

PZ268D
P-616 NanoCube® XYZ Nanopositioner
User Manual

Version: 1.0.2

Date: 17.01.2018



This document describes the following product:

- **P-616.3C**
Parallel-kinematic NanoCube®
XYZ nanopositioner,
100 µm × 100 µm × 100 µm travel range,
capacitive sensors



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The products described in this document are in part protected by the following patents:

German patent no. 10021919C2

German patent no. 10234787C1

German patent no. 10348836B3

German patent no. 102005015405B3

German patent no. 102007011652B4

US patent no. 7,449,077

Japanese patent no. 4667863

Chinese patent no. ZL03813218.4

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Subject to change without notice. This manual is superseded by any new release. The latest release is available for download (p. 3) on our website.

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1 About this Document

In this Chapter

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1.1 Objective and Target Audience of this User Manual

This user manual contains the information needed for the intended use of the P-616. Basic knowledge of servo systems, drive technologies, and suitable safety measures is assumed.

1.2 Symbols and Typographic Conventions

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

CAUTION



Dangerous situation

If not avoided, the dangerous situation will result in minor 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.	Action consisting of several steps whose sequential order must be observed
2.	
➤	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 affixed to the product that refer to detailed information in this manual.

1.3 Figures

For better understandability, the colors, proportions, and degree of detail in illustrations can deviate from the actual circumstances. Photographic illustrations may also differ and must not be seen as guaranteed properties.

1.4 Other Applicable Documents

The devices and software tools that are mentioned in this documentation are described in their own manuals.

The latest versions of the user manuals are available for download (p. 3) on our website.

Product	Document
E-727 Digital multi-channel piezo controller	E727T0005 user documentation
PIMikroMove	SM148E software manual
P-5xx / P-6xx / P-7xx piezo positioning systems	PZ240EK short instructions

1.5 Downloading Manuals

INFORMATION

If a manual is missing or problems occur with downloading:

- Contact our customer service department (p. 31).

INFORMATION

For products that are supplied with software (CD in the scope of delivery), access to the manuals is protected by a password. Protected content is only displayed on the website after entering the access data.

You need the product CD to get the access data.

For products with CD: Get access data

1. Insert the product CD into the PC drive.
2. Switch to the Manuals directory on the CD.
3. In the Manuals directory, open the Release News (file including *releasenews* in the file name).
4. Get the access data for downloading protected content in the "User login for software download" section of the Release News. Possible methods for getting:
 - Link to a page for registering and requesting the access data
 - Direct input of user name and password
5. If the access data needs to be requested via a registration page:
 - a) Follow the link in the Release News.
 - b) Enter the required information in the browser window.
 - c) Click **Show login data** in the browser window.
 - d) Note the user name and password shown in the browser window.

Downloading Manuals

If you have requested access data for protected contents via a registration page (see above):

- Click the links in the browser window to change to the content for your product and login in using the access data that you received.

General procedure:

1. Open the website **www.pi.ws**.
2. If access to the manuals is protected by a password:
 - a) Click **Login**.
 - b) Log in with the user name and password.
3. Click **Search**.

4. Enter the product number up to the period (e.g., P-882) or the product family (e.g., PICMA® Bender) into the search field.
5. Click **Start search** or press the **Enter** key.
6. Open the corresponding product detail page in the list of search results:
 - a) If necessary: Scroll down the list.
 - b) If necessary: Click **Load more results** at the bottom of the list.
 - c) Click the corresponding product in the list.
7. Scroll down to the **Downloads** section on the product detail page.

The manuals are shown under **Documentation**.
8. Click the desired manual and save it to the hard disk of your PC or to a data storage medium.

2 Safety

In this Chapter

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General Safety Instructions.....	5
Organizational Measures.....	6

2.1 Intended Use

The P-616 is a laboratory device as defined by DIN EN 61010-1. It is intended for indoor use and use in an environment that is free of dirt, oil, and lubricants.

In accordance with its design, the P-616 is intended for fine positioning in three axes at right angles to each other with one center of rotation (parallel kinematics). The P-616 is suitable for fast precision motion of smaller objects. It can be mounted in any orientation.

The intended use of the P-616 is only possible in conjunction with suitable electronics (p. 11) available from PI. The electronics are not included in the scope of delivery of the P-616.

The electronics must provide the required operating voltages. For closed-loop operation, it must be in a position to read out and process the signals of the position sensors.

2.2 General Safety Instructions

The P-616 is built according to state-of-the-art technology and recognized safety standards. Improper use can result in personal injury and/or damage to the P-616.

- Only use the P-616 for its intended purpose, and only use it if it is in a good working order.
- Read the user manual.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for the correct installation and operation of the P-616.

The P-616 is driven by piezo actuators. Temperature changes and compressive stresses can induce charges in piezo actuators. After disconnection from the electronics, piezo actuators can remain charged for several hours. Touching or short-circuiting the contacts in the connector of the P-616 can lead to minor injuries from electric shock. The piezo actuators can be destroyed by an abrupt contraction.

- Do **not** open the P-616.

- 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 the connector out of the electronics during operation.

For stages with Sub-D connector:

Touching the contacts in the connector can lead to an electric shock (max. 130 V DC) and minor injuries.

- Do **not** touch the contacts in the connector.
- Secure the connector of the stage with screws against being pulled out of the controller.

If a protective earth conductor is not or not properly connected, dangerous touch voltages can occur on the P-616 in the case of malfunction or failure of the system. If touch voltages exist, touching the P-616 can result in minor injuries from electric shock.

- Connect the P-616 to a protective earth conductor (p. 16) before startup.
- 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-616 to the protective earth conductor before starting it up again.

Mechanical forces can damage or misalign the P-616.

- Avoid impacts that affect the P-616.
- Do **not** drop the P-616.
- Do **not** exceed the maximum permissible stress and load capacities according to the specifications (p. 33).
- Only hold the P-616 by the holding surfaces of the base body (p. 13).

The P-616 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 manual.
- Do **not** open the P-616.

2.3 Organizational Measures

User manual

- Always keep this user manual available with the P-616.
The latest versions of the user manuals are available for download (p. 3) on our website.
- Add all information from the manufacturer to the user manual, for example supplements or technical notes.

- If you give the P-616 to other users, also include this user manual as well as other relevant information provided by the manufacturer.
- Only use the device on the basis of the complete user manual. Missing information due to an incomplete user manual can result in minor injury and damage to equipment.
- Only install and operate the P-616 after you have read and understood this user manual.

Personnel qualification

The P-616 may only be installed, started up, operated, maintained, and cleaned by authorized and appropriately qualified personnel.

3 Product Description

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 Suitable Electronics..... 11
 Technical Features 12

3.1 Product View

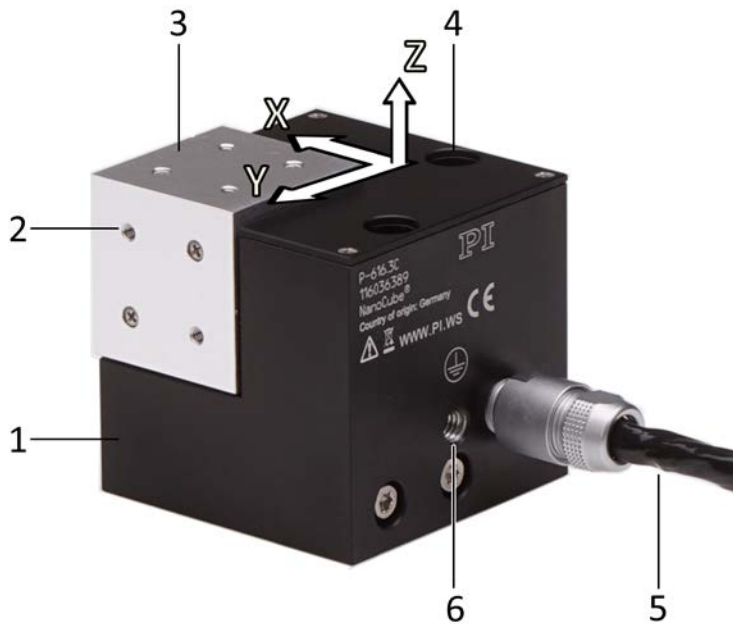


Figure 1: P-616

- 1 Base body
 - 2 M2 hole for mounting the load, depth 2.5 mm (3 × 2 M2 holes)
 - 3 XYZ mounting platform (moving part of the P-616, also designated "motion platform")
 - 4 Countersunk holes for mounting onto a surface (2×)
 - 5 Cable exit (supply voltage, sensor)
 - 6 M4 hole for protective earth connection
- The arrows each represent the positive direction of motion.

3.2 Product Labeling

Labeling	Description
P-616.3C	Product name
117031266	Serial number (example), individual for each P-616 Meaning of the places (counting from left): 1 = internal information, 2 and 3 = year of manufacture, 4 to 9 = consecutive numbers
NanoCube®	Brand name
Country of origin: Germany	Country of origin
	Manufacturer's logo
	Warning sign "Observe manual!"
	Old equipment disposal (p. 39)
WWW.PI.WS	Manufacturer's address (website)
	CE conformity mark
	Symbol for the protective earth conductor, marks the protective earth connection of the P-616 (p. 16)



Figure 2: "Residual Voltage" warning sign on the connector of the P-616

Warning sign "Residual Voltage": Indicates risk of electric shock (p. 5)

3.3 Scope of Delivery

Product number	Components
P-616	Parallel-kinematic NanoCube® XYZ nanopositioner, 100 µm × 100 µm × 100 µm travel range, capacitive sensors
000036450	M4 screw set for protective earth, consisting of: <ul style="list-style-type: none"> ▪ 1 flat-head screw with cross recess, M4x8, ISO 7045 ▪ 2 safety washers ▪ 2 flat washers
P616T0004	TN for unpacking the P-616
PZ240EK	Short instructions for piezo positioning systems
Only when ordering a system with analog controller or amplifier*	
P-895.3DLC	Adapter cable sub-D 25W3 (f) to LEMO for piezo actuator nanopositioning systems with capacitive sensors, 3 channels, 0.3 m

* E-500.00 / E-501.00 and E-663.00 (p. 11)

3.4 Accessories

Product number	Description
E-518.I3	Interface module, 3 channels, TCP/IP, USB, and RS-232 interfaces
E-515.03	Display module for piezo voltage and displacement, 3 channels

➤ To order, contact our customer service department (p. 31).

3.5 Suitable Electronics

The P-616 must be connected to suitable electronics. The following devices from PI are suitable for operation of the P-616:

Product number	Description
E-727.3CD	Digital multi-channel piezo controller, 3 axes, -30 to 130 V, capacitive sensors, sub-D 25W3 socket
E-727.3CDA	Digital multi-channel piezo controller, 3 axes, -30 to 130 V, capacitive sensors, Sub-D 25W3 socket, analog inputs
E-500.00 / E-501.00	Modular piezo controller, consisting of: <ul style="list-style-type: none"> ▪ E-503.00 piezo amplifier module ▪ E-509.C3A sensor / servo controller module Optional: E-518 interface module and E-515 display module
E-663.00	Piezo amplifier, 3 channels, -20 to 120 V, benchtop device

INFORMATION

The P-895.3DLC adapter cable is necessary for the analog controller and/or E-500/E-501 and E-663 drivers, available as optional accessories (p. 11).

PC software is included in the scope of delivery of the controllers from PI. The operation of the controllers is described in the corresponding user manuals.

3.6 Technical Features

3.6.1 PICMA® Piezo Actuators

P-616 stages are driven by PICMA® piezo actuators. PICMA® actuators have all-ceramic insulation and are therefore far superior to conventional actuators in respect to performance and lifetime. The monolithic piezoceramic block is protected against humidity and failure due to increased leakage current by a ceramic insulation layer. In this way, an especially high reliability is achieved even under extreme ambient conditions. In contrast to motorized drives, there are no rotating parts or friction. The piezo actuators are therefore free of backlash, maintenance, and wear.

3.6.2 Flexure Guides

P-616 stages have flexure guides (flexures) for frictionless motion and high guiding accuracy.

A flexure guide is an element which is free from static and sliding friction. It is based on the elastic deformation (bending) of a solid (e.g., steel) and does not have any rolling or sliding parts. Flexure elements have a high stiffness and load capacity. Flexure guides are maintenance and wear free. They are 100 % vacuum compatible, function in a wide temperature range and do not require any lubricants.

3.6.3 Capacitive Sensors

Capacitive sensors measure the position directly on the motion platform (direct metrology) and work without contact. Neither friction nor hysteresis interferes with the motion, which allows excellent linearity values to be achieved together with the high position resolution. In conjunction with suitable electronics, capacitive sensors achieve the best resolution, stability, and bandwidth.

4 Unpacking

NOTICE



Damage to the P-616 due to incorrect handling!

Impermissible mechanical stress on the cover of the bottom side of the P-616 and the XYZ mounting platform can damage the P-616 and lead to loss of accuracy.

- Avoid mechanical stress on the bottom side of the P-616 and the XYZ mounting platform, see figure below.

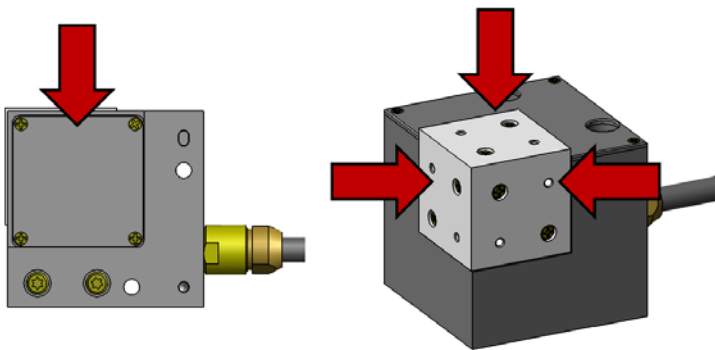


Figure 3: The marked surfaces may not be subject to mechanical stress. Left: Cover of the bottom side of the P-616, right: The surfaces of the XYZ mounting platform

1. Unpack the P-616 with care.
 - Do not exert any force onto the following points:
 - the cover of the bottom side of the P-616
 - the surfaces of the XYZ mounting platform
2. Compare the contents with the items listed in the contract and the packing list.
3. Inspect the contents for signs of damage. If there is any sign of damage or missing parts, contact PI immediately.
4. Keep all packaging materials in case the product needs to be returned.

5 Installation

In this Chapter

General Notes on Installation	15
Connecting the P-616 to the Protective Earth Conductor	16
Mounting the P-616	17
Affixing the Load	19
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5.1 General Notes on Installation

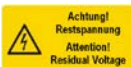
CAUTION



Dangerous voltage and residual charge on piezo actuators!

The P-616 is driven by piezo actuators. Temperature changes and compressive stresses can induce charges in piezo actuators. After disconnection from the electronics, piezo actuators can remain charged for several hours. Touching or short-circuiting the contacts in the connector of the P-616 can lead to minor injuries from electric shock. The piezo actuators can be destroyed by an abrupt contraction.

- Do **not** open the P-616.
- 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 the connector out of the electronics during operation.



For stages with Sub-D connector:

Touching the contacts in the connector can lead to an electric shock (max. 130 V DC) and minor injuries.

- Do **not** touch the contacts in the connector.
- Secure the connector of the stage with screws against being pulled out of the controller.

NOTICE



Mechanical overload from incorrect handling!

Impermissible mechanical loading of the motion platform as well as certain surfaces of the P-616 can cause damage to the piezo actuators, sensors and flexures of the P-616 as well as loss of accuracy. In addition, the P-616 can be damaged by tensile forces on the cable exit and bending of the connecting cable.

- Hold the P-616 by its base body (p. 9) only.
- Avoid tensile forces on the cable exit and do not bend the cable.

NOTICE**Damage due to unsuitable cables!**

Unsuitable cables can damage the P-616 and the electronics.

- Only use cables provided by PI for connecting the P-616 to the electronics.

NOTICE**Damage due to improper mounting!**

Improper mounting of the P-616 or incorrectly mounted parts can damage the P-616.

- Only mount the P-616 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. 37) given for the screws used during installation.

INFORMATION


Extended cables can reduce the positioning accuracy of the P-616 or affect the sensor processing by the electronics.

- If you need longer cables, contact our customer service department (p. 31).

5.2 Connecting the P-616 to the Protective Earth Conductor

INFORMATION

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

The P-616 has an M4 hole for mounting the protective earth conductor. This hole is marked with the symbol for the protective earth conductor  (see "Dimensions" (p. 36)).

Requirements

- ✓ You have read and understood the general notes on installation (p. 15).
- ✓ The P-616 is **not** connected to the electronics.

Tools and accessories

- Suitable protective earth conductor: Cross-sectional area of the cable $\geq 0.75 \text{ mm}^2$
- Supplied M4 protective earth screw set (p. 11) for connecting the protective earth conductor
- Suitable screwdriver

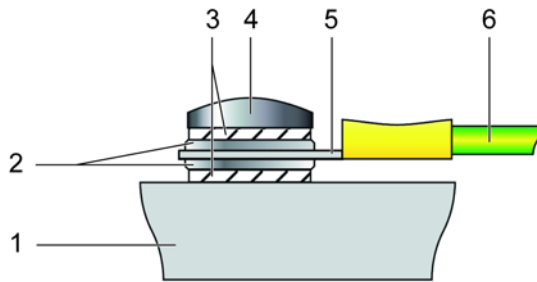


Figure 4: Connecting the protective earth conductor (profile view)

- | | |
|---|----------------------------|
| 1 | Base body of the P-616 |
| 2 | Flat washer |
| 3 | Safety washer |
| 4 | Screw |
| 5 | Cable lug |
| 6 | Protective earth conductor |

Connecting the P-616 to the protective earth conductor

1. If necessary, attach a suitable cable lug to the protective earth conductor.
2. Use the M4 screw (together with the washers and self-locking washers) to affix the cable lug of the protective earth conductor to the protective earth connection of the P-616 as shown in the profile view.
3. Tighten the M4 screw with a torque of 1.2 Nm to 1.5 Nm.
4. Make sure that the contact resistance at all connection points relevant for connecting the protective earth conductor is $<0.1 \Omega$ at 25 A.

5.3 Mounting the P-616

NOTICE



Warping of the P-616 due to mounting on uneven surfaces!

Mounting the P-616 on an uneven surface can warp the P-616. Warping reduces the accuracy.

- Mount the P-616 onto an even surface. The recommended flatness of the surface is $\leq 100 \mu\text{m}$.
- For applications with large temperature changes:
Only mount the P-616 on surfaces that have the same or similar thermal expansion properties as the P-616.

NOTICE



Protruding screw heads!

Protruding screw heads can damage the P-616.

- Ensure that the screw heads do not protrude from countersunk holes so that they do not interfere with the stage motion.

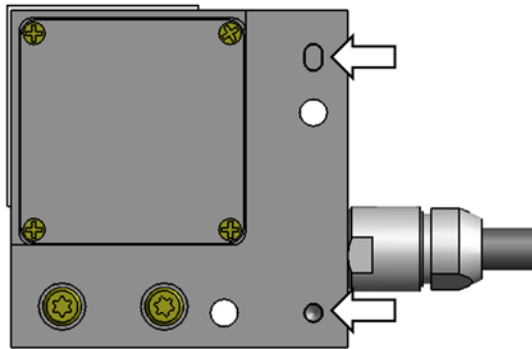


Figure 5: Holes for the locating pins on the bottom side of the P-616 for aligning the P-616

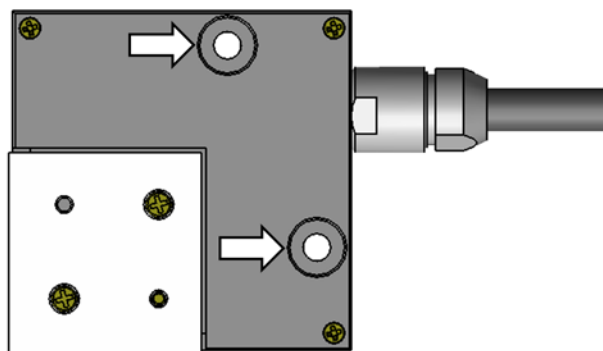


Figure 6: Countersunk holes, \varnothing 3.2 mm / \varnothing 6.5 mm for mounting the P-616

Requirements

- ✓ You have read and understood the general notes on installation (p. 15).

Tools and accessories

- For the dimensions of the P-616 and the position and depth of the holes, see "Dimensions" (p. 36).
- Optional: 2 locating pins (e.g., 2m6 or 2h6) of suitable length, for holes \varnothing 2 mm H7
- 2 M3 screws of suitable length, at least M3x25
- Suitable screwdriver

Mounting the P-616

1. Position the stage on an even surface. Optional: Align the P-616 on the surface with the locating pins.
2. Insert the screws into the countersunk holes in the base body of the P-616 from above.
3. Tighten the screws.

Maximum torque: 1.1 Nm

5.4 Affixing the Load

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-616. Mechanical overload can cause damage to the piezo actuators, sensors, and flexures of the P-616 and lead to loss in accuracy.

- Observe the torque range (p. 37) given for the screws used during installation.
- Avoid torques >50 Ncm on the motion platform.
- Do **not** exceed the maximum permissible stress and load capacities according to the specifications (p. 33).

NOTICE



Warping of the P-616 due to affixing of loads with uneven contact surface!

Affixing loads with an uneven contact surface can warp the P-616. Warping reduces the accuracy.

- Only affix loads on the P-616 whose contact surface with the motion platform of the stage has a flatness of at least 100 µm.
- For applications with large temperature changes:
Only affix loads to the P-616 that have the same or similar thermal expansion properties as the P-616.

NOTICE



Center of load at unsuitable position!

If the center of load is located too far away from the center of the motion platform (e.g., tall loads and unwanted lever effect), the P-616 can be damaged by high strain on the flexure guides, high torques, and oscillation, especially when operated dynamically.

- If the center of the load to be affixed is too far above or to the side of the motion platform, adjust the controller settings before startup or contact our customer service department (p. 31).

NOTICE



Screws that are too long!

The P-616 can be damaged by screws that are too long.

- Note the depth of the mounting holes in the motion platform (p. 36).
- Only use screws of the correct length for the respective mounting holes.

INFORMATION

The positive direction of motion of the axes is given in the product view (p. 9).

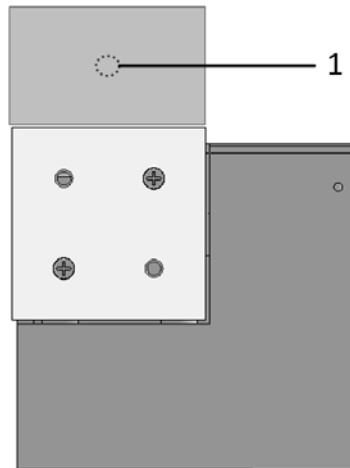
Center of load at the optimum position:

Figure 7: Example of an optimally placed load

1 Load center

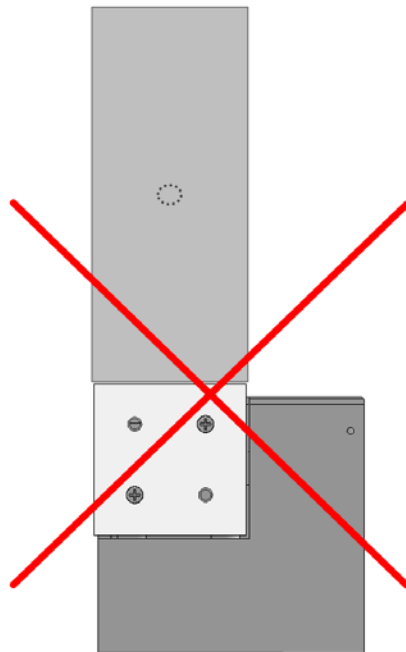
Center of load at an unsuitable position:

Figure 8: Tall load and center of load too far above the motion platform

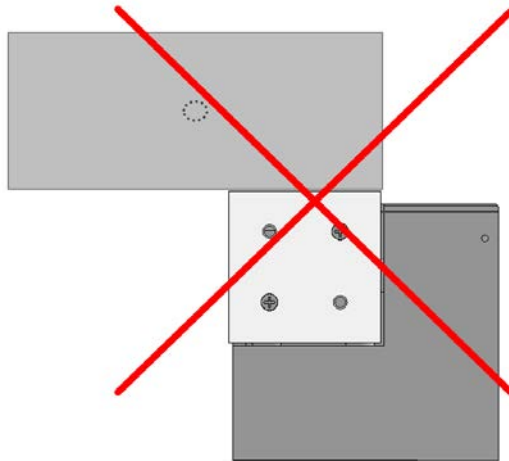


Figure 9: Unwanted lever effect and center of load on the side of the motion platform

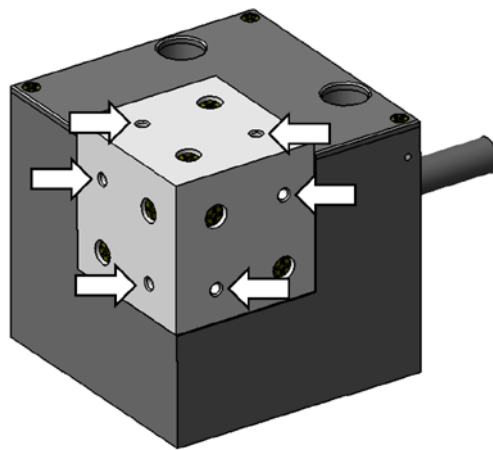


Figure 10: Holes for affixing the load

Requirements

- ✓ You have read and understood the general notes on installation (p. 15).

Tools and accessories

- M2 screws of suitable length, see "Dimensions" (p. 36)
- Suitable tools

Affixing the load

- Only affix loads with suitable screws to the threaded holes intended for this purpose:
 - Pay attention to the specified torque range (p. 37) for the screws.
 - Avoid torques >50 Ncm on the motion platform.
- Affix the load so that its center is at the middle of the XYZ mounting platform.

5.5 Connecting the P-616 to the Electronics

INFORMATION

Systems consisting of a P-616 and electronics are calibrated at the factory to achieve optimum performance.

- Pay attention to the assignment of the axes to the channels that are specified on the calibration label of the electronics.

Requirements

- ✓ You have read and understood the general notes on installation (p. 15).
- ✓ You have installed suitable electronics (p. 11).
- ✓ You have read and understood the user manual of the electronics.
- ✓ The electronics are switched off, i.e., **not** connected to the power supply.

Tools and accessories

- When connecting to electronics with LEMO sockets: P-895.3DLC (p. 11) adapter cable

Connecting the P-616 to the E-727 controller

1. Plug the connector of the P-616 into the corresponding socket of the controller (see user manual of the controller).
2. Use the integrated screws to secure the connection against accidental disconnection.

Connect the P-616 to the E-50x modules or E-663.00 piezo amplifier with the P-895.3DLC adapter cable

1. Connect the Sub-D 25W3 (m) connector of the P-616 to the Sub-D 25W3 (f) connection of the adapter cable.
2. Connect the piezo connections of the adapter cable to the piezo connection of the E-503.00 or E-663.00 piezo amplifier module as follows.
 - **PZT1** to **PZT** for channel 1 (**CH1**)
 - **PZT2** to **PZT** for channel 2 (**CH2**)
 - **PZT3** to **PZT** for channel 3 (**CH3**)
3. When connecting to the E-50x modules: Connect the sensor connections of the adapter cable to the E-509.C3A control module as follows:
 - **T1** to **T** for channel 1 (**SERVO 1**)
 - **P1** to **P** for channel 1 (**SERVO 1**)
 - **T2** to **T** for channel 2 (**SERVO 2**)
 - **P2** to **P** for channel 2 (**SERVO 2**)
 - **T3** to **T** for channel 3 (**SERVO 3**)
 - **P3** to **P** for channel 3 (**SERVO 3**)

6 Startup and Operation

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6.1 General Notes on Startup and Operation

CAUTION



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-616 in the case of malfunction or failure of the system. If touch voltages exist, touching the P-616 can result in minor injuries from electric shock.

- Connect the P-616 to a protective earth conductor (p. 16) before startup.
- 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-616 to the protective earth conductor before starting it up again.

NOTICE



Destruction of the piezo actuator due to electric flashovers!

Using the P-616 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 (e.g., 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-616 in environments that can increase the electric conductivity.
- Only operate the P-616 within the permissible ambient conditions and classifications (p. 35).

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 ceramic.

- When the P-616 is not used but the electronics remain switched on to ensure temperature stability, discharge the P-616 (p. 25).

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

Operating voltages that are too high or incorrectly connected can cause damage to the P-616.

- Only operate the P-616 with controllers/drivers and original accessories from PI.
- Do **not** exceed the operating voltage range (p. 34) for which the P-616 is specified.
- Only operate the P-616 when the operating voltage is properly connected; see "Pin Assignment" (p. 37).

NOTICE**Uncontrolled oscillation!**

Oscillation can cause irreparable damage to the P-616. Oscillation is indicated by a humming noise and can be caused by the following:

- A change in the load and/or dynamics requires the servo-control parameters to be adjusted.
- The P-616 is operated near to its resonant frequency.

If you notice oscillation:

- In closed-loop operation, switch off the servo mode immediately.
- In open-loop operation, stop the P-616 immediately.

INFORMATION

The positive direction of motion of the axes is given in the product view (p. 9).

INFORMATION

Sound and vibration (e.g., footfall, knocks) can be transmitted to the P-616 and can affect its performance with regard to position stability.

- Avoid sound and vibration while the P-616 is being operated.

6.2 Operating the P-616

- Follow the instructions in the manual of the controller (p. 11) used for startup and operation of the P-616.

6.3 Discharging the P-616

The P-616 must be discharged in the following cases:

- Before installation
- If the P-616 is not used and the controller remains switched on to ensure temperature stability
- Before demounting (e.g., before cleaning and transporting the P-616 and for modifications)

The P-616 is discharged via the internal discharge resistor of the controller from PI.

Discharging an P-616 that is connected to the controller

In closed-loop operation:

1. Switch off the servo mode on the controller.
2. Set the piezo voltage to 0 V on the controller.

In open-loop operation:

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

Discharging an P-616 that is not connected to the controller

- Connect the P-616 to the switched-off controller from PI.

7 Maintenance

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7.1 General Notes on Maintenance

NOTICE



Misalignment due to loosening screws!

The P-616 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 manual.
- Do **not** open the P-616.

7.2 Cleaning the P-616

Requirements

- ✓ You have discharged the piezo actuators of the P-616 (p. 25).
- ✓ You have disconnected the P-616 from the controller.

Cleaning the P-616

- Clean the surfaces of the P-616 with a cloth dampened with a mild cleanser or disinfectant (e.g., isopropyl alcohol).
- Do **not** do any ultrasonic cleaning.

8 Troubleshooting

Problem	Possible causes	Solution
No or limited motion	Cable not connected correctly	➤ Check the cable connections.
	Excessive load	➤ Do not exceed the maximum permissible stress and load capacities according to the specifications (p. 33).
	Zero-point adjustment of the sensor for the following reasons: <ul style="list-style-type: none"> ▪ Load applied in direction of motion ▪ Ambient/ operating temperature of the stage far above or below calibration temperature (21°C to 24°C) 	➤ Perform a zero-point adjustment of the sensor (see controller manual).
Reduced accuracy	Warping of the base body or the XYZ mounting platform	<ul style="list-style-type: none"> ➤ Only mount the P-616 on surfaces with the following characteristics: <ul style="list-style-type: none"> – Flatness of at least 100 µm – The thermal expansion properties are similar to those of the P-616 (e.g., surfaces made of aluminum). ➤ Only affix loads with the following characteristics on the P-616: <ul style="list-style-type: none"> – The contact surface of the load has a flatness of at least 100 µm. – The thermal expansion properties are similar to those of the P-616 (e. g. loads made of aluminum).

	The stage is not connected to the corresponding controller (only with several systems)	➤ Observe the assignment of the devices when several systems are connected. The assignment is indicated on the calibration label of the controller (see rear panel or bottom side), which contains the serial number of the stage to be connected.
The stage starts oscillating or positions inaccurately	Servo-control parameters incorrectly set because e. g. the load was changed	<ol style="list-style-type: none"> 1. Immediately switch off the servo mode of the corresponding stage axes. 2. Check the settings of the servo-control parameters on the controller. 3. Adjust the servo-control parameters on the controller according to the load change.
	Open-loop operation near the resonant frequency	➤ In open-loop operation, only operate the stage with a frequency that is below the resonant frequency.

If the problem that occurred with your system is not listed in the table above or cannot be solved as described, contact our customer service department (p. 31).

9 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 available)
 - Version of the driver or the software (if available)
 - Operating system on the PC (if available)
- If possible: Take photographs or make videos of your system that can be sent to our customer service department if requested.

The latest versions of the user manuals are available for download (p. 3) on our website.

10 Technical Data

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10.1 Specifications

10.1.1 Data Table

	P-616.3C	Unit	Tolerance
Motion and positioning			
Active axes	X, Y, Z		
Travel range at -20 to 120 V, open loop	110 / axis	μm	+20 % / -0 %
Closed-loop travel range	100 / axis	μm	+20 % / -0 %
Resolution, 1 σ , open loop*	0.3	nm	typ.
Resolution, 1 σ , closed loop*	0.4	nm	typ.
Linearity error, for the entire travel range, with digital controller (E-727.3CD)	0.03	%	typ.
Bidirectional repeatability, 1 σ , 10 % travel range	<10	nm	typ.
Bidirectional repeatability, 1 σ , 100 % travel range	<15	nm	typ.
Sensor			
Sensor type	Capacitive sensors		
Mechanical properties			
Stiffness	0.5	N/μm	±10 %
Resonant frequency X / Y / Z, no load	700	Hz	±10 %
Resonant frequency with 38 g load X / Y / Z	380	Hz	±20 %
Resonant frequency with 100 g load X / Y / Z	250	Hz	±20 %
Push/pull force capacity	15	N	max.
Maximum permissible torque	0.4	Nm	max.
Recommended maximum load	300	g	max.

	P-616.3C	Unit	Tolerance
Drive properties			
Ceramic type	PICMA® P-885.50		
Electrical capacitance	1.5 / axis	µF	±20 %
Miscellaneous			
Operating temperature range	-20 to 80	°C	
Material	Aluminum, steel		
Dimensions	40 × 40 × 40	mm	
Moved mass without load	0.021	kg	
Mass without cable	0.125	kg	
Mass with cable	0.4	kg	
Cable length	1.5	m	±10 mm
Connection	Sub-D 25W3 (m)		

* The resolution of PI piezo nanopositioning systems is not limited by friction. Specification as position noise with E-727 controller.

All specifications based on room temperature (22 °C ±3 °C).

10.1.2 Maximum Ratings

P-616 stages are designed for the following operating data:

Maximum operating voltage	Maximum operating frequency (unloaded) ¹	Maximum power consumption ²
-20 to +120 V	220 Hz (in X) 220 Hz (in Y) 220 Hz (in Z)	4.3 W (per axis)

¹ To ensure stable operation, the maximum operating frequency has been defined as around one third of the mechanical resonant frequency.

² The heat that is generated by the piezo actuator during dynamic operation limits the value for maximum power consumption.

Details can be found at the following website:

<http://piceramic.com/piezo-technology/properties-piezo-actuators/electrical-operation.html>

10.1.3 Ambient Conditions and Classifications

The following ambient conditions and classifications for the P-616 must be observed:

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	-20 °C to 80 °C
Storage temperature	-20 °C to 80 °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

10.2 Dimensions

Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.

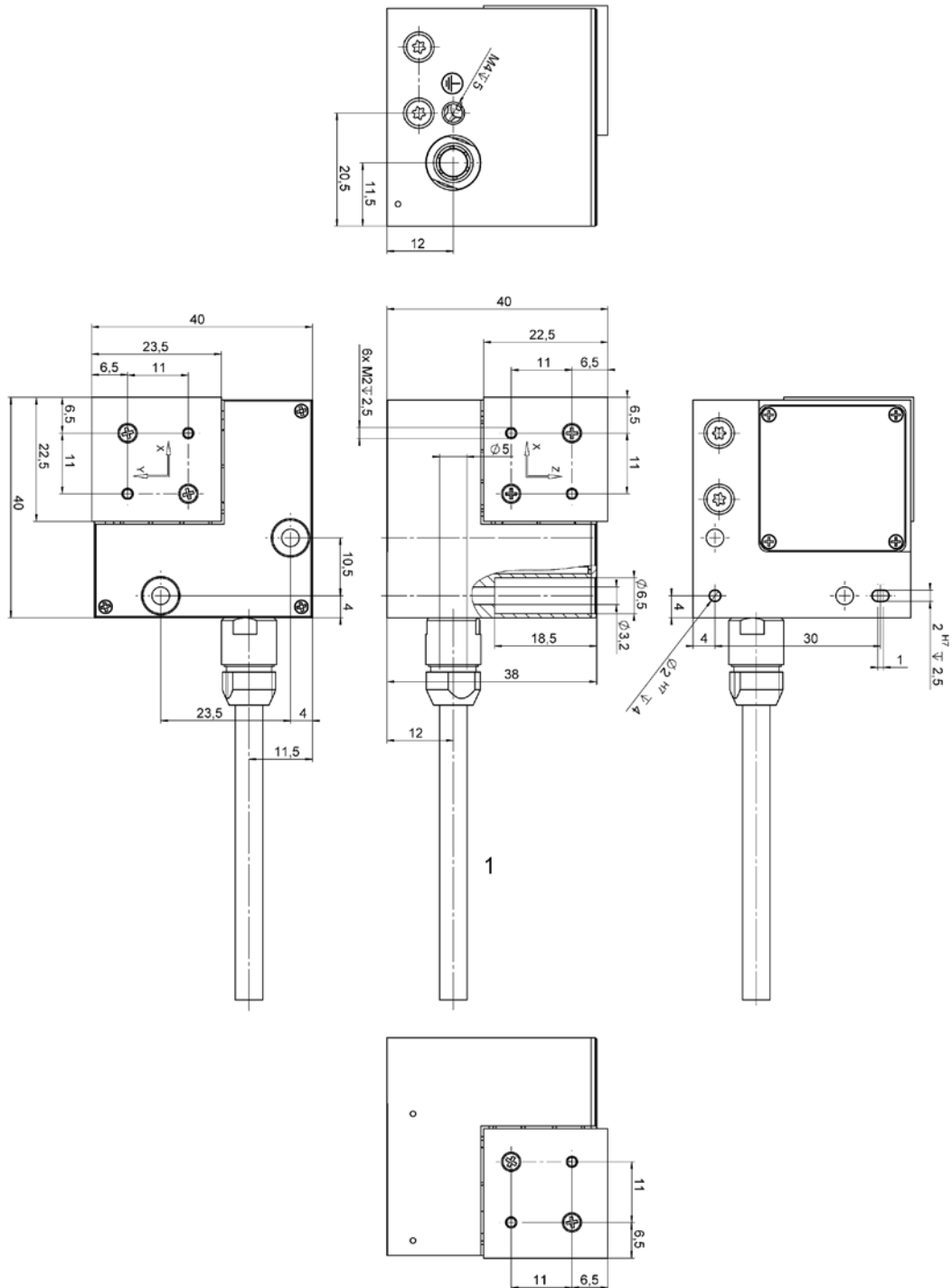


Figure 11: P-616.3C

1 Cable exit

10.3 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

10.4 Pin Assignment

Piezo and sensor connection Sub-D 25W3 (m)

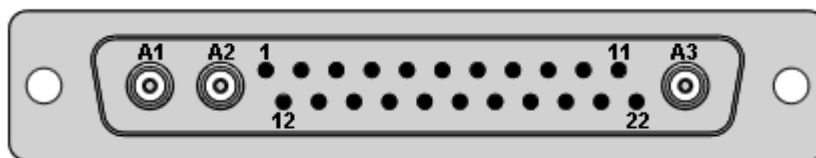


Figure 12: Sub-D 25W3 connector (m): Front side with connections

Pin	Signal*	Function
A1 inner conductor	Output	Probe sensor signal, channel 2 (nonmoving part of the capacitive sensor)
A1 outer conductor	GND	Shield of probe sensor signal, channel 2
A2 inner conductor	Output	Probe sensor signal, channel 3 (nonmoving part of the capacitive sensor)
A2 outer conductor	GND	Shield of probe sensor signal, channel 3
A3 inner conductor	Output	Probe sensor signal, channel 1 (nonmoving part of the capacitive sensor)
A3 outer conductor	GND	Shield of probe sensor signal, channel 1
1	Input	Target sensor signal, channel 2 (moving part of the capacitive sensor)
2	Input	Target sensor signal, channel 3 (moving part of the capacitive sensor)

Pin	Signal*	Function
3	GND	Ground of ID chip, channel 1
4	Bidirectional	Data line for ID-Chip, channel 1
5	GND	Ground of ID chip, channel 2
6	Bidirectional	Data line for ID-Chip, channel 2
7	-	-
8	Input	Piezo voltage +, channel 3
9	Input	Piezo voltage +, channel 2
10	Input	Piezo voltage +, channel 1
11	Input	Target sensor signal, channel 1 (moving part of the capacitive sensor)
12	GND	Shield of target sensor signal, channel 2
13	GND	Shield of target sensor signal, channel 3
14	-	-
15	-	-
16	GND	Ground of ID chip, channel 3
17	Bidirectional	Data line for ID-Chip, channel 3
18	-	-
19	Input	Piezo voltage –, channel 3
20	Input	Piezo voltage –, channel 2
21	Input	Piezo voltage –, channel 1
22	GND	Shield of target sensor signal, channel 1

* The "-" sign indicates that the corresponding pin has not been assigned.

11 Old Equipment Disposal

In accordance with EU law, electrical and electronic equipment may not be disposed of in EU member states via the municipal residual waste.

Dispose of your old equipment according to international, national, and local rules and regulations.

In order to fulfil its responsibility as the product manufacturer, Physik Instrumente (PI) GmbH & Co. KG undertakes environmentally correct disposal of all old PI equipment made available on the market after 13 August 2005 without charge.

Any old PI equipment can be sent free of charge to the following address:

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



12 EU Declaration of Conformity

For the P-616, an EU Declaration of Conformity has been issued in accordance with the following European directives:

Low Voltage Directive

EMC Directive

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

