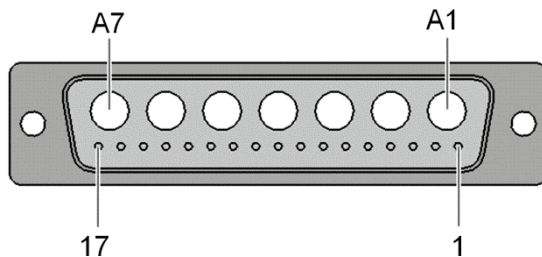


Figure 10: Back view of the Sub-D 24W7 (m) connector (solder side)

Pin(s)	Signal	Function	Remarks
A1	PZT X +	Piezo voltage +, X axis	On the inner conductor
A3	PZT Y +	Piezo voltage +, Y axis	On the inner conductor
A5	PZT Z +	Piezo voltage +, Z axis	On the inner conductor
A7	PZT Z GND	Piezo voltage –, Z axis	
1	PZT X GND	Piezo voltage –, X axis	
2-5	NC	Not connected	
6	PZT Y GND	Piezo voltage –, Y axis	
7-17	NC	Not connected	

Old Equipment Disposal

In accordance with the applicable EU law, electrical and electronic equipment may not be disposed of with unsorted municipal wastes in the member states of the EU.

When disposing of your old equipment, observe the international, national and local rules and regulations.

To meet the manufacturer's product responsibility with regard to this product, Physik Instrumente (PI) GmbH & Co. KG ensures environmentally correct disposal of old PI equipment that was first put into circulation after 13 August 2005, free of charge.

If you have old PI equipment, you can send it postage-free to the following address:

Physik Instrumente (PI) GmbH & Co. KG
Auf der Roemerstr. 1
D-76228 Karlsruhe, Germany



EC Declaration of Conformity

For the P-313, an EC Declaration of Conformity has been issued in accordance with the following European directives:

2006/95/EC, Low Voltage Directive
2004/108/EC, EMC Directive
2011/65/EU, RoHS Directive

The applied standards certifying the conformity are listed below.

Safety (Low Voltage Directive): EN 61010-1
EMC: EN 61326-1
RoHS: EN 50581

