

PZ253E P-611 Positioners User Manual

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Date: 13.04.2021



This document describes the following products:

- **P-611.1**
Linear nanopositioner
P-611.1S/.10
- **P-611.XZ / P-611.2**
XZ and XYZ nanopositioner
P-611.2S/.20/.XZS/.XZ0
- **P-611.3**
NanoCube® XYZ nanopositioner
P-611.3S/.3SF/.30/.3OF
- **P-611.Z**
Vertical nanopositioning stage
P-611.ZS/.Z0

.1S/.10/.2S/.20/.XZS/.XZ0/.ZS/.Z0
= with LEMO connector(s)

.3S/.3SF/.30/.3OF
= with D-sub connector



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The patents held by PI are found in our patent list: <https://www.physikinstrumente.com/en/about-pi/patents>

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Original instructions

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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 This manual is superseded by any new release.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

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Symbols and Typographic Conventions 1

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1.1 Objective and Target Group of this User Manual

This user manual contains the information required for using the P-611 as intended ("x" stands for the different models (p. 9)).

Basic knowledge of control technology, drive technologies, and suitable safety measures is assumed.

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

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 cause damage to equipment.

- Precautionary measures for avoiding the risk.

INFORMATION

Information for easier handling, tricks, tips, etc.

Symbol/Label	Meaning
1.	Action consisting of several steps with strict sequential order
2.	
➤	Action consisting of one or more steps without relevant sequential order.
▪	Bullet
p. 5	Cross-reference to page 5
RS-232	Label on the product indicating an operating element (example: RS-232 interface socket)
 	Warning signs attached to the product that refer to detailed information in this manual.

1.3 Definition of Terms

Term	Explanation
Positioner	Electrically driven mechanics (here: P-611) with one or more motion axes
Electronics	Piezo amplifier or piezo controller that supplies the operating voltage for positioners or piezo actuators
Piezo amplifier	Electronics without sensor evaluation for open-loop operation of positioners and piezo actuators
Piezo controller	Electronics with sensor evaluation for closed-loop operation of positioners and piezo actuators

1.4 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.

1.5 Other Applicable Documents

The devices and software tools from PI mentioned in this documentation are described in separate manuals.

Product	Document
E-503 Piezo Amplifier Module	PZ62E User Manual
E-505 Piezo Amplifier Module	
E-610 Piezo Amplifier/Servo Controller (OEM Module)	PZ70E User Manual
E-621 Piezo Amplifier/Servo Controller Module	PZ115E User Manual
E-625 Piezo Servo Controller	PZ166E User Manual
E-663 Piezo Amplifier	PZ69E User Manual
E-664 NanoCube® Piezo Controller	PZ99E User Manual
E-665 Piezo Amplifier / Servo Controller	PZ127E User Manual
E-727.x • E-727.xAP Digital Multi-Channel Piezo Controller	E727T0005 User Manual
E-727.xF Digital Multi-Channel Piezo Controller	
E-836 Piezo Amplifier	PZ250E User Manual
PIMikroMove	SM148E Software Manual
P-5xx / P-6xx / P-7xx Piezo Positioners	PZ240EK Short Instructions

1.6 Downloading Manuals

INFORMATION

If a manual is missing or problems occur with downloading:

- Contact our customer service department (p. 33).

Downloading Manuals

1. Open the website **www.pi.ws**.
2. Search the website for the product number (e.g., P-611) or the product family (e.g., nanopositioner).
3. Click the corresponding product to open the product detail page.
4. Click the **Downloads** tab.

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

5. Click the desired manual and fill out the inquiry form.

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

2 Safety

In this Chapter

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2.1 Intended Use

The P-611 is a laboratory device as defined by DIN EN 61010-1. It is intended to be used in interior spaces and in an environment which is free of dirt, oil, and lubricants.

Based on its design and realization, the P-611 is intended for fine positioning as well as the fast and precise motion of small objects. The specifications of the P-611 apply to horizontal mounting. The motion is performed as follows depending on the model:

Model	Motion	Axis
.1S/.10	in one axis horizontally	X
.2S/.20	in two axes horizontally	X, Y
.XZS/.XZ0	in one axis horizontally and in one axis vertically	X, Z
.3S/.3SF/.3O/.3OF	in two axes horizontally and in one axis vertically	X, Y, Z
.ZS/.Z0	in one axis vertically	Z

Vertical mounting is only possible under certain conditions.

It is only possible to use the P-611 as intended in conjunction with suitable electronics (p. 13) from PI. The electronics are not included in the scope of delivery of the P-611.

The electronics must provide the required operating voltages. To ensure proper performance of the servo control system, the electronics must also be able to read out and process the signals from the position sensors.

2.2 General Safety Instructions

The P-611 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-611.

- Use the P-611 for its intended purpose only, and only when it is in perfect technical condition.
- Read the user manual.
- Eliminate any malfunctions that may affect safety immediately.

The operator is responsible for the correct installation and operation of the P-611.

The P-611 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 in the P-611 can lead to minor injuries from electric shock. The piezo actuators can be destroyed by an abrupt contraction.

- Do **not** open the P-611.
- 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 a protective earth conductor is not or not properly connected, dangerous touch voltages can occur on the P-611 in the case of malfunction or failure of the system. If there are touch voltages, touching the P-611 can result in minor injuries from electric shock.

- Connect the P-611 to a protective earth conductor (p. 18) 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-611 to the protective earth conductor before restarting.

Mechanical forces can damage or misalign the P-611.

- Avoid impacts that affect the P-611.
- Do **not** drop the P-611.
- Do **not** exceed the maximum permissible stress and load capacities according to the specifications (p. 35).
- Grip the surfaces indicated on the P-611's base body (p. 15) only.

The P-611 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-611.

2.3 Organizational Measures

User manual

- Always keep this user manual together with the P-611.
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-611 to a third party, include this user manual as well as 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-611 only after you have read and understood this user manual.

Personnel qualification

The P-611 may only be installed, started, operated, maintained, and cleaned by authorized and appropriately qualified personnel.

3 Product Description

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Suitable Electronics.....	13
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Technical Features	14

3.1 Model Overview

The following standard versions of the P-611 are available:

P-611.1: Linear nanopositioner

Model	Description
P-611.1S	Linear nanopositioner, 100 μm , strain gauge sensor
P-611.10	Linear nanopositioner, 120 μm , without sensor

P-611.XZ / P-611.2: XZ and XYZ nanopositioner

Model	Description
P-611.2S	XY nanopositioner, 100 μm \times 100 μm , strain gauge sensors
P-611.20	XY nanopositioner, 120 μm \times 120 μm , without sensor
P-611.XZS	XZ nanopositioner, 100 μm \times 100 μm , strain gauge sensors
P-611.XZ0	XZ nanopositioner, 120 μm \times 120 μm , without sensor

P-611.3: NanoCube® XYZ nanopositioner

Model	Description
P-611.3S	NanoCube® XYZ nanopositioner, 100 μm \times 100 μm \times 100 μm , strain gauge sensors
P-611.3SF	NanoCube® XYZ nanopositioner, 100 μm \times 100 μm \times 100 μm , strain gauge sensors, integrated fiber holder
P-611.3O	NanoCube® XYZ nanopositioner, 120 μm \times 120 μm \times 120 μm , without sensor
P-611.3OF	NanoCube® XYZ nanopositioner, 120 μm \times 120 μm \times 120 μm , without sensor, integrated fiber holder

P-611.Z: Vertical nanopositioning stage

Model	Description
P-611.ZS	Vertical nanopositioning stage, 100 µm, strain gauge sensor
P-611.Z0	Vertical nanopositioning stage, 120 µm, without sensor

3.2 Product View

The figures serve as examples and can differ from your positioner model.

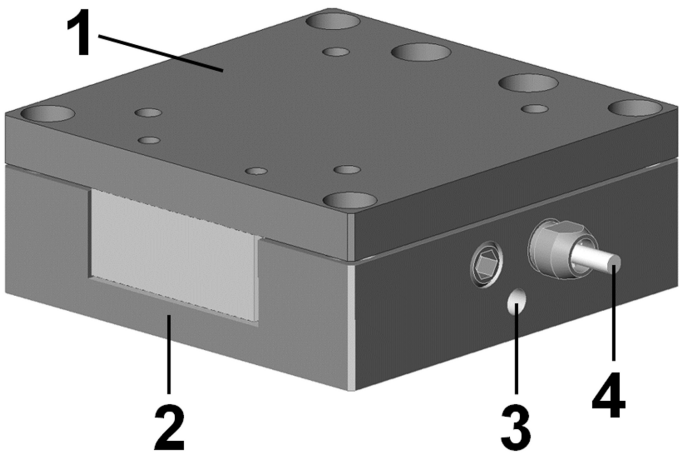

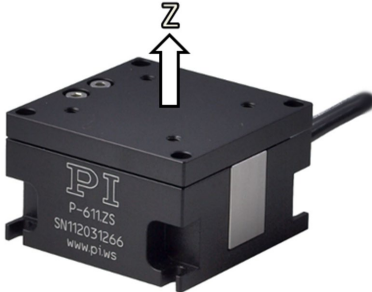
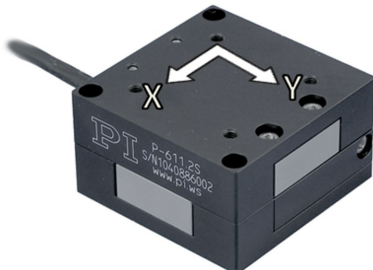
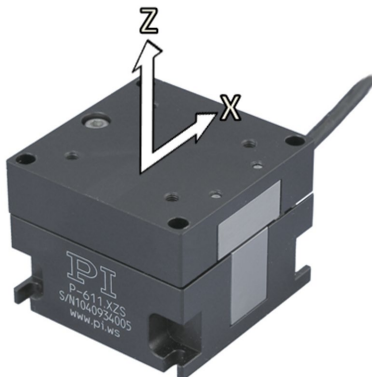
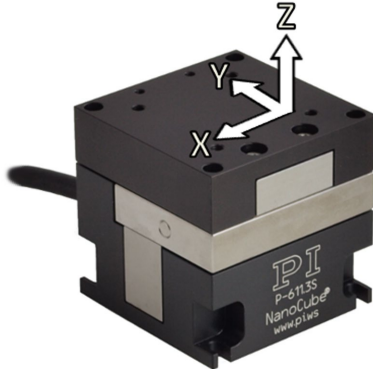


Figure 1: Example of product view

- 1 Motion platform
- 2 Base body
- 3 Protective earth connector
- 4 Cable exit

Direction of motion of the P-611

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

<p>P-611.1x</p> 	<p>P-611.Zx</p> 
<p>P-611.2x</p> 	<p>P-611.XZx</p> 
<p>P-611.3x / P-611.3xF</p> 	

3.3 Product Labeling






Labeling	Description
P-611.XZS	Product name (example), the characters following the period refer to the model
123456789	Serial number (example), individual for each P-611 Meaning of each position (from the left): 1 = internal information 2 and 3 = year of manufacture 4 to 9 = consecutive number
NanoCube®	Brand name (.3x and .3xF models only)
Country of origin: Germany	Country of origin
	Warning sign "Pay attention to the manual!"
	Old equipment disposal (p. 53)
WWW.PI.WS	Manufacturer's address (website)
	Manufacturer's logo
	CE conformity mark
	Symbol for the protective earth conductor, marks the protective earth connector of the P-611 (p. 18)



Figure 2: "Residual Voltage" warning sign on the connector of the P-611

"Residual Voltage" warning: Risk of electric shock (p. 6) for models with D-sub connector

3.4 Scope of Delivery

Product number	Description
P-611	Positioner according to order (p. 9)
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 lock washers 2 flat washers
PZ240EK	Short instructions for P-5xx / P-6xx / P-7xx piezo positioners

3.5 Suitable Electronics

You need suitable electronics to operate a P-611. Selecting the device depends on the application and the connectors available.

Electronics	Connector*	Channels**
E-505 Piezo Amplifier Module	LEMO	1
E-610 Piezo Amplifier / Servo Controller (OEM module)	LEMO	1
E-836 Piezo Amplifier	LEMO	1
E-503 Piezo Amplifier Module	LEMO	3
E-663 Piezo Amplifier	LEMO	3
E-621 Piezo Amplifier/Servo Controller Module	D-sub 7W2	1
E-625 Piezo Servo Controller	D-sub 7W2	1
E-665 Piezo Amplifier / Servo Controller	D-sub 7W2	1
E-664 NanoCube® Piezo Controller	D-sub 25	3
E-727.x • E-727.xAP Digital Multi-Channel Piezo Controller	D-sub 25W3	3
E-727.xF Digital Multi-Channel Piezo Controller	D-sub 25W3	3

* In some cases, adapter cables (p. 13) are necessary for connecting.

** When using single-channel electronics, each motion axis requires its own individual electronics.

3.6 Accessories

Adapter cables for models with LEMO plug connectors

Product number	Description
P-895.1LDC	Adapter cable LEMO to D-sub 7W2 (m) for piezo actuator nanopositioning systems with capacitive sensors, 1 channel, length: 0.3 m.
P-895.3LDC	Adapter cable LEMO to D-sub 25W3 (m) for piezo actuator nanopositioning systems with capacitive sensors, 3 channels, length: 0.3 m.

➤ To order, contact our customer service department (p. 33).

3.7 Technical Features

3.7.1 PICMA® Piezo Actuators

P-611 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.

3.7.2 Flexure Guides

P-611 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.

3.7.3 Strain Gauge Sensors (SGS)

Strain gauge sensors derive the position information from their expansion. They are attached at a suitable position in the drivetrain, where they measure the displacement of the positioner's moving part against the base body. This type of position measuring is indirect and requires contact, because the position of the platform is derived from a measurement on the lever, guide or piezo stack.

The sensors operate in thermally drift-free full bridge circuitry and therefore ensure optimum position stability in the nanometer range.

4 Unpacking

NOTICE



Mechanical overload from incorrect handling!

Impermissible mechanical loading of the motion platform as well as certain surfaces of the P-611 can lead to damage to the piezo actuators, sensors and flexure joints of the P-611 as well as to loss of accuracy. In addition, the P-611 can be damaged from tensile forces on the cable exit and bending of the connecting cable.

- Grip the surfaces indicated on the P-611's base body (p. 15) only.
- Avoid tensile forces on the cable exit and do not bend the cable.

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

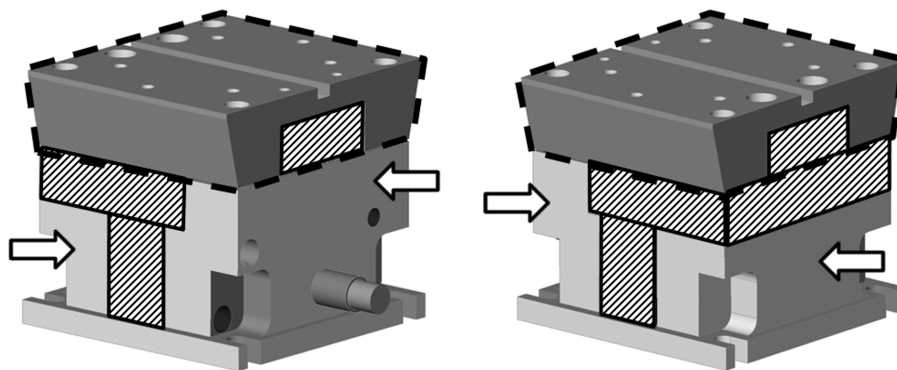


Figure 3: P-611: Holding surfaces to be used on the base body (see arrows)

Areas to be protected against the application of force:

- Motion platform (framed with a dashed line)
- Nonanodized surfaces (crosshatched)

1. Unpack the P-611 with care:
 - a) Spread the foam packaging apart with one hand.
 - b) Grip the positioner on the surfaces marked by the arrows.
 - c) Grip all of the positioner's connecting cables with your other hand.
 - d) At the same time, remove the positioner and the connecting cables carefully from the foam packaging.
2. Compare the contents of the shipment with the items listed in the contract and the delivery note.
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 Installing	17
Connecting the P-611 to the Protective Earth Conductor	18
Mounting the P-611	20
Fixing the Load	22

5.1 General Notes on Installing

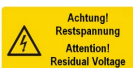
CAUTION



Dangerous voltage and residual charge in piezo actuators!

The P-611 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 in the P-611 can lead to minor injuries from electric shock. The piezo actuators can be destroyed by an abrupt contraction.

- Do **not** open the P-611.
- 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-611 can lead to damage to the piezo actuators, sensors and flexure joints of the P-611 as well as to loss of accuracy. In addition, the P-611 can be damaged from tensile forces on the cable exit and bending of the connecting cable.

- Grip the surfaces indicated on the P-611's base body (p. 15) 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-611 and the electronics.

- Use cables provided by PI only to connect the P-611 to the electronics.

NOTICE**Damage due to improper mounting!**

Improper mounting of the P-611 or incorrectly mounted parts can damage the P-611.

- Only use the holes or threads intended for the purpose of fixing the P-611 and loads.
- Install the P-611 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. 49) specified for the screws used during installation.

INFORMATION

Extension cables can reduce the positioning accuracy of the P-611 or affect sensor processing by the electronics.

- Do **not** use extension cables. If you need longer cables, contact our customer service department (p. 33).

5.2 Connecting the P-611 to the Protective Earth Conductor


INFORMATION

In the case of P-611 positioners with D-sub connectors, ground loops can occur when the positioner is grounded via its protective earth connector as well as via the connecting cable's shielding for the electronics.

- If a ground loop occurs, contact our customer service department (p. 33).

INFORMATION

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

The P-611 has an M4 hole for attaching the protective earth conductor. This hole is marked with the symbol for the protective earth conductor . For the exact position of the hole, see "Dimensions" (p. 42).

Requirements

- ✓ You have read and understood the general notes on installation (p. 17).
- ✓ The positioner 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. 12) supplied for connecting the protective earth conductor
- Suitable screwdriver

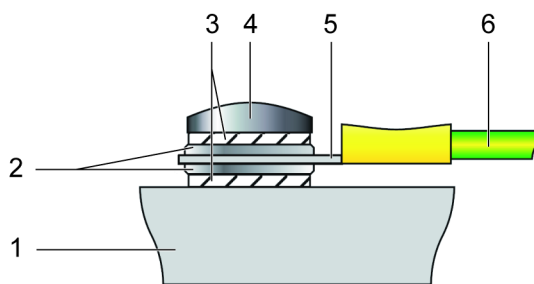


Figure 4: Connecting the protective earth conductor (profile view)

- | | |
|---|----------------------------|
| 1 | Base body of the P-611 |
| 2 | Flat washer |
| 3 | Lock washer |
| 4 | Screw |
| 5 | Cable lug |
| 6 | Protective earth conductor |

Connecting the P-611 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 flat and lock washers) to attach the cable lug of the protective earth conductor to the threaded hole in the P-611 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-611

NOTICE

**Warping the P-611 when mounting onto uneven surfaces!**

The P-611 could warp if mounted on an uneven surface. Warping reduces the accuracy.

- Mount the P-611 onto a flat surface. The recommended flatness of the surface is $\leq 20 \mu\text{m}$.
- For applications with large temperature changes:
Mount the P-611 only onto surfaces that have the same or similar thermal expansion properties as the P-611.

NOTICE

**Tensile stress on piezo actuator due to mounting in wrong orientation!**

The P-611 is intended for mounting in horizontal orientation (standing on a surface, not suspended). Mounting in other orientations can cause tensile stress that reduces the preload and destroys the piezo actuator.

- If you want to mount the P-611 in a different orientation to that intended (e.g., vertically or upside down), contact our customer service department (p. 33).

The following figures serve as examples and can differ from your positioner model.

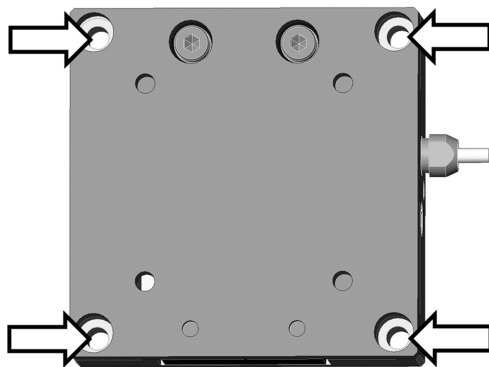


Figure 5: P-611.1x and .2x: Holes for mounting the positioner onto an underlying surface

Number of mounting holes:

P-611.1x: 4

P-611.2x: 3

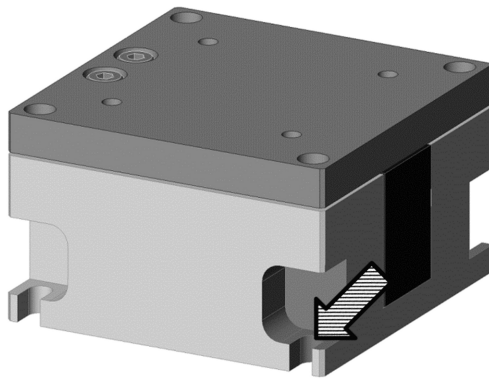


Figure 6: P-611.XZx, .3x, .3xF, and .Zx: One of four recesses in the base body for mounting the positioner onto an underlying surface

Requirements

- ✓ You have read and understood the general notes on installation (p. 17).
- ✓ The P-611 is **not** connected to the electronics.

Tools and accessories

- When mounting a P-611.2x:
 - 3 screws of suitable size and length (p. 42)
- When mounting other models of the P-611:
 - 4 screws of suitable size and length (p. 42)
- Suitable screwdriver

Mounting the P-611

1. Position the P-611 on a flat underlying surface.
2. Insert the screws:
 - When mounting a P-611.1x or .2x:
 - Insert the screws from above into the countersunk holes in the base body of the P-611.
 - When mounting a P-611.XZx, .3x, .3xF or .Zx:
 - Insert the screws into the recesses in the base body of the P-611 from the side.
3. Tighten the screws. Pay attention to the specified torque range (p. 49) while doing so.

5.4 Fixing the Load

NOTICE

**Mechanical overload of the platform!**

High torques during fastening of the load as well as high loads can overload the platform of the P-611. Mechanical overload can cause damage to the piezo actuators, sensors, and flexures of the P-611 and lead to loss of accuracy.

- Avoid torques > 50Ncm on the platform.
- Do **not** exceed the maximum permissible loads according to the specifications (p. 35).
- Hold the load and adhere to the specified torque range (p. 49) when tightening (or loosening) the screws.

NOTICE

**Warping the P-611 when fixing loads with an uneven contact surface!**

Fixing loads with an uneven contact surface could warp the P-611. Warping reduces the accuracy.

- Fix loads on the P-611 only when the surface contacting the P-611's platform has a flatness of at least 20 µm.
- For applications with large temperature changes:
Fix loads to the P-611 only when they have the same or similar thermal expansion properties as the P-611.

NOTICE

**Center of load at unsuitable position!**

If the center of load is located too far away from the center of the platform (e.g., tall loads and unwanted lever effect), the P-611 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 platform, adjust the controller settings before starting or contact our customer service department (p. 33).

NOTICE

**Excessively long screws!**

The P-611 could be damaged by screws inserted too deeply.

- Pay attention to the depth of the mounting holes in the platform (p. 42).
- 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. 10).

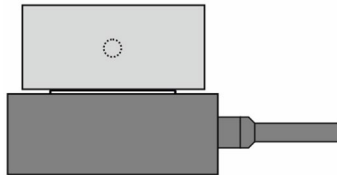
Center of load at the optimal position:

Figure 7: Example of an optimally placed load

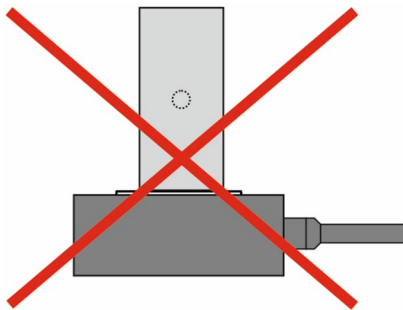
Center of load at an unsuitable position:

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

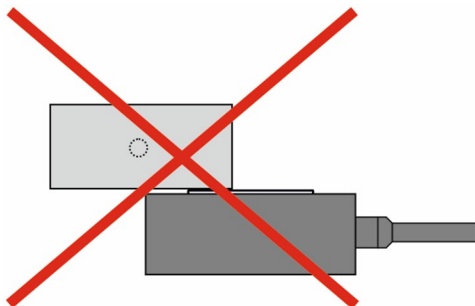


Figure 9: Unwanted lever effect and center of load on the side of the platform

Requirements

- ✓ You have read and understood the general notes on installation (p. 17).
- ✓ The P-611 is **not** connected to the electronics.

Tools and accessories

- Screws of suitable size and length (p. 42)
- Suitable screwdriver

Fixing the load

1. Align the load on the P-611 so that the mounting holes in the load and the holes in the platform are in line.
2. Hold the load so that it cannot move while tightening the screws.
3. Fix the load by tightening the screws in the mounting holes (p. 42) provided. Pay attention to the specified torque range (p. 49) for the screws.
4. Check that the load is sitting firmly on the platform.

6 Starting and Operating

In this Chapter

General Notes on Starting	25
Operating the P-611.....	26
Discharging the P-611.....	27

6.1 General Notes on Starting

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-611 in the case of malfunction or failure of the system. If there are touch voltages, touching the P-611 can result in minor injuries from electric shock.

- Connect the P-611 to a protective earth conductor (p. 18) 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-611 to the protective earth conductor before restarting.

NOTICE



Destruction of the piezo actuator due to electric flashovers!

Using the P-611 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-611 in environments that can increase the electric conductivity.
- Operate the P-611 only within the permissible ambient conditions and classifications (p. 41).

NOTICE



Decreased lifetime due to permanently high voltage!

Applying a continuous high static voltage to piezo actuators reduces the lifetime of the piezo ceramic.

- When the P-611 is not used but the electronics remain switched on to ensure temperature stability, discharge the P-611 (p. 27).

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

Operating voltages that are too high or incorrectly connected can cause damage to the P-611.

- Operate the P-611 only with controllers/drivers and original accessories from PI.
- Do **not** exceed the operating voltage range (p. 40) for which the P-611 is specified.
- Operate the P-611 only when the operating voltage is properly connected; see "Pin Assignment" (p. 49).

NOTICE**Uncontrolled oscillation!**

Oscillation can cause irreparable damage to the P-611. 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-611 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-611 immediately.

INFORMATION

Positive direction of axis motion is specified in the product view (p. 10).

INFORMATION

Sound and vibration (e.g., footfall, knocks) can be transmitted to the P-611 and can affect its performance with regard to position stability.

- Avoid sound and vibration while the P-611 is being operated.

6.2 Operating the P-611

- Follow the instructions in the manual for the electronics (p. 13) used for starting and operating the P-611.

6.3 Discharging the P-611

The P-611 must be discharged in the following cases:

- Before Installation
- When the P-611 is not in use but the electronics remain switched on to ensure temperature stability
- Before demounting (e.g., before cleaning and transporting the P-611 and for modifications)

The P-611 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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Cleaning the P-611.....	29

7.1 General Notes on Maintenance

NOTICE



Misalignment due to loosening screws!

The P-611 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-611.

7.2 Cleaning the P-611

NOTICE



Damage from ultrasonic cleaning!

Ultrasonic cleaning can damage the P-611.

- Do **not** do any ultrasonic cleaning.

Requirements

- ✓ You have discharged the piezo actuators of the P-611 (p. 27).
- ✓ You have disconnected the P-611 from the electronics.

Cleaning the P-611

- Clean the surfaces of the P-611 with a cloth dampened with a mild cleanser or disinfectant (e.g., isopropyl alcohol).

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. 35).
	Zero shift of the sensor for the following reasons: <ul style="list-style-type: none"> ▪ Load in direction of motion ▪ Ambient/operating temperature of the positioner is far above or below the calibration temperature (21 °C to 24 °C) 	➤ Adjust the zero-point of the sensor (refer to the controller manual).
Reduced accuracy	The base body or the motion platform is warped	➤ Mount the P-611 onto surfaces with the following characteristics only: <ul style="list-style-type: none"> – Flatness of at least 20 µm – The thermal expansion properties are similar to those of the P-611 (e.g., surfaces made of aluminum). ➤ Mount loads onto the P-611 with the following characteristics only: <ul style="list-style-type: none"> – The contact surface of the load has a flatness of at least 20 µm. – The thermal expansion properties are similar to those of the P-611 (e.g., loads made of aluminum).
	P-611 or controller has been replaced	It is necessary to recalibrate the axis displacement after replacing the P-611 or controller. ➤ Recalibrate the axis displacement (see controller manual) or contact our customer service department (p. 33).

Problem	Possible causes	Solution
	Axes were mixed up during connection (only with LEMO connectors)	➤ Pay attention to the assignment of the axes when connecting the positioner to the controller. This assignment is indicated by labels on the devices.
	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 incorrectly set because for example, the load was changed	<ol style="list-style-type: none"> 1. Switch off the servo mode of the corresponding motion axes immediately. 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, operate the positioner only with a frequency that is 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 department (p. 33).

9 Customer Service

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

- If you have any 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)
 - 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 department if requested.

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

10 Technical Data

In this Chapter

Specifications	35
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Torque for Stainless Steel Screws (A2-70)	49
Pin Assignment	49

10.1 Specifications

10.1.1 Data Table

	P-611.1S	P-611.10	Unit	Tolerance
Active axes	X	X		
Motion and positioning				
Integrated sensor	SGS	-		
Travel range at -20 to +120 V, open loop	120	120	μm	+20 % / -0 %
Travel range, closed loop	100	-	μm	
Resolution, open loop	0.2	0.2	nm	typ.
Resolution, closed loop	2	-	nm	typ.
Linearity error, closed loop	0.1	-	%	typ.
Repeatability	<10	-	nm	typ.
Pitch	±5	±5	μrad	typ.
Yaw	±20	±20	μrad	typ.
Flatness	10	10	nm	typ.
Mechanical properties				
Stiffness in motion direction	0.2	0.2	N/μm	±20 %
Resonant frequency, no load	400	400	Hz	±20 %
Resonant frequency, under load, 30 g	300	300	Hz	±20 %
Resonant frequency, under load, 100 g	195	195	Hz	±20 %
Push/pull force capacity in motion direction	15 / 10	15 / 10	N	max.
Load capacity	15	15	N	max.

	P-611.1S	P-611.10	Unit	Tolerance
Drive properties				
Ceramic type	PICMA® P-885	PICMA® P-885		
Electrical capacitance	1.5	1.5	μF	±20 %
Miscellaneous				
Operating temperature range	-20 to 80	-20 to 80	°C	
Material	Aluminum, steel	Aluminum, steel		
Dimensions	44 mm × 44 mm × 17 mm	44 mm × 44 mm × 17 mm		
Mass	0.135	0.135	kg	±5 %
Cable length	1.5	1.5	m	±10 mm
Voltage connection	LEMO	LEMO		
Sensor connection	LEMO	-		
Recommended electronics	E-503, E-505, E-610, E-621, E-625, E-665, E-836	E-503, E-505, E-610, E-621, E-625, E-665, E-836		

The resolution of the system is limited only by the noise of the amplifier and the measuring technology because PI piezo nanopositioning systems are free of friction.

	P-611.2S	P-611.20	P-611.XZS	P-611.XZ0	Unit	Tolerance
Active axes	X, Y	X, Y	X, Z	X, Z		
Motion and positioning						
Integrated sensor	SGS	–	SGS	–		
Travel range at -20 to 120 V, open loop	120	120	120	120	μm	+20 % / -0 %
Travel range, closed loop	100	–	100	–	μm	
Resolution, open loop	0.2	0.2	0.2	0.2	nm	typ.
Resolution, closed loop	2	–	2	–	nm	typ.
Linearity error	0.1	–	0.1	–	%	typ.
Repeatability	<10	–	<10	–	nm	typ.
Pitch in X, Y	±5	±5	±5	±5	μrad	typ.
Tilt θ _x (motion in Z)	–	–	±10	±10	μrad	typ.
Yaw in X	±20	±20	±20	±20	μrad	typ.
Yaw in Y	±10	±10	–	–	μrad	typ.
Tilt θ _y (motion in Z)	–	–	±10	±10	μrad	typ.

	P-611.2S	P-611.20	P-611.XZS	P-611.XZ0	Unit	Tolerance
Mechanical properties						
Stiffness	0.2	0.2	0.2 Z: 0.35	0.2 Z: 0.35	N/μm	±20 %
Resonant frequency, no load	X: 345; Y: 270	X: 345; Y: 270	X: 365; Z: 340	X: 365; Z: 340	Hz	±20 %
Resonant frequency, under load, 30 g	X: 270; Y: 225	X: 270; Y: 225	X: 280; Z: 295	X: 280; Z: 295	Hz	±20 %
Resonant frequency, under load, 100 g	X: 180; Y: 165	X: 180; Y: 165	X: 185; Z: 230	X: 185; Z: 230	Hz	±20 %
Push/pull force capacity in motion direction	15 / 10	15 / 10	15 / 10	15 / 10	N	max.
Load capacity	15	15	15	15	N	max.
Drive properties						
Ceramic type	PICMA® P-885	PICMA® P-885	PICMA® P-885	PICMA® P-885		
Electrical capacitance	1.5	1.5	1.5	1.5	μF	±20 %
Miscellaneous						
Operating temperature range	-20 to 80	-20 to 80	-20 to 80	-20 to 80	°C	
Material	Aluminum, steel	Aluminum, steel	Aluminum, steel	Aluminum, steel		
Dimensions	44 mm × 44 mm × 25 mm	44 mm × 44 mm × 25 mm	44 mm × 44 mm × 34 mm	44 mm × 44 mm × 34 mm		
Mass	0.235	0.235	0.27	0.27	kg	±5 %
Cable length	1.5	1.5	1.5	1.5	m	±10 mm
Sensor connection	LEMO	—	LEMO	—		
Voltage connection	LEMO	LEMO	LEMO	LEMO		
Recommended electronics	E-503, E-505, E-663, E-664, E-727	E-503, E-505, E-663, E-664, E-727	E-503, E-505, E-663, E-664, E-727	E-503, E-505, E-663, E-664, E-727		

The resolution of the system is limited only by the noise of the amplifier and the measuring technology because PI piezo nanopositioning systems are free of friction.

	P-611.3S P-611.3SF	P-611.3O P-611.3OF	Unit	Tolerance
Active axes	X, Y, Z	X, Y, Z		
Motion and positioning				
Integrated sensor	SGS			
Travel range at -20 to 120 V, open loop	120 / axis	120 / axis	μm	+20 % / -0 %
Travel range, closed loop	100 / axis	–	μm	
Resolution, open loop	0.2	0.2	nm	typ.
Resolution, closed loop	1	–	nm	typ.
Linearity error	0.1	–	%	typ.
Repeatability	<10	–	nm	typ.
Pitch in X, Y	±5	±5	μrad	typ.
Tilt θ_x (motion in Z)	±10	±10	μrad	typ.
Yaw in X	±20	±20	μrad	typ.
Yaw in Y	±10	±10	μrad	typ.
Tilt θ_y (motion in Z)	±10	±10	μrad	typ.
Mechanical properties				
Stiffness	0.3	0.3	N/μm	±20 %
Resonant frequency X / Y / Z, no load	350 / 220 / 250	350 / 220 / 250	Hz	±20 %
Resonant frequency under load in X / Y / Z, 30 g	270 / 185 / 230	270 / 185 / 230	Hz	±20 %
Resonant frequency under load in X / Y / Z, 100 g	180 / 135 / 200	180 / 135 / 200	Hz	±20 %
Push/pull force capacity in motion direction	15 / 10	15 / 10	N	max.
Load capacity	15	15	N	max.
Drive properties				
Ceramic type	PICMA® P-885	PICMA® P-885		
Electrical capacitance	1.5	1.5	μF	±20 %
Miscellaneous				
Operating temperature range	-20 to 80	-20 to 80	°C	
Material	Aluminum, steel	Aluminum, steel		
Dimensions	P-611.3S: 44 mm × 44 mm × 43.2 mm P-611.3SF: 48 mm × 50 mm × 44.2 mm	P-611.3O: 44 mm × 44 mm × 43.2 mm P-611.3OF: 44 mm × 50 mm × 44.2 mm		
Mass	0.32	0.32	kg	±5 %
Cable length	1.5	1.5	m	±10 mm

	P-611.3S P-611.3SF	P-611.3O P-611.3OF	Unit	Tolerance
Voltage connection	D-sub 25 (m)	D-sub 25 (m)		
Sensor connection	D-sub 25 (m)	–		
Recommended electronics	E-503, E-505, E-663, E-664, E-727	E-503, E-505, E-663, E-664, E-727		

The resolution of the system is limited only by the noise of the amplifier and the measuring technology because PI piezo nanopositioning systems are free of friction.

Adapter cables with LEMO connectors for sensor and operating voltage available.

	P-611.ZS	P-611.ZO	Unit	Tolerance
Active axes	Z	Z		
Motion and positioning				
Integrated sensor	SGS	-		
Travel range at -20 to +120 V, open loop	120	120	μm	+20 % / -0 %
Travel range, closed loop	100	-	μm	
Resolution, open loop	0.2	0.2	nm	typ.
Resolution, closed loop	2	-	nm	typ.
Linearity error	0.1	-	%	typ.
Repeatability	<10	-	nm	typ.
Tilt θ_z (motion in Z)	±5	±5	μrad	typ.
Tilt θ_x (motion in Z)	±20	±20	μrad	typ.
Tilt θ_y (motion in Z)	±5	±5	μrad	typ.
Mechanical properties				
Stiffness	0.45	0.45	N/μm	±20 %
Resonant frequency, no load	460	460	Hz	±20 %
Resonant frequency under load, 30 g	375	375	Hz	±20 %
Resonant frequency under load, 100 g	265	265	Hz	±20 %
Push/pull force capacity	15 / 10	15 / 10	N	max.
Drive properties				
Ceramic type	PICMA® P-885	PICMA® P-885		
Electrical capacitance	1.5	1.5	μF	±20 %
Miscellaneous				
Operating temperature range	-20 to 80	-20 to 80	°C	
Material	Aluminum, steel	Aluminum, steel		
Dimensions	44 mm × 44 mm × 27 mm	44 mm × 44 mm × 27 mm		

	P-611.ZS	P-611.Z0	Unit	Tolerance
Mass	176	176	g	±5 %
Cable length	1.5	1.5	m	±10 mm
Sensor connection	LEMO	-		
Voltage connection	LEMO	LEMO		
Recommended electronics	E-610, E-625, E-665, E-836	E-610, E-625, E-665, E-836		

The resolution of the system is limited only by the noise of the amplifier and the measuring technology because PI piezo nanopositioning systems are free of friction.

System properties:




System configuration: P-611.ZS and E-665.SR controller with 30 g load

Small signal bandwidth: 40 Hz

Settling time (10 % step width): 25 ms

10.1.2 Maximum Ratings

P-611 positioners are designed for the following operating data:

Positioner	Maximum operating voltage 	Maximum operating frequency (no load) ¹ 	Maximum power consumption ² 
P-611.1S P-611.10	-20 to +120 V	133 Hz	3.9 W
P-611.2S P-611.20	-20 to +120 V	115 Hz (in X) 90 Hz (in Y)	3.4 W (in X) 2.6 W (in Y)
P-611.XZS P-611.XZ0	-20 to +120 V	122 Hz (in X) 113 Hz (in Z)	3.6 W (in X) 3.3 W (in Z)
P-611.3S P-611.3SF P-611.3O P-611.3OF	-20 to +120 V	117 Hz (in X) 73 Hz (in Y) 83 Hz (in Z)	3.4 W (in X) 2.1 W (in Y) 2.4 W (in Z)
P-611.ZS P-611.Z0	-20 to +120 V	153 Hz	4.5 W

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:

<https://www.physikinstrumente.com/en/technology/piezo-technology/properties-piezo-actuators/electrical-operation/>

10.1.3 Ambient Conditions and Classifications

Pay attention to the following ambient conditions and classifications for the P-611:

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 a comma is used in the drawings instead of a decimal point.

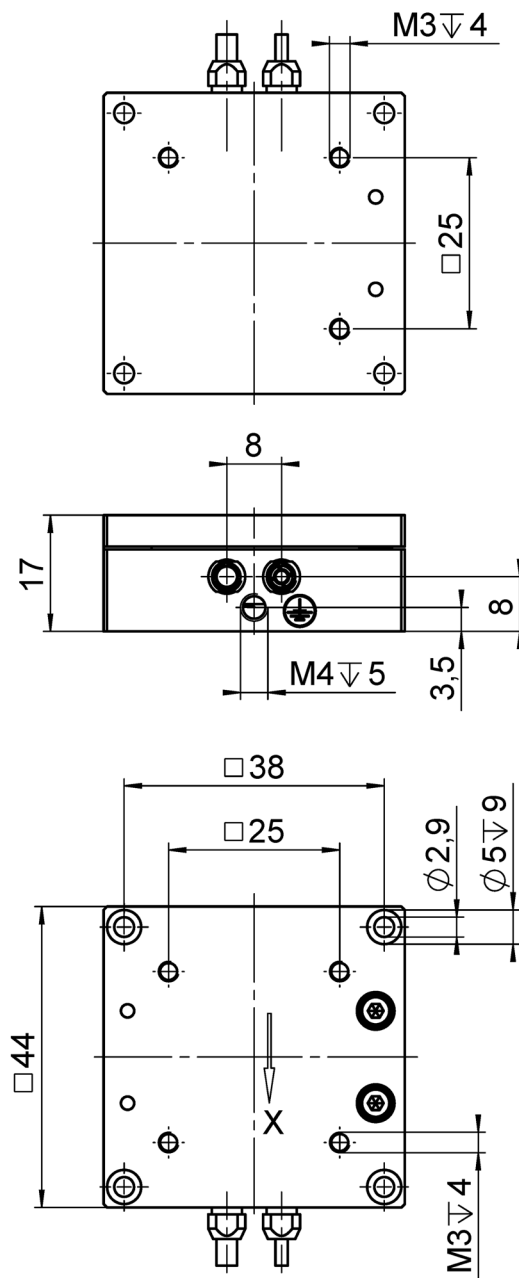


Figure 10: P-611.1S

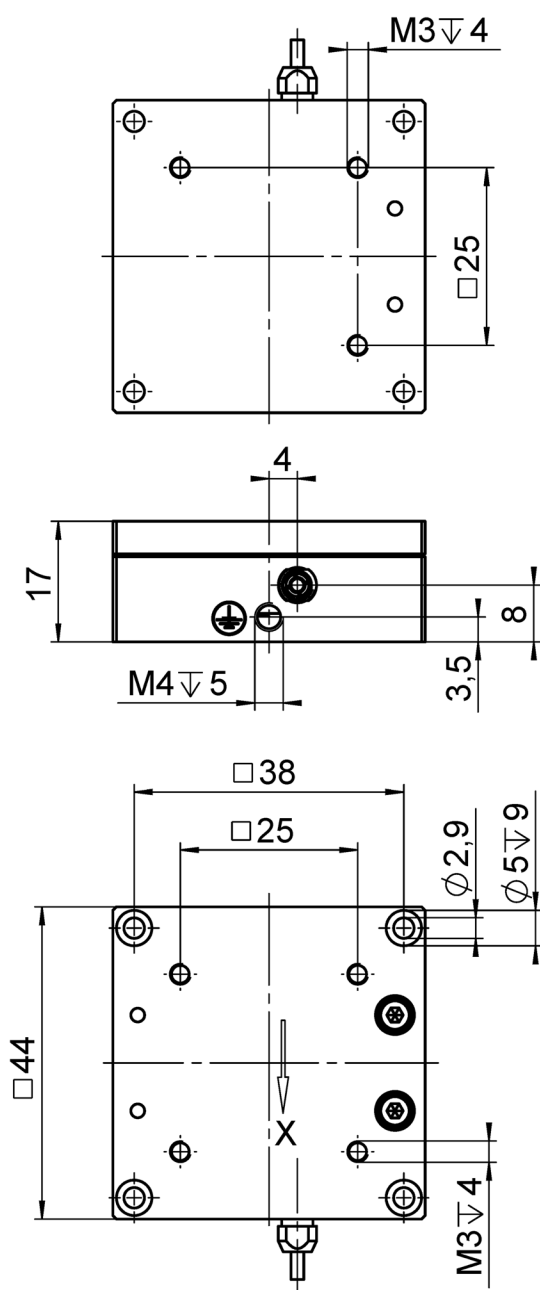


Figure 11: P-611.10

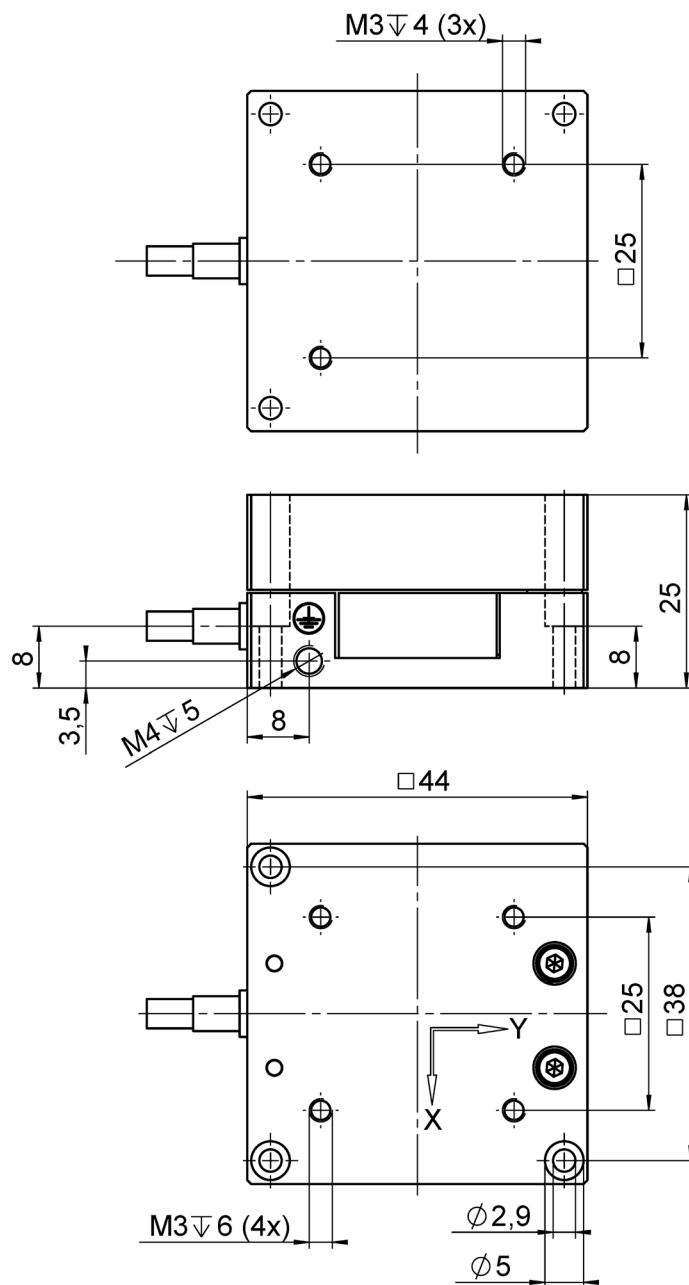


Figure 12: P-611.2S and P-611.20

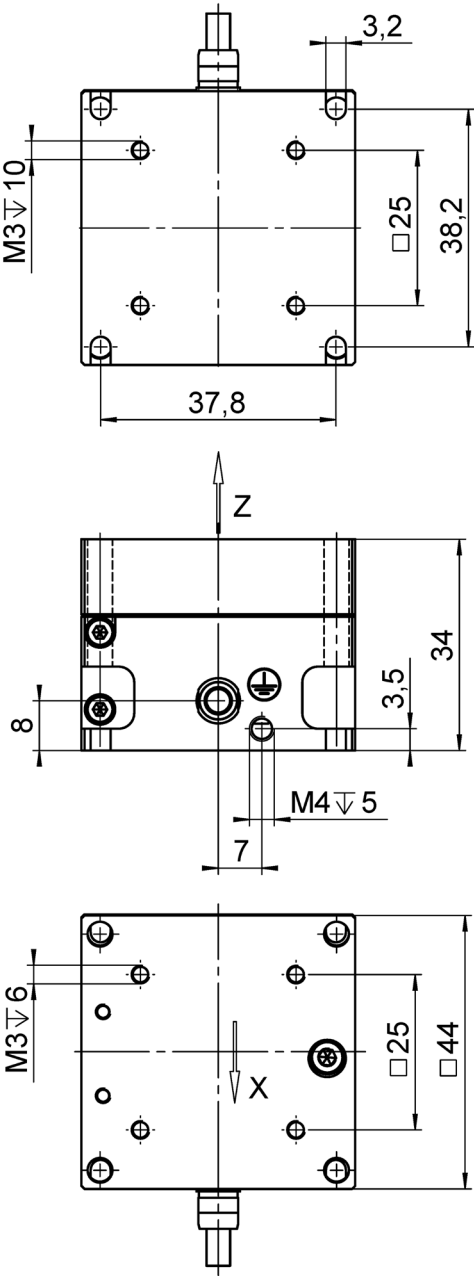


Figure 13: P-611.XZS and P-611.XZ0

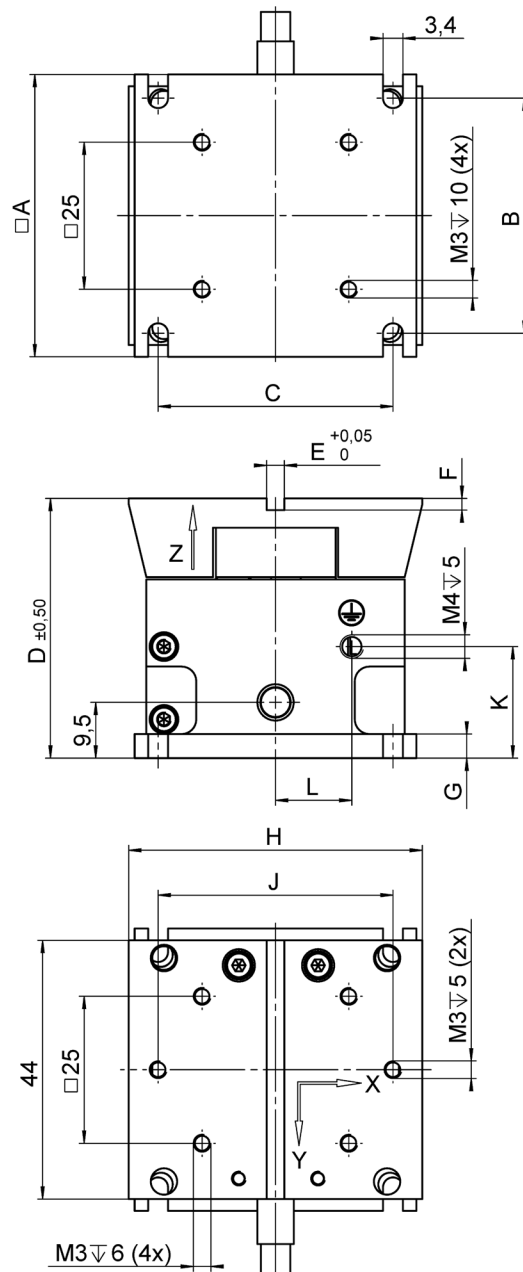


Figure 14: P-611.3O, P-611.3S, P-611.3OF and P-611.3SF

	A	B	C	D	i	F	G	H	J	K	L
P-611.3O	44	38.2	37.8	43.2	-	-	3.5	44	-	3.5	10
P-611.3S	44	38.2	37.8	43.2	-	-	3.5	44	-	3.5	10
P-611.3OF	44	38.2	37.8	44.2	3	2	3.5	50	40	3.5	10
P-611.3SF	48	40	40	44.2	3	2	4.1	50	40	19	13

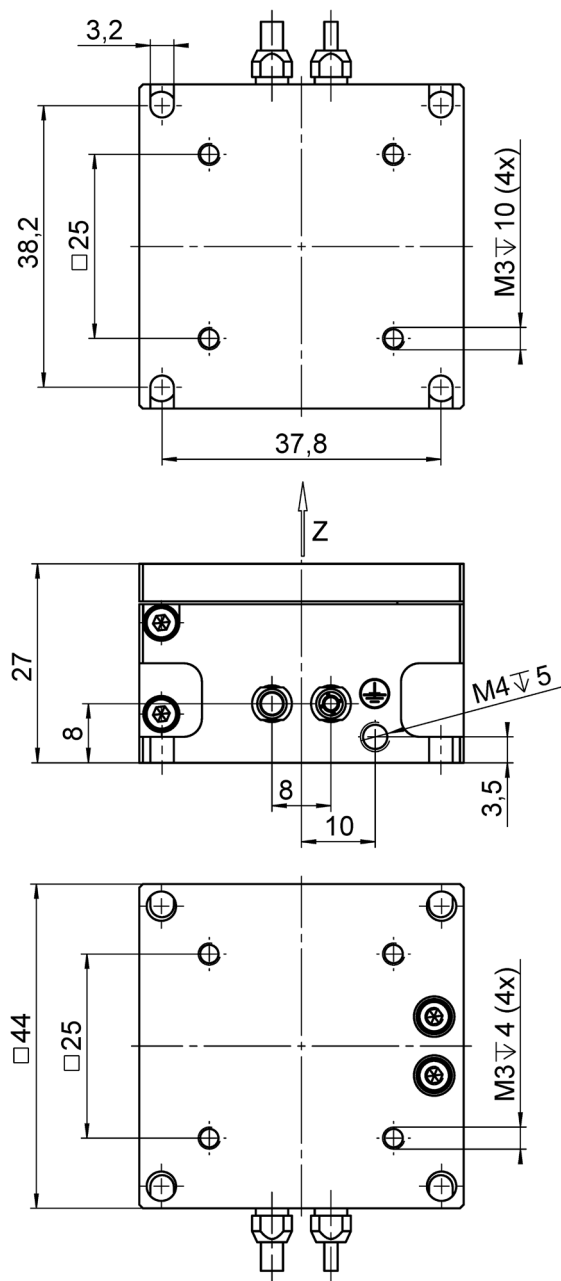


Figure 15: P-611.ZS

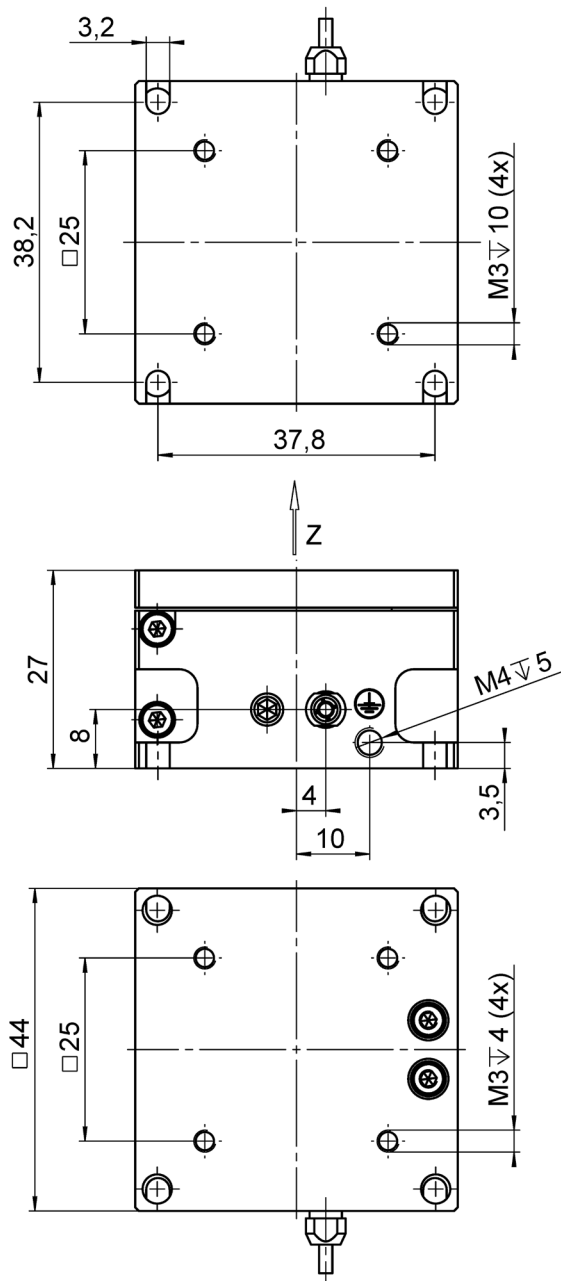


Figure 16: P-611.Z0

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

D-sub 25 connector

For P-611.3S/.3SF/.3O/.3OF only:

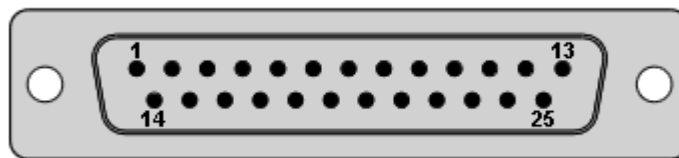


Figure 17: D-sub 25 connector: Front with connections

D-sub 25 connector pin assignment for the P-611.3S/.3SF

Pin	Signal	Function
1	Output	SGS 3-B1 sensor signal
2	Input	SGS 3 reference voltage
3	Output	SGS 2-B1 sensor signal
4	Input	SGS 2 reference voltage
5	Output	SGS 1-B1 sensor signal
6	Input	SGS 1 reference voltage
7 to 10	Free	---
11	Input	Piezo voltage +, channel 3, Z axis
12	Input	Piezo voltage +, channel 2, Y axis
13	Input	Piezo voltage +, channel 1, X axis
14	Output	SGS 3-B2 sensor signal

Pin	Signal	Function
15	GND	SGS 3 GND
16	Output	SGS 2-B2 sensor signal
17	GND	SGS 2 GND
18	Output	SGS 1-B2 sensor signal
19	GND	SGS 1 GND
20 to 22	Free	---
23	Input	Piezo voltage –, channel 3, Z axis
24	Input	Piezo voltage –, channel 2, Y axis
25	Input	Piezo voltage –, channel 1, X axis

D-sub 25 connector pin assignment for the P-611.30/.30F

Pin	Signal	Function
1 to 10	Free	---
11	Input	Piezo voltage +, channel 3, Z axis
12	Input	Piezo voltage +, channel 2, Y axis
13	Input	Piezo voltage +, channel 1, X axis
14 to 22	Free	---
23	Input	Piezo voltage –, channel 3, Z axis
24	Input	Piezo voltage –, channel 2, Y axis
25	Input	Piezo voltage –, channel 1, X axis

LEMO connectors

Only for P-611.1S/.10/.2S/.20/.XZS/.XZ0/.ZS/.Z0

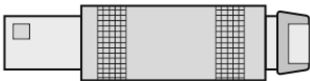




Figure 18: LEMO connector (side view)

LEMO connectors according to model (one connector per axis)

P-611 model	Connector (front view)	Pin	Signal	Function	Connector shell
.1S / .10 .2S / .20 .XZS / .XZ0 .ZS / .Z0		Inner connector	Input	Piezo voltage -20 to 120 V	Ground
.1S / .2S / .XZS / .ZS		1	Input	Supply voltage for strain gauge sensor	Cable shield
		2	Output	Sensor signal 1	
		3	Output	Sensor signal 2	
		4	GND	Supply voltage ground	

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-611, 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 or EN IEC 63000

