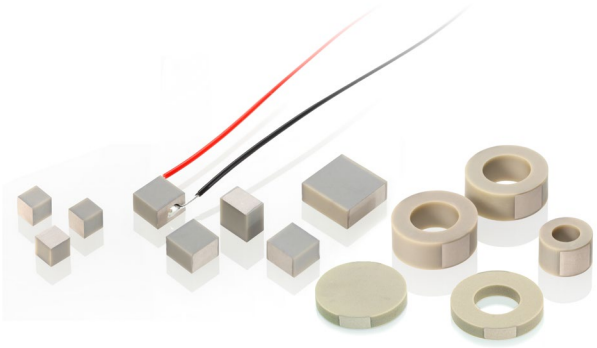
PZ265E

PL0xx/PDxxx Piezo Actuator

User Manual

Version: 1.1.0 Date: 27.09.2021



This document describes the following products:

- **PL022 / PL033 / PL055 / PL088**
  PICMA® Chip miniature multilayer piezo actuators
- **PD161**
  Round PICMA® Chip miniature multilayer piezo actuators
- **PD050 / PD080 / PD120 / PD150 / PD160**
  Round PICMA® Chip miniature multilayer piezo actuators with inner hole

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Contents

1 About this Document

In this Chapter

1.1 Objective and Target Audience of this User Manual

This user manual contains the necessary information for the intended use of the PL0xx/PDxxx (x stands for the different models (p. 9)).

Basic knowledge of drive technologies and suitable safety measures is assumed.

1.2 Validity for Custom Products

This user manual also applies to custom products from the following product lines if nothing else is stated in their accompanying documentation:

- PICMA® Chip actuators
- Round PICMA® Chip actuators

The product line is stated on the delivery note of the custom product.

The properties of custom products may differ from those stated in this manual.

The latest versions of the user manuals are available for download (p. 3) on our website.

1.3 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 injuries or damage to equipment.

➢ Precautionary measures for avoiding the risk.

NOTICE

Dangerous situation
Failure to comply could cause damage to equipment.

➢ Precautionary measures for avoiding the risk.

INFORMATION

Information for easier handling, tricks, tips, etc.

Symbol / Label	Meaning
	General hazard symbol
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	Operating element labeling on the product (example: Socket of the RS-232 interface)

1.4 Figures

For better understandability, the colors, proportions, and degree of detail in illustrations can deviate from the actual circumstances. Photographic illustrations may also differ and must not be seen as guaranteed properties.

1.5 Other Applicable Documents

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

The latest versions of the user manuals are available for download (p. 3) on our website.

Product	Document
E-503 piezo amplifier module	PZ62E user manual
E-504 piezo amplifier module	PZ62E user manual
E-505 piezo amplifier module	PZ62E user manual
E-506 piezo charge amplifier	PZ62E user manual

Product	Document
E-610 piezo amplifier / servo controller	PZ72E user manual
	PZ70E user manual
E-617 high-performance piezo amplifier	PZ201E user manual
E-618 high-performance piezo amplifier / servo controller	PZ221E user manual
E-663 piezo amplifier	PZ69E user manual
E-831 piezo amplifier module	PZ191E user manual
	PZ235E user manual
E-836 compact piezo amplifier / OEM module	PZ250E user manual

1.6 Downloading Manuals

INFORMATION

If a manual is missing or problems occur with downloading:

➢ Contact our customer service department (p. 47).

Downloading Manuals

1. Open the website **www.pi.ws**.
2. Search the website for the product number (e.g., PL055) or the product family (e.g., PICMA® Chip).
3. Click the corresponding product to open the product detail page.
4. Click the ***Downloads*** tab.

   The manuals are shown under ***Documentation***. Software manuals are shown under ***General Software Documentation***.
5. Click the desired manual and fill out the inquiry form.

   The download link will then be sent to the email address entered.

2 Safety

In this Chapter

2.1 Intended Use

The PL0xx/PDxxx is intended to be used in an environment which is free of dirt, oil, and lubricants.

In accordance with its design, the PL0xx/PDxxx is intended for integration into a mechanical system and for the following applications:

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

The operator is responsible for a standards-compliant integration of the PL0xx/PDxxx into the overall system.

The motion of the PL0xx/PDxxx takes place on one axis. When mounting the actuator without applying a preload, pay attention to the maximum tensile stress capacity (p. 52).

For operation of the PL0xx/PDxxx, suitable electronics that provide the required operating voltages are required. The electronics are not included in the scope of delivery of the PL0xx/PDxxx. We recommend the use of suitable electronics (p. 12) from PI.

2.2 General Safety Instructions

The PL0xx/PDxxx is built according to state-of-the-art technology and recognized safety standards. Improper use can result in personal injury and/or damage to the PL0xx/PDxxx.

- ➢ Use the PL0xx/PDxxx for its intended purpose only, and only when it is in perfect technical condition.
- ➢ Read the user manual.
- ➢ Eliminate any malfunctions that may affect safety immediately.

The operator is responsible for the correct installation and operation of the PL0xx/PDxxx.

Temperature changes and compressive stress can induce charges in the PL0xx/PDxxx piezo actuator. The piezo actuator can remain charged for several hours after disconnecting the electronics. Touching the live parts on the PL0xx/PDxxx can result in minor injury from electric shock.

- Do not touch the piezo actuator unless it is discharged (p. 40).
- When handling the piezo actuator, wear powder-free nitrile or latex gloves.
- Keep the piezo actuator short-circuited (p. 41) when it is not connected to the electronics.

The system into which the piezo actuator 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 restarting.

During operation, the piezo actuator carries voltages of up to 100 V. Touching the piezo actuator can lead to minor injuries from electric shock.

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

Mechanical forces can damage the PL0xx/PDxxx.

- Avoid impacts that affect the PL0xx/PDxxx.
- Do **not** drop the PL0xx/PDxxx.
- Avoid torques and lateral forces on the PL0xx/PDxxx.
- Do **not** use metal tools during installation.
- Do **not** exceed the maximum permissible stress and load capacities according to the specifications (p. 49).
- Do **not** exceed the maximum compressive/tensile stress capacity (p. 52).

2.3 Organizational Measures

User manual

- Always keep this user manual together with the PL0xx/PDxxx.
  The latest versions of the user manuals are available for download (p. 3) on our website.
- Add all information from the manufacturer to the user manual, for example supplements or technical notes.
- If you give the PL0xx/PDxxx to a third party, include this user manual as well as other relevant information provided by the manufacturer.
- Do the work only if the user manual is complete. Missing information due to an incomplete user manual can result in minor injury and damage to equipment.
- Install and operate the PL0xx/PDxxx only after you have read and understood this user manual.

Personnel qualification

The PL0xx/PDxxx may only be installed, started, operated, maintained, and cleaned by authorized and appropriately qualified personnel.

3 Product Description

In this Chapter

3.1 Model Overview

PICMA® Chip miniature multilayer piezo actuators

Model	Description
PL022.31	PICMA® Chip miniature piezo actuator, 2.2 µm travel range, 2 mm × 2 mm × 2 mm, stranded wires
PL033.31	PICMA® Chip miniature piezo actuator, 2.2 µm travel range, 3 mm × 3 mm × 2 mm, stranded wires
PL055.31	PICMA® Chip miniature piezo actuator, 2.2 µm travel range, 5 mm × 5 mm × 2 mm, stranded wires
PL088.31	PICMA® Chip miniature piezo actuator, 2.2 µm travel range, 10 mm × 10 mm × 2 mm, stranded wires

Round PICMA® Chip miniature multilayer piezo actuators

Model	Description
PD161.31	Round PICMA® Chip miniature piezo actuator, 2.3 µm travel range, OD 16 mm × TH 2.5 mm, stranded wires

Round PICMA® Chip miniature multilayer piezo actuators with inner hole

Model	Description
PD050.31	Round PICMA® Chip miniature piezo actuator with inner hole, 2.0 µm travel range, OD 5 mm × ID 2.5 mm × TH 2.5 mm, stranded wires
PD080.31	Round PICMA® Chip miniature piezo actuator with inner hole, 2.0 µm travel range, OD 8 mm × ID 4.5 mm × TH 2.5 mm, stranded wires

Model	Description
PD120.31	Round PICMA® Chip miniature piezo actuator with inner hole, 2.0 µm travel range, OD 12 mm × ID 6 mm × TH 2.5 mm, stranded wires
PD150.31	Round PICMA® Chip miniature piezo actuator with inner hole, 1.8 µm travel range, OD 15 mm × ID 9 mm × TH 2 mm, stranded wires
PD160.31	Round PICMA® Chip miniature piezo actuator with inner hole, 2.0 µm travel range, OD 16 mm × ID 8 mm × TH 2.5 mm, stranded wires

All models are available with optional solderable contacts. The product numbers of the models with solderable contacts end with the number 0 (e.g., PL022.30 or PD050.30).

3.2 Product View

The figures serve as examples and can differ from your model. The models with stranded wires (not shown) have a red stranded wire at the positive electrode (+) and a black stranded wire at the negative electrode (-).

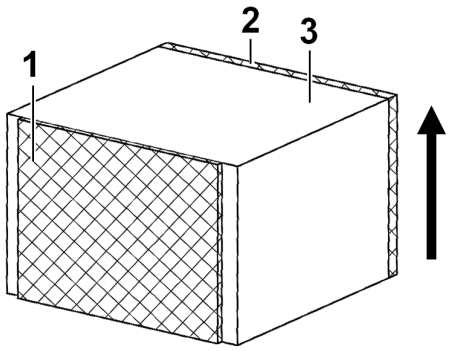


Figure 1: PL0xx: Exemplary product view

1: Positive electrode: Voltage connection (+)
The positive electrode does not cover the entire side surface.

2: Negative electrode: Connection for ground (-)
The negative electrode covers the entire side surface.

3: Ceramic end surface (passive PZT)

Arrow: Expansion direction of the piezo actuator when a positive voltage is applied

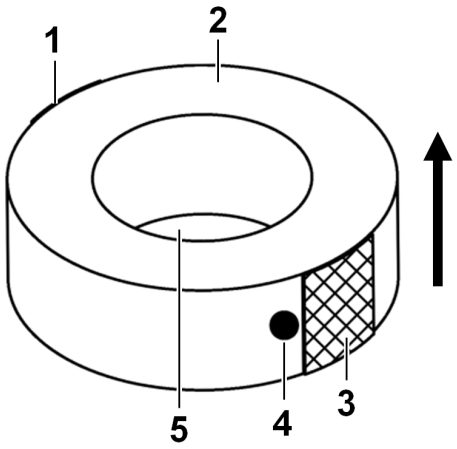


Figure 2: PDxxx: Exemplary product view of a model with inner hole

1: Negative electrode: Connection for ground (-)
2: Ceramic end surface (passive PZT)
3: Positive electrode: Voltage connection (+)
4: Point for identifying the positive electrode
5: Inner hole (depending on model type)
Arrow: Expansion direction of the piezo actuator when a positive voltage is applied

3.3 Product Labeling

Before delivery, each PL0xx/PDxxx is vacuum-packed in an ESD protective bag that prevents the piezo actuator from being charged during transport. Larger actuators are additionally packed in tubes to protect them against breakage.

Every ESD protection bag has a sticker with the following information:

Labeling	Description
	Data Matrix code (example; contains the abbreviated batch number and the product number)
PL055.30	Product number (example), the digits after the period refer to the model The product number of custom products consists of nine digits (without identification of the model).
16CEP0653128979	Batch number (example), individual for each PL0xx/PDxxx
PI	Manufacturer's logo
1 Stueck	Quantity
Country of origin: Germany	Country of origin
WWW.PICERAMIC.COM	Manufacturer's address (website)

3.4 Scope of Delivery

Product number	Description
PL0xx/PDxxx	Piezo actuator according to order (p. 9)
PZ264EK	Short instructions for unhoused and encapsulated PICMA® piezo actuators

3.5 Suitable Electronics

To operate a PL0xx/PDxxx, you need electronics. The device is selected depending on the type of application. The table below lists the suitable devices.

Product number	Description
E-503	Piezo amplifier module (for E-500 piezo controller system)
E-504	Piezo amplifier module (for E-500 piezo controller system)
E-505	Piezo amplifier module (for E-500 piezo controller system)
E-506	Piezo charge amplifier (for E-500 piezo controller system)
E-610	Piezo amplifier / servo controller
E-617	High-performance piezo amplifier
E-618	High-performance piezo amplifier / servo controller
E-663	Piezo amplifier
E-831	Piezo amplifier module
E-836	Compact piezo amplifier / OEM module

- ➢ To order, contact our customer service department (p. 47).
- ➢ Before selecting electronics, calculate the power requirements of your application (p. 39).

3.6 Accessories

Product number	Description
P-890.10	Cable for piezo voltage, LEMO connector/open end, 1 m
P-890.20	Cable for piezo voltage, LEMO connector/open end, 5 m
The P-890.xx cable is for connecting the PL0xx/PDxxx to a low-voltage piezo amplifier. The cable is soldered on the actuator side. Connector: LEMO FFS.00.250.CTCE24, coaxial Cable: RG 178 (Teflon)	

- ➢ To order, contact our customer service department (p. 47).

3.7 Technical Features

PICMA® piezo actuators

PL0xx/PDxxx are PICMA® multilayer piezo actuators for static and dynamic applications. PICMA® actuators have all-ceramic insulation and their performance and lifetime are therefore far superior to conventional actuators. The ceramic insulation layer protects the monolithic piezoceramic block against humidity and failure due to increased leakage current. In this way, an especially high reliability is achieved even under extreme ambient conditions.

4 Unpacking

NOTICE

Destruction of the piezo actuator due to contamination!
Contamination on the surface of the PL0xx/PDxxx can result in the destruction of the piezo actuator by electric flashovers during operation.

- When handling the piezo actuator, wear powder-free nitrile or latex gloves.
- Prevent the piezo actuator from coming into contact with conductive liquids (e.g., finger sweat) and conductive materials (e.g., metal dust).
- If the piezo actuator has been accidentally contaminated, clean it in accordance with the instructions in "Cleaning the PL0xx/PDxxx" (p. 43).

1. Unpack the PL0xx/PDxxx with care.
2. Compare the contents with the scope of delivery according to the contract and the delivery note.
3. Inspect the contents for signs of damage. If any parts are damaged or missing, contact our customer service department (p. 47) immediately.
4. Keep all packaging materials in case the product needs to be returned.

5 Installation

In this Chapter

5.1 General Notes on Installing

CAUTION

Dangerous voltage and residual charge in piezo actuators!
Temperature changes and compressive stress can induce charges in the PL0xx/PDxxx piezo actuator. The piezo actuator can remain charged for several hours after disconnecting the electronics. Touching the live parts on the PL0xx/PDxxx can result in minor injury from electric shock.

- Do not touch the piezo actuator unless it is discharged (p. 40).
- When handling the piezo actuator, wear powder-free nitrile or latex gloves.
- Keep the piezo actuator short-circuited (p. 41) when it is not connected to the electronics.

NOTICE

Destruction of the piezo actuator due to rapid discharging!
If the piezo actuator is not connected to the electronics, it must be short-circuited in order to prevent the piezo actuator from becoming charged during temperature changes and compressive stress. Unsuitable short-circuiting leads to an abrupt contraction of the piezo actuator due to excessively fast discharging. Abrupt contraction can destroy the piezo actuator.

- ➢ As soon as you have removed the piezo actuator from the conductive original packaging, short-circuit it as follows:
  - – Models with stranded wires: Twist the stranded wires of the piezo actuator with each other.
  - – Models without stranded wires: Affix a suitable, conductive aid on the piezo actuator that does not leave any scratches on the surface of the piezo actuator (e.g., conductive rubber).
- ➢ Only disconnect the short-circuit connection of the piezo actuator if this is necessary for installation or operation.
- ➢ If the piezo actuator is not short-circuited:
  - – Ensure adequate protection against touching live parts.
  - – Discharge the piezo actuator in a suitable way before short-circuiting again (p. 40).

NOTICE

Destruction of the piezo actuator due to excessively high loads!
Excessive loads can destroy the PL0xx/PDxxx.

- ➢ Do **not** exceed the maximum compressive/tensile stress capacity (p. 52).

NOTICE

Damage to the piezo actuator due to excessive preloading!
Excessive preloading can mechanically depolarize the piezo actuator. Depolarization damages the piezo actuator.

- ➢ Only apply preloads that are just as high as necessary.
- ➢ Do **not** exceed the maximum preload (p. 52).

NOTICE

Destruction of the piezo actuator due to mechanical overload!

Torques and lateral forces can destroy the piezo actuator.

- Avoid torques and lateral forces on the piezo actuator.
- Make sure that the center of load of the moving system is on the motion axis of the piezo actuator.
- Avoid an uneven load distribution by using suitable structures or guide elements (e.g., ball tips or flexure guides).
- Establish contact over as large an area as possible on the end surfaces of the piezo actuator, and select opposing surfaces with a flatness of only a few micrometers. Minor unevenness can be compensated by full-surface gluing, for example.

NOTICE

Damage due to tensile stress on the stranded wires of the piezo actuators!

Impermissible forces on the stranded wires (if applicable) can damage the piezo actuator.

- Avoid tensile stress on the stranded wires of the piezo actuator.

NOTICE

Damage due to scratches on the surface of the piezo actuator!

The surface of the piezo actuator is scratch-sensitive. Scratches on the surface can cause damage to the piezo actuator.

- Do not use metal tools to install the piezo actuator.
- Install the piezo actuator so that the ceramic insulation and the end surfaces of the piezo actuator are not scratched during installation and operation.

NOTICE

Heating up of the PL0xx/PDxxx during operation!

The heat produced during operation of the PL0xx/PDxxx can affect your application.

- Install the PL0xx/PDxxx so that your application is not affected by the dissipating heat.

INFORMATION

Ground loops can occur when the piezo actuator is installed in a housing that is grounded via the shield of the connecting cable of the piezo actuator as well as a separate protective earth conductor.

- If a ground loop occurs, contact our customer service department (p. 47).

Avoiding mounting errors

Piezo actuators may only be loaded axially. Moreover, piezo actuators should be preloaded (p. 27) mechanically in order to avoid tensile stress. The following figures are to help you avoid mounting errors.

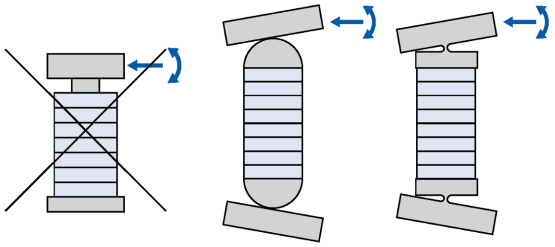


Figure 3: Prevention of lateral forces and torques

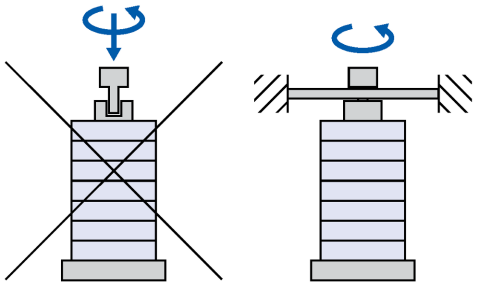


Figure 4: Prevention of torques

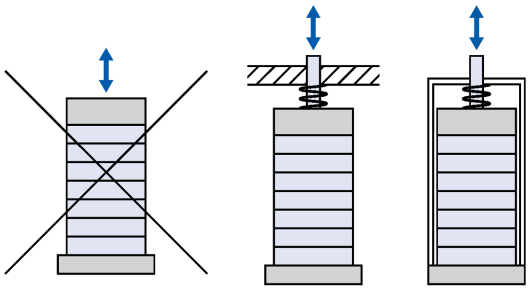


Figure 5: Prevention of tensile stresses by means of a mechanical preload

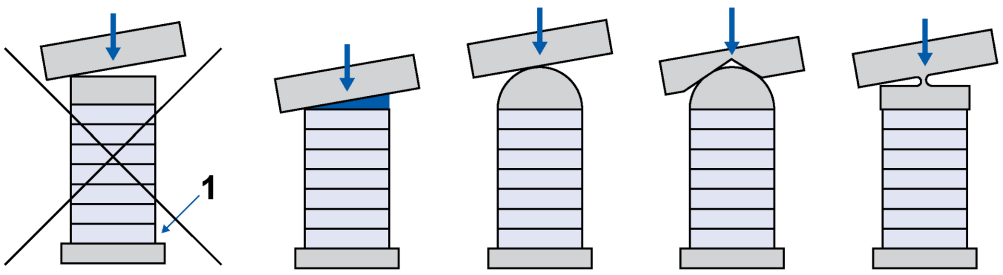


Figure 6: Prevention of an irregular load application (1: Tensile stresses)

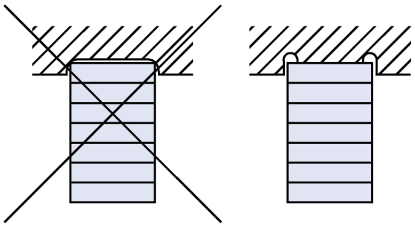


Figure 7: Full-area contact of the piezo actuator

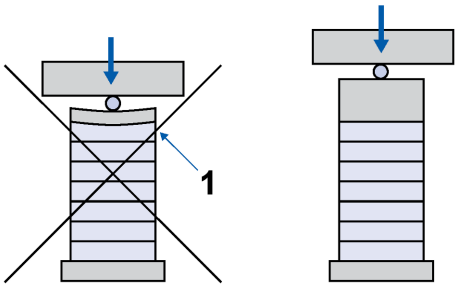


Figure 8: Proper dimensioning of the end pieces in the case of point contact (1: Tensile stresses)

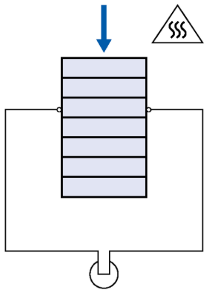


Figure 9: Mechanical or thermal loads electrically charge the piezo actuator. Mount only when short-circuited.

5.2 Connecting a Piezo Actuator with Stranded Wires (Models Without Stranded Wires Only)

The electrodes can make contact in one of the following ways:

- Soldering the stranded wires (p. 22)
- Gluing the stranded wires (p. 24)

If your application permits it, we recommend using models that already have stranded wires.

5.2.1 Soldering Stranded Wires to a Piezo Actuator (Models Without Stranded Wires Only)

NOTICE

Damage due to overheating of the piezo actuator during soldering!
Heat spreading from the piezo actuator that rises above the Curie temperature leads to depolarization of the piezo ceramic. Depolarization can damage the piezo ceramic. Long and repeated soldering processes can cause damage to the electrode.

- ➢ The soldering temperature should not be any higher than necessary (max. 350 °C).
- ➢ Make sure that the soldering time does **not** exceed one second.
- ➢ Allow the solder point to cool down before resoldering.

NOTICE

Damage due to mechanical stress on the solder connection!
Mechanical stress on the solder connection due to moved stranded wires can damage the piezo actuator.

- ➢ Avoid tensile stress and shear forces on the solder connections.

INFORMATION

The electrode marking is shown in the product view (p. 10).

- ➢ Use a red stranded wire for the voltage connection (+).
- ➢ Use a black stranded wire for ground (-).

Requirements

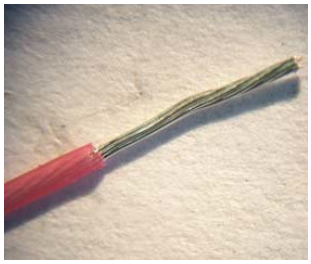
- ✓ You have read and understood the general notes on installation (p. 17).
- ✓ The PL0xx/PDxxx is discharged (p. 40) and short-circuited (p. 41).

Tools and accessories

- Suitable stranded wires that meet the applicable standards for the conditions of use
- Suitable soldering iron
- Suitable solder: Sn 95.5, Ag 3.8, Cu 0.7
- Suitable flux according to one of the following standards:
  - DIN EN 29454, part 1, category 1.1.3 or 1.2.3
  - ANSI J-STD-004, flux type ROL0
- Suitable cable tools

Soldering stranded wires to a piezo actuator (only models without stranded wires)

1. Prepare the stranded wire according to the following illustrations:

Twisting	Tinning	Shortening to 2 mm
		

2. Apply the flux to the tinned end of the wire and the intended soldering point of the electrode.
3. Hold the stranded wire flat with the tinned end on the solder joint.
4. Coat the tip of the soldering iron with a small amount of solder.
5. Hold the tip of the soldering iron at the soldering point on the tinned end of the stranded wire for a maximum of one second so that the solder flows and a flat or point-shaped solder connection results after soldering.

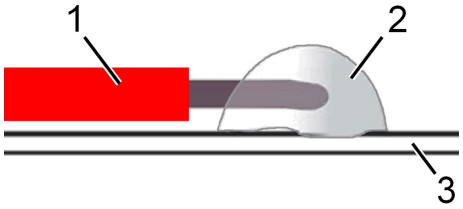


Figure 10: Solder connection [2] of stranded wire [1] and electrode [3]

6. Repeat steps 1 to 5 for the second stranded wire.
7. Remove flux residue according to the instructions in the section "Cleaning the PL0xx/PDxxx" (p. 43).

5.2.2 Gluing Stranded Wires to a Piezo Actuator (Models Without Stranded Wires Only)

CAUTION

Risk of electric shock when stranded wires become detached from the piezo actuator!
In the case of unsuitable adhesives or improper gluing, the adhesive connection can fail, especially in the case of mechanical stress, causing stranded wires to become detached from the actuator. If stranded wires detach from the piezo actuator during operation, touching the stranded wires or other conductive parts that come into contact with them can cause minor injuries from electric shock.

- ➢ Use only suitable adhesives (e.g., electrically conductive, silver-filled epoxy resin adhesive) to glue the stranded wires to the piezo actuator.
- ➢ Use only suitable stranded wires that meet the applicable standards for the conditions of use.
- ➢ Make sure that the adhesion surfaces are dry, dust-free, and grease-free.
- ➢ Avoid mechanical stress on the adhesive connections.
- ➢ If stranded wires become detached during operation, switch off the electronics immediately.

NOTICE

Damage due to mechanical stress on the adhesive connection!
Moving stranded wires can cause mechanical stress on the adhesive connection and damage the piezo actuator.

- ➢ Avoid tensile stress and shear forces on the adhesive connections.

NOTICE

Short-circuit damage due to improper gluing!
Improper gluing (e.g., unfavorable spreading of the electrically conductive adhesive) can cause the piezo actuator and the connected electronics to be damaged by short-circuits.

- ➢ When gluing the stranded wires to the electrodes, make sure that the adhesive does not spread beyond the glueing point at any time.

INFORMATION

For optimum electrical contacting, it is recommended to use the following materials:

- Silver-plated stranded wires
- Electrically conductive, silver-filled epoxy resin adhesive

INFORMATION

The electrode marking is shown in the product view (p. 10).

- ➢ Use a red stranded wire for the voltage connection (+).
- ➢ Use a black stranded wire for ground (-).

Requirements

- ✓ You have read and understood the general notes on installation (p. 17).
- ✓ The PL0xx/PDxxx is discharged (p. 40) and short-circuited (p. 41).
- ✓ You have read and understood the user information of the manufacturer of the adhesive.

Tools and accessories

- Suitable stranded wires that meet the applicable standards for the conditions of use
- Electrically conductive, silver-filled epoxy resin adhesive
- Suitable cable tools

Gluing stranded wires to a piezo actuator (only models without stranded wires)

1. If necessary, clean the bonding surfaces so that they are dry, dust-free and grease-free.
2. Remove the insulation at the end of the stranded wire to be glued and shorten the stripped end to a length of 2 mm.
3. Glue the untwisted stranded wire on the electrode so that the glue does not flow beyond the adhesive point at any time:
   a) Apply the thinnest possible layer of adhesive to the adhesive point provided on the electrode.
   b) Apply a small amount of adhesive to the stripped end of the stranded wire.
   c) Hold the stranded wire in the desired orientation on the adhesive point and fix the stranded wire.
4. Repeat steps 2 and 3 for the second stranded wire.
5. Wait until the adhesive has completely hardened.

5.3 Mounting the PL0xx/PDxxx

PL0xx/PDxxx piezo actuators are glued to metal or ceramic surfaces.

CAUTION

Risk of electric shock and short-circuit from incorrect gluing of the piezo actuator!
The electrodes of the piezo actuator extend to the ceramic end surfaces. If the piezo actuator is glued to a conductive surface without insulation of the electrodes, the surface can be electrically live during operation. Touching the surface or conductive parts connected can result in minor injuries from electric shock. The electronics can be damaged by a short-circuit.

➢ If the piezo actuator is to be glued to a conductive surface, insulate the surface from the electrodes of the piezo actuator by suitable means:
  – Place a nonconductive insulating layer on the surface
  – Cut the surface to clear the entire area around the electrode

Requirements

✓ You have read and understood the general notes on installation (p. 17).

✓ The PL0xx/PDxxx is discharged (p. 40) and short-circuited (p. 41).

✓ You have read and understood the user information of the manufacturer of the adhesive.

Tools and accessories

- Level surface that is dry, dust-free, and grease-free
- Suitable adhesive (e.g., cold-hardening epoxy resin adhesive)

Mounting the PL0xx/PDxxx

1. Glue the piezo actuator to the surface:
   – Apply the thinnest possible layer of adhesive.
   – During the hardening process, maintain the operating temperature range (p. 52) specified for the piezo actuator.
   – Pay attention to the temperature expansion coefficients of the materials involved.
2. Press the piezo actuator until the adhesive has hardened.

5.4 Applying a Preload

The tensile stress capacity of piezo actuators is relatively low. It is therefore recommended to mechanically preload the piezo actuators in the application, either externally in the mechanical structure or internally in a housing.

Requirements

- ✓ You have read and understood the general notes on installation (p. 17).
- ✓ The PL0xx/PDxxx is discharged (p. 40) and short-circuited (p. 41).

Tools and accessories

- When installing in a housing: Suitable housing
- Suitable guide elements
- When creating the preload with a spring:

  Suitable preload spring with the following characteristics:

  – The stiffness of the preload spring does not exceed 10 % of the stiffness of the piezo actuator. This is to minimize the displacement loss. If the stiffness of the preload spring is equal to that of the actuator, the free displacement drops by half.

    The stiffness of the piezo actuator can be calculated as follows:

    $$k_A = \frac{F_{max}}{\Delta L_O}$$

    k_A Actuator stiffness

    F_{max} Blocking force*

    ΔL_0 Nominal displacement*

    * See data table (p. 49).

  – With highly dynamic applications:
    The resonant frequency (p. 49) of the preload spring exceeds that of the piezo actuator.

Applying a preload

➢ Apply the preload near the axis within the core cross section of the piezo actuator.

5.5 Applying the Load

The PL0xx/PDxxx can be coupled to a load in various ways, depending on the application:

- Gluing the piezo actuator (p. 26) into the mechanical system to be moved or into a flexure
- Using a ball tip:
  - Gluing a hardened ball tip, which establishes a single-point contact to an even surface
  - Gluing a hardened ball tip, which establishes a ring-shaped contact to a calotte

INFORMATION

Diagrams showing how to couple the PL0xx/PDxxx to a load can be found in "General Notes on Installation" (p. 20).

Requirements

✓ You have read and understood the general notes on installation (p. 17).

✓ The PL0xx/PDxxx is discharged (p. 40) and short-circuited (p. 41).

Tools and accessories

- Suitable adhesive (e.g., cold-hardening epoxy resin adhesive)
- When using a ball tip: Suitable ball tip
- When using a flexure: Suitable flexure

Applying the load

➢ Apply the load evenly.

If the piezo actuator is coupled in a milling pocket:

➢ Ensure that there is full-area contact at the end surface of the piezo actuator. For this purpose, choose the dimensions of the milling pocket correspondingly or make free cuts in the milling pocket.

If a point load is applied to the end piece of the piezo actuator:

➢ Dimension the end piece so that its thickness corresponds to half the cross-sectional dimension in order to prevent tensile stress on the piezo actuator.

5.6 Connecting the PL0xx/PDxxx to the Electronics

The PL0xx/PDxxx piezo actuator is connected to a LEMO socket, a terminal, or soldering pins, depending on the electronics.

This section describes how the PL0xx/PDxxx piezo actuator is connected with the P-890.xx coaxial cable to electronics with a LEMO coaxial socket.

- For connection to the electronics with other LEMO connectors, contact our customer service department (p. 47).
- If you use a self-made connecting cable instead of the P-890.xx coaxial cable, pay attention to the relevant standards as well as the assembly information of the manufacturer of the connector used.
- For connection to terminals or solder pins, refer to the manual of the respective electronics used (p. 2).

INFORMATION

The models with stranded wires have color-coded wires:

- Red stranded wire: Voltage connection (+)
- Black stranded wire: Ground (-)

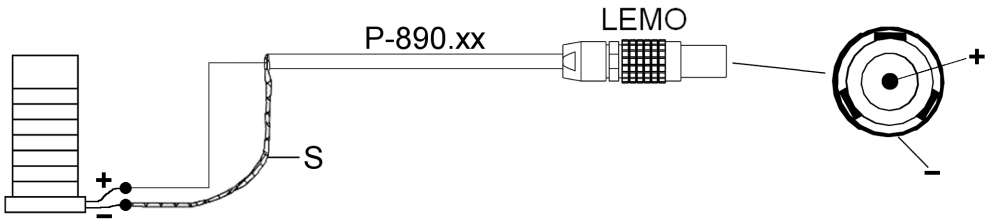


Figure 11: Connection of the PL0xx/PDxxx piezo actuator to the P-890.xx coaxial cable

+	On the piezo actuator (left): Red stranded wire for voltage connection On the LEMO connector (right): Inner contact for voltage connection
-	On the piezo actuator (left): Black stranded wire for ground On the LEMO connector (right): Connector housing
S	Cable shield
LEMO	LEMO FFS.00.250.CTCE24 coaxial connector

Requirements

- ✓ You have read and understood the general notes on installation (p. 17).
- ✓ You have read and understood the user manual of the electronics used.
- ✓ If the PL0xx/PDxxx is not short-circuited: The PL0xx/PDxxx is discharged (p. 40).
- ✓ The electronics are **switched off**.
- ✓ The electronics have a suitable LEMO socket for the connector on the P-890.xx coaxial cable.
- ✓ Models without stranded wires: You have soldered (p. 22) or glued (p. 24) a red stranded wire to the positive electrode (+) and a black stranded wire to the negative electrode (-) of the PL0xx/PDxxx.

Tools and accessories

- P-890.xx coaxial cable (p. 12), LEMO to open end (can be ordered separately)
- Suitable soldering iron
- Suitable solder
- Suitable cable tools

Connecting the PL0xx/PDxxx to the electronics

1. If necessary, shorten the wire and the cable shield of the coaxial cable to the correct length.
2. Make the stranded wires of the PL0xx/PDxxx accessible:
   - When the stranded wires of the PL0xx/PDxxx are short-circuited, disconnect the connection between the stranded wires.
   - Remove all aids and components that have been connected to the PL0xx/PDxxx for short-circuiting or discharging (e.g., conductive rubber or discharging resistor).
3. Solder the red stranded wire of the PL0xx/PDxxx to the wire of the coaxial cable connected to the inner contact of the LEMO connector.
4. Solder the black stranded wire of the PL0xx/PDxxx to the cable shield of the coaxial cable.
5. Insulate the soldered cable connections in a suitable manner.
6. Connect the connector of the PL0xx/PDxxx to the corresponding connection on the electronics.

6 Starting and Operating

In this Chapter

6.1 General Notes on Starting

CAUTION

Dangerous voltage in piezo actuators during operation!

During operation, the piezo actuator carries voltages of up to 100 V. Touching the piezo actuator can lead to minor injuries from electric shock.

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

CAUTION

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

The system into which the piezo actuator 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 restarting.

CAUTION

Burning from hot surface!

The surface of the PL0xx/PDxxx and the surrounding area can heat up during operation. Touching the PL0xx/PDxxx and surrounding parts can result in minor injuries from burning.

- Cool the PL0xx/PDxxx so that the temperature of its surface and surrounding parts does **not** exceed 65 °C. Do **not** use liquids for cooling. If liquid cooling is to be used, contact our customer service department (p. 47).
- If sufficient cooling is not possible: Make sure that the hot PL0xx/PDxxx and its surrounding parts **cannot** be touched.
- If sufficient cooling and protection against contact are not possible: Mark the danger zone in accordance with the legal regulations.

NOTICE

Destruction of the piezo actuator due to electric flashovers!

Using the PL0xx/PDxxx 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).

- Avoid operating the PL0xx/PDxxx in environments that can increase the electrical conductivity.
- Only operate the PL0xx/PDxxx within the permissible ambient conditions and classifications (p. 52).
- Prevent the piezo actuator from coming into contact with liquids. If liquid cooling is to be used, contact our customer service department (p. 47).
- Protect the piezo actuator against moisture by means of hermetic sealing or the supply of dry air.
- If the PL0xx/PDxxx is to be operated in a special gas atmosphere, contact our customer service department (p. 47).

NOTICE

Destruction of the piezo actuator by dynamic forces!

During dynamic operation, dynamic forces can occur that cancel the preload of the piezo actuator. Operation without a preload can destroy the actuator.

- Do **not** exceed the maximum compressive/tensile stress capacity (p. 52).
- Pay attention to the notes in "Determining the Operating Parameters" (p. 35).

NOTICE

Destruction of the piezo actuator due to excessive operating frequencies!

An excessive operating frequency can cause thermal and mechanical overloading that destroys the piezo actuator.

- ➢ Select the operating frequency so that the following conditions are met:
  - The operating frequency of the piezo actuator does not exceed one third of the resonant frequency. The resonant frequency according to the data table (p. 49) applies to unclamped operation without load. In an arrangement with unilateral clamping, the value must be halved. For loaded piezo actuators that are clamped on one side, see "Calculating the Maximum Operating Frequency of the Loaded Piezo Actuator" (p. 37).
  - The dynamic forces occurring during operation do **not** exceed the maximum compressive/tensile stress capacity of the piezo actuator (see "Calculating the Forces that Occur During Dynamic Operation" (p. 38) and "Compressive/Tensile Stress Capacity and Preload" (p. 52)).
- ➢ Reduce the voltage at high operating frequencies to minimize the heating of the piezo actuator.
- ➢ If your application involves the operation of a piezo actuator which is not clamped on both sides, contact our customer service department (p. 47).

NOTICE

Damage due to steep edges in the control signal!

If the actuator does not have a preload, steep edges in the control signal can trigger strong dynamic forces which damage the piezo actuator. Steep edges can occur, for example, when digital wave generators are switched on.

- ➢ Avoid steep edges in the control signal on actuators with low preload.

NOTICE

Damage after reconnecting due to a charged piezo actuator!

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

- ➢ Do **not** pull the connecting cable of the piezo actuator out of the electronics during operation.

If the connecting cable of the piezo actuator was accidentally pulled out of the electronics during operation:

- ➢ Discharge the piezo actuator accordingly before reconnecting (p. 40).
- ➢ Switch off the electronics before you reconnect the piezo actuator.

NOTICE

Reduced lifetime due to permanently high voltage and high air humidity!

Applying a continuous high static voltage to piezo actuators reduces the lifetime of the piezo ceramic. This applies in particular to operation in a humid environment.

- When the PL0xx/PDxxx is not in use but the electronics remain switched on to ensure temperature stability: Set the piezo voltage to 0 V on the electronics.
- If possible: Limit the maximum operating voltage during continuous operation.
- Reduce offset voltages to a minimum.
- Protect the piezo actuator against moisture by means of hermetic sealing or the supply of dry air.
- Make sure that the air humidity in the vicinity of the PL0xx/PDxxx does not exceed the relative humidity specified in "Ambient Conditions and Classifications" (p. 52).

NOTICE

Operating voltage excessively high or incorrectly connected!

Operating voltages that are too high or incorrectly connected can cause damage to the PL0xx/PDxxx.

- Do **not** exceed the operating voltage range (p. 50) for which the PL0xx/PDxxx is specified.
- Operate the PL0xx/PDxxx only when the operating voltage is properly connected; see "Connecting the PL0xx/PDxxx to the Electronics" (p. 29).
- If you have applied the operating voltage with the wrong polarity accidentally, contact our customer service department (p. 47).

NOTICE

Destruction of the piezo actuator due to overheating!

During the operation of the piezo actuator, dielectric losses that are converted into heat energy occur in the piezo ceramic due to ferroelectric polarization processes. The resulting heat can overheat and destroy the piezo actuator, especially in dynamic operation.

- Adjust the operating voltage, operating frequency, and/or operating time so that the maximum operating temperature of the piezo actuator is not exceeded; see "Ambient Conditions and Classifications" (p. 52), "Maximum Ratings" (p. 50), and "Determining the Operating Parameters" (p. 35).
- Cool the piezo actuator. Do **not** use liquids for cooling. If liquid cooling is to be used, contact our customer service department (p. 47).

NOTICE

Destruction of the piezo actuator due to rapid cooling or heating!
Cooling down or heating up too quickly leads to a thermomechanical load that can destroy the piezo actuator.

➢ Allow the piezo actuator to cool down or warm up slowly.

NOTICE

Uncontrolled oscillation!
Oscillation can cause irreparable damage to the PL0xx/PDxxx. 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 PL0xx/PDxxx 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 PL0xx/PDxxx immediately.

INFORMATION

The positive direction of motion (p. 10) corresponds to the expansion direction of the piezo actuator when a positive voltage is applied.

6.2 Determining the Operating Parameters

INFORMATION

For determination of the the operating parameters, it is assumed that the piezo actuator is clamped on one side.

➢ If you require operating parameters for unclamped operation of the piezo actuator, contact our customer service department (p. 47).

6.2.1 Overview of Limiting Factors

Limiting factors for the operation of the piezo actuator:

Resonant frequency:

The resonant frequency of the piezo actuator serves as a basis for calculating the operating frequency, which must **not** exceed one third of the resonant frequency. The resonant frequency according to the data table (p. 49) applies to unclamped operation without load. In an arrangement with unilateral clamping, the value must be halved.

For **loaded** piezo actuators that are clamped on one side, see "Calculating the Maximum Operating Frequency of the Loaded Piezo Actuator" (p. 37).

Maximum compressive/tensile stress capacity (p. 52):

The mass of the load to be moved, the preload, and the operating frequency of the piezo actuator must be selected so that the dynamic forces occurring during operation do not exceed the maximum compressive/tensile stress capacity of the piezo actuator. See "Calculating the Forces that Occur During Dynamic Operation" (p. 38).

Maximum permissible operating temperature of the piezo actuator (p. 52):

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. 50).

When cooling measures are used, the limit values for the operating frequency, operating voltage and operating time increase.

Peak and average output current of the electronics (p. 12) used:

The electronics must be selected so that they fulfill the following requirements:

- The electronics can provide the required current. See "Calculating the Power Requirement for Sinusoidal Operation" (p. 39).
- The output current of the electronics does not exceed the maximum power consumption of the piezo actuator. See "Maximum Ratings" (p. 50).

6.2.2 Calculating the Effective Mass

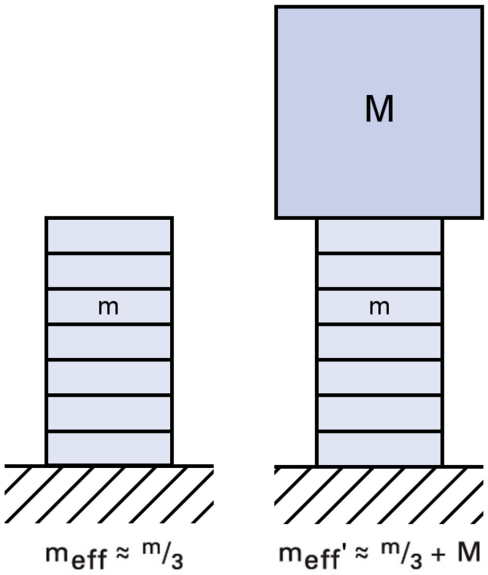


Figure 12: Calculation of the effective mass of a unilaterally clamped piezo stack actuator without load (left) and with additional load (right).

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

6.2.3 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. 50).

1. Calculate the resonant frequency of the loaded, unilaterally clamped piezo actuator using the following formula:

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

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

   f_0 = Resonant frequency of the unloaded piezo actuator [Hz]: The resonant frequency according to the data table (p. 49) applies to unclamped operation without load. In an arrangement with unilateral clamping, the value must be halved.

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

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

   See also "Calculating the Effective Mass" (p. 37).

2. Calculate the maximum operating frequency of the loaded, unilaterally clamped piezo actuator using the following formula:

   $f_{max} = f_0'/3$

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

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

6.2.4 Calculating the Forces that Occur During Dynamic Operation

➢ Calculate the dynamic forces acting on the unilaterally clamped piezo actuator during sinusoidal operation at the frequency f using the following formula:

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

F_{dyn} = Dynamic force [N]

m_{eff}' = Effective mass m_{eff} (approx. 1/3 of the mass of the piezo actuator) + additional load M [kg], see also "Calculating the Effective Mass" (p. 37)

ΔL = Displacement in the application (peak-to-peak) [m]

f = Frequency [Hz]

Example: The dynamic forces at 1000 Hz, 2 µm displacement (peak-to-peak) and 1 kg effective mass are approximately ±40 N.

6.2.5 Calculating the Power Requirement for Sinusoidal Operation

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

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

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

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

Variable	Description	Notes
I_a	Required average current of the amplifier (source / sink) [A]	It is essential that the power supply 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 "Overview of Limiting Factors" (p. 36).
C	Capacitance of the piezo actuator [F (= As/V)]	See "Data Table" (p. 49) 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.
$U_{p\text{-}p}$	Operating voltage (peak-to-peak) [V]	Voltage difference between positive and negative peak voltage

6.3 Operating the PL0xx/PDxxx

Requirements

✓ You have read and understood the general notes on starting and operating (p. 31).

✓ You have determined the operating parameters for your application (p. 35).

✓ You have installed (p. 17) the PL0xx/PDxxx correctly and connected it to the electronics (p. 29).

✓ You have provided suitable electronics that can supply the required currents (p. 39).

✓ You have read and understood the user manual of the electronics used.

Operating the PL0xx/PDxxx

➢ For starting up and operating the PL0xx/PDxxx, follow the instructions in the manual for the electronics (p. 2) used.

6.4 Discharging the PL0xx/PDxxx

The PL0xx/PDxxx must be discharged in the following cases:

- If the PL0xx/PDxxx has become accidentally charged due to thermal or mechanical loading
- If a charged PL0xx/PDxxx is to be short-circuited (p. 41)
- If the connecting cable of the PL0xx/PDxxx is accidentally pulled out of the electronics during operation

Requirements

✓ You have read and understood the general notes on installation (p. 17).

Tools and accessories

If the PL0xx/PDxxx is not connected to the electronics:

- Only for PL0xx/PDxxx **without** connector (condition as supplied):
  - 10 kΩ discharge resistor (not included in scope of delivery); touchable parts must be adequately insulated for the operating voltage range (p. 50) of the actuator
- Only for PL0xx/PDxxx **with** connector (p. 29):
  - Electronics (p. 12) from PI

Discharging a PL0xx/PDxxx connected to the electronics

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

Discharging a PL0xx/PDxxx not connected to the electronics

If the PL0xx/PDxxx does **not** have a connector:

1. If necessary, let the PL0xx/PDxxx cool down.
2. Ensure adequate protection against touching live parts.
3. Short-circuit the electrodes of the PL0xx/PDxxx for at least a few seconds using a **10 kΩ discharge resistor**.

If the PL0xx/PDxxx has a connector:

➢ Connect the voltage connector of the PL0xx/PDxxx to the **switched-off** PI electronics, which has an internal discharge resistor, for at least a few seconds.

6.5 Short-Circuiting the PL0xx/PDxxx

The PL0xx/PDxxx must be discharged (p. 40) and short-circuited before demounting (e.g., before cleaning and transportation of the PL0xx/PDxxx) as well as for modifications.

Requirements

- ✓ You have read and understood the general notes on installation (p. 17).
- ✓ You have discharged the PL0xx/PDxxx and disconnected it from the electronics.

Tools and accessories

- If no open stranded wires are accessible on the piezo actuator: Suitable conductive aid for short-circuiting the piezo actuator that does not scratch the surface of the piezo actuator (e.g., conductive rubber)

Short-circuiting the PL0xx/PDxxx

- ➢ If bare stranded wires are accessible on the PL0xx/PDxxx:
  Twist the stranded wires of the **discharged** piezo actuator with each other.
- ➢ If no bare stranded wires are accessible on the PL0xx/PDxxx:
  a) If necessary, let the PL0xx/PDxxx cool down.
  b) Affix a suitable, conductive aid on the **discharged** piezo actuator that does not scratch the surface of the piezo actuator (e.g., conductive rubber).

7 Maintenance

In this Chapter

7.1 General Notes on Maintenance

The PL0xx/PDxxx is maintenance-free.

7.2 Cleaning the PL0xx/PDxxx

NOTICE

Destruction of the piezo actuator due to electric flashovers!
If it comes into contact with liquids, the piezo actuator can be destroyed by electric flashovers.
Before cleaning the PL0xx/PDxxx:

- ➢ Ensure that the PL0xx/PDxxx is discharged (p. 40) and short-circuited (p. 41).

After cleaning the PL0xx/PDxxx:

- ➢ Dry the PL0xx/PDxxx completely in a drying cabinet (recommended duration: 30 minutes at 40 °C).

NOTICE

Damage due to use of unsuitable cleaning agents!
Some cleaning agents may cause damage to the PL0xx/PDxxx.

- ➢ Do **not** use acetone and do **not** use water for cleaning.

Requirements

- ✓ The PL0xx/PDxxx is discharged (p. 40) and short-circuited (p. 41).
- ✓ The PL0xx/PDxxx is disconnected from the electronics.

Cleaning the PL0xx/PDxxx

- ➢ Touch the piezo actuator only with powder-free nitrile or latex gloves.
- ➢ When necessary, clean the surfaces of the PL0xx/PDxxx with a lint-free cloth that is dampened with a mild cleanser (e.g., isopropyl alcohol or ethanol).

- When cleaning in an ultrasonic bath:
  - Reduce the energy input to the necessary minimum.
  - Use isopropyl alcohol or ethanol as cleaning fluid only.
  - Make sure that the cleaning time is 5 minutes.
- After cleaning, dry the PL0xx/PDxxx completely in a drying cabinet (recommended duration: 30 minutes at 40 °C).

8 Troubleshooting

Problem	Possible causes	Solution
No or limited motion	Cable not connected correctly	➢ Check the cable connections.
	Excessive load	➢ Do not exceed the maximum compressive/tensile stress capacity (p. 52).
	Piezo actuator is depolarized due to overheating or reverse polarity	➢ Contact our customer service department (p. 47).
Piezo actuator moves in the opposite direction to that specified when voltage increases	Reverse polarity of the piezo actuator	➢ Contact our customer service department (p. 47).

If the problem that occurred with your system is not listed in the table above or cannot be solved as described, contact our customer service department (p. 47).

9 Customer Service

You can contact PI Ceramic by telephone under +49 36604 882-0 or by email at the following address:

- For general questions or for orders:
  info@piceramic.com
- In the case of technical problems or faults:
  service@piceramic.com

➢ If you have any questions concerning your product, provide the following information:

  – Product and serial numbers of all products concerned
  – Firmware version of the electronics (if applicable)
  – Version of the driver or the software (if applicable)
  – Operating system on the PC (if applicable)

➢ If possible: Take photographs or make videos of your system that can be sent to our customer service department if requested

The latest versions of the user manuals are available for download (p. 3) on our website.

10 Technical Data

In this Chapter

Subject to change. You can find the latest product specifications on the product web page at www.pi.ws (https://www.pi.ws).

10.1 Specifications

10.1.1 Data Table

PICMA® Chip multilayer piezo actuators

	PL022.3x	PL033.3x	PL055.3x	PL088.3x	Unit	Tolerance
Side length (A)	2 ±0.10	3 ±0.10	5 ±0.15	10 ±0.20	mm	
Side length (B)	2 ±0.10	3 ±0.10	5 ±0.15	10 ±0.20	mm	
Height (TH)	2 ±0.10	2 ±0.10	2 ±0.10	2 ±0.10	mm	
Travel range*	2.2	2.2	2.2	2.2	µm	±20 %
Blocking force**	>120	>300	>500	>2000	N	
Electrical capacitance***	25	75	250	1100	nF	±20 %
Axial resonant frequency****	>600	>600	>600	>600	kHz	
Piezo ceramic	PIC252	PIC252	PIC252	PIC252		
Operating voltage range	-20 to 100	-20 to 100	-20 to 100	-20 to 100	V	
Operating temperature range	-40 to 150	-40 to 150	-40 to 150	-40 to 150	°C	
Recommended preload for dynamic operation	15	15	15	15	MPa	
Maximum preload for constant force	30	30	30	30	MPa	
Recommended electronics	E-610, E-617, E-831, E-836	E-610, E-617, E-831, E-836	E-610, E-617, E-831, E-836	E-610, E-617, E-831, E-836		

Standard connections: PL0xx.31: PTFE-insulated stranded wires, UHV compatible, 100 mm, AWG 32, Ø 0.49 mm; PL0xx.30: Solderable contacts

* At 0 to 100 V. The values refer to the unattached component and can be lower when glued on.

** At 0 to 100 V

*** Measured at 1 V_{pp}, 1 kHz, RT

**** Measured at 1 V_{pp}, no load, unclamped. The value is halved for unilateral clamping. Depending on the installation situation, the lateral resonant frequencies can be lower than the axial resonant frequencies.

Ask about customized versions.

PICMA® Chip multilayer piezo actuators with and without inner hole

	PD050.3x	PD080.3x	PD120.3x	PD150.3x	PD160.3x	PD161.3x	Unit	Tolerance
Outer diameter (OD)	5 ±0.2	8 ±0.3	12 ±0.4	15 ±0.3	16 ±0.5	16 ±0.5	mm	
Inner diameter (ID)	2.5 ±0.15	4.5 ±0.15	6 ±0.2	9 ±0.15	8 ±0.25	–	mm	
Height (TH)	2.5 ±0.05	2.5 ±0.05	2.5 ±0.05	2 ±0.05	2.5 ±0.05	2.5 ±0.05	mm	
Travel range*	1.8	2	2	1.8	2	2.3	µm	±20 %
Blocking force**	>400	>1000	>2500	>3300	>4400	>6000	N	
Electrical capacitance***	110	300	900	1000	1700	2400	nF	±20 %
Axial resonant frequency****	>500	>500	>500	>600	>500	>500	kHz	
Piezo ceramic	PIC252	PIC252	PIC252	PIC252	PIC252	PIC252		
Operating voltage range	-20 to 100	-20 to 100	-20 to 100	-20 to 100	-20 to 100	-20 to 100	V	
Operating temperature range	-40 to 150	-40 to 150	-40 to 150	-40 to 150	-40 to 150	-40 to 150	°C	
Recommended preload for dynamic operation	15	15	15	15	15	15	MPa	
Maximum preload for constant force	30	30	30	30	30	30	MPa	
Recommended electronics	E-610, E-617, E-831, E-836	E-610, E-617, E-831, E-836	E-610, E-617, E-831, E-836	E-610, E-617, E-831, E-836	E-610, E-617, E-831, E-836	E-610, E-617, E-831, E-836		

Standard connections: PDxxx.31: PTFE-insulated stranded wires, UHV compatible, 100 mm, AWG 32, Ø 0.49 mm; PDxxx.30: Solderable contacts

* At 0 to 100 V. The values refer to the unattached component and can be lower when glued on.

** At 0 to 100 V

*** Measured at 1 V_{pp}, 1 kHz, RT

**** Measured at 1 V_{pp}, unloaded, unclamped. The value is halved for unilateral clamping. Depending on the installation situation, the lateral resonant frequencies can be lower than the axial resonant frequencies.

Ask about customized versions.

10.1.2 Maximum Ratings

PL0xx/PDxxx 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 values apply to unilaterally clamped piezo actuators and are calculated as follows: A third of the resonant frequency of the unloaded piezo actuator (operation when not clamped on both sides) divided by two.

- 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 **120 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.

- Maximum power consumption:

  Power consumption of the unloaded, uncooled piezo actuator that is operated at a voltage of **120 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
PL022.3x	-20 V to 100 V	100 kHz	290 Hz	0.1 W
PL033.3x	-20 V to 100 V	100 kHz	130 Hz	0.2 W
PL055.3x	-20 V to 100 V	100 kHz	80 Hz	0.4 W
PL088.3x	-20 V to 100 V	100 kHz	40 Hz	0.8 W
PD050.3x	-20 V to 100 V	83.3 kHz	160 Hz	0.3 W
PD080.3x	-20 V to 100 V	83.3 kHz	100 Hz	0.6 W
PD120.3x	-20 V to 100 V	83.3 kHz	50 Hz	0.9 W
PD150.3x	-20 V to 100 V	100 kHz	50 Hz	1.0 W
PD160.3x	-20 V to 100 V	83.3 kHz	40 Hz	1.3 W
PD161.3x	-20 V to 100 V	83.3 kHz	30 Hz	1.4 W

* The letter x in the product number of the piezo actuator stands for the model:

1: Models with stranded wires

0: Models without stranded wires

10.1.3 Compressive/Tensile Stress Capacity and Preload

Piezo ceramic withstands a pressure of up to 250 MPa but starts to depolarize at significantly lower compressive loads. Since stacked piezo actuators are also made of different materials (piezo ceramic, metallic electrodes), the mechanical load capacity does not depend solely on the strength of the ceramic material. Consideration must be given to additional parameters such as slenderness ratio, bending, tilt and homogeneity of the force application.

The tensile stress capacity of piezo actuators is just 5 to 10 % of the compressive load capacity. It is therefore recommended to mechanically preload the actuators. The preload should be chosen only as high as necessary.

Compressive/tensile stress capacity and preload of the PL0xx/PDxxx

Type of mechanical stress	PL0xx/PDxxx*
Maximum compressive load capacity	30 MPa
Maximum tensile stress capacity without preload	2 MPa**
Recommended preload for dynamic operation	15 MPa
Maximum preload for constant force	30 MPa

* 1 MPa corresponds to a pressure of 1 N per square millimeter of the base area of the piezo actuator. Dimensions see data table (p. 49).

** Depends on the strength of the glued connections (p. 26)

10.1.4 Ambient Conditions and Classifications

Pay attention to the following ambient conditions and classifications for the PL0xx/PDxxx:

Area of application	For indoor use only
Air pressure	500 hPa to 1500 hPa ➢ If you want to operate the PL0xx/PDxxx outside of the specified air pressure range, contact our customer service department (p. 47).
Relative humidity	Maximum relative humidity 55 % Continuous operation with high static voltage in humid environments significantly reduces piezo actuator lifetime. ➢ If you want to operate the PL0xx/PDxxx at a relative humidity of more than 55 %, contact our customer service department (p. 47). ➢ Pay attention to the information on service life, which can be found here: – "General Notes on Starting" (p. 31) section – Internet site of PI Ceramic (www.piceramic.com/piezo-technologie/picma.html)
Operating temperature	-40 °C to 150 °C
Storage temperature	-40 °C to 80 °C

Transport temperature	-40 °C to 80 °C
Overvoltage category	II
Degree of pollution	1

The PL0xx/PDxxx is intended for installation in devices that fulfill the following classifications:

Protection class	I
Degree of protection according to IEC 60529	IP20

10.2 Dimensions

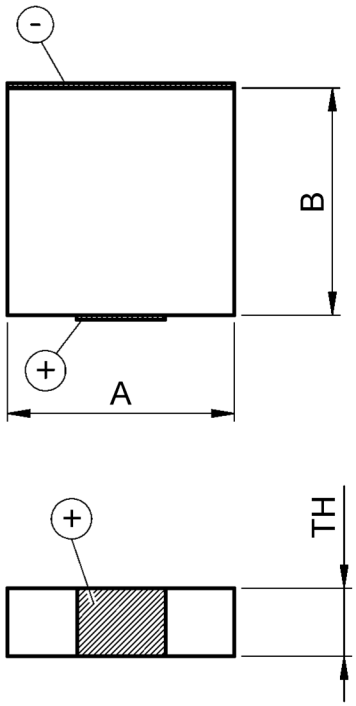


Figure 13: PL0xx: Dimensions

Model	Length A	Length B	Height TH	Unit
PL022.3x	2 (±0.10)	2 (±0.10)	2 (±0.10)	mm
PL033.3x	3 (±0.10)	3 (±0.10)	2 (±0.10)	mm
PL055.3x	5 (±0.15)	5 (±0.15)	2 (±0.10)	mm
PL088.3x	10 (±0.20)	10 (±0.20)	2 (±0.10)	mm

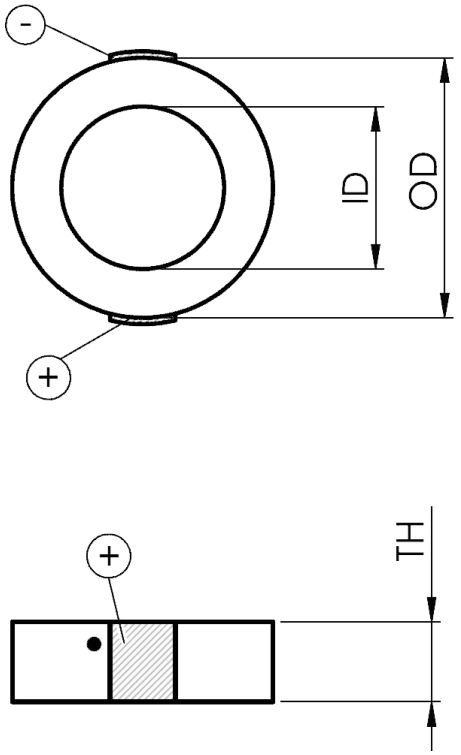


Figure 14: PDxxx: Dimensions (end surfaces of the piezo actuator lapped)

Model	Outer diameter OD	Inner diameter ID	Height TH	Unit
PD050.3x	5 (±0.2)	2.5 (±0.15)	2.5 (±0.05)	mm
PD080.3x	8 (±0.3)	4.5 (±0.15)	2.5 (±0.05)	mm
PD120.3x	12 (±0.4)	6 (±0.2)	2.5 (±0.05)	mm
PD150.3x	15 (±0.3)	9 (±0.15)	2 (±0.05)	mm
PD160.3x	16 (±0.5)	8 (±0.25)	2.5 (±0.05)	mm
PD161.3x	16 (±0.5)	–	2.5 (±0.05)	mm

11 Disposal

In accordance with EU law, electrical and electronic equipment may not be disposed of in EU member states via the municipal residual waste.

For disposal, observe the international, national, and local rules and regulations.

In order to fulfil the responsibility as the product manufacturer, PI Ceramic GmbH offers the environmentally correct disposal of PI products made available on the market after August 13, 2005, without charge.

Any product from PI Ceramic that is to be disposed of can be sent free of shipping costs to the following address:

PI Ceramic GmbH

Lindenstrasse

D-07589 Lederhose, Germany

12 EU Declaration of Conformity

An EU Declaration of Conformity was issued for the PL0xx/PDxxx in accordance with the following European directives:

RoHS Directive

The applied standards certifying the conformity are listed below.

RoHS: EN 50581 or EN IEC 63000

If an electrical operating device is designed to be integrated into another electrical operating device: The operator is responsible for standards compliant integration of the electrical device into the overall system.