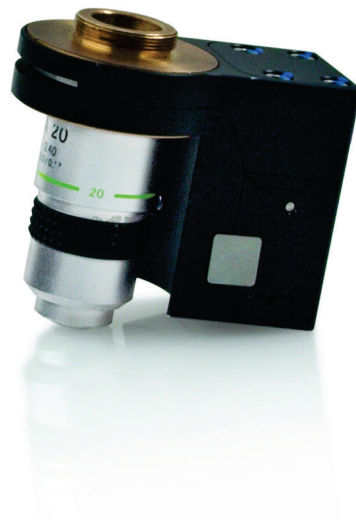


## P-721 Fast PIFOC® Piezo Nanofocusing Z Drive



## Contents

<b>About this Document</b> .....	<b>3</b>
Symbols and Typographic Conventions .....	3
Figures.....	3
<b>Safety</b> .....	<b>3</b>
Intended Use .....	3
Safety Precautions.....	4
<b>Product Description</b> .....	<b>5</b>
Model Overview .....	5
Product View.....	6
Product Labeling .....	6
Scope of Delivery .....	7
Accessories .....	7
Suitable Electronics .....	8
<b>Installation</b> .....	<b>9</b>
Connecting the P-721 to a Protective Earth Conductor .....	9
Affixing the P-721 to the Microscope.....	10
Installing the Objective.....	10
<b>Start-Up and Operation</b> .....	<b>11</b>
General Notes on Start-Up and Operation .....	11
Starting Up and Operating the P-721 .....	12
<b>Discharging the P-721</b> .....	<b>12</b>
<b>Maintenance</b> .....	<b>13</b>
Cleaning the P-721 .....	13
<b>Customer Service</b> .....	<b>14</b>
<b>Technical Data</b> .....	<b>14</b>
P-721 Fast PIFOC® Nanofocusing Z Drive .....	14
<b>Dimensions</b> .....	<b>16</b>
P-721.xxQ, P-721.SL2 .....	16
P-721.xDA .....	17
<b>Pin Assignments</b> .....	<b>18</b>
P-721.CLQ, P-721.0LQ.....	18
P-721.SL2.....	19
P-721.CDx .....	20
P-721.SDA.....	20
<b>Maximum Ratings</b> .....	<b>21</b>
<b>Ambient Conditions and Classifications</b> .....	<b>21</b>
<b>Old Equipment Disposal</b> .....	<b>22</b>

## About this Document

### Symbols and Typographic Conventions

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

#### **CAUTION**



##### **Dangerous situation**

If not avoided, the dangerous situation will result in minor injury.

- Actions to take to avoid the situation.

#### **NOTICE**



##### **Dangerous situation**

If not avoided, the dangerous situation will result in damage to the equipment.

- Actions to take to avoid the situation.

#### **INFORMATION**

Information for easier handling, tricks, tips, etc.

## 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.

## Safety

### Intended Use

The P-721 Z drive 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-721 is intended for positioning and shifting microscope objectives in one axis.

The P-721 can be mounted horizontally or vertically. The specifications refer to a vertically mounted P-721.

The intended use of the P-721 is only possible in a completely assembled and connected state. The P-721 must be operated with a suitable controller that is available from PI. The controller is not included in the scope of delivery of the P-721.

## Safety Precautions

### CAUTION



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

The P-721 is driven by piezo actuators. Temperature changes and compressive stresses can induce charges in piezo actuators. After being disconnected from the electronics, piezo actuators can also stay charged for several hours. Touching or short-circuiting the contacts in the connector of the P-721 can lead to minor injuries. In addition, the piezo actuators can be destroyed by an abrupt contraction.

- Do **not** open the P-721.
- Discharge the piezo actuators before installation:  
Connect the Z drive to the switched-off PI controller for 10 seconds.
- Do **not** pull out the connector from the electronics during operation.



For P-721 with sub-D connector:

Touching the contacts in the connector can lead to an electric shock (max. 120 V DC) and minor injuries.

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

### 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 and there is a risk of electric shock. In the case of malfunction or failure of the system, touching the P-721 can result in minor injuries.

- Connect the P-721 to a protective earth conductor before start-up.
- Do **not** remove the protective earth conductor during operation.
- Use electrically conductive materials (e.g., screws and flat washers) for mounting the protective earth conductor.
- Make sure that the contact resistance is  $<0.1 \Omega$  at 25 A at all connection points relevant for mounting the protective earth conductor.
- If the protective earth conductor has to be temporarily removed (e.g., for modifications), reconnect the P-721 to the protective earth conductor before starting it up again.

### NOTICE



#### Unsuitable cables!

Unsuitable cables can damage the electronics.

- Only use cables from PI for connecting the P-721 to the electronics.

### INFORMATION

Extended cables can affect the performance of the P-721.

- Do **not** use cable extensions. If you need longer cables, contact our customer service department (p. 14).

## Product Description

### Model Overview

The models of the P-721 differ in terms of:

- Sensor
- Connector
- Thread adapter

Product number	Description
P-721.CLQ	Fast PIFOC® nanofocusing Z drive, 100 µm, direct metrology, capacitive sensor, LEMO connector(s), for QuickLock thread adapters
P-721.CDQ	Fast PIFOC® nanofocusing Z drive, 100 µm, direct metrology, capacitive sensor, Sub-D connector, for QuickLock thread adapters
P-721.CDA	Fast PIFOC® nanofocusing Z drive, 100 µm, direct metrology, capacitive sensor, Sub-D connector, for large aperture QuickLock thread adapters
P-721.SL2	Fast PIFOC® nanofocusing Z drive, 100 µm, SGS sensor, LEMO connector(s), for QuickLock thread adapters
P-721.SDA	Fast PIFOC® nanofocusing Z drive, 100 µm, SGS sensor, Sub-D connector, for large aperture QuickLock thread adapters
P-721.OLQ	Fast PIFOC® nanofocusing Z drive, 100 µm, open-loop, LEMO connector(s), for QuickLock thread adapters






## Product View



**Figure 1: Components of the Z drive, example of a P-721.SDA, here without labeling**

- 1 Cable exit
- 2 Threaded aperture
- 3 Base body
- 4 Protective earth connection

## Product Labeling

Labeling	Description
P-721.SDA	Product number (example), the digits after the period refer to the model
117013291	Serial number (example), individual for each P-721 Meaning of the places (counting from left): 1 = internal information 2 and 3 = manufacturing year 4 to 9 = consecutive numbers
PIFOC®	Brand name
Country of origin: Germany	Country of origin
	Warning sign "Observe manual!"
	Old equipment disposal (p. 22)
WWW.PI.WS	Manufacturer's address (website)
	CE conformity mark
	Manufacturer's logo
	Symbol for the protective earth conductor (p. 9), marks the protective earth connection of the P-721

## Scope of Delivery

Product number	Description
P-721	Fast PIFOC® nanofocusing Z drive according to order (p. 5)
000036450	M4 screw set for protective earth, consisting of: <ul style="list-style-type: none"> <li>▪ 1 M4x8 flat-head screw with cross recess, ISO 7045</li> <li>▪ 2 safety washers</li> <li>▪ 2 flat washers</li> </ul>
PZ240EK	Short instructions for piezo positioning systems
P721T0002	Technical note for QuickLock thread option

## Accessories

### Extension tubes

Product number	Description
P-721.90Q	Extension tube, 12.5 mm, thread W0.8 x 1/36"
P-721.91Q	Extension tube, 12.5 mm, thread M25 x 1/36"
P-721.92Q	Extension tube, 12.5 mm, thread M26 x 1/36"
P-721.93Q	Extension tube, 12.5 mm, thread M27 x 1/36"
P-721.94Q	Extension tube, 12.5 mm, thread M28 x 1/36"
P-721.95Q	Extension tube, 12.5 mm, thread M32 x 1/36"
P-721.96Q	Extension tube, 12.5 mm, thread M26 x 1/36"
P-721.98Q	Extension tube, 12.5 mm, thread M19 x 1/36"

### QuickLock thread adapters

Product number	Description
<b>Only for P-721.xxQ / .SL2</b>	
P-721.02Q	QuickLock thread adapter, M26 x 0.75 mm, Ø 21 mm
P-721.03Q	QuickLock thread adapter, M27 x 0.75 mm, Ø 21 mm
P-721.04Q	QuickLock thread adapter, M28 x 0.75 mm, Ø 21 mm
P-721.05Q	QuickLock thread adapter, M32 x 0.75 mm, Ø 21 mm
P-721.06Q	QuickLock thread adapter, M26 x 1/36", Ø 21 mm
P-721.08Q	QuickLock thread adapter, M19 x 0.75 mm, Ø 14 mm
P-721.11Q	QuickLock thread adapter, M25 x 0.75 mm, Ø 21 mm
P-721.12Q	QuickLock thread adapter, W0.8 x 1/36", Ø 14 mm

Product number	Description
<b>Only for P-721.xxA</b>	
P-721.02A	QuickLock thread adapter for large apertures, M26 x 0.75 mm, Ø 23 mm
P-721.03A	QuickLock thread adapter for large apertures, M27 x 0.75 mm, Ø 24 mm
P-721.04A	QuickLock thread adapter for large apertures, M28 x 0.75 mm, Ø 25 mm
P-721.05A	QuickLock thread adapter for large apertures, M32 x 0.75 mm, Ø 29 mm
P-721.06A	QuickLock thread adapter for large apertures, M26 x 1/36", Ø 23 mm
P-721.11A	QuickLock thread adapter for large apertures, M25 x 0.75 mm, Ø 22 mm

### Adapter cables

Product number	Description
P-895.1DLC	Adapter cable Sub-D 7W2 (f) to LEMO for piezo actuator nanopositioning systems with capacitive sensors, 1 channel, 0.3 m. Fits controllers with LEMO connectors (1× voltage, 2× sensor).
P-895.1LDC	Adapter cable LEMO to sub-D 7W2 (m) for piezo actuator nanopositioning systems with capacitive sensors, 1 channel, 0.3 m. Fits motion controllers with Sub-D 7W2 (f) socket.

### Suitable Electronics

Model / Mechanics	Model / Electronics
Capacitive sensor, Sub-D connection: P-721.CDQ P-721.CDA	<ul style="list-style-type: none"> <li>▪ E-621 controller module</li> <li>▪ E-625 servo controller, bench-top</li> <li>▪ E-665 display servo controller, with digital interface, bench-top</li> <li>▪ E-754 single-channel digital controller</li> <li>▪ E-709 single-channel digital controller</li> </ul>
Capacitive sensor, LEMO connection: P-721.CLQ	<ul style="list-style-type: none"> <li>▪ E-610 servo controller / amplifier</li> <li>▪ E-500 modular piezo controller system with E-505 high-performance amplifier module and E-509 controller</li> </ul>
SGS sensor, Sub-D connection: E-721.SDA	<ul style="list-style-type: none"> <li>▪ E-709 single-channel digital controller</li> </ul>
SGS sensor, LEMO connection: E-721.SL2	<ul style="list-style-type: none"> <li>▪ E-610 servo controller / amplifier</li> <li>▪ E-625 servo controller, bench-top</li> <li>▪ E-665 display servo controller, with digital interface, bench-top</li> </ul>
No sensor, LEMO connection: P-721.0LQ	<ul style="list-style-type: none"> <li>▪ E-500 modular piezo controller system with E-505 high-performance amplifier module</li> <li>▪ E-610.00 amplifier</li> </ul>



## Installation

### Connecting the P-721 to a Protective Earth Conductor

#### INFORMATION

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

The P-721 is equipped with an M4 hole for fastening the protective earth conductor. This hole is marked with the protective earth conductor symbol  $\oplus$  (see "Dimensions", p.16).

#### Requirements

- ✓ You have read and understood the safety precautions (p. 4).
- ✓ The P-721 is **not** connected to the electronics.

#### Tools and accessories

- Suitable protective earth conductor: Cross-sectional area of the cable  $\geq 0.75 \text{ mm}^2$
- Supplied M4 protective earth screw set (p. 7) for connecting the protective earth conductor
- Suitable screwdriver

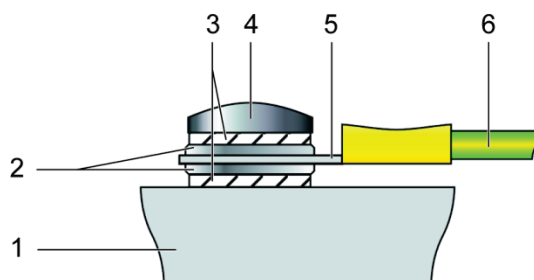


Figure 2: Mounting of the protective earth conductor (profile view)

- 1 Base body of the P-721
- 2 Flat washer
- 3 Safety washer
- 4 Screw
- 5 Cable lug
- 6 Protective earth conductor

### Connecting the P-721 to the protective earth conductor

1. If necessary, fasten a suitable cable lug to the protective earth conductor.
2. Use the M4 screw (together with the washers and self-locking washers) to affix the cable lug of the protective earth conductor to the protective earth connection of the P-721 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 mounting the protective earth conductor is  $< 0.1 \Omega$  at 25 A.

## Affixing the P-721 to the Microscope

### Requirements

- ✓ You have read and understood the safety precautions (p. 4).

### Tools and accessories

- P721T0002 technical note for PIFOC® QuickLock thread option (p. 7)
- QuickLock thread adapter (p. 7) (not included)

## Affixing the P-721 to the Microscope

- Install the P-721 as described in the P721T0002 technical note for PIFOC® QuickLock thread option (p. 7).

## Installing the Objective

### Correct:

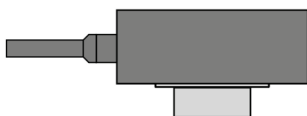


Figure 3: Center of load close to aperture

### Incorrect:

Mounting the load incorrectly causes high strain on the flexure guides in the Z drive, high torques and the danger of oscillations.

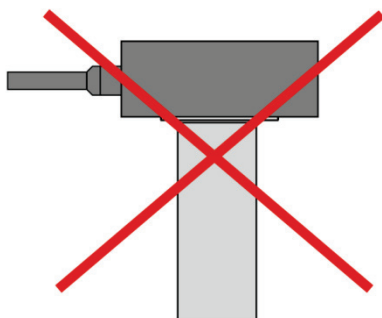


Figure 4: Center of load far below the aperture

## Requirements

- ✓ You have read and understood the safety precautions (p. 4).
- ✓ You have affixed the P-721 to the microscope (p. 10).

## Tools and accessories

- P721T0002 technical note for PIFOC® QuickLock thread option (p. 7)
- QuickLock thread adapter (p. 7) (not included)
- Objective to be installed (not included)
- Suitable tools

## Installing the objective

- Screw the objective into the P-721. See the P721T0002 technical note (p. 7) for details.

## Start-Up and Operation

### General Notes on Start-Up and Operation

#### NOTICE



#### **Destruction of the piezo actuator by electric flashovers!**

The use of the P-721 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 such as 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-721 in environments that can increase the electric conductivity.
- Only operate the P-721 within the permissible ambient conditions and classifications (p. 21).

#### NOTICE



#### **Destruction of the piezo actuator by continuously high voltage!**

The constant application of high voltage to piezo actuators can lead to leakage currents and flashovers that destroy the ceramic.

If the P-721 is not used, but the controller is to remain switched on to ensure temperature stability:

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

**NOTICE****Uncontrolled oscillation!**

Oscillations can cause irreparable damage to the P-721. Oscillations are indicated by a humming and can result from the following causes:

- The load and/or dynamics of operation differ too much from the calibration settings.
- The P-721 is operated near its resonant frequency.
- If you notice oscillations, stop the P-721 immediately.

**INFORMATION**

Systems are calibrated at the factory to achieve optimum performance. Replacing the system components will cause a loss in performance when Z drives without ID chip are used, or whose ID chip does not contain any calibration data, or when Z drives with LEMO connectors or analog controllers are used.

Only P-721.CDQ and P-721.CDA Z drives are equipped with an ID chip.

- Note the assignment of the Z drive axis to the controller channel, which is given by the calibration label of the piezo servo controller.
- For systems without ID chip:  
If the piezo servo controller or the Z drive has to be replaced, recalibrate the axis displacement (see controller manual) or contact our customer service department (p. 14).

**Starting Up and Operating the P-721****Requirements**

- ✓ You have read and understood the safety precautions (p. 4).
- ✓ You have read and understood the general notes on start-up and operation (p. 11).

**Starting up and operating the P-721**

- Follow the instructions in the manual of the piezo controller used for start-up and operation of the P-721.

**Discharging the P-721**

The P-721 must be discharged before demounting. Demounting is necessary e.g., before cleaning or transporting the P-721 as well as for modifications.

### Discharging a P-721 that is connected to the controller

In closed-loop operation:

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

In open-loop operation:

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

### Discharging a P-721 that is not connected to the controller

- Connect the P-721 to the switched-off PI controller for 10 seconds.

## Maintenance

### NOTICE



#### Misalignment from loosening screws on the base body!

The P-721 is maintenance-free and precisely aligned.

- Only loosen screws according to the instructions in this manual.
- Do **not** open the P-721.

## Cleaning the P-721

### Requirements

- ✓ You have discharged the piezo actuators of the P-721.
- ✓ You have disconnected the P-721 from the controller.

### Cleaning the P-721

- Clean the surface of the P-721 with a cloth that is lightly dampened with a mild cleanser or disinfectant (e.g., ethanol or isopropyl alcohol).
- Do **not** do any ultrasonic cleaning.

## Customer Service

For inquiries and orders, contact your PI sales engineer or send us an email ([info@pi.ws](mailto:info@pi.ws)).

- If you have questions concerning your system, have the following information ready:
  - Product and serial numbers of all products in the system
  - Firmware version of the controller (if present)
  - Version of the driver or the software (if present)
  - Operating system on the PC (if present)
- If possible: Take photographs or make videos of your system that can be sent to our customer service department if requested.

The latest versions of the user manuals are available for download on our website ([www.pi.ws](http://www.pi.ws)).

## Technical Data

### P-721 Fast PIFOC® Nanofocusing Z Drive

Model	P-721.CLQ	P-721.CDQ P-721.CDA	P-721.SL2 P-721.SDA	P-721.0LQ open-loop version	Units	Tolerance
Active axes	Z	Z	Z	Z		
<b>Motion and positioning</b>						
Integrated sensor	Capacitive	Capacitive	SGS	-		
Open-loop travel, -20 to +120V	140	140	140	140	µm	min. (+20 %/ -0 %)
Closed-loop travel	100	100	100	-	µm	calibrated
Open-loop resolution	0.5	0.5	0.5	0.5	nm	typ.
Closed-loop resolution	0.7	0.7	5	-	nm	typ.
Linearity, closed-loop	0.03	0.03	0.2	-	%	typ.
Repeatability	±5	±5	±10	-	nm	typ.
Runout $\theta_x, \theta_y$	13	13	13	13	µrad	typ.
Crosstalk in X, Y	100	100	100	100	nm	typ.
<b>Mechanical properties</b>						
Stiffness in motion direction	0.3	0.3	0.3	0.3	N/µm	± 20 %

Model	P-721.CLQ	P-721.CDQ P-721.CDA	P-721.SL2 P-721.SDA	P-721.0LQ open-loop version	Units	Tolerance
Unloaded resonant frequency	580	580	580	580	Hz	± 20 %
Resonant frequency @ 120 g	235	235	235	235	Hz	± 20 %
Resonant frequency @ 200 g	180	180	180	180	Hz	± 20 %
Push/pull force capacity in motion direction	100 / 20	100 / 20	100 / 20	100 / 20	N	max.
<b>Drive properties</b>						
Ceramic type	PICMA® P-885	PICMA® P-885	PICMA® P-885	PICMA® P-885		
Electrical capacitance	3.1	3.1	3.1	3.1	µF	± 20 %
Dynamic operating current coefficient	3.9	3.9	3.9	3.9	µA/(Hz x µm)	± 20 %
<b>Miscellaneous</b>						
Operating temperature range*	-20 to 80	-20 to 80	-20 to 80	-20 to 80	°C	
Material	Aluminum	Aluminum	Aluminum	Aluminum		
Max. objective diameter	39	39	39	39	mm	
Mass	0.24	0.24	0.22	0.22	kg	± 5 %
Maximum objective diameter	39	39	39	39	mm	
Cable length	1	1	1	1	m	±10 mm
Sensor- / voltage connection	LEMO	Sub-D special	LEMO / Sub-D special	LEMO (no sensor)		

\*Specifications assured from 17°C to 23°C. The Z drive has to be recalibrated for temperatures outside this range.

## Dimensions

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

### P-721.xxQ, P-721.SL2

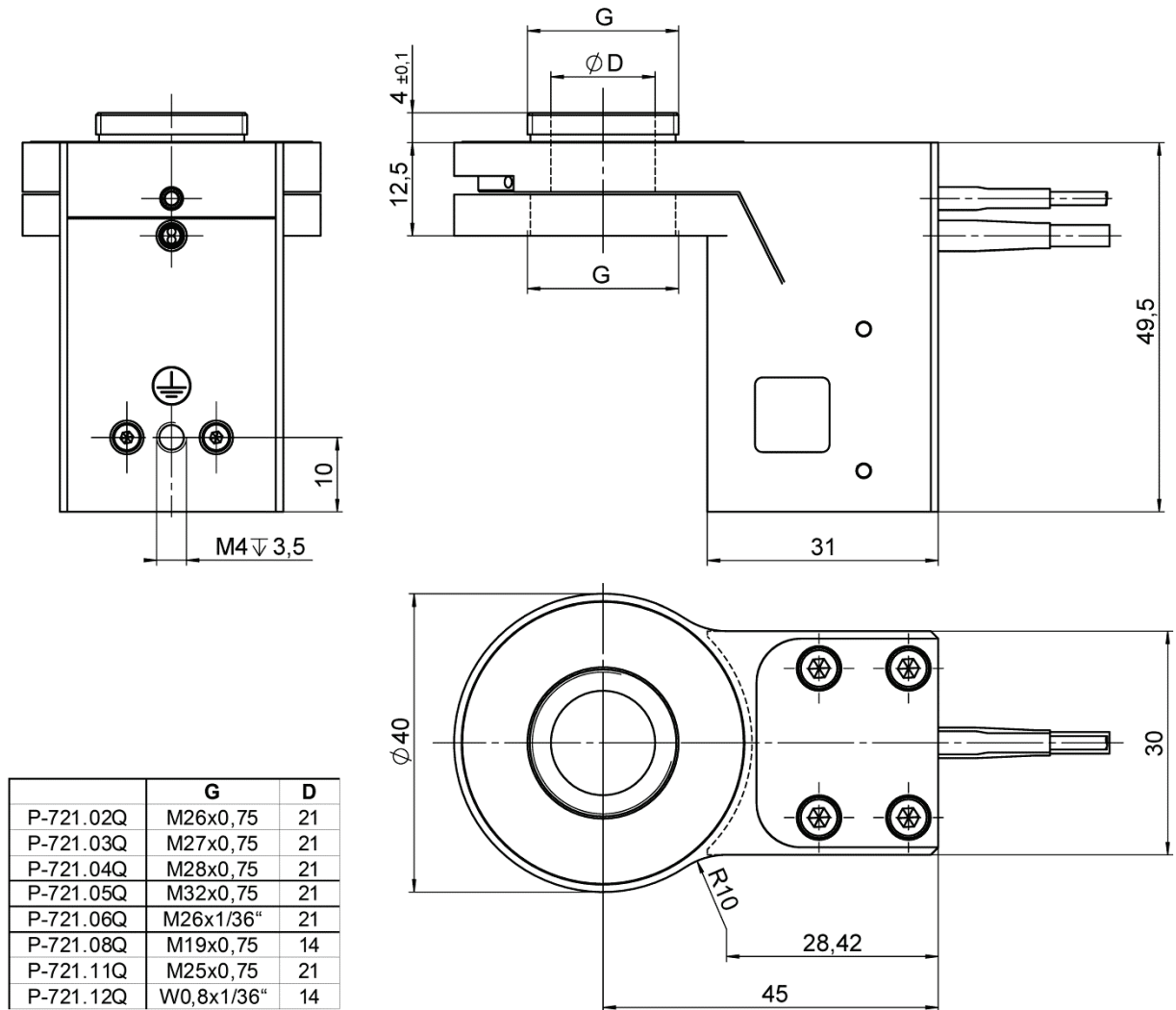
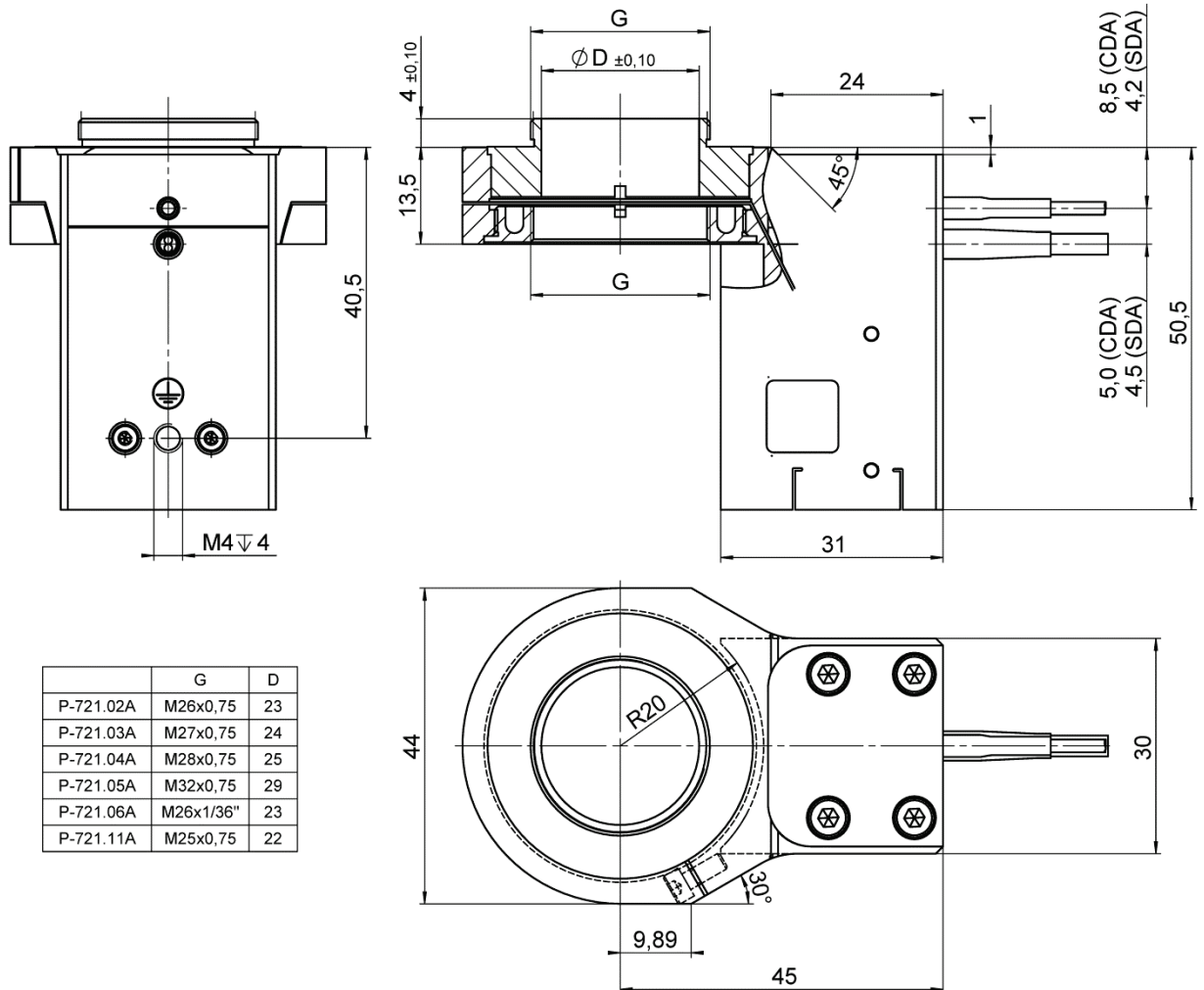


Figure 5: P-721.xxQ, P-721.SL2 (P-721.xxQ adapter to be ordered separately)



**P-721.xDA**



**Figure 6: P-721.xDA (P-721.xx A adapter to be ordered separately)**

## Pin Assignments

### P-721.CLQ, P-721.0LQ

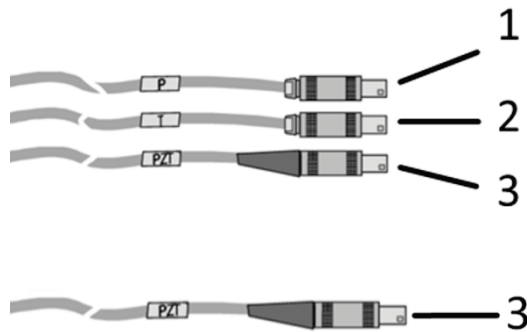


Figure 7: LEMO connectors of P-721.CLQ (top) and P-721.0LQ (bottom)

- 1 LEMO coaxial connector for capacitive sensor (Probe)
- 2 LEMO coaxial connector for capacitive sensor (Target)
- 3 LEMO coaxial connector for piezo voltage

### LEMO coaxial connectors

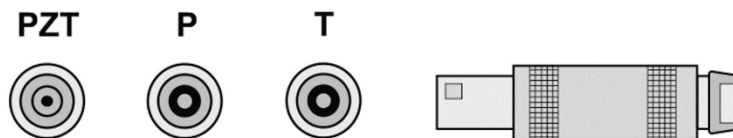
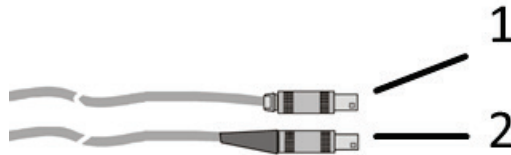


Figure 8: LEMO coaxial connectors

Connector	Signal	Function	Connector shell
P	Probe	Probe sensor signal (moving part of the capacitive sensor)	Cable shield
T	Target	Target sensor signal (non-moving part of the capacitive sensor)	Cable shield
PZT	PZT	Piezo voltage	Ground of piezo voltage on cable shield


## P-721.SL2



**Figure 9: LEMO connectors of P-721.SL2**

- 1 4-pin LEMO connector for strain gauge sensor
- 2 LEMO coaxial connector for piezo voltage

### LEMO connector for strain gauge sensor (front view):

Pin	Function	
1	$V_{ref}$	
2	Sensor 1 (-)	
3	Sensor 2 (+)	
4	GND	

### LEMO coaxial connector for piezo voltage:

See LEMO connector **PZT** as used in “LEMO coaxial connectors” on p. 18.

### P-721.CDx

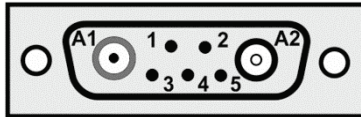


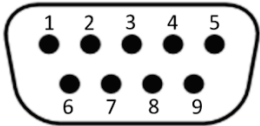
Figure 10: Sub-D 7W2 (m) connector, front view

Pin	Signal	Function
A1 inner conductor	Input	Piezo voltage +
A2 inner conductor	Output	Probe sensor signal (nonmoving part of the capacitive sensor)
A2 outer conductor	GND	Shield
1	Bidirectional	Data line for ID chip
2	GND	Shield of Target Ground of ID chip when switched on
3	Input	Piezo voltage –
4	N.C.	Not connected
5	Input	Target sensor signal (movable part of the capacitive sensor)

The connector shell is connected to the cable shield.

### P-721.SDA




Connector type: Sub-D 9 male, front view

Pin	Function	
1	PZT +	
2	Not connected	
3	Not connected	
4	SGS +	
5	SGS GND	
6	PZT GND	
7	Not connected	
8	SGS Ref.	
9	SGS -	

The connector shell is connected to the cable shield.

## Maximum Ratings

The P-721 is designed for the following maximum ratings:

Maximum operating voltage 	Maximum operating frequency (unloaded) 	Maximum power consumption 
-20 to 120 V	193 Hz	8.6 W

## Ambient Conditions and Classifications

The following ambient conditions and classifications must be observed for the P-721:

Area of application	For indoor use only
Maximum altitude	2000 m
Air pressure	1100 hPa to 1013 hPa
Relative humidity	Highest relative humidity 80 % for temperatures up to 31 °C Decreasing linearly to 50 % relative humidity at 40 °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

## 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:

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