ARTISAN®
TECHNOLOGY GROUP

Your **definitive** source for quality pre-owned equipment.

Artisan Technology Group
(217) 352-9330 | sales@artisantg.com | artisantg.com

Full-service, independent repair center
with experienced engineers and technicians on staff.

We buy your excess, underutilized, and idle equipment
along with credit for buybacks and trade-ins.

Custom engineering
so your equipment works exactly as you specify.

- Critical and expedited services
- In stock / Ready-to-ship
- Leasing / Rentals / Demos
- ITAR-certified secure asset solutions

Expert team | Trust guarantee | 100% satisfaction

All trademarks, brand names, and brands appearing herein are the property of their respective owners.

Find the *Physik Instrumente S-330* at our website: *Click HERE*

PZ 107E User Manual

S-330 Tip/Tilt Platform

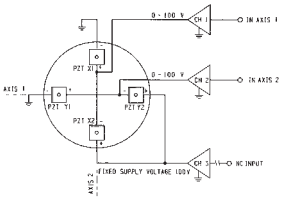
Release: 1.1.1 Date: 2003-09-09

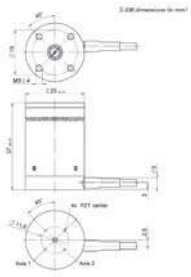


This document describes the following product(s):

- **S-330.10**
  Piezo Tip/Tilt Platform, ±1 mrad, Closed-Loop
- **S-330.P10**
  Piezo Tip/Tilt Platform, ±1 mrad,
  Closed-Loop with PICMA Ceramic
- **S-330.30**
  Piezo Tip/Tilt Platform, ±1 mrad







© Physik Instrumente (PI) GmbH & Co. KG
Auf der Römerstr. 1 · 76228 Karlsruhe, Germany
Tel. +49-721-4846-0 · Fax: +49-721-4846-299
info@pi.ws · www.pi.ws

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Table of Contents :

0 Manufacturer Declarations 2
0.1 Quality and Warranty Clauses 2
0.2 Safety Precautions 2

1 Introduction 3
1.1 Features 3
1.2 Design 3
1.3 Models Available 3

2 Quick Start 4
2.1 Mounting 4
2.2 Connecting to Controller and Starting 4

3 Working Principle 5
3.1 Operating Voltages 5
3.2 Motion Polarities 6
3.3 Position Sensors 7

4 Drive Electronics 8

5 Dynamic Behavior 9

6 S-330 Technical Data 10
6.1 Connectors 11
6.2 Dimensions 11

© Copyright 1997-2004 by Physik Instrumente (PI) GmbH& Co. KG

Release: 1.1.1
File:S-330UserPZ107E111.doc, 244736 Bytes

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

0 Manufacturer Declarations

0.1 Quality and Warranty Clauses

Certification

Physik Instrumente GmbH & Co. KG (**PI**) certifies that this product met its published specifications at the time of shipment. The device was calibrated and tested before shipment.

Warranty

This Physik Instrumente product is warranted against defects in materials and workmanship for a period of one year from date of shipment. Duration and conditions of warranty for this product may be superseded when the product is integrated into (becomes a part of) other Physik Instrumente products. During the warranty period, Physik Instrumente will, at its option, either repair **or** replace products which prove to be defective.

Limitation of Warranty

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by the Buyer, Buyer supplied products or interfacing, unauthorised modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

The design and connection of any circuitry to this product is the sole responsibility of the Buyer. **PI** does not warrant the Buyer's circuitry or malfunctions of **PI** products that result from the Buyer's circuitry. In addition, **PI** does not warrant any damage that occurs as a result of the Buyer's circuit or any defects that result from Buyer-supplied products.

No other warranty is expressed or implied. Physik Instrumente specifically disclaims the implied warranties of merchantability and fitness for a particular purpose.

0.2 Safety Precautions

Warning: Be careful when mounting the platform

Never use the hole on the platforms surface for mounting an object.

Never put anything in the flexure gaps of the body.

Do not clamp the body since this can block the flexure guiding system.

Warning: Resonance Can Cause Permanent Damage

The system must never be operated close to the resonant frequency or permanent damage can result. If you hear or see resonant behavior, switch off the unit immediately.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

1 Introduction

The S-330 tip/tilt platform is an active tip/tilt stage system based on the differential-piezo-drive design incorporating two pairs of LVPZT (low voltage piezoelectric translator) actuators. The system is designed for fast and precise laser beam steering in two axes and for stabilizing and correcting optical axes or paths.

1.1 Features

- Sub-µrad Resolution
- For Mirrors to 50 mm ∅
- Closed-Loop Versions
- Differential Design for Excellent Temperature Stability



Fig. 1. S-330 tip/tilt mirror

1.2 Design

The tip/tilt platform is mounted on four LVPZT stacks, located at the corners of a square. Tilting around one axis requires synchronized movement of two diagonally opposite LVPZT actuators. To ensure that one actuator will contract by exactly the same amount as the other expands, the actuator pairs are individually matched at the factory. The actuators in each pair are then connected electrically in differential push-pull mode, eliminating Z-axis freedom.

Note that with this design the pivot point is fixed and the same for both rotation axes. Whether you choose to measure the angles in vertical planes or in planes perpendicular to the platform depends on the requirements of your application.

1.3 Models Available

S-330.10	PZT Tip/Tilt Platform, 2 Axes, ±1 mrad, Closed-Loop
S-330.P10	same as S-330.10 but with PICMA ceramic actuator
S-330.30	PZT Tip/Tilt Platform, 2 Axes, ±1 mrad, Open-Loop

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

2 Quick Start

2.1 Mounting

You can mount the object to be positioned (for example, a mirror) on the platform using glue.

Warnings

Never use the hole on the platform surface for mounting an object.

Never put anything in or across the gaps (flexure guiding system) of the body.

Do not clamp the body since this can block the flexure guiding system.

The platform can be mounted in any orientation. If you mount it on a vertical plane, however, the maximum “sideways” force limitation of 1 N will limit the load capacity accordingly.

By default, the platform metal case is not connected electrically. You should ground the mechanics if so required.

2.2 Connecting to Controller and Starting

The following instructions describe starting the S-330 tip/tilt platform using PI’s E-500-series control electronics (E-500 or E-501 chassis including E-503.00S amplifier module and, when using the closed-loop model, E-509.S3S servo-control module). If you use other modules from the E-500 series the steps are the same, but the connections details may differ. In this case please consult “Drive Electronics” Section on p. 8 for further information.

1. Make sure the control electronics is switched off.
2. Closed-loop models (S-330.10 and S-330.P10) only: Connect the S-330 tip/tilt mirror to the E-509.S3S servo-control module.

   The sensor cable of the S-330, which has a 4-pin connector and is labeled “CH1”, must be plugged into the corresponding socket of the servo-control module (labeled “SERVO 1”). This cable carries sensor signals from channels 1 and 2.
3. Connect the S-330 tip/tilt platform to the E-503.00S amplifier module.

   The supply voltage cables of the S-330 have brown connectors and are labeled “CH 1”, “CH 2” and “CH 3”. They must be plugged into the corresponding output sockets of the amplifier module.

   Note: Do not mix up the cables while connecting, since the amplifier channels are connected internally so as to supply the platform channels 1 and 2 with variable drive signals, while channel 3 is supplied with a constant and very stable voltage of +100 volts.

   Warning: Resonance Can Cause Permanent Damage

   The system must never be operated close to the resonant frequency or permanent damage can result. If you hear or see resonant behavior, switch off the unit immediately.

   See “Dynamic Behavior” Section on p. 9 for more details.
4. Switch on the control electronics.

   Consult the E-500 User Manual, and, if you have an E-516 interface module installed, the E-516 E-User Manual for information on commanding the S-330 tip/tilt platform. If

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

you have the closed-loop model, see also the User Manual of the servo-control module (E-509) for details on servo-control settings.

3 Working Principle

The S-330 contains two pairs of PZT actuators. The actuators in each pair are connected in differential push-pull mode: any change in the operating voltage causes one actuator of the pair to see a voltage increase, the other to see a decrease of the exact same magnitude.

Because the symmetrical design of the tip/tilt platform system, temperature changes will not effect the angular orientation but only the Z-axis position (axial thermal drift). Most applications are much less sensitive to this kind of instability as long as the angular orientation remains stable.

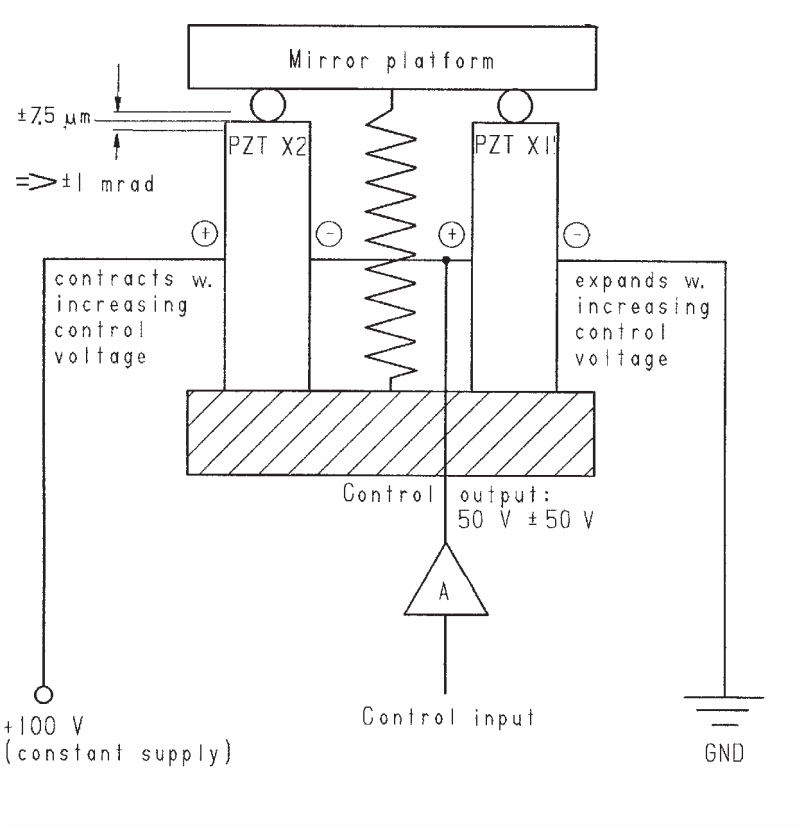


Fig. 2. S-330 Differential-drive tip/tilt platform, working principle (only Axis-1 tip motion shown)

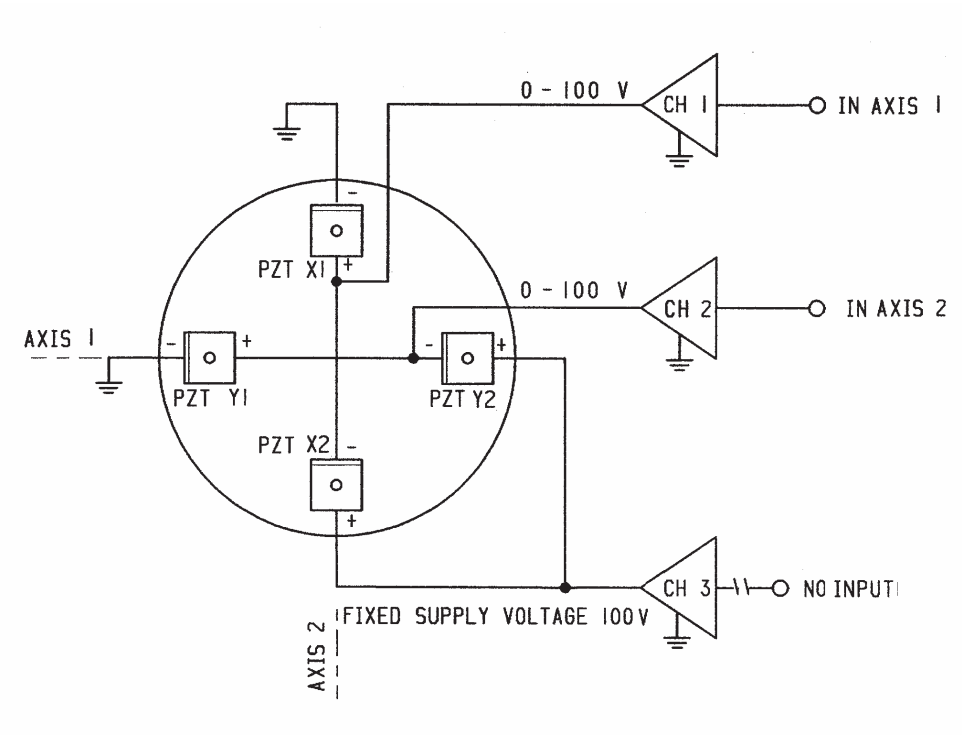
3.1 Operating Voltages

Each tilt axis of the tip/tilt platform system requires one controlled operating voltage in the range of 0 to +100 volts and one constant voltage of +100 V. At the zero position (tilt angle zero) both actuators of a pair are expanded to 50% of their maximum expansion (i.e. to 7.5 µm). Control voltages below 50 volts cause tilting in one direction, above 50 volts, tilting in the other. A 0 to 10 V control input thus covers the full tilt range. Operation over an extended range of -20 to +120 V is possible with certain limitations.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

3.2 Motion Polarities

The diagram below shows the relative positions of the four PZT stacks and makes the relative rotation polarities clear.



Dwg#: S330_layout.tif

Fig. 3. S-330 viewed from above with Axis 1 (controlled by channel 1) running left and right.

Keeping in mind that the grounded PZTs expand with increasing input, it can be seen that if after a positive Axis 1 tilt, you look “uphill” across the platform, a subsequent positive Axis 2 tilt would go up to the left and down to the right. Conversely, facing “uphill” after a positive Axis 2 tilt, a positive Axis 1 tilt would go down to the left and up to the right. The “handedness” of an open-loop system (with no sensor cable) can thus be inverted by interchanging the axes and rotating the unit 90°.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

3.3 Position Sensors

The closed-loop versions, S-330.10 and S-330.P10, are equipped with two pairs of strain gauge position feedback sensors operated in a bridge circuit for ultra-high resolution and angular stability. These sensors permit angular movements to be executed with sub-µrad resolution and repeatability.

The S-330.10 and S-330.P10 use strain gauge sensors in a half-bridge configuration.

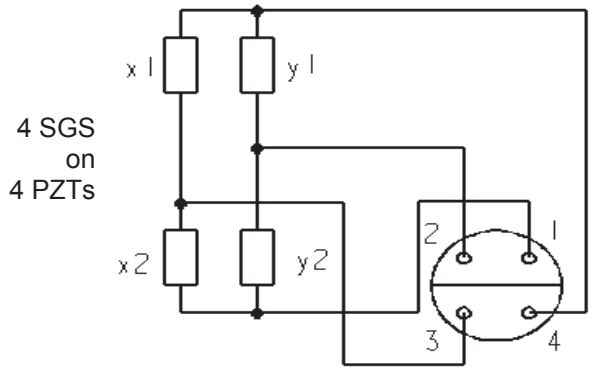


Fig. 4. S-330 sensor cable connections and pinout. X1, Y1,... refer to the PZT on which the respective sensors are mounted (see Fig. 3)

Note that both sensor channels are routed over a single sensor connector. If using an E-509.S3S controller, connect this cable to the CH1 socket. The CH2 and CH3 sockets are not connected.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

4 Drive Electronics

The S-330 tip/tilt platform system can be controlled by electronics of the E-500 series:

Amplifier (choice of the following, always required):

E-503.00S	Amplifier module special connected for differential-drive LVPZT tip/tilt platforms; 2 channels with variable drive signals (output sockets “CH1” and “CH2”) plus 100 V fixed output (output socket “CH3”)
2 x E-505.00 1 x E-505.00S	Single Channel modules. With two E-505.00 modules on the left and one E-505.00S on the right, “CH1” of the platform must be connected to the leftmost module, “CH2” to the center module and “CH3” to the E-505.00S

Note: On amplifiers for tip/tilt mirrors, the DC-offset potentiometer for channel 3, if present at all, is disabled and the output is clamped internally to +100 volts. The analog input of this channel is also disabled. External control voltages thus must be supplied to the CONTROL INPUT sockets of CH1 and CH2.

Controller (required in addition to amplifier for closed-loop operation):

E-509.S3S	Position servo-control module for SGS sensors; channel 1 (labeled “SERVO 1”) must be used with the platforms sensor cable, second and third channel (input sockets “SERVO 2” and “SERVO 3”) are not used. **Note:** This controller has the same front panel as a regular 3-channel version, but with the CH3 controls/connections deactivated and sensor channels 1 and 2 both routed through the CH1 sensor socket.

Display Module (displays position or voltage of axes, not required):

E-515.03	3½-digit LED position or voltage display for each of 3 channels (channel 3 not used)
E-515.01	3½-digit LED position or voltage display, 1 channel (2 modules needed for 2-axis display)

Computer Interface and Display Module (replaces display above, required for computer-controlled operation):

E-516.i3*	Computer Interface and Display Module, 3 channels, (channel 3 not used)

*The discontinued E-515.i3 can also be used.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

5 Dynamic Behavior

In addition to the amplifier, controller and sensor bandwidths, the maximum operating frequency of a tilt platform depends on its mechanical resonant frequency. To estimate the effective resonant frequency of the tilt mirror system (platform + mirror), the moment of inertia of the mirror substrate must first be calculated.

Moment of inertia of a rotationally symmetric mirror:

$$I_m = m\left[\frac{3R^2 + H^2}{12} + \left(\frac{H}{2} + T\right)^2\right]$$

Moment of inertia of a rectangular mirror:

$$I_m = m\left[\frac{L^2 + H^2}{12} + \left(\frac{H}{2} + T\right)^2\right]$$

where:

m = Mirror mass [g]

I_M = Moment of inertia of the mirror [g·mm^2]

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

H = Mirror thickness [mm]

T = Distance, pivot point to platform surface (see technical data table for individual model) [mm]

R = Mirror radius [mm]

Using the resonant frequency of the unloaded platform (see Technical Data table) and the moment of inertia of the mirror substrate, the system resonant frequency is calculated according to the following equation:

Resonant frequency of a tilt platform / mirror system:

$$f' = \frac{f_0}{\sqrt{1 + I_M / I_0}}$$

where:

f' = Resonant frequency of platform with mirror [Hz]

f_0 = Resonant frequency of unloaded platform [Hz]

I_0 = Moment of inertia of the platform (see technical data table) [g·mm^2]

I_M= Moment of inertia of the mirror [g·mm^2]

For more information on static and dynamic behavior of piezo actuators, see the "Tutorial" section of the PI Catalog, in particular pages 4-27 *ff.*

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

6 S-330 Technical Data

Models	S-330.30 (open-loop)	S-330.10 / S-330.P10 (closed-loop)	Units
Active axes (fixed orthogonal tilt axes)	2	2	
Tip/tilt range 0 to 100 V[1]	±1	±1	mrad ±20%
Closed-loop tilt angle ≥	–	±1	mrad
Integrated feedback sensor	–	4 x strain gauge	
Open-loop / closed-loop resolution[2] ≤	0.05	0.1	µrad
Closed-loop linearity (typ.)	–	±0.2	%
Full-range repeatability (typ.)[3]	–	±2	µrad
Electrical capacitance[4]	3.6 per axis	3.6 per axis	µF ±20%
Dynamic operating current coefficient (DOCC)[5]	0.22 per axis	0.22 per axis	µA/(Hz x µrad)
Resonant frequency (f_0) without mirror[6]	3.3	3.3	kHz ±20%
Resonant frequency w/ Ø 25 x 8 mm glass mirror[7]	2.4	2.4	kHz ±20%
Distance, pivot point to platform surface	6	6	mm
Platform moment of inertia	1530	1530	g·mm^2
Operating temperature range[8]	-20 to 80	-20 to 80	°C
Voltage connection	3 x Lemo fem. 2m cable	3 x Lemo fem. 2m cable	
Sensor connection	–	1 x Lemo, 2m cable	
Weight (w/o cables)	200	200	g ±5%
Material	Stainless steel case, Invar platform	Stainless steel case, Invar platform	
PICMA ceramic actuator[9]	no	no / yes	

Notes:

[1] Range: Operation over a -20 to +120 V range is possible if excursions to the limits are of short duration. See “Lifetime of PZTs” in the PI Catalog for more information. Special open-loop version with ± 2.5 mrad for 0-100 V is available on request.

[2] Resolution of PZT tip/tilt platforms is not limited by friction or stiction. Value is typical (RMS, 1σ) noise-equivalent motion with E-503 amplifier module.

[3] Full-Range Repeatability: Typical values, closed-loop mode. Since repeatability is a percentage of angle traveled, repeatability is significantly better for small ranges.

[4] Temperature Range: Small-signal value (measured at 1 V, 1000 Hz, 20 °C, no load); large-signal values at room temperature are 30 to 50% higher. The capacitance of PZT ceramics changes with amplitude, temperature, and load up to 200% of the unloaded, small-signal capacitance at room temperature. For detailed information on power requirements, refer to the amplifier frequency response curves in the "PZT Control Electronics" section of the PI Catalog.

[5] Dynamic Operating Current Coefficient in µA per hertz and µrad. Example: Sinusoidal scan of 100 µrad at 10 Hz requires approximately 0.22 mA drive current.

[6] Unloaded Resonant Frequency: Lowest tilt resonant frequency around an active axis without mirror (well above the maximum operating frequency). For more resonance considerations, see p. 4-28 in the PI Catalog.

[7] Resonant Frequency with Mirror: Example of how a load (mirror) affects the (calculated) resonant frequency.

[8] Standard range, other temperature ranges on request. Closed-loop systems are calibrated for optimum performance at room temperature. Recalibration is recommended if operation is at a significantly higher or lower temperature.

[9] PICMA™ ceramics offer extended lifetime and compatibility with harsh conditions.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

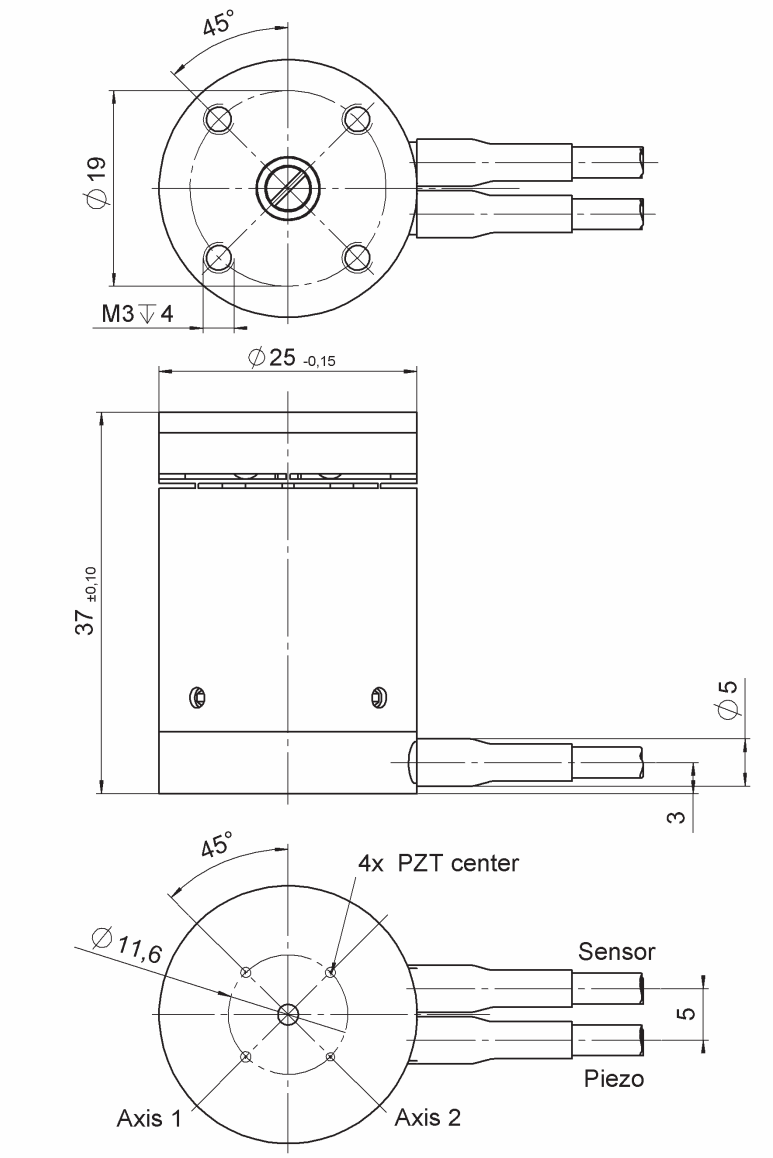
6.1 Connectors

The S-330 tip/tilt platform is equipped with three cables for supply voltage and and one cable for the sensor signals. Its LEMO connectors match the amplifier and servo controller modules.

The supply voltage cables of the S-330.xx are labeled “CH 1”, “CH 2” and “CH 3”.

The sensor cable of the S-330.10 and S-330.P10 (with 4-pin connector) is labeled “CH 1”. It carries sensor signals for both channels 1 and 2 (see Section 3.3, p. 7)

6.2 Dimensions



S-330 dimensions in mm, decimal places separated by a comma in drawings

Note: On the open-loop model (S-330.30) the unused sensor cable outlet is plugged with silicon.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Piezo · Nano · Positioning

PZ 149E User Manual

S-330 Tip/Tilt Platform

Release: 1.1.0 Date: 2007-07-24



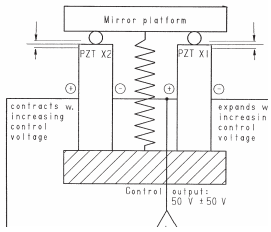
This document describes the following product(s):

- **S-330.2SL, S-330.4SL, S-330.8SL**
  High-dynamics piezo tip/tilt platforms, SGS, LEMO connector, travel 2, 5, and 10 mrad* respectively
- **S-330.2SD, S-330.4SD, S-330.8SD**
  High-dynamics piezo tip/tilt platforms, SGS, Sub-D connector, travel 2, 5, and 10 mrad* respectively
- **S-330.20L, S-330.40L, S-330.80L**
  High-dynamics piezo tip/tilt platforms, open-loop, LEMO connector, travel 2, 5, and 10 mrad* resp.

*Values are mechanical travel in closed-loop mode; optical beam deflection is twice mechanical travel







© Physik Instrumente (PI) GmbH & Co. KG
Auf der Römerstr. 1 · 76228 Karlsruhe, Germany
Tel. +49-721-4846-0 · Fax: +49-721-4846-299
info@pi.ws · www.pi.ws

Moving the NanoWorld | www.pi.ws

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Declaration of Conformity

according to ISO / IEC Guide 22 and EN 45014

Manufacturer:	**Physik Instrumente (PI) GmbH & Co. KG**
Manufacturer´s Address:	Auf der Römerstrasse 1 D-76228 Karlsruhe, Germany

CE

The manufacturer hereby declares that the product,

Product Name: **Tip/Tilt Platform**
Model Numbers: **S-330**
Product Options: **all**

when operated with a complying controller from PI, complies with the following European directives:

73/23/EWG, Niederspannungsrichtlinie / 73/23/EEC, Low voltage directive
89/336/EWG, EMV- Richtlinie / 89/336/EEC, EMC-Directive
98/37/EG, Maschinenrichtlinie / 98/37/EC, Machinery Directive

The applied standards certifying the conformity are listed below.

Electromagnetic Emission:	EN 61000-6-3, EN 55011
Electromagnetic Immunity:	EN 61000-6-1
Safety (Low Voltage Directive) :	EN 61010-1
Safety of Machinery:	EN 12100

15 July, 2007
Karlsruhe, Germany

Dr. Karl Spanner
President

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Copyright 1999–2007 by Physik Instrumente (PI) GmbH & Co. KG, Karlsruhe, Germany.
The text, photographs and drawings in this manual enjoy copyright protection. With regard thereto, Physik Instrumente (PI) GmbH & Co. KG reserves all rights. Use of said text, photographs and drawings is permitted only in part and only upon citation of the source

First printing 2007-07-24
Document Number PZ 149E, Release 1.1.0
S-330_User_PZ149E110.doc

This manual has been provided for information only and product specifications are subject to change without notice.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

About This Document

Users of This Manual

This manual is designed to help the reader to install and operate the S-330 Tip/Tilt Platform. It assumes that the reader has a fundamental understanding of basic servo systems, as well as motion control concepts and applicable safety procedures.
The manual describes the physical specifications and dimensions of S-330 Tip/Tilt Platforms as well as the software and hardware installation procedures which are required to put the associated motion system into operation.
Updated releases are available for download from www.pi.ws.or email: contact your PI Sales Engineer or write info@pi.ws.

Conventions

The notes and symbols used in this manual have the following meanings:

WARNING

Calls attention to a procedure, practice or condition which, if not correctly performed or adhered to, could result in injury or death.



CAUTION

Calls attention to a procedure, practice, or condition which, if not correctly performed or adhered to, could result in damage to equipment.

!

NOTE

Provides additional information or application hints.

Related Documents

The motion controller and the software tools which may be delivered with S-330 Tip/Tilt Platform are described in their own manuals. Updated releases are available for download from www.pi.ws.or email: contact your PI Sales Engineer or write info@pi.ws.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Contents

1 Introduction 2

1.1 Features 2
1.2 Parallel Kinematics....2
1.3 Operation 3
1.4 Superior Lifetime 3
1.5 Models Available 4
1.6 Safety Precautions 4
1.7 Prescribed Use....5

2 Quick Start 6

2.1 Mounting 6
2.2 Connecting to Controller and Starting 6

3 Working Principle 9

3.1 Design 9
3.2 Operating Voltages....10
3.3 Motion Polarities....10

4 Drive Electronics 12

4.1 Sub-D-Connector Versions (S-330.xxD) 12
4.2 LEMO-Connector Versions (S-330.xxL)....12

5 Dynamic Behavior 14

6 Old Equipment Disposal 15

7 Technical Data 16

7.1 Connectors....18
7.1.1 Sub-D Versions 18
7.1.2 LEMO Versions 19
7.2 Dimensions 20

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

1 Introduction

S-330 piezo platforms are fast and compact tip/tilt units providing precise angular motion of the top platform around two coplanar, orthogonal axes. These flexure-guided platforms can provide high accelerations, enabling step response times in the sub-millisecond range.

On closed-loop versions, high-resolution, absolute measuring strain gauge sensors (SGS) are applied to appropriate places on the drive train and feed the platform position information back to a piezoelectric controller. The sensors are connected in a full-bridge configuration to eliminate thermal drift; they assure optimal position stability and rapid response with nanometer resolution.

Both open- and closed-loop versions in 3 different tilt ranges up to 10 mrad (20 mrad optical deflection) are available.

1.1 Features

- Resolution to 20 nrad, Excellent Position Stability
- Coplanar Rotation Axes, Single Moving Platform
- Optical Beam Deflection to 20 mrad (>1°)
- Higher Dynamics, Stability & Linearity Through Parallel-Kinematics Design
- Sub-Millisecond Response For Mirrors up to 50 mm Diameter
- Closed-Loop Versions for Better Linearity
- Excellent Temperature Stability

1.2 Parallel Kinematics

These PI piezo tip/tilt platforms are based on a parallel-kinematics design with coplanar rotational axes and a single moving platform driven by two pairs of differential actuators. The advantage is jitter-free, multi-axis motion with excellent temperature stability. The single pivot-point design also avoids the drawback of polarization rotation, common with stacked systems like galvo-scanners.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

1.3 Operation

S-330 tip/tilt platforms must be operated in conjunction with three highly stable piezo amplifiers, and the closed-loop versions with electronics including a servo-controller for each motion axis. See Section 4 “Drive Electronics” for more information.

The electronics can in general be controlled in a number of different ways, including manual control (via 10-turn potentiometers), low-voltage control signals (perhaps from a DAQ-board in a PC), or convenient high-level ASCII commands from a host PC. See the documentation of the electronics for more details. All electronics, including analog controllers, have comprehensive software available, and all documentation can be freely downloaded from www.pi.ws.

1.4 Superior Lifetime

Highest possible reliability is assured by the use of awardwinning PICMA® multilayer piezo actuators. PICMA® actuators are the only ceramic encapsulated actuators on the market, which makes them uniquely resistant to ambient humidity and leakage-current failures. They are thus far superior to conventional actuators in reliability and lifetime.



Fig. 1: S-330.2SL, S-330.4SL and S-330.8SL tip/tilt platforms

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

1.5 Models Available

Travel ranges in parentheses are optical beam deflection angles and are thus twice the mechanical tip/tilt value.

S-330.2SL	High-dynamics piezo tip/tilt platform, 2 (4) mrad, SGS, LEMO Connector
S-330.2SD	High-dynamics piezo tip/tilt platform, 2 (4) mrad, SGS, Sub-D Connector
S-330.20L	High-dynamics piezo tip/tilt platform, 2 (4) mrad, Open-Loop, LEMO Connector
S-330.4SL	High-dynamics piezo tip/tilt platform, 5 (10) mrad, SGS, LEMO Connector
S-330.4SD	High-dynamics piezo tip/tilt platform, 5 (10) mrad, SGS, Sub-D Connector
S-330.40L	High-dynamics piezo tip/tilt platform, 5 (10) mrad, Open-Loop, LEMO Connector
S-330.8SL	High-dynamics piezo tip/tilt platform, 10 (20) mrad, SGS, LEMO Connector
S-330.8SD	High-dynamics piezo tip/tilt platform, 10 (20) mrad, SGS, Sub-D Connector
S-330.80L	High-dynamics piezo tip/tilt platform, 10 (20) mrad, Open-Loop, LEMO Connector

1.6 Safety Precautions

CAUTION

Be careful when mounting

Never use the hole on the platform's surface for mounting an object.

Never put anything in the flexure gaps of the body.

Do not clamp the body since this can block the flexure guiding system.

Calibrated System

If you purchased a motion system consisting of tip/tilt platform and controller, do not interchange parts or channels; they are matched and calibrated together. Respect the assignment of the platform's supply voltage and sensor channels to the individual controller channels, as indicated by the serial numbers on the labels affixed to the devices.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Resonance Can Cause Permanent Damage

The system must never be operated close to the resonant frequency or permanent damage can result. If you hear or see resonant behavior, switch off the unit immediately.

1.7 Prescribed Use

Based on its design and realization, the S-330 Tip/Tilt Platform is intended precision positioning of small payloads about two rotation axes when connected to a compatible PI piezo motion controller. It is a laboratory apparatus as defined by DIN EN 61010 and meets the following minimum specifications for safe operation (any more stringent specifications in the technical data table, p. 16, e.g. operating temperature -20°C to 80°C, are of course, also met):

- Indoor use only
- Altitude up to 2000 m
- Temperature range 5°C to 40°C
- Max. relative humidity 80% for temperatures up to 31°C, decreasing linearly to 50% relative humidity at 40°C
-

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

2 Quick Start

2.1 Mounting

You can mount the object to be positioned (for example, a mirror) on the platform using glue.

CAUTION

Never use the hole on the platform surface for mounting an object.

Never put anything in or across the gaps (flexure guiding system) of the body.

Do not clamp the body since this can block the flexure guiding system.

The platform can be mounted in any orientation. If you mount it on a vertical plane, however, the maximum “sideways” force limitation of 1 N will limit the load capacity accordingly.

By default, the platform metal case is not connected electrically. You should ground the mechanics if so required.

2.2 Connecting to Controller and Starting

The following instructions describe starting the S-330 tip/tilt platform using PI’s E-500-series control electronics (E-500 or E-501 chassis including either an E-616 amplifier/controller or an E-503.00S amplifier module and, when using the closed-loop model, an E-509.S3 servo-control module). If you use other modules from the E-500 series the steps are the same, but the connections details may differ. In this case please consult “Drive Electronics” Section on p. 12 for further information.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

!

CAUTION

Calibrated System

If you purchased a motion system consisting of tip/tilt platform and controller, do not interchange parts or channels; they are matched and calibrated together. Respect the assignment of the platform's supply voltage and sensor channels to the individual controller channels, as indicated by the serial numbers on the labels affixed to the devices.

Resonance Can Cause Permanent Damage

The system must never be operated close to the resonant frequency or permanent damage can result. If you hear or see resonant behavior, switch off the unit immediately. See "Dynamic Behavior" Section on p. 14 for more details.

1 Make sure the control electronics is switched off.

2 Closed-loop, sub-D-connector models (S-330.xSD): Connect the sub-D connector to the PZT+Sensor socket of the control electronics and go to Step 4.

3 LEMO-connector models (S-330.xxL):

a) Connect the drive cables from the S-330 tip/tilt platform to the E-503.00S amplifier module.

The drive voltage cables have brown connectors and are labeled "CH 1", "CH 2" and "CH 3". They must be plugged into the corresponding output sockets of the amplifier module.

NOTE

Do not mix up the cables while connecting, since the amplifier channels are connected internally so as to supply the platform channels 1 and 2 with variable drive signals, while channel 3 is supplied with a constant and very stable voltage of +100 volts.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

b) Closed-loop models (S-330.xSL) only: Connect the sensor cables from the tip/tilt platform to the E-509.S3 servo-control module.

   The two sensor cables with 4-pin connectors labeled “CH1” and "CH2" must be plugged into the corresponding sockets of the servo-control module (labeled “SERVO 1” and "SERVO 2").

4 Switch on the control electronics.
Consult the E-500 User Manual, and, if you have an E-516 or E-616 module installed, the corresponding User Manual for information on commanding the S-330 tip/tilt platform. If you have and E-509 servo-control module, consult also its User Manual.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

3 Working Principle

3.1 Design

The tip/tilt platform is mounted on four LVPZT stacks, located at the corners of a square. Tilting around one axis requires synchronized movement of two diagonally opposite LVPZT actuators. To ensure that one actuator will contract by exactly the same amount as the other expands, the actuator pairs are individually matched at the factory. The actuators in each pair are then connected electrically in differential push-pull mode, eliminating Z-axis freedom.

NOTE

With this design the pivot point is fixed and the same for both rotation axes. Whether you choose to measure the angles in vertical planes or in planes perpendicular to the platform depends on the requirements of your application.

Because the symmetrical design of the tip/tilt platform system, temperature changes will not effect the angular orientation but only the Z-axis position (axial thermal drift). Most applications are much less sensitive to this kind of instability as long as the angular orientation remains stable.

The closed-loop versions are equipped with two pairs of strain gauge position feedback sensors operated in a bridge circuit for ultra-high resolution and angular stability. These sensors permit angular movements to be executed with sub-µrad resolution and repeatability.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

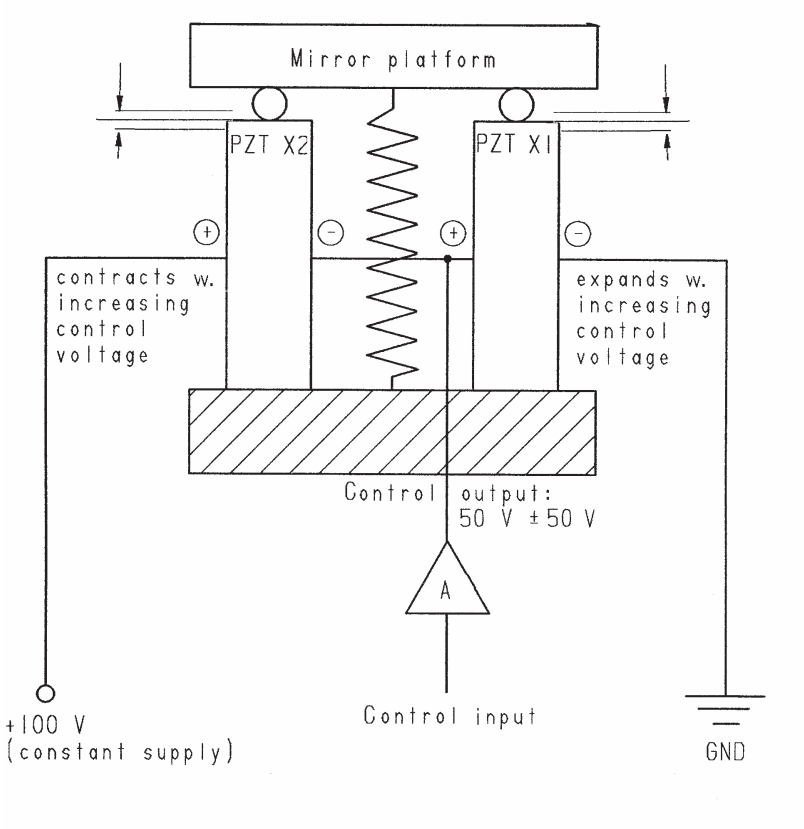


Fig. 2: S-330 Differential-drive tip/tilt platform, working principle (only Axis-1 tip motion shown)

3.2 Operating Voltages

Each tilt axis of the tip/tilt platform system requires one controlled operating voltage in the range of 0 to +100 volts and one constant voltage of +100 V. At the zero position (tilt angle zero) both actuators of a pair are expanded to 50% of their maximum expansion (i.e. to 7.5 µm). Control voltages below 50 volts cause tilting in one direction, above 50 volts, tilting in the other. Operation over an extended range of -20 to +120 V is possible, but excursions above 100 V and below -20 V should be kept of short duration.

3.3 Motion Polarities

The diagram below shows the relative positions of the four PZT stacks and makes the relative rotation polarities clear.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

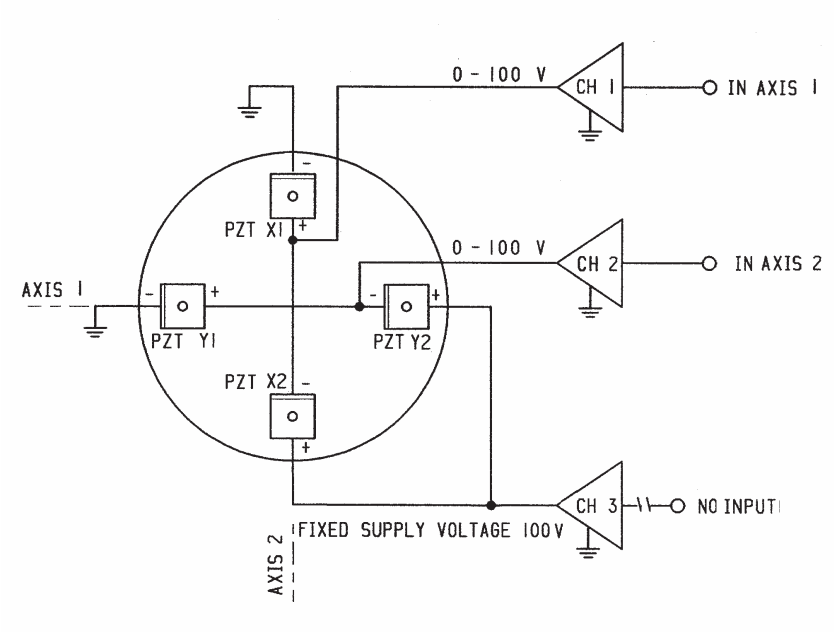


Fig. 3 S-330 viewed from above with Axis 1 (controlled by channel 1) running left and right.

Keeping in mind that the grounded PZTs expand with increasing input, it can be seen that if after a positive Axis 1 tilt, you look “uphill” across the platform, a subsequent positive Axis 2 tilt would go up to the left and down to the right. Conversely, facing “uphill” after a positive Axis 2 tilt, a positive Axis 1 tilt would go down to the left and up to the right.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

4 Drive Electronics

4.1 Sub-D-Connector Versions (S-330.xxD)

Versions with the sub-D connector can be connected directly to the E-616 Amplifier/Controller.

4.2 LEMO-Connector Versions (S-330.xxL)

LEMO-connector versions can be controlled by the following combinations of E-500-series modules:

Amplifier (choice of the following, always required):

E-503.00S	Amplifier module special connected for differential-drive LVPZT tip/tilt platforms; 2 channels with variable drive signals (output sockets “CH1” and “CH2”) plus 100 V fixed output (output socket “CH3”)
2 x E-505.00 1 x E-505.00S	Single Channel modules. With two E-505.00 modules on the left and one E-505.00S on the right, “CH1” of the platform must be connected to the leftmost module, “CH2” to the center module and “CH3” to the E-505.00S

NOTE

On amplifiers for differential-drive tip/tilt mirrors, the DC-offset potentiometer for channel 3, if present at all, is disabled and the output is clamped internally to +100 volts. The analog input of this channel is also disabled. External control voltages thus must be supplied to the CONTROL INPUT sockets of CH1 and CH2.

Controller (required in addition to amplifier for closed-loop operation):

E-509.S3	Position servo-control module for SGS sensors; channel 1 and 2 (labeled “SERVO 1” and "SERVO 2") must be used with the platforms sensor cables "CH1" and "CH2" accordingly

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Display Module (displays position or voltage of axes, not required):

E-515.03	3½-digit LED position or voltage display for each of 3 channels (channel 3 not used)
E-515.01	3½-digit LED position or voltage display, 1 channel (2 modules needed for 2-axis display)

Computer Interface and Display Module (replaces display above, allows digital computer operation*):

E-516.i3	Computer Interface and Display Module, 3 channels, (channel 3 not used)

* Computer-generated analog signals can, of course, be used to control any S-330, with or without an E-516. For certain National Instrument DAQ cards operating with LabVIEW in a PC, PI provides an Analog Driver Set which makes the high-level PI General Command Set available over an analog interface. See the controller documentation, which should include Technical Note E500T0011 with complete instructions and the password for downloading the Analog Drivers. They are under E-500 in the download section of www.pi.ws. The associated documentation is available without password.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

5 Dynamic Behavior

In addition to the amplifier, controller and sensor bandwidths, the maximum operating frequency of a tilt platform depends on its mechanical resonant frequency. To estimate the effective resonant frequency of the tilt mirror system (platform + mirror), the moment of inertia of the mirror substrate must first be calculated.

Moment of inertia of a rotationally symmetric mirror:

$$I_m = m\left[\frac{3R^2 + H^2}{12} + \left(\frac{H}{2} + T\right)^2\right]$$

Moment of inertia of a rectangular mirror:

$$I_m = m\left[\frac{L^2 + H^2}{12} + \left(\frac{H}{2} + T\right)^2\right]$$

where:
m = *Mirror mass [g]*
I_M = *Moment of inertia of the mirror [g•mm2]*
L =*Mirror length perpendicular to the tilt axis [mm]*
H = *Mirror thickness [mm]*
T = *Distance, pivot point to platform surface (see technical data table for individual model) [mm]*
R = *Mirror radius [mm]*

Using the resonant frequency of the unloaded platform (see Technical Data table on p. 16) and the moment of inertia of the mirror substrate, the system resonant frequency is calculated according to the following equation:

Resonant frequency of a tilt platform / mirror system:

$$f' = \frac{f_0}{\sqrt{1 + I_M / I_0}}$$

where:
f' = *Resonant frequency of platform with mirror [Hz]*
f_0 = *Resonant frequency of unloaded platform [Hz]*
I_0 = *Moment of inertia of the platform (see technical data table, p. 9) [g•mm^2]*
I_M = *Moment of inertia of the mirror [g•mm^2]*

For more information on static and dynamic behavior of piezo actuators, see the "Tutorial" section of the PI Catalog.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

6 Old Equipment Disposal

In accordance with EU directive 2002 / 96 / EC (WEEE), as of 13 August 2005, electrical and electronic equipment may not be disposed of in the member states of the EU mixed with other wastes.

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

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

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



Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

7 Technical Data

Models	S-330.20L S-330.40L S-330.80L	S-330.2SL	S-330.4SL	S-330.8SL	S-330.2SD S-330.4SD S-330.8SD		
Active axes	θ_X, θ_Y	θ_X, θ_Y	θ_X, θ_Y	θ_X, θ_Y	θ_X, θ_Y		
Motion and positioning							
Integrated sensor	-	4x SGS	4x SGS	4x SGS	4x SGS		
Open-loop tilt angles[8] for -20 to +120 V	see SL version	3.5	7	15	see SL version	mrad	min.
Closed-loop tilt angle θ_X, θ_Y	-	2	5	10	see SL version	mrad	
Open-loop angular resolution[1] in θ_X, θ_Y	see SL version	0.02	0.1	0.2	see SL version	µrad	typ.
Closed-loop angular resolution[1] in θ_X, θ_Y	-	0.05	0.25	0.5	see SL version	µrad	typ.
Repeatability[2] in θ_X, θ_Y	-	0.15	0.5	1	see SL version	µrad	typ.
Mechanical properties							
Unloaded resonant frequnency[5] in θ_X, θ_Y	see SL version	3.7	3.3	3.1	see SL version	Hz	±20%
Resonant frequency under load[6] in θ_X and θ_Y	see SL version	2.6 (with glass mirror, 25 mm diam., 8 mm thick)	1.6 (with glass mirror, 25 mm diam., 8 mm thick)	1.0 (with glass mirror, 25 mm diam., 8 mm thick)	see SL version	Hz	±20%
Distance, pivot point to platform surface	6	6	6	6	6	mm	±1 mm
Inertia, of mirror	1530	1530	1530	1530	1530	g x mm²	±20%
Drive properties							
Ceramic type	PICMA®	PICMA®	PICMA®	PICMA®	PICMA®		
Electrical Capacitance	12.5 per axis	3 per axis	6 per axis	12.5 per axis	12.5 per axis	µF	±20%
Dynamic operating current coefficient[4] (DOCC)		0.22 per axis				$\frac{\mu A}{Hz \times mrad}$	±20%

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Models	**S-330.20L S-330.40L S-330.80L**	**S-330.2SL**	**S-330.4SL**	**S-330.8SL**	**S-330.2SD S-330.4SD S-330.8SD**		
Miscellaneous							
Operating temperature range[7]	-20 to 80	-20 to 80	-20 to 80	-20 to 80	-20 to 80	°C	
Material case	Stainless steel, non-magnetic	Stainless steel, non-magnetic	Stainless steel, non-magnetic	Stainless steel, non-magnetic	Stainless steel, non-magnetic		
Platform material	Invar	Invar	Invar	Invar	Invar		
Mass	see SL version	0.2	0.38	0.7	see SL version	kg	±5%
Cable length	1.5	1.5	1.5	1.5	1.5	m	±10 mm
Sensor connection	-	2x Lemo connector (SGS sensor)	2x Lemo connector (SGS sensor)	2x Lemo connector (SGS sensor)	Sub-D connector, 25-pin		
Voltage connection	3x Lemo connector (low voltage)	3x Lemo connector (low voltage)	3x Lemo connector (low voltage)	3x Lemo connector (low voltage)	Sub-D connector, 25-pin		
Recommended controller / amplifier	E-616:	E-500 modular control system E-501.00 chassis, E-503.00S amplifier, E-509.S3 servo-controller and optional E-516 interface module For high-dynamics applications with E-500.00 chassis and one E-505.00S and two E-505.00 amplifiers					
Mirror mounting							
Standard mirror, mounted	BK7, λ/5, R > 98% (λ = 500 nm to 2 µm)	BK7, λ/5, R > 98% (λ = 500 nm to 2 µm)	BK7, λ/5, R > 98% (λ = 500 nm bis 2 µm)	BK7, λ/5, R > 98% (λ = 500 nm to 2 µm)	BK7, λ/5, R > 98% (λ = 500 nm to 2 µm)		
Mirror diameter	10 mm	10 mm	10 mm	10 mm	10 mm	mm	max.
Mirror thickness	2 mm	2 mm	2 mm	2 mm	2 mm	mm	max.

1 Resolution of PZT tip/tilt platforms is not limited by friction or stiction. Value is typical (RMS, 1σ) noise-equivalent motion with E-503 amplifier module.
2 Full-Range Repeatability: Typical values, closed-loop mode. Since repeatability is a percentage of the angle traveled, repeatability is significantly better for small ranges.
3 Small-signal value (measured at 1 V, 1000 Hz, 20°C, no load); large-signal values at room temperature are 30 to 50% higher. The capacitance of PZT ceramics changes with amplitude, temperature, and load up to 200% of the unloaded, small-signal capacitance at room temperature. For detailed information on power requirements, refer to the amplifier frequency response curves in the "PZT Control Electronics" section of the PI Catalog.
4 Dynamic Operating Current Coefficient in µA per hertz and µrad. Example: Sinusoidal scan of 100 µrad at 10 Hz requires approximately 0.22 mA drive current.
5 Unloaded Resonant Frequency: Lowest tilt resonant frequency around an active axis without mirror (well above the maximum operating frequency). For more resonance considerations, see ”Tutorial” in the PI Catalog.
6 Resonant Frequency with Mirror: Example of how a load (mirror) affects the (calculated) resonant frequency.

7 Standard range, other temperature ranges on request. Closed-loop systems are calibrated for optimum performance at room temperature. Recalibration is recommended if operation is at a significantly higher or lower temperature.
8 Mechanical tilt, optical beam deflection is twice as large. Special version with 10 mrad available on request.

7.1 Connectors

7.1.1 Sub-D Versions

The S-330.xxD versions are equipped with a single sub-D25m plug carrying both the piezo voltages and the sensor signals. This connector interfaces directly with the E-616 Amplifier/Controller module. The pinout is as shown below:

Pin	Signal
1	SGS3-B1
14	SGS3-B2
2	Not used
15	Not used
3	SGS2-B1
16	SGS2-B2
4	SGS-REF
17	SGS-GND
5	SGS1-B1
18	SGS1-B2
6	SGS-REF
19	SGS-GND
7	Connected to GND in plug*
20	GAIN1
8	-15 V
21	GAIN2
9	+15 V
22	GAIN3
10	GND
23	PZT1-GND
11	PZT1-OUT
24	PZT2-GND
12	PZT2-OUT
25	PZT3-GND
13	PZT3-OUT

* Sensed by E-616, which then outputs a constant 100 V on PZT3-OUT

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

7.1.2 LEMO Versions

The S-330.xxL versions are equipped with LEMO connectors for the individual piezo voltages and sensor signals, including a third piezo cable for the constant-voltage, 100 V, reference supply. The open-loop versions (S-330.x0L) have no sensor cables.

The piezo supply voltage cables are labeled “CH 1”, “CH 2” and “CH 3”, whereby CH3 connects to the constant 100 V supply.

The sensor cables (if present) have 4-pin connectors and are labeled “CH 1” and "CH2".

Always connect the cables as labeled during calibration.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

7.2 Dimensions

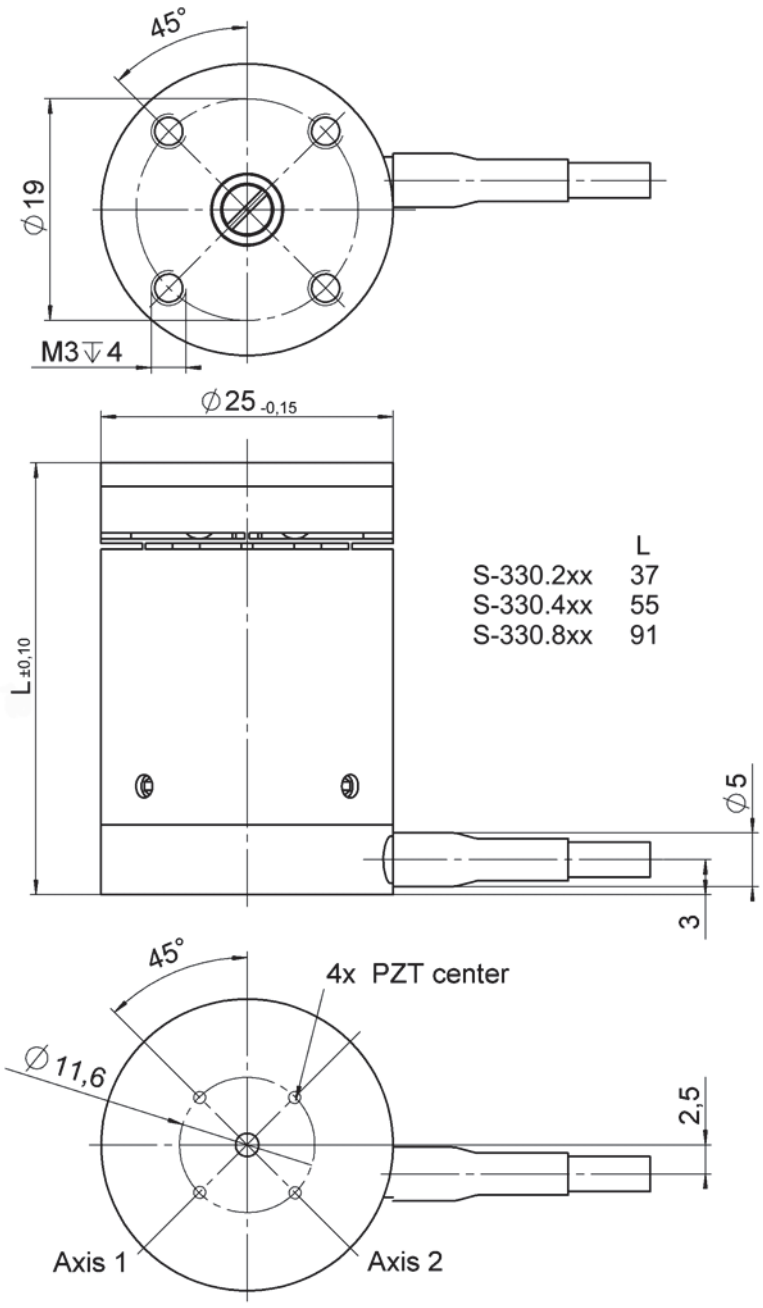


Fig. 4: S-330 dimensions in mm, decimal places separated by a comma in drawings

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Artisan Technology Group is an independent supplier of quality pre-owned equipment

Gold-standard solutions

Extend the life of your critical industrial, commercial, and military systems with our superior service and support.

We buy equipment

Planning to upgrade your current equipment? Have surplus equipment taking up shelf space? We'll give it a new home.

Learn more!

Visit us at **artisantg.com** for more info on price quotes, drivers, technical specifications, manuals, and documentation.

Artisan Scientific Corporation dba Artisan Technology Group is not an affiliate, representative, or authorized distributor for any manufacturer listed herein.

We're here to make your life easier. How can we help you today?

(217) 352-9330 | sales@artisantg.com | artisantg.com

ARTISAN® TECHNOLOGY GROUP