



# User Manual

P-845.XXV PRELOADED PIEZO ACTUATORS (VACUUM VERSIONS)

# Contents

<b>1</b>	<b>Legal Information.....</b>	<b>4</b>
<b>2</b>	<b>About this Document.....</b>	<b>5</b>
2.1	Objective and Target Group.....	5
2.2	Other Applicable Documents.....	5
2.3	Explanation of Symbols.....	5
2.3.1	Typographic Conventions.....	6
2.3.2	Symbols Used.....	6
2.4	Figures.....	7
2.5	Downloading Manuals.....	7
<b>3</b>	<b>Safety.....</b>	<b>8</b>
3.1	Intended Use.....	8
3.2	General Safety Instructions.....	8
3.3	Organizational Measures.....	9
3.3.1	User Manual.....	9
3.3.2	General Personnel Qualification.....	9
<b>4</b>	<b>Product Description.....</b>	<b>10</b>
4.1	Model Overview.....	10
4.2	Product Labeling.....	10
4.2.1	Type Plate.....	10
4.3	Scope of Delivery.....	10
4.4	Overview.....	11
4.5	Suitable Electronics.....	11
4.6	Accessories.....	12
<b>5</b>	<b>Unpacking.....</b>	<b>13</b>
<b>6</b>	<b>Installation.....</b>	<b>14</b>
6.1	Avoiding Mounting Errors.....	14
6.2	Mounting the P-845.xxV and Connecting to a Protective Earth Conductor .....	15
6.3	Fixing the Load.....	16
6.4	Connecting the P-845.xxV.....	17
<b>7</b>	<b>Startup and Operation.....</b>	<b>18</b>
7.1	Determining the Operating Parameters.....	18
7.1.1	Calculating the Effective Mass.....	18
7.1.2	Calculating the Maximum Operating Frequency of the Loaded Piezo Actuator.....	19
7.1.3	Calculating the Forces that Occur During Dynamic Operation....	19
7.1.4	Calculating the Power Requirement for Sinusoidal Operation....	19
7.2	Starting and Operating the P-845.xxV.....	20
7.3	Discharging the P-845.xxV.....	22



- 8 Maintenance.....24**
  - 8.1 Cleaning.....24
- 9 Troubleshooting.....25**
- 10 Transportation.....26**
- 11 Customer Service Department.....27**
- 12 Technical Data.....28**
  - 12.1 Specifications.....28
  - 12.2 Maximum Ratings.....29
  - 12.3 Ambient Conditions and Classifications.....29
  - 12.4 Dimensions.....31
- 13 Old Equipment Disposal.....32**
- 14 Appendix.....33**
  - 14.1 Pin Assignment.....33
    - 14.1.1 Voltage Connector.....33
    - 14.1.2 Sensor Connector.....33
- 15 EU Declaration of Conformity.....34**

# 1 Legal Information



The following company names and brands are registered trademarks of Physik Instrumente (PI) GmbH & Co. KG:

PI®, PIC®, NanoCube®, PICMA®, PIFOC, PLine®, NEXLINE®, PiezoWalk®, PicoCube®, PiezoMove, PIMikroMove, NEXACT®, Picoactuator®, Plnano®, NEXSHIFT®, PITOUCH®, PIMag®, PIHera, Q-Motion®

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

© 2021 Physik Instrumente (PI) GmbH & Co. KG, Karlsruhe, Germany. The text, photographs, and drawings in this manual are protected by copyright. With regard thereto, Physik Instrumente (PI) GmbH & Co. KG reserves all rights. The use of any text, images and drawings is permitted only in part and only when indicating the source.

Original instructions

First print: 2/23/2021

Document number: P845M0002en, CBo

Subject to change. This manual is superseded by any new release. The latest versions of the user manuals are available for [download \(p. 7\)](#) at [www.pi.ws](http://www.pi.ws).

## **Publisher:**

Physik Instrumente (PI) GmbH & Co. KG  
Auf der Roemerstrasse 1  
76228 Karlsruhe  
Germany  
[info@pi.de](mailto:info@pi.de)  
[www.pi.de](http://www.pi.de)

## **Customer service department:**

Physik Instrumente (PI) GmbH & Co. KG  
Auf der Roemerstrasse 1  
76228 Karlsruhe  
Germany  
[service@pi.de](mailto:service@pi.de)  
[www.pi.de](http://www.pi.de)

## 2 About this Document

### 2.1 Objective and Target Group

This user manual contains the information needed for the intended use of the P-845.xxV. Basic knowledge of closed-loop systems, motion control concepts, and applicable safety measures is assumed.

### 2.2 Other Applicable Documents

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

Document number	Document type	Product
PZ62	User manual	E-503 piezo amplifier module, 3 channels, -30 to 130 V
PZ62	User manual	E-505 piezo amplifier module, 1 channel, -30 to 130 V
PZ70 / PZ72	User manual	E-610 piezo amplifier / servo controller, 1 channel, -30 to 130 V
PZ201	User manual	E-617 high-power piezo amplifier, 1 channel, -30 to 130 V
PZ115 / PZ160	User manual	E-621 piezo amplifier / servo controller module, 1 channel, -30 to 130 V
PZ166 / PZ167	User manual	E-625 piezo amplifier / servo controller, 1 channel, -30 to 130 V
PZ69	User manual	E-663 piezo amplifier, 3 channels, -20 to 120 V
PZ127 / E665T0009	User manual / technical note	E-665 piezo amplifier / servo controller, 1 channel, -30 to 130 V
PZ222	User manual	E-709 digital piezo controller, 1 channel, -30 to 130 V
PZ151 / PZ191 / PZ235	User manual	E-831 piezo amplifier module, 1 channel, -30 to 130 V

The latest versions of the user manuals can be [downloaded \(p. 7\)](#) at [www.pi.ws](http://www.pi.ws).


### 2.3 Explanation of Symbols

This chapter explains the symbols and markings used by PI in their user manuals.

### 2.3.1 Typographic Conventions

Symbol / label	Meaning
1.	Action consisting of one or several steps with strict sequential order
2.	
►	Action consisting of one or more steps without relevant sequential order
■	Lists
p. 5	Cross-reference to page 5
RS-232	Label on the product indicating an operating element (example: RS-232 interface socket)
<i>Start &gt; Settings</i>	Menu path in the PC software (example: to open the menu, <b>Start</b> and <b>Settings</b> must be clicked successively)
POS?	Command line or a command from PI's General Command Set (GCS) (example: command to get the axis position)
<i>Device S/N</i>	Parameter name (example: parameter where the serial number is stored)
5	Value that must be entered or selected via the PC software

### 2.3.2 Symbols Used

Symbol / Label	Meaning
	General hazard symbol



#### **DANGER**

##### **Dangerous situation**

Failure to comply could lead to death or serious injury.

► Precautionary measures for avoiding the risk.



#### **WARNING**

##### **Dangerous situation**

Failure to comply could lead to serious injury.

► Precautionary measures for avoiding the risk.



#### **CAUTION**

##### **Dangerous situation**

Failure to comply could lead to minor injury.

► Precautionary measures for avoiding the risk.

#### **NOTICE**



##### **Dangerous situation**

Failure to comply could lead to material damage.

► Precautionary measures for avoiding the risk.

### Information

Additional information on the P-845.xxV that can affect your application.

## 2.4 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.

## 2.5 Downloading Manuals

### Information

If a manual is missing or problems occur with downloading:

- Contact our [customer service department \(p. 27\)](#).

### Downloading Manuals

1. Open the website [www.pi.ws](http://www.pi.ws).
2. Search the website for the product number (e.g., P-882) or the product family (e.g., PICMA® bender).
3. Click the corresponding product to open the product detail page.
4. Click the **Downloads** tab.  
→ *The manuals are shown under **Documentation**.*
5. Click the desired manual and fill out the inquiry form.  
→ *The download link will then be sent to the email address entered.*

## 3 Safety

### 3.1 Intended Use

The P-845.xxV 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.

In accordance with its design, the P-845.xxV is intended for the following applications:

- Positioning of loads; see ["Specifications" \(p. 28\)](#)
- Dynamic positioning
- Vibration absorption
- Force generation

Motion is along one axis.

The P-845.xxV is **not** intended for applications in areas where failure would result in considerable risks for human beings or the environment.

The intended use of the P-845.xxV is only possible when completely mounted and connected. The P-845.xxV must be operated with [suitable electronics \(p. 11\)](#) from PI. The electronics are not in the scope of delivery of the P-845.xxV.

The P-845.xxV may not be used for purposes other than those stated in this user manual. The P-845.xxV may only be used in compliance with the technical specifications and instructions in this user manual.

### 3.2 General Safety Instructions

Temperature changes and compressive stress can induce charges in the P-845.xxV piezo actuator. After disconnection from the electronics, the piezo actuator can remain charged for several hours. Touching live parts of the P-845.xxV can result in minor injury from electric shock.

- ▶ Do **not** open the P-845.xxV.

If the protective earth conductor is missing or not properly connected, risk of dangerous touch voltages on the P-845.xxV in the event of malfunction or failure of the system. If touch voltages exist, touching the P-845.xxV can lead to minor injury from electric shock.

- ▶ Connect the P-845.xxV to a protective earth conductor before startup.
- ▶ 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 P-845.xxV to the protective earth conductor before restarting.

Mechanical forces can destroy the P-845.xxV.

- ▶ Avoid knocks that affect the P-845.xxV.
- ▶ Do **not** drop the P-845.xxV.
- ▶ Avoid torques, bending forces, and lateral forces on the tip of the P-845.xxV.
- ▶ Do **not** exceed the [maximum permissible loads \(p. 28\)](#).

The P-845.xxV is built according to state-of-the-art technology and recognized safety standards. Improper use of the P-845.xxV may result in personal injury and/or damage to the P-845.xxV.

- ▶ Use the P-845.xxV only for its intended purpose and when it is in perfect condition.
- ▶ Read the user manual.
- ▶ Eliminate any malfunctions that may affect safety immediately.

The operator is responsible for installing and operating the P-845.xxV correctly.



### 3.3 Organizational Measures

#### 3.3.1 User Manual

- ▶ Always keep this user manual available with the P-845.xxV. The latest versions of the user manuals can be [downloaded \(p. 7\)](#) at [www.pi.ws](http://www.pi.ws).
- ▶ Add all information from the manufacturer such as supplements or technical notes to the user manual.
- ▶ If you give the P-845.xxV to a third party, also include this user manual as well as other relevant information provided by the manufacturer.
- ▶ Only use the device on the basis of the complete user manual. Missing information due to an incomplete user manual can result in minor injury and damage to equipment.
- ▶ Only install and operate the P-845.xxV after you have read and understood this user manual.

#### 3.3.2 General Personnel Qualification

The P-845.xxV may only be installed, started up, operated, maintained, and cleaned by authorized and appropriately qualified personnel.

## 4 Product Description

### 4.1 Model Overview

Actuators with sensor, vacuum compatible

Product number	Description
P-845.10V	Preloaded piezo actuator, 15 µm travel range, 3000 N / 700 N, strain gauge sensor, vacuum compatible to 10 <sup>-6</sup> hPa
P-845.20V	Preloaded piezo actuator, 30 µm travel range, 3000 N / 700 N, strain gauge sensor, vacuum compatible to 10 <sup>-6</sup> hPa
P-845.30V	Preloaded piezo actuator, 45 µm travel range, 3000 N / 700 N, strain gauge sensor, vacuum compatible to 10 <sup>-6</sup> hPa
P-845.40V	Preloaded piezo actuator, 60 µm travel range, 3000 N / 700 N, strain gauge sensor, vacuum compatible to 10 <sup>-6</sup> hPa
P-845.60V	Preloaded piezo actuator, 90 µm travel range, 3000 N / 700 N, strain gauge sensor, vacuum compatible to 10 <sup>-6</sup> hPa

### 4.2 Product Labeling

#### 4.2.1 Type Plate

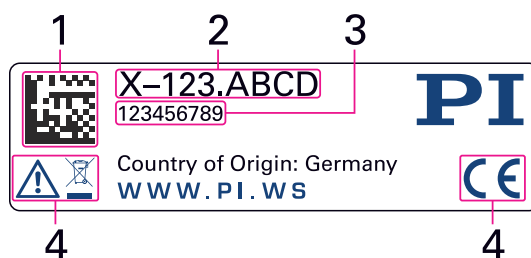


Figure 1: Type plate of the P-845.xxV

1. Data matrix code (example; contains the serial number)
2. Product number (example)
3. Serial number (example), individual for each P-845.xxV  
Meaning of the position (counting from the left):  
1 = internal information,  
2 and 3 = year of manufacture,  
4 to 9 = consecutive numbers
4. Warning and conformity symbols ([old equipment disposal \(p. 32\)](#), [CE mark \(p. 34\)](#))

### 4.3 Scope of Delivery

Product number	Description
P-845.xxV	Actuator model according to <a href="#">order (p. 10)</a>

## 4.4 Overview

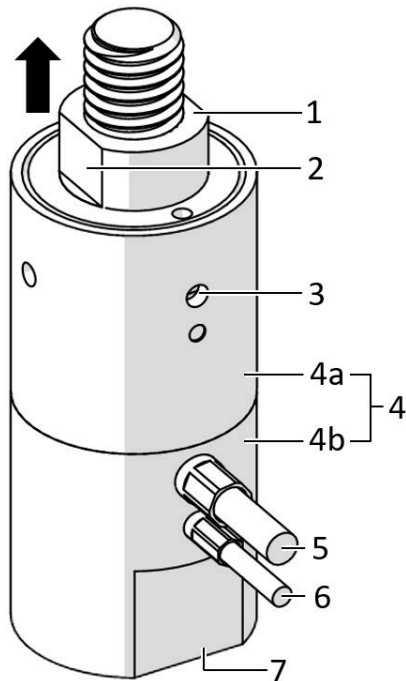


Figure 2: Example product view

1. Tip with M8 thread
2. AF10 wrench flat for open-end wrench
3. Gas emission hole (4x in housing tube, 1x in base)
4. Housing, consisting of housing tube [4a] and base [4b]
5. Cable exit (sensor connector)
6. Cable exit (voltage connector)
7. AF17 wrench flat for open-end wrench

Arrow: Positive direction of motion of the tip

## 4.5 Suitable Electronics

The P-845.xxV must be connected to suitable electronics that provide the voltages necessary for operating and if required, evaluate the signals from the position sensor. The following electronics are suitable:

Product number	Description
E-503	Piezo amplifier module, 3 channels, -30 to 130 V
E-505	Piezo amplifier module, 1 channel, -30 to 130 V
E-610	Piezo amplifier / servo controller, 1 channel, -30 to 130 V
E-617	High-power piezo amplifier, 1 channel, -30 to 130 V
E-621	Piezo amplifier / servo controller module, 1 channel, -30 to 130 V
E-625	Piezo amplifier / servo controller, 1 channel, -30 to 130 V
E-663	Piezo amplifier, 3 channels, -20 to 120 V
E-665	Piezo amplifier / servo controller, 1 channel, -30 to 130 V
E-709	Digital piezo controller, 1 channel, -30 to 130 V
E-831	Piezo amplifier module, 1 channel, -30 to 130 V

To order, contact our [customer service department \(p. 27\)](#).

## 4.6 Accessories

Product number	Description
P-891.VA	Vacuum feedthrough for piezo voltage, to 10 <sup>6</sup> hPa, 100 °C, LEMO connectors, incl. air side cable, 2 m
P-892.VA	Vacuum feedthrough strain gauge sensor, to 10 <sup>6</sup> hPa, 100 °C, LEMO connectors, incl. air side cable, 2 m

To order, contact our [customer service department \(p. 27\)](#).

## 5 Unpacking

### Tools and Accessories

- Powder-free gloves

### NOTICE



#### **Destruction of the P-845.xxV due to mechanical overload!**

Mechanical forces can destroy the P-845.xxV.

- ▶ Avoid knocks that affect the P-845.xxV.
- ▶ Do **not** drop the P-845.xxV.

### Information

At PI, all parts are cleaned before assembly. Afterwards, the P-845.xxV is wipe-cleaned again and then shrink-wrapped twice in vacuum-compatible film.

#### **Unpacking the P-845.xxV**

1. Put powder-free gloves on.
2. Unpack the P-845.xxV with care.
3. Compare the contents with the scope of delivery according to the contract and the delivery note.
4. Inspect the contents for signs of damage. If any parts are damaged or missing, contact our [customer service department \(p. 27\)](#) immediately.
5. Keep all packaging materials in case the product needs to be returned.

## 6 Installation

### 6.1 Avoiding Mounting Errors

Piezo actuators may only be loaded axially. The following figures intend to help you to avoid mounting errors.

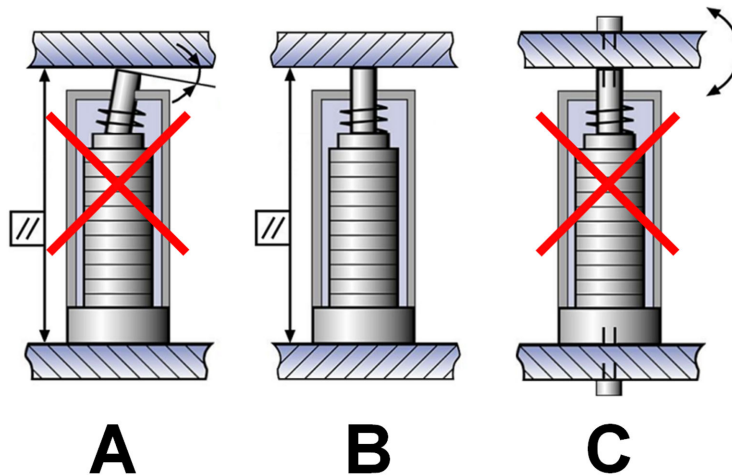


Figure 3: Not tightly screwed at both ends and no angles

A: Wrong: Angular error at the tip

B: Right: Axial loading of the actuator

C: Wrong: The actuator is screwed tight at both ends

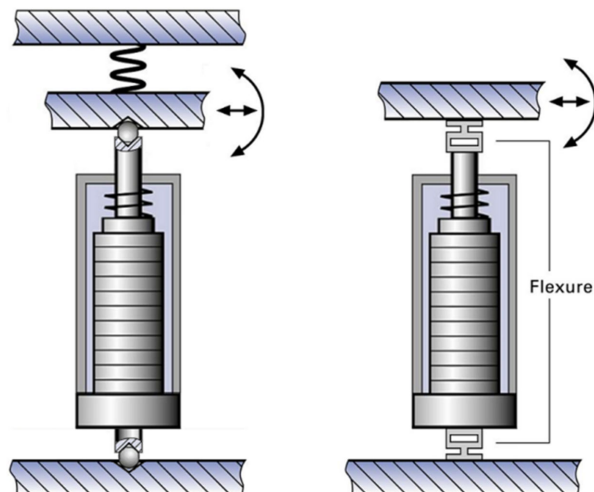


Figure 4: Ball tips or flexures for decoupling lateral forces and bending forces

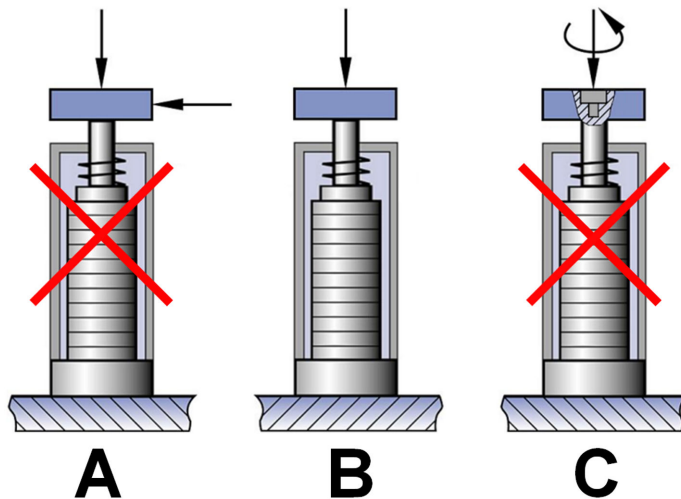


Figure 5: No lateral forces or torques

A: Wrong: Shearing force due to lateral force

B: Right: Axial loading of the actuator

C: Wrong: Torsion due to torque

## 6.2 Mounting the P-845.xxV and Connecting to a Protective Earth Conductor

The protective earth for the P-845.xxV is connected as follows:

- Mounting hole in the base of the P-845.xxV
- Suitable, conductive screw
- The underlying surface connected to the protective earth conductor

### Tools and Accessories

- Suitable protective earth conductor: Cable cross section  $\geq 0.75 \text{ mm}^2$
- Electrically conductive screw of suitable size and length (see ["Dimensions" \(p. 31\)](#))
- Open-end wrench for holding the [base \(p. 11\)](#) of the P-845.xxV (see ["Dimensions" \(p. 31\)](#) for across flats size)
- Suitable screwdriver

### Requirements

- ✓ You have read and understood the [general safety instructions \(p. 8\)](#).
- ✓ You have read and understood the section ["Avoiding Mounting Errors" \(p. 14\)](#).
- ✓ The P-845.xxV is **not** connected to the electronics.
- ✓ The P-845.xxV is [discharged \(p. 22\)](#).
- ✓ You have provided a suitable surface for mounting the P-845.xxV:
  - The underlying surface has suitable [mounting holes \(p. 31\)](#).
  - The underlying surface is connected to a protective earth conductor.
  - The underlying surface is sufficiently conductive to ensure proper function of the protective earth conductor.
- ✓ You have accounted for the space required to route cables without bending and according to regulations.

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

If the protective earth conductor is missing or not properly connected, risk of dangerous touch voltages on the P-845.xxV in the event of malfunction or failure of the system. If there are touch voltages, touching the P-845.xxV can lead to minor injury due to electric shock.

- ▶ Connect the P-845.xxV to a protective earth conductor before startup.
- ▶ Do **not** remove the protective earth conductor during operation.
- ▶ If the protective earth conductor has to be removed temporarily (e.g., for modifications), reconnect the P-845.xxV to the protective earth conductor before restarting.

**Information**

The P-845.xxV can heat up during operation. The heat produced during operation can affect your application.

**Information**

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

**Mounting the P-845.xxV**

1. Use the open-end wrench to hold the base of the P-845.xxV in position.
2. Screw the P-845.xxV onto a suitable underlying surface. For this purpose, screw into the [mounting hole in the bottom of the base \(p. 31\)](#).
3. Remove the open-end wrench from the base.
4. Check that the P-845.xxV is firmly seated and ensure that the contact resistance at all joints relevant to the protective conductor assembly is  $<0.1 \Omega$  at 25 A.
5. If anything vibrates in your application, use suitable means (e.g., liquid adhesive) to prevent the protective earth screw connection(s) from loosening.

## 6.3 Fixing the Load

**Tools and Accessories**

- Nut of suitable size and length (see ["Dimensions" \(p. 31\)](#))
- Open-end wrench for holding the [tip \(p. 11\)](#) of the P-845.xxV (see ["Dimensions" \(p. 31\)](#) for across flats size)
- Suitable tool for tightening the nuts

**Requirements**

- ✓ You have read and understood the [general safety instructions \(p. 8\)](#).
- ✓ You have read and understood the section ["Avoiding Mounting Errors" \(p. 14\)](#).
- ✓ The P-845.xxV is **not** connected to the electronics.
- ✓ The P-845.xxV is [discharged \(p. 22\)](#).



**NOTICE****Destruction of the piezo actuator due to mechanical overload!**

Torques, bending and lateral forces, tensile stress, and excessive loads can destroy the piezo actuator.

- ▶ Do **not** exceed the maximum permissible loads according to the [specifications \(p. 28\)](#).
- ▶ Avoid torques, bending forces and lateral forces on the tip of the piezo actuator.
- ▶ Avoid torques on the base when the tip is tightly clamped.
- ▶ Make sure that the center of load of the moving system is on the motion axis of the piezo actuator.
- ▶ Use suitable structures or guide elements (e.g., ball tips or flexure guides) to avoid uneven load distribution.
- ▶ Pay attention to the information on parallelism in the ["Dimensions" section \(p. 31\)](#).
- ▶ Do **not** screw the piezo actuator tight at both ends.

**Fixing the Load**

1. Use the open-end wrench to hold the tip of the P-845.xxV in place.
2. Tighten the nut to secure the load on the tip.
3. Remove the open-end wrench from the tip.

## 6.4 Connecting the P-845.xxV

**Tools and Accessories**

- If necessary: Suitable cable set
- If necessary: Suitable screwdriver for the locking screws of the connectors.

**Requirements**

- ✓ You have read and understood the [general safety instructions \(p. 8\)](#).
- ✓ You have read and understood the user manual for the electronics used.
- ✓ You have installed the electronics properly.
- ✓ The electronics are switched off.

**NOTICE****Damage due to incorrect connection of the P-845.xxV!**

Connecting unsuitable electronics or a wrong cable can damage the P-845.xxV or the electronics.

- ▶ Connect the P-845.xxV only to [suitable electronics from PI \(p. 11\)](#).
- ▶ Use cables from PI only to connect the P-845.xxV to the electronics.

**Connecting the P-845.xxV**

1. Connect the P-845.xxV's voltage plug to the voltage socket on the electronics.
2. Connect the P-845.xxV's sensor plug to the sensor socket on the electronics.

## 7 Startup and Operation

### 7.1 Determining the Operating Parameters

Limiting factors for the operation of the piezo actuator:

- Resonant frequency:  
The operating frequency may not exceed one third of the resonant frequency of the loaded piezo actuator. See ["Calculating the Maximum Operating Frequency of the Loaded Piezo Actuator" \(p. 19\)](#).
- Maximum [push/pull force capacity \(p. 28\)](#):  
The mass of the load to be moved and the operating frequency of the piezo actuator must be selected so that any dynamic forces generated during operation do not exceed the maximum push/pull force capacity of the piezo actuator. See ["Calculating the Forces that Occur During Dynamic Operation" \(p. 19\)](#).
- Maximum permissible [operating temperature of the piezo actuator \(p. 29\)](#):  
The greater the operating frequency, the operating voltage (peak-to-peak), and the capacitance of the piezo actuator, the greater the thermal power generated in the piezo actuator. The operating frequency, operating voltage and operating time must be selected so that the maximum permissible operating temperature of the piezo actuator is not exceeded. For the maximum permissible operating frequency without cooling, see column B of the table in ["Maximum Ratings" \(p. 29\)](#).

**Peak and average output current of the electronics:**

The [electronics used \(p. 11\)](#) for operating the P-845.xxV must meet the following requirements:

- The electronics can provide the required current. See ["Calculating the Power Requirement for Sinusoidal Operation" \(p. 19\)](#).
- The output current of the electronics does not exceed the maximum power consumption of the piezo actuator. See ["Maximum Ratings" \(p. 29\)](#).

#### 7.1.1 Calculating the Effective Mass

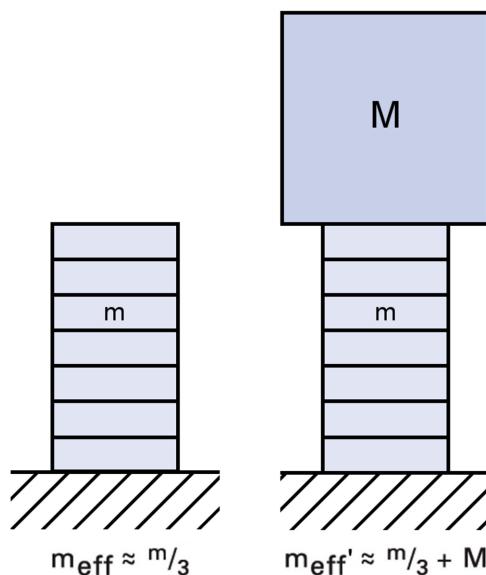


Figure 6: Calculation of the effective mass of a unilaterally clamped piezo stack actuator without load (left) and with additional load (right).

1. Find the mass  $m$  of your piezo actuator in the [data table \(p. 28\)](#).

2. Determine the additional load  $M$ .
3. Calculate the effective mass  $m_{\text{eff}}$  of the unloaded piezo actuator and  $m_{\text{eff}}'$  of the loaded piezo actuator using the formulas in the figure above.

### 7.1.2 Calculating the Maximum Operating Frequency of the Loaded Piezo Actuator

#### Information

In the following calculation, the maximum permissible operating temperature of the piezo actuator is **not** taken into account. During operation without cooling, the maximum operating temperature may already be exceeded when the operating frequency is still below the limit value calculated in the following.

- For the maximum permissible operating frequency without cooling, see column B of the table in ["Maximum Ratings" \(p. 29\)](#).

1. Calculate the resonant frequency of the loaded piezo actuator with the following formula:

$$f_0' = f_0 \sqrt{\frac{m_{\text{eff}}}{m_{\text{eff}}'}}$$

#### Variables:

$f_0'$  = Resonant frequency of the loaded piezo actuator [Hz]

$f_0$  = Resonant frequency of the unloaded piezo actuator [Hz]; see ["Data Table" \(p. 28\)](#).

$m_{\text{eff}}$  = Effective mass; approx. 1/3 of the mass of the piezo actuator [kg]

$m_{\text{eff}}'$  = Effective mass  $m_{\text{eff}}$  + additional load  $M$  [kg]

See also ["Calculating the Effective Mass" \(p. 18\)](#).

2. Calculate the maximum operating frequency of the loaded piezo actuator with the following formula:

$$f_{\text{max}} = f_0'/3$$

#### Variables:

$f_{\text{max}}$  = Maximum operating frequency of the loaded piezo actuator [Hz]

$f_0'$  = Resonant frequency of the loaded piezo actuator [Hz]

### 7.1.3 Calculating the Forces that Occur During Dynamic Operation

1. Use the following formula to calculate the dynamic forces acting on the piezo actuator during sinusoidal operation with the frequency  $f$ :

$$F_{\text{dyn}} \approx \pm 4\pi^2 \cdot m_{\text{eff}}' \left( \frac{\Delta L}{2} \right) f^2$$

#### Variables:

$F_{\text{dyn}}$  = Dynamic force [N]

$m_{\text{eff}}'$  = Effective mass  $m_{\text{eff}}$  (approx. 1/3 of the mass of the piezo actuator) + additional load  $M$  [kg], see also ["Calculating the Effective Mass" \(p. 18\)](#)

$\Delta L$  = Displacement in the application (peak-to-peak) [m]

$f$  = Frequency [Hz]

**Example:** The dynamic forces are approximately  $\pm 40$  N at 1000 Hz, 2  $\mu\text{m}$  displacement (peak-peak) and 1 kg effective mass.

### 7.1.4 Calculating the Power Requirement for Sinusoidal Operation

1. Calculate the average current requirement for sinusoidal operation using the following formula:

$$I_a \approx f \cdot C \cdot U_{p-p}$$

- Calculate the peak current requirement for sinusoidal operation using the following formula:

$$I_{max} \approx f \cdot \pi \cdot C \cdot U_{p-p}$$

Variable	Description	Notes
$I_a$	Required average current of the amplifier (source / sink) [A]	It is essential that the power adapter can supply enough current.
$I_{max}$	Required peak current of the amplifier (source / sink) [A]	The provided peak current depends on the internal storage capacity of the amplifier.
$f$	Operating frequency [Hz]	Details on the operating frequency see <a href="#">"Overview of Limiting Factors" (p. 18)</a> .
$C$	Capacitance of the piezo actuator [F (= As/V)]	See <a href="#">"Data Table" (p. 28)</a> for the small-signal capacitance of the piezo actuator.  For large-signal conditions, a safety factor of 70 % should be added to the small-signal capacitance.
$U_{p-p}$	Operating voltage (peak-to-peak) [V]	Voltage difference between positive and negative peak voltage

## 7.2 Starting and Operating the P-845.xxV

### Tools and Accessories

- [Electronics from PI \(p. 11\)](#)

### Requirements

- ✓ You have read and understood the [general safety instructions \(p. 8\)](#).
- ✓ You have [installed \(p. 14\)](#) the P-845.xxV correctly.
- ✓ You have read and understood the user manual for the electronics used.
- ✓ If a digital controller is used: You have read and understood the manual for the PC software used.
- ✓ The electronics and if required, the PC software, have been installed (see the user manual for the electronics).



### CAUTION



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

If the protective earth conductor is missing or not properly connected, risk of dangerous touch voltages on the P-845.xxV in the event of malfunction or failure of the system. If there are touch voltages, touching the P-845.xxV can lead to minor injury due to electric shock.

- ▶ Connect the P-845.xxV to a protective earth conductor before startup.
- ▶ Do **not** remove the protective earth conductor during operation.
- ▶ If the protective earth conductor has to be removed temporarily (e.g., for modifications), reconnect the P-845.xxV to the protective earth conductor before restarting.

**CAUTION****Burning due to hot surface!**

The surface of the P-845.xxV and the surroundings can heat up during operation. Touching the P-845.xxV and surrounding parts can result in minor injuries from burning.

- ▶ Make sure that the hot P-845.xxV and the surrounding parts cannot be touched.

**NOTICE****Destruction of the piezo actuator due to electric flashovers**

Using the P-845.xxV 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-845.xxV in environments that can increase the electrical conductivity.
- ▶ Operate the P-845.xxV only within the permissible [ambient conditions and classifications](#) (p. 29).
- ▶ When using in a vacuum under 100 hPa:  
Do not operate the P-845.xxV while evacuating or ventilating.

**NOTICE****Destruction of the piezo actuator due to dynamic forces!**

Dynamic forces can be generated during dynamic operation that cancel out the preload of the piezo actuator. Operating without a preload can destroy the actuator.

- ▶ Do not exceed the maximum push/pull capacity according to the [specifications](#) (p. 28).
- ▶ Pay attention to the notes in ["Determining the Operating Parameters"](#) (p. 18).

**NOTICE****Destruction of the piezo actuator due to excessive operating frequencies!**

Excessive operating frequencies can destroy the piezo actuator.

- ▶ Select the operating frequency so that the following conditions are met:
  - The maximum operating frequency may not exceed one third of the resonant frequency (see ["Data Table"](#) (p. 28) for the resonant frequency of the unloaded piezo actuator and see ["Calculating the Maximum Operating Frequency of the Loaded Piezo Actuator"](#) (p. 19) for the resonant frequency of the loaded piezo actuator).
  - Any dynamic forces generated during operation do not exceed the maximum push/pull force of the piezo actuator (see ["Calculating the Forces that Occur During Dynamic Operation"](#) (p. 19) and ["Specifications"](#) (p. 28)).

**NOTICE****Reduced lifetime of the piezo actuator due to permanently high voltage!**

The permanent application of a high voltage to piezo actuators leads to a considerable reduction in the lifetime of the piezo ceramic.

- ▶ When the P-845.xxV is not being used (e.g., to ensure temperature stability of the electronics), [discharge](#) (p. 22) it.
- ▶ If possible, limit the maximum operating voltage during continuous operation.

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

Operating voltages that are too high or incorrectly connected can cause damage to the P-845.xxV.

- ▶ Pay attention to the [operating voltage range \(p. 29\)](#), which is specified for the P-845.xxV.
- ▶ Pay attention to correct [pin assignment \(p. 33\)](#).

**NOTICE****Damage after reconnecting due to a charged P-845.xxV!**

The P-845.xxV can remain charged when the connecting cable is pulled out of the electronics during operation. Reconnecting a charged P-845.xxV to electronics during operation can cause a mechanical impulse that will damage the P-845.xxV.

- ▶ Do **not** pull the connecting cable of the P-845.xxV out of the electronics during operation.
- ▶ If the connecting cable of the P-845.xxV is accidentally pulled out of the electronics during operation: Switch off the electronics before you reconnect the P-845.xxV.

**NOTICE****Destruction of the piezo actuator due to overheating!**

Overheating can destroy the piezo actuator.

- ▶ Adjust the operating voltage, operating frequency and/or operating time so that the [maximum operating temperature \(p. 28\)](#) of the piezo actuator is not exceeded; see ["Maximum Ratings" \(p. 29\)](#) and ["Determining the Operating Parameters" \(p. 18\)](#).

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

Oscillation can cause irreparable damage to the P-845.xxV. 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-845.xxV 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-845.xxV immediately.

**Starting and Operating the P-845.xxV**

1. Start up the electronics (see the user manual for the electronics).
2. Configure the electronics for the P-845.xxV during startup. If you are using a digital controller from PI, run the PC software and select the entry in the positioner database that matches the P-845.xxV exactly.
3. Start a few motion cycles for testing purposes (see the user manual for the electronics).

**7.3 Discharging the P-845.xxV**

The P-845.xxV must be discharged in the following cases:

- When the P-845.xxV is not in use but the electronics remain switched on to ensure temperature stability
- If the P-845.xxV is accidentally disconnected from the electronics during operation
- Before disassembling (e.g., before cleaning and transporting the P-845.xxV) as well as for modifications

### Requirements

- ✓ You have read and understood the [general safety instructions \(p. 8\)](#).

### Tools and Accessories

- [Electronics from PI \(p. 11\)](#)

### Discharging a P-845.xxV Connected to the Electronics

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

### Discharging a P-845.xxV not Connected to the Electronics

1. Insert the P-845.xxV's voltage connector into the **switched-off** electronics from PI and maintain the connection for a few seconds.

## 8 Maintenance

The P-845.xxV is maintenance-free.

### 8.1 Cleaning

#### Requirements

- ✓ You have disconnected the P-845.xxV from the electronics.
- ✓ The P-845.xxV is [discharged \(p. 22\)](#).

#### Auxiliary Materials Required

- Disposable powder-free gloves
- Soft, lint-free cloth
- Suitable cleaning agent or disinfectant (e.g., alcohol, isopropyl or acetone)

If you have any questions on the auxiliary materials recommended for the P-845.xxV, contact our [customer service department \(p. 27\)](#).

#### NOTICE



##### Short-circuiting due to cleaning fluid penetrating the housing!

Cleaning fluid penetrating the P-845.xxV's housing can short-circuit the actuator and drive electronics.

- ▶ Disconnect the P-845.xxV from the electronics before cleaning.
- ▶ Prevent cleaning fluid from penetrating the P-845.xxV's housing.

#### NOTICE



##### Damage due to unsuitable cleaning agents!

Some cleaning agents may cause damage to the P-845.xxV.

- ▶ Use a suitable cleaning agent or disinfectant only (e.g., alcohol, isopropyl or acetone).

#### NOTICE



##### Damage from ultrasonic cleaning!

Ultrasonic cleaning can damage the P-845.xxV.

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

#### Cleaning the P-845.xxV

1. Put disposable powder-free gloves on.
2. Dampen the cloth with the cleaning agent or disinfectant.
3. Carefully wipe the surfaces of the P-845.xxV.



## 9 Troubleshooting

No or limited motion	
Cable not connected correctly	► Check the cable connections.
Excessive load	► Do <b>not</b> exceed the maximum push/pull capacity according to the <a href="#">specifications (p. 28)</a> .
Zero shifting of the position sensor for the following reasons: Load in direction of motion Surrounding/operating temperature of the piezo actuator is much higher or lower than the calibration temperature (21 °C to 24 °C)	► Readjust the sensor's zero-point (see manual for the electronics).
Piezo actuator is depolarized due to overheating	► Contact our <a href="#">customer service department (p. 27)</a> .
Defective actuator	► If possible, replace the defective actuator with another actuator and test the new combination.
Reduced accuracy	
The electronics or mechanics were replaced	► Recalibrate the axis displacement (see controller manual) or contact our <a href="#">customer service department (p. 27)</a> .
Axes were mixed up during connection	► In the case of calibrated systems, pay attention to the assignment of the axes when connecting several piezo actuators to a multi-channel controller. This assignment is indicated by labels on the devices.
The piezo actuator starts oscillating or positions inaccurately	
Servo control parameters set incorrectly because for example, the load was changed	► Switch off the servo mode of the corresponding axes immediately. ► Check the servo control parameter settings on the controller. ► Adjust the servo control parameters on the controller according to the load change.
Operating with an excessively high frequency	► Operate the piezo actuator at a maximum of one third of the resonant frequency (see <a href="#">"Data Table" (p. 28)</a> for resonant frequency of the unloaded piezo actuator, see <a href="#">"Calculating the Maximum Operating Frequency of the Loaded Piezo Actuator" (p. 19)</a> for resonant frequency of the loaded piezo actuator).

# 10 Transportation

## Preparing the P-845.xxV for Transportation

1. Pay attention to the [ambient conditions and classifications \(p. 29\)](#).
2. Pack the P-845.xxV in the original packaging.
3. If the P-845.xxV is to be sent, use a stable outer box.

# 11 Customer Service Department

For enquiries and orders, contact your PI representative or send us an [email](#).

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.

## **Customer service address:**

Physik Instrumente (PI) GmbH & Co. KG  
Auf der Roemerstrasse 1  
76228 Karlsruhe  
Germany

[service@pi.de](mailto:service@pi.de)  
[www.pi.de](http://www.pi.de)

## 12 Technical Data

### 12.1 Specifications

	P-845.10	P-845.20	P-845.30	P-845.40	P-845.60	Unit	Tolerance
Travel range at 0 to 100 V	15	30	45	60	90	μm	
Sensor*	SGS	SGS	SGS	SGS	SGS		
Resolution**	0.3	0.6	0.9	1.2	1.8	nm	
Static large signal stiffness***	225	107	75	57	38	N/μm	±20 %
Push force capacity	3000	3000	3000	3000	3000	N	
Pull force capacity	700	700	700	700	700	N	
Torque on tip	1	1	1	1	1	Nm	max.
Electrical capacitance	6	12	18	24	36	μF	±20 %
Resonant frequency f <sub>0</sub> (no load)	16	12	9	7.5	5.5	kHz	±20 %
Operating temperature range	-40 to 80	-40 to 80	-40 to 80	-40 to 80	-40 to 80	°C	
Mass without cable	84	108	132	156	204	g	±5 %
Length L	47	65	83	101	137	mm	
Voltage connector	LEMO FFA. 00.250 (coaxial)	LEMO FFA. 00.250 (coaxial)	LEMO FFA. 00.250 (coaxial)	LEMO FFA. 00.250 (coaxial)	LEMO FFA. 00.250 (coaxial)		
Sensor connector	LEMO FFA.0S. 304	LEMO FFA.0S. 304	LEMO FFA.0S. 304	LEMO FFA.0S. 304	LEMO FFA.0S. 304		
Cable length	1	1	1	1	1	m	-0 mm / +50 mm
Recommended electronics	E-503, E-505, E-610, E-617, E-621, E-625, E-663, E-665, E-709, E-831	E-503, E-505, E-610, E-617, E-621, E-625, E-663, E-665, E-709, E-831	E-503, E-505, E-610, E-617, E-621, E-625, E-663, E-665, E-709, E-831	E-503, E-505, E-610, E-617, E-621, E-625, E-663, E-665, E-709, E-831	E-503, E-505, E-610, E-617, E-621, E-625, E-663, E-665, E-709, E-831		

\* Versions with SGS allow closed-loop linearity up to 0.15 % and are shipped with a calibration log.

\*\* 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.

\*\*\* Dynamic small-signal stiffness is approx. 30 % higher.

Housing / tip material: Stainless steel.

Vacuum versions to 10<sup>-6</sup> hPa are available under the order number P-845.x0V.

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

Specifications for vacuum versions can differ.

## 12.2 Maximum Ratings

P-845.xxV piezo actuators are designed for the operating data specified in the table below.

### Additional information on the maximum ratings table

- Maximum operating frequency without load, without considering thermal aspects, column A:  
The value corresponds to one third of the resonant frequency of the unloaded piezo actuator. For further restrictions, see ["Overview of Limiting Factors" \(p. 18\)](#).
- Maximum operating frequency without load, considering thermal aspects, column B:  
In order to prevent the maximum permissible operating temperature from being exceeded, the operating frequency of the unloaded, uncooled piezo actuator must not exceed the specified frequency when the operating voltage is 100 V peak-to-peak. In the case of smaller amplitudes of the operating voltage and/or the use of cooling measures, higher operating frequencies are possible. For further restrictions, see ["Overview of Limiting Factors" \(p. 18\)](#).
- Maximum power consumption:  
The value corresponds to the power consumption of the unloaded, uncooled piezo actuator that is operated at a voltage of 100 V peak-to-peak with the operating frequency from column B of this table.

Piezo actuator*	Maximum operating voltage range	Maximum operating frequency without load		Maximum power consumption
		A: Without considering thermal aspects	B: Considering thermal aspects	Considering thermal aspects
P-84x.10V	0 to 100 V	5333 Hz	27 Hz	2.9 W
P-84x.20V	0 to 100 V	4000 Hz	24 Hz	5.7 W
P-84x.30V	0 to 100 V	3000 Hz	23 Hz	8.6 W
P-84x.40V	0 to 100 V	2500 Hz	21 Hz	11.4 W
P-84x.60V	0 to 100 V	1833 Hz	20 Hz	17 W

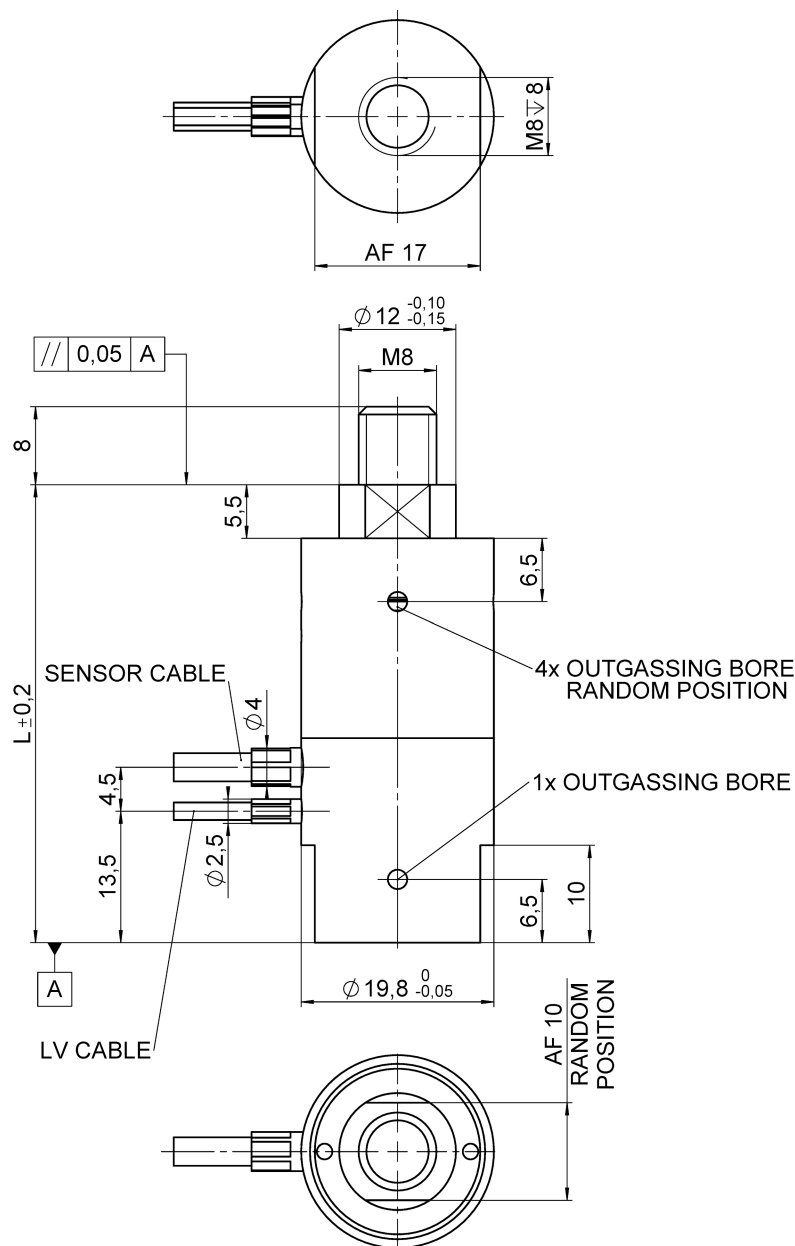
\* The letter x in the product number of the piezo actuator stands for "4" or "5".

## 12.3 Ambient Conditions and Classifications

The following ambient conditions and classifications for the P-845.xxV must be observed:

Area of application	For indoor use only
Maximum altitude	2000 m above msl
Air pressure	1100 hPa to 100 hPa 1 hPa to 10 <sup>-6</sup> 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	-20 °C to 80 °C
Maximum bakeout temperature	P-845.xxV piezo actuators: 80 °C Vacuum feedthroughs: 100 °C
Overvoltage category	II
Protection class	I
Degree of pollution	1
Degree of protection according to IEC 60529	IP20

## 12.4 Dimensions



Model	Travel Range	L	Cable Length
P-845.10V	15 $\mu$ m	47 mm	1 m
P-845.20V	30 $\mu$ m	65 mm	1 m
P-845.30V	45 $\mu$ m	83 mm	1 m
P-845.40V	60 $\mu$ m	101 mm	1 m
P-845.60V	90 $\mu$ m	137 mm	1 m

Figure 7: Dimensions of the P-845.xxV

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

The exact position of the wrench flats on the tip is not defined, i.e., the tip and base can be offset from each other at any angle with respect to the wrench flats.

## 13 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, PI undertakes environmentally correct disposal of all PI equipment free of charge, if it was made available to the market after August 13, 2005.

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

Physik Instrumente (PI) GmbH & Co. KG

Auf der Roemerstrasse 1

76228 Karlsruhe

Germany

[info@pi.de](mailto:info@pi.de)

[www.pi.de](http://www.pi.de)





# 14 Appendix

## 14.1 Pin Assignment

### 14.1.1 Voltage Connector

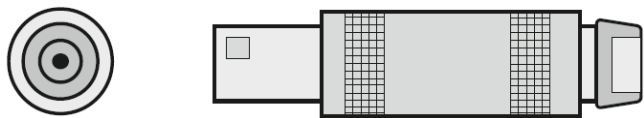


Figure 8: Voltage connector: LEMO FFA.00.250.CTAC22

Pin	Signal	Function
Inner contact	Input	Piezo voltage 0 to 100 V
Connector shell / cable shield	Input	Piezo voltage ground

### 14.1.2 Sensor Connector

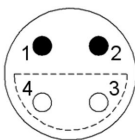


Figure 9: Sensor connector: LEMO FFA.0S.304.CLAC32

Pin	Signal	Function
1	Input	Supply voltage for strain gauge sensor
2	Output	Sensor signal 1
3	Output	Sensor signal 2
4	GND	Ground

The connector shell is connected to the cable shield.

## 15 EU Declaration of Conformity

An EU Declaration of Conformity was issued for the P-845.xxV in accordance with the following European directives:

- Low Voltage Directive
- EMC Directive
- RoHS Directive

The standards applied for certifying conformity are listed below.

- Safety (Low Voltage Directive): EN 61010-1
- EMC: EN 61326-1
- RoHS: EN 50581 or EN IEC 63000