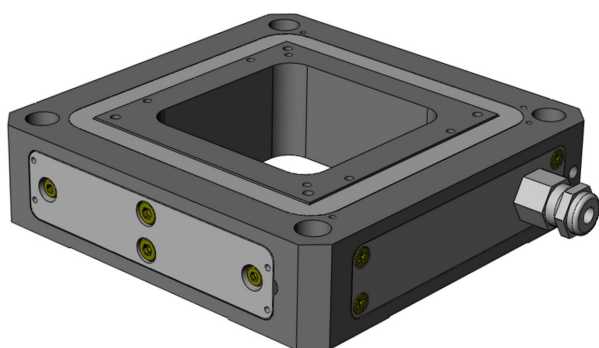


PZ103E P-73x Nanopositioner User Manual

Version: 1.1.0

Date: 26.10.2020



This document describes the following products:

- **P-733.2**
XY nanopositioner
P-733.2CD/.2CL, $100\ \mu\text{m} \times 100\ \mu\text{m}$
P-733.2DD, $30\ \mu\text{m} \times 30\ \mu\text{m}$, high dynamics,
direct drive
- **P-734.2**
XY nanopositioner
P-734.2CD/.2CL, $100\ \mu\text{m} \times 100\ \mu\text{m}$, very high
travel accuracy
- **P-733.3**
XYZ nanopositioner
P-733.3CD/.3CL, $100\ \mu\text{m} \times 100\ \mu\text{m} \times 10\ \mu\text{m}$
P-733.3DD, $30\ \mu\text{m} \times 30\ \mu\text{m} \times 10\ \mu\text{m}$, high
dynamics, direct drive
- **P-733.Z**
Nanopositioner Z stage
P-733.ZCD/.ZCL, $100\ \mu\text{m}$

.2CD/.3CD/.2DD/.3DD with D-sub 25W3
connector (m)

.ZCD with D-sub 7W2 connector (m)

.2CL/.3CL/.ZCL with LEMO connector (m)



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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 This manual is superseded by any new release.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

Definition of Terms 2

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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-73x 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-73x) 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 PZ72E User Manual

Product	Document
E-621 Piezo Amplifier/Servo Controller Module	PZ160E User Manual
E-625 Piezo Servo Controller (Benchtop Device)	PZ166E User Manual
E-712 Digital Piezo Controller (Modular System)	PZ195E User Manual
E-727 Digital Multi-Channel Piezo Controller	E727T0005 User Manual
E-754 Digital Piezo Controller	E754T0001 User Manual
PIMikroMove	SM148E Software Manual
P-5xx / P-6xx / P-7xx Piezo Positioning Systems	PZ240EK Short Instructions

1.6 Downloading Manuals

INFORMATION

If a manual is missing or problems occur with downloading:

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

Downloading manuals

1. Open the website **www.pi.ws**.
2. Search the website for the product number (e.g., P-733) or the product family (e.g., piezo 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-73x is a laboratory device as defined by DIN EN 61010-1. It is intended for indoor use and use in an environment that is free of dirt, oil, and lubricants.

According to its design, the P-73x is intended for fine positioning as well as moving small objects quickly and precisely. The specifications for the P-73x apply to horizontal mounting (standing on a surface, not suspended). Depending on the version, moving is done as follows:

Model	Motion	Axis
P-73x.2xx	In two axes horizontally	X, Y
P-733.3xx	In three axes horizontally and vertically	X, Y, Z
P-733.ZCx	In one axis vertically	Z

The P-73x can only be used as intended in conjunction with suitable electronics (p. 13) available from PI. The electronics are not in the P-73x's scope of delivery.

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

2.2 General Safety Instructions

The P-73x 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-73x.

- Use the P-73x 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-73x.

The P-73x is driven by piezo actuators. Temperature changes and compressive stresses 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-73x can lead to minor injuries from electric shock. The piezo actuators can be destroyed by an abrupt contraction.

- Do **not** open the P-73x.
- 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-73x in the case of malfunction or failure of the system. If there are touch voltages, touching the P-73x can result in minor injuries from electric shock.

- Connect the P-73x to a protective earth conductor (p. 20) 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-73x to the protective earth conductor before restarting.

Mechanical forces can damage or misalign the P-73x.

- Avoid impacts that affect the P-73x.
- Do **not** drop the P-73x.
- Do **not** exceed the maximum permissible stress and load capacities according to the specifications (p. 37).
- Do **not** touch any sensitive parts (e.g., platform) when handling the P-73x.

The P-73x 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-73x.

2.3 Organizational Measures

User manual

- Always keep this user manual together with the P-73x.
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-73x 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-73x only after you have read and understood this user manual.

Personnel qualification

The P-73x may only be installed, started, operated, maintained, and cleaned by authorized and appropriately qualified personnel.

3 Product Description

In this Chapter

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Technical Features	15

3.1 Model Overview

The P-73x is available in the following versions:

3.1.1 XY Nanopositioner

Model	Description
P-733.2CD	High-precision XY nanopositioner, 100 μm \times 100 μm , capacitive sensors, parallel metrology, D-sub connector
P-733.2CL	High-precision XY nanopositioner, 100 μm \times 100 μm , capacitive sensors, parallel metrology, LEMO connectors
P-734.2CD	High-precision XY nanopositioner with very high travel accuracy, 100 μm \times 100 μm , capacitive sensors, parallel metrology, D-sub connector
P-734.2CL	High-precision XY nanopositioner with very high travel accuracy, 100 μm \times 100 μm , capacitive sensors, parallel metrology, LEMO connectors

3.1.2 XY Nanopositioner with Direct Drive

Model	Description
P-733.2DD	High dynamics, high-precision XY nanopositioner, 30 μm \times 30 μm , direct drive, capacitive sensors, parallel metrology, D-sub connector

3.1.3 XYZ Nanopositioner

Model	Description
P-733.3CD	Precision XYZ nanopositioner, 100 μm \times 100 μm \times 10 μm , capacitive sensors, parallel metrology, D-sub connector
P-733.3CL	Precision XYZ nanopositioner, 100 μm \times 100 μm \times 10 μm , capacitive sensors, parallel metrology, LEMO connectors

3.1.4 XYZ Nanopositioner with Direct Drive

Model	Description
P-733.3DD	High dynamics, precision XYZ nanopositioner, 30 μm \times 30 μm \times 10 μm , direct drive, capacitive sensors, parallel metrology, D-sub connector

3.1.5 Nanopositioner Z Stage

Model	Description
P-733.ZCD	Compact, precision nanopositioner Z stage, 100 μm , capacitive sensor, D-sub connector
P-733.ZCL	Compact, precision nanopositioner Z stage, 100 μm , capacitive sensor, LEMO connectors

3.2 Product View

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

- Pay attention to the symbols on your device.

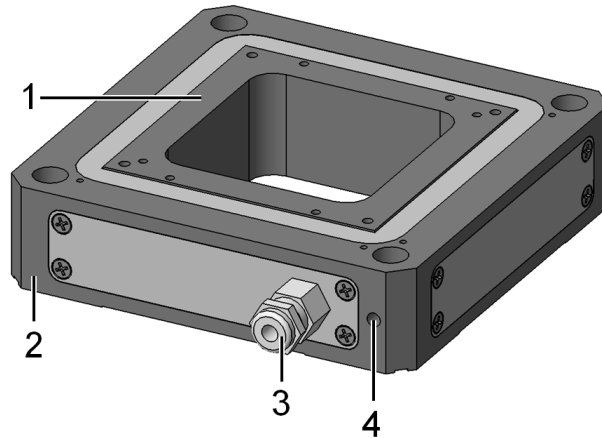


Figure 1: P-733: Exemplary product view

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

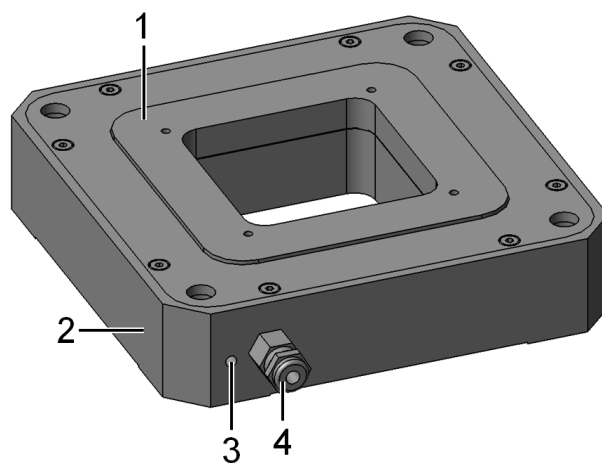
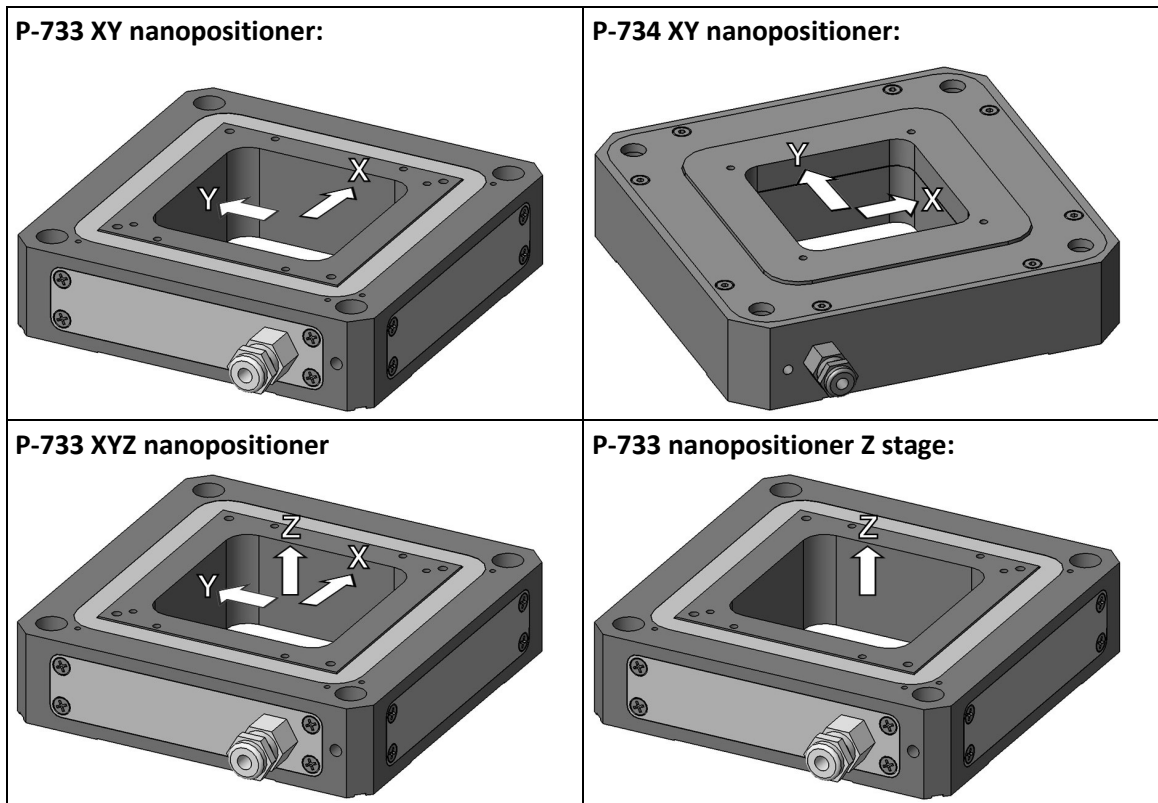


Figure 2: P-734: Exemplary product view






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

Direction of P-73x motion

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



3.3 Product Labeling

Labeling	Description
P-733.2CD	Product number (example), the digits after the period refer to the model
123456789	Serial number (example), individual for each P-73x Meaning of each position (from the left): 1 = internal information 2 and 3 = year of manufacture 4 to 9 = consecutive number
	Manufacturer's logo
	Warning sign "Pay attention to the manual!"
	Old equipment disposal (p. 53)
	CE conformity mark
Country of origin: Germany	Country of origin
WWW.PI.WS	Manufacturer's address (website)
	Symbol for the protective earth conductor (p. 20)

If applicable:

- The arrows indicate the positive direction of motion.
- The letter X, Y, and Z indicate the axis.



Figure 3: "Residual Voltage" warning sign on the connector of the P-73x

"Residual Voltage" warning: Risk of electric shock (p. 5) for models with D-sub plug connector

3.4 Scope of Delivery

Product number	Description
P-73x	Positioner according to order (p. 9)
000036450	M4 screw set for protective earth, consisting of: <ul style="list-style-type: none"> ▪ 1 M4x8 flat-head screw with cross recess, ISO 7045 ▪ 2 lock washers ▪ 2 flat washers
PZ240EK	Short instructions for piezo positioning systems

3.5 Suitable Electronics

You need suitable electronics to operate a P-73x. 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-503 Piezo Amplifier Module	LEMO	3
E-621 Piezo Amplifier / Servo Controller Module	D-sub 7W2	1
E-625 Piezo Servo Controller (Benchtop Device)	D-sub 7W2	1
E-754 Digital Piezo Controller	D-sub 7W2	1
E-727 Digital Multi-Channel Piezo Controller	D-sub 25W3	3
E-712 Digital Piezo Controller (Modular System)	D-sub 25W3	3/6

* In some cases, adapter cables (p. 14) 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 D-sub plug connector(s)

Product number	Description
P-895.2D1DDC*	Adapter cable D-sub 25W3 (f) and D-sub 7W2 (f) to D-sub 25W3 (m) for piezo actuator nanopositioning systems with capacitive sensors, 3 channels, length: 0.3 m.
P-895.2DDC	Adapter cable 2× D-sub 7W2 (f) to D-sub 25W3 (m) for piezo actuator nanopositioning systems with capacitive sensors, 2 channels, length: 0.3 m.
P-895.3DDC	Adapter cable 3× D-sub 7W2 (f) to D-sub 25W3 (m) for piezo actuator nanopositioning systems with capacitive sensors, 3 channels, length: 0.3 m.

* 2 channels to D-sub 25W3 (f) and 1 channel to D-sub 7W2 (f) available.

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.

3.6.1 Adapter Plates

Product number	Description
P-733.AP1	Adapter plate for mounting P-733 piezo stages onto M-545 XY stages and U-760 XY stage systems

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

3.7 Technical Features

3.7.1 PICMA® Piezo Actuators

P-73x 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-73x 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 Capacitive Sensors

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

3.7.4 ID Chip (Models with D-sub Connector Only)

An ID chip is located in the D-sub connector of the P-73x. When the P-73x is calibrated at the factory with digital electronics, the calibration data is saved on the ID chip together with specific product information. During switch-on, the digital electronics read the data from the ID chip of the P-73x connected. A P-73x with an ID chip containing calibration data can therefore be connected to any suitable digital electronics without renewed calibration.

Refer to the manual for the controller for more information on the ID chip.

4 Unpacking

NOTICE

**Mechanical overload due to incorrect handling!**

An impermissible mechanical load on the platform of the P-73x can cause damage to the piezo actuators, sensors, and flexures of the P-73x as well as loss of accuracy.

➤ Do **not** touch any sensitive parts (e.g., platform) when handling the P-73x.

1. Unpack the P-73x with care.
2. Compare the contents with the scope of delivery according to the contract and the delivery note.
3. Inspect the contents for signs of damage. If any parts are damaged or missing, contact our customer service department (p. 35) immediately.
4. Keep all packaging materials in case the product needs to be returned.

5 Installation

In this Chapter

General Notes on Installation	19
Connecting the P-73x to the Protective Earth Conductor	20
Mounting the P-73x	22
Fixing the Load	23
Connecting the P-73x to the Electronics.....	25

5.1 General Notes on Installation

CAUTION



Dangerous voltage and residual charge in piezo actuators!

The P-73x is driven by piezo actuators. Temperature changes and compressive stresses 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-73x can lead to minor injuries from electric shock. The piezo actuators can be destroyed by an abrupt contraction.

- Do **not** open the P-73x.
- 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 due to incorrect handling!

An impermissible mechanical load on the platform of the P-73x can cause damage to the piezo actuators, sensors, and flexures of the P-73x as well as loss of accuracy.

- Do **not** touch any sensitive parts (e.g., platform) when handling the P-73x.

NOTICE**Damage due to unsuitable cables!**

Unsuitable cables can damage the P-73x and the electronics.

- Use cables provided by PI only to connect the P-73x to the electronics.

NOTICE**Damage due to improper mounting!**

Improper mounting of the P-73x or incorrectly mounted parts can damage the P-73x.

- Only use the holes or threads intended for the purpose of fixing the P-73x and loads.
- Install the P-73x 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. 48) specified for the screws used during installation.

INFORMATION

Extension cables can reduce the positioning accuracy of the P-73x or affect sensor processing by the electronics.

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

5.2 Connecting the P-73x to the Protective Earth Conductor

INFORMATION

In the case of P-73x 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. 35).

INFORMATION

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

The P-73x has an M4 hole for attaching the protective earth conductor. This hole is marked with the symbol for the protective earth conductor (⏏). Refer to "Dimensions" (p. 43) for the exact position of the hole.

Requirements

- ✓ You have read and understood the general notes on installation (p. 19).
- ✓ The P-73x 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. 13) supplied for connecting the protective earth conductor
- Suitable screwdriver

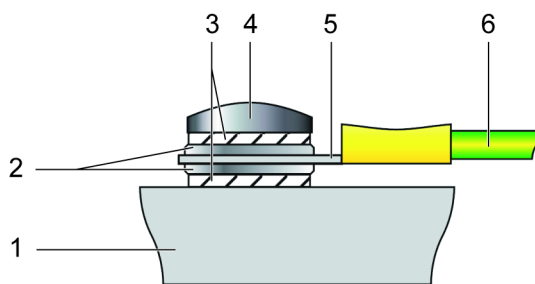


Figure 4: Connecting the protective earth conductor (profile view)

- | | |
|---|----------------------------|
| 1 | Base body of the P-73x |
| 2 | Flat washer |
| 3 | Lock washer |
| 4 | Screw |
| 5 | Cable lug |
| 6 | Protective earth conductor |

Connecting the P-73x 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-73x 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-73x

NOTICE

**Warping the P-73x when mounting onto uneven surfaces!**

The P-73x could warp if mounted on an uneven surface. Warping reduces the accuracy.

- Mount the P-73x 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-73x only onto surfaces that have the same or similar thermal expansion properties as the P-73x.

NOTICE

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

The P-73x 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-73x in a different orientation to that intended (e.g., vertically or upside down), contact our customer service department (p. 35).

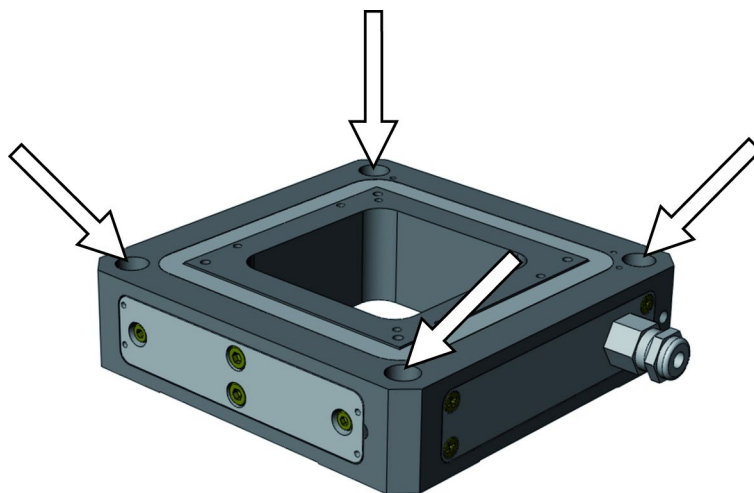


Figure 5: Mounting holes in the base body

Requirements

- ✓ You have read and understood the general notes on installation (p. 19).

Tools and accessories

- Screws of suitable size and length (see "Dimensions" (p. 43))
- Suitable tools

Mounting the P-73x

1. Align the P-73x on the mounting surface so that the holes in the P-73x and mounting surface are in line.
2. For the P-73x.2Cx and P-733.3Cx models:
Ensure a distance of at least 0.5 mm between the stage and the surrounding objects.
3. Insert suitable screws into the mounting holes (see figure) to fix the P-73x. Pay attention to the specified torque range (p. 48) for the screws.

5.4 Fixing the Load**NOTICE****Mechanical overload of the platform!**

Fixing loads with high torques and heavy loads in general can overload the platform of the P-73x. Mechanical overload can damage the piezo actuators, sensors, and flexures of the P-73x and lead to loss of accuracy.

- Avoid torques on the platform.
- Do **not** exceed the maximum permissible loads according to the specifications (p. 37).
- Hold the load and adhere to the specified torque range when tightening (or loosening) the screws (p. 48).

NOTICE**Warping the P-73x when fixing loads with an uneven contact surface!**

Fixing loads with an uneven contact surface could warp the P-73x. Warping reduces the accuracy.

- Fix loads on the P-73x only when the surface contacting the P-73x's platform has a flatness of at least 20 µm.
- For applications with large temperature changes:
Fix loads to the P-73x only when they have the same or similar thermal expansion properties as the P-73x.

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-73x 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. 35).

NOTICE**Excessively long screws!**

The P-73x could be damaged by screws inserted too deeply.

- Pay attention to the depth of the mounting holes in the platform (p. 43).
- 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. 11).

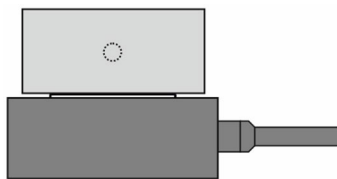
Center of load at the optimal position:

Figure 6: Example of an optimally placed load

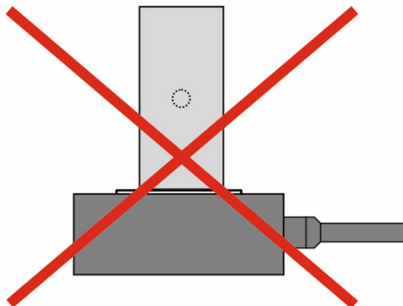
Center of load at an unsuitable position:

Figure 7: Tall load and center of load too far above the platform

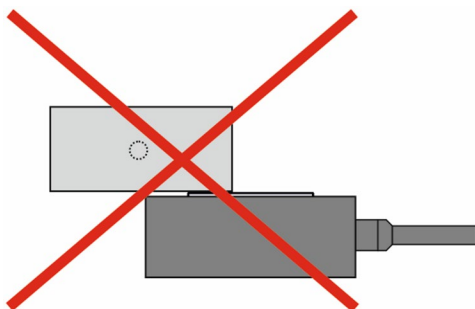


Figure 8: Unwanted lever effect and center of load on the side of the platform

Requirements

- ✓ You have read and understood the general notes on installation (p. 19).
- ✓ The P-73x is **not** connected to the electronics.

Tools and accessories

- Screws of suitable size and length (p. 43)
- Suitable screwdriver

Fixing the load

1. Align the load on the P-73x 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. 43) provided. Pay attention to the specified torque range (p. 48) for the screws.
4. Check that the load is sitting firmly on the platform.

5.5 Connecting the P-73x to the Electronics

INFORMATION

- When connecting, pay attention to the assignment specified on the labeling of the sockets, plug connectors, and cables.

Requirements

- ✓ You have read and understood the general notes on installation (p. 19).
- ✓ You have installed suitable electronics (p. 13).
- ✓ You have read and understood the user manual for the electronics.
- ✓ The electronics are switched off.

Tools and accessories

- If intended for your system: Adapter cable (p. 14)

Connecting the P-73x to the electronics

1. If adapter cables are intended, connect the adapter cable to the P-73x.
2. Connect all of the P-73x's connectors (or the adapter cable connected to it) to the electronics (refer to the user manual for the electronics).
3. If possible, secure the connector(s) against accidental disconnection.

6 Starting and Operating

In this Chapter

General Notes on Starting and Operating	27
Operating the P-73x	29
Discharging the P-73x	29

6.1 General Notes on Starting and Operating

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-73x in the case of malfunction or failure of the system. If there are touch voltages, touching the P-73x can result in minor injuries from electric shock.

- Connect the P-73x to a protective earth conductor (p. 20) 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-73x to the protective earth conductor before restarting.

NOTICE



Destruction of the piezo actuator due to electric flashovers!

Using the P-73x 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-73x in environments that can increase the electric conductivity.
- Operate the P-73x only within the permissible ambient conditions and classifications (p. 42).

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-73x is not used but the electronics remain switched on to ensure temperature stability, discharge the P-73x (p. 29).

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

Operating voltages that are too high or incorrectly connected can cause damage to the P-73x.

- Operate the P-73x only with controllers/drivers and original accessories from PI.
- Do **not** exceed the operating voltage range (p. 42) for which the P-73x is specified.
- Operate the P-73x only when the operating voltage is properly connected; see "Pin Assignment" (p. 49).

NOTICE**Uncontrolled oscillation!**

Oscillation can cause irreparable damage to the P-73x. 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-73x 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-73x immediately.

INFORMATION

The P-73x's direction of motion is indicated in the product view (p. 11).

INFORMATION

Systems are calibrated at the factory to achieve optimum positioning accuracy. Replacing the system components can lead to a reduction of position accuracy when positioners are used with an ID-chip (p. 15) that does not contain calibration data or when LEMO plug connectors are used.

- When connecting the positioner, pay attention to the assignment of the motion axes to the controller channels, which is specified on the calibration label of the controller.

If position accuracy is reduced after replacing the P-73x or the controller:

- Recalibrate the axis displacement (refer to the controller manual) or contact our customer service department (p. 35).

INFORMATION

Sound and vibration (e.g., footfall, knocks) can be transmitted to the P-73x and can affect its performance with regard to position stability.

- Avoid sound and vibration while the P-73x is being operated.

6.2 Operating the P-73x

- Follow the instructions in the manual for the electronics (p. 13) used for starting and operating the P-73x.

6.3 Discharging the P-73x

The P-73x must be discharged in the following cases:

- Before Installation
- When the P-73x is not in use but the electronics remain switched on to ensure temperature stability
- Before demounting (e.g., before cleaning and transporting the P-73x and for modifications)

The P-73x 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

General Notes on Maintenance.....	31
Cleaning the P-73x	31

7.1 General Notes on Maintenance

NOTICE



Misalignment from loosening screws!

The P-73x 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 any screws only when instructed in this manual.
- Do **not** open the P-73x.

7.2 Cleaning the P-73x

NOTICE



Damage from ultrasonic cleaning!

Ultrasonic cleaning can damage the P-73x.

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

Requirements

- ✓ You have discharged the piezo actuators of the P-73x (p. 29).
- ✓ You have disconnected the P-73x from the electronics.

Cleaning the P-73x

- Clean the surfaces of the P-73x 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. 37).
	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 platform is warped	➤ Mount the P-73x 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-73x (e.g., surface made of aluminum). ➤ Mount loads onto the P-73x 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-73x (e.g., load made of aluminum).
	P-73x or controller has been replaced	When using positioners with an ID chip (p. 15) that does not contain any calibration data, or with LEMO plug connectors, axis displacement has to be recalibrated after the P-73x or the controller has been replaced. ➤ Recalibrate the axis displacement (refer to the controller manual) or contact our customer service department (p. 35).

Problem	Possible causes	Solution
	Axes were mixed up during connection (LEMO connectors only)	➤ 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 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. 35).

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

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10.1 Specifications

10.1.1 Data Table

	P-733.2CD P-733.2CL	P-733.2DD	Unit	Tolerance
Active axes	X, Y	X, Y		
Motion and positioning				
Integrated sensor	Capacitive	Capacitive		
Travel range at -20 to 120 V, open loop	115 μm \times 115 μm	33 μm \times 33 μm		+20 % / -0 %
Travel range, closed loop	100 μm \times 100 μm	30 μm \times 30 μm		
Resolution, open loop	0.2	0.1	nm	Typ.
Resolution, closed loop	0.3	0.1	nm	Typ.
Linearity error (X, Y)	0.03	0.03*	%	Typ.
Repeatability (X, Y)	<2	<2	nm	Typ.
Pitch (X, Y)	± 3	± 5	μrad	Typ.
Yaw (X, Y)	± 10	± 10	μrad	Typ.
Mechanical properties				
Stiffness	1.5	20	N/ μm	± 20 %
Resonant frequency, no load	500	2230	Hz	± 20 %
Resonant frequency, under load, 120 g	370	—	Hz	± 20 %
Resonant frequency, under load, 200 g	340	1550	Hz	± 20 %
Push/pull force capacity in motion direction	50 / 20	50 / 20	N	Max.
Drive properties				
Piezo ceramic	PICMA® P-885	PICMA® P-885		
Electrical capacitance	6 (per axis)	6.2 (per axis)	μF	± 20 %

	P-733.2CD P-733.2CL	P-733.2DD	Unit	Tolerance
Miscellaneous				
Operating temperature range	-20 to 80	-20 to 80	°C	
Material	Aluminum	Aluminum		
Mass	0.58	0.58	kg	±5 %
Cable length	1.5	1.5	m	±10 mm
Sensor/voltage connector	CD version: D-sub 25W3 (m) CL version: LEMO	D-sub 25W3 (m)		
Recommended electronics	E-503, E-505, E-610, E-621, E-625, E-712, E-727	E-503, E-505, E-610, E-621, E-625, E-712, E-727		

* With digital controller. With analog controllers, the typical linearity error for direct drive positioners can be up to 0.1 %.

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.

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

	P-733.3CD P-733.3CL	P-733.3DD	Unit	Tolerance
Active axes	X, Y, Z	X, Y, Z		
Motion and positioning				
Integrated sensor	Capacitive	Capacitive		
Travel range at -20 to 120 V, open loop	115 µm × 115 µm × 12 µm	33 µm × 33 µm × 14 µm		+20 % / -0 %
Travel range, closed loop	100 µm × 100 µm × 10 µm	30 µm × 30 µm × 10 µm		
Resolution, open loop	0.2 (X), 0.2 (Y), 0.1 (Z)	0.1	nm	Typ.
Resolution, closed loop	0.3 (X), 0.3 (Y), 0.2 (Z)	0.1	nm	Typ.
Linearity error (X, Y)	0.03	0.03*	%	Typ.
Linearity error (Z)	0.03	0.03*	%	Typ.
Repeatability (X, Y)	<2	<2	nm	Typ.
Repeatability (Z)	<1	<1	nm	Typ.
Pitch (X, Y)	±3	±5	µrad	Typ.
Yaw (X, Y)	±10	±10	µrad	Typ.
Tilt with motion in Z	±5	±5	µrad	Typ.

	P-733.3CD P-733.3CL	P-733.3DD	Unit	Tolerance
Mechanical properties				
Stiffness	1.4 (X), 1.4 (Y), 9 (Z)	4 (X), 4 (Y), 10 (Z)	N/μm	±20 %
Resonant frequency, no load	460 (X), 460 (Y), 1400 (Z)	1200 (X), 1200 (Y), 1100 (Z)	Hz	±20 %
Resonant frequency, under load, 120 g	340 (X), 340 (Y), 1060 (Z)	—	Hz	±20 %
Resonant frequency, under load, 200 g	295 (X), 295 (Y), 650 (Z)	530 (X), 530 (Y), 635 (Z)	Hz	±20 %
Push/pull force capacity in motion direction	50 / 20	50 / 20	N	Max.
Drive properties				
Piezo ceramic	PICMA® P-885	PICMA® P-885		
Electrical capacitance	6 (X), 6 (Y), 2.4 (Z)	6.2 (X), 6.2 (Y), 3.3 (Z)	μF	±20 %
Miscellaneous				
Operating temperature range	-20 to 80	-20 to 80	°C	
Material	Aluminum	Aluminum		
Mass	0.675	0.675	kg	±5 %
Cable length	1.5	1.5	m	±10 mm
Sensor/voltage connector	CD version: D-sub 25W3 (m) CL version: LEMO	D-sub 25W3 (m)		
Recommended electronics	E-503, E-505, E-610, E-621, E-625, E-712, E-727	E-503, E-505, E-610, E-621, E-625, E-712, E-727		

* With digital controller. With analog controllers, the typical linearity error for direct drive positioners can be up to 0.1 %.

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.

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

	P-733.ZCD / P-733.ZCL	Unit	Tolerance
Active axes	Z		
Motion and positioning			
Integrated sensor	Capacitive		
Travel range at -20 to 120 V, open loop	115	μm	+20 % / -0 %
Travel range, closed loop	100	μm	
Resolution, open loop	0.2	nm	Typ.
Resolution, closed loop	0.3	nm	Typ.
Linearity error	0.03	%	Typ.
Repeatability	<2	nm	Typ.
Rotation around Z	<10	μrad	Typ.
Rotation around X	<5	μrad	Typ.
Rotation around Y	<5	μrad	Typ.
Mechanical properties			
Stiffness	2.5	N/μm	±20 %
Resonant frequency, no load	700	Hz	±20 %
Resonant frequency, under load, 120 g	530	Hz	±20 %
Resonant frequency, under load, 200 g	415	Hz	±20 %
Push / pull force capacity	50 / 20	N	Max.
Drive properties			
Piezo ceramic	PICMA® P-885		
Electrical capacitance	6	μF	±20 %
Miscellaneous			
Operating temperature range	-20 to 80	°C	
Material	Aluminum		
Dimensions	100 mm × 100 mm × 25 mm		
Mass	580	g	±5 %
Cable length	1.5	m	±10 mm
Sensor / voltage connection	CD version: D-sub 7W2 (m) CL version: LEMO		
Recommended electronics	E-503, E-505, E-610, E-621, E-625, E-754		

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.

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




	P-734.2CL	P-734.2CD	Unit	Tolerance
Active axes	X, Y	X, Y		
Motion and positioning				
Integrated sensor	Capacitive	Capacitive		
Travel range at -20 to 120 V, open loop	110 μm \times 110 μm	110 μm \times 110 μm		+20 % / -0 %
Travel range, closed loop	100 μm \times 100 μm	100 μm \times 100 μm		
Resolution, open loop	0.2	0.2	nm	Typ.
Resolution, closed loop	0.3	0.3	nm	Typ.
Linearity error	0.03	0.03	%	Typ.
Repeatability	2.5	2.5	nm	Typ.
Pitch	3	3	μrad	Typ.
Yaw	10	10	μrad	Typ.
Flatness	5	5	nm	Typ.
Mechanical properties				
Stiffness	3	3	N/ μm	± 20 %
Resonant frequency, unloaded	500	500	Hz	± 20 %
Resonant frequency at 200 g	350	350	Hz	± 20 %
Resonant frequency at 500 g	250	250	Hz	± 20 %
Push/pull force capacity in positioning direction	300 / 100	300 / 100	N	Max.
Load capacity	20	20	N	Max.
Drive properties				
Ceramic type	PICMA [®] P-885	PICMA [®] P-885		
Electrical capacitance	6.2	6.2	μF	± 20 %
Miscellaneous				
Operating temperature range	-20 to 80	-20 to 80	$^{\circ}\text{C}$	
Material	Aluminum	Aluminum		
Mass (with cables)	1.04	1.04	kg	± 5 %
Cable length	1.5	1.5	m	± 10 mm
Sensor/voltage connector	LEMO	D-sub 25W3 (m)		
Recommended electronics	E-503, E-505, E-712, E-727	E-503, E-505, E-712, 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.

All specifications based on room temperature (22 $^{\circ}\text{C}$ ± 3 $^{\circ}\text{C}$).

10.1.2 Maximum Ratings

P-73x positioners are designed for the following operating data:

Model	Maximum operating voltage 	Maximum operating frequency (unloaded) ¹ 	Maximum power consumption ² 
P-733.2CD, P-733.2CL	-20 to +120 V	167 Hz (in X and Y)	20 W (in X and Y)
P-733.2DD	-20 to +120 V	743 Hz (in X and Y)	86 W (in X and Y)
P-734.2CD, P-734.2CL	-20 to +120 V	167 Hz (in X and Y)	20 W (in X and Y)
P-733.3CD, P-733.3CL	-20 to +120 V	153 Hz (in X and Y) 467 Hz (in Z)	18 W (in X and Y) 24 W (in Z)
P-733.3DD	-20 to +120 V	400 Hz (in X and Y) 367 Hz (in Z)	46 W (in X and Y) 29 W (in Z)
P-733.ZCD, P-733.ZCL	-20 to +120 V	233 Hz	28 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-73x:

Area of application	For indoor use only
Maximum altitude	2000 m
Air pressure	1100 hPa to 700 hPa
Relative humidity	Highest relative humidity 80 % for temperatures up to 31 °C Decreasing linearly to 50 % relative humidity at 40 °C
Operating temperature	-20 °C to 80 °C
Storage temperature	-20 °C to 80 °C
Transport temperature	-25 °C to 85 °C
Overvoltage category	II
Protection class	I
Degree of pollution	1
Degree of protection according to IEC 60529	IP20

10.2 Dimensions

Dimensions in mm. Note that a comma is used in the drawings instead of a decimal point.

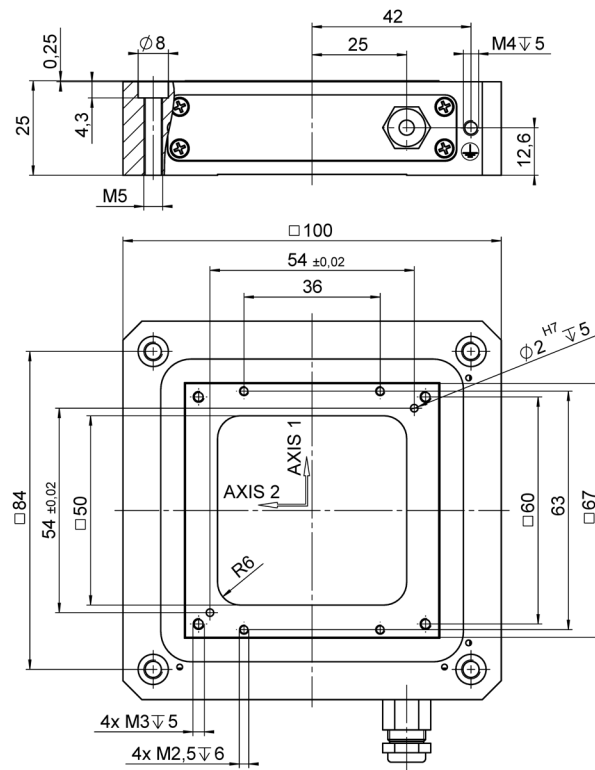


Figure 9: P-733.2Cx

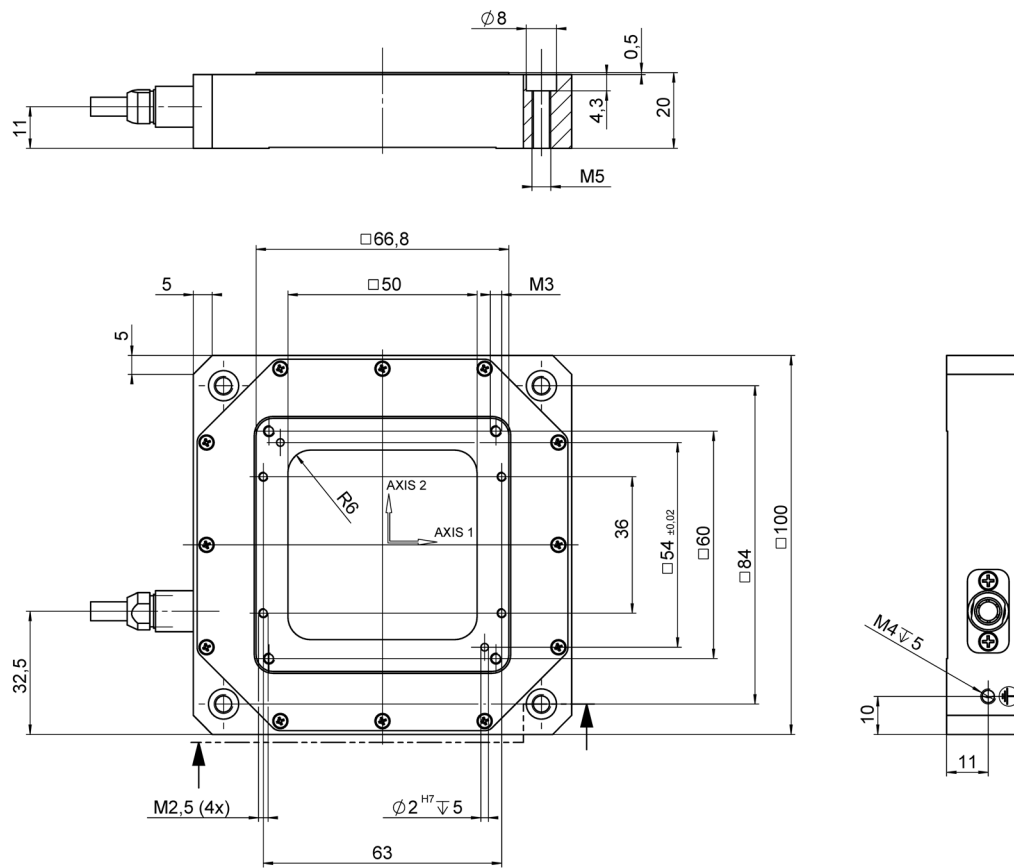


Figure 10: P-733.2DD

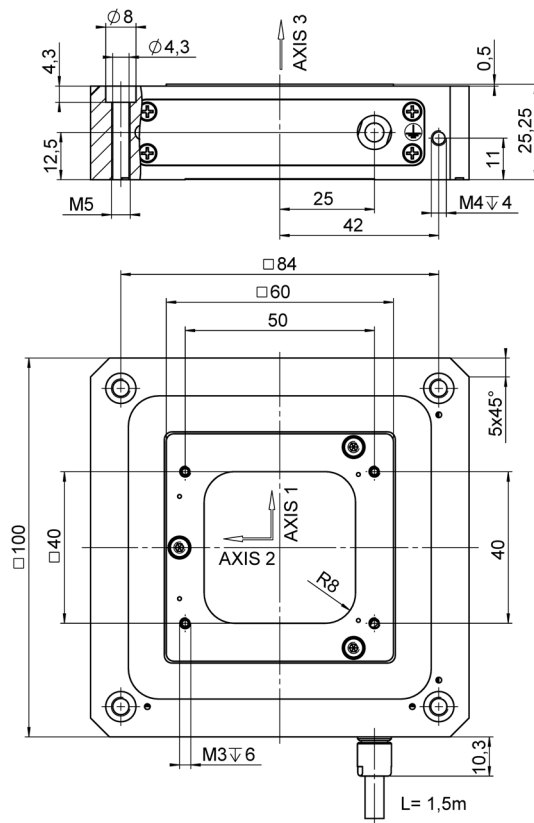


Figure 11: P-733.3Cx

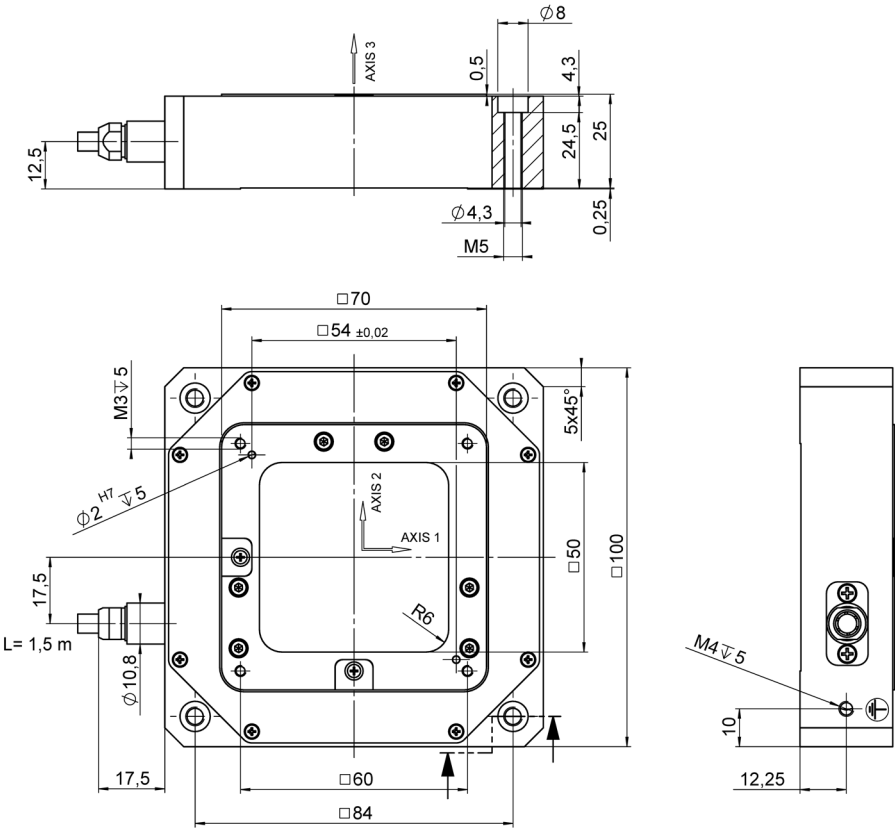


Figure 12: P-733.3DD

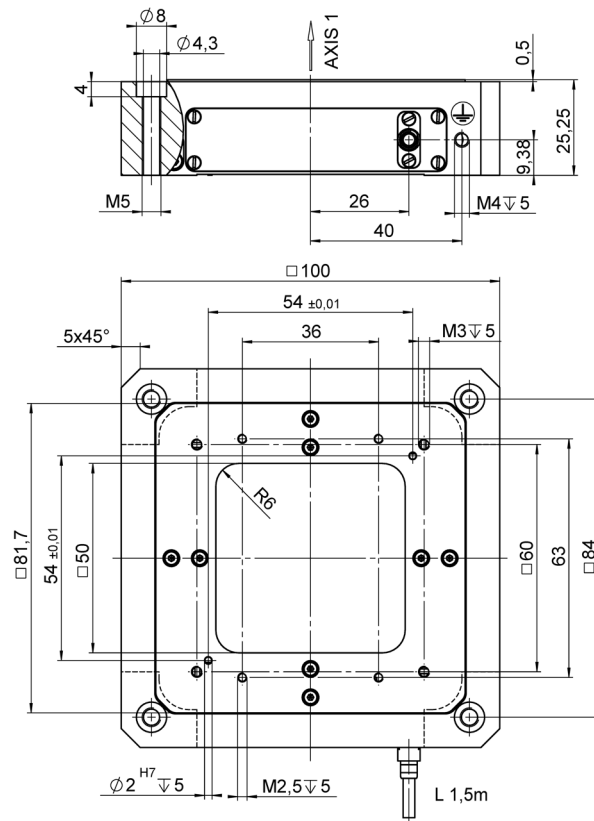


Figure 13: P-733.ZCx

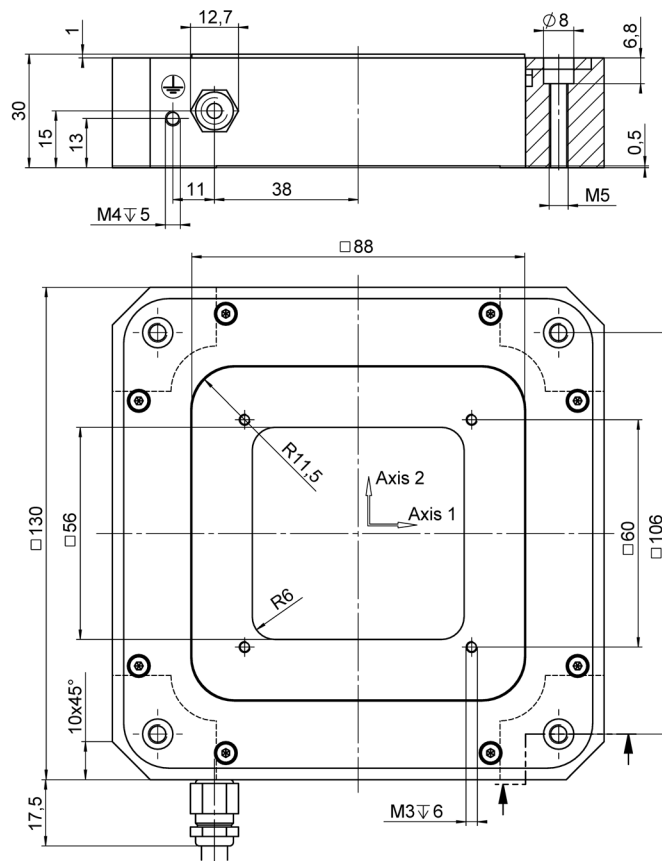


Figure 14: P-734.2Cx

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 25W3 connector (m)

For P-73x.2CD/.2DD/.3CD/.3DD only:

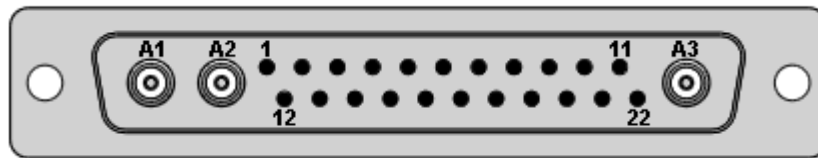


Figure 15: D-sub 25W3 connector (m): Front with connections

Pin	Signal	Function
A1 inner conductor	Output	Probe sensor signal, channel 2 (immovable part of the capacitive sensor)
A1 outer conductor	GND	Shield of Probe sensor signal, channel 2
A2 inner conductor	Output	Probe sensor signal, channel 3 (immovable part of the capacitive sensor)
A2 outer conductor	GND	Shield of Probe sensor signal, channel 3
A3 inner conductor	Output	Probe sensor signal, channel 1 (immovable part of the capacitive sensor)
A3 outer conductor	GND	Shield of 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	Ground of ID chip
4	Bidirectional	Data line for ID chip
5	Free	–
6	Free	–
7	Input	Piezo voltage +, channel 4
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	Shield of Target sensor signal, channel 2
13	GND	Shield of Target sensor signal, channel 3
14	Free	–
15	Free	–
16	Free	–

Pin	Signal	Function
17	Free	–
18	Input	Piezo voltage –, channel 4
19	Input	Piezo voltage –, channel 3
20	Input	Piezo voltage –, channel 2
21	Input	Piezo voltage –, channel 1
22	GND	Shield of Target sensor signal, channel 1

Model-dependent assignment of the D-sub 25W3 connector (m) (X = used):

Model	Piezo voltage				Sensor signal (Probe / Target / shield)		
	Channel 1 Pins 10 and 21	Channel 2 Pins 9 and 20	Channel 3 Pins 8 and 19	Channel 4 Pins 7 and 18	Channel 1 Pins A3, 11 and 22	Channel 2 Pins A1, 1 and 12	Channel 3 Pins A2, 2 and 13
P-733.2CD	X	X	–	–	X	X	–
P-733.2DD	X	X	–	–	X	X	–
P-733.3CD	X	X	X	–	X	X	X
P-733.3DD	X	X	X	–	X	X	X
P-734.2CD	X	X	–	–	X	X	–

D-sub 7W2 connector (m)

For P-733.ZCD only:

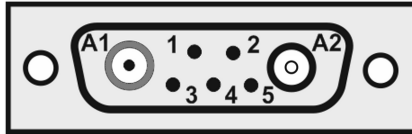


Figure 16: D-sub 7W2 connector (m): Front with connections

Pin	Signal	Function
A1 inner conductor	Input	Piezo voltage +
A2 inner conductor	Output	Probe sensor signal (immovable part of the capacitive sensor)
A2 outer conductor	GND	Shield
1	Bidirectional	Data line for ID chip
2	GND	<ul style="list-style-type: none"> Shield of Target Ground of ID chip when switched on
3	Input	Piezo voltage –
4	Free	–
5	Input	Target sensor signal (movable part of the capacitive sensor)

LEMO coaxial connector

For P-73x.2CL/.3CL/.ZCL only (one PZT, P and T connector each per axis):



Figure 17: LEMO connectors: PZT, P and T

Connector	Signal	Function	Connector shell
P	Output	Probe sensor signal (immovable part of the capacitive sensor)	Cable shield
T	Input	Target sensor signal (movable part of the capacitive sensor)	Cable shield
PZT	Input	Piezo 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-73x, 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

