

P-876 and P-878

DuraAct and DuraAct Power Patch Transducers

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User Manual

P876T0001, applies to P-876 and P-878
CBo, 07.07.2023



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About this Document

This document describes the following products (hereinafter referred to as "P-87x" or "patch transducer"; x stands for the respective model):

- P-876 DuraAct patch transducers
- P-878 DuraAct power patch transducers

This document also applies to custom products of the DuraAct and DuraAct Power product lines if nothing else is stated in their accompanying documentation. 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.

Symbols and Typographic Conventions

The following symbols and typographic conventions are used in this document:

DANGER



Immediate threat of danger!

Failure to comply could lead to death or serious injury.

- Measures for avoiding the risk.

CAUTION



Dangerous situation!

Failure to comply could lead to minor injury.

- Measures for avoiding the risk.

NOTICE



Dangerous situation

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

- Measures for avoiding the risk.

INFORMATION

Additional information that can affect your application.

Symbol/Label

1.

2.



p. 5

Meaning

Action consisting of several steps with strict sequential order

Action consisting of one or more steps without relevant sequential order

Lists

Cross-reference to page 5

Other Applicable Documents

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

Product	Document
E-413	PZ199E User Manual
E-503	PZ62E User Manual
E-504	PZ62E User Manual
E-505	PZ62E User Manual
E-506	PZ62E User Manual E506T0002 Technical Note
E-610	PZ70E User Manual
E-617	PZ201E User Manual
E-663	PZ69E User Manual
E-821	E821T0001 Technical Note
E-831	PZ151E User Manual PZ191E User Manual PZ235E User Manual
E-835	PZ211E User Manual
E-836	PZ250E User Manual E836T0001 Technical Note

Downloading Manuals

INFORMATION

If a manual is missing or problems occur with downloading:

- Contact our customer service department (p. 16).

Downloading manuals

1. Open the website **www.pi.ws**.
2. Search the website for the product number (e.g., P-876).
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 **ADD TO LIST** button for the desired manual and then click **REQUEST**.
6. Fill out the request form and click **SEND REQUEST**.
The download link will then be sent to the email address entered.

Safety

Intended Use

In accordance with its design, the P-87x is intended for integration into a mechanics and for the following applications:

- Actuator technology: The application of voltage creates a mechanical deformation in the P-87x (inverse piezoelectric effect)
- Sensor technology: Measuring the loads and/or electric voltage generated by push/pull forces occurring during mechanical deformation of the P-87x

Generally, integration into a mechanics is done by gluing the patch transducer to a structure.

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.

Depending on the design, the mechanical deformation will be as follows:

Model	Deformation
P-876	Longitudinal and transverse contraction (p. 9)
P-878	Longitudinal displacement caused by transverse contraction (p. 9)

To operate the P-87x as piezo actuator, suitable electronics are required that supply the required operating voltages. The electronics are not included in the scope of delivery of the P-87x. We recommend the use of suitable electronics (p. 9) from PI.

General Safety Information

The P-87x is built according to state-of-the-art technology and recognized safety standards. Improper use of the P-87x may result in personal injury and/or damage to the P-87x.

- Use the P-87x for its intended purpose only and when it is in perfect technical condition.
- Read the documentation.
- Eliminate any malfunctions that may affect safety immediately.

The operator is responsible for installing and operating the P-87x correctly.

Personnel Qualification

The patch transducer may only be installed, started, operated, maintained, and cleaned by authorized and appropriately qualified personnel.

- Follow general accident prevention rules!

Safety Precautions

Electrical Dangers

DANGER



Dangerous voltage in piezo actuators during operation!

Depending on the model, the P-87x is subject to voltages up to 1000 V during operation as piezo actuator. Touching the live parts of the P-87x can result in serious injury or death from electric shock.

- Do **not** touch the patch transducer during operation.
- Before startup, electrically insulate the solder joints of the patch transducer to protect against direct or indirect contact with live parts. Pay attention to both the clearance and creepage distances required for the operating voltage and the standards applicable to your application.

NOTICE



Excessively high or wrongly connected operating voltage!

Excessively high or wrongly connected operating voltages can cause damage to the P-87x.

- Do **not** exceed the specified operating voltage range of the P-87x (see "Specifications", p. 17).
- Operate the P-87x only when the operating voltage is properly connected (see "Electrical Contacting", p. 12).

NOTICE



Destruction of the patch transducer due to contamination!

If the patch transducer is contaminated with conductive materials (e.g., metal dust), it can be destroyed during operation by flashovers.

- Avoid contact of conductive materials (e.g., metal dust) with the electrodes (solder joints) of the patch transducer.

Mechanical Dangers

NOTICE



Destruction of the patch transducer due to mechanical overload!

DuraAct patch transducers are bendable (exception: patch transducers without a specified bending radius). Bending the patch transducer with an excessively low bending radius can mechanically overload the patch transducer. Mechanical overload leads to destruction of the patch transducer.

- Do **not** bend the patch transducer with a lower bending radius than stated in the specifications (p. 17).
- If a bending radius is not stated in the specifications: Avoid bending forces on the patch transducer.

NOTICE



Destruction of the patch transducer due to pull forces!

Excessive pull forces can destroy the piezo ceramic of the patch transducer.

- Avoid pull forces on the patch transducer >30 MPa.

NOTICE



Damage due to filing, grinding, and roughening!

The surface of the patch transducer consists of a polymer material that serves as electrical insulation and mechanical stabilization. Removing the surface material damages the patch transducer.

- Avoid filing, grinding, and roughening the surface of the patch transducer.

NOTICE



Damage due to moving stranded wires!

Mechanical stress (e.g., shear forces) on the soldered or connectors glued to the stranded wires could lead to damage to the patch transducer.

- Make sure that moving stranded wires are relieved of strain by using shrink tubing or fixing with adhesive.

Thermal Dangers

NOTICE



Destruction of the patch transducer due to overheating!

Overheating can destroy the patch transducer.

- Do **not** exceed the operating temperature range specified for the P-87x (see "Specifications", p. 17).

Product Description

Model Overview

The P-87x is available in the following versions:

Model	Description
P-876.A11	DuraAct patch transducer, 61 mm × 35 mm × 0.4 mm
P-876.A12	DuraAct patch transducer, 61 mm × 35 mm × 0.5 mm
P-876.A15	DuraAct patch transducer, 61 mm × 35 mm × 0.8 mm
P-876.SP1	DuraAct patch transducer, 16 mm × 13 mm × 0.5 mm
P-878.A1	DuraAct Power patch transducer, 27 mm × 9.4 mm × 0.6 mm

Product View

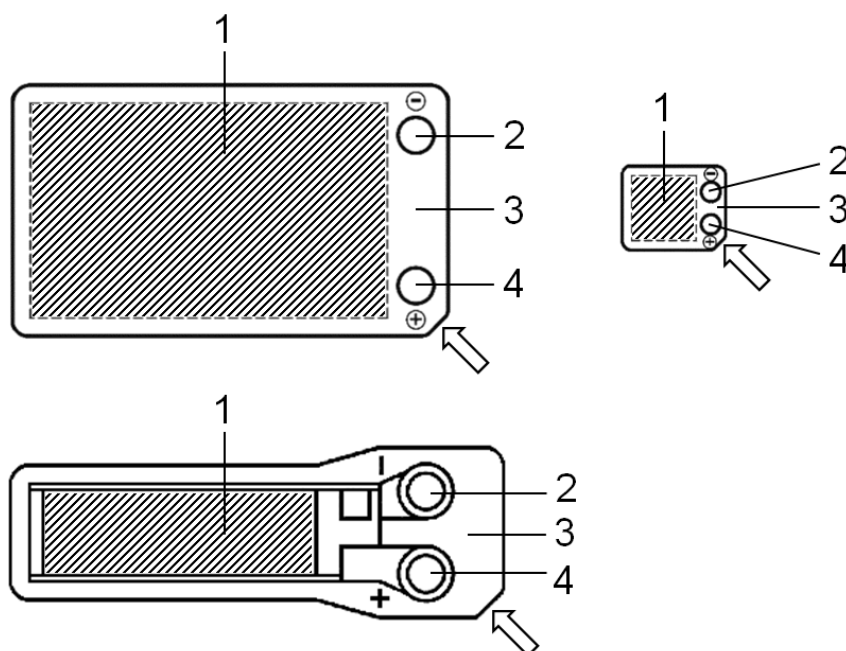


Fig. 1: P-876.A1x (top left), P-876.SP1 (top right) and P-878.A1 (bottom)

- 1 Active element (piezo ceramic; see hatched area)
- 2 Negative electrode (solder pad)
- 3 Base body (embedded in a polymer material)
- 4 Positive electrode (solder pad)

Arrow: Bevel marks the positive electrode

Direction of Mechanical Deformation

Mechanical Deformation of the P-876

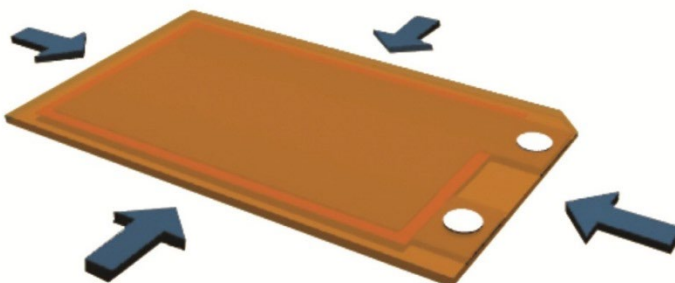


Fig. 2: Longitudinal and transverse contraction of P-876 when applying electrical voltage (in the direction of polarization)

Mechanical Deformation of the P-878

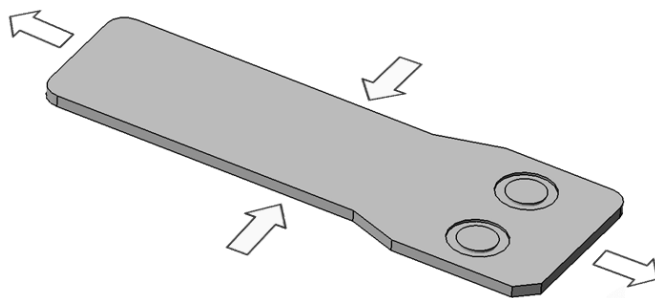


Fig. 3: Longitudinal expansion during transverse contraction of the P-878 after voltage is applied (in the direction of polarization)

Suitable Electronics

Suitable Electronics for the P-876

Product number	Description
E-413	Piezo amplifier for piezoceramic DuraAct patch transducers
E-821	Electronics module for energy harvesting
E-835	OEM piezo amplifier for DuraAct patch transducers

- To order, contact the customer service department (p. 16).

Suitable Electronics for the P-878

Product number	Description
E-503	Piezo amplifier module
E-504	High-power piezo amplifier module
E-505	Piezo amplifier module
E-506	Highly linear piezo amplifier module
E-610	Piezo amplifier
E-617	High-power piezo amplifier
E-663	Piezo amplifier
E-821	Electronics module for energy harvesting
E-831	Piezo amplifier
E-836	Piezo amplifier

- To order, contact the customer service department (p. 16).

Installation

General Notes on Installation

For gluing DuraAct patch transducers, it is possible to use epoxy resins as well as many other acrylate- and polyurethane-based glues. The choice of adhesive depends on the surface to be glued and the application conditions.

Gluing to Surfaces Made of Hard Materials (Metal, Glass, etc.)

Basically, a hard adhesive bond is beneficial when gluing to hard surfaces where the glass transition temperature (glass point) of the adhesive used needs to be above the operating temperature. According to experience, epoxy-based glues without filler have better properties on hard surfaces than those with filler.

Gluing to Surfaces Made of Composite Materials (GRP)

Ceramic-filled glues have proved to be reliable for gluing composite materials such as glass-fiber reinforced plastic (GRP). It is much easier to fill cavities in uneven surfaces.

Gluing on Flexible Surfaces (Polymers)

Gluing on flexible surfaces (e.g., PVC) and other polymers is particularly critical. Due to the complex surface chemistry, it is recommended to consult a specialist for adhesives.

Gluing the Patch Transducer to the Surface

CAUTION



Risk of electric shock after thermal hardening!

Thermal treatment to cure the adhesive can charge the P-87x electrically (pyroelectric effect). Touching the charged P-87x can result in minor injuries from electric shock.

- If possible, short-circuit the contacts of the patch transducer during thermal treatment.
- Do **not** touch live parts on the P-87x after thermal treatment.
- Discharge the P-87x with a 10 kΩ discharge resistor after thermal treatment.

NOTICE



Connecting a charged P-87x can destroy the electronics!

Thermal treatment to cure the adhesive can charge the P-87x electrically. Connecting a charged P-87x can destroy the electronics.

- Prior to connecting P-87x to the electronics, discharge the P-87x with a 10 kΩ discharge resistor after thermal treatment.

NOTICE



Damage due to overheating during thermal hardening!

Allowing the entire patch transducer to heat up to an operating temperature higher than recommended results in loss of mechanical preload for the embedded piezo ceramics and consequently destroys the patch transducer.

- Make sure that thermal treatment to harden the adhesive does **not** exceed temperatures of 150°C.

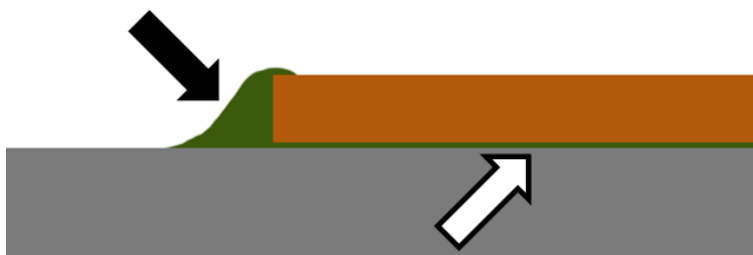


Fig. 4: Gluing a DuraAct patch transducer (sectional view): Complete wetting with adhesive on one side (black arrow) and adhesive layer between the patch transducer and the surface (white arrow)

Requirements

- ✓ You have read and understood the safety information and hazard warnings (p. 5 to p. 7).
- ✓ You have read and understood the user information from the manufacturer of the adhesive.
- ✓ The surfaces of the parts to be glued are dry and free of dust and grease.

Tools and accessories

- Suitable adhesive (see "General Notes on Installation", p. 10)

Gluing the patch transducer to the surface

1. If necessary, roughen the surface, on which the patch transducer is to be glued.
2. Apply the adhesive to the clean surfaces of the parts to be joined according to the instructions of the adhesive manufacturer:
 - Make sure that the adhesive is completely spread over the sides of the DuraAct patch transducer (see Fig. 4, p. 11) to ensure even force and signal input, and absorb peel and shear forces (e. g., on curved surfaces).
 - Avoid air pockets to ensure optimal performance of the glued patch transducer.
3. Glue the parts to each other according to the instructions of the adhesive manufacturer.
4. Wait until the adhesive has hardened completely.

Electrical Contacting

DuraAct patch transducers are equipped with electrodes where the outer end points are the solder pads, which consist of lead-free solder. The electrodes can make contact in one of the following ways:

- Soldering the stranded wires (p. 13)
- Gluing the stranded wires (p. 14)

For exact identification of the connections, it is recommended to use a red stranded wire for contacting the positive electrode and a black stranded wire for contacting the negative electrode.

Indicating the Polarity

The polarity is indicated by the plus and minus signs on the patch transducer or a bevel that marks the positive electrode (see "Product View", p. 8).

Soldering the Stranded Wires

NOTICE



Damage due to overheating of the patch transducer during soldering!

Overheating of the patch transducer leads to deformation that damages the patch transducer. Long and repeated soldering processes can cause damage to the electrode.

- The soldering temperature should not be any higher than necessary ($\leq 350^\circ\text{C}$).
- Make sure that the soldering time does **not** exceed 1 to 2 seconds.
- Allow the soldering point to cool down before resoldering.

INFORMATION

Any residual polymer on the electrodes resulting from the manufacturing process can impede wetting with solder.

- Roughen the electrodes carefully with a glass fiber brush or steel wool.

Requirements

- ✓ You have read and understood the safety information and hazard warnings (p. 5 to p. 7).

Tools and accessories

- Suitable stranded wires that meet the applicable standards for the conditions of use
- Suitable soldering iron
- Suitable lead-free solder: Sn 95.5, Ag 3.8, Cu 0.7
- Suitable flux according to one of the following standards:
 - DIN EN 29454, part 1, paragraph 1.1.1 or 1.2.3
 - ANSI J-STD-004, flux type ROL0 / ROM0
- Suitable cable tools

Soldering the stranded wires

1. Twist and tin the stripped end of the stranded wire. Shorten the tinned end to a length of 2 mm.

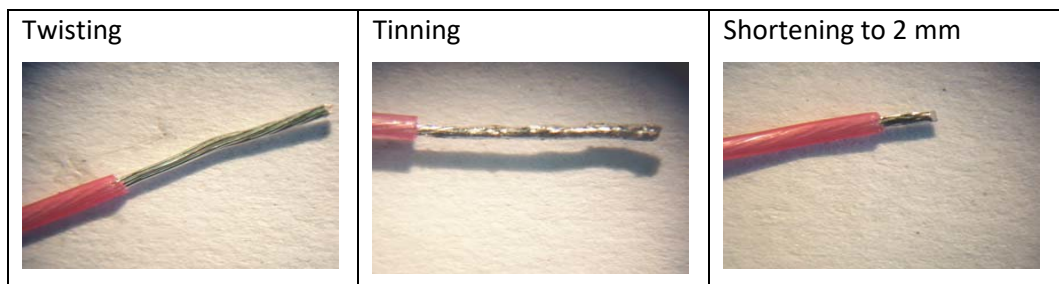


Fig. 5: Preparing the stranded wire

2. Apply the flux to the tinned end of the stranded wire and the soldering point provided for the electrode (solder pad).
3. Hold the stranded wire flat with the tinned end on the soldering point.

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 1 to 2 seconds so that the solder flows. The soldered joint must be flat or punctiform.

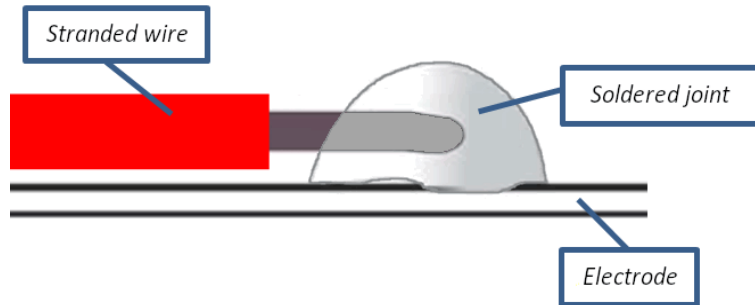


Fig. 6: Punctiform soldered joint (sectional view)

6. Repeat steps 1 to 5 for the second stranded wire.
7. Remove any residual flux with isopropyl alcohol.

Gluing the Stranded Wires

CAUTION



Risk of electric shock after thermal hardening!

Thermal treatment to cure the adhesive can charge the P-87x electrically (pyroelectric effect). Touching the charged P-87x can result in minor injuries from electric shock.

- If possible, short-circuit the contacts of the patch transducer during thermal treatment.
- Do **not** touch live parts on the P-87x after thermal treatment.
- Discharge the P-87x with a 10 kΩ discharge resistor after thermal treatment.

NOTICE



Connecting a charged P-87x can destroy the electronics!

Thermal treatment to cure the adhesive can charge the P-87x electrically. Connecting a charged P-87x can destroy the electronics.

- Prior to connecting P-87x to the electronics, discharge the P-87x with a 10 kΩ discharge resistor after thermal treatment.

NOTICE



Damage due to overheating during thermal hardening!

Allowing the entire patch transducer to heat up to an operating temperature higher than recommended results in loss of mechanical preload for the embedded piezo ceramics and consequently destroys the patch transducer.

- Make sure that thermal treatment to harden the adhesive does **not** exceed temperatures of 150°C.

INFORMATION

For optimal electrical contacting, it is recommended to use silver-plated stranded wires.

Requirements

- ✓ You have read and understood the safety information and hazard warnings (p. 5 to p. 7).
- ✓ You have read and understood the user information from 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 the 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 and untinned stranded wire to the electrode (solder pad):
 - a) Apply the thinnest possible layer of adhesive to the bonding surface 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 hardened completely.

Customer Service Department

For inquiries and orders, contact your PI sales engineer or send us an email (service@pi.de).

- If you have 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)
 - PC operating system (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 on our website (p. 4) for download.

Specifications

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

P-876 Data Table

	P-876.A11	P-876.A12	P-876.A15	P-876.SP1	Unit	Tolerance
Motion						
Min. lateral contraction	400	650	800	650	µm/m	
Rel. lateral contraction	1.6	1.3	0.64	1.3	µm/m/V	
Drive properties						
Operating voltage	-50 to 200	-100 to 400	-250 to 1000	-100 to 400	V	
Drive type	DuraAct	DuraAct	DuraAct	DuraAct		
Actuator type	Transducer	Transducer	Transducer	Transducer		
Piezo material	PIC255	PIC255	PIC255	PIC255		
Piezoceramic height	100	200	500	200	µm	
Electrical capacitance	150	90	45	8	nF	±20 %
Mechanical properties						
Min. bending radius	12	20	70	–	mm	
Blocking force	90	265	775	280	N	
Miscellaneous						
Operating temperature range	-20 to 150	-20 to 150	-20 to 150	-20 to 150	°C	
Connector	Solderable contacts	Solderable contacts	Solderable contacts	Solderable contacts		
Recommended electronics	E-413, E-821, E-835	E-413, E-821, E-835	E-413, E-821, E-835	E-413, E-821, E-835		

Customized versions or different specifications on request.

P-878 Data Table

	P-878.A1	Unit	Tolerance
Motion			
Min. axial strain	1200	μm/m	
Rel. axial strain	10	μm/m/V	
Min. lateral contraction	250	μm/m	
Rel. lateral contraction	1.2	μm/m/V	
Drive properties			
Operating voltage	-20 to 120	V	
Drive type	DuraAct		
Actuator type	Transducer		
Piezo material	PIC252		
Active element	15 mm × 5.4 mm		
Electrical capacitance	100	nF	±20 %
Mechanical properties			
Min. bending radius	24	mm	
Blocking force	44	N	
Miscellaneous			
Operating temperature range	-20 to 150	°C	
Connector	Solderable contacts		
Recommended electronics	E-503, E-504, E-505, E-506, E-610, E-617, E-663, E-821, E-831, E-836		

Electrical capacitance: measured at 1 V_{pp}, 1 kHz, RT.
Customized versions or different specifications on request.

Dimensions

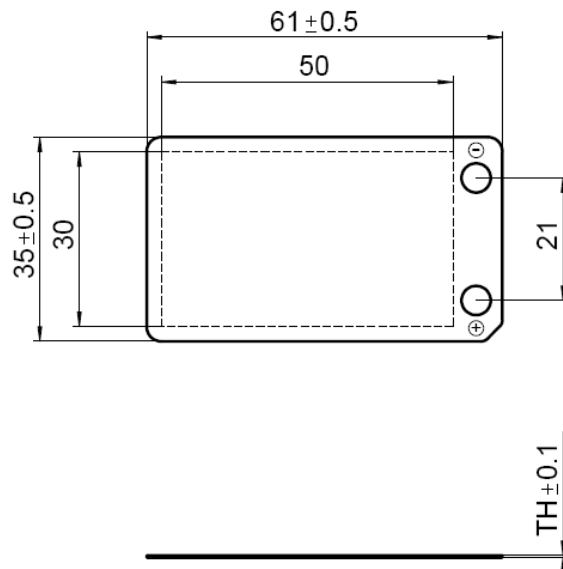


Fig. 7: P-876.A1x, dimensions in mm

Model	Height (TH)
P-876.A11	0.4 mm
P-876.A12	0.5 mm
P-876.A15	0.8 mm

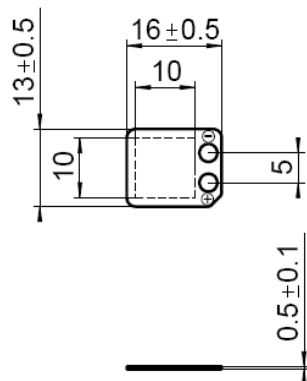


Fig. 8: P-876.SP1, dimensions in mm

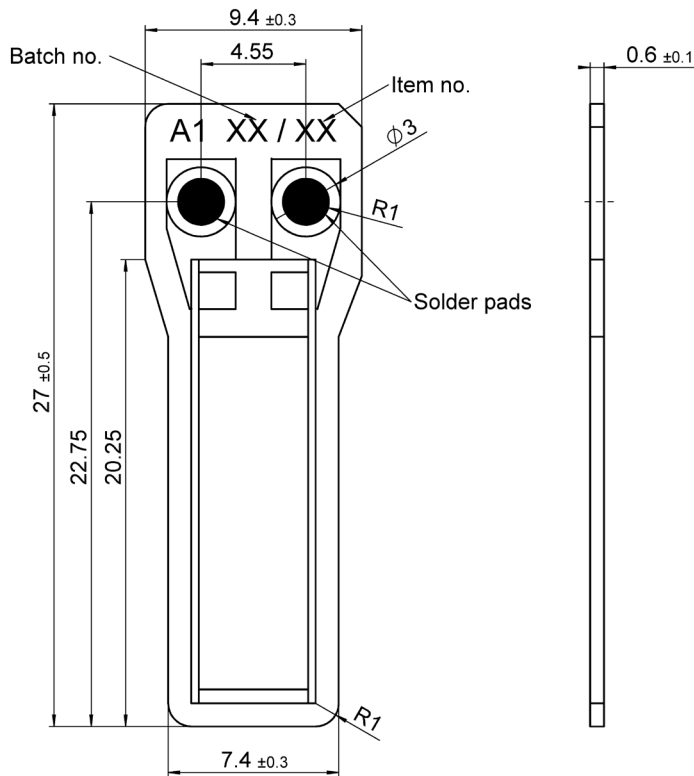


Fig. 9: P-878.A1, dimensions in mm

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 fulfill the responsibility as the product manufacturer, PI Ceramic GmbH undertakes environmentally correct disposal of all old PI equipment made available on the market after August 13, 2005 without charge.

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

PI Ceramic GmbH
Lindenstrasse
07589 Lederhose, Germany



EU Declaration of Conformity

For the P-876/P-878, an EU Declaration of Conformity has been issued in accordance with the following European directives:

RoHS Directive

The standards applied for certifying conformity are listed below.

RoHS: EN 50581

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.