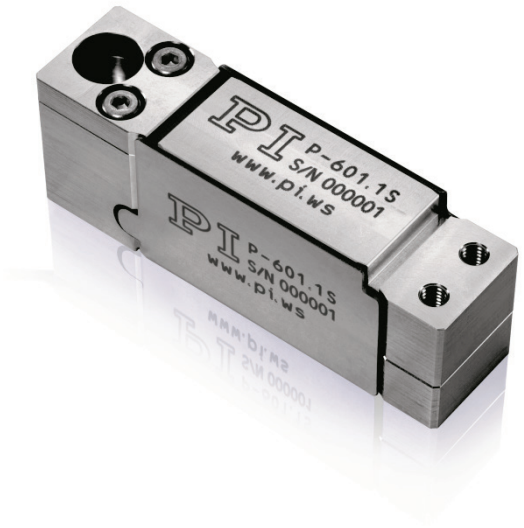
User Manual

KSch/CBo, 2017-02-27
P601T0001, valid for P-601, all models

P-601 PiezoMove
Flexure-Guided Linear Actuator



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PIEZO NANO POSITIONING

Contents

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.

Symbol/Label	Meaning
1. 2.	Action consisting of several steps whose sequential order must be observed
➢	Action consisting of one or several steps whose sequential order is irrelevant
▪	List item
p. 5	Cross-reference to page 5
RS-232	Labeling of an operating element on the product (example: socket of the RS-232 interface)
	Warning sign affixed to the product that refers to detailed information in this manual.

Downloading Manuals

INFORMATION

If a manual is missing or problems occur with downloading:

➢ Contact our customer service department (p. 14).

INFORMATION

For products that are supplied with software (CD in the scope of delivery), access to the manuals is protected by a password. Protected manuals are only displayed on the website after entering the password.

The password is included on the CD of the product.

For products with CD: Identify the password

1. Insert the product CD into the PC drive.
2. Switch to the Manuals directory on the CD.
3. In the Manuals directory, open the Release News (file including ***releasenews*** in the file name).
4. Find the user name and the password in the section "User login for software download" in the Release News.

Downloading manuals

1. Open the website **www.pi.ws**.
2. If access to the manuals is protected by a password:
   a) Click ***Login***.
   b) Log in with the user name and password.
3. Click ***Search***.
4. Enter the product number up to the period (e.g., P-882) or the product family (e.g., PICMA® Bender) into the search field.
5. Click ***Start search*** or press the Enter key.
6. Open the corresponding product detail page in the list of search results:
   a) If necessary: Scroll down the list.
   b) If necessary: Click ***Load more results*** at the end of the list.
   c) Click the corresponding product in the list.
7. Scroll down to the ***Downloads*** section on the product detail page.
   The manuals are displayed under ***Documentation***.
8. Click the desired manual and save it to the hard disk of your PC or to a data storage medium.

Safety

Intended Use

The P-601 PiezoMove Z actuator provides motion on the Z axis.
Depending on the version, the actuators provide different travel ranges and push/pull forces, see “Technical Data” on p. 15. The P-601.xSx versions are equipped with SGS sensors.

The P-601 actuators are components which are intended to be integrated in other equipment: The user is responsible for compliant connection regarding electronic safety according to EN 61010-1:2010 and regarding electromagnetic compatibility of the P-601 according to EN 61326-1:2013 when implementing the total system. The actuators comply to the RoHS directive, i.e. the standards defined by EN 50581:2012.

The P-601 actuators are intended for indoor use and in an environment which is free of dirt, oil and lubricants.

The intended use of the P-601 is only possible in conjunction with suitable electronics that are available from PI. For information on the piezo controller, refer to its separate documentation.

Safety Precautions

CAUTION

Dangerous voltage and residual charge on piezo actuators!

The P-601 contains piezo actuators. Mechanical shock, temperature changes and compressive stresses will cause high voltages to be developed. Touching the contacts of the P-601 can lead to minor injuries. In addition, the piezo actuators can be destroyed by an abrupt contraction.

- Only touch the P-601 when you have discharged it.
- Do **not** open the P-601.
- Only handle the actuator with the shorting connector affixed on the stranded wires as shown in Figure 1 above as labeled by the red arrows.
- If the P-601 features a connector:
  Do **not** disconnect the P-601 from the electronics during operation.

If the P-601 is **not** connected to a shorting connector:

- Discharge the piezo actuators of the P-601 before installation:
  Connect the P-601 to the switched-off PI controller for 10 seconds.

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-601 can result in minor injuries.

- Install the actuator before start-up so that any risk of electric shock is prevented:
  - Connect the actuator to a protective earth conductor via an electrically conductive surface or
  - Connect the actuator to a protective earth conductor via its mounting interfaces or
  - Install the actuator so that it is electrically insulated according to protection class II.
- 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 ohm 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-601 to the protective earth conductor before starting it up again.

NOTICE

Destruction of the piezo actuator due to rapid discharging!

If the P-601 is not connected to the electronics, the stranded wires must be short-circuited in order to prevent the piezo actuator from charging during temperature changes and compressive stresses. Unsuitable short-circuiting leads to an abrupt contraction of the piezo actuator due to excessively fast discharging. Abrupt contraction can destroy the piezo actuator.

- Remove the shorting clamp supplied (p. 8) from the stranded wires only if this is required for installation or operation.
- If the shorting clamp has been removed:
  - Ensure adequate protection against touching live parts.
  - Short-circuit the stranded wires of the P-601 using a **10 kΩ discharge resistor** or discharge the piezo actuator (p. 12) in a suitable manner before reconnecting the shorting clamp.
- If the piezo actuator is discharged: Keep the stranded wires of the P-601 short-circuited using the supplied shorting clamp.

NOTICE

Destruction of the piezo actuator due to excessive loads!

Excessive loads can destroy the P-601.

- Do **not** exceed the maximum compressive/tensile stress capacity (p. 15).

NOTICE

Heating up of the P-601 during operation!

The heat produced during dynamic operation of the P-601 can affect your application.

➢ Install the P-601 so that your application is not affected by the dissipating heat.

Product Description

Model Overview

Product number	Description
P-601.10	PiezoMove OEM flexure-guided, lever-amplified actuator, 100 µm, open-loop
P-601.10L	PiezoMove OEM flexure-guided, lever-amplified actuator, 100 µm, open-loop, LEMO connector(s)
P-601.1S	PiezoMove OEM flexure-guided, lever-amplified actuator, 100 µm, SGS sensor
P-601.1SL	PiezoMove OEM flexure-guided, lever-amplified actuator, 100 µm, SGS sensor, LEMO connector(s)
P-601.30	PiezoMove OEM flexure-guided, lever-amplified actuator, 250 µm, open-loop
P-601.30L	PiezoMove OEM flexure-guided, lever-amplified actuator, 250 µm, open-loop, LEMO connector(s)
P-601.3S	PiezoMove OEM flexure-guided, lever-amplified actuator, 250 µm, SGS sensor
P-601.3SL	PiezoMove OEM flexure-guided, lever-amplified actuator, 250 µm, SGS sensor, LEMO connector(s)
P-601.40	PiezoMove OEM flexure-guided, lever-amplified actuator, 400 µm, open-loop
P-601.40L	PiezoMove OEM flexure-guided, lever-amplified actuator, 400 µm, open-loop, LEMO connector(s)
P-601.4S	PiezoMove OEM flexure-guided, lever-amplified actuator, 400 µm, SGS sensor
P-601.4SL	PiezoMove OEM flexure-guided, lever-amplified actuator, 400 µm, SGS sensor, LEMO connector(s)

Product View

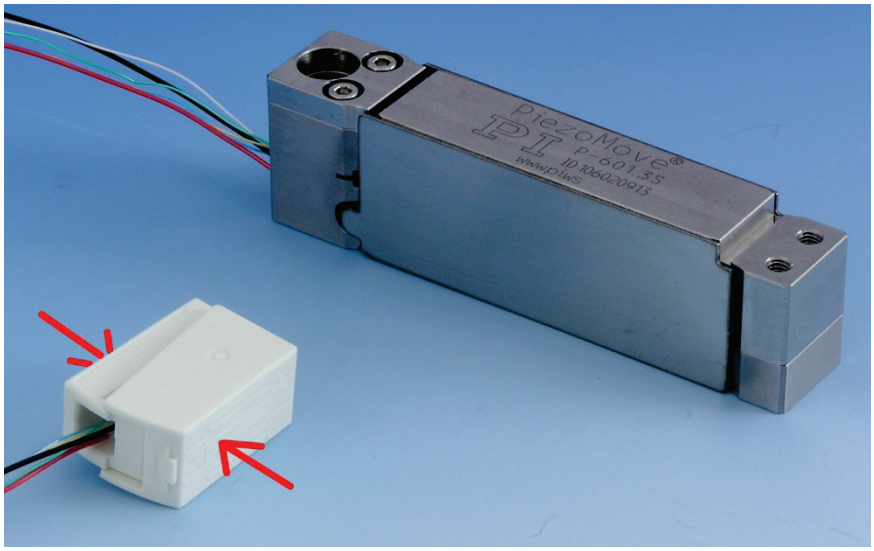


Figure 1: P-601.3S actuator with shorting clamp on the stranded wires

Scope of Delivery

Product number	Description
P-601	PiezoMove flexure-guided linear actuator according to order (p. 7)
P601T0001	User manual for P-601 (this document)

Unpacking

NOTICE

Damage to the actuator

When you unpack the actuator, mechanical shock or damage to the thin stranded wires can damage the actuator.

➢ Remove any outer packaging carefully.

Installation

Preventing the Risk of Electric Shock

The P-601 actuator does not feature a separate protective earth connection and must be installed so that any risk of electric shock is prevented.

You have the following options:

1. Connect the actuator to a protective earth conductor via an electrically conductive surface or
2. Connect the actuator to a protective earth conductor via its mounting interfaces or
3. Install the actuator such that it is electrically insulated according to protection class II.

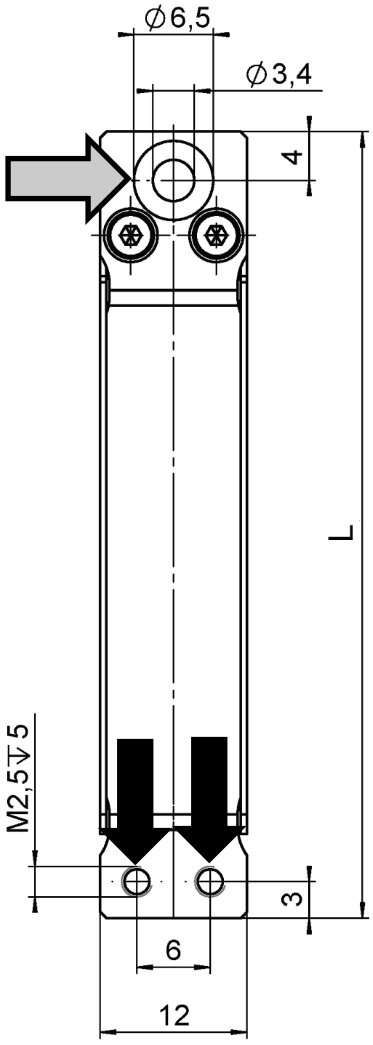
When you choose the first or the second option:

1. Make sure that the contact resistance is <0.1 ohm at 25 A at all connection points relevant for mounting the protective earth conductor.
2. Observe the applicable standards for mounting the protective earth conductor.

Preparing a P-601 with Stranded Wires for Connection to a Controller

When you prepare a P-601 actuator with stranded wires for connection to a controller, pay attention to the assignment of the stranded wires as specified in “Color coding of stranded wires” (p. 21).

Mounting the P-601 and Mounting a Load



	L
P-601.1S	46,5
P-601.3S	64,5
P-601.4S	82,5

Figure 2: The gray arrow indicates where to mount the P-601.xS on a surface, the black arrows indicate where to mount a load.
Mounting holes are the same for P-601.xS and P-601.xSL but for the dimensions of P-601.xSL see Figure 4 on p. 19.

Requirements

✓ You have read and understood the safety precautions (p. 5).

Tools and accessories

- 1 x M3 screw of suitable length for mounting the actuator on a surface
- 2 M2.5 screws of suitable length for mounting a load to the actuator
- Suitable tools

Mounting the P-601 and mounting a load

1. Only mount the P-601 on the counterbore hole intended for this purpose (see Figure 2).
2. Only fasten a load to the 2 x M2.5 mounting holes intended for this purpose (see Figure 2).
3. When the actuator is installed, release the stranded wires from the shorting connector by pressing it together in the direction shown by the red arrows (see Figure 1 on p. 8).

INFORMATION

If the shorting connector needs to be used again, make sure that the stranded wires are stripped before inserting them.

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-601 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-601 in environments that can increase the electric conductivity.
- ➢ Only operate the P-601 within the permissible ambient conditions and classifications (p. 17).

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-601 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-601. 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-601 is operated near to its resonant frequency.

➢ If you notice oscillations, stop the P-601 immediately.

Starting Up and Operating the P-601

INFORMATION

Respect Serial Number IDs

Always connect the actuator to the controller channel with which it has been calibrated. Each PI controller channel is given a label with the ID or S/N of the piezo with which it was calibrated.

Requirements

✓ You have read and understood the following sections:

- Safety Precautions (p. 5)
- General Notes on Start-Up and Operation (p. 11)

✓ You have discharged the actuator.

Starting up and operating the P-601

➢ Follow the instructions in the manual of the used piezo controller for start-up and operation of the P-601.

Discharging the P-601

The P-601 must be discharged in the following cases:

- When the P-601 is not in use but the electronics remains switched on to ensure temperature stability
- When the stranded wires of the P-601 are to be short-circuited without a discharge resistor, e.g. with the shorting clamp (p. 8) supplied
- If the connection cable of the P-601 is accidentally pulled out of the electronics during operation

Requirements

✓ You have read and understood the following sections:

- Safety Precautions (p. 5)
- General Notes on Start-Up and Operation (p. 11)

Tools and accessories

If the P-601 is not connected to the electronics:

- Only for P-601 **without** connector:
  - 10 kΩ discharge resistor (not included in scope of delivery), the touchable parts must be adequately insulated for the actuator's operating voltage range (p. 17)
- Only for P-601 **with** connector:
  - Electronics from PI or suitable shorting plug

Discharging a P-601 connected to the electronics

➢ Set the piezo voltage to 0 V on the electronics.

Discharging a P-601 not connected to the electronics

If the P-601 does **not** have a connector:

1. Ensure adequate protection against touching live parts.
2. Short-circuit the stranded wires of the P-601 for at least a few seconds using a **10 kΩ discharge resistor**.

If the P-601 has a connector:

➢ Connect the voltage connector of the P-601 to the switched off PI electronics, which has an internal discharge resistor, for at least a few seconds.

➢ Alternative: Connect a suitable shorting plug with integrated discharge resistor to the voltage connector of the P-601 for at least a few seconds.

Maintenance

NOTICE

Misalignment due to screws loosening!

The P-601 is maintenance-free and precision aligned.

➢ Do **not** loosen any screws on the P-601.

Cleaning the P-601

Requirements

- ✓ You have discharged the P-601.
- ✓ You have disconnected the P-601 from the controller.

Cleaning the P-601

- ➢ When necessary, clean the surfaces of the P-601 with a cloth that is slightly dampened with a mild cleanser (e.g. ethanol or isopropanol)
- ➢ Do **not** do any ultrasonic cleaning.

Customer Service

For inquiries and orders, contact your PI sales engineer or send us an e-mail (info@pi.ws).

If you have questions concerning your system, have the following information ready:

- Product codes 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)

Technical Data

Specifications

	P-601.1S P-601.1SL	P-601.3S P-601.3SL	P-601.4S P-601.4SL	P-601.x0 P-601.x0L open-loop versions	Unit	Tolerance
Active axes	Z	Z	Z	Z		
Motion and positioning						
Integrated sensor	SGS	SGS	SGS	–		
Open-loop travel, -20 to 120 V	100	250	400	as P-601.xS	µm	min. (+20 %/ -0 %)
Closed-loop travel	100	250	400	–	µm	calibrated
Open-loop resolution	0.2	0.3	0.4	as P-601.xS	nm	typ.
Closed-loop resolution	2	6	12	–	nm	typ.
Closed-loop non-linearity	0.1	0.3	0.3	–	%	typ.
Repeatability	8	10	30	–	nm	typ.
Mechanical properties						
Stiffness in motion direction	0.8	0.38	0.28	as P-601.xS	N/µm	±20 %
Unloaded resonant frequency	750	440	350	as P-601.xS	Hz	±20 %
Resonant frequency at 30 g	620	350	290	as P-601.xS	Hz	±20 %
Push / pull force capacity in motion direction	30 / 10	20 / 10	15 / 10	as P-601.xS	N	max.
Lateral force	30	30	30	as P-601.xS	N	max.

	P-601.1S P-601.1SL	P-601.3S P-601.3SL	P-601.4S P-601.4SL	P-601.x0 P-601.x0L open-loop versions	Unit	Tolerance
Drive properties						
Ceramic type	PICMA® P-885	PICMA® P-885	PICMA® P-885	as P-601.xS		
Electrical capacitance	1.5	3.1	4.6	as P-601.xS	µF	±20 %
Dynamic operating current coefficient (DSK)	1.9	1.6	1.4	as P-601.xS	µA/(Hz × µm)	±20 %
Miscellaneous						
Material	Stainless steel	Stainless steel	Stainless steel	Stainless steel		
Mass without cables	0.05	0.08	0.11	as P-601.xS	kg	±5 %
Cable length	S versions: 0.3 m SL versions: 1.5 m		0.3		m	±10 mm
Sensor / voltage connection	S versions: stranded wires SL versions: LEMO		x0 versions: Stranded wires x0L versions: LEMO			
Recommended controller / amplifier	E-610.S0 controller E-625.SR controller, bench-top device E-709.SRG controller, bench-top device with digital linearization		E-610.00 amplifier E-831 OEM amplifier module			

Maximum Ratings

The P-601 is designed for the following maximum ratings:

Actuator	Maximum operating voltage	Maximum operating frequency (unloaded)[1]	Maximum power consumption[2]
P-601.1xx	120 V	250 Hz	4.3 W
P-601.3xx	120 V	140 Hz	8.6 W
P-601.4xx	120 V	115 Hz	12.9 W

[1] To ensure stable operation, the maximum operating frequency is defined as approximately 1/3 of the mechanical resonant frequency.

[2] The heat generated by the piezo actuator during dynamic operation limits the value for maximum power consumption.
Details can be found online:
http://piceramic.com/piezo-technology/properties-piezo-actuators/electrical-operation.html

Ambient Conditions and Classifications

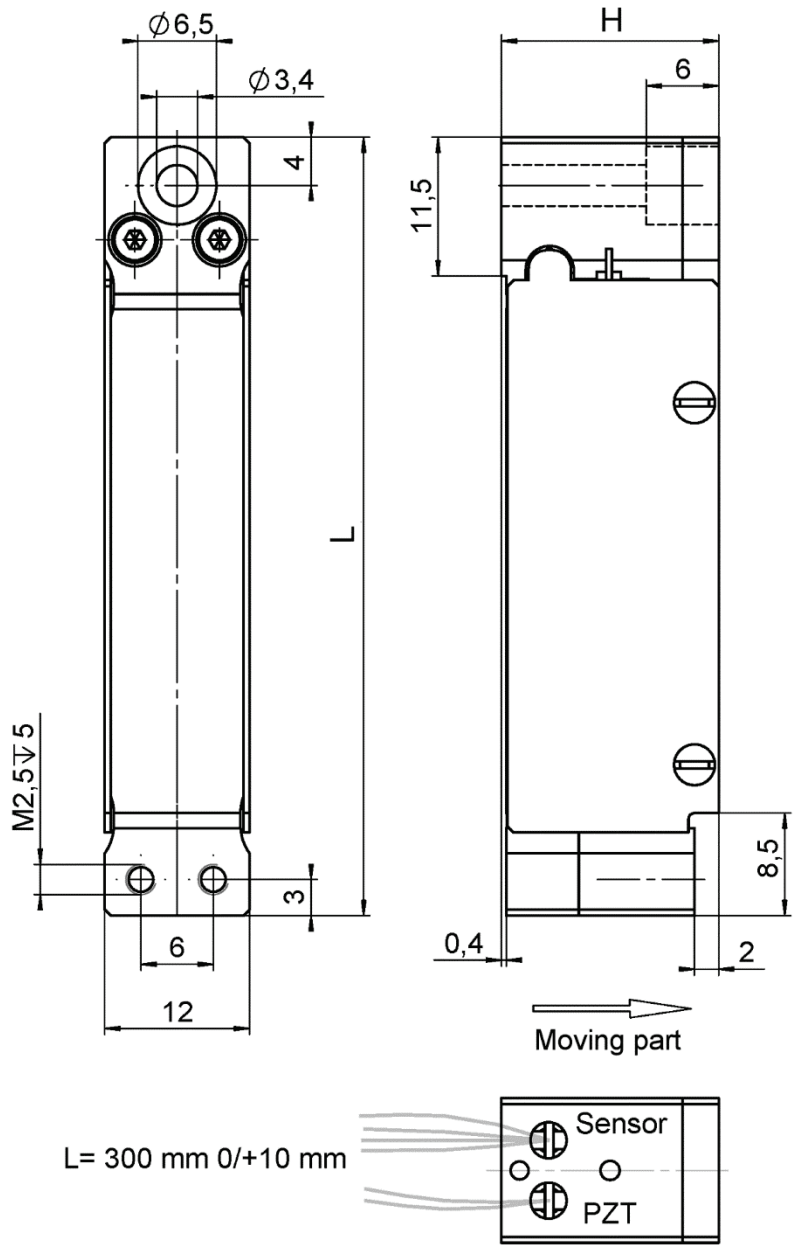
The following ambient conditions and classifications must be observed for the P-601:

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

*Specifications assured from 17°C to 23°C, performance may be reduced outside this range.

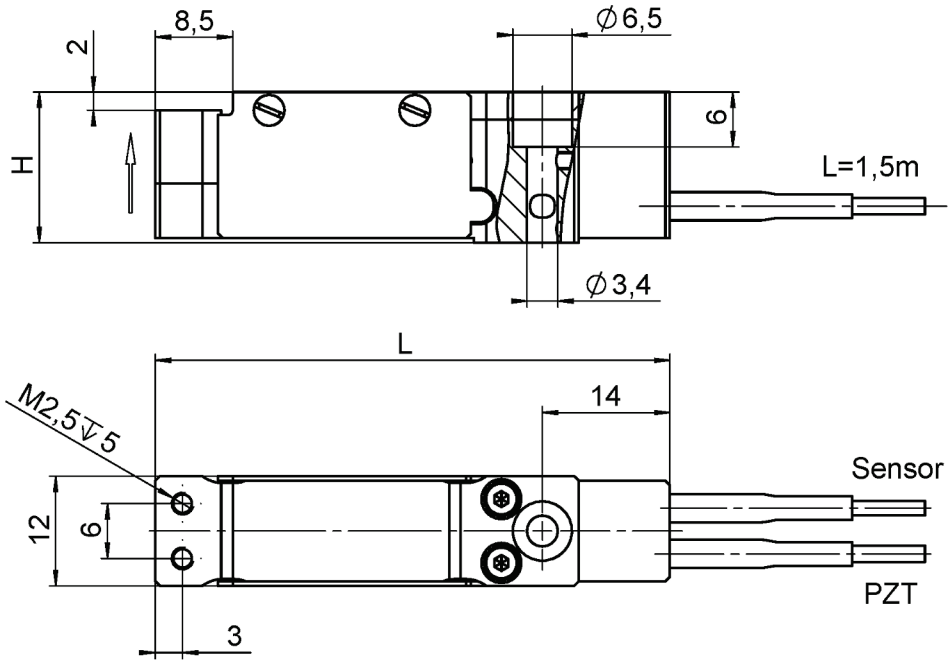
Dimensions

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



Model	L	H	Unit
P-601.1S / .10	46,5	16,5	mm
P-601.3S / .30	64,5	18,0	mm
P-601.4S / .40	82,5	20,5	mm

Figure 3: P-601.xS and P-601.x0 (.x0 models without sensor)



Model	H	L	Unit
P-601.1SL / .10L	16,5	56,5	mm
P-601.3SL / .30L	18,0	74,5	mm
P-601.4SL / .40L	20,5	92,5	mm

Figure 4: P-601.xSL and P-601.x0L (.x0L models without sensor)

Pin Assignment

Sensor connector

P-601.xSL only

Figure 5: Sensor connector, LEMO FFA.0S.304.CLAC32, front view

Pin	Function
1	5 V
2	Sensor -
3	Sensor +
4	GND

PZT connector

P-601.xxL only

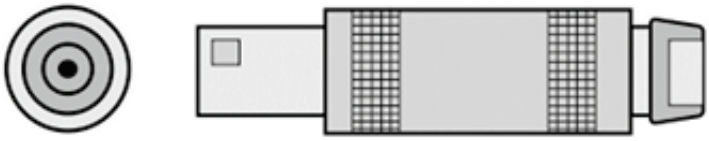


Figure 6: PZT connector, LEMO FFS.00.250.CTCE24, front view

Pin	Function
Inner contact	PZT + (-20 to 120 V)
Connector shell	PZT - (GND)

Color coding of stranded wires

Only for models that are equipped with stranded wires

Color	Function	Remarks
Red	PZT + (-20 to 120 V)	
Black	PZT - (GND)	
Green	Sensor: +5 V	Only if a sensor is present
White	Sensor: GND	Only if a sensor is present
Yellow	Sensor +	Only if a sensor is present
Blue	Sensor -	Only if a sensor is present

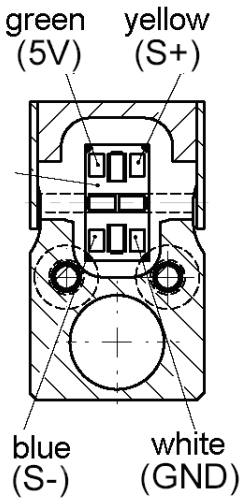


Figure 7: Color coding of stranded wires from full-bridge SGS sensor (P-601.xS only)

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

Any old PI equipment can be sent free of charge to the following address:

Physik Instrumente (PI) GmbH & Co. KG
Auf der Roemerstr. 1
D-76228 Karlsruhe, Germany