

PZ276E
S-335 Tip/Tilt Platform
User Manual

Version: 1.2.0

Date: 23.08.2018



This document describes the following products:

- S-335.2SH
High-dynamics tip/tilt platform, 35 mrad,
strain gauge sensors, Sub-D connector
- S-335.2SHM1
High-dynamics tip/tilt platform, 35 mrad,
strain gauge sensors, Sub-D connector,
incl. mirror Ø 12.5 mm
- S-335.2SHM2
High-dynamics tip/tilt platform, 35 mrad,
strain gauge sensors, Sub-D connector,
incl. mirror Ø 25.4 mm



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The patents held by PI are found in our patent list: (<http://www.physikinstrumente.com/en/about-pi/patents>)

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Subject to change without notice. This manual is superseded by any new release. The latest release is available for download (p. 2) on our website.

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1 About this Document

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1.1 Objective and Target Audience of this User Manual

This user manual contains the information needed for the intended use of the S-335. Basic knowledge of servo systems, drive technologies, and suitable safety measures is assumed.

1.2 Symbols and Typographic Conventions

The following symbols and typographic conventions are used in this user manual:

CAUTION



Dangerous situation

If not avoided, the dangerous situation will result in minor injury.

- Actions to take to avoid the situation.

NOTICE



Dangerous situation

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

- Actions to take to avoid the situation.

INFORMATION

Information for easier handling, tricks, tips, etc.

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

1.3 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.

1.4 Other Applicable Documents

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

Product	Document
E-727.3SD/E-727.3SDA digital multi-channel piezo controllers for SGS	E727T0005 user documentation

The latest versions of the user manuals are available on our website for download (p. 2).

1.5 Downloading Manuals

INFORMATION

If a manual is missing or problems occur with downloading:

- Contact our customer service department (p. 43).

INFORMATION

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

You need the product CD to get the access data.

For products with CD: Get access data

1. Insert the product CD into the PC drive.
2. Switch to the Manuals directory on the CD.
3. In the Manuals directory, open the Release News (file including *releasenews* in the file name).
4. Get the access data for downloading protected content in the "User login for software download" section of the Release News. Possible methods for getting:
 - Link to a page for registering and requesting the access data
 - Direct input of user name and password
5. If the access data needs to be requested via a registration page:
 - a) Follow the link in the Release News.
 - b) Enter the required information in the browser window.
 - c) Click **Show login data** in the browser window.
 - d) Note the user name and password shown in the browser window.

Downloading manuals

If you have requested access data for protected contents via a registration page (see above):

- Click the links in the browser window to change to the content for your product and log in using the access data that you received.

General procedure:

1. Open the website www.pi.ws.
2. If access to the manuals is protected by a password:
 - a) Click **Login**.
 - b) Log in with the user name and password.
3. Click **Search**.
4. Enter the product number up to the period (e.g., P-882) or the product family (e.g., PICMA® Bender) into the search field.
5. Click **Start search** or press the key.

6. Open the corresponding product detail page in the list of search results:
 - a) If necessary: Scroll down the list.
 - b) If necessary: Click **Load more results** at the bottom of the list.
 - c) Click the corresponding product in the list.
7. Click the **Downloads** tab.

The manuals are shown under **Documentation**.
8. Click the desired manual and save it to the hard disk of your PC or to a data storage medium.

2 Safety

In this Chapter

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2.1 Intended Use

The S-335 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 S-335 is intended for precision positioning and alignment of a mirror in two orthogonal axes with a common pivot point (parallel kinematics). The S-335 can be mounted in any orientation. The S-335 is available with and without mirror. All models are equipped with strain gauge sensors (SGS).

The intended use of the S-335 is only possible in conjunction with suitable electronics (p. 12) available from PI. The electronics are not included in the scope of delivery of the S-335.

The electronics must provide the required operating voltages. To ensure proper performance of the servo control system, the electronics must also be able to read out and process the signals from the strain gauge sensors.

2.2 General Safety Instructions

The S-335 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 S-335.

- Only use the S-335 for its intended purpose, and only use it if it is in a good working order.
- Read the user manual.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for the correct installation and operation of the S-335.

2.3 Organizational Measures

User manual

- Always keep this user manual available with the S-335. The latest versions of the user manuals are available for download (p. 2) on our website.
- Add all information from the manufacturer to the user manual, for example supplements or technical notes.
- If you give the S-335 to other users, 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 S-335 after you have read and understood this user manual.

Personnel qualification

The S-335 may only be installed, started up, operated, maintained, and cleaned by authorized and appropriately qualified personnel.

3 Product Description

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3.1 Model Overview

Model	Description
S-335.2SH	High-dynamics tip/tilt platform, 35 mrad, strain gauge sensors, Sub-D connector
S-335.2SHM1	High-dynamics tip/tilt platform, 35 mrad, strain gauge sensors, Sub-D connector, incl. mirror Ø 12.5 mm
S-335.2SHM2	High-dynamics tip/tilt platform, 35 mrad, strain gauge sensors, Sub-D connector, incl. mirror Ø 25.4 mm

- For further technical data, see the specifications (p. 45).

3.2 Product View

The S-335.2SHM1 and S-335.2SHM2 models have a mirror. Details on the mirrors can be found under "Mirrors" (p. 14) and under "Dimensions" (p. 48).

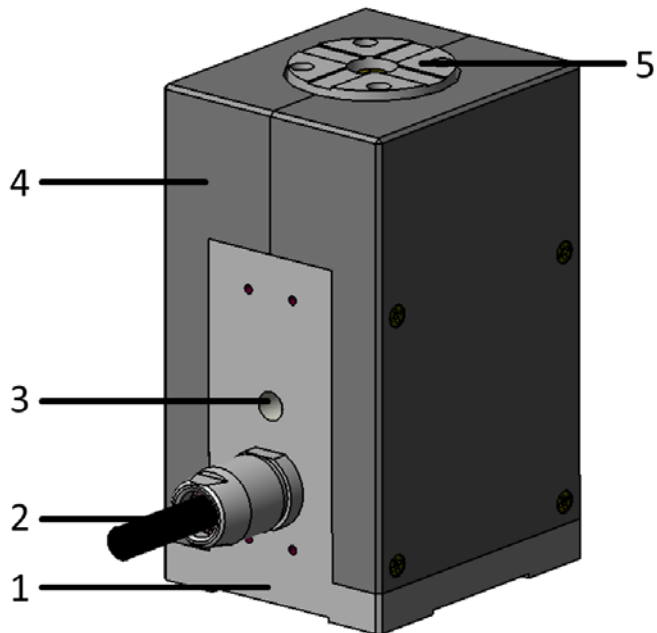


Figure 1: Product view of an S-335 tip/tilt platform

- 1 Base body
- 2 Cable exit
- 3 Protective earth connection
- 4 Housing
- 5 Motion platform

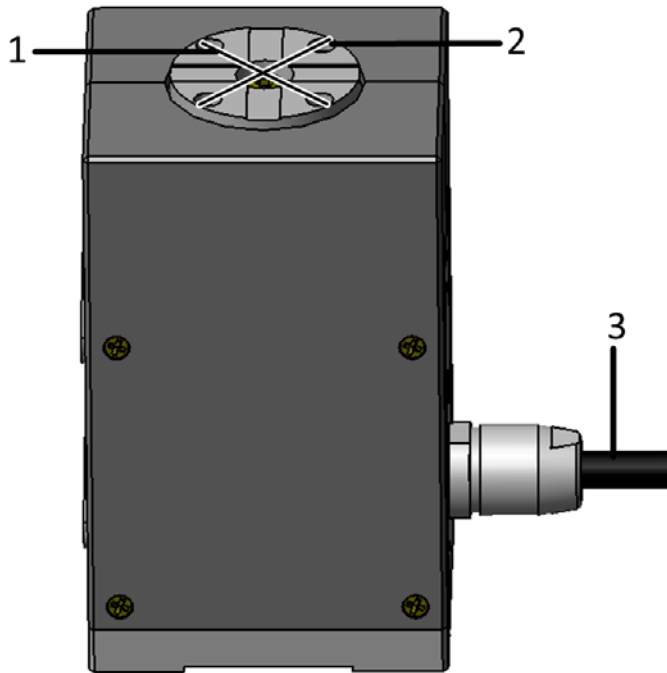


Figure 2: Alignment of the axes of the S-335 in relation to the cable exit

- 1 Axis 1 (corresponds to channel 1 on the E-727.3SD/A controller)
- 2 Axis 2 (corresponds to channel 2 on the E-727.3SD/A controller)
- 3 Cable exit

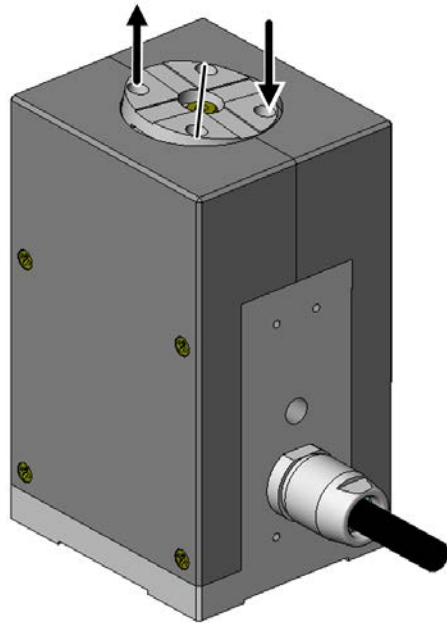


Figure 3: Maximum displacement in the positive direction of motion around axis 1. The output voltage U_{piezo} at channel 1 of the amplifier connected is 120 V. The displacement shown is strongly exaggerated for better understanding.

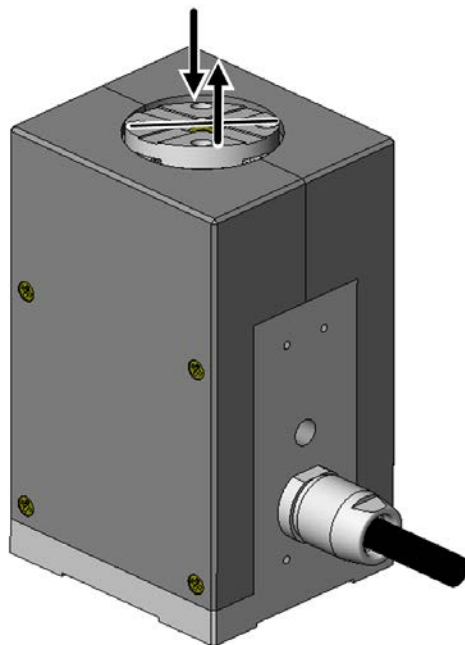


Figure 4: Maximum displacement in the positive direction of motion around axis 2. The output voltage U_{piezo} at channel 2 of the amplifier connected is 120 V. The displacement shown is strongly exaggerated for better understanding.

3.3 Product Labeling

Labeling	Description
S-335.2SH	Product name
116010244	Serial number (example), individual for each S-335 Meaning of the places (counting from left): 1 = internal information, 2 and 3 = year of manufacture, 4 to 9 = consecutive numbers
	Manufacturer's logo
Country of origin: Germany	Country of origin
	Warning sign "Observe manual!"
	Old equipment disposal (p. 53)
	CE conformity mark
WWW.PI.WS	Manufacturer's address (website)
	Symbol for the protective earth conductor, marks the protective earth connection of the S-335 (p. 30)

Labeling of the Sub-D 37 connector (m)



Figure 5: Sub-D 37 connector (m) on the connecting cable of the S-335



Warning sign "Residual Voltage": Indicates risk of electric shock (p. 5)

3.4 Scope of Delivery

Item number	Components
S-335	Tip/tilt platform according to order
-	Protective cover made of plastic (POM)
000036450	M4 screw set for protective earth, consisting of: <ul style="list-style-type: none"> ▪ 1 flat-head screw with cross recess, M4x8, ISO 7045 ▪ 2 safety washers ▪ 2 flat washers
PZ277EK	Printed short instructions for S-3xx piezo tip/tilt platforms

3.5 Suitable Controllers

Controller
E-727.3SD Digital multi-channel piezo controller, 3 axes, -30 to 130 V, strain gauge sensors, Sub-D 37 socket
E-727.3SDA Digital multi-channel piezo controller, 3 axes, -30 to 130 V, strain gauge sensors, Sub-D 37 socket, analog inputs

- To order, contact our customer service department (p. 43).

3.6 Control

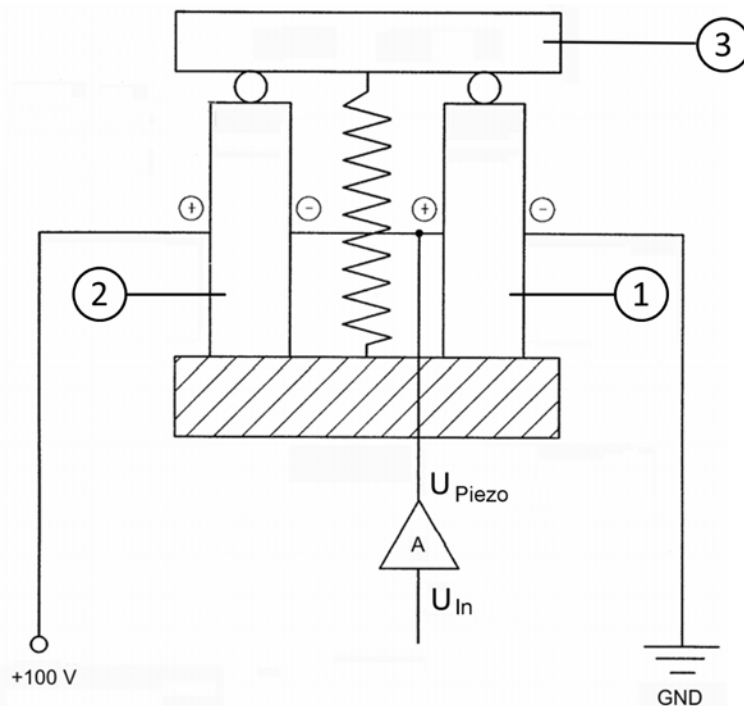


Figure 6: Differential drive of the tip/tilt platform, functional principle using the tilting of a single axis as an example

- 1 Piezo actuator 1 of the axis
- 2 Piezo actuator 2 of the axis
- 3 Motion platform

The S-335 is a tip/tilt platform with differential piezo drive. Four piezo actuators are interconnected in pairs to realize tip/tilt motions on two axes.

Both pairs of actuators are electrically switched so that when piezo voltage U_{piezo} is changed, the voltage is increased to one actuator of a pair while the voltage to the other actuator is decreased by the same amount. The actuator with the increased voltage expands while the other actuator with the decreased voltage contracts. This produces the tip/tilt motion.

For a simplified representation of the functional principle, only one axis is shown in the figure above. The motion platform is shown with a tilt of 0° .

When the control input voltage U_{in} increases, piezo actuator 1 expands and piezo actuator 2 contracts. This produces a tilt in the positive direction.

Because of the way they are interconnected, both actuator pairs always move in opposite directions. It is therefore impossible to command linear motions in the Z axis.

The position of the Z axis can change with temperature fluctuations, however: Due to the symmetrical design of the tip/tilt platform, temperature fluctuations do not cause the motion platform to tilt but cause the length of the piezo actuators to change evenly in the direction of the Z axis.

Most applications are not very sensitive to such deviations as long as the tip/tilt angle does not change.

Each of the four piezo actuators of the S-335 is equipped with a strain gauge sensor. Therefore, in addition to the amplifier channel, a servo loop with a sensor channel must be available for each actuator pair.

3.7 Mirror

The S-335.2SHM1 and S-335.2SHM2 models are each equipped with a factory-mounted mirror that have the following characteristics:

S-335.2SHM1

- Diameter 12.5 mm
- 3 mm thickness

S-335.2SHM2

- Diameter 25.4 mm
- 4 mm thickness

Other common characteristics

- Surface accuracy $\lambda/10$
- Surface quality 20-10
- Parallelism 30 arc seconds

However, these three characteristics can be influenced by gluing to the tip/tilt platform. Therefore, deviations to the mirror characteristics specified here are possible after gluing.

3.8 Dynamic Behavior

The maximum operating frequency of a piezo tip/tilt platform depends on the following factors:

- Bandwidth of amplifier, controller, and sensor
- Resonant frequency of the tip/tilt platform including mirror and where appropriate, mirror holder

The resonant frequency is estimated in two steps:

- a) Calculating the moments of inertia for mirror and mirror holder (p. 15)
- b) Calculating (p. 18) resonant frequency of the tip/tilt platform including mirror and mirror holder.

3.8.1 Calculating Moments of Inertia for Mirror and Mirror Holder

Calculating the distance from the axis through the center of gravity of the mirror to the rotational axis

Before the moment of inertia of the mirror is calculated, it is necessary to calculate the distance from the axis through the center of gravity of the mirror to the rotational axis of the platform. When a mirror holder is used, it must be included in the calculation.

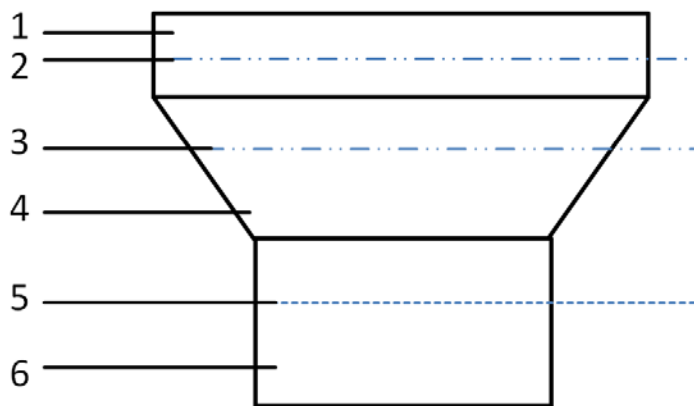


Figure 7: Example diagram: Platform with mirror holder and mirror

- 1 Mirror
- 2 Axis through the center of gravity of the mirror
- 3 Axis through the center of gravity of the mirror holder
- 4 Mirror holder (example of a geometry)
- 5 Axis through the pivot point of the platform of the S-335 ("rotational axis")
- 6 Platform

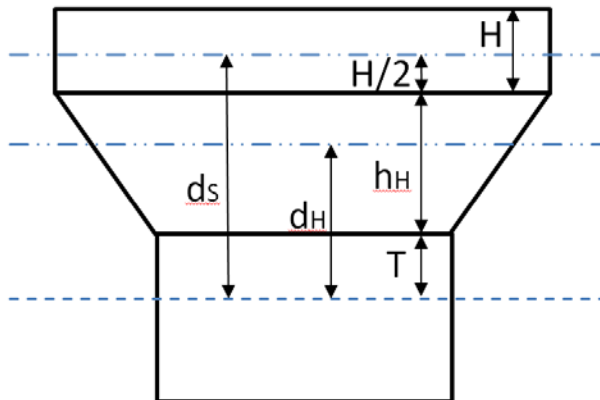


Figure 8: Example diagram: Platform with mirror holder and mirror; here with variables required for calculating the moments of inertia

- d_S Distance from the axis through the center of gravity of the mirror to the rotational axis
- d_H Distance from the axis through the center of gravity of the mirror holder to the rotational axis
- $H/2$ Half the mirror thickness
- h_H Thickness of the mirror holder
- T Distance from the rotational axis to the platform surface (see "Data Table" (p. 45))
- H Mirror thickness

Formula for calculating the distance from the axis through the center of gravity of the mirror to the rotational axis of the platform:

When a mirror is attached without a mirror holder:

$$d_S = \frac{H}{2} + T$$

When a mirror is attached with a mirror holder:

$$d_S = \frac{H}{2} + h_H + T$$

with:

d_S = Distance from the axis through the center of gravity of the mirror to the rotational axis [mm]

H = Mirror thickness [mm]

h_H = Thickness of the mirror holder [mm]

T = Distance from the rotational axis to the platform surface [mm], see "Data Table" (p. 45)

Calculating the moment of inertia of the mirror

Formula for calculating the moment of inertia of a rotationally symmetric mirror:

$$I_{S,P} = m_S \left[\frac{3R^2 + H^2}{12} + d_S^2 \right]$$

Formula for calculating the moment of inertia of a rectangular mirror:

$$I_{S,P} = m_S \left[\frac{L^2 + H^2}{12} + d_S^2 \right]$$

with:

$I_{S,P}$ = Moment of inertia of the mirror, in relation to the rotational axis [$\text{g} \cdot \text{mm}^2$]

m_S = Mirror mass [g]

R = Mirror radius [mm]

L = Mirror length perpendicular to the rotational axis [mm]

H = Mirror thickness [mm]

d_S = Distance from the axis through the center of gravity of the mirror to the rotational axis [mm]; for calculation see separate formulas (p. 15)

Calculating the moment of inertia of the mirror holder

$$I_{H,P} = I_H + m_H * (d_H)^2$$

with:

$I_{H,P}$ = Moment of inertia of the mirror holder, in relation to the rotational axis [$\text{g} \cdot \text{mm}^2$]

I_H = Moment of inertia of the mirror holder, dependent on the geometry of the mirror holder [$\text{g} \cdot \text{mm}^2$]

m_H = Mass of the mirror holder [g]

d_H = Distance from the axis through the center of gravity of the mirror holder to the rotational axis of the platform [mm], see above illustration (p. 15)

3.8.2 Calculating the Resonant Frequency of the Tip/Tilt Platform

Mirror without mirror holder

When the mirror is mounted without a mirror holder, the resonant frequency of the system is calculated with the following formula:

$$f' = \frac{f_0}{\sqrt{1 + \frac{I_{S,P}}{I_0}}}$$

with:

f' = Resonant frequency of the S-335 with mirror [Hz]

f_0 = Resonant frequency of the unloaded S-335 [Hz]; see "Data Table" (p. 45)

I_0 = Moment of inertia of the platform of the S-335 [$g \cdot mm^2$], see "Data Table" (p. 45)

$I_{S,P}$ = Moment of inertia of the mirror, in relation to the rotational axis, [$g \cdot mm^2$]; calculation see separate formulas (p. 17)

Mirror with mirror holder

When the mirror is mounted with a mirror holder, the resonant frequency of the tip/tilt platform is calculated with the following formula:

$$f' = \frac{f_0}{\sqrt{1 + \frac{(I_{S,P} + I_{H,P})}{I_0}}}$$

with:

f' = Resonant frequency of the S-335 with mirror and mirror holder [Hz]

f_0 = Resonant frequency of the unloaded S-335 [Hz], see "Data Table" (p. 45)

I_0 = Moment of inertia of the platform of the S-335 [$g \cdot mm^2$], see "Data Table" (p. 45)

$I_{S,P}$ = Moment of inertia of the mirror, in relation to the rotational axis, [$g \cdot mm^2$]; for calculation see separate formulas (p. 17)

$I_{H,p}$ = Moment of inertia of the mirror holder, in relation to the rotational axis, [$\text{g}\cdot\text{mm}^2$];
calculation see separate formula (p. 17)

Further information on dynamic or static operation can be found in the PI catalog (CAT 130), in the section "Fundamentals of Piezo Technology". The catalog can be downloaded from our website <http://www.pi.ws> under Service > Downloads > Catalogs, Brochures & Certificates.

4 Unpacking

NOTICE



Mechanical overload from incorrect handling!

Impermissible mechanical overload of the motion platform of the S-335 can cause damage to the piezo actuators, sensors, and flexures of the S-335 as well as loss of accuracy.

- Ship the S-335 in the original packaging only.
- Touch the base body of the S-335 on the outside only.

INFORMATION

The S-335 is delivered with a protective cover.

For models with mirror:

- To avoid scratching the mirror surface during mounting, it is recommended not to remove the protective cover before mounting (p. 32).

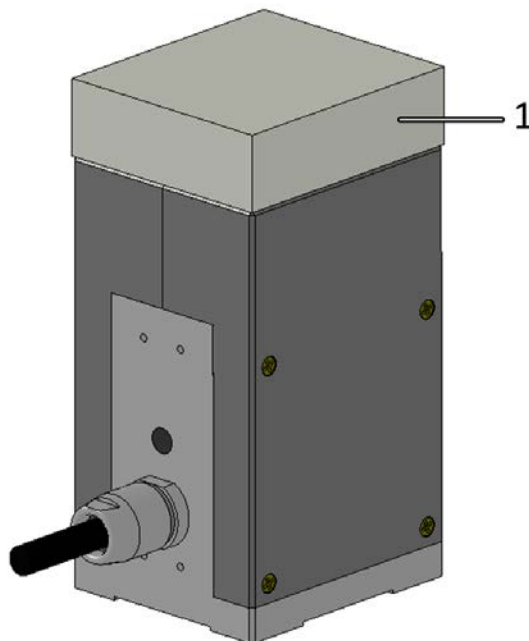


Figure 9: S-335 with protective cover, identical for all models

- 1 Plastic cover (POM) for protecting during transit

1. Unpack the S-335 with care.
2. Compare the contents with the items listed in the contract and the packing list.
3. Inspect the contents for signs of damage. If there is any sign of damage or missing parts, contact PI immediately.
4. Keep all packaging materials in case the product needs to be returned.

5 Installation

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5.1 General Notes on Installation

CAUTION



Dangerous voltage and residual charge in piezo actuators!

The S-335 is driven by piezo actuators. Temperature changes and compressive stresses can induce charges in piezo actuators. After disconnection from the electronics, piezo actuators can remain charged for several hours. Touching or short-circuiting the contacts in the connector of the S-335 can lead to minor injuries from electric shock. The piezo actuators can be destroyed by an abrupt contraction.

- Do not open the S-335.
- Discharge the piezo actuators of the S-335 before installation:
Connect the S-335 to the switched-off PI controller, which is equipped with an internal discharge resistor.
- Do not pull the connector out of the electronics during operation.



Touching the contacts in the connector can lead to an electric shock (max. 120 V DC) and minor injuries.

- Do not touch the contacts in the connector.
- Use the screws to secure the connector of the S-335 against being pulled out of the controller.

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

Using the S-335 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 S-335 in environments that can increase the electric conductivity.
- Only operate the S-335 within the permissible ambient conditions and classifications (p. 47).

NOTICE**Destruction of the piezo actuator due to short-circuiting without a discharge resistor!**

When a charged piezo actuator is short-circuited without a discharge resistor, this can lead to a contraction shock and thus to the destruction of the piezo ceramic.

- Only discharge the S-335 according to the instructions in "Discharging S-335" (p. 37).

NOTICE**Damage when the mirror is removed!**

The following applies to models with mirror: The mirror of the S-335 may only be replaced by PI. Otherwise, the S-335 can be damaged.

- Do not remove the mirror of the S-335.
- If you need a different mirror, contact our customer service department (p. 43).

NOTICE**Warping of the S-335 due to mounting on uneven surfaces!**

Mounting the S-335 on an uneven surface can warp the S-335. Warping reduces the accuracy.

- Mount the S-335 onto an even surface. The recommended flatness of the surface is $\leq 30 \mu\text{m}$.
- For applications with large temperature changes:
Only mount the S-335 on surfaces that have the same or similar thermal expansion properties as the S-335.

NOTICE**Damage due to unsuitable cables!**

Unsuitable cables can damage the S-335 and the electronics.

- Only use cables provided by PI for connecting the S-335 to the electronics.

5.2 Mounting the Mirror on the S-335.2SH

The mirror can be glued to the motion platform of the S-335.

If the mirror is glued directly to the motion platform, the interchangeability of the mirror will depend on the adhesive used.

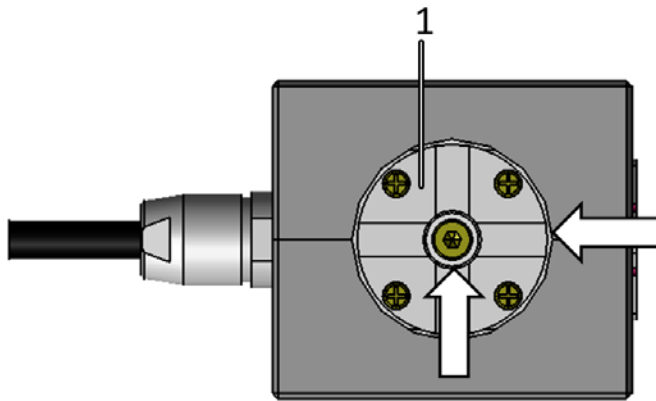


Figure 10: Glue the mirror to the S-335

1 Motion platform

Arrows: Adhesive may not penetrate into the slots

NOTICE



Impermissibly high forces and torques!

Impermissibly high forces and torques that are applied to the motion platform can damage the S-335.

- Avoid high forces and torques on the motion platform when mounting the mirror.

NOTICE**Reduced positioning accuracy due to improper mounting!**

Improper mounting can reduce the positioning accuracy of the tip/tilt platform.

- Avoid overtightening the mirror:
 - To glue the mirror, choose an adhesive that hardens at room temperature and contracts as little as possible during drying and hardening. Recommendation: Two-component adhesive made of epoxy resin that hardens in 24 hours at a temperature above 25 °C and is resistant to shearing forces.
 - In the case of applications with large temperature changes: Make sure that the mirror and, if necessary, the mirror holder have the same or similar thermal expansion properties as the motion platform of the S-335 (material of the platform: titanium).
- Make sure that adhesive does not penetrate into the following:
 - Between the motion platform and the housing of the S-335
 - Into the hole in the middle of the motion platform, see figure above.

INFORMATION

Recommended characteristics of the mirror:

- Diameter: 25.4 mm (1")
- Thickness: 5 mm
- Material: Glass, e.g., borosilicate crown glass (BK7), whose moment of inertia matches the application (for details, see "Dynamic Behavior" (p. 14)), and whose thermal expansion coefficient is almost the same as titanium.

INFORMATION

The following aids are recommended for gluing the mirror:

- Suitable template for applying the adhesive
- Suitable centering aid for aligning the mirror

For examples, see figures below.

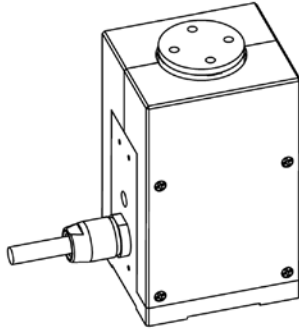


Figure 11: Example: S-335 with template for applying the adhesive to the four points

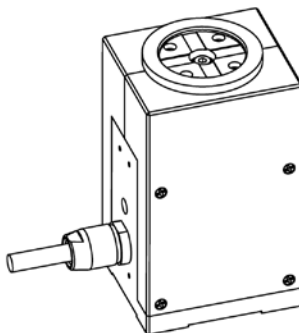


Figure 12: Example: S-335 with centering aid for aligning the mirror

Requirements

- ✓ You have read and understood the general notes on installation (p. 23).
- ✓ The S-335 is not connected to the electronics.

Tools and accessories

- Suitable mirror, see above and "Dynamic Behavior" (p. 14)
- Suitable adhesive, see note above
- Optional:
 - Suitable template for applying the adhesive to four points
 - Suitable centering aid for aligning the mirror

- Cotton swab
- Isopropyl alcohol
- Powder-free gloves

Gluing the mirror to the S-335

1. Clean the motion platform of the S-335 with a cotton swab and isopropyl alcohol.
2. Apply the adhesive to the motion platform:
 - a) If you use a template: Align the centering aid on the motion platform of the S-335 carefully and fix the template appropriately.
 - b) Apply a small amount of adhesive to four suitable points or between the four template recesses on the motion platform. Only apply a pinhead-sized amount to each point
 - c) If you use a template: Remove the template.
3. Affix the mirror to the motion platform:
 - a) If you use a centering aid: Carefully align the centering aid on the S-335 and affix it appropriately.
 - b) Align the mirror appropriately or use the centering aid and place it carefully onto the motion platform of the S-335. Avoid touching the mirror surface.
 - c) Carefully and briefly press the mirror onto the motion platform with a cotton swab.
 - d) If necessary, remove the adhesive residue with a cotton swab and isopropyl alcohol.
 - e) Allow the adhesive to harden according to the instructions of the adhesive manufacturer.
 - f) If you use a centering aid: Remove the centering aid.

5.3 Mounting the S-335

You have two options for mounting the S-335:

- Mounting holes on the bottom
- Mounting holes on the side

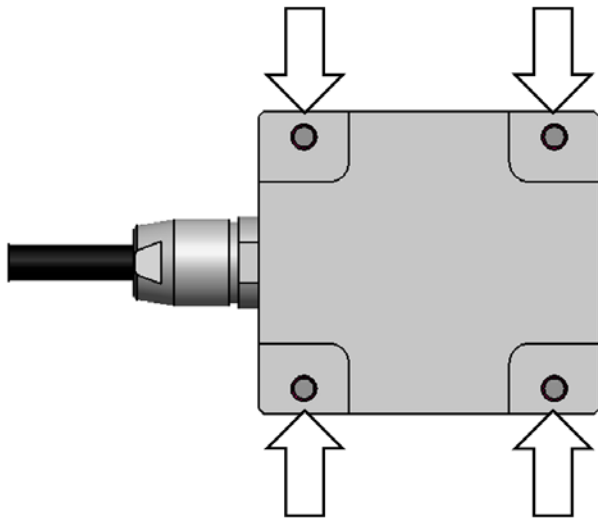


Figure 13: M2.5 holes in the bottom of the S-335 for mounting onto a surface

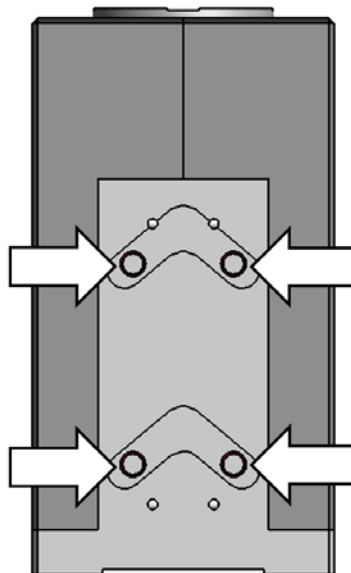


Figure 14: M2.5 holes in the side of the S-335 for mounting onto a suitable area

Requirements

- ✓ You have read and understood the general notes on installation (p. 23).
- ✓ The S-335 is not connected to the electronics.
- ✓ You have accounted for the space required to route cables without bending and according to regulations.

Tools and accessories


- For the dimensions of the S-335 and the position and depth of the M2.5 holes, see "Dimensions" (p. 48).
- You have provided a suitable mounting surface:
 - Four through-holes for M2.5 screws are provided.
 - The flatness of the mounting surface is $\leq 30 \mu\text{m}$.
- 4 M2.5 screws of suitable length (p. 48)
- Suitable tools

Mounting the S-335

1. Align the S-335 on the mounting surface so that the M2.5 holes in the S-335 and mounting surface overlap.
2. Insert the four screws through the holes in the mounting surface in the base body of the S-335.
Make sure that any dirt or particles on the screws cannot get into the S-335.
3. Tighten the four screws.
 - Maximum torque: 0.6 Nm
 - Maximum screw-in depth: 4 mm
4. Check that the S-335 is affixed firmly.

5.4 Connecting the S-335 to the Protective Earth Conductor**INFORMATION**

- Observe the applicable standards for connecting the protective earth conductor.

The S-335 has an M4 hole for mounting the protective earth conductor. This hole is marked with the symbol for the protective earth conductor  (see "Dimensions" (p. 48)).

Requirements

- ✓ You have read and understood the general notes on installation (p. 23).
- ✓ The S-335 is not connected to the electronics.

Tools and accessories

- Suitable protective earth conductor: Cross-sectional area of the cable $\geq 0.75 \text{ mm}^2$
- Supplied M4 protective earth screw set (p. 12) for connecting the protective earth conductor
- Suitable screwdriver

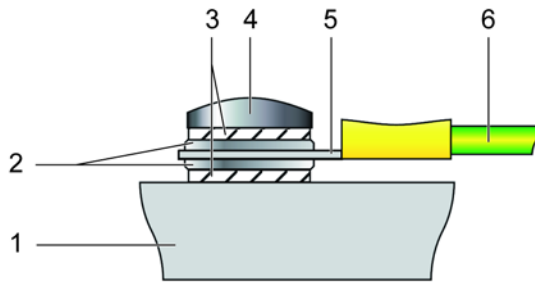


Figure 15: Connecting the protective earth conductor (profile view)

- 1 Base body of the S-335
- 2 Flat washer
- 3 Safety washer
- 4 Screw
- 5 Cable lug
- 6 Protective earth conductor

Connecting the S-335 to the protective earth conductor

1. If necessary, attach a suitable cable lug to the protective earth conductor.
2. Use the M4 screw (together with the washers and self-locking washers) to affix the cable lug of the protective earth conductor to the protective earth connection of the S-335 as shown in the profile view.
3. Tighten the M4 screw with a torque of 1.2 Nm to 1.5 Nm.
4. Make sure that the contact resistance at all connection points relevant for connecting the protective earth conductor is $<0.1 \Omega$ at 25 A.

5.5 Removing the Transport Safeguard

The S-335 is delivered with a protective cover.

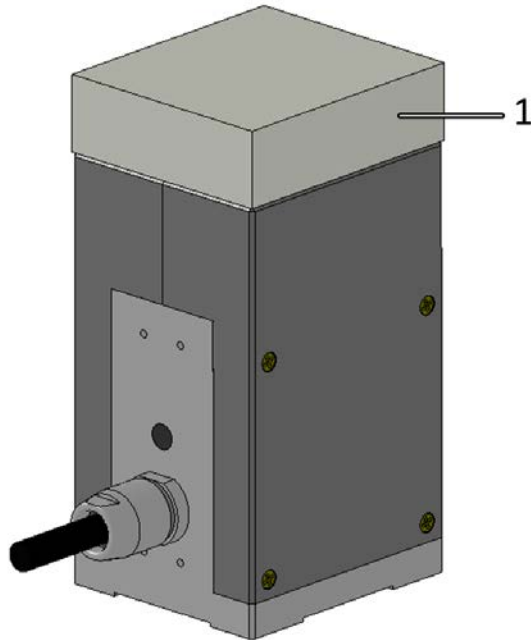


Figure 16: S-335 with protective cover, identical for all models

- 1 Plastic cover (POM) for protecting during transit

Requirements

- ✓ You have mounted the S-335.

Removing the protective cover

1. Remove the protective cover carefully.
2. Keep the protective cover in case the product needs to be transported later.

5.6 Connecting the S-335 to the Controller

Requirements

- ✓ You have read and understood the general notes on installation (p. 23).
- ✓ You have installed a suitable controller (p. 12).

- ✓ You have read and understood the user manual of the controller.
- ✓ The controller is switched off.

Connecting the S-335 to the controller E-727.3SD

1. Plug the connector of the S-335 into the corresponding socket of the controller (see user manual of the controller).
2. Use the integrated screws to secure the connection against accidental disconnection.

6 Startup and Operation

In this Chapter

General Notes on Startup and Operation.....	35
Operating the S-335.....	36
Discharging the S-335.....	37

6.1 General Notes on Startup and Operation

CAUTION



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

If a protective earth conductor is not or not properly connected, dangerous touch voltages can occur on the S-335 in the case of malfunction or failure of the system. If touch voltages exist, touching the S-335 can result in minor injuries from electric shock.

- Before startup, establish contact between the S-335 and the protective earth conductor.
- Do not remove the protective earth conductor during operation.
- Make sure that the contact resistance at all connection points relevant for mounting the protective earth conductor is $<0.1 \Omega$ at 25 A.
- If the protective earth conductor has to be temporarily removed (e.g., for modifications), reconnect the S-335 to the protective earth conductor before starting it up again.

NOTICE



Destruction of the piezo actuator due to electric flashovers!

Using the S-335 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 S-335 in environments that can increase the electric conductivity.
- Only operate the S-335 within the permissible ambient conditions and classifications (p. 47).

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

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

- When the S-335 is not in use but the electronics remain switched on to ensure temperature stability, discharge the S-335 (p. 37).

NOTICE**Damage due to startup with transport safeguard!**

If the transport safeguard has not been removed before startup, the mirror can collide with the transport safeguard. Collisions can cause damage to the mirror.

- Remove the transport safeguard before you start up the S-335 (p. 32).

INFORMATION

S-335 and controller systems are calibrated at the factory to achieve optimum performance according to the specifications (p. 45).

- Set the dynamic servo control parameters if the application requires it (see controller manual).

INFORMATION

Sound and vibration (e.g., footfall, knocks) can be transmitted to the S-335 and can affect its performance with regard to position stability.

- Avoid sound and vibration while the S-335 is being operated.

INFORMATION

The expansion of the piezo actuators depends on the ambient temperature and can vary by up to 10 % in the given temperature ranges (p. 47).

6.2 Operating the S-335

Requirements

- ✓ You have read and understood the general notes on startup and operation (p. 35).
- ✓ You have read and understood the user manual of the controller.
- ✓ You have properly installed the S-335 (p. 23).
- ✓ The controller and the required PC software have been installed. All connections with the controller have been established (see user manual of the controller).

Operating the S-335

- Follow the instructions in the manual for the electronics (p. 12) used for startup and operation of the S-335.

6.3 Discharging the S-335

The S-335 must be discharged in the following cases:

- Before installation
- If the S-335 is not used and the controller remains switched on to ensure temperature stability
- Before demounting (e.g., before cleaning and transporting the S-335 and for modifications)

The S-335 is discharged via the internal discharge resistor of the controller from PI.

Discharging an S-335 that is connected to the controller

In closed-loop operation:

1. Switch off the servo mode on the controller.
2. Set the piezo voltage to 0 V on the controller.

In open-loop operation:

- Set the piezo voltage to 0 V on the controller.

Discharging an S-335 that is not connected to the controller

- Connect the S-335 to the switched-off controller from PI.

7 Maintenance

In this Chapter

General Notes on Maintenance.....	39
Cleaning the S-335	39
Preparing the S-335 for Transport.....	40

7.1 General Notes on Maintenance

NOTICE



Misalignment due to loosening screws!

The S-335 is maintenance-free and achieves its positioning accuracy as a result of the optimum alignment of mechanical components and piezo actuators. Loosened screws cause a loss in positioning accuracy.

- Only loosen screws according to the instructions in this manual.
- Do not open the S-335.

NOTICE



Damage when the mirror is removed!

The following applies to models with mirror: The mirror of the S-335 may only be replaced by PI. Otherwise, the S-335 can be damaged.

- Do not remove the mirror of the S-335.
- If you need a different mirror, contact our customer service department (p. 43).

7.2 Cleaning the S-335

NOTICE



Damage due to incorrect cleaning!

The mirror of the S-335 can be damaged from applying force during cleaning.

- Only clean the mirror when actually necessary.
- Avoid exerting any force on the mirror during cleaning.
- Do not use compressed air.

Requirements

- ✓ You have discharged the piezo actuators of the S-335 (p. 37).
- ✓ You have disconnected the S-335 from the controller.

Tools and accessories

- Bellows
- Optic brush

Cleaning the S-335

- Clean the surfaces and the mirror of the S-335 with bellows and/or an optic brush without exerting force.
- Do not use compressed air for cleaning.
- Do not do any ultrasonic cleaning.

7.3 Preparing the S-335 for Transport

NOTICE**Mechanical overload from incorrect handling!**

Impermissible mechanical overload of the motion platform of the S-335 can cause damage to the piezo actuators, sensors, and flexures of the S-335 as well as loss of accuracy.

- Ship the S-335 in the original packaging only.
- Touch the base body of the S-335 on the outside only.

Accessory

- Cover for protection during transit (p. 21)

Preparing the S-335 for transport

- Place the protective cover carefully onto the motion platform (p. 21).

8 Troubleshooting

Problem	Possible causes	Solution
No or uncontrolled motion	<ul style="list-style-type: none"> ▪ Cable not connected correctly ▪ Controller defective ▪ Cable defective ▪ Piezo ceramic defective after electric flashover 	<ul style="list-style-type: none"> ➤ Check the cable connections (p. 32). ➤ Contact our customer service department (p. 43).
Reduced accuracy	Warped base body	<p>Only mount the S-335 on surfaces with the following characteristics:</p> <ul style="list-style-type: none"> ▪ Flatness of at least 30 μm ▪ The thermal expansion properties are similar to those of the S-335 (e.g., surfaces made of steel)
	Adhesive has run into the middle hole or between the motion platform and the housing of the S-335	<ul style="list-style-type: none"> ➤ Contact our customer service department (p. 43).
	Mirror with mirror mount was replaced	<p>The change of the mass that has to be moved by the S-335 influences the dynamic characteristics such as the resonant frequency of the tip/tilt platform.</p> <ul style="list-style-type: none"> ➤ Adjust the notch filter and servo control parameters of the controller, (see controller manual).
	Operating temperature outside of the permissible range (p. 45)	<ul style="list-style-type: none"> ➤ Contact our customer service department (p. 43).

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. 43).

9 Customer Service

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

- If you have questions concerning your system, have the following information ready:
 - Product and serial numbers of all products in the system
 - Firmware version of the controller (if available)
 - Version of the driver or the software (if available)
 - Operating system on the PC (if available)
- 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. 2) on our website.

10 Technical Data

In this Chapter

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10.1 Specifications

10.1.1 Data Table

	S-335.2SH*	S-335.2SHM1**	S-335.2SHM2***	Unit	Tolerance
Active axes	θ_x, θ_y	θ_x, θ_y	θ_x, θ_y		
Motion and positioning					
Integrated sensor	SGS	SGS	SGS		
Tip/tilt angle, closed loop (static motion at 0 to 120 V)	± 17.5	± 17.5	± 17.5	mrad	
Resolution, open loop	0.1	0.1	0.1	μ rad	typ.
Resolution, closed loop	1.0	1.0	1.0	μ rad	typ.
Linearity	0.05 (unidirectional)	0.05 (unidirectional)	0.05 (unidirectional)	%	typ.
Repeatability	1 (bidirectional)	1 (bidirectional)	1 (bidirectional)	μ rad	typ.
Mechanical properties					
Resonant frequency, no load	2	-	-	kHz	± 20 %
Resonant frequency, under load, with \varnothing 12.5 mm \times 3 mm quartz glass mirror	1.6	1.6	-	kHz	± 20 %
Resonant frequency, under load, with \varnothing 25.4 mm \times 4 mm quartz glass mirror	0.7	-	0.7	kHz	± 20 %
Gap between the center of rotation and platform surface	3.3	3.3	3.3	mm	± 0.25 mm
Drive properties					
Ceramic type	PICMA® P-885	PICMA® P-885	PICMA® P-885		
Electrical capacitance per axis	6.2	6.2	6.2	μ F	± 20 %

	S-335.2SH*	S-335.2SHM1**	S-335.2SHM2***	Unit	Tolerance
Miscellaneous					
Operating temperature range	-20 to 80	-20 to 80	-20 to 80	°C	
Material platform	Titanium	Titanium	Titanium		
Mass (with cable and connector)	320	325	330	g	±5 %
Cable length	2	2	2	m	+100 mm / -0 mm
Sensor/voltage connection	Sub-D 37 (m)	Sub-D 37 (m)	Sub-D 37 (m)		
Recommended electronics	E-727	E-727	E-727		

* 2SH version without mirror

** 2SHM1 version with mirror Ø 12.5 mm




*** 2SHM2 version with mirror Ø 25.4 mm

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

The specifications apply to 21 °C ±10 °C. The specifications can deviate outside of this range. If you have any questions, contact your PI representative.

10.1.2 Maximum Ratings

The S-335 is designed for the following operating data:

Maximum operating voltage 	Maximum Operating Frequency ¹ 	Maximum power consumption ² 
-20 to +120 V	S-335.2SH ³ : 0.67 kHz S-335.2SHM1: 0.53 kHz S-335.2SHM2: 0.23 kHz	17 W/axis

¹ To ensure stable operation, the maximum operating frequency has been defined as around one third of the mechanical resonant frequency. To calculate the resonant frequency of the system of S-335 and mirror, see "Dynamic Behavior" (p. 14).

² The heat that is generated by the piezo actuator during dynamic operation limits the value for maximum power consumption.

Details can be found at the following website:

<http://piceramic.com/piezo-technology/properties-piezo-actuators/electrical-operation.html>

³ without load

10.1.3 Ambient Conditions and Classifications

The following ambient conditions and classifications for the S-335 must be observed:

Area of application	For indoor use only
Maximum altitude	2000 m
Air pressure	1100 hPa to 0.1 hPa
Relative humidity	Highest relative humidity 80 % for temperatures up to 31 °C Decreasing linearly to 50 % relative humidity at 40 °C
Storage temperature	–20 °C to 80 °C
Transport temperature	–25 °C to 85 °C
Overvoltage category	II
Protection class	I
Degree of pollution	1
Degree of protection according to IEC 60529	IP20

10.2 Dimensions

10.2.1 S-335.2SH

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

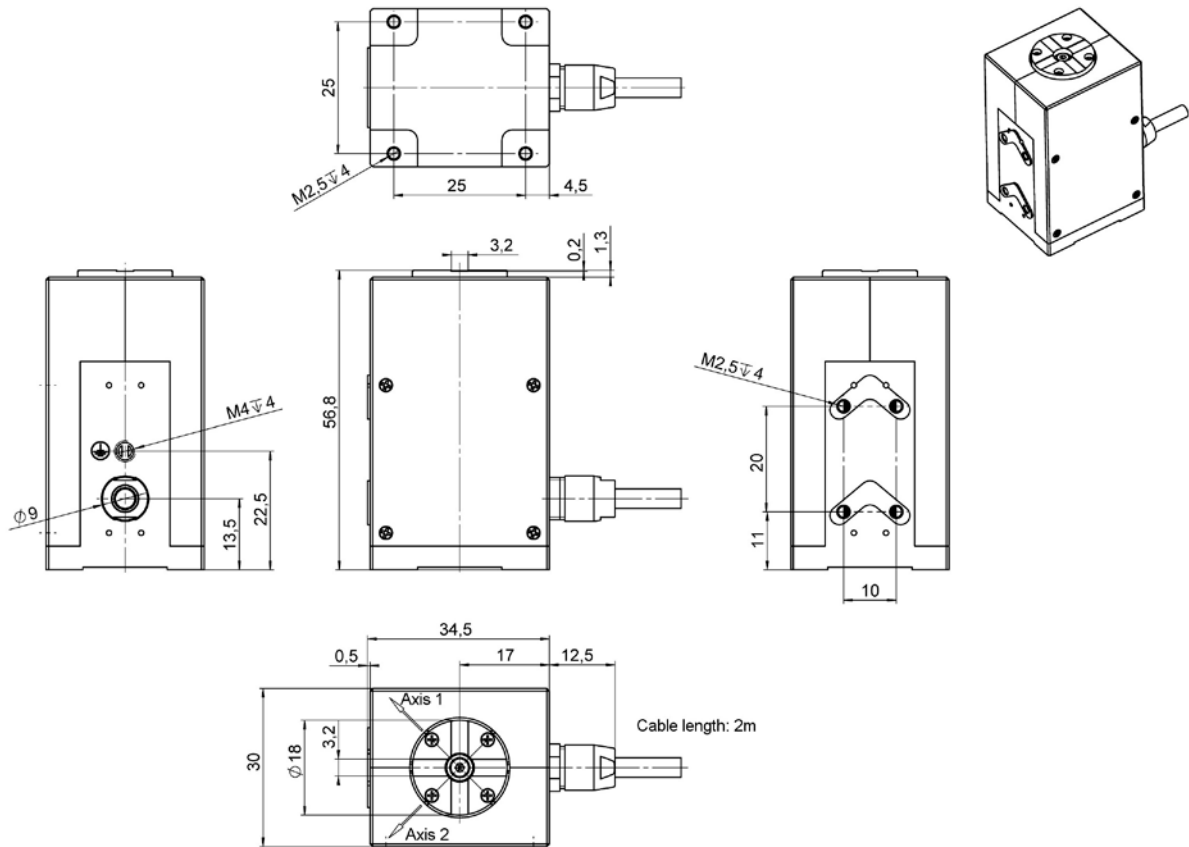


Figure 17: S-335.2SH

10.2.2 S-335.2SHM1

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

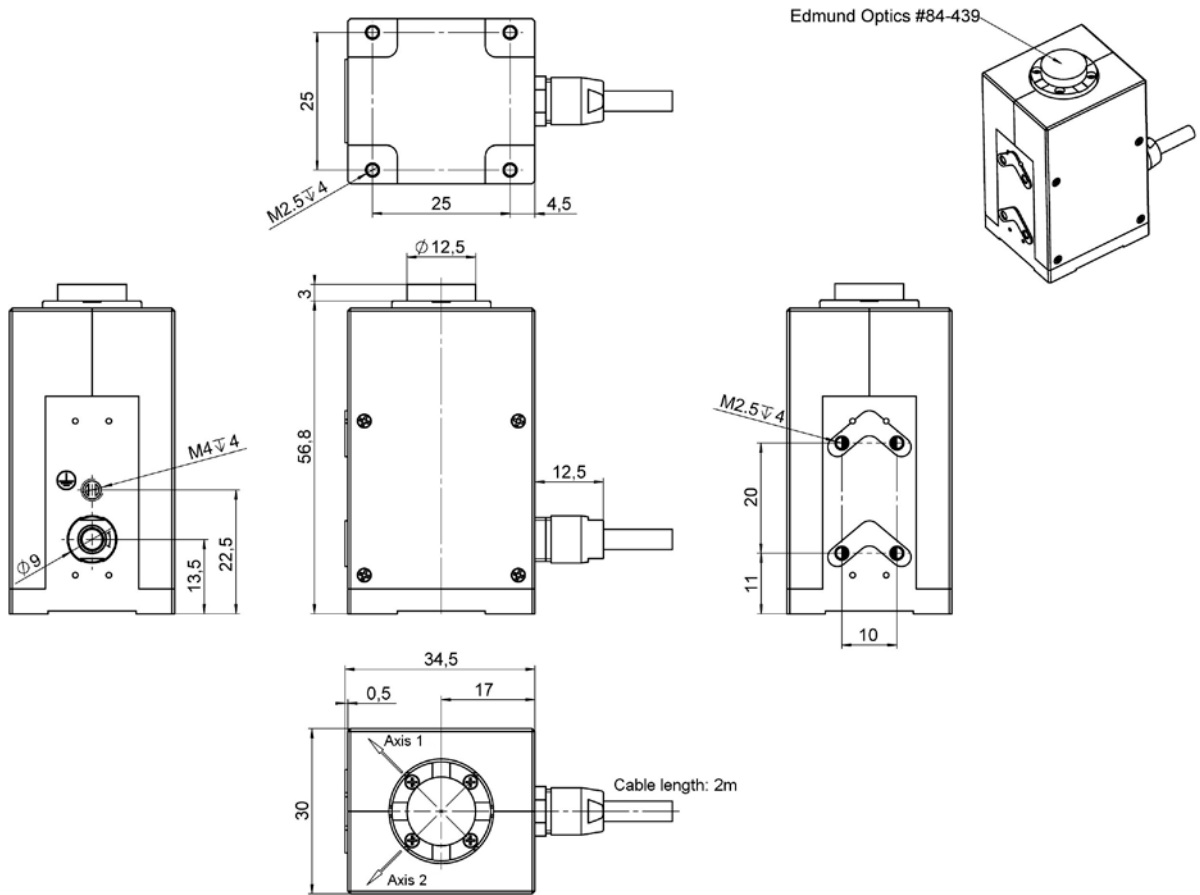


Figure 18: S-335.2SHM1

10.2.3 S-335.2SHM2

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

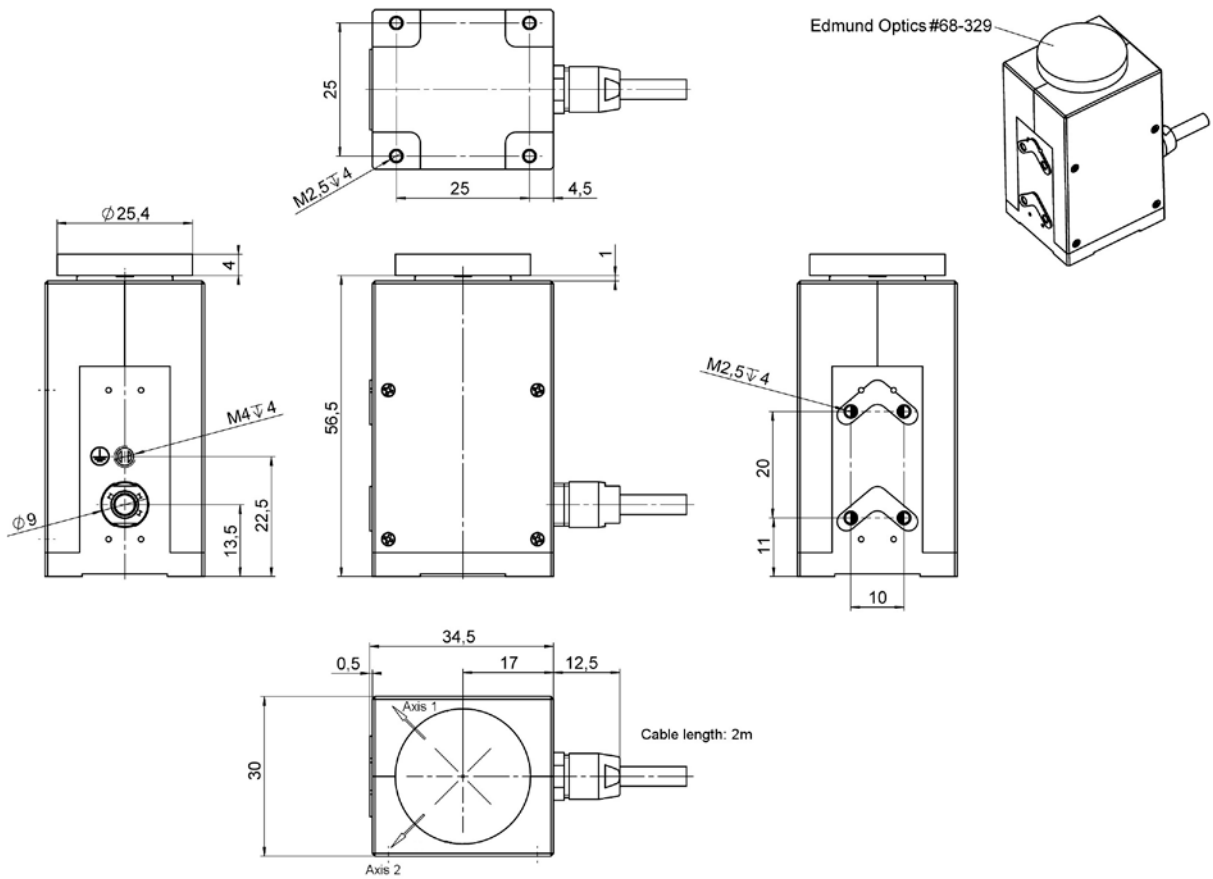


Figure 19: S-335.2SHM2

10.3 Pin Assignment



Figure 20: Sub-D 37 (m) piezo and sensor connection

Pin	Signal*	Function
1	-	-
2	GND	Ground
3	Reserved	Reserved for ID chip
4	-	-
5	Reserved	Reserved for ID chip
6	-	-
7	GND	Ground
8	-	-
9	GND	Ground
10	SGS CH2+	SGS signal axis 2 (positive)
11	GND	Ground
12	CH1+ SGS	SGS signal axis 1 (positive)
13	GND	-
14	Reserved	Reserved
15	Reserved	Reserved
16	Piezo CH1+	Piezo voltage, axis 1 (positive)
17	Piezo CH2+	Piezo voltage, axis 2 (positive)
18	Piezo CH3+	100 V fixed voltage
19	-	-
20	-	-
21	Reserved	Reserved for ID chip
22	Reserved	Reserved for ID chip
23 to 27	-	-
28	SGS CH2-	SGS signal axis 2 (negative)
29	SGS CH2 Ref	SGS reference axis 2

Pin	Signal*	Function
30	SGS CH1-	SGS signal axis 1 (negative)
31	SGS CH1 Ref	SGS reference axis 1
32	Reserved	Reserved
33	Reserved	Reserved
34	Piezo CH1-	Piezo voltage, axis 1 (negative)
35	Piezo CH2-	Piezo voltage, axis 2 (negative)
36	Piezo CH3-	Ground 100 V fixed voltage
37	-	-

* The "-" sign indicates that the corresponding pin has not been assigned.

11 Old Equipment Disposal

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

Dispose of your old equipment according to international, national, and local rules and regulations.

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

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

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



12 EU Declaration of Conformity

For the S-335, an EU Declaration of Conformity has been issued in accordance with the following European directives:

Low Voltage Directive

EMC Directive

RoHS Directive

The applied standards certifying the conformity are listed below.

Safety (Low Voltage Directive): EN 61010-1

EMC: EN 61326-1

RoHS: EN 50581

