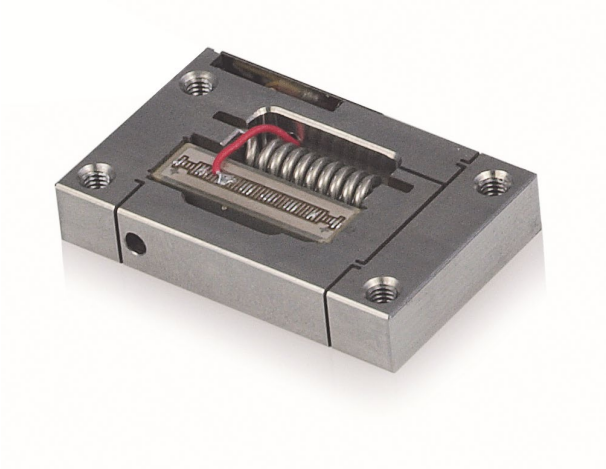
User Manual

P603T0001, valid for P-603
CBo, 1/11/2021

P-603

Inexpensive PiezoMove Linear Actuator



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Contents

About this Document

This user manual contains information necessary for the intended use of the P-603.

It assumes that the reader has a fundamental understanding of basic servo systems as well as motion control concepts and applicable safety procedures.

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 or cause damage to equipment.

➢ Precautionary measures for avoiding.

NOTICE

Dangerous situation
Failure to comply could cause damage to equipment.

➢ Precautionary measures for avoiding.

INFORMATION

Additional information that can affect your application.

Symbol/Label	Meaning
1. 2.	Action consisting of several steps with strict sequential order
➢	Action consisting of one or more steps without relevant sequential order
▪	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 on the product that refers to detailed information in the documentation.

Other Applicable Documents

The devices mentioned in this technical note are described in separate manuals.

Product	Document
E-610 piezo amplifier / servo controller	PZ70 user manual PZ72 user manual
E-625 piezo servo controller	PZ167 user manual
E-831 piezo amplifier module	PZ191 user manual PZ235 user manual

Downloading Manuals

INFORMATION

If a manual is missing or problems occur with downloading:

➢ Contact our customer service department (p. 15).

Downloading manuals

1. Open the website **www.pi.ws**.
2. Search the website for the product number (e.g., P-603) or the product family (e.g., PiezoMove).
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.

Safety

Intended Use

The P-603 PiezoMove linear actuator is intended to be used in an environment which is free of dirt, oil, and lubricants.

In accordance with its design, the P-603 is intended for the following applications:

- Positioning of loads
- Dynamic positioning
- Vibration damping
- Force generation

The P-603 is designed to be integrated into systems that meet the EN 61010-1 safety standard and the EN 61326-1 EMC standard. The operator is responsible for electrical safety and electromagnetic compatibility when integrating the P-603 into the overall system. The P-603 complies with the RoHS directive, i.e., the standards defined by EN 50581.

The motion of the P-603 takes place on one axis. The P-603.xSx versions are equipped with position sensors.

The P-603 can only be used as intended in conjunction with suitable drive and control electronics (p. 10) available from PI. The electronics are not included in the scope of delivery of the P-603.

The electronics must provide the required operating voltages. To ensure proper performance of the servo-control system (P-603.xSx only), the electronics must also be able to read out and process the signals from the position sensors.

For information about the electronics refer to their separate documentation (p. 5).

Safety Precautions

Electrical Dangers

CAUTION

Dangerous voltage and residual charge in piezo actuators!
The P-603 can remain charged if its connecting cable is disconnected from the electronics during operation. Touching the live parts of the P-603 can result in minor injury from electric shock.

- Do **not** disconnect the P-603 from the electronics during operation. If the P-603's connecting cable was accidentally disconnected from the electronics during operation, discharge the P-603 appropriately (p. 14).

CAUTION

Dangerous voltage in piezo actuators during operation!
During operation, the piezo actuator of the P-603 carries voltages of up to 120 V. Touching the P-603 can lead to minor injuries from electric shock.

- Do **not** touch the P-603 during operation.
- Before startup, insulate the piezo actuator of the P-603 electrically from the surrounding mechanical system to prevent direct or indirect contact with live parts. Pay attention to the clearances and creepage distances required for the operating voltage, and pay attention to the standards applicable to your application.

CAUTION

Risk of electric shock if the protective earth conductor is not connected!

The system into which the P-603 is integrated (e.g., housing or surrounding mechanical system) must be connected to a protective earth conductor. If the protective earth conductor is not or not properly connected, touching the system in which the piezo actuator was incorporated can lead to minor injury from electric shock in the case of a malfunction.

- Before startup, connect the overall system to a protective earth conductor in accordance with the applicable standards.
- Do **not** remove the protective earth conductor during operation.
- If the protective earth conductor has to be temporarily removed (e.g., for modifications), reconnect the overall system to the protective earth conductor before starting it up again.

NOTICE

Destruction of the piezo actuator by electric flashovers!

The use of the P-603 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-603 in environments that can increase the electric conductivity.
- Only operate the P-603 within the permissible ambient conditions and classifications (p. 18).

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-603 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.

Mechanical Dangers

NOTICE

External push or pull forces!

External push or pull forces acting on the moving part (p. 10) in the direction of motion can cause damage to the P-603.

The maximum permissible forces depend on the model:

P-603.1xx:

- Do **not** exceed the **maximum push force of 40 N** on the moving part.
- Do **not** exceed the **maximum pull force of 20 N** on the moving part.

P-603.3xx:

- Do **not** exceed the **maximum push force of 35 N** on the moving part.
- Do **not** exceed the **maximum pull force of 13 N** on the moving part.

P-603.5xx:

- Do **not** exceed the **maximum push force of 30 N** on the moving part.
- Do **not** exceed the **maximum pull force of 10 N** on the moving part.

In dynamic operation, take special care not to exceed the maximum push/pull forces.

NOTICE

Mechanical overload due to high torques!

High torques can damage the P-603 and lead to loss in accuracy.

When mounting the P-603 onto a surface:

- Do **not** exceed a torque of **0.7 Nm** for the mounting holes in the mounting interface (p. 10).

When fixing a load to the P-603:

- Do **not** exceed a torque of **0.5 Nm** for the mounting holes in the moving part (p. 10).

NOTICE

Uncontrolled oscillation!

Oscillations can cause irreparable damage to the P-603. 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-603 is operated near to its resonant frequency.

- If you notice oscillations, stop the P-603 immediately.

NOTICE

Damage after reconnecting due to a charged P-603!
The P-603 can remain charged if its connecting cable is disconnected from the electronics during operation. Reconnecting a charged P-603 to electronics during operation can cause a mechanical impulse that will damage the P-603.

- Do **not** disconnect the P-603 from the electronics during operation.
- If the P-603's connecting cable was accidentally disconnected from the electronics during operation, switch off the electronics before reconnecting.

Thermal Dangers

CAUTION

Burning from hot surface!
The surface of the P-603 and the surrounding area can heat up during operation. Touching the P-603 and surrounding parts can result in minor injuries from burning.

- Make sure that the hot P-603 and its surrounding parts cannot be touched.

NOTICE

Heating up of the P-603 during operation!
The heat produced during dynamic operation of the P-603 can affect your application.

- Install the P-603 so that your application is not affected by the dissipating heat.

Product Description

Model Overview

Model	Travel range	Sensor	Connection to electronics
P-603.101	100 µm	-	Stranded wires
P-603.1S1	100 µm	SGS	Stranded wires
P-603.1S2	100 µm	SGS	LEMO
P-603.301	300 µm	-	Stranded wires
P-603.3S1	300 µm	SGS	Stranded wires
P-603.3S2	300 µm	SGS	LEMO
P-603.501	500 µm	-	Stranded wires
P-603.5S1	500 µm	SGS	Stranded wires
P-603.5S2	500 µm	SGS	LEMO

Product View

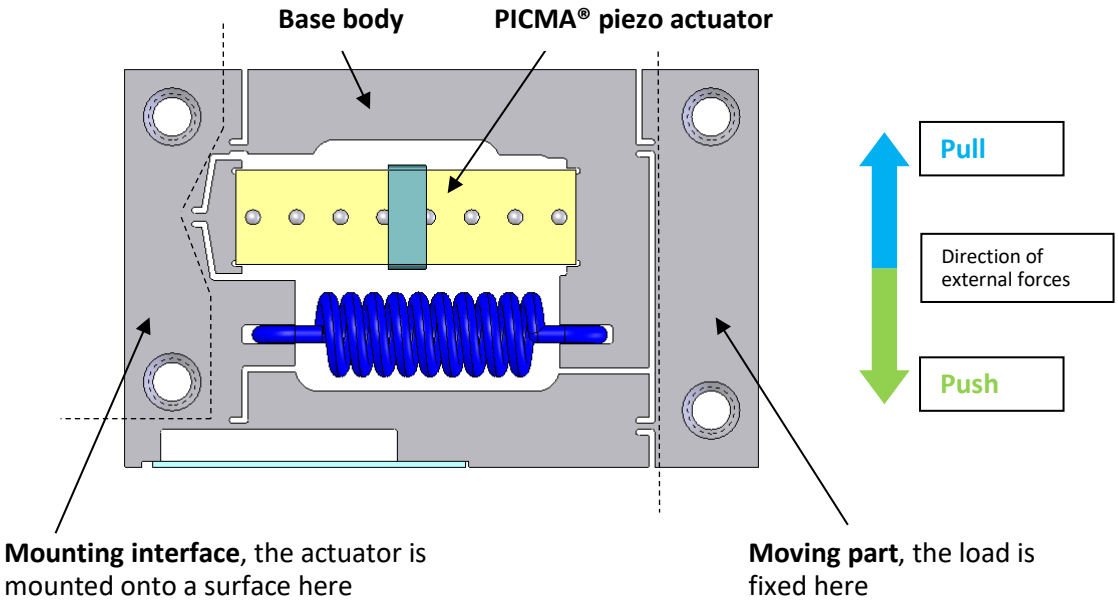


Figure 1: Overview of the P-603 actuator

Scope of Delivery

Product number	Description
P-603	PiezoMove OEM linear actuator according to order (p. 9)
P603T0001	User manual for P-603 (this document)

Suitable Electronics

Product number	Description	Suitability
E-610	Piezo amplifier / servo controller	All P-603 models
E-625	Piezo servo controller	P-603.xSx (models with sensor)
E-831	Piezo amplifier module	P-603.x01 (models without sensor)

➢ To order, contact our customer service department (p. 15).

Unpacking

NOTICE

Damage due to pull forces on the connecting cable or stranded wires!
Pull forces on the connecting cable or stranded wires can damage the P-603.

- Avoid pull forces on the connecting cable or stranded wires.

NOTICE

Destruction of the piezo actuator due to contamination!
Contamination on the surface of the piezo actuator of the P-603 can result in the destruction of the piezo actuator by electric flashovers during operation.

- When handling the P-603, wear powder-free nitrile or latex gloves.
- Prevent the P-603 from coming into contact with conductive liquids (e.g., finger sweat) and conductive materials (e.g., metal dust).
- If the piezo actuator of the P-603 has been accidentally contaminated, contact our customer service department (p. 15).

NOTICE

Destruction of the piezo actuator by mechanical overload!
Mechanical forces can damage the piezo actuator of the P-603.

- Avoid impacts that affect the P-603.
- Do **not** drop the P-603.

Unpacking the P-603

1. Unpack the P-603 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 immediately.
4. Keep all packaging materials in case the product needs to be returned.

Installation

Preventing the Risk of Electric Shock

The P-603 actuator does not feature a separate protective earth connection, but must be installed in a way that a risk of electric shock is prevented.

You have the following options:

- Mount the actuator onto an electrically conductive surface that is connected to a protective earth conductor.
- Connect the actuator to a protective earth conductor via its mounting interface.
- Install the actuator such that it is electrically insulated according to protection class II.

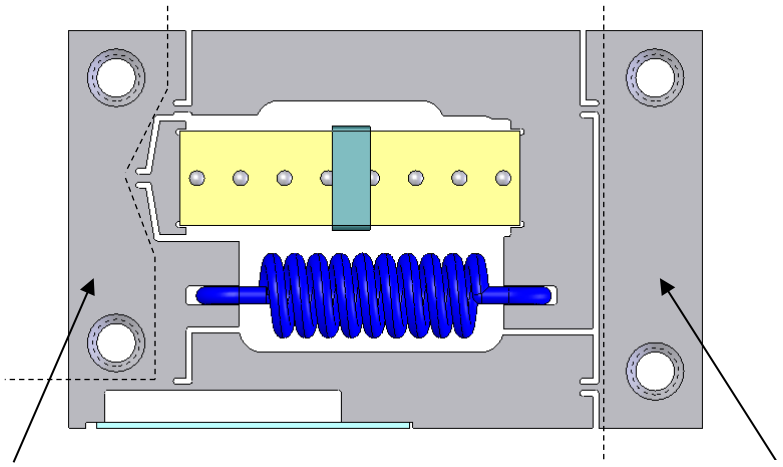
When you choose the first or the second option:

1. Pay attention to the applicable standards for mounting the protective earth conductor.
2. Make sure that the contact resistance is **<0.1 Ω at 25 A** at all connection points relevant for mounting the protective earth conductor.
3. Install touch protection (e.g., housing, insulation) to prevent direct or indirect contact with live parts.

Preparing a P-603 with Stranded Wires for Connection to a Controller

When you prepare a P-603 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-603 and Mounting a Load



Mounting interface, the actuator is mounted onto a surface here

Moving part, the load is fixed here

Figure 2: Mounting interface and moving part

Requirements

- ✓ You have read and understood the safety precautions (p. 6).
- ✓ You have provided a suitable underlying surface for mounting the P-603:
  - The surface is connected to a protective earth conductor (p. 12).
  - The surface has two suitable through holes. Refer to “Dimensions” (p. 19) for details.
  - The holes for the screws are sufficiently conductive to ensure that the protective earth conductor functions properly.
  - The flatness of the surface is ≤40 µm.
- ✓ You have discharged the P-603 (p. 14).

Tools and accessories

- Two M2.5 screws of suitable length (p. 19) for mounting the actuator onto a surface
- Two M2.5 screws of suitable length (p. 19) for mounting a load to the actuator
- Suitable tools

Mounting the P-603 and mounting a load

1. Only mount the P-603 onto a surface using the mounting holes intended for this purpose (refer to Figure 2, p. 12).
   Maximum torque: 0.7 Nm
2. Only fix a load to the P-603 using the mounting holes intended for this purpose (refer to Figure 2, p. 12).
   Maximum torque: 0.5 Nm

Startup and Operation

Starting and Operating the P-603

Requirements

- ✓ You have read and understood the safety precautions (p. 6).

Starting and operating the P-603

- ➢ Follow the instructions in the user manual for the electronics used for startup and operation of the P-603.

Discharging the P-603

The P-603 must be discharged in the following cases:

- Before installation
- When the P-603 is not in use but the electronics remains switched on to ensure temperature stability
- Before demounting (e.g., before cleaning and transporting the P-603 and for modifications)
- If the connecting cable of the P-603 is accidentally disconnected from the electronics during operation

Requirements

✓ You have read and understood the safety precautions (p. 6).

Tools and accessories

If the P-603 is **not** connected to the electronics:

- Only for P-603 **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-603 **with** connector:
  Electronics from PI

Discharging a P-603 connected to the electronics

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

Discharging a P-603 not connected to the electronics

If the P-603 does **not** have a connector:

1. Ensure adequate protection against touching live parts.
2. Short-circuit the stranded wires of the P-603 for at least a few seconds using a **10 kΩ discharge resistor**.

If the P-603 has a connector:

➢ Connect the voltage connector of the P-603 to the **switched off** PI electronics, which have an internal discharge resistor, for at least a few seconds.

Maintenance

The P-603 is maintenance-free.

Cleaning the P-603

Requirements

- ✓ You have discharged the P-603 (p. 14).
- ✓ You have disconnected the P-603 from the electronics.

Cleaning the P-603

- ➢ Touch the piezo actuator only with powder-free nitrile or latex gloves.
- ➢ Use pH-neutral cleansers only.
- ➢ Do **not** use acetone and do **not** use water for cleaning.
- ➢ When necessary, clean the base body (**not** the actuator!) of the P-603 with a lint-free cloth that is dampened with a mild cleanser (e.g., isopropanol or ethanol).

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. 5) on our website.

Technical Data

Specifications

	P-603.1S1 P-603.1S2	P-603.3S1 P-603.3S2	P-603.5S1 P-603.5S2	P-603.x01 Open-loop versions	Unit
Active axes	Z	Z	Z	Z	
Motion and positioning					
Integrated sensor	SGS	SGS	SGS	–	
Travel range at -20 to 120 V, open loop	120	380	550	as P-603.xS1	µm
Travel range, closed loop	100	300	500	–	µm
Resolution, open loop, 180 g	2	3	5	as P-603.xS1	nm
Resolution, closed loop, 180 g	10	20	25	–	nm
Linearity error, closed loop	0.2	0.2	0.2	–	%
Unidir. Repeatability, 10%, 1 Sigma	7	10	20	–	nm
Mechanical properties				–	
Stiffness in motion direction	0.3	0.14	0.06	as P-603.xS1	N/µm
Resonant frequency, no load	900	410	300	as P-603.xS1	Hz
Resonant frequency, under load, 180 g	160	110	80	as P-603.xS1	Hz
Push/pull force capacity in motion direction	40 / 20	35 / 13	30 / 10	as P-603.xS1	N
Drive properties					
Piezo ceramic	PICMA® P-885	PICMA® P-885	PICMA® P-885	as P-603.xS1	
Electrical capacitance	1.5	3.1	3.7	as P-603.xS1	µF
Miscellaneous					
Operating temperature range	-20 to 80	-20 to 80	-20 to 80	as P-603.xS1	°C
Material	Stainless steel	Stainless steel	Stainless steel	as P-603.xS1	
Dimensions	33.5 mm × 21 mm × 6 mm	52 mm × 21 mm × 6 mm	62 mm × 21 mm × 6 mm	as P-603.xS1	
Mass	S1 version: 0.03 S2 version: 0.04	S1 version: 0.04 S2 version: 0.05	S1 version: 0.05 S2 version: 0.06	as P-603.xS1	kg
Cable length	0.5	0.5	0.5	as P-603.xS1	m

	P-603.1S1 P-603.1S2	P-603.3S1 P-603.3S2	P-603.5S1 P-603.5S2	P-603.x01 Open-loop versions	Unit
Voltage connection	S1 versions: Bare stranded wires S2 versions: LEMO (low voltage)	S1 versions: Bare stranded wires S2 versions: LEMO (low voltage)	S1 versions: Bare stranded wires S2 versions: LEMO (low voltage)	as P-603.xS1	
Sensor connection	S1 versions: Bare stranded wires S2 versions: LEMO (strain gauge sensor)	S1 versions: Bare stranded wires S2 versions: LEMO (strain gauge sensor)	S1 versions: Bare stranded wires S2 versions: LEMO (strain gauge sensor)	–	
Recommended electronics	E-610, E-625	E-610, E-625	E-610, E-625	E-610, E-831	

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

Ask about customized versions.

Maximum Ratings

P-603 PiezoMove linear flexure actuators are designed for the following operating data:

Model	Maximum operating voltage	Maximum operating frequency (unloaded)[1]	Maximum power consumption[2]
P-603.101	-20 to 120 V	300 Hz	6 W
P-603.1S1	-20 to 120 V		6 W
P-603.1S2	-20 to 120 V		6 W
P-603.301	-20 to 120 V	135 Hz	8 W
P-603.3S1	-20 to 120 V		8 W
P-603.3S2	-20 to 120 V		8 W
P-603.501	-20 to 120 V	100 Hz	10 W
P-603.5S1	-20 to 120 V		10 W
P-603.5S2	-20 to 120 V		10 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:
https://www.physikinstrumente.com/en/technology/piezo-technology/properties-piezo-actuators/electrical-operation/

Ambient Conditions and Classifications

Pay attention to the following ambient conditions and classifications for the P-603:

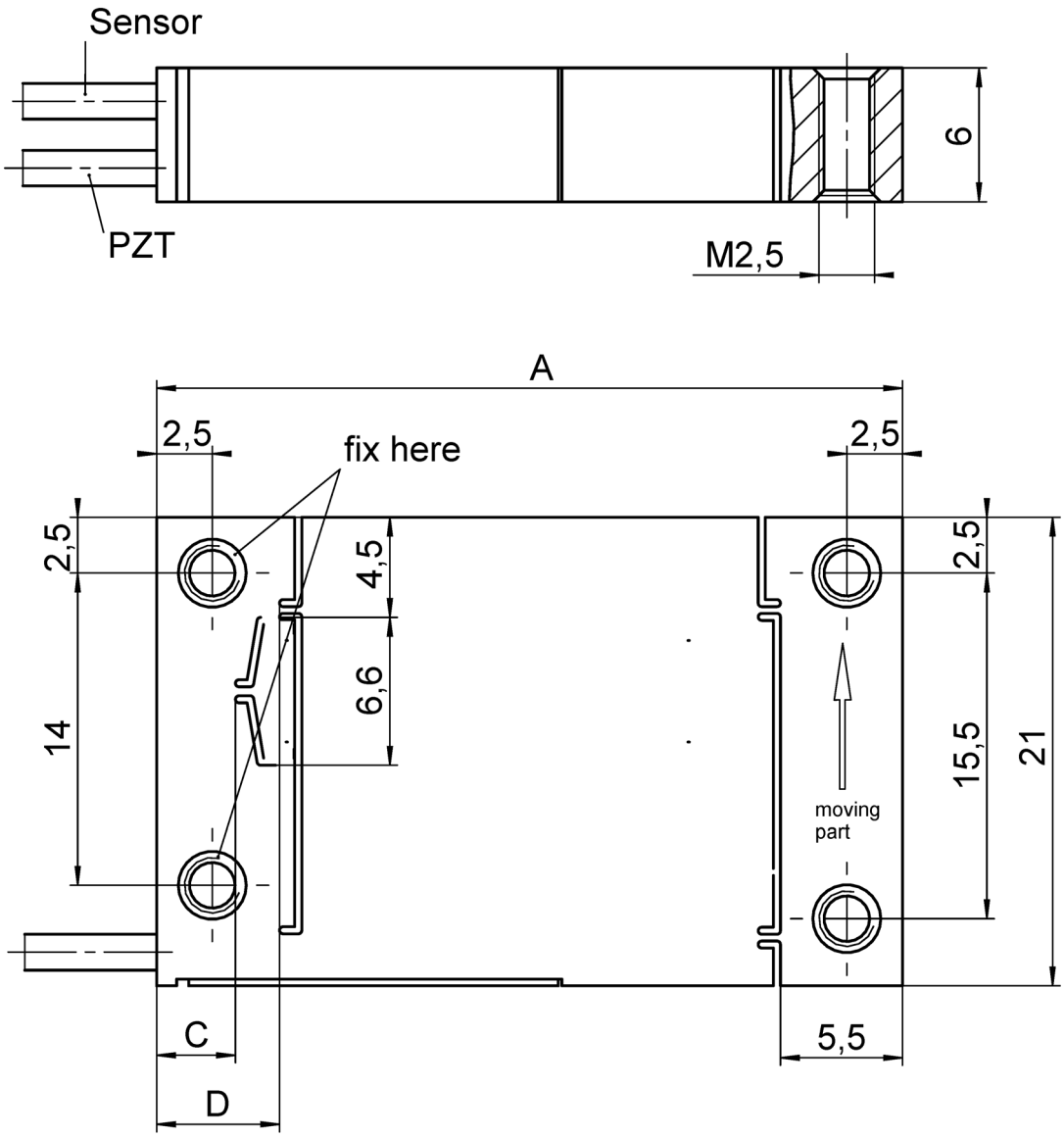
Area of application	For indoor use only
Maximum altitude	2000 m
Air pressure	1100 hPa to 0.1 hPa
Relative humidity	Highest relative humidity 80 % for temperatures up to 31 °C Decreasing linearly to 50 % relative humidity at 40 °C
Storage temperature	-20°C to 80°C
Transport temperature	-25°C to 85°C
Overvoltage category	II
Degree of pollution	1

The P-603 is intended for installation in devices that fulfil the following classifications:

Protection class	I
Degree of protection according to IEC 60529	IP20

Dimensions

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



Model	A	C	D	Unit
P-603.1S1 / .1S2 / .101	33.5	3.5	5.5	mm
P-603.3S1 / .3S2 / .301	52	3.5	5.6	mm
P-603.5S1 / .5S2 / .501	62	4.5	6.2	mm

Figure 3: Dimensions of the P-603 (.x01 models without sensor)

Pin Assignment

Sensor connector

P-603.xS2 only

Figure 4: Sensor connector, LEMO FFA.0S.304.CLAC32, front view

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

PZT connector

P-603.xS2 only

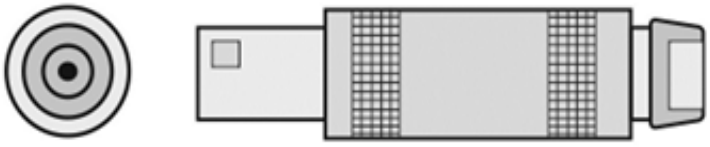


Figure 5: PZT connector, LEMO FFA.00.250.CTAC15, front view (left)

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
Black/white	PZT - (GND)	Both wires connected together for an increased cross-sectional area of the cable
Red/yellow	PZT + (-20 to 120 V)	Both wires connected together for an increased cross-sectional area of the cable
Black	Reference (5 V)	Only if the model has a sensor
Red	Sensor -	Only if the model has a sensor
Yellow	Sensor +	Only if the model has a sensor
White	GND	Only if the model has a sensor

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