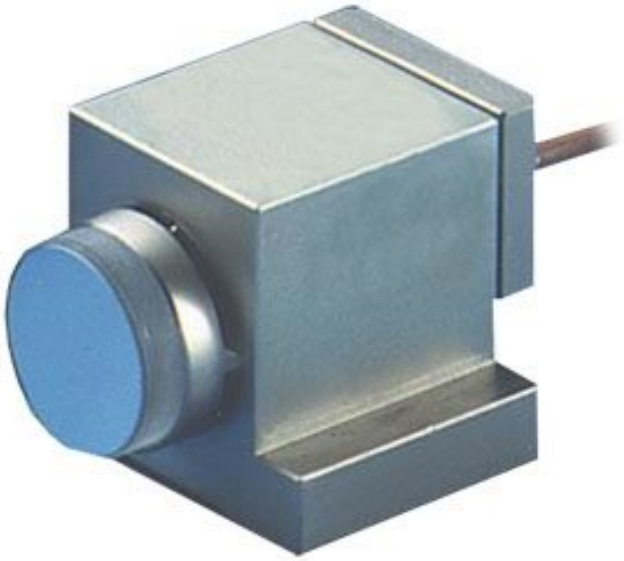
User Manual

S224M0001EN, valid for S-224 and S-226

CBo, 9/24/2019

S-224 / S-226
Piezo Tip/Tilt Mirror



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Contents

About this Document

This user manual contains information necessary for the intended use of the S-224 and S-226 piezo tip/tilt mirrors (hereinafter also referred to as “S-22x”).

It assumes that the reader has a fundamental understanding of basic servo systems as well as motion control concepts and applicable safety procedures.

Symbols and Typographic Conventions

CAUTION

Dangerous situation

Failure to comply could lead to minor injury or cause damage to equipment.

➢ Precautionary measures for avoiding.

NOTICE

Dangerous situation

Failure to comply could cause damage to equipment.

➢ Precautionary measures for avoiding.

INFORMATION

Information for easier handling, tricks, tips, etc.

The following symbols and markings are used in the user manuals of PI:

Symbol	Meaning
1.	Action consisting of several steps whose sequential order must be observed
2.	
➢	Action consisting of one or several steps whose sequential order is irrelevant
▪	List item
S. 5	Cross-reference to page 5
	Warning sign affixed to the product that refers to detailed information in this user manual.

Other Applicable Documents

The devices that are mentioned in this user manual are described in their own manuals.

Product	Document
E-610.00 piezo amplifier E-610.S0 piezo amplifier / servo controller	PZ70 user manual
E-621.SR piezo amplifier / servo controller module	PZ115 user manual
E-625.SR piezo amplifier / servo controller	PZ167 user manual
E-663 piezo amplifier	PZ69 user manual
E-665.SR piezo amplifier / servo controller	PZ127 user manual
E-709.SRG digital piezo controller	PZ222 user manual
E-836.1G piezo amplifier	PZ250 user manual

The current versions of the user manuals are available for download on our website.

Downloading Manuals

INFORMATION

If a manual is missing or problems occur with downloading:

➢ Contact our customer service department (p. 19).

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 the access data:
   - Link to a page for registering and requesting the access data
   - User name and password is specified
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., S-226) or the product family (e.g., tip/tilt mirror) into the search field.
5. Click ***Start search*** or press the Enter 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.

Safety

Intended Use

The S-22x 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.

Based on its design and realization, the S-22x is intended to position a Ø 15 mm × 4 mm glass mirror. Different materials (e.g., copper mirror) are available on request. The motion takes place rotationally on one axis (θ_X).

The intended use of the S-22x is only possible when completely mounted and connected and only in conjunction with suitable electronics (p. 9) that provide the required operating voltages. To ensure proper performance of the servo-control system (S-226 only), the electronics must also be able to read out and process the signals from the position sensor.

The S-22x can be mounted horizontally or vertically.

The S-22x may only be started up, operated, maintained and cleaned by authorized and qualified staff.

General Safety Instructions

The S-22x 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-22x.

- Use the S-22x only for its intended purpose, and only when it is in perfect technical condition.
- Read the user manual.
- Eliminate any faults and malfunctions that may affect safety immediately.

The operator is responsible for the correct installation and operation of the S-22x.

Organizational Measures

User manual

- Always keep this user manual together with the S-22x.
- The latest versions of the user manuals are available for download (p. 5) on our website.
- Add all information from the manufacturer to the user manual, for example supplements or technical notes.
- If you give the S-22x to other users, include this user manual as well as other relevant information provided by the manufacturer.
- Use the device only if the user manual is complete. Missing information due to an incomplete user manual can lead to minor injury and damage to equipment.
- Install and operate the S-22x only after you have read and understood this user manual.

Personnel qualification

The S-22x may only be installed, started up, operated, maintained, and cleaned by authorized and appropriately qualified personnel.

Product Description

Model Overview

Model	Description
S-224.00	Compact piezo tip/tilt mirror, 4.4 mrad optical beam deflection angle, with BK7 Ø 15 × 4 mm mirror
S-226.00	Compact piezo tip/tilt mirror, 4.4 mrad optical beam deflection angle, with BK7 Ø 15 × 4 mm mirror, strain gauge sensor

Product View

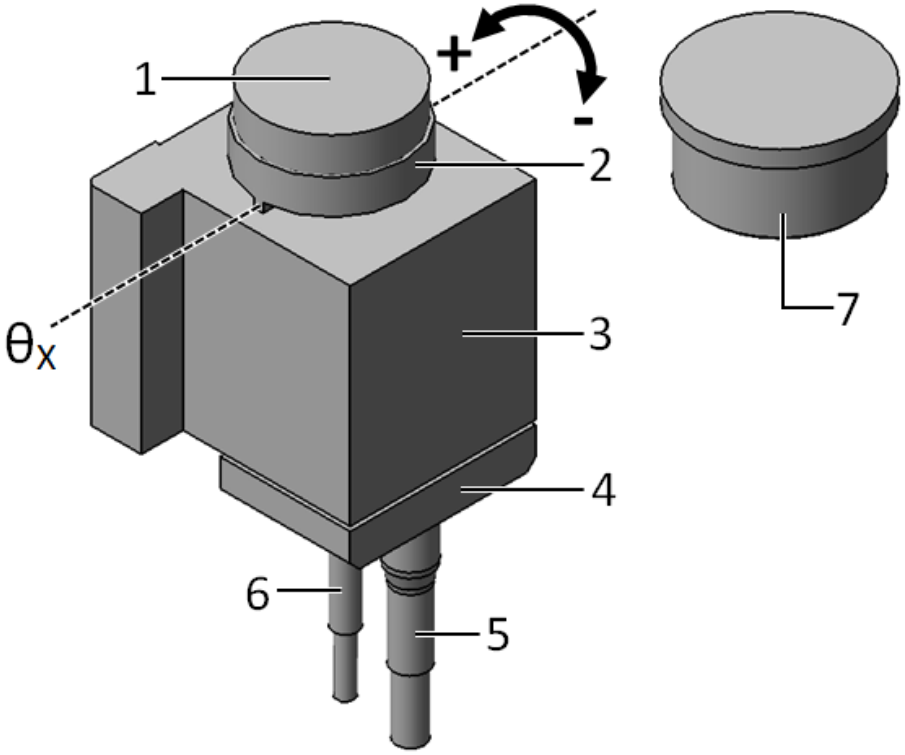


Figure 1: Example view of an S-226

1: Mirror, Ø 15 mm × 4 mm
2: Motion platform
3: Housing
4: Flange (holds the piezo actuator; do **not** unscrew the flange)
5: Sensor cable (S-226 only)
6: Voltage cable
7: Protective cap (installed on the mirror of the S-22x on delivery)

θ_x: Motion axis of the S-22x
Double arrow: Positive (+) and negative (-) direction of motion

Product Labeling

Labeling	Description
S-226.00	Product name (example), the characters following the period refer to the model
123456789	Serial number (example), individual for each S-22x Meaning of the places (counting from left): 1 = internal information 2 and 3 = year of manufacture 4 to 9 = consecutive numbers
PI	Manufacturer's logo
Country of origin: Germany	Country of origin
⚠	Warning sign "Observe manual!"
	Old equipment disposal (p. 23)
CE	CE conformity mark
WWW.PI.WS	Manufacturer's address (website)
⏚	Symbol for the protective earth conductor (p. 12)

Scope of Delivery

Product number	Description
S-224 or S-226	Piezo tip/tilt mirror according to order (p. 7)
951	Protective cap (installed on the mirror of the S-22x on delivery)
S224M0001EN	User manual for S-224 / S-226

Suitable Electronics

Product number	Description
E-610.00	Piezo amplifier
E-610.S0	Piezo amplifier / servo controller
E-621.SR	Piezo amplifier / servo controller module
E-625.SR	Piezo amplifier / servo controller
E-663	Piezo amplifier

Product number	Description
E-665.SR	Piezo amplifier / servo controller
E-709.SRG	Digital piezo controller
E-836.1G	Piezo amplifier

➢ To order, contact our customer service department (p. 19).

Unpacking

NOTICE

Mechanical overload due to incorrect handling!

An impermissible mechanical load on the motion platform can damage the S-22x and lead to loss in accuracy.

➢ Ship the S-22x in the original packaging only.
➢ Do **not** touch any sensitive parts (e.g., motion platform, mirror) when handling the S-22x.
➢ Avoid shocks and drops.

INFORMATION

The S-22x is delivered with a protective cap to avoid scratching the mirror surface.

➢ If possible, do **not** remove the protective cap until startup of the S-22x.
➢ Keep the protective cap in case the product needs to be transported later.

Unpacking the S-22x

1. Unpack the S-22x with care.
2. Compare the contents with the scope of delivery according to the contract and the delivery note.
3. Inspect the contents for signs of damage. If any parts are damaged or missing, contact our customer service department immediately.
4. Keep all packaging materials in case the product needs to be returned.

Installation

General Notes on Installation

CAUTION

Dangerous voltage and residual charge on the piezo actuator!

The S-22x is driven by a piezo actuator. Temperature changes and compressive stresses can induce charges in the piezo actuator of the S-22x. After being disconnected from the electronics, the piezo actuator can stay charged for several hours. Touching the contacts in the connector of the S-22x can result in minor injury from electric shock. The piezo actuator can be destroyed by an abrupt contraction.

- Do **not** open the S-22x.
- Do **not** touch the contacts in the connector(s) of the S-22x.
- Do **not** pull the connector(s) out of the electronics during operation.

NOTICE

Damage when the mirror is removed!

The mirror of the S-22x may only be replaced by PI. Otherwise, the S-22x can be damaged.

- Do **not** remove the mirror of the S-22x.
- If you need a different mirror, contact our customer service department (p. 19).

NOTICE

Warping of the S-22x due to mounting onto uneven surfaces!

Mounting the S-22x onto an uneven surface can warp the S-22x. Warping reduces the accuracy.

- Mount the S-22x onto an even surface. The recommended flatness of the surface is ≤30 µm.
- For applications with large temperature changes:
  Only mount the S-22x onto surfaces that have the same or similar thermal expansion properties as the S-22x.

NOTICE

Heating up of the S-22x during operation!

Emitted heat may adversely affect your application if you operate the S-22x at a higher frequency (in the kHz range).

- Install the S-22x so that the application is not impaired by the emitted heat.

NOTICE

Damage due to unsuitable cables!

Unsuitable cables can damage the S-22x and the electronics.

➢ Only use cables provided by PI for connecting the S-22x to the electronics.

INFORMATION

Extended cables can affect the performance of the S-22x.

➢ If you need longer cables, contact our customer service department (p. 19).

Connecting the S-22x to the Protective Earth Conductor

INFORMATION

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

INFORMATION

When a positioner is grounded via its protective earth connection as well as by the shield of the connecting cable for the electronics, ground loops can occur.

➢ If a ground loop occurs, contact our customer service department (p. 19).

The S-22x does not feature a separate protective earth connection but must be connected conductively to a surface that is connected to a protective earth conductor.

➢ See “Mounting the S-22x onto a Surface” (p. 13) for instructions.

Mounting the S-22x onto a Surface

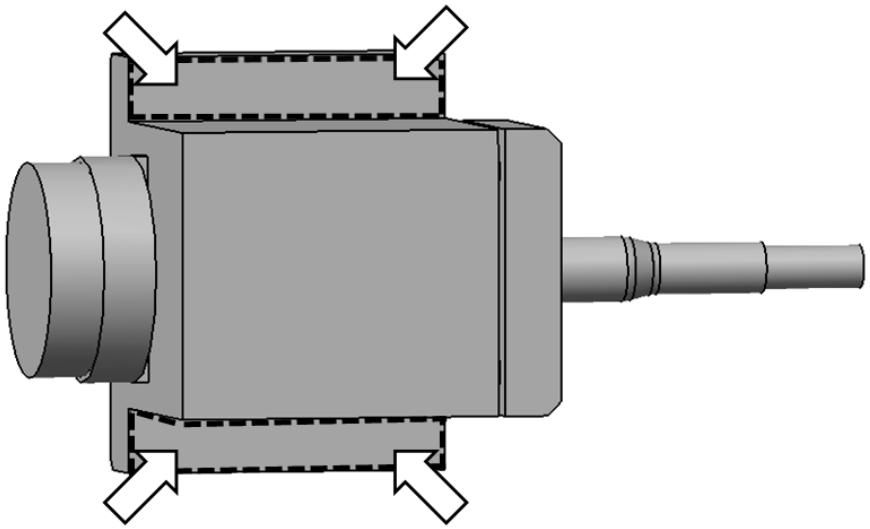


Figure 2: Clamping surfaces of the S-22x

Requirements

- ✓ You have read and understood the general notes on installation (p. 11).
- ✓ The S-22x is **not** connected to the electronics.
- ✓ All mounting materials (e.g., screws and washers) are electrically conductive.
- ✓ The mechanical mounting in which the S-22x is to be installed fulfills the following requirements:
  - The flatness of the mounting surface is ≤30 µm.
  - The mechanical mounting and the mounting surface are electrically conductive.
  - The mechanical mounting is connected to a suitable protective earth conductor: Cross-sectional area of the cable ≥0.75 mm^2.
  - For applications with large temperature changes: The mounting surface has the same thermal expansion properties as the S-22x.
- ✓ You have accounted for the space required to route cables without bending and according to regulations.

Mounting the S-22x onto a surface

1. Clamp the S-22x to the mechanical mounting.
2. Make sure that the contact resistance is <0.1 Ω at 25 A at all connection points relevant for mounting the protective earth conductor.
3. Check that the S-22x is fixed firmly to the mounting surface.

Connecting the S-22x to the Electronics

Requirements

- ✓ You have read and understood the general notes on installation (p. 11).
- ✓ You have read and understood the user manual for the electronics (p. 5).
- ✓ The electronics are switched off, i.e., **not** connected to the power source.

Connecting the S-22x to the electronics

1. Plug the voltage connector of the S-22x into the corresponding voltage socket of the electronics (see user manual for the electronics).
2. S-226 only: Plug the sensor connector of the S-226 into the corresponding sensor socket of the electronics (see user manual for the electronics).

Startup and Operation

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-22x in the event of malfunction or failure of the system. If touch voltages exist, touching the S-22x can result in minor injury from electric shock.

- ➢ Connect the S-22x to a protective earth conductor (p. 12) before startup.
- ➢ Do **not** remove the protective earth conductor during operation.
- ➢ If the protective earth conductor has to be removed temporarily (e.g., for modifications), reconnect the S-22x to the protective earth conductor before restarting.

CAUTION

Burning from hot surface!

The surface of the S-22x can heat up during operation. Touching the S-22x can result in minor injuries from burning.

- ➢ Make sure that the hot S-22x and the surrounding parts cannot be touched.

NOTICE

Destruction of the piezo actuator by electric flashovers!

Using the S-22x 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-22x in environments that can increase the electric conductivity.
- ➢ Operate the S-22x only within the permissible ambient conditions and classifications (p. 21).

NOTICE

Reduced lifetime of the piezo actuator due to continuous high voltage!

Applying a high static voltage to piezo actuators continuously leads to a considerable reduction in the lifetime of the piezo ceramic.

- ➢ When the S-22x is not used but the electronics remain switched on to ensure temperature stability, discharge the S-22x (p. 16).

NOTICE

Operating voltage too high or incorrectly connected!

Operating voltages that are too high or incorrectly connected can cause damage to the S-22x.

- ➢ Operate the S-22x with electronics and original accessories from PI.
- ➢ Do **not** exceed the operating voltage range (p. 20) for which the S-22x is specified.
- ➢ Operate the S-22x only when the operating voltage is properly connected; see "Pin Assignment" (p. 22).

NOTICE

Uncontrolled oscillation!

Oscillation can cause irreparable damage to the S-22x. Oscillation is indicated by a humming noise and can be caused by the following:

- A change in the load and/or dynamics requires the servo control parameters / operating parameters to be adjusted.
- The S-22x is operated near to its resonant frequency.

If you notice oscillation:

- ➢ In closed-loop operation, switch off the servo mode immediately.
- ➢ In open-loop operation, stop the S-22x immediately.

NOTICE

Damage from reconnecting a charged S-22x!

The piezo actuator of the S-22x can remain charged if its connecting cable is pulled out of the electronics during operation. Reconnecting a charged piezo actuator to electronics that are still running can cause a mechanical impulse which might damage the piezo actuator.

➢ Do **not** pull the connector of the S-22x out of the electronics during operation. If the connector was accidentally pulled out during operation, switch off the electronics before you reconnect the S-22x.

Starting and Operating the S-22x

Requirements

✓ You have read and understood the general notes on startup and operation (p. 14).

✓ You have installed (p. 11) the S-22x correctly and connected it to the electronics (p. 14).

✓ You have removed the protective cap (p. 8) from the mirror.

Starting and operating the S-22x

➢ Follow the instructions in the manual for the electronics used for startup and operation of the S-22x.

Discharging the S-22x

The S-22x must be discharged in the following cases:

- When the S-22x is not used but the electronics remain switched on to ensure temperature stability
- Before demounting (e.g., before cleaning and transportation of the S-22x as well as for modifications)
- Before pulling the connector(s) of the S-22x out of the electronics

Discharging an S-22x connected to the electronics

In closed-loop operation:

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

In open-loop operation:

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

Discharging an S-22x <u>not</u> connected to the electronics

➢ Connect the voltage connector of the S-22x to the **switched-off** electronics for 10 seconds.

Maintenance

NOTICE

Misalignment from loosening screws!
The S-22x is maintenance-free and precisely aligned.

- Loosen any screws only when instructed in this user manual.
- Do **not** open the S-22x.

Cleaning the S-22x

NOTICE

Damage due to incorrect cleaning!
The mirror of the S-22x can be damaged from applying force during cleaning.

- Clean the mirror only when actually necessary.
- Avoid exerting any force on the mirror during cleaning.
- Do **not** use compressed air.

NOTICE

Short-circuiting due to cleaning fluid penetrating the housing!
Cleaning fluid penetrating the P-22x's housing can short-circuit the actuator and electronics.

- Disconnect the P-22x from the electronics before cleaning.
- Prevent cleaning fluid from penetrating the P-22x's housing.

NOTICE

Damage due to unsuitable cleaning agents!
Some cleaning agents may cause damage to the P-22x.

- Use mild cleaning agents or disinfectants only.

NOTICE

Damage from ultrasonic cleaning!
Ultrasonic cleaning can damage the S-22x.

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

Requirements

- ✓ You have discharged (p. 16) the piezo actuator of the S-22x.
- ✓ You have disconnected the S-22x from the electronics.

Auxiliary materials required

- For cleaning the housing:
  - Soft, lint-free cloth
  - Mild cleaning agent or disinfectant (e.g., isopropyl alcohol or ethanol)
- For cleaning the mirror:
  - Bellows
  - Optic brush
  - Optic wipes (only if wet cleaning is necessary)
  - Optic cleaning agent (only if wet cleaning is necessary)

If you have any questions on the auxiliary materials recommended for the P-22x, contact our customer service department (p. 19).

Cleaning the housing

1. Dampen the cloth with the cleaning agent or disinfectant.
2. Carefully wipe the surfaces of the P-22x.

Cleaning the mirror

➢ Clean the mirror of the S-22x with bellows and/or an optic brush without exerting force. If wet cleaning is necessary, use special optic wipes and optic cleaning agents.

Preparing the S-22x for Transport

NOTICE

Mechanical overload due to incorrect handling!

An impermissible mechanical load on the motion platform can damage the S-22x and lead to loss in accuracy.

➢ Ship the S-22x in the original packaging only.
➢ Do **not** touch any sensitive parts (e.g., motion platform, mirror) when handling the S-22x.
➢ Avoid shocks and drops.

Accessories

- Protective cap (p. 9)

Preparing the S-22x for transport

➢ Place the protective cap carefully onto the mirror of the S-22x (p. 8).

Customer Service

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

- If you have any questions concerning your system, provide the following information:
  - Product and serial numbers of all products in the system
  - Firmware version of the controller (if applicable)
  - Version of the driver or the software (if applicable)
  - Operating system on the PC (if applicable)
- If possible: Take photographs or make videos of your system that can be sent to our customer service department if requested.

The latest versions of the user manuals are available for download (p. 5) on our website.

Technical Data

Data Table

	S-224.00	S-226.00	Unit	Tolerance
Active axis	θ_X	θ_X		
Motion and positioning				
Integrated sensor	–	SGS		
Tip/tilt angle, open loop, at 0 to 100 V	2.2*	2.2*	mrad	±20 %
Tip/tilt angle, closed loop	–	2.0*	mrad	
Resolution, closed loop / open loop	– / 0.05	0.1 / 0.05	µrad	
Linearity error, closed loop	–	0.2	%	typ.
Repeatability, full travel range	–	±3	µrad	typ.
Mechanical properties				
Resonant frequency, unloaded	9.0	9.0	kHz	±20 %
Resonant frequency, under load, with Ø 15 mm × 4 mm glass mirror	7.5	7.5	kHz	±20 %
Resonant frequency, under load, with Ø 15 mm × 4 mm copper mirror**	5.7	5.7	kHz	±20 %
Distance from pivot point to platform surface	4	4	mm	
Platform moment of inertia	215	215	g × mm^2	

	S-224.00	S-226.00	Unit	Tolerance
Drive properties				
Ceramic type	PICMA® P-885	PICMA® P-885		
Electrical capacitance	1.5	1.5	µF	±20 %
Miscellaneous				
Operating temperature range	-20 to 80	-20 to 80	°C	
Housing material	Nonmagnetic stainless steel	Nonmagnetic stainless steel		
Platform material	Nonmagnetic stainless steel	Nonmagnetic stainless steel		
Mass without cable	98	98	g	±5 %
Cable length	1	1	m	+10 mm
Voltage connector	LEMO FFA.00.250	LEMO FFA.00.250		
Sensor connector	–	LEMO FFA.0S.304		
Recommended electronics	E-663, E-610.00, E-836.1G	E-665.SR, E-610.S0, E-621.SR, E-625.SR, E-709.SRG		

* Mechanical tilt, optical beam deflection is twice as large.
** Copper mirror on request
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.
Ask about customized versions.

Maximum Ratings

The S-22x is designed for the following maximum ratings:

Maximum operating voltage	Maximum operating frequency[1, 2]	Maximum power consumption[3]
0 to +100 V	2.5 kHz	4.3 W

[1] With 15 mm × 4 mm glass mirror, at 100 V_{pp}

[2] To ensure stable operation, the maximum operating frequency is defined as approximately 1/3 of the mechanical resonant frequency.

[3] The heat generated by the piezo actuator during dynamic operation limits the value for maximum power consumption.

Details can be found online:
http://piceramic.com/piezo-technology/properties-piezo-actuators/electrical-operation.html

Ambient Conditions and Classifications

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
Operating temperature	-20 °C to 80 °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

Dimensions

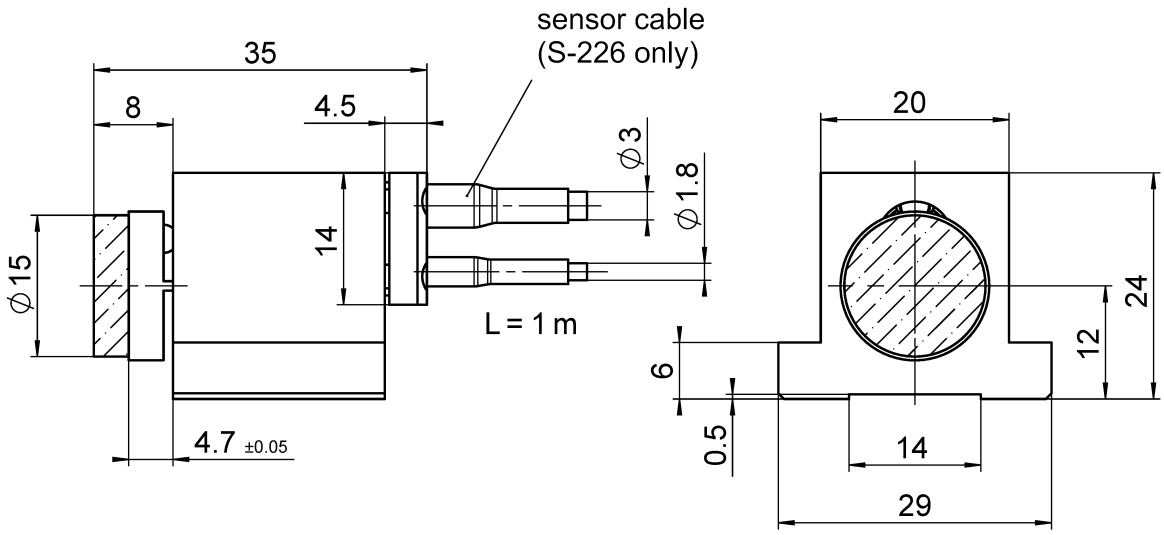


Figure 3: S-224 / S-226, dimensions in mm.

Pin Assignment

Voltage Connector

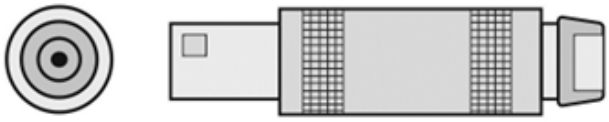


Figure 4: LEMO coaxial connector

Pin	Signal	Signal direction	Function	Connector shell
Inner conductor	PZT	Input	Piezo voltage (0 to 100 V)	Piezo voltage ground

Sensor Connector (S-226 only)

Figure 5: LEMO 4-pin connector (front view; not the soldering side)

Pin	Signal	Signal direction	Function	Connector shell
1	SGS Ref	Input	Supply voltage for strain gauge sensor	Cable shield
2	SGS-	Output	SGS signal (negative)	
3	SGS+	Output	SGS signal (positive)	
4	SGS GND	GND	Supply voltage ground	

Old Equipment Disposal

In accordance with the applicable EU law, electrical and electronic equipment may not be disposed of with unsorted municipal wastes in the member states of the EU.

When disposing of your old equipment, observe the international, national and local rules and regulations.

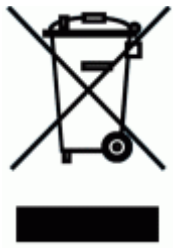
To meet the manufacturer's product responsibility with regard to this product, Physik Instrumente (PI) GmbH & Co. KG ensures environmentally correct disposal of old PI equipment that was first put into circulation after 13 August 2005, free of charge.

If you have old PI equipment, you can send it postage-free to the following address:

Physik Instrumente (PI) GmbH & Co. KG

Auf der Roemerstr. 1

D-76228 Karlsruhe, Germany



EU Declaration of Conformity

For the S-224 / S-226, 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