

PZ268D

## P-616 NanoCube® XYZ Nanopositioner

User manual

Version: 1.2.0

Date: 04.04.2024



**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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Original instructions

First printing: 04.04.2024

Document number: PZ268D, CBo/KSch, Version 1.2.0

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 This manual is superseded by any new release.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

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# 1 About this Document

## In this Chapter

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Symbols and Typographic Conventions ..... 1

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### 1.1 Objective and Target Audience of this User Manual

This user manual contains the information required for using the P-616 as intended.

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**  
Failure to comply could lead to minor injury.

- Precautionary measures for avoiding the risk.



**NOTICE**




**Dangerous situation**  
Failure to comply could result in damage to the equipment.

- Precautions to avoid the risk.

**INFORMATION**

Information for easier handling, tricks, tips, etc.

Symbol/ Label	Meaning
1. 2.	Action consisting of several steps with strict sequential order
➤	Action consisting of one or more steps without relevant sequential order.
▪	Bullet point
p. 5	Cross-reference to page 5
RS-232	Label on the product indicating an operating element (example: RS-232 interface socket)
	Warning signs on 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 from PI mentioned in this documentation are described in separate manuals.

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

Product	Document
E-727 digital multi-channel piezo controller	E727T0005 User Manual
PIMikroMove	SM148E software manual
P-5xx / P-6xx / P-7xx piezo positioners	PZ240EK short instructions
F-603.41 / F-603.42 / F-603.43 fiber holder for P-616 (NanoCube®) piezo positioners	F603T0003 User Manual

## 1.5 Downloading Manuals

### **INFORMATION**

If a manual is missing or problems occur with downloading:

- Contact our customer service department (p. 35).

### **Downloading manuals**

1. Open the website **www.pi.ws**.
2. Search the website for the product number (e.g., P-616).
3. In the search results, select the product to open the product detail page.
4. Select **Downloads**.

The manuals are shown under **Documentation**. Software manuals are shown under **General Software Documentation**.

5. For the desired manual, select **ADD TO LIST** and then **REQUEST**.
6. Fill out the request form and select **SEND REQUEST**.

The download link will be sent to the email address entered in the form.





## 2 Safety

### In this Chapter

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### 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 of the P-616 may result in personal injury and/or damage to the P-616.

- Use the P-616 for its intended purpose only, and only when it is in perfect condition.
- Read the user manual.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for installing and operating the P-616 correctly.

The P-616 is driven by piezo actuators. Temperature changes and compressive stress can induce charges in piezo actuators. Piezo actuators can remain charged for several hours after disconnecting the electronics. Touching or short-circuiting the contacts in the P-616's connector 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 positioner's piezo actuators before installing:  
Connect the positioner to the switched-off PI electronics equipped with an internal discharge resistor.
- Do **not** pull the plug connector out of the electronics during operation.

Positioners with D-sub plug connector:

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

- Do **not** touch the contacts in the plug connector.
- Use screws to secure the positioner's connector against being pulled out of the electronics.

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

- Connect the P-616 to a protective earth conductor (p. 17) before starting.
- 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 restarting.

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. 37).
- Grip the surfaces indicated on the P-616's base body (p. 13) only.

The P-616 is maintenance-free and achieves its positioning accuracy as a result of the optimal alignment of mechanical components and piezo actuators. Loosened screws cause a loss in positioning accuracy.

- Loosen screws only when instructed in this manual.
- Do **not** open the P-616.

## 2.3 Organizational Measures

### User manual

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

- If you give the P-616 to other users, include this user manual as well as all other relevant information provided by the manufacturer.
- Do the work only if the user manual is complete. Missing information due to an incomplete user manual can result in minor injury and damage to equipment.
- Install and operate the P-616 only after you have read and understood this user manual.

### **Personnel qualification**

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



## 3 Product Description

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### 3.1 Product View

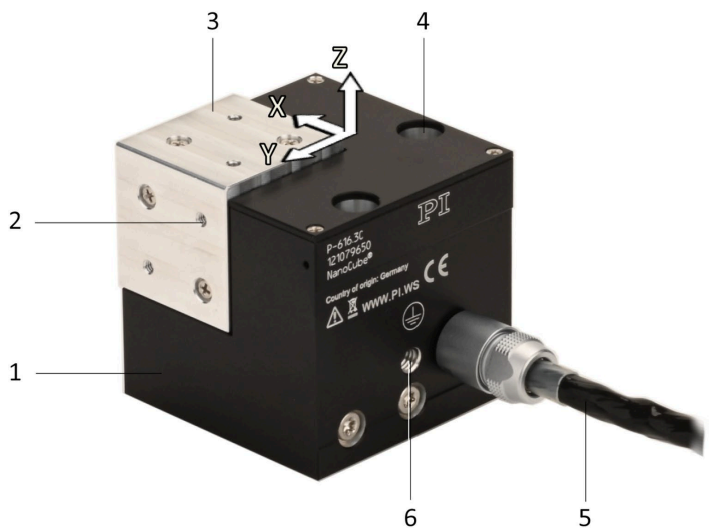


Figure 1: P-616

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

The arrows indicate the positive direction of motion in each case.

The letters X, Y, and Z indicate the axis.

## 3.2 Product Labeling






Labeling	Description
P-616.3C	Product name
123456789	Serial number (example), individual for each P-616 Meaning of each position (from the left): 1 = internal information, 2 and 3 = year of manufacture, 4 to 9 = consecutive number
NanoCube®	Brand name
Country of origin: Germany	Country of origin
	Manufacturer's logo
	Warning sign "Pay attention to the manual!"
	Old equipment disposal (p. 45)
WWW.PI.WS	Manufacturer's address (website)
	CE conformity mark
	Symbol for the protective earth conductor, marks the protective earth connector of the P-616 (p. 17)



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

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

## 3.3 Scope of Delivery

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

Product number	Description
000036450	M4 screw set for protective earth, consisting of: <ul style="list-style-type: none"> <li>▪ One flat-head screw with cross recess, M4x8, ISO 7045</li> <li>▪ 2 lock washers</li> <li>▪ 2 flat washers</li> </ul>
P616T0004	Technical note with unpacking instructions for P-616
PZ240EK	Short instructions for P-5xx / P-6xx / P-7xx piezo positioners
Only when ordering a system with analog controller or amplifier*	
P-895.3DLC	Adapter cable D-sub 25W3 (f) to LEMO for piezo actuator nanopositioning systems with capacitive sensors, 3 channels, length: 0.3 m

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

### 3.4 Optional 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
F-603.41	Fiber holder 10° for P-616, short, with fiber optic ferrules 1.25 mm, 2.5 mm, and 3.2 mm
F-603.42	Fiber holder 10° for P-616, long, with fiber optic ferrules 1.25 mm, 2.5 mm, and 3.2 mm
F-603.43	Fiber holder 90° for P-616, with fiber optic ferrules 1.25 mm, 2.5 mm, and 3.2 mm

➤ To order, contact our customer service department (p. 35).

### 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, D-sub 25W3 socket
E-727.3CDA	Digital multi-channel piezo controller, 3 axes, -30 to 130 V, capacitive sensors, D-sub 25W3 socket, analog inputs
E-712.3CD	Modular digital piezo controller, 3 axes, capacitive sensors, TCP/IP, USB, RS-232, SPI interfaces for communication

Product number	Description
E-712.3CDA	Modular digital piezo controller, 3 axes, capacitive sensors, analog inputs and outputs, TCP/IP, USB, RS-232, SPI interfaces for communication
E-500.00 / E-501.00	Modular piezo controller, consisting of: <ul style="list-style-type: none"> <li>▪ E-503.00 piezo amplifier module</li> <li>▪ E-509.C3A sensor / servo controller module</li> </ul> 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 positioners are driven by PICMA® piezo actuators. PICMA® actuators have all-ceramic insulation and their performance and lifetime are therefore far superior to conventional actuators. The ceramic insulation layer protects the monolithic piezoceramic block against humidity and failure due to increased leakage current. 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 positioners have flexure guides for friction-free motion and high guiding accuracy.

A flexure guide is an element that is free of 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 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 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 of the P-616 and the XYZ mounting platform, see figure below.

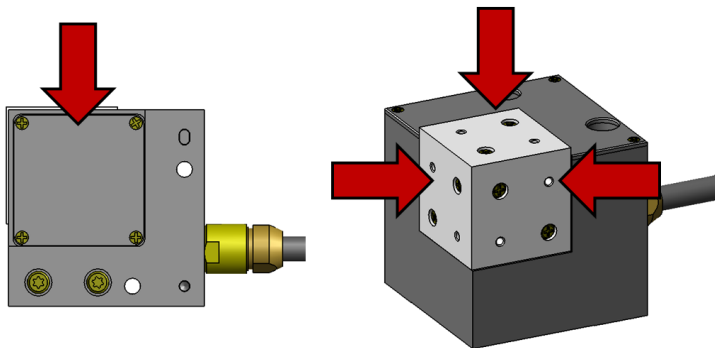


Figure 3: The marked surfaces may not be subject to mechanical stress. Left: Cover for the bottom of the P-616, right: The surfaces of the XYZ mounting platform

1. Unpack the P-616 with care.
  - Do not exert any force onto the following points:
    - the cover of the bottom of the P-616
    - the surfaces of the XYZ mounting platform
2. Compare the contents with the scope of delivery according to the contract and the delivery note.
3. Inspect the contents for signs of damage. If any parts are damaged or missing, contact our customer service department (p. 35) immediately.
4. Keep all packaging materials in case the product needs to be returned.



## 5 Installing

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Mounting the P-616 .....	18
Fixing the Load .....	20
Fixing the fiber holder .....	24
Connecting the P-616 to the Electronics .....	25

### 5.1 General Notes on Installation

#### CAUTION



#### Dangerous voltage and residual charge in piezo actuators!

The P-616 is driven by piezo actuators. Temperature changes and compressive stress can induce charges in piezo actuators. Piezo actuators can remain charged for several hours after disconnecting the electronics. Touching or short-circuiting the contacts in the P-616's connector 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 positioner's piezo actuators before installing:  
Connect the positioner to the switched-off PI electronics equipped with an internal discharge resistor.
- Do **not** pull the plug connector out of the electronics during operation.



Positioners with D-sub plug connector:

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

- Do **not** touch the contacts in the plug connector.
- Use screws to secure the positioner's connector against being pulled out of the electronics.

**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.

- Use cables provided by PI only to connect 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 use the holes or threads intended for the purpose of fixing the P-616 and loads.
- Install the P-616 so that the platform and all parts attached to it can move freely within the entire travel range.

**NOTICE****Damage due to incorrectly tightened screws!**

Incorrectly tightened screws can cause damage.

- Pay attention to the torque range (p. 42) specified for the screws used during installation.

**INFORMATION**

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

- Do **not** use extension cables. If you need longer cables, contact our customer service department (p. 35).

## 5.2 Connecting the P-616 to the Protective Earth Conductor

### INFORMATION

- Pay attention to the applicable standards for connecting the protective earth conductor.

### INFORMATION

- If there is any vibration in your application, secure the screw connection for the protective earth conductor in a suitable manner (e.g., with conductive liquid adhesive) to prevent it from unscrewing by itself.

The P-616 has an M4 hole for attaching the protective earth conductor. This hole is marked with the symbol for the protective earth conductor  $\oplus$  (see "Dimensions" (p. 41)).

### 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: Cable cross section  $\geq 0.75 \text{ mm}^2$
- M4 protective earth screw set (p. 10) supplied for connecting the protective earth conductor
- Suitable screwdriver

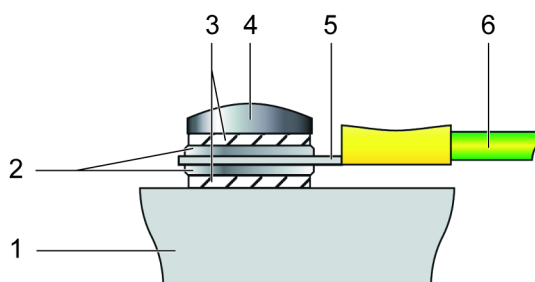


Figure 4: Connecting the protective earth conductor (profile view)

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

**Connecting the P-616 to the Protective Earth Conductor**

1. If necessary, firmly attach a suitable cable lug to the protective earth conductor.
2. Use the M4 screw (together with the flat and lock washers) to attach the cable lug of the protective earth conductor to the threaded hole in 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.

**5.3 Mounting the P-616****NOTICE****Warping the P-616 when mounting onto uneven surfaces!**

The P-616 could warp if mounted on an uneven surface. Warping reduces the accuracy.

- Mount the P-616 onto a flat surface. The recommended flatness of the surface is  $\leq 100 \mu\text{m}$ .
- For applications with large temperature fluctuations:  
Mount the P-616 only onto 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.

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

**NOTICE****Cable break due to pull forces and bending of the cable!**

Pull forces on the connecting cable and bending the cable can damage the P-616.

- Avoid pull forces on the connecting cable.
- Install the P-616 so that the cable is not bent or crushed too strongly.

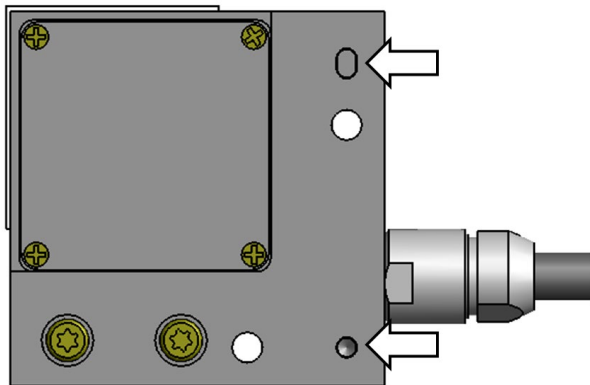


Figure 5: Holes for the locating pins on the bottom side of the P-616 for aligning the P-616

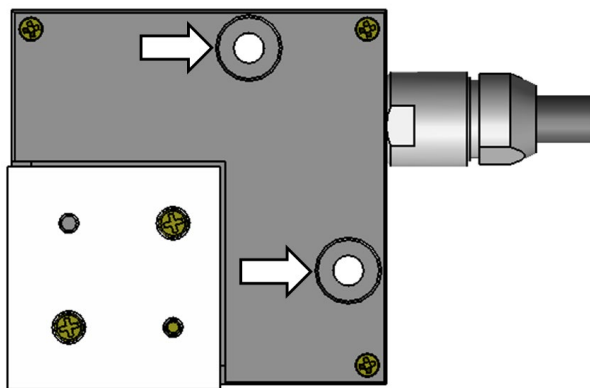


Figure 6: Countersunk holes,  $\varnothing 3.2 \text{ mm}$  /  $\varnothing 6.5 \text{ mm}$  for mounting the P-616

### 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

- 2 M3 screws of suitable length, at least M3x25
- Optional: 2 locating pins (e.g., 2m6 or 2h6) of suitable length, for holes  $\varnothing 2 \text{ mm}$  H7
- Suitable screwdriver

For the dimensions of the P-616 and the position and depth of the holes, see "Dimensions" (p. 41).

### Mounting the P-616

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

**Maximum torque: 1.1 Nm**

## 5.4 Fixing the Load

You have two options for fixing the load:

- The load is fixed to the XYZ mounting platform.
- The XYZ mounting platform is removed, and a fiber holder (e.g. F-603.41) is mounted directly to the mounting interfaces of the P-616.

### NOTICE



#### Mechanical overload due to too high torques and high loads!

High torques when fixing the load, as well as high loads, can overload the XYZ mounting platform of the P-616. Mechanical overload can damage the piezo actuators, sensors, and flexures of the P-616 and lead to loss of accuracy.

- When fixing the load, do not exceed the following values :
  - Maximum torque 0.4 Nm
  - Maximum push force capacity 15 N
- Take into account the influence of the fixed load. For example, if a load of 0.5kg is fixed to the P-616, a weight force of 5 N acts vertically on the P-616. This reduces the maximum push force capacity in Z by N to 10 N.
- When removing the XYZ mounting platform, when you loosen the screws hold onto it tightly to avoid an excessive torque to the flexures.

### NOTICE



#### Warping the P-616 when fixing loads with an uneven contact surface!

Fixing loads with an uneven contact surface could warp the P-616. Warping reduces the accuracy.

- Fix loads on the P-616 only when the surface contacting the P-616's motion platform has a flatness of at least 100 µm.
- For applications with large temperature fluctuations:  
Fix loads to the P-616 only when they have the same or similar thermal expansion properties as the P-616.



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

If the center of the load is located far away from the center of the motion platform (e.g. , tall load and unwanted lever effect), the P-616 can, especially in dynamic operation, be damaged by the high strain on the flexure guides, high torques and oscillations.

- If the center of the load to be fixed is too high or to the side of the motion platform, adjust the controller settings before startup or contact our customer service department (p. 35).
- Respect the leverage effect of the fiber holder.
- Ensure sufficient strain relief of the connected fibers.

**NOTICE****Excessively long screws!**

The P-616 could be damaged by screws inserted too deeply.

- Pay attention to the depth of the mounting holes in the motion platform (p. 41).
- Use screws of the correct length for the respective mounting holes only.

**INFORMATION**

Positive direction of axis motion is specified in the product view (p. 9).

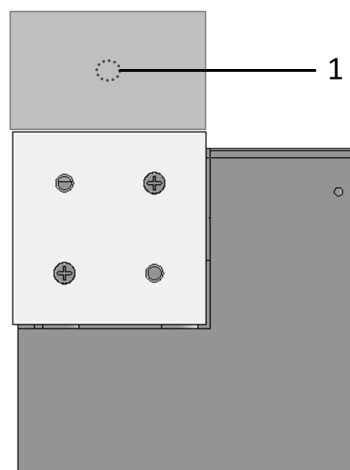
**Center of load at the optimum position:**

Figure 7: Example of an optimally placed load

1 Load center

Center of load at an unsuitable position:

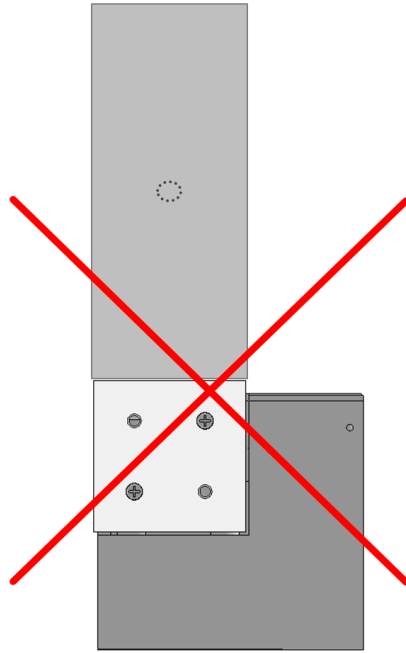


Figure 8: Tall load and center of load too far above the motion platform

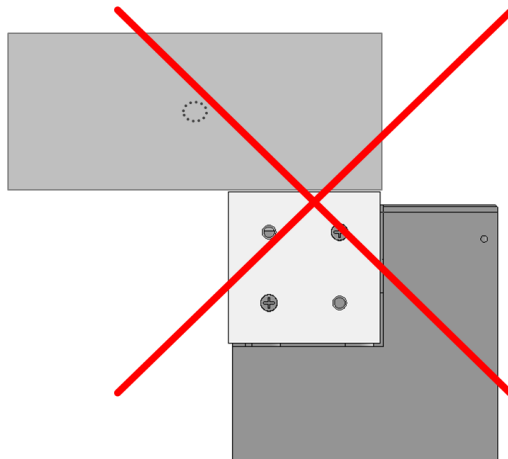


Figure 9: Unwanted lever effect and center of load on the side of the motion platform

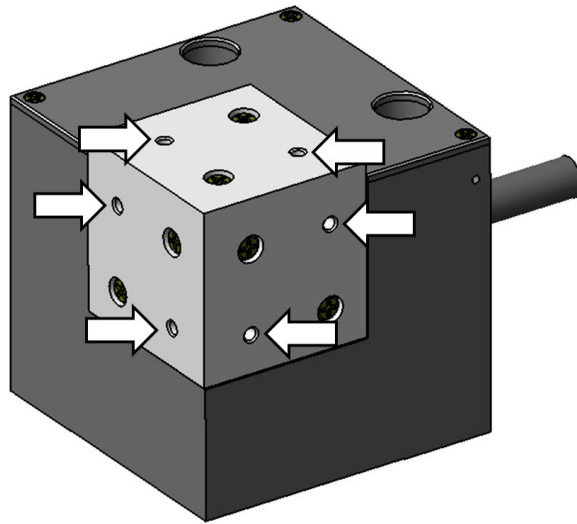


Figure 10: Holes for fixing the load

### 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

- M2 screws of suitable length, see "Dimensions" (p. 41)
- Suitable tools

### Fixing the load

- Fix loads only by inserting suitable screws into the threaded holes provided:
  - Avoid torques  $>0.4$  Nm on the motion platform.
  - Hold the load when tightening the screws and adhere to the torque range (p. 42) specified for the screws.
  - Pay attention to the maximum screw-in depth of 2.5 mm.
- Fix the load so that its center is in the middle of the XYZ mounting platform.

## 5.5 Fixing the fiber holder

### XYZ mounting platform

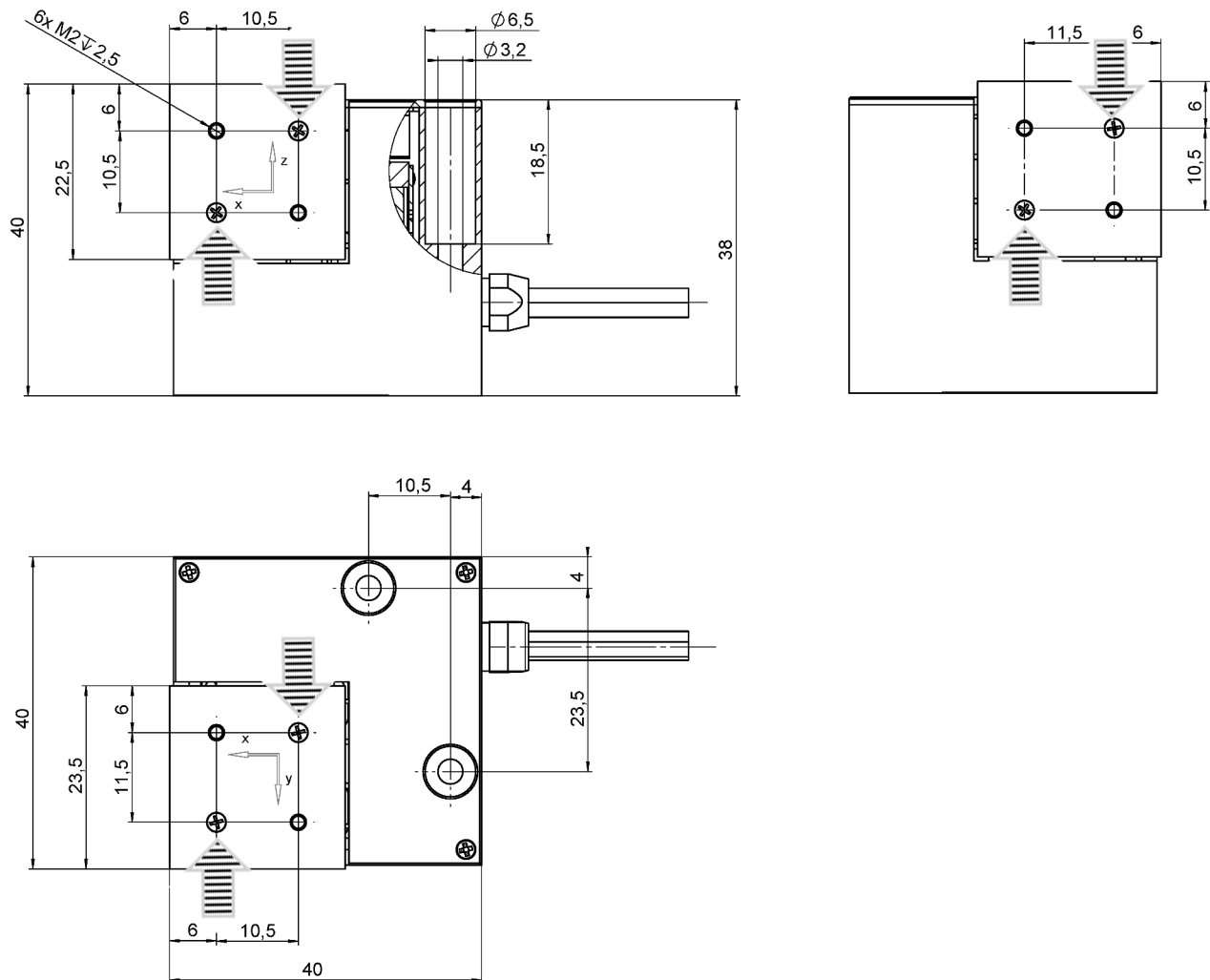


Figure 11: The arrows show the screws used to disassemble the XYZ mounting platform.

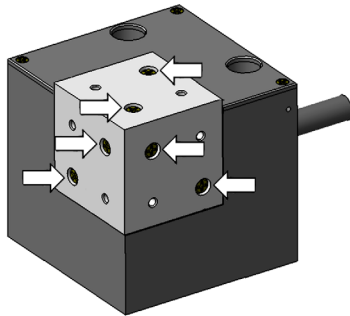


Figure 12: The arrows show the position of the 6 mounting screws of the fiber holder.

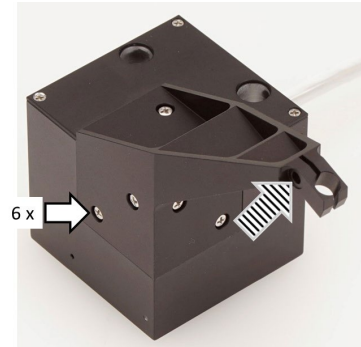


Figure 13: The fixed fiber holder with 5 or 6 visible mounting screws.

### 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 fiber holder with the respective screws
- Suitable Phillips-head screwdriver

### Fixing the fiber holder

1. Disassemble the XYZ platform from the P-616 using the screws shown in the figure at the top left.
2. Using suitable screws, fix the fiber holder to the six threaded holes, see the figure on the top right.

**Maximum torque: 0.3 Nm**

## 5.6 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. 10) 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 Starting and Operating

### In this Chapter

General Notes on Starting and Operating .....	27
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Discharging the P-616.....	29

### 6.1 General Notes on Starting and Operating

#### CAUTION



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

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

- Connect the P-616 to a protective earth conductor (p. 17) before starting.
- 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 restarting.

#### 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.
- Operate the P-616 only within the permissible ambient conditions and classifications (p. 40).

**NOTICE****Decreased lifetime due to permanently high voltage!**

Applying a continuous 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. 29).

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

Excessively high or wrongly connected operating voltages can damage the P-616.

- Operate the P-616 with controllers/drivers and original accessories from PI.
- Do **not** exceed the operating voltage range (p. 39) specified for the P-616.
- Operate the P-616 only when the operating voltage is properly connected; see "Pin Assignment" (p. 42).

**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 close to its resonant frequency, or with too high operating 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**

Positive direction of axis motion is specified 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

### Requirements

- ✓ You have read and understood the general notes on starting and operating (p. 27).
- ✓ You have read and understood the user manual for the electronics.
- ✓ You have read and understood the user manual for the PC software.
- ✓ You have correctly installed (p. 15) the P-616 and connected it to the protective earth conductor (p. 17).
- ✓ The electronics and the required PC software were installed. All connections to the electronics were made (refer to the user manual for the electronics).

### Operating the P-616

- Follow the instructions for starting and operating the P-616 in the manual for the electronics (p. 11) used.

## 6.3 Discharging the P-616

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

- Before Installation
- When the P-616 is not used but the electronics remain 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 discharge resistor inside the electronics from PI.

### Discharging a positioner connected to the electronics

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 electronics.

### Discharging a positioner not connected to the electronics

- Connect the positioner to the switched-off electronics from PI.



## 7 Maintenance

### In this Chapter

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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 optimal alignment of mechanical components and piezo actuators. Loosened screws cause a loss in positioning accuracy.

- Loosen screws only when instructed 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. 29).
- ✓ You have disconnected the P-616 from the electronics.

#### 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 <b>not</b> exceed the maximum permissible loads according to the specifications (p. 37).
	Zero point shifting of the sensor for the following reasons: <ul style="list-style-type: none"> <li>▪ Load applied in direction of motion</li> <li>▪ Ambient/operating temperature of the positioner far above or below the calibration temperature (21 °C to 24 °C)</li> </ul>	➤ Adjust the zero point of the sensor (see controller manual).
Reduced accuracy	Warping of the base body or the XYZ mounting platform	➤ Mount the P-616 onto surfaces with the following characteristics only: <ul style="list-style-type: none"> <li>– Flatness of at least 100 µm</li> <li>– The thermal expansion properties are similar to those of the P-616 (e.g., surfaces made of aluminum).</li> </ul> ➤ Mount loads onto the P-616 with the following characteristics only: <ul style="list-style-type: none"> <li>– The contact surface of the load has a flatness of at least 100 µm.</li> <li>– The thermal expansion properties are similar to those of the P-616 (e.g., loads made of aluminum).</li> </ul>

Problem	Possible causes	Solution
	The positioner is not connected to the corresponding controller (only when there are several systems)	➤ Pay attention to 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), which contains the serial number of the positioner to be connected.
The positioner starts oscillating or positions inaccurately	Servo control parameters set incorrectly because for example, the load was changed	<ol style="list-style-type: none"> <li>1. Immediately switch off the servo mode of the corresponding positioning axes.</li> <li>2. Check the servo control parameter settings on the controller.</li> <li>3. Adjust the servo control parameters on the controller according to the load change.</li> </ol>
	Open-loop operation near to the resonant frequency	➤ In open-loop operation, operate the stage only at a frequency 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. 35)).

## 9 Customer Service Department

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

- If you have questions concerning your system, provide the following information:
  - Product and serial numbers of all products in the system
  - Firmware version of the controller (if applicable)
  - Version of the driver or the software (if applicable)
  - PC operating system (if applicable)
- 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 on our website (p. 3).





## 10 Technical Data

Subject to change. You can find the latest product specifications on the product web page at [www.pi.ws](https://www.pi.ws) (<https://www.pi.ws>).

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### 10.1 Specifications

#### 10.1.1 Data Table

##### Spezifikationen

Motion	P-616.3C	Tolerance
Active axes	X, Y, Z	
Travel range in X	100 µm	
Travel range in Y	100 µm	
Travel range in Z	100 µm	
Travel range in X, open loop	110 µm	±20 %
Travel range in Y, open loop	110 µm	±20 %
Travel range in Z, open loop	110 µm	±20 %
Linearity error in X	0.03 %	typ.
Linearity error in Y	0.03 %	typ.
Linearity error in Z	0.03 %	typ.

Positioning	P-616.3C	Tolerance
Bidirectional repeatability in X	10 nm	typ.
Bidirectional repeatability in Y	20 nm	typ.
Bidirectional repeatability in Z	10 nm	typ.
Resolution in X, open loop	0.3 nm	typ.

Positioning	P-616.3C	Tolerance
Resolution in Y, open loop	0.3 nm	typ.
Resolution in Z, open loop	0.3 nm	typ.
Integrated sensor	Capacitive, direct position measuring	
System resolution in X	0.4 nm	
System resolution in Y	0.4 nm	
System resolution in Z	0.4 nm	

Drive properties	P-616.3C	Tolerance
Drive type	PICMA®	
Electrical capacitance in X	1.5 µF	±20 %
Electrical capacitance in Y	1.5 µF	±20 %
Electrical capacitance in Z	1.5 µF	±20 %

Mechanical properties	P-616.3C	Tolerance
Stiffness in X	0.5 N/µm	±20 %
Stiffness in Y	0.5 N/µm	±20 %
Stiffness in Z	0.5 N/µm	±20 %
Resonant frequency in X, unloaded	700 Hz	±20 %
Resonant frequency in X, under load with 38 g	380 Hz	±20 %
Resonant frequency in X, under load with 100 g	250 Hz	±20 %
Resonant frequency in Y, unloaded	700 Hz	±20 %
Resonant frequency in Y, under load with 38 g	380 Hz	±20 %
Resonant frequency in Y, under load with 100 g	250 Hz	±20 %
Resonant frequency in Z, unloaded	700 Hz	±20 %
Resonant frequency in Z, under load with 38 g	380 Hz	±20 %
Resonant frequency in Z, under load with 100 g	250 Hz	±20 %
Permissible push force in X	15 N	max.
Permissible push force in Y	15 N	max.
Permissible push force in Z	15 N	max.




Mechanical properties	P-616.3C	Tolerance
Permissible pull force in X	15 N	max.
Permissible pull force in Y	15 N	max.
Permissible pull force in Z	15 N	max.
Permissible torque in $\theta_X$	0.4 N·m	max.
Permissible torque in $\theta_Y$	0.4 N·m	max.
Permissible torque in $\theta_Z$	0.4 N·m	max.
Moved mass in X, unloaded	21 g	
Moved mass in Y, unloaded	21 g	
Moved mass in Z, unloaded	21 g	
Guide	Flexure guide with lever amplification	
Overall mass	400 g	
Mass without cable	125 g	
Material	Aluminum, steel	

Miscellaneous	P-616.3C	Tolerance
Operating temperature range	-20 to 80 °C	
ID chip	Yes	
Connector	D-sub 25W3 (m)	
Cable length	1.5 m	
Recommended controllers / drivers	E-503, E-663, E-712, E-727	

The bidirectional repeatability refers to a 10% step and is a 1 sigma value.

### 10.1.2 Maximum Ratings

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

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

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

<sup>2</sup> 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.de/de/piezo-technologie/eigenschaften-piezoaktoren/ansteuerverhalten/>  
(<http://piceramic.com/piezo-technology/properties-piezo-actuators/electrical-operation.html>)

### 10.1.3 Ambient Conditions and Classifications

Pay attention to the following ambient conditions and classifications for the P-616:

Area of application	For indoor use only
Maximum altitude	2000 m
Air pressure	1100 hPa to 700 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 points are separated by a comma in the drawings.

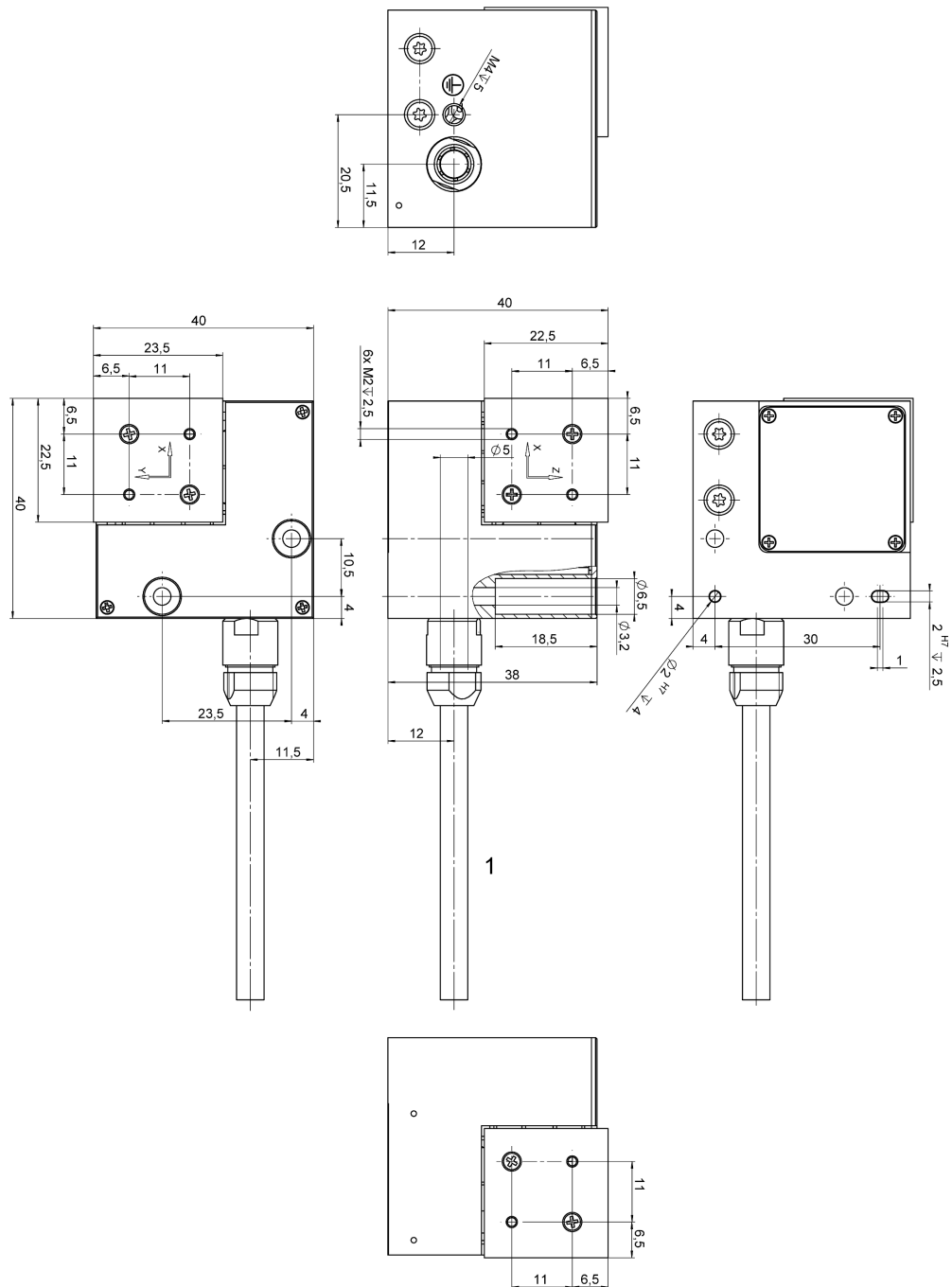


Figure 14: P-616.3C

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

- Pay attention to the screw-in depth required for the respective material according to the VDI directive 2230.

### 10.4 Pin Assignment

#### Piezo and sensor connector D-sub 25W3 (m)

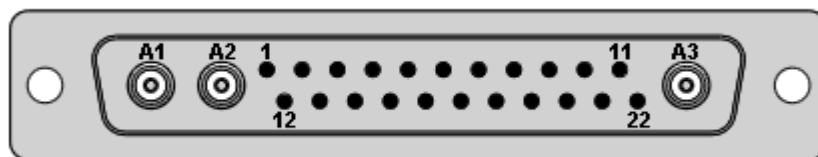


Figure 15: D-sub 25W3 connector (m): Front with connections

Pin	Signal*	Function
A1 inner conductor	Output	Probe sensor signal, channel 2 (immovable part of the capacitive sensor)
A1 line conductor	GND	Shielding for probe sensor signal, channel 2
A2 inner conductor	Output	Probe sensor signal, channel 3 (immovable part of the capacitive sensor)
A2 line conductor	GND	Shielding for probe sensor signal, channel 3
A3 inner conductor	Output	Probe sensor signal, channel 1 (immovable part of the capacitive sensor)
A3 line conductor	GND	Shielding for probe sensor signal, channel 1

Pin	Signal*	Function
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)
3	GND	ID chip ground, channel 1
4	Bidirectional	Data line for ID-Chip, channel 1
5	GND	ID chip ground, 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	Shielding for target sensor signal, channel 2
13	GND	Shielding for target sensor signal, channel 3
14	-	-
15	-	-
16	GND	ID chip ground, 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	Shielding for 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.

To fulfill the 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 Römerstraße 1  
76228 Karlsruhe, Germany





## 12 European Declarations of Conformity

For the P-616, declarations of conformity were issued according to the following European statutory requirements:

Low Voltage Directive

EMC Directive

RoHS Directive

The standards applied for certifying conformity are listed below.

Safety (Low Voltage Directive): EN 61010-1

EMC: EN 61326-1

RoHS: EN IEC 63000

