

PZ276E
S-335 Tip/Tilt Platform
User Manual

Version: 1.3.0

Date: 01.03.2024



This document describes the following products:

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



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 This manual is superseded by any new release.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

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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 required for using the S-335 as intended.

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
Failure to comply could result in minor injuries.

- Precautions to avoid the risk.

NOTICE




Dangerous situation
Failure to comply could result in damage to the equipment.

- Precautions to avoid the risk.

INFORMATION

Information for easier handling, tricks, tips, etc.

Symbol/ Label	Meaning
1. 2.	Action consisting of several steps with strict sequential order
➤	Action consisting of one or more steps without relevant sequential order.
▪	Bullet point
p. 5	Cross-reference to page 5
RS-232	Label on the product indicating an operating element (example: RS-232 interface socket)
	Warning signs on 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 separate 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. 39).

Downloading manuals

1. Open the website **www.pi.ws**.
2. Search the website for the product number (e.g., S-335).

3. In the search results, select the product to open the product detail page.
4. Select **Downloads**.

The manuals are shown under **Documentation**. Software manuals are shown under **General Software Documentation**.

5. For the desired manual, select **ADD TO LIST** and then **REQUEST**.
6. Fill out the request form and select **SEND REQUEST**.

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

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. 11) 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 of the S-335 may result in personal injury and/or damage to the S-335.

- Use the S-335 for its intended purpose only, and only when it is in perfect condition.
- Read the user manual.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for installing and operating the S-335 correctly.

2.3 Organizational Measures

User manual

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

Personnel qualification

The S-335 may only be installed, started, 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, D-sub connector
S-335.2SHM1	High-dynamics tip/tilt platform, 35 mrad, strain gauge sensors, D-sub connector, incl. mirror Ø 12.5 mm
S-335.2SHM2	High-dynamics tip/tilt platform, 35 mrad, strain gauge sensors, D-sub connector, incl. mirror Ø 25.4 mm

- Refer to the specifications (p. 41) for further technical data.

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. 13) and under "Dimensions" (p. 45).

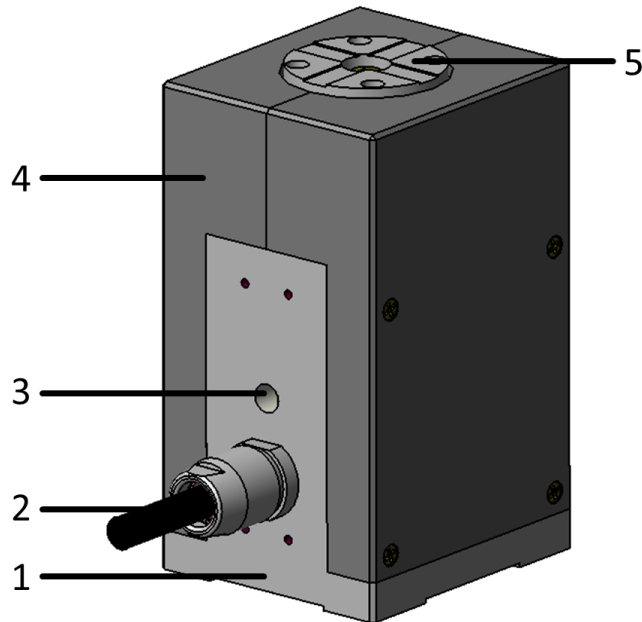


Figure 1: Product view of an S-335 tip/tilt platform

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

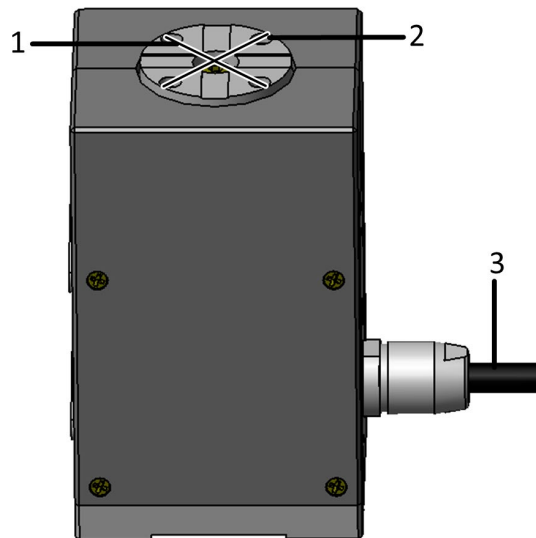


Figure 2: Alignment of the axes of the S-335 in relation to the cable exit

- 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

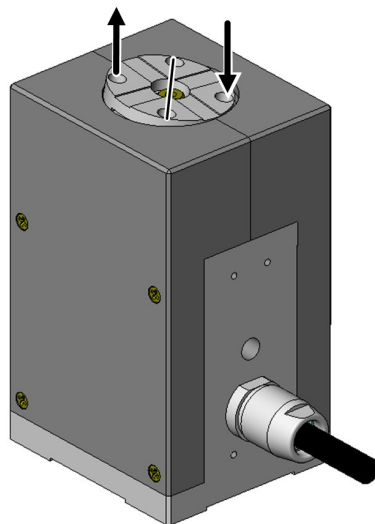


Figure 3: Maximum displacement in the positive direction of motion around axis 1. The output voltage U_{Piezo} at channel 1 of the amplifier connected is 120 V. The displacement shown is strongly exaggerated for better understanding.

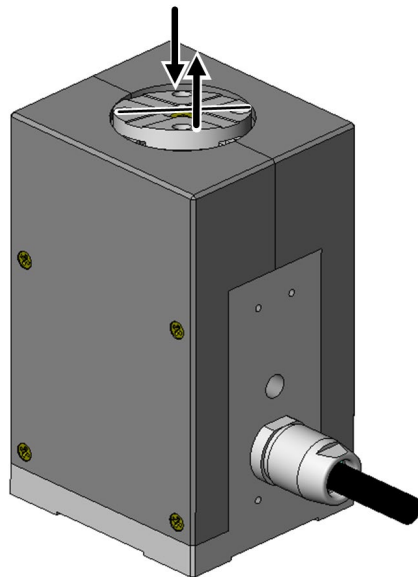


Figure 4: Maximum displacement in the positive direction of motion around axis 2. The output voltage U_{Piezo} at channel 2 of the amplifier connected is 120 V. The displacement shown is strongly exaggerated for better understanding.

3.3 Product Labeling

Labeling	Description
S-335.2SH	Product name
116010244	Serial number (example), individual for each S-335 Meaning of each position (from the left): 1 = internal information, 2 and 3 = year of manufacture, 4 to 9 = consecutive number
PI	Manufacturer's logo
Country of origin: Germany	Country of origin
⚠	Warning sign "Pay attention to the manual!"
♻	Old equipment disposal (p. 49)
CE	CE conformity mark
WWW.PI.WS	Manufacturer's address (website)
⏏	Symbol for the protective earth conductor, marks the protective earth connector of the S-335 (p. 27)

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

➤ To order, contact our customer service department (p. 39).

3.6 Control

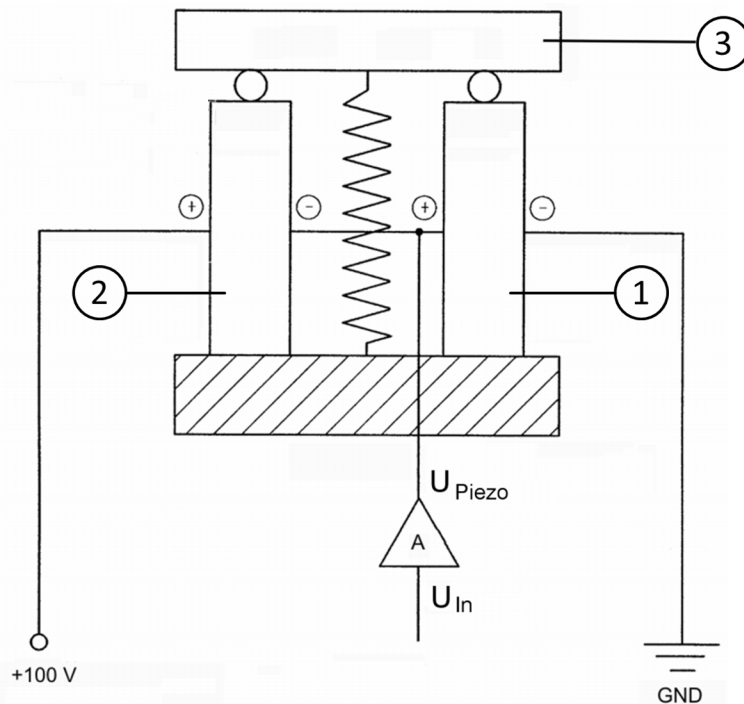


Figure 6: Differential drive of the tip/tilt platform, functional principle using the tilting of a single axis as an example

- 1 Piezo actuator 1 of the axis
- 2 Piezo actuator 2 of the axis
- 3 Platform

The S-335 is a tip/tilt platform with differential piezo drive. Four piezo actuators are interconnected in pairs to realize tip/tilt motion 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 platform is shown rotated around 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 motion 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 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. 14)
- b) Calculating (p. 17) 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.

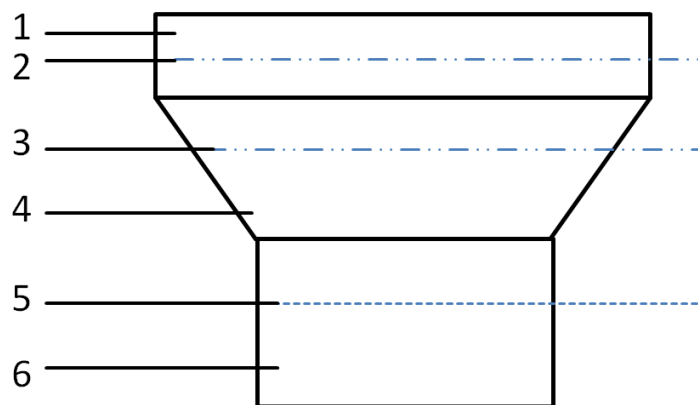


Figure 7: Example diagram: Platform with mirror holder and mirror

- 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

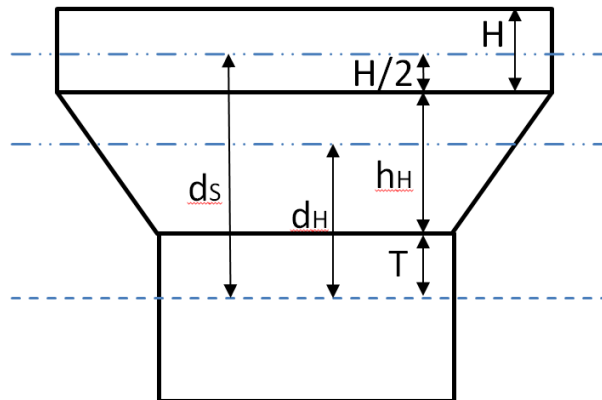


Figure 8: Example diagram: Platform with mirror holder and mirror; here with variables required for calculating the moments of inertia

- 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. 41))
- 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. 41)

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. 14)

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. 14)

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. 41)

I_0 = Moment of inertia of the platform of the S-335 [$\text{g} \cdot \text{mm}^2$], see "Data Table" (p. 41)

$I_{S,P}$ = Moment of inertia of the mirror, in relation to the rotational axis, [$\text{g} \cdot \text{mm}^2$]; calculation see separate formulas (p. 16)

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. 41)

I_0 = Moment of inertia of the platform of the S-335 [$\text{g} \cdot \text{mm}^2$], see "Data Table" (p. 41)

$I_{S,P}$ = Moment of inertia of the mirror, in relation to the rotational axis, [$\text{g} \cdot \text{mm}^2$]; for calculation see separate formulas (p. 16)

$I_{H,p}$ = Moment of inertia of the mirror holder, in relation to the rotational axis, [g•mm²];
calculation see separate formula (p. 16)

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 due to 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.
- Do **not** touch any sensitive parts (e.g., motion platform) when handling the S-335.

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. 29).

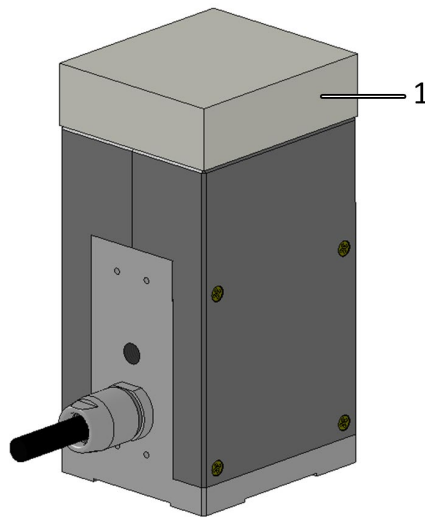


Figure 9: S-335 with protective cover, identical for all models

- 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 Installing

In this Chapter

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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 stress can induce charges in piezo actuators. Piezo actuators can remain charged for several hours after disconnecting the electronics. Touching or short-circuiting the contacts in the S-335's connector 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.
- Operate the S-335 only within the permissible ambient conditions and classifications (p. 44).

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 the S-335" (p. 33).

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. 39).

NOTICE**Warping the S-335 when mounting onto uneven surfaces!**

The S-335 could warp if mounted on an uneven surface. Warping reduces the accuracy.

- Mount the S-335 onto a flat surface. The recommended flatness of the surface is $\leq 30 \mu\text{m}$.
- For applications with large temperature fluctuations:
Mount the S-335 only onto 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.

- Use cables provided by PI only to connect 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.

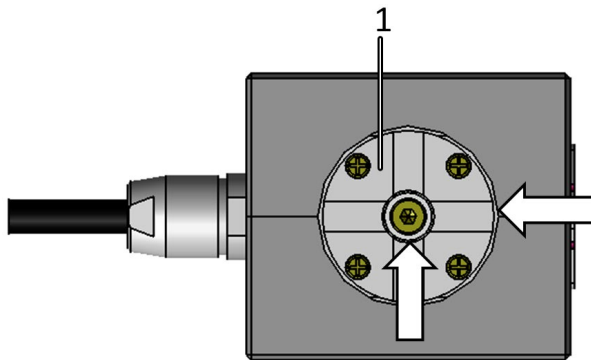


Figure 10: Glue the mirror to the S-335

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. 13)), 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.

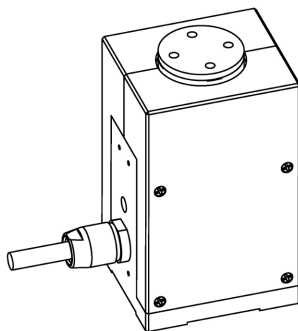


Figure 11: Example: S-335 with template for applying the adhesive to the four points

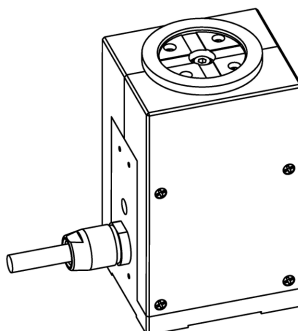


Figure 12: Example: S-335 with centering aid for aligning the mirror

Requirements

- ✓ You have read and understood the General Notes on Installation (p. 21).
- ✓ The S-335 is **not** connected to the electronics.

Tools and accessories

- Suitable mirror, see above and "Dynamic Behavior" (p. 13)
- 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

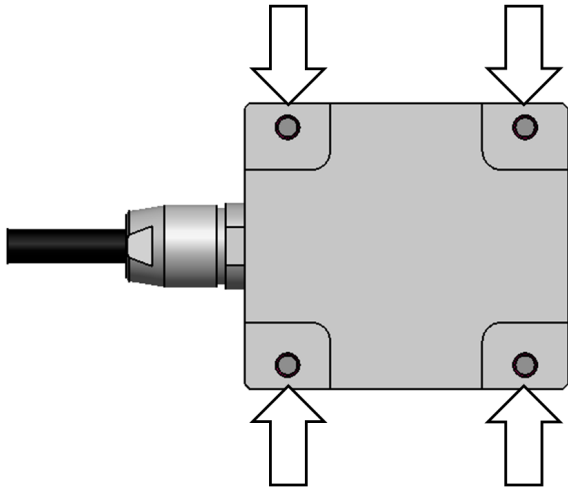


Figure 13: M2.5 holes in the bottom of the S-335 for mounting onto a surface

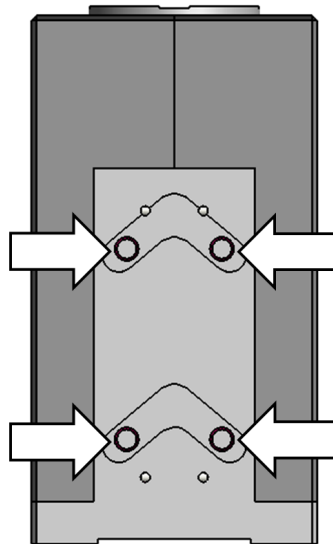


Figure 14: M2.5 holes in the side of the S-335 for mounting onto a suitable area

Requirements

- ✓ You have read and understood the General Notes on Installation (p. 21).
- ✓ 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. 45).
- 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. 45)
- 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**

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

INFORMATION

- If there is any vibration in your application, secure the screw connection for the protective earth conductor in a suitable manner (e.g., with conductive liquid adhesive) to prevent it from unscrewing by itself.

The S-335 has an M4 hole for attaching the protective earth conductor. This hole is marked with the symbol for the protective earth conductor \oplus (see "Dimensions" (p. 45)).

Requirements

- ✓ You have read and understood the General Notes on Installation (p. 21).
- ✓ The S-335 is **not** connected to the electronics.

Tools and accessories

- Suitable protective earth conductor:
 - Cross-sectional area of the cable $\geq 0.75 \text{ mm}^2$
 - Contact resistance $< 0.1 \Omega$ at 25 A at all connection points relevant for mounting the protective earth conductor
- M4 protective earth screw set (p. 11) supplied for connecting the protective earth conductor
- Suitable screwdriver

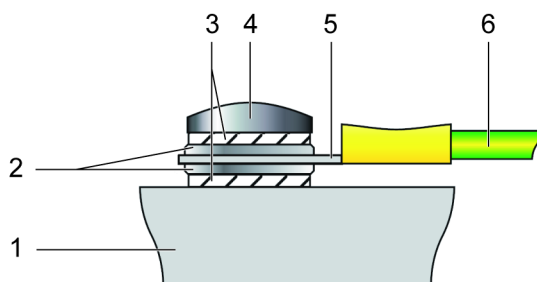


Figure 15: Connecting the protective earth conductor (profile view)

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

Connecting the S-335 to the Protective Earth Conductor

1. If necessary, firmly attach a suitable cable lug to the protective earth conductor.
2. Use the M4 screw (together with the flat and lock washers) to attach the cable lug of the protective earth conductor to the threaded hole in 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.

5.5 Removing the Transport Safeguard

The S-335 is delivered with a protective cover.

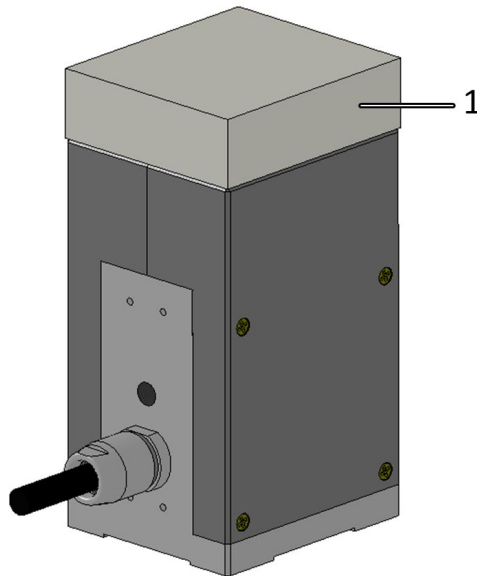


Figure 16: S-335 with protective cover, identical for all models

- 1 Plastic cover (POM) for protecting during transit

Requirements

- ✓ You have mounted the S-335 (p. 27).

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. 21).
- ✓ You have installed a suitable controller (p. 11).
- ✓ 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 Starting and Operating

In this Chapter

General Notes on Starting and Operating	31
Operating the S-335	32
Discharging the S-335	33

6.1 General Notes on Starting and Operating

CAUTION



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

If the protective earth conductor is not or not properly connected, dangerous touch voltages can occur on the S-335 in the event of a malfunction or failure of the system. If there are touch voltages, 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 (p. 27).
- Do **not** remove the protective earth conductor during operation.
- If the protective earth conductor has to be removed temporarily (e.g., for modification), reconnect the S-335 to the protective earth conductor before restarting.

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.
- Operate the S-335 only within the permissible ambient conditions and classifications (p. 44).

NOTICE



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

Applying a continuous 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. 33).

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. 29).

INFORMATION

S-335 and controller systems are calibrated at the factory to achieve optimum performance according to the specifications (p. 41).

- 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. 44).

6.2 Operating the S-335

Requirements

- ✓ You have read and understood the general notes on startup and operation (p. 31).
- ✓ You have read and understood the user manual of the controller.
- ✓ You have properly installed the S-335 (p. 21).
- ✓ 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**Requirements**

- ✓ You have read and understood the general notes on starting and operating (p. 31).
- ✓ You have read and understood the user manual for the electronics.
- ✓ You have read and understood the user manual for the PC software.
- ✓ You have correctly installed (p. 21) the S-335 and connected it to the protective earth conductor (p. 27).

- ✓ The electronics and the required PC software were installed. All connections to the electronics were made (refer to the user manual for the electronics).

Operating the S-335

- Follow the instructions for starting and operating the S-335 in the manual for the electronics (p. 11) used.

6.3 Discharging the S-335

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

- Before Installation
- When the S-335 is not used but the electronics remain 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 discharge resistor inside the electronics from PI.

Discharging a positioner connected to the electronics

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 electronics.

Discharging a positioner not connected to the electronics

- Connect the positioner to the switched-off electronics from PI.

7 Maintenance

In this Chapter

General Notes on Maintenance.....	35
Cleaning the S-335	35
Preparing the S-335 for Transport.....	36

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 optimal alignment of mechanical components and piezo actuators. Loosened screws cause a loss in positioning accuracy.

- Loosen screws only when instructed 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. 39).

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. 33).
- ✓ 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 due to 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.
- Do **not** touch any sensitive parts (e.g., motion platform) when handling the S-335.

Accessory

- Cover for protection during transit (p. 19)

Preparing the S-335 for transport

- Place the protective cover carefully onto the motion platform (p. 19).

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. 29). ➤ Contact our customer service department (p. 39).
Reduced accuracy	Warped base body	Mount the S-335 onto surfaces with the following characteristics only: <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. 39).
	Mirror with mirror mount was replaced	The change of the mass to be moved by the S-335 influences dynamic characteristics such as the resonant frequency of the tip/tilt platform. <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. 41)	<ul style="list-style-type: none"> ➤ Contact our customer service department (p. 39).

If the problem with your system is not listed in the table above or cannot be solved as described, contact our customer service department (p. 39).

9 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 for download on our website (p. 2).

10 Technical Data

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

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Pin Assignment	47

10.1 Specifications

10.1.1 Data Table

Motion	Unit	Tolerance	S-335.2SH	S-335.2SHM1	S-335.2SHM2
Active axes			$\theta X, \theta Y$	$\theta X, \theta Y$	$\theta X, \theta Y$
Rotation range in θX	mrad		35	35	35
Rotation range in θY	mrad		35	35	35
Linearity error in θX , unidirectional	%	Typ.	0.05	0.05	0.05
Linearity error in θY , unidirectional	%	Typ.	0.05	0.05	0.05

Positioning	Unit	Tolerance	S-335.2SH	S-335.2SHM1	S-335.2SHM2
Bidirectional repeatability in θX	μrad	Typ.	1	1	1
Bidirectional repeatability in θY	μrad	Typ.	1	1	1
Resolution in θX , open loop	μrad	Typ.	0.1	0.1	0.1
Resolution in θY , open loop	μrad	Typ.	0.1	0.1	0.1
Integrated sensor			SGS, direct position measuring	SGS, direct position measuring	SGS, direct position measuring
System resolution in θX	μrad		1	1	1
System resolution in θY	μrad		1	1	1

Drive Properties	Unit	Tolerance	S-335.2SH	S-335.2SHM1	S-335.2SHM2
Drive type			PICMA®	PICMA®	PICMA®
Electrical capacitance in θX	μF	$\pm 20 \%$	6.2	6.2	6.2
Electrical capacitance in θY	μF	$\pm 20 \%$	6.2	6.2	6.2

Mechanical Properties	Unit	Tolerance	S-335.2SH	S-335.2SHM1	S-335.2SHM2
Resonant frequency in θX , unloaded	kHz	$\pm 20 \%$	2		
Resonant frequency in θX , under load with glass mirror ($\varnothing 12.5$ mm; thickness 3 mm)	kHz	$\pm 20 \%$	1.6	1.6	
Resonant frequency in θX , under load with glass mirror ($\varnothing 25.4$ mm; thickness 4 mm)	kHz	$\pm 20 \%$	0.7		0.7
Resonant frequency in θY , unloaded	kHz	$\pm 20 \%$	2		
Resonant frequency in θY , under load with glass mirror ($\varnothing 12.5$ mm; thickness 3 mm)	kHz	$\pm 20 \%$	1.6	1.6	
Resonant frequency in θY , under load with glass mirror ($\varnothing 25.4$ mm; thickness 4 mm)	kHz	$\pm 20 \%$	0.7		0.7
Distance of pivot point to platform surface	mm	± 0.25 mm	3.3	3.3	3.3
Overall mass	g	$\pm 5 \%$	320	325	330
Material			Platform and base body: titanium. Housing cover: aluminum.	Platform and base body: titanium. Housing cover: aluminum.	Platform and base body: titanium. Housing cover: aluminum.

Miscellaneous	Unit	Tolerance	S-335.2SH	S-335.2SHM1	S-335.2SHM2
Operating temperature range	$^{\circ}C$		-20 to 80	-20 to 80	-20 to 80
Connector			D-sub 37-pin (m)	D-sub 37-pin (m)	D-sub 37-pin (m)
Cable length	m	+100 / - 0 mm	2	2	2

Miscellaneous	Unit	Tolerance	S-335.2SH	S-335.2SHM1	S-335.2SHM2
Recommended controllers / drivers			E-727	E-727	E-727

S-335.2SH: Version without mirror

S-335.2SHM1: Version with mirror \varnothing 12.5 mm




S-335.2SHM2: Version with mirror \varnothing 25.4 mm

Rotation range in θ_X / θ_Y : Quasistatic motion at 0 to 120 V.

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.

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. 13).

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

Pay attention to the following ambient conditions and classifications for the S-335:

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

10.1.4 System Frequency Response with E-727 Controllers

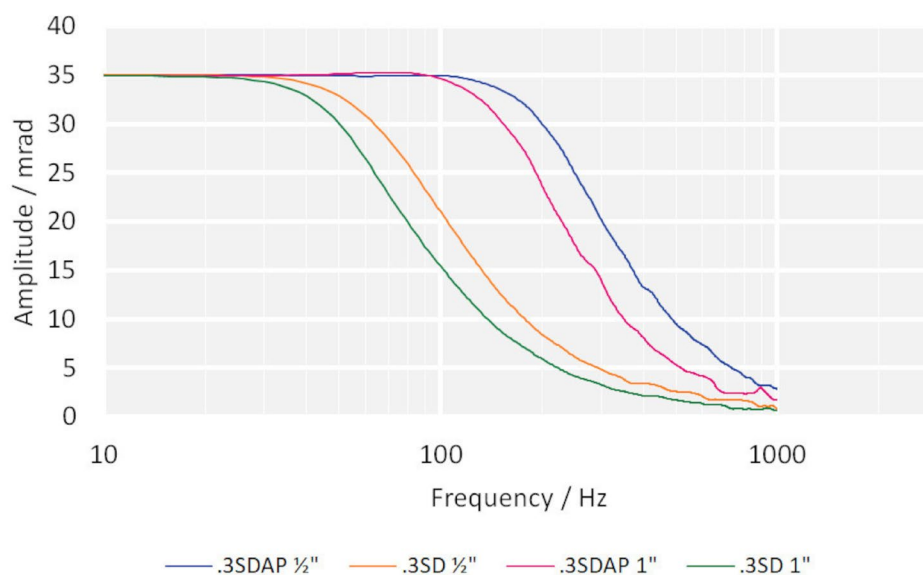


Figure 17: System frequency response with different E-727 controllers and mirror sizes

The different performance of the E-727 controller variants and the different mirror masses (1/2" or 1" mirror) influence the dynamic properties of the system significantly.

E-727.3SD: 35 mrad, tuning optimized for 20 Hz.

E-727.3SDAP: 35 mrad, tuning optimized for 100 Hz

10.2 Dimensions

10.2.1 S-335.2SH

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

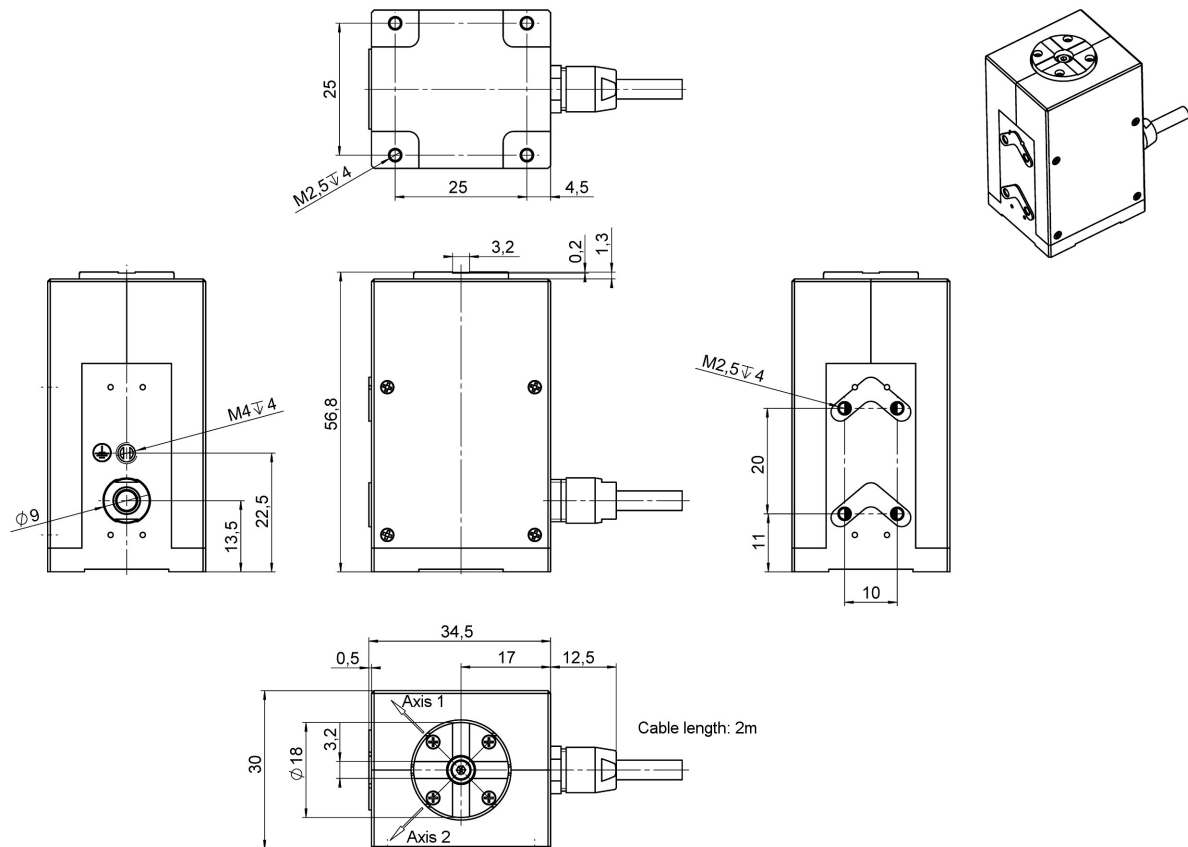


Figure 18: S-335.2SH

10.2.2 S-335.2SHM1

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

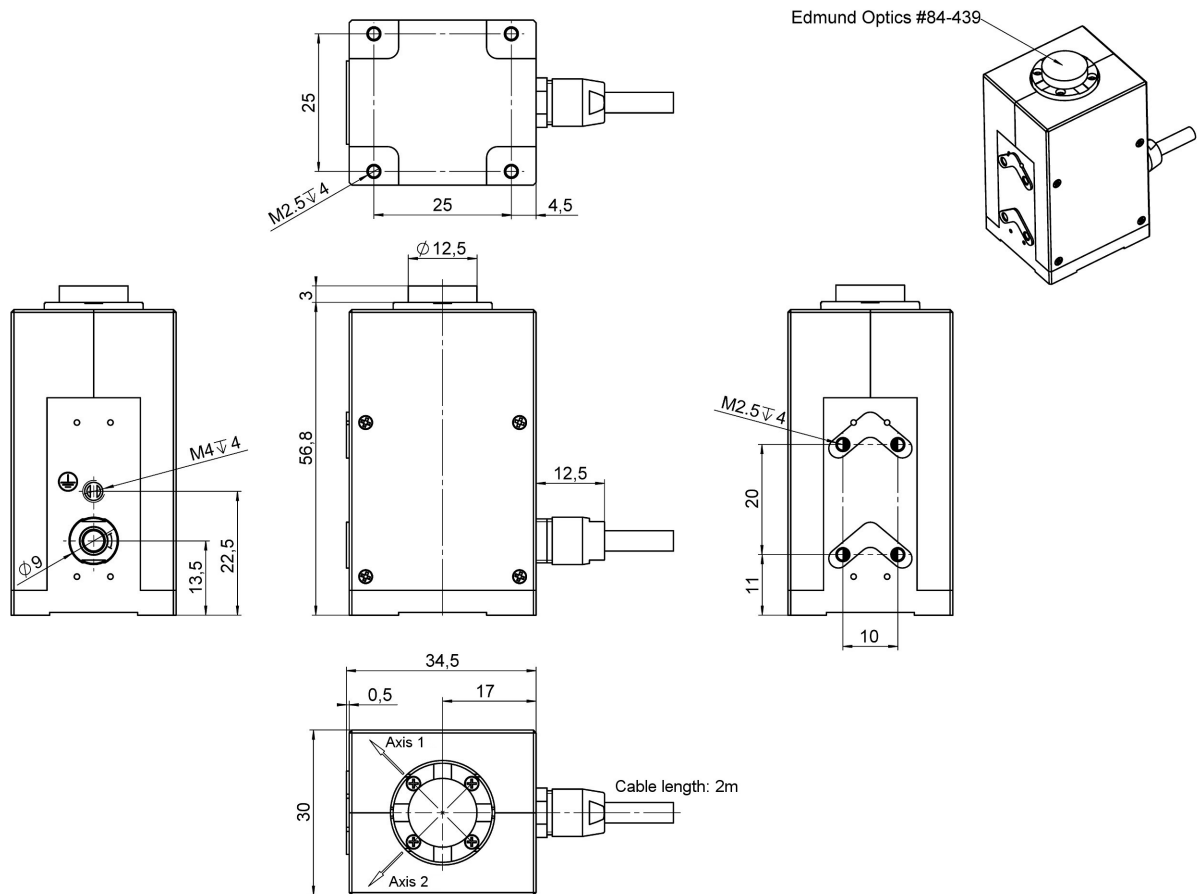


Figure 19: S-335.2SHM1

10.2.3 S-335.2SHM2

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

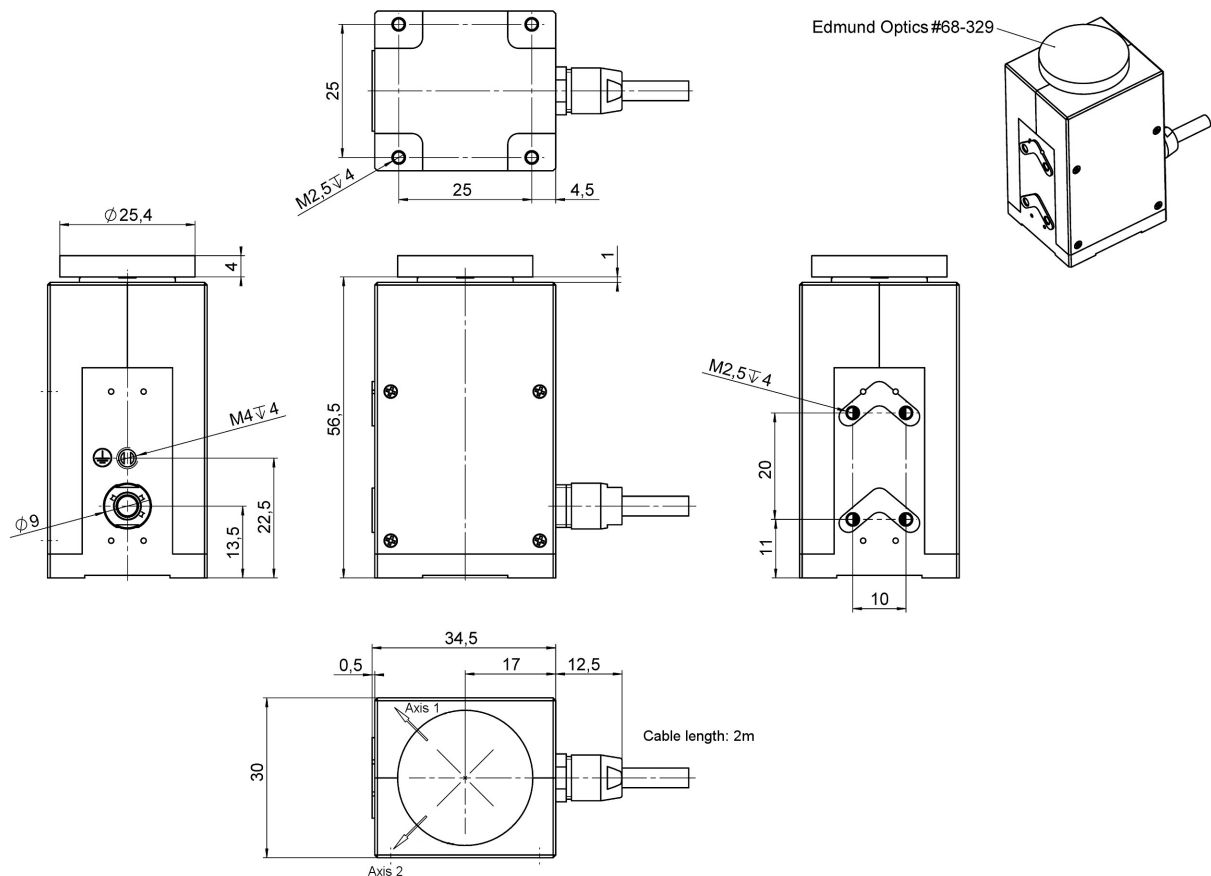


Figure 20: S-335.2SHM2

10.3 Pin Assignment

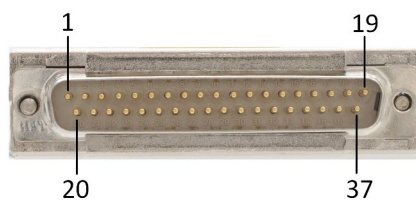


Figure 21: Sub-D 37 (m) piezo and sensor connection

Pin	Signal*	Function
1	-	-
2	GND	Ground
3	Reserved	Reserved for ID chip

Pin	Signal*	Function
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
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.

To fulfill the 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 Römerstraße 1
76228 Karlsruhe, Germany



12 European Declarations of Conformity

For the S-335, declarations of conformity were issued according to the following European statutory requirements:

Low Voltage Directive

EMC Directive

RoHS Directive

The standards applied for certifying conformity are listed below.

Safety (Low Voltage Directive): EN 61010-1

EMC: EN 61326-1

RoHS: EN IEC 63000

