User Manual

P-616 NanoCube® Nanopositioner

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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Contents

1 About this document

1.1 Objective and target group of this user manual

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

Basic knowledge of closed-loop 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 can result in minor injuries.

➢ Precautions to avoid the risk.

NOTICE

Dangerous situation

Failure to comply can 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
–	Enumeration
⚠	Warning sign on the product which refers to detailed information in this manual.

1.3 Figures

For better clarity, the illustrations can vary in color, proportions, and level of detail compared to actual circumstances. Photographic illustrations can 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.

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 positioner	F603T0003 user manual

2 Downloading manuals

Information

If a manual is missing or problems occur while downloading:

➢ Contact our customer service (p. 34).

Downloading manuals

1. Open the website www.pi.ws.
2. Search for the product number (e.g., P-616) on the website.
3. Select the corresponding product to open the product page.
4. Select the **Downloads** tab.
   → 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 then be sent to the email address entered.

3 Safety

3.1 Intended use

The P-616 is a laboratory device according to DIN EN 61010-1. It is intended for indoor use and use in an environment free from dirt, oil, and lubricants.

According to 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 alignment.

The P-616 can only be used as intended in conjunction with suitable electronics (p. 13) 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 able to read out and process the signals of the position sensors.

3.2 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 can result in personal injury and/or damage to the P-616.

- Use the P-616 only for its intended purpose and when it is in perfect technical 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 connector of the P-616 could 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 that have been equipped with an internal discharge resistor.
- Do not disconnect the plug connector from 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 connector of the positioner against being disconnected from the electronics.

If the protective earth conductor is not connected or is not connected properly, hazardous touch voltages can occur on the P-616 during system malfunction or failure. Touching the P-616 when touch voltages are present can result in minor injury due to electric shock.

- Connect the P-616 to a protective earth conductor (p. 17) before startup.
- Do not remove the protective earth conductor during operation.
- If the protective earth conductor has to be removed temporarily (e.g., for modifications), reconnect the P-616 to the protective earth conductor before restarting.

Mechanical forces can damage or misalign the P-616.

- Avoid knocks that affect the P-616.
- Do not drop the P-616.
- Do not exceed the maximum permissible loads according to the specifications (p. 35).
- Hold the P-616 only using the gripping surfaces on the base body (p. 15).

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 this manual contains instructions to do so.
- Do not open the P-616.

3.3 Organizational measures

3.3.1 User manual

- Always keep this user manual together with the P-616.
- The latest versions of the user manuals are available for download from our website.
- Add all information from the manufacturer, such as supplements or technical notes, to the user manual.
- If you pass on the P-616 to a third party, 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.
- Install and operate the P-616 only after you have read and understood this user manual.

3.3.2 Personnel qualification

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

4 Product description

4.1 Product view

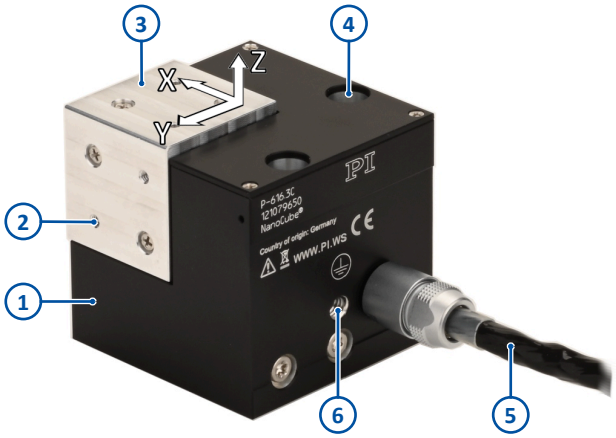


Fig. 1: P-616 product view

1 Base body

2 M2 hole for mounting the load, depth 2.5 mm (3 × 2 holes)

3 XYZ mounting platform (movable part of the P-616, also referred to as "motion platform")

4 Countersunk hole (2×) for mounting onto surface

5 Cable exit (supply voltage, sensor)

6 M4 hole for connecting the protective earth conductor

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

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

4.2 Product labeling

Label	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 numbers
NanoCube®	Brand name
Country of origin: Germany	Country of origin
PI	Manufacturer's logo
⚠	Warning sign "Pay attention to the manual!"

Label	Description
	Old equipment disposal (p. 41)
WWW.PI.WS	Manufacturer's address (website)
CE	CE conformity mark
	Protective earth symbol, indicates the protective earth connector (p. 17) on the P-616
	"Residual Voltage" warning sign on the connector of the P-616: Indicates risk of electric shock (p. 28)

4.3 Scope of delivery

Order number	Part
P-616.3C	Parallel-kinematic NanoCube® XYZ nanopositioner 100 µm × 100 µm × 100 µm travel range, capacitive sensors
000036450	M4 screw set for protective earth, consisting of: – 1 flat-head screw with cross recess, M4x8, ISO 7045 – 2 lock washers – 2 flat washers
P616T0004	Technical note with unpacking instructions for P-616
PZ240EK	Short instructions for P-5xx / P-6xx / P-7xx piezo positioners

4.4 Optional accessories

Order number	Part
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
P-895.3DLC	Adapter cable, D-sub 25W3 (f) to LEMO for piezo actuator nanopositioning systems with capacitive sensors, 3 channels, 0.3 m

➢ To order, contact our customer service (p. 34).

4.5 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 multichannel piezo controller, 3 axes, -30 to 130 V, capacitive sensors, D-sub 25W3 socket
E-727.3CDA	Digital multichannel 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
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: – 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

* P-895.3DLC adapter cable required, available as optional accessory (p. 12)

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.

4.6 Technical features

4.6.1 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, 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 backlash-free, maintenance-free, and non-wearing.

4.6.2 Flexure-based guides

P-616 positioners have flexure-based guides for friction-free motion and high guide 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-based guides are maintenance-free and non-wearing. They are 100 % vacuum compatible, function in a wide temperature range, and do not require any lubricants.

4.6.3 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 in conjunction with the high position resolution. In conjunction with suitable electronics, capacitive sensors achieve the best resolution, stability, and bandwidth.

5 Unpacking

NOTICE

Damage to the P-616 due to incorrect handling!

Impermissible mechanical stress on the cover on the underside 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 cover on the underside of the P-616 and the XYZ mounting platform (see figure below).

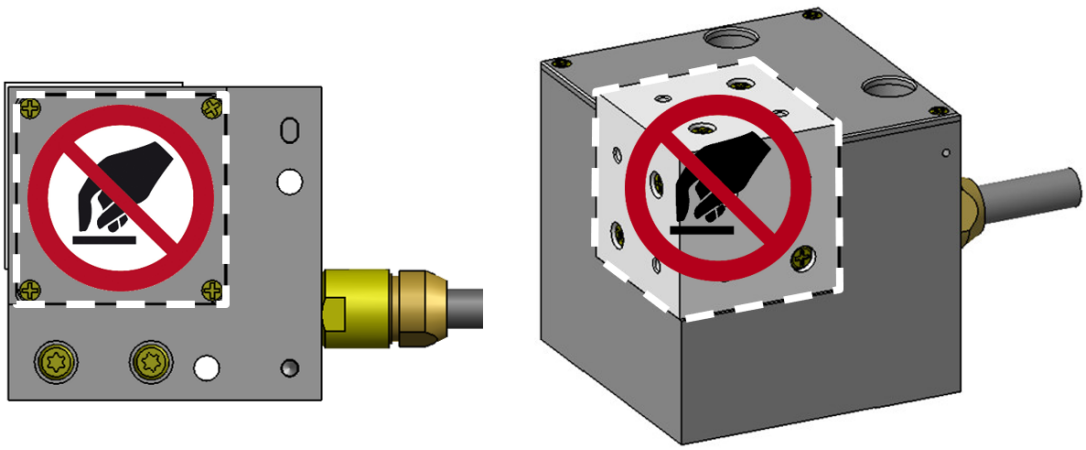


Fig. 2: The marked surfaces must not be subjected to mechanical stress.
Left: Cover on the underside of the P-616.
Right: Surfaces of the XYZ mounting platform.

Unpacking the P-616

1. Unpack the P-616 with care. Avoid exerting any force on the following points:
   - Cover on the underside of the P-616
   - 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 (p. 34) immediately.
4. Keep all packaging materials in case the product needs to be returned.

6 Installation

6.1 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 connector of the P-616 could lead to minor injuries from electric shock. The piezo actuators can be destroyed by an abrupt contraction.

- Do not open the P-616.
- Discharge (p. 30) the piezo actuators before installing the positioner.
- Do not disconnect the plug connector from the electronics during operation.
- Positioners with D-sub plug connector: Do not touch the contacts in the plug connector.
- Positioners with D-sub plug connector: Use screws to secure the connector of the positioner against being disconnected from the electronics.

NOTICE

Mechanical overload due to incorrect handling!

Impermissible mechanical loading (p. 15) 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 could be damaged by tensile forces on the cable exit and bending of the connecting cable.

- Hold the P-616 by its base body (p. 11) only.
- Avoid tensile forces on the cable exit and do not bend the cable.

NOTICE

Damage from unsuitable cables!

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

- Use cables from PI only 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 use the holes or threads intended for the purpose of fixing the P-616 and loads.
- ➢ Install the P-616 so that the motion 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. 37) 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 (p. 34).

6.2 Connecting the product 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, additionally 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 protective earth conductor symbol ⏚. For more details refer to Product view (p. 11) and Dimensions (p. 40).

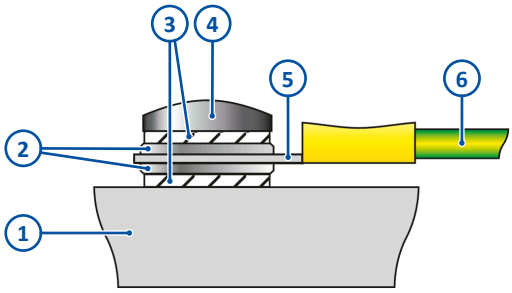


Fig. 3: Installing the protective earth conductor (profile view)

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

Requirements

- You have read and understood the general notes on installation (p. 16).
- The P-616 is not connected to the electronics.

Tools and accessories

- Suitable protective earth conductor:
  - Cable cross-section ≥ 0.75 mm²
  - Contact resistance at all points relevant for mounting the protective earth conductor < 0.1 Ω at 25 A
- M4 protective earth screw set (p. 12) supplied for connecting the protective earth conductor
- Suitable screwdriver

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 washers and self-locking washers) to affix the cable lug of the protective earth conductor to the protective earth connector 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.

6.3 Mounting the product

NOTICE

Warping of the P-616 when mounted on uneven surfaces!

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

- Mount the P-616 on an even surface. The recommended flatness of the surface is ≤ 100 µm.
- For applications with large temperature fluctuations:
  Only mount the P-616 on surfaces that have the same or similar thermal expansion properties as the P-616 (e.g., surfaces made of aluminum).

NOTICE

Protruding screw heads!

Protruding screw heads can damage the P-616.

- Make sure that the screw heads are fully countersunk and cannot interfere with 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 squashed too strongly.

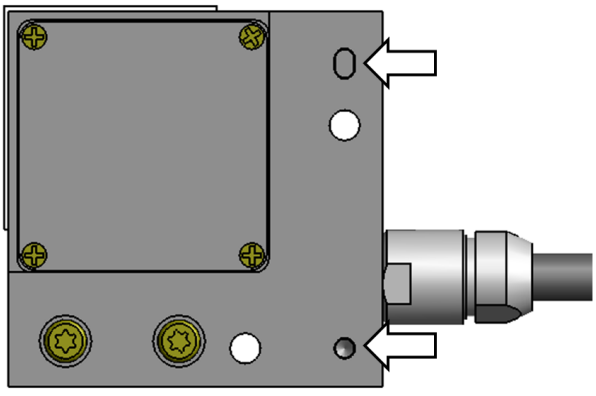


Fig. 4: Holes for the locating pins on the underside of the P-616 for aligning the P-616

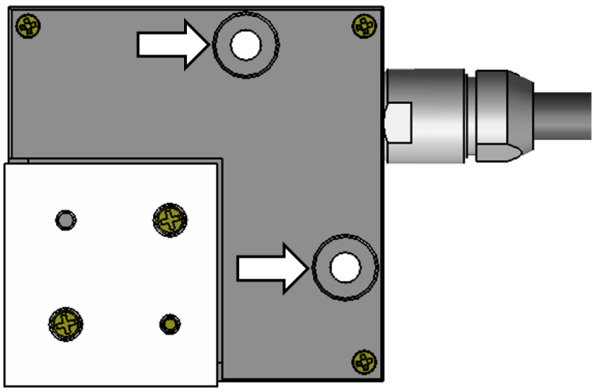


Fig. 5: Countersunk holes, Ø 3.2 mm / Ø 6.5 mm for mounting the P-616

Requirements

- You have read and understood the general notes on installation (p. 16).
- 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 Ø 2 mm H7
- Suitable screwdriver

For the dimensions of the P-616 and the position and depth of the holes, see Dimensions (p. 40).

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

6.4 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 excessive 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 precision.

- 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 0.5 kg 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 5 N to 10 N.
- When removing the XYZ mounting platform: When you loosen the screws, hold onto the mounting platform tightly to avoid an excessive torque to the flexures.

NOTICE

Warping of 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 to the P-616 only when the surface contacting the P-616's platform has a flatness of at least 100 µm.
- For applications with large temperature fluctuations: Fix loads to the P-616 only that have the same or similar thermal expansion properties as the P-616 (e.g., loads made of aluminum).

NOTICE

Center of load at unsuitable position!

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

- If the center of the load to be fixed is too high above or to the side of the motion platform, adjust the controller settings before startup or contact our customer service (p. 34).
- Take into consideration the leverage effect of the fiber holder.
- Ensure sufficient strain relief of the connected fibers.

NOTICE

Excessively long screws!

Screws inserted too deeply can damage the P-616.

- Pay attention to the depth of the mounting holes in the motion platform (p. 40).
- Only use screws with the correct length for the respective mounting holes.

Information

Positive direction of axis motion is specified in the product view (p. 11).

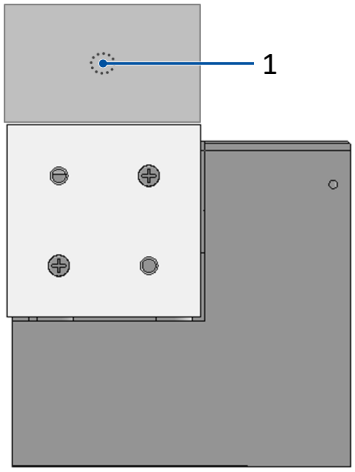


Fig. 6: P-616.3C: Example of an optimally placed load

1 Center of load

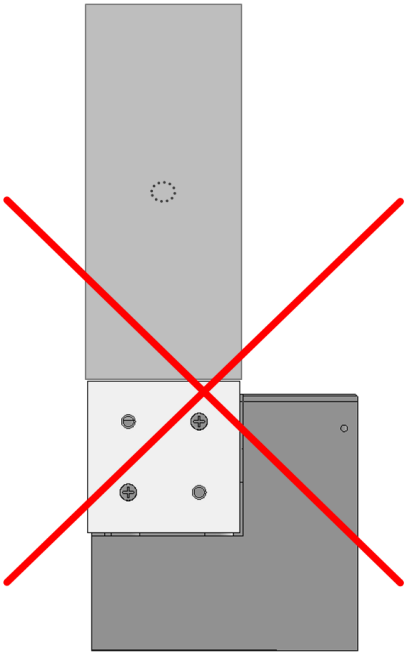


Fig. 7: P-616.3C: Tall setup and center of load too far above the motion platform

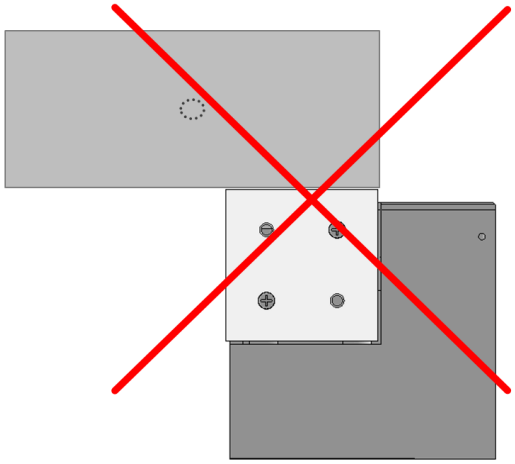


Fig. 8: P-616.3C: Unwanted levering effect and center of load to the side of the motion platform

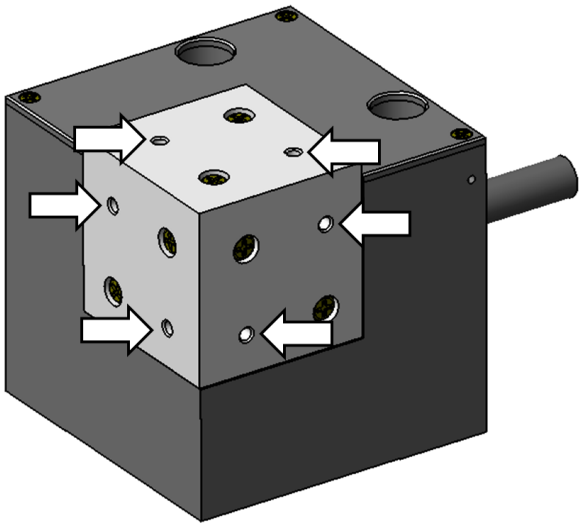


Fig. 9: P-616.3C: Holes for fixing the load

Requirements

- You have read and understood the general notes on installation (p. 16).
- The P-616 is not connected to the electronics.

Tools and accessories

- M2 screws of suitable length, see Dimensions (p. 40)
- 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 pay attention to the torque range (p. 37) 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.

6.5 Fixing the fiber holder

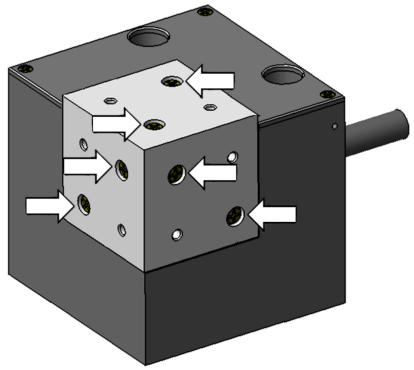


Fig. 10: P-616.3C. Position of the 6 fastening screws for the XYZ mounting platform

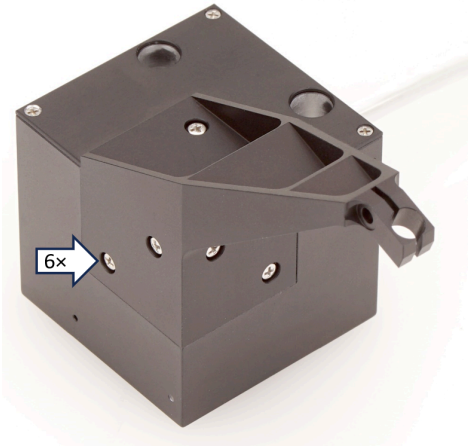


Fig. 11: P-616.3C: Mounted fiber holder (1 of the 6 fastening screws is concealed)

Requirements

- You have read and understood the general notes on installation (p. 16).
- The P-616 is not connected to the electronics.

Tools and accessories

- Suitable fiber holder with the respective screws (p. 12)
- Suitable cross-head screwdriver

Fixing the fiber holder

1. Disassemble the XYZ platform from the P-616 by removing the screws shown in Fig. 10 (p. 25).
2. Fix the fiber holder to the 6 threaded holes provided using suitable screws as shown in Fig. 11 (p. 25). Maximum torque: 0.3 Nm.

6.6 Connecting the product 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 electronics channels specified on the calibration label of the electronics.

Requirements

– You have read and understood the general notes on installation (p. 16).
– You have installed suitable electronics (p. 13).
– You have read and understood the user manual for 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 adapter cable (p. 12) (not in the scope of delivery)

6.6.1 Connecting the product to the E-727 controller

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

6.6.2 Connecting the product to the E-50x modules or E-663.00 piezo amplifier

1. Connect the D-sub 25W3 (m) connector on the P-616 to the D-sub 25W3 (f) plug connector of the P-895.3DLC adapter cable.
2. Connect the piezo connectors of the P-895.3DLC adapter cable to the piezo connectors 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 E-50x modules: Connect the sensor connectors of the P-895.3DLC adapter cable to the E-509.C3 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**)

7 Starting and operating

7.1 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 connected or is not connected properly, hazardous touch voltages can occur on the P-616 during system malfunction or failure. Touching the P-616 when touch voltages are present can result in minor injury due to electric shock.

- Connect the P-616 to a protective earth conductor (p. 17) before startup.
- Do not remove the protective earth conductor during operation.
- If the protective earth conductor has to be removed temporarily (e.g., for modifications), reconnect the P-616 to the protective earth conductor before restarting.

NOTICE

Destruction of the piezo actuator by electric flashovers!

Using the P-616 in environments that increase electrical conductivity can lead to electric flashovers that destroy the piezo actuator. Electric flashovers can be caused by moisture, high humidity, liquids, and conductive materials (e.g., metal dust). In addition, electric flashovers can occur because of increased conductivity in certain air pressure ranges.

- Avoid operating the P-616 in environments that can increase electrical conductivity.
- Operate the P-616 only under permissible ambient conditions and classifications (p. 37).

NOTICE

Reduced lifetime due to continuous high voltage!

Applying a high static voltage to piezo actuators continuously leads to a considerable reduction in the lifetime of the piezo ceramics.

- When the P-616 is not in use but the electronics remain switched on to ensure temperature stability, discharge (p. 30) the P-616.

NOTICE

Operating voltage excessively high or incorrectly connected!

Excessively high or incorrectly connected operating voltages can cause damage to the P-616.

- Operate the P-616 only with controllers/drivers and original accessories from PI.
- Do not exceed the operating voltage range (p. 36) specified for the P-616.
- Operate the P-616 only when the operating voltage is properly connected; see Pin assignment (p. 38).

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 operating or servo control parameters to be adjusted.
- The P-616is being operated close to its resonant frequency, or at too high an 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. 11).

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

7.2 Operating the product

Requirements

- You have read and understood the general notes on starting and operating (p. 28).
- 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. 16) 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 on starting and operating the P-616 in the user manual for the electronics (p. 13) used.

7.3 Discharging the product

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

– Before Installation
– When the P-616 is not in use but the electronics remain switched on to ensure temperature stability
– Before disassembling (e.g., before cleaning and transporting the P-616 and prior to 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.

8 Maintenance

8.1 General notes on maintenance

NOTICE

Misalignment from 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 this manual contains instructions to do so.
- ➢ Do not open the P-616.

NOTICE

Damage from ultrasonic cleaning!

Ultrasonic cleaning can damage the P-616.

- ➢ Do not perform any ultrasonic cleaning.

NOTICE

Short-circuiting due to cleaning fluid getting into the housing!

Cleaning fluid getting into the P-616's housing can short-circuit the piezo actuators and electronics.

- ➢ Disconnect the P-616 from the electronics before cleaning.
- ➢ Prevent any cleaning liquid from getting into the P-616's housing.

8.2 Cleaning the product

Requirements

- – You have discharged (p. 30) the piezo actuators of the P-616.
- – You have disconnected the P-616 from the electronics.

Cleaning the P-616

- ➢ Clean the surfaces of the P-616 using a cloth dampened with a mild cleanser or disinfectant (e.g., isopropyl alcohol).

9 Troubleshooting

Malfunction	Possible causes	Solution
No or limited motion	Cable is not connected correctly	➢ Check the cable connections.
	Excessive load	➢ Do not exceed the maximum permissible loads according to the specifications (p. 35).
	Zero shifting of the sensor for the following reasons: – Load in direction of motion – Ambient/operating temperature of the positioneris much higher or lower than the calibration temperature (21 °C to 24 °C)	➢ 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: – Flatness of at least 100 µm – The thermal expansion properties are similar to those of the P-616 (e.g., surfaces made of aluminum) Mount loads onto the P-616 with the following characteristics only: – 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 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 underside), which contains the serial number of the positioner to be connected.

Malfunction	Possible causes	Solution
The positioner starts oscillating or positions inaccurately	Servo control parameters wrongly set because, for example, the load was changed	1. Immediately switch off the servo mode of the corresponding positioner axes. 2. Check the servo control parameter settings on the controller. 3. Adjust the servo control parameters on the controller according to the load change.
	Open-loop operation near to the resonant frequency	➢ In open-loop operation, operate the positioner only at a frequency below the resonant frequency.

➢ If the problem with your system is not listed in the table above or cannot be solved as described, contact our customer service (p. 34).

10 Customer service

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

If you have questions regarding your system, provide us with 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 PC software (if applicable)
- Operating system on the PC (if applicable)

If possible: Take photographs or make videos of your system that can be sent to our customer service if requested.

Customer service address:

Physik Instrumente (PI) SE & Co. KG
Auf der Römerstraße 1
76227 Karlsruhe
Germany

11 Specifications

11.1 Technical data

Subject to change without notice. You can find the latest product specifications on the product web page at www.pi.ws.

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

Positioning	Unit	Tolerance	P-616.3C
Bidirectional repeatability in X	nm	Typ.	10
Bidirectional repeatability in Y	nm	Typ.	20
Bidirectional repeatability in Z	nm	Typ.	10
Resolution in X, open loop	nm	Typ.	0.3
Resolution in Y, open loop	nm	Typ.	0.3
Resolution in Z, open loop	nm	Typ.	0.3
Integrated sensor			Capacitive, direct position measuring
System resolution in X	nm		0.4
System resolution in Y	nm		0.4
System resolution in Z	nm		0.4

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

Mechanical Properties	Unit	Tolerance	P-616.3C
Stiffness in X	N/µm	±20 %	0.5
Stiffness in Y	N/µm	±20 %	0.5
Stiffness in Z	N/µm	±20 %	0.5
Resonant frequency in X, unloaded	Hz	±20 %	700
Resonant frequency in X, under load with 38 g	Hz	±20 %	380
Resonant frequency in X, under load with 100 g	Hz	±20 %	250
Resonant frequency in Y, unloaded	Hz	±20 %	700
Resonant frequency in Y, under load with 38 g	Hz	±20 %	380
Resonant frequency in Y, under load with 100 g	Hz	±20 %	250
Resonant frequency in Z, unloaded	Hz	±20 %	700
Resonant frequency in Z, under load with 38 g	Hz	±20 %	380
Resonant frequency in Z, under load with 100 g	Hz	±20 %	250
Permissible push force in X	N	Max.	15
Permissible push force in Y	N	Max.	15
Permissible push force in Z	N	Max.	15
Permissible pull force in X	N	Max.	9
Permissible pull force in Y	N	Max.	9
Permissible pull force in Z	N	Max.	9
Permissible torque in θX	N·m	Max.	0.4
Permissible torque in θY	N·m	Max.	0.4
Permissible torque in θZ	N·m	Max.	0.4
Moved mass in X, unloaded	g		21
Moved mass in Y, unloaded	g		21
Moved mass in Z, unloaded	g		21
Guide			Flexure guide with lever amplification
Overall mass	g		400
Mass without cable	g		125
Material			Aluminum, steel

Miscellaneous	Unit		P-616.3C
Operating temperature range	°C		-20 to 80
ID chip			Yes
Connector			D-sub 25W3 (m)
Cable length	m		1.5
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.

At PI, technical data is specified at 22 ±3 °C. Unless otherwise stated, the values are for unloaded conditions. Some properties are interdependent. The designation "typ." indicates a statistical average for a property; it does not indicate a guaranteed value for every product supplied. During the final inspection of a product, only selected properties are analyzed, not all. Please note that some product characteristics may deteriorate with increasing operating time.

11.2 Maximum ratings

P-616 positioners 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 on the following website:
https://www.physikinstrumente.com/en/expertise/technology/piezo-technology/properties-piezo-actuators/electrical-operation

11.3 Ambient conditions and classifications

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

Area of application	Indoor use only
Maximum altitude	2000 m
Air pressure	1100 hPa to 700 hPa
Relative humidity	Highest relative humidity of 80 % for temperatures up to 31 °C decreasing linearly to a relative humidity of 50 % 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

11.4 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

Screw size	Minimum torque	Maximum torque
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 in accordance with VDI directive 2230.

11.5 Pin assignment

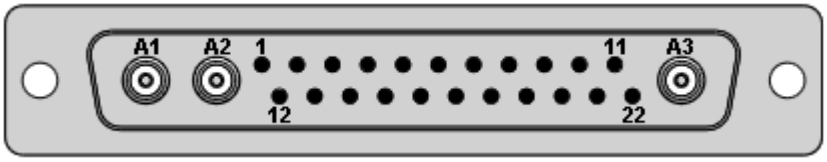


Fig. 12: D-sub 25W3 connector (contact side)

Pin	Signal	Function
A1 inner conductor	Output	Probe sensor signal, channel 2 (immovable part of the capacitive sensor)
A1 outer 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 outer 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 outer conductor	GND	Shielding for Probe sensor signal, channel 1
1	Input	Target sensor signal, channel 2 (movable part of the capacitive sensor)
2	Input	Target sensor signal, channel 3 (movable 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

Pin	Signal	Function
7	---	(not assigned)
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 movable part of the capacitive sensor)
12	GND	Shielding for target sensor signal, channel 2
13	GND	Shielding for target sensor signal, channel 3
14	---	(not assigned)
15	---	(not assigned)
16	GND	ID chip ground, channel 3
17	Bidirectional	Data line for ID-Chip, channel 3
18	---	(not assigned)
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

11.6 Dimensions

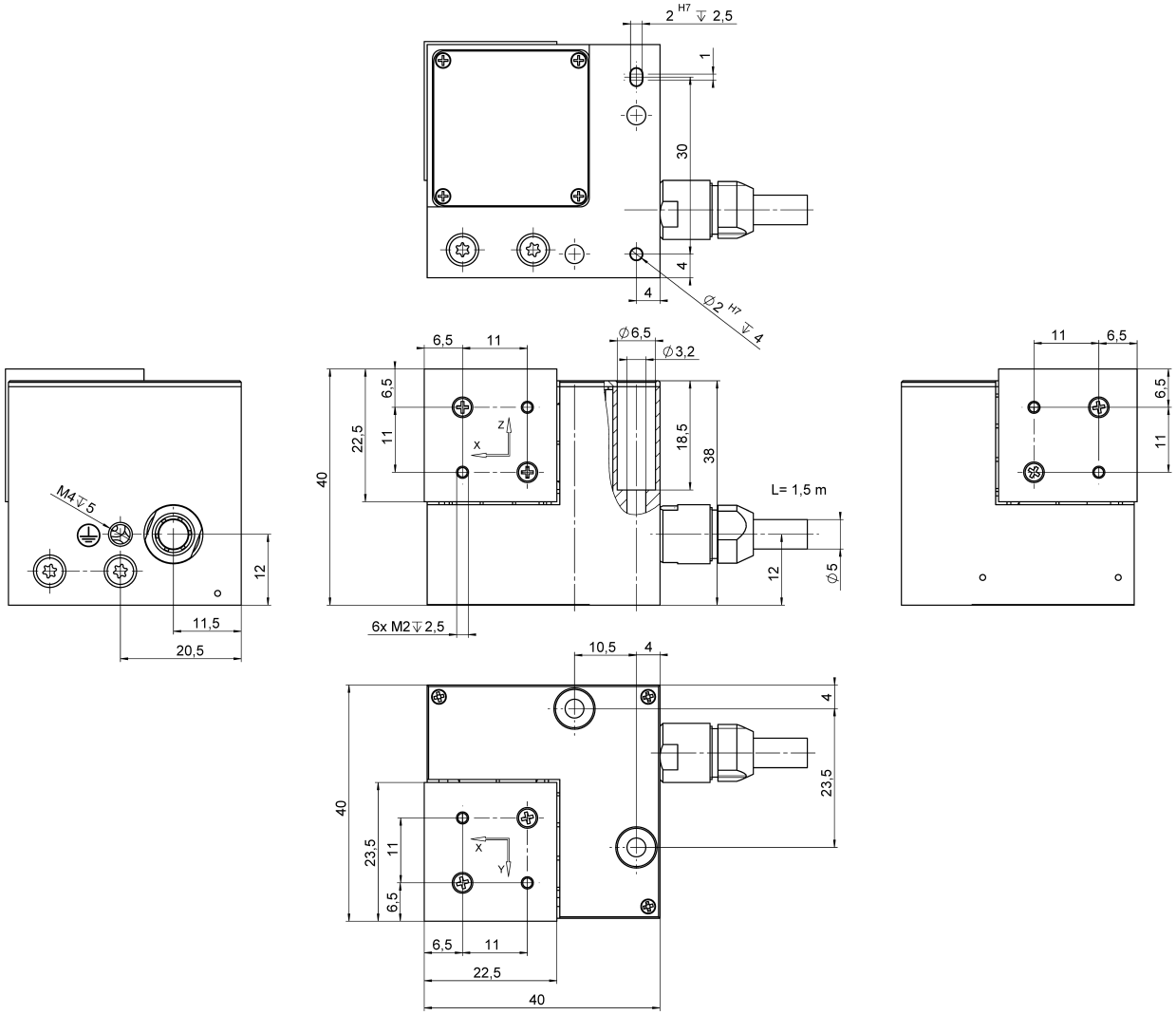


Fig. 13: P-616.3C, dimensions in mm. Note that the decimal points are separated by a comma in the drawings.

12 Old equipment disposal

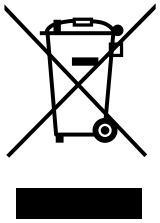
In accordance with EU law, electrical and electronic equipment may not be disposed of in EU member states via the municipal residual waste.

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

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

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

Physik Instrumente (PI) SE & Co. KG
Auf der Römerstraße 1
76227 Karlsruhe
Germany



13 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

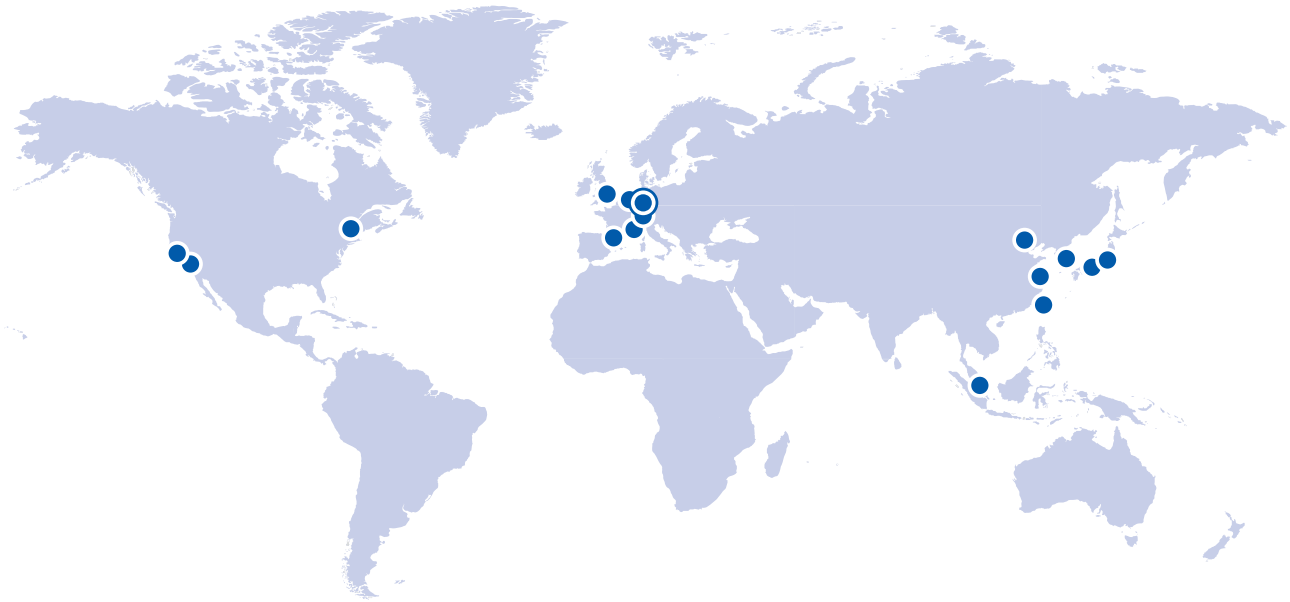
RoHS Directive

The applied standards certifying the conformity are listed below.

Safety (Low Voltage Directive): EN 61010-1

EMV: EN 61326-1

RoHS: EN IEC 63000



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