PI

MP150E
L-406 Compact Linear Stage
User Manual

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This document describes the following products:
- L-406.x0DG10:
  With DC gear motor and rotary encoder
- L-406.x0DD10:
  With DC motor and rotary encoder
- L-406.x0SD00:
  with 2-phase stepper motor, without encoder

x stands for travel range:
1 = 26 mm
2 = 52 mm
4 = 102 mm

MOTION | POSITIONING

PI

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Subject to change. This manual is superseded by any new release. The latest respective release is available for download (p. 3) on our website.

Contents

1 About this Document

1.1 Objective and Target Audience of this User Manual

This manual contains information on using the L-406 as intended.

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

The latest versions of the user manuals are available for download (p. 3) on our website.

1.2 Other Applicable Documents

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

Product	Document
L-406	MP146EK Short Instructions for Positioners with Electric Motors
C-863.12 DC Motor Controller	MS249E User Manual
C-663.12 stepper motor controller	MS241E User Manual
C-884 DC Motor Controller	MS213E User Manual

1.3 Symbols and Typographic Conventions

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

CAUTION

Dangerous situation
Failure to comply could lead to minor injury.

➢ Precautionary measures for avoiding the risk.

> **NOTICE**
>
> **Dangerous situation**
> Failure to comply could cause damage to equipment.
>
> ➢ Precautionary measures for avoiding the risk.

> **INFORMATION**
>
> Information for easier handling, tricks, tips, etc.

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

1.4   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.

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1.5 Downloading Manuals

INFORMATION
If a manual is missing or problems occur with downloading:
➢ Contact our customer service department (p. 41).

Downloading manuals

1. Open the website **www.pi.ws**.
2. Search the website for the product number (e.g., P-882) or the product family (e.g., PICMA® bender).
3. Click the corresponding product to open the product detail page.
4. Click *Downloads*.

   The manuals are shown under *Documentation*.
5. Click the desired manual and fill out the inquiry form.

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

2   Safety

2.1   Intended Use

The L-406 is a laboratory device as defined by DIN EN 61010. 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 L-406 is intended for single-axis positioning, adjusting and shifting of loads at different velocities. The L-406 is **not** intended for applications in areas in which a failure would present severe risks to human beings or the environment.

The L-406 is intended for horizontal or vertical mounting. For the load limits with vertical mounting, see "General Notes on Installation" (p. 15).

The intended use of the L-406 is only possible when completely mounted and connected.

The L-406 must be operated with a suitable controller (p. 11). The controller is not included in the scope of delivery of the L-406.

2.2   General Safety Instructions

The L-406 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 L-406.

> ➢ Use the L-406 for its intended purpose only, and only when it is in perfect technical condition.

> ➢ Read the user manual.

> ➢ Eliminate any malfunctions that may affect safety immediately.

The operator is responsible for the correct installation and operation of the L-406.

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2.3   Organizational Measures

User manual

➢ Always keep this user manual together with the L-406.
The latest versions of the user manuals are available for download (p. 3) on our website.

➢ Add all information from the manufacturer to the user manual, for example supplements or technical notes.

➢ If you give the L-406 to a third party, include this user manual as well as 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 L-406 only after you have read and understood this user manual.

Personnel qualification

The L-406 may only be installed, started, operated, maintained, and cleaned by authorized and appropriately qualified personnel.

3 Product Description

3.1 Model Overview

Order number	Product name
L-406.10DG10	Compact linear stage, 65 mm width, DC gear motor, 26 mm travel range, optical limit switches
L-406.10DD10	Compact linear stage, 65 mm width, DC motor, 26 mm travel range, optical limit switches
L-406.10SD00	Compact linear stage, 65 mm width, stepper motor, 26 mm travel range, optical limit switches
L-406.20DG10	Compact linear stage, 65 mm width, DC gear motor, 52 mm travel range, optical limit switches
L-406.20DD10	Compact linear stage, 65 mm width, DC motor, 52 mm travel range, optical limit switches
L-406.20SD00	Compact linear stage, 65 mm width, stepper motor, 52 mm travel range, optical limit switches
L-406.40DG10	Compact linear stage, 65 mm width, DC gear motor, 102 mm travel range, optical limit switches
L-406.40DD10	Compact linear stage, 65 mm width, DC motor, 102 mm travel range, optical limit switches
L-406.40SD00	Compact linear stage, 65 mm width, stepper motor, 102 mm travel range, optical limit switches

3.2   Product View
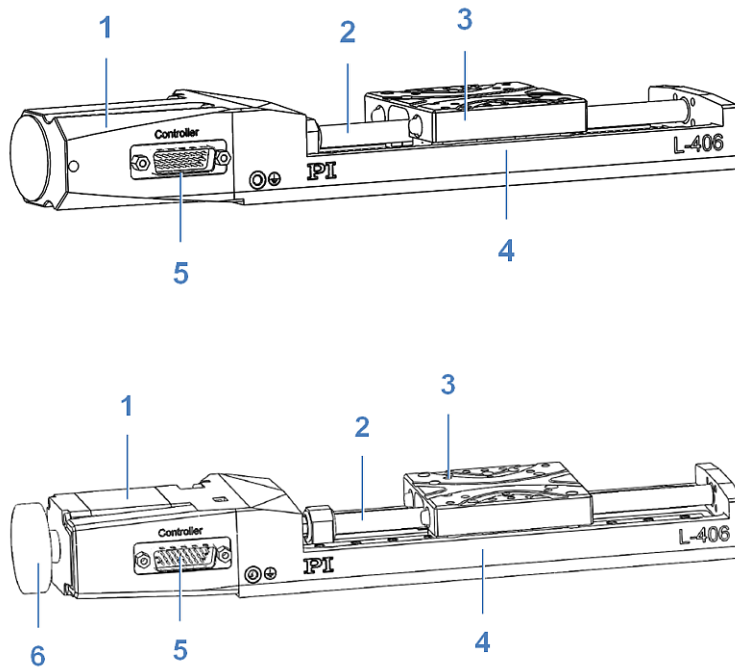
Figure 1: Parts of the L-406 with DC motor / DC gear motor (above), L-406 with stepper motor (below)

1   Motor
2   Drive screw
3   Motion platform
4   Base body
5   Motor connector (HD D-sub 26 panel plug)
6   Vibration absorber

3.3 Direction of Motion
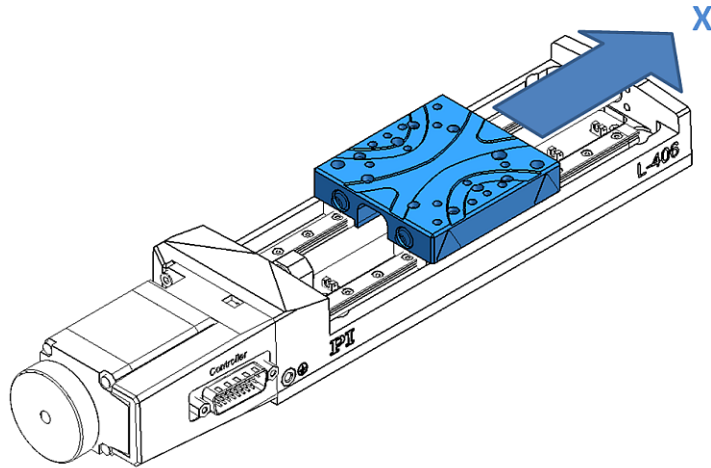
Figure 2: Direction of motion of the motion platform

    X   (arrow direction:) Direction of motion on positive command

3.4 Product Labeling
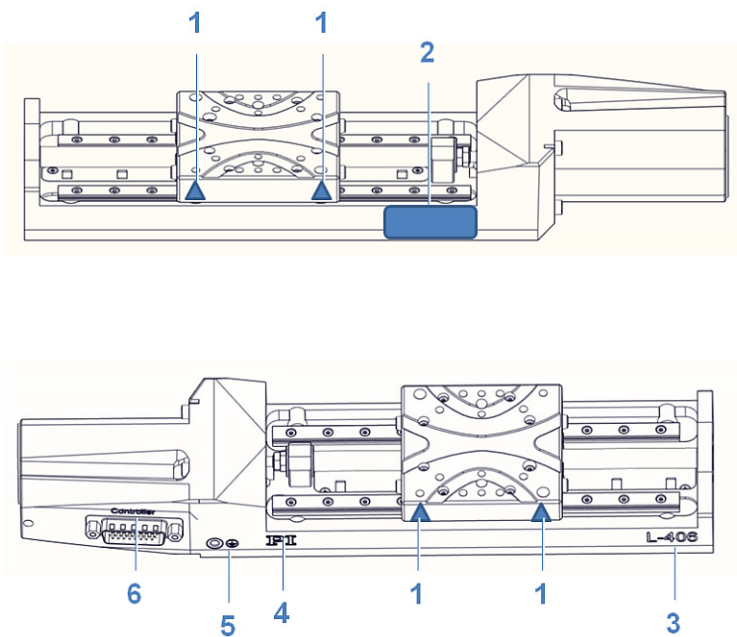
Figure 3: Product labeling

Position	Labeling	Description
1	⚠	Warning sign "Risk of crushing": Reference to dangerous forces (p. 31)
2	⌧	Old equipment disposal
2	Country of origin: Germany	Country of origin
2	(data matrix)	Data matrix code (example; contains the serial number)
2	L-406.20DG10	Product name (example), the characters following the period refer to the model
2	415002159	Serial number (example), individual for each L-406 Meaning of each position (from the left): 1 = internal information, 2 and 3 = year of manufacture, 4 to 9 = consecutive number
2	CE	CE conformity mark
2	WWW.PI.WS	Manufacturer's address (website)
2	⚠	Warning sign "Pay attention to the manual!"
2, 3	L-406	Product series
2, 4	PI	Manufacturer's logo
5	⏚	Symbol for the protective earth conductor, marks the protective earth connection of the L-406 (p. 18)
6	Controller	Motor connection

3.5   Scope of Delivery

Item number	Component
	L-406 according to the order (p. 7)
6233500074	Screw set for mounting of the L-406: ▪ 8 socket head screws, ISO 4762 - M4x12 ▪ 2 dowel pins, ISO 2338 - 3h8x6-A1 ▪ 2 dowel pins, ISO 2338 - 4h8x10-A1
MP146EK	Short instructions for positioners with electric motors

3.6   Accessories

Order number	Description
L-500.AV3	Adapter bracket for vertical mounting of positioners with up to 100 mm width and 300 mm length, mounting kit included ▪ 4 socket head screws, ISO 4762 - M6x12 ▪ 2 dowel pins ISO 2338 - 3h8x12-A1 ▪ 2 dowel pins ISO 2338 - 4h8x12-A1

To order, contact our customer service department (p. 41).

3.7   Suitable Controllers

The L-406 must be connected to a suitable controller. The following controllers from PI are suitable for operating the L-406:

Models	Controller
L-406.x0SD00	C-663.12 Compact Mercury Step stepper motor controller, 1 axis, closed-loop and open-loop operation, HD D-sub 26, 48 V
L-406.x0DG10 L-406.x0DD10	C-863.12 Mercury servo controller, for DC motors and PWM motor driver, 1 axis, HD D-sub 26, USB, RS-232, I/O, connector for analog joystick
	C-884.4DC • C-884.6DC Controller for DC motors, 4 / 6 axes, USB, RS-232, Ethernet, SPI, I/O, joystick connection

The required PC software is included in the scope of delivery of the controllers from PI. The operation of the controllers is described in the corresponding user manuals.

Note that the cables required for connecting the L-406 to the electronics must be ordered separately.

To order, contact our customer service department (p. 41).

3.8 Technical Features

3.8.1 Rotary Encoder

The L-406.x0DG10 and L-406.x0DD10 models are equipped with an incremental rotary encoder.

A rotary encoder is implemented at a rotating point in the drivetrain, e.g., the motor shaft.

3.8.2 Limit Switches

The L-406 is equipped with optical limit switches.

Each limit switch sends its signal to the controller on a dedicated line. The controller then stops the motion. If the controller does not stop the motion in time, the positioner runs into the hard stop.

See "Limit Switch Specifications" (p. 46) for more information.

3.8.3 Reference Switch

The positioner is equipped with a direction-sensing reference switch, which is located at about the midpoint of the travel range. This sensor sends a TTL signal indicating whether the positioner is on the positive or negative side of the reference switch.

See the controller user manual and/or associated software manuals for the commands that make use of the reference point signal.

4 Unpacking

NOTICE

Electrostatic hazard

Touching the pins on the connector of the L-406 can damage electrostatic-sensitive (also: ESD) components of the L-406. For this reason, the L-406 is supplied with ESD protection on all connectors.

➢ Remove the ESD protection from the connector only when you connect the L-406 to the controller.

1. Unpack the L-406 with care.

2. Do **not** remove the ESD protection from the L-406's connector.

3. Compare the contents with the items listed in the contract and the packing list.

4. Inspect the contents for signs of damage. If there is any sign of damage or missing parts, contact PI immediately.

5. Keep all packaging materials and the ESD protection in case the product needs to be returned.

5   Installation

5.1   General Notes on Installation

NOTICE
Unwanted changes in position when mounted vertically! If the load exceeds the holding force of the L-406 when the drive is mounted vertically, unwanted changes in the position of the platform will occur. Unwanted changes in the position of the platform can damage the drive, the load or the surroundings. ➢ When the L-406 is mounted vertically, make sure that the installed load is lower than the self-locking of the drive (see specification of the holding force in the "data table" (p. 43)).

NOTICE
Electrostatic hazard Touching the pins on the connector of the L-406 can damage electrostatic-sensitive (also: ESD) components of the L-406. For this reason, the L-406 is supplied with ESD protection on all connectors. ➢ Remove the ESD protection from the connector only when you connect the L-406 to the controller.

NOTICE
Cable break! A cable break leads to failure of the positioner. ➢ Install the positioner so that the cable is not bent too strongly or crushed.

NOTICE
Heating up of the L-406 during operation! The heat produced during operation of the L-406 can affect your application. ➢ Install the L-406 so that your application is not affected by the dissipating heat.

INFORMATION
For optimum repeatability, all components must be connected firmly together.

INFORMATION

The use of locating pins during mounting reduces deviations from the ideal alignment of the L-406.

> ➢ If possible, simulate the positioner motions with a mounted load or make suitable calculations to detect collisions or unfavorable center of gravity constellations.
>
> ➢ If necessary, take suitable constructive measures to avoid collisions and instability in the overall system.
>
> ➢ Avoid or mark danger zones that result from the installation of the positioner and the application, in accordance with the legal regulations.

5.2 Mounting the L-406 onto a Surface

NOTICE

Protruding screw heads!
Protruding screw heads can damage the L-406.

> ➢ Ensure that the screw heads do not protrude from countersunk holes so that they do not interfere with the motion.

NOTICE

Warping of the L-406 when mounted on uneven surfaces!
The L-406 could warp if mounted on an uneven surface. Warping reduces the accuracy.

> ➢ Mount the L-406 onto an even surface. The recommended flatness of the surface is ≤10 µm.
>
> ➢ For applications with large temperature changes:
> Mount the L-406 only onto surfaces that have the same or similar thermal expansion properties as the L-406.

For mounting onto an underlying surface, the L-406 has mounting holes for M4 screws in its base body. The number depends on the model:

- ▪ L-406.1xxxxx: **4** mounting holes
- ▪ L-406.2xxxxx, L-406.4xxxxx: **8** mounting holes

A sufficient number of screws and locating pins is included in the scope of delivery of the L-406.

Position of the holes for alignment and mounting of the L-406
(bottom; dark arrows: Mounting holes, long light arrows respectively: Locating holes 3 mm, short light arrows: Locating holes 4 mm)

L-406.1xxxxx models (example L-406.10SD00)	L-406.2xxxxx and L-406.4xxxxx models (example L-406.40SD00)

Requirements

✓ You have read and understood the general notes on installation (p. 15).

✓ You have provided a suitable underlying surface (for the required position and depth of the holes for accommodating the screws and locating pins, see "Dimensions" (p. 46)):

– 4 or 8 M4 threaded holes are present (depends on the model).

– If you use locating pins to align the L-406: Two locating holes Ø 3 mm or Ø 4 mm are provided.

– The surface flatness is ≤ 10 µm.

– For applications with large temperature fluctuations: The surface should have the same thermal expansion properties as the L-406 (e.g., underlying surface made of aluminum).

✓ You have accounted for the space required to route cables according to regulations and without bending them.

Tools and accessories

- Mounting kit, included in the scope of delivery (p. 10)
  - 4 or 8 socket head screws, ISO 4762 - M4x12
  - Optional: 2 dowel pins, ISO 2338 - 4h8x10 or 3h8x6 for use as locating pins
- Hex key, AF 3

Attaching the positioner to an underlying surface

1. Align the L-406 on the underlying surface so that the corresponding mounting holes in the L-406 and underlying surface are in line.

   If you use locating pins to align the L-406:
   a) Insert the locating pins into the respective holes in the underlying surface.
   b) Put the L-406 onto the underlying surface so that the locating pins are inserted into the corresponding locating holes on the other side.

2. Allow access to the mounting holes in the base body of the L-406. Possible measures:
   - Temporary startup of the positioner (p. 31) and commanding the platform to a suitable position
   - Moving the platform by hand (p. 36)

3. Tighten the screws in all accessible mounting holes completely.

4. Repeat steps 2 to 4 for all necessary holes required.

5. Check that the L-406 is fixed firmly to the underlying surface.

5.3 Connecting the L-406 to the Protective Earth Conductor

INFORMATION

It is only necessary to connect the L-406 to the protective earth conductor when both of the following conditions are met:

- The load on the platform of the L-406 must be connected to the protective earth conductor, but it is not possible to connect the protective earth conductor directly to the load.
- The load and the platform are connected conductively to each other.

INFORMATION

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

There is an M4 hole in the base body of the L-406 for the protective earth conductor connection. In the following figure, this hole is marked with an arrow.
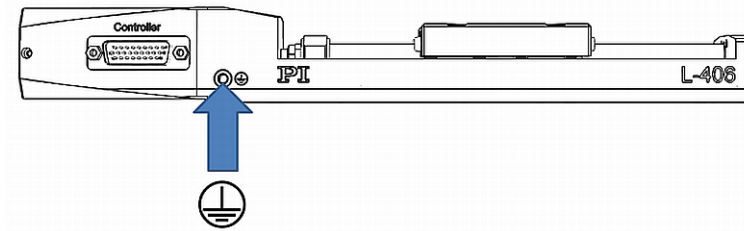
Figure 4: Position of the hole for attaching the protective earth conductor
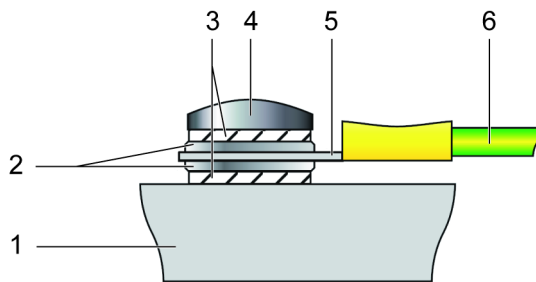
Figure 5: Connecting the protective earth conductor (profile view)

1	Base body of the L-406
2	Flat washer
3	Safety washer
4	Screw
5	Cable lug
6	Protective earth conductor

Requirements

✓ You have read and understood the general notes on installation (p. 15).

Tools and accessories

- Suitable protective earth conductor: Cross-sectional area of the cable ≥ 0.75 mm^2
- Screw, M4x8, ISO 7045
- 2 washers ISO 7089-4
- 2 safety washers S4
- Suitable screwdriver

Connecting the L-406 to the protective earth conductor

1. If necessary, attach a suitable cable lug to the protective earth conductor.

2. Use the M4 screw (together with the flat and lock washers) to attach the cable lug of the protective earth conductor to the threaded hole in the L-406 as shown in the profile view.

3. Tighten the M4 screw with a torque of 1.2 Nm to 1.5 Nm.

4. Make sure that the contact resistance at all connection points relevant for connecting the protective earth conductor is <0.1 Ω at 25 A.

5.4 Fixing the Load to the L-406

NOTICE

Impermissibly high load on the positioner!
An impermissible high load impairs the motion of the motion platform and can damage the positioner.

➢ For mounting type and mass of the load, pay attention to the maximum permissible forces that are allowed to act on the motion platform according to the specification (p. 43).

NOTICE

Excessively long screws!
Screws and locating pins inserted too deeply can damage the lower positioner.

➢ Pay attention to the depth of the mounting holes in the motion platform (p. 46) of the lower positioner.
➢ Only use screws and locating pins of the correct length for the respective mounting holes.

Requirements

✓ You have read and understood the general notes on installation (p. 15).

✓ You have mounted the L-406 onto an underlying surface (p. 16) properly.

✓ The L-406 is **not** connected to the controller.

✓ You have prepared the load so that it can be fixed to the mounting holes in the platform:

  − The gap between the center of gravity of the load and the center of the platform is as small as possible in all directions.

  − At least two points are provided for fixing the load to the platform (ideally: three or four attachment points).

– If you use locating pins for aligning the load: You have drilled two locating holes with Ø 3 mm into the load to accommodate the locating pins.

Tools and accessories

- At least 2 screws of suitable length. Options:
    – M4 screws
    – M6 screws
- Suitable tool for tightening the screws
- Optional: 2 dowel pins, ISO 2338 - 3h8 of suitable length for aligning the load on the L-406.

Fixing the Load

1. Align the load so that the mounting holes selected in the platform can be used to fix it.

    If you use locating pins to align the load:

    a) Insert the locating pins into the corresponding locating holes in the platform.

    b) Put the load on the platform so that the locating pins are inserted into the corresponding locating holes on the other side.

2. Use the screws (p. 51) to fix the load to the selected mounting holes in the platform.

3. Check that the load is sitting firmly on the platform of the L-406.

5.5 Building a Multi-Axis System

The L-406 can be used in multi-axis systems.

Typical combinations:

- XY system (p. 22)
- Z system (XZ or XYZ combination) (p. 25)
- ➢ Contact our customer service department (p. 41) for possible combinations with other positioners.

5.5.1 General Information on Building a Multi-Axis System

NOTICE

Impermissibly high load on the positioners!
In a multi-axis system, the positioner must also be moved for the Y and/or Z axis. Impermissibly high loads impair the motion and can damage the positioners.

- ➢ Include the masses of the positioner that is moved and the mounting adapters (p. 11) in the calculation of the load to be moved.
- ➢ For all positioners in a multi-axis system: Do **not** exceed the maximum permissible load.
- ➢ When the positioner is mounted vertically, make sure that the installed load is lower than the self-locking of the drive.

- ➢ Only install and operate the multi-axis system after you have read and understood the user manuals for all components of the multi-axis system.

- ➢ If you need special mounting adapters, contact our customer service department (p. 41).

5.5.2 Building an XY System

NOTICE

Excessively long screws!
Screws and locating pins inserted too deeply can damage the lower positioner.

- ➢ Pay attention to the depth of the mounting holes in the motion platform (p. 46) of the lower positioner.
- ➢ Only use screws and locating pins of the correct length for the respective mounting holes.

Designations in these instructions:

- **Lower positioner**: Forms the basis of the multi-axis system (X axis), is attached to an underlying surface

- **Upper positioner**: Forms the Y axis of the multi-axis system, is attached to the lower positioner rotated by 90°
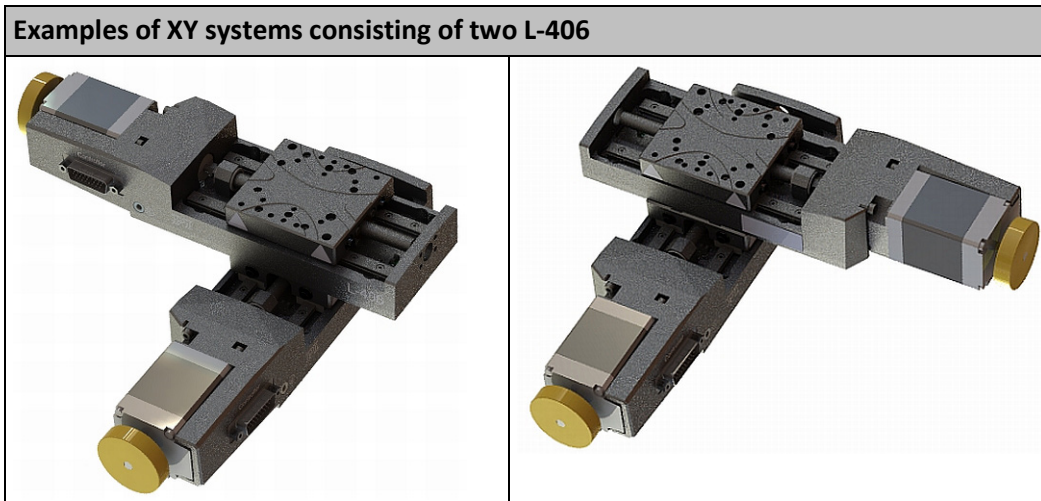
Examples of XY systems consisting of two L-406

Requirements

- ✓ You have read and understood the general notes on installation (p. 15).
- ✓ You have read and understood the general notes on setting up a multi-axis system (p. 22).
- ✓ You have accounted for the space required to route cables according to regulations and without bending them.
- ✓ You have mounted the lower L-406 onto the surface (p. 16) properly.

Tools and accessories

- Mounting kit from the scope of delivery of the upper L-406:
  - 2 screws, ISO 4762 M4x12
  - Optional: 2 dowel pins, ISO 2338 - 3h8x6 for use as locating pins
- Hex key, AF 3

Building an XY System
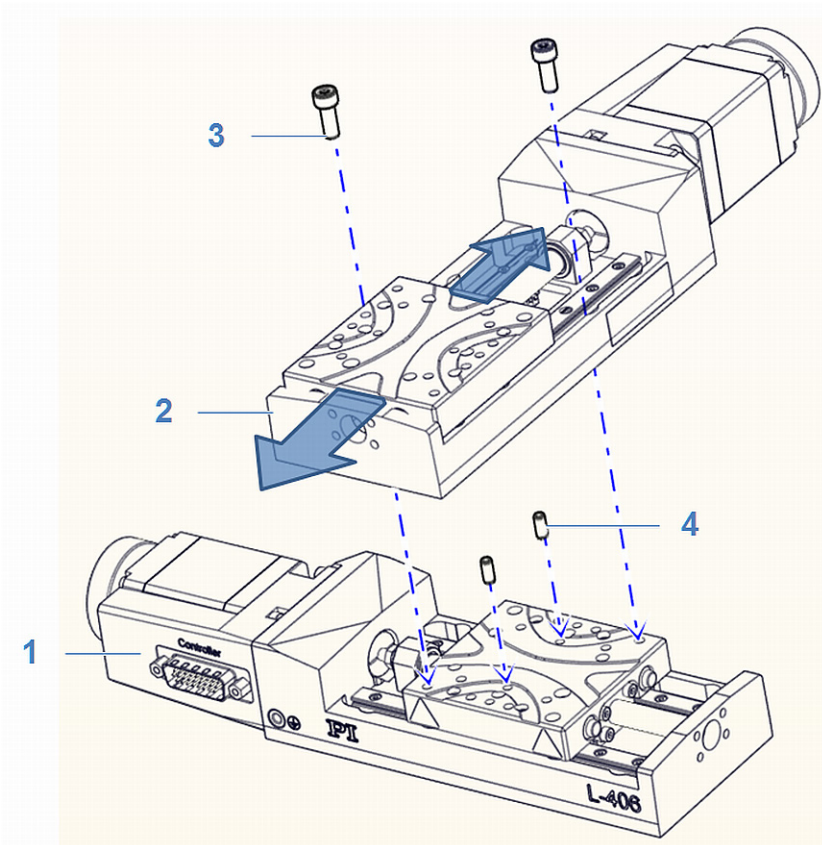
Figure 6: Moving the motion platform and mounting the screws and locating pins

1	Lower positioner
2	Upper positioner
3	M4x12 screw
4	Locating pin 3h8x6

1. If you use locating pins to align the upper positioner:

   a) Insert the two locating pins into the locating holes in the platform of the lower L-406 (see figure above).

   b) Put the upper L-406 onto the lower L-406 so that the locating pins are inserted into the corresponding locating holes on the other side.

2. Make the mounting hole required in the base body of the upper positioner accessible. Possible measures:

   – Temporary startup of the upper positioner (p. 31) and commanding the platform to a suitable position

   – Moving the platform by hand (p. 36)

3. Fix the L-406 to the mounting hole made accessible on the lower L-406: Tighten the screw in the mounting hole completely.

4. Repeat steps 2 and 3 for the other mounting holes required in the base body of the upper positioner.

5. Check that the upper positioner is firmly seated.

5.5.3 Setting Up a Z System

NOTICE

Excessively long screws!
Screws and locating pins inserted too deeply can damage the lower positioner.

➢ Pay attention to the depth of the mounting holes in the motion platform (p. 46) of the lower positioner.
➢ Only use screws and locating pins of the correct length for the respective mounting holes.

Designations in these instructions:

▪ **Lower positioner**: X axis in an XZ combination; Y axis in an XYZ combination. The positioner that the upper positioner is mounted on with an adapter bracket.

▪ **Upper positioner**: Forms the Z axis of the multi-axis system, is mounted in a vertical alignment to the lower positioner with an adapter bracket.
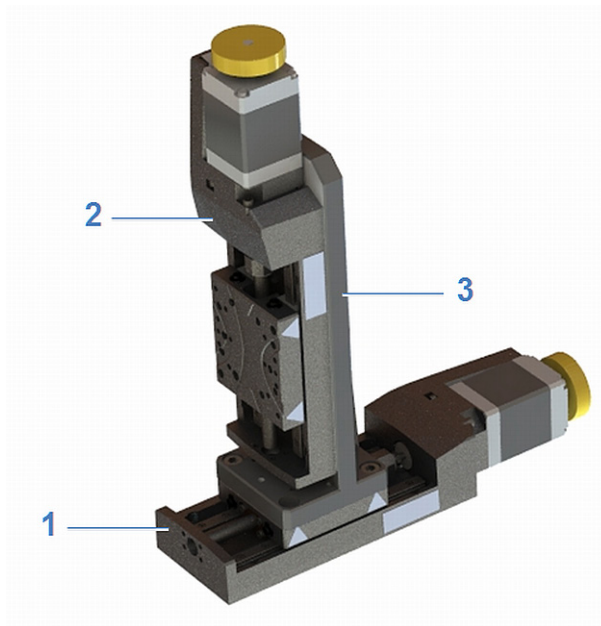
Figure 7: Example of an XZ system consisting of two L-406 and an adapter bracket

1	Lower positioner
2	Upper positioner
3	Adapter bracket

Requirements

✓ You have read and understood the general notes on installation (p. 15).

✓ You have read and understood the general notes on setting up a multi-axis system (p. 22).

✓ You have accounted for the space required to route cables according to regulations and without bending them.

✓ If you are building an XZ combination: You have attached the lower positioner onto an underlying surface (p. 16) properly.

✓ If you are building an XYZ combination: You have attached the positioner for the X and Y axis (p. 22) properly.

Tools and accessories

▪ L-500.AV3 adapter bracket, available as optional accessory (p. 11)

▪ Mounting kit from the scope of delivery of the upper L-406:

    – 4 or 8 socket head screws, ISO 4762 M4x12

    – 2 dowel pins, ISO 2338 - 3h8x6, for use as locating pins

    – 2 dowel pins, ISO 2338 - 4h8x10, for use as locating pins

- Mounting kit from the scope of delivery of the adapter bracket:
  - 2 socket head cap screws, ISO 4762 M6x12
- Hex key, AF 3
- Hex key, AF 5

Building a Z system
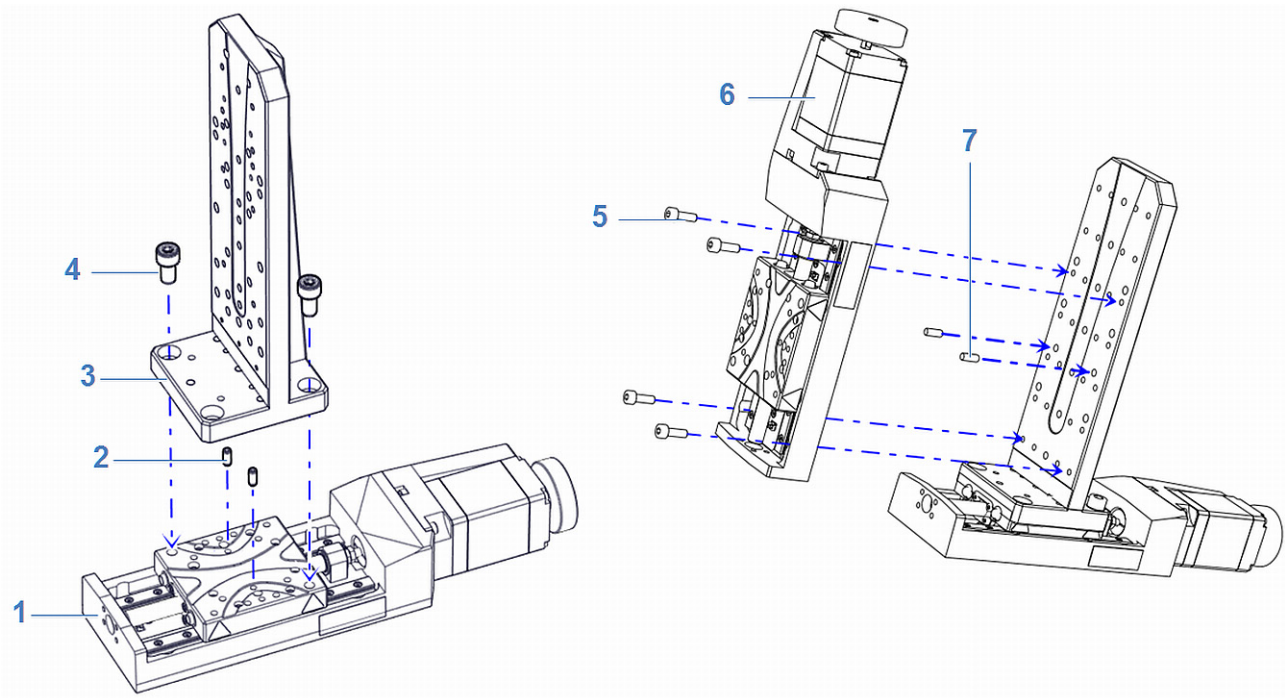
Figure 8: Mounting the adapter bracket (left) and the upper stage (right)

1	Lower positioner
2	Locating pin 3h8x6
3	Adapter bracket
4	M6x12 screw
5	M4x12 screw
6	Upper positioner
7	Locating pin 4h8x10

1. Mount the short side of the adapter bracket onto the platform of the lower positioner (see figure above):

   a) Insert the locating pins 3h8x6 into the locating holes in the short side of the adapter bracket from below and up to approx. 2/3 of their length.

b) Put the short side of the adapter bracket on the platform of the lower positioner so that the locating pins are inserted into the corresponding locating holes in the platform.

c) Fix the adapter bracket to the positioner with two M6x12 screws.

2. Mount the upper positioner onto the long side of the adapter bracket (see figure above):

a) Insert the locating pins 4h8x10 into the locating holes in the long side of the adapter bracket.

b) Align the positioner on the surface so that the locating pins in the positioner are inserted into the corresponding locating holes.

c) Put the positioner onto the long side of the adapter bracket so that the corresponding mounting holes in the positioner and the adapter bracket are in line.

d) Fix the positioner with at least four M6x12 screws. If necessary: Make the required holes accessible in the base body of the positioner, see "Building an XY System" (p. 22).

e) Check that the positioner is firmly seated.

5.6   Connecting the L-406 to the Controller

NOTICE
Damage if an incorrect controller or motor cable is connected! Connecting the L-406 to an unsuitable controller or using an unsuitable motor cable can damage the L-406 or the controller. ➢ Connect the L-406 to a suitable controller (p. 11) only. ➢ To connect the L-406 to the controller, only use a motor cable that is suitable for the controller.

Requirements

✓ You have read and understood the general notes on installation (p. 15).

✓ You have installed the controller.

✓ You have read and understood the user manual for the controller.

✓ The controller is switched off.

Tools and accessories

▪ Motor cable, suitable for the controller (p. 11) used

▪ Suitable tools for tightening the screws to the connections

Connecting the L-406 to the controller

1. Remove the ESD protection from the L-406's connector.

2. Connect the L-406, cable, and controller to each other.

3. Use the integrated screws to secure the connections against accidental disconnection.

6   Startup

6.1   General Notes on Startup

CAUTION

Risk of crushing by moving parts!

There is a risk of minor injuries from crushing between the moving parts of the positioner or the load and a fixed part or obstacle.

> ➢ Use protective structures to keep limbs away from areas in which they could be caught by moving parts.
> ➢ Observe the safety distances in accordance with DIN EN ISO 13857 when installing protective structures.

NOTICE

Damage due to collisions!

Collisions can damage the positioner, the load to be moved, and the surroundings.

> ➢ Make sure that no collisions are possible between the positioner, the load to be moved, and the surroundings in the motion range of the positioner.
> ➢ Do not place any objects in areas where they can be caught by moving parts.
> ➢ Stop the motion immediately if a controller malfunction occurs.
> ➢ If possible, adapt the travel range limits of your mechanical system in the software that you use for commanding the motion.

NOTICE

Operating voltage excessively high or incorrectly connected!

Operating voltages that are too high or incorrectly connected can cause damage to the L-406.

> ➢ Do **not** exceed the operating voltage range (p. 45) for which the L-406 is specified.
> ➢ Only operate the L-406 when the operating voltage is properly connected; see "Pin Assignment" (p. 52).

NOTICE

Damage or considerable wear due to high accelerations!

High accelerations can cause damage to or considerable wear on the mechanical system.

➢ Stop the motion immediately if a controller malfunction occurs.

➢ Ensure that the end of the travel range is approached at low velocity.

➢ Determine the maximum velocity for your application.

NOTICE

Unintentional motion!

Unintentional motion of the stage is possible when connecting the L-406 to the controller. Defective software or wrong operation of the software can also result in unintentional motion.

➢ Do not place any objects in areas where they can be caught by moving parts.

➢ Before connecting the L-406, check whether a macro is defined as the startup macro in the controller and cancel the selection of the startup macro if necessary.

INFORMATION

The maximum velocity for an L-406.x0SD00 should be determined in the application. If the commanded velocity is too high, the stepper motor might stop without the controller detecting this condition.

INFORMATION

The repeatability of the positioning is only ensured when the reference switch is always approached from the same side. Controllers from PI fulfill this requirement due to the automatic direction sensing for reference moves to the reference switch.

For L-406.x0DD10 and L-406.x0DG10 models:

INFORMATION

Improper setting of the servo control parameters can impair the performance of the L-406. This can have the following consequences:

▪ Oscillation

▪ Imprecise approach of the position

▪ Settling time is too long

➢ If the performance of the L-406 is not satisfactory, check the settings for the servo control parameters of your controller.

6.2 Starting and Operating the L-406

Requirements

- ✓ You have read and understood the general notes on startup (p. 31).
- ✓ You have installed (p. 15) the L-406 correctly.
- ✓ You have connected (p. 28) the L-406 with the controller properly.
- ✓ You have read and understood the user manual for the controller used.
- ✓ The required PC software has been installed.
- ✓ You have read and understood the manual for the PC software.

Starting and operating the L-406

1. Start and operate the controller (refer to the user manual for the controller).

   Configure the controller during startup using the PC software for the L-406 used (see the user manual for the controller, and the PC software):

   - If you use a PI controller: Select the correct entry from the positioner database that fits (p. 33) the model of the L-406 exactly.

   - If you use a controller from another manufacturer: Enter the parameters into the corresponding PC software that fit the model of the L-406 exactly; see the overview of the operating parameter for DC motor controllers or stepper motor controllers (p. 34).

2. Start a few motion cycles for testing purposes (refer to the user manual for the controller).

6.3 L-406 Entries in the PI Positioner Database

For PI controllers, you can select the connected positioner from a positioner database in the corresponding PC software. The appropriate operating parameters are therefore loaded to the controller. You can find a detailed description in the user manual for the controller or in the manual for the PC software used.

6.3.1 Operating Parameters of the Models with DC Motor

If you use a DC motor controller from a third-party supplier, it may be necessary to enter operating parameters for adaptation to the positioner used.

Parameter	L-406.x0DD10	L-406.x0DG10	Unit
P term	400	90	-
I term	300	100	-

Parameter	L-406.x0DD10	L-406.x0DG10	Unit
D term	200	60	-
I limit	2000	2000	-
Maximum acceleration	200	30	mm/s²
Maximum velocity*	20	3	mm/s
Maximum velocity*	81920	182120	counts/s
Gear ratio	-	2401:81	-
Encoder resolution	1024	15176.69	counts/mm
Limit switch polarity	Active high	Active high	-

* Recommended for continuous operation

6.3.2 Operating Parameters of the Models with Stepper Motor

If you use a stepper motor controller from a third-party supplier, it may be necessary to enter operating parameters to adapt it to the L-406 used.

Parameters	L-406.x0SD00	Unit
Positioner properties		
Max. acceleration	200	mm/s^2
Max. velocity*	20	mm/s
Limit switch polarity	Active high	-
Motor characteristics		
Motor type	2-phase stepper motor, bipolar, half coil	
Phase current	1.2	a
Step angle	1.8	°
Full steps	200	steps/revolution
Phase resistance	3.3	ohm
Phase inductance	2.8	mH
Holding torque	320	mNm
Drive screw pitch	1	mm/revolution
Motor resolution/full step	5	µm

* Recommended for continuous operation

7   Maintenance

7.1   General Notes on Maintenance

NOTICE

Damage due to improper maintenance!
Improper maintenance can lead to misalignment and failure of the L-406.

➢   Only loosen screws according to the instructions in this manual.

7.2   Performing a Maintenance Run

Depending on the operating conditions and the period of use of the L-406, the following maintenance measures are required:

Maintenance run

The maintenance run serves the purpose of distributing the existing lubricant.

➢   After 500 operating hours or at least after 1 year, do a maintenance run over the entire travel range, in order for the existing lubricant to be distributed evenly.

➢   If you move the L-406 continuously over a short travel range (<20 % of the entire travel range) in industrial operation, do a run across the entire travel range every 2000 motion cycles.

Lubrication

Under laboratory conditions, it is only necessary to relubricate the L-406 in exceptional cases. For continuous industrial use, the lubrication intervals must be determined individually.

➢   If you have any questions on relubricating, contact our customer service department (p. 41).

7.3 Cleaning the L-406

Requirements

✓ You have disconnected the positioner from the controller.

Cleaning the positioner

➢ When necessary, clean the surface of the positioner with a cloth dampened lightly with a mild cleanser or disinfectant.

7.4 Moving the Motion Platform Manually

INFORMATION

In the following cases, it can be necessary to manually move the platform:

▪ To allow access to the mounting holes in the positioner's base body for the screws.

▪ To move the platform away from the hard stop to re-establish operational readiness of the positioner.
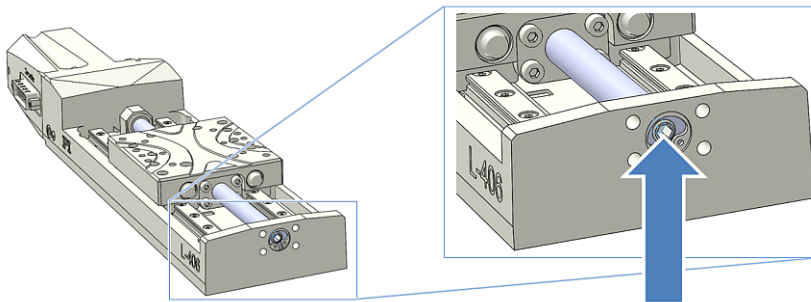

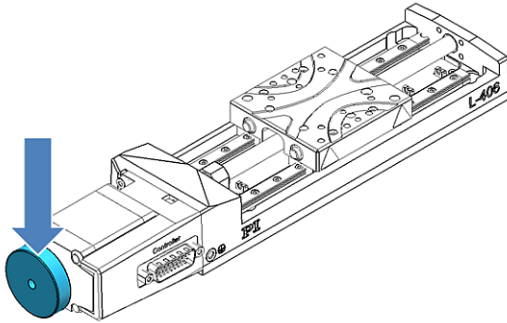Figure 9: Position of the spindle access (all models)

Figure 10: Position of the vibration absorber (L-406.x0SD00 models only)

Requirements

The L-406 is **not** connected to the controller.

Tools

- If you want to use the drive screw access: Hex key AF 3

Moving the Platform by Hand

If you want to use the drive screw access:

1. Insert the hex key into the drive screw access until you sense resistance.
2. Turn the hex key as far as necessary:
   - Clockwise rotation: Platform moves away from the motor
   - Counterclockwise rotation: Platform moves in the direction of the motor

If the L-406 is equipped with a vibration absorber:

➢ Turn the vibration absorber as far as necessary:
   - Clockwise rotation: Platform moves in the direction of the motor
   - Counterclockwise rotation: Platform moves away from the motor

PI

8　Troubleshooting

8.1　Possible Causes and Correction

Problem	Possible causes	Solution
Reduced positioning accuracy	Warped base body	➢ Mount the L-406 onto a flat surface. The recommended flatness of the surface is ≤ 10 μm.
	When the L-406 is mounted vertically: The load exceeds the self-locking of the drive.	➢ Reduce the load. Make sure that the self-locking (see specification of the holding force in the data table (p. 43)) of the drive is not exceeded.
	Increased wear due to small motion over a long period of time	➢ Perform a maintenance run over the entire travel range (p. 35).
Function impairment after system modification	▪ Controller was replaced. ▪ L-406 was replaced with another model.	Controller from PI: ➢ Load the parameters from the positioner database that correspond to the combination of controller and L-406 model. Controller from a third-party supplier: ➢ Check the operating parameters.
Mechanics do not move; no operating	Controller not correctly connected or defective.	➢ Check all connecting cables. ➢ Check the controller.

Problem	Possible causes	Solution
noise can be heard.	When a PI controller is used: Axis motion error.	Motion error = The difference between the current position and the commanded position exceeds the specified maximum value in closed-loop operation. Motion errors can be caused for example, by malfunctions of the drive or the position sensor of the L-406. 1. Read out the error code of the controller in the PC software. If there is a motion error, error code -1024 is output. 2. Check your system and make sure that all axes can be moved safely. 3. Switch the servo mode on in the PC Software for the affected axis. Refer to the user manual for the controller for details.
	Platform has triggered the limit switch.	If you use a controller from PI: 1. Switch the servo mode on in the PC software for the affected axis again. 2. Command an axis motion away from the limit switch in the PC software.
For L-406.x0SD00 models: Actual position deviates from the displayed position.	The motor is overloaded by an external load torque or the mass to be driven in the case of strong acceleration or deceleration.	The motor skips steps. The information on the current position is lost without the controller detecting the state. ➢ Use a stepper motor in the application to determine the maximum velocity for a L-406. ➢ Start a new reference move.

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. 41).

9 Customer Service

For inquiries and orders, contact your PI sales engineer or send us an email (mailto: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. 3) on our website.

10 Technical Data

10.1 Specifications

10.1.1 Data Table

	L-406.x0DD10	L-406.x0DG10	L-406.x0SD00	Unit	Tolerance
	Linear stage with DC motor and rotary encoder	Linear stage with DC gear motor and rotary encoder	Linear stage with stepper motor		
Active axis	X	X	X		

Motion and positioning	L-406.x0DD10	L-406.x0DG10	L-406.x0SD00	Unit	Tolerance
Travel range	26 / 52 / 102	26 / 52 / 102	26 / 52 / 102	mm	
Integrated sensor	Rotary encoder	Rotary encoder	–		
Sensor resolution rotary encoder	4096	2048	–	cts./rev.	
Design resolution	0.244	0.0165	5 (full step)	µm	
Minimum incremental motion	0.5	0.2	0.2	µm	Typ.
Unidirectional repeatability	0.5	0.5	0.5	µm	Typ.
Bidirectional repeatability	±5	±5	±5	µm	Typ.
Pitch / yaw	±70 / ±90 / ±100	±70 / ±90 / ±100	±70 / ±90 / ±100	µrad	Typ.
Straightness / flatness	±2 / ±4 / ±6	±2 / ±4 / ±6	±2 / ±4 / ±6	µm	Typ.
Max. velocity	20	3	20	mm/s	Max.
Reference and limit switches	Forked photoelectric sensor, N/C contact, 5V, NPN	Forked photoelectric sensor, N/C contact, 5V, NPN	Forked photoelectric sensor, N/C contact, 5V, NPN		

Mechanical properties	L-406.x0DD10	L-406.x0DG10	L-406.x0SD00	Unit	Tole-rance
Guide type	Recirculating ball bearing guide	Recirculating ball bearing guide	Recirculating ball bearing guide		
Drive screw type	Leadscrew	Leadscrew	Leadscrew		
Drive screw pitch	1	1	1	mm	
Gear ratio	−	2401:81	−		
Load capacity	100	100	100	N	Max.
Push/pull force	15	100	50	N	Max.
Permissible lateral force	50	50	50	N	Max.
Self-locking	15	100	50	N	Max.
Permissible torque in θ_X, θ_Y, θ_Z	7.5	7.5	7.5	N·m	Max.

Drive properties	L-406.x0DD10	L-406.x0DG10	L-406.x0SD00	Unit	Tole-rance
Motor type	DC motor	DC gear motor	2-phase stepper motor		
Step resolution	−	−	200	Full steps/rev.	
Operating voltage, nominal	24	12	24	V	Nom.
Operating voltage, max.	48	24	48		Max.

Miscellaneous	L-406.x0DD10	L-406.x0DG10	L-406.x0SD00	Unit	Tole-rance
Operating temperature range	5 to 40	5 to 40	5 to 40	°C	
Material	Aluminum, steel	Aluminum, steel	Aluminum, steel		
Mass	0.8 / 0.9 / 1.0	0.8 / 0.9 / 1.0	0.8 / 0.9 / 1.0	kg	±5 %
Moved mass	0.16	0.16	0.16	kg	±5 %
Connector	HD D-sub 26 (m)	HD D-sub 26 (m)	HD D-sub 26 (m)		
Recommended controllers	C-863 (single axis) C-884 (up to 6 axes) C-885 with C-863.20C885 (to 40 axes)	C-863 (single axis) C-884 (up to 6 axes) C-885 with C-863.20C885 (to 40 axes)	C-663.12 (single axis) SMC Hydra (double axis) C-885 with C-

Miscellaneous	L-406.x0DD10	L-406.x0DG10	L-406.x0SD00	Unit	Tole-rance
	ACS modular controller	ACS modular controller	663.12C885 (up to 20 axes) ACS modular controller		

10.1.2 Maximum Ratings

The L-406 positioners are designed for the following operating data:

Product	Maximum operating voltage ⚠️	Operating frequency ⚠️	Maximum power consumption ⚠️
L-406.x0DG10	12 V	0 Hz	8.5 W
L-406.x0DD10	24 V	0 Hz	21 W
L-406.x0SD00	24 V	0 Hz	10.8 W

10.1.3 Ambient Conditions and Classifications

The following ambient conditions and classifications for the L-406 must be observed:

Area of application	For indoor use only
Maximum altitude	2000 m
Relative humidity	Max. 80 % for temperatures up to 31 °C Linearly decreasing to 50 % at 40 °C
Storage temperature	0 °C to 80 °C
Transport temperature	0 °C to 80 °C
Supply fluctuations	Max. ±10 % of the nominal voltage
Degree of pollution	2
Degree of protection according to IEC 60529	IP40

10.1.4   Limit Switch Specifications

Type	Optical sensor
Supply voltage	+5 V / ground
Signal output	TTL level
Signal logic	The signal level changes when passing the limit switch. The signal logic is active high. That means: ▪ Normal motor operation: low (0 V) ▪ Limit switch reached: high (+5 V)

10.1.5   Reference Switch Specifications

Type	Optical sensor
Supply voltage	+5 V / GND, supply via the motor connector
Signal output	TTL level
Signal logic	Direction sensing by means of different signal levels on the left- and right-hand side of the reference switch: The signal level changes from 0 to +5 V when the reference switch is passed.

10.2   Dimensions

10.2.1   L-406.x0DD10 and L-406.x0DG10

Dimensions in mm. Note that a comma is used in the drawings instead of a decimal point.

See "Hole Pattern of the Platform of the L-406" (p. 49) for a detailed view of the platform.
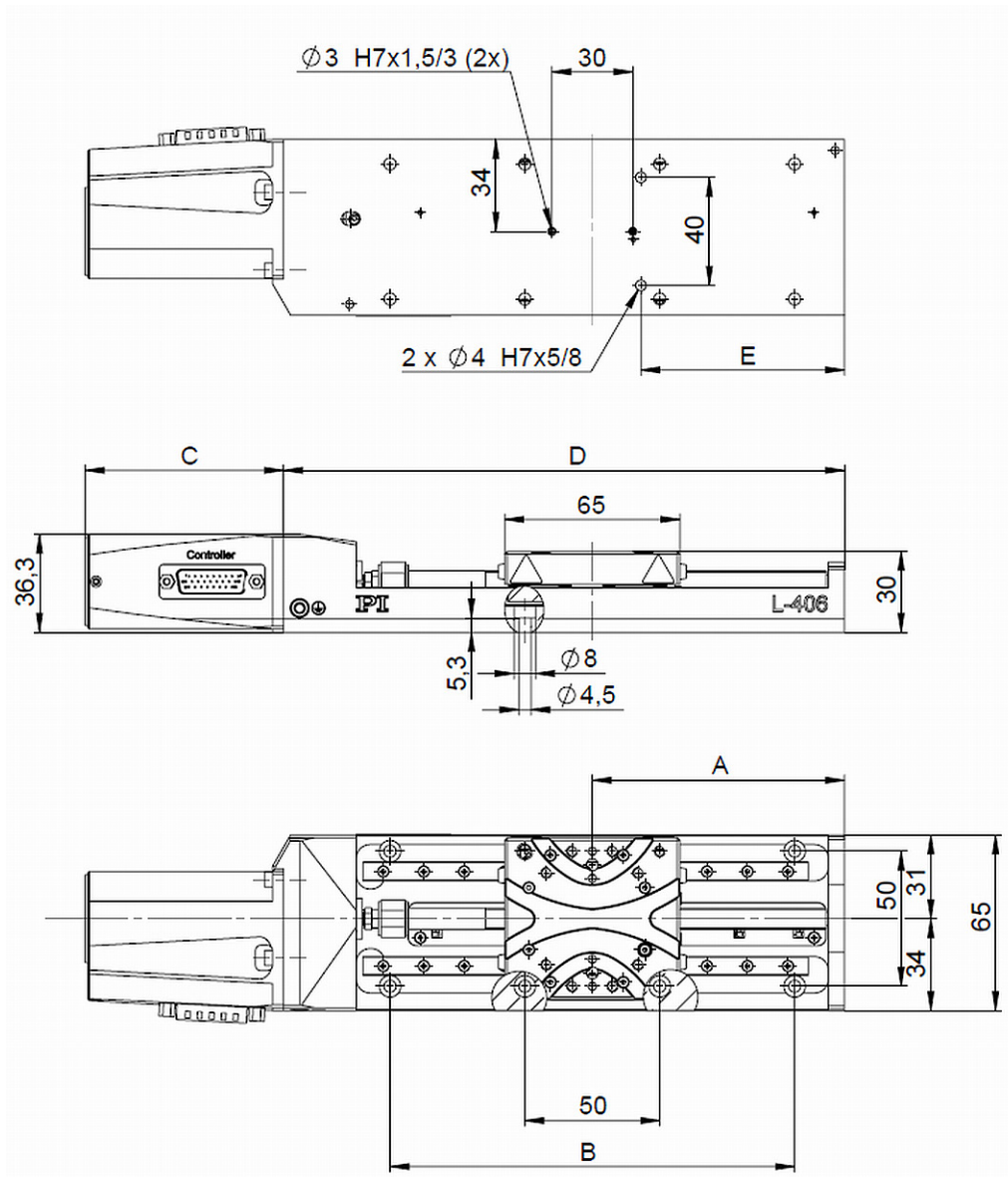
Figure 11: L-406.x0DG10 and L-406.x0DD10 models

Model	A	B	C	D	E
L-406.10DD10, L-406.10DG10	55.5	-	73.5	132	62.5
L-406.20DD10, L-406.20DG10	68.5	100	73.5	158	75.5
L-406.40DD10, L-406.40DG10	93.5	150	73.5	208	75.5

10.2.2   L-406.x0SD00

Dimensions in mm. Note that a comma is used in the drawings instead of a decimal point.

See "Hole Pattern of the Platform of the L-406" (p. 49) for a detailed view of the platform.
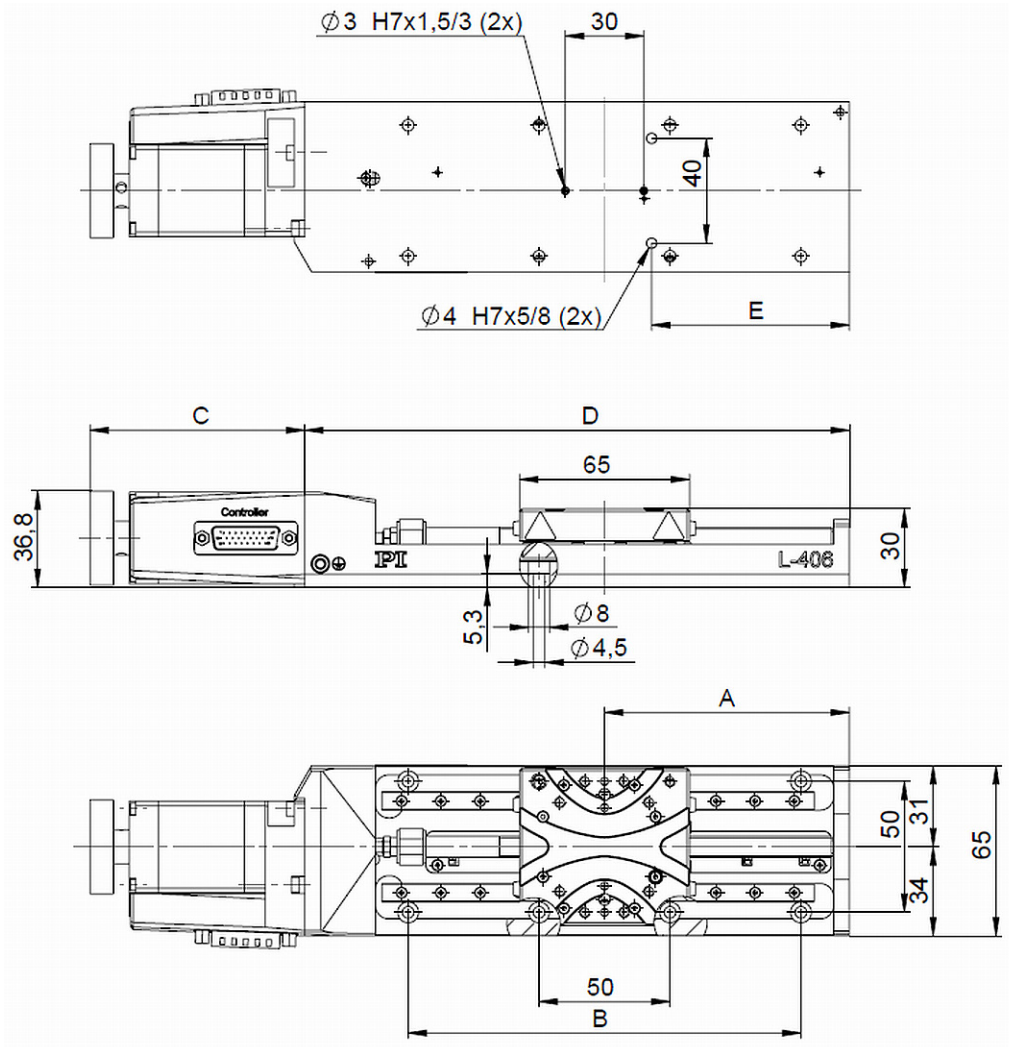

Figure 12: L-406.x0SD00 models

Model	A	B	C	D	E
L-406.10SD00	55.5	-	82	132	62.5
L-406.20SD00	68.5	100	82	158	75.5
L-406.40SD00	93.5	150	82	208	75.5

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10.2.3 Hole Pattern of the Moving Platform of the L-406

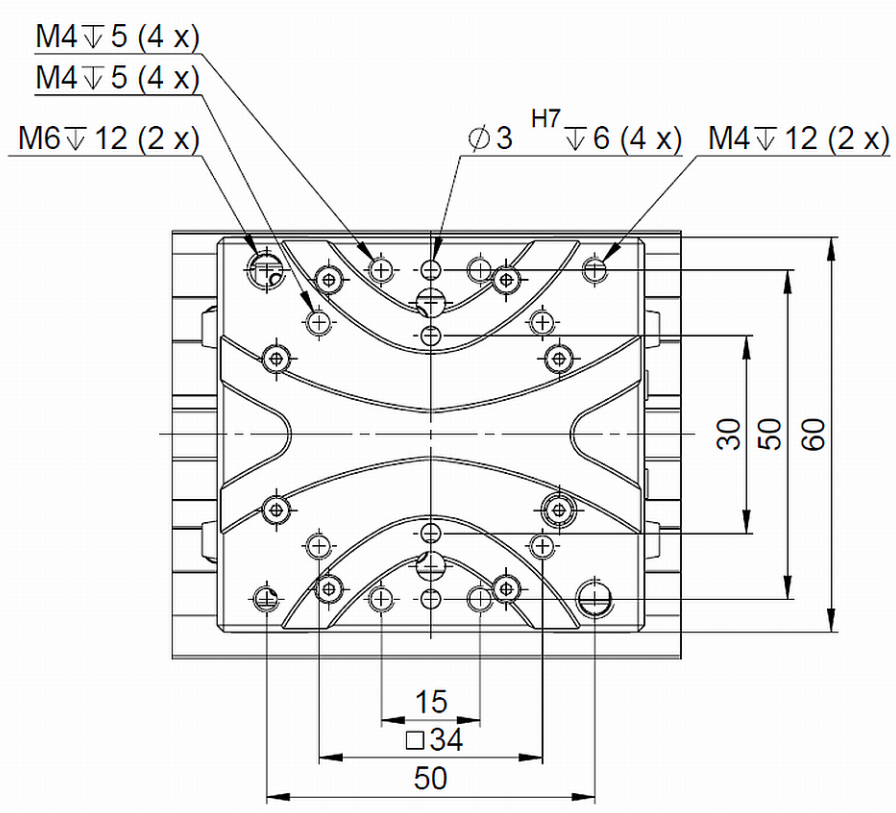Dimensions in mm. Note that a comma is used in the drawings instead of a decimal point.

Figure 13: Hole Pattern of the Motion Platform

PI

10.2.4   L-500.AV3 Adapter Bracket

Dimensions in mm. Note that a comma is used in the drawings instead of a decimal point.
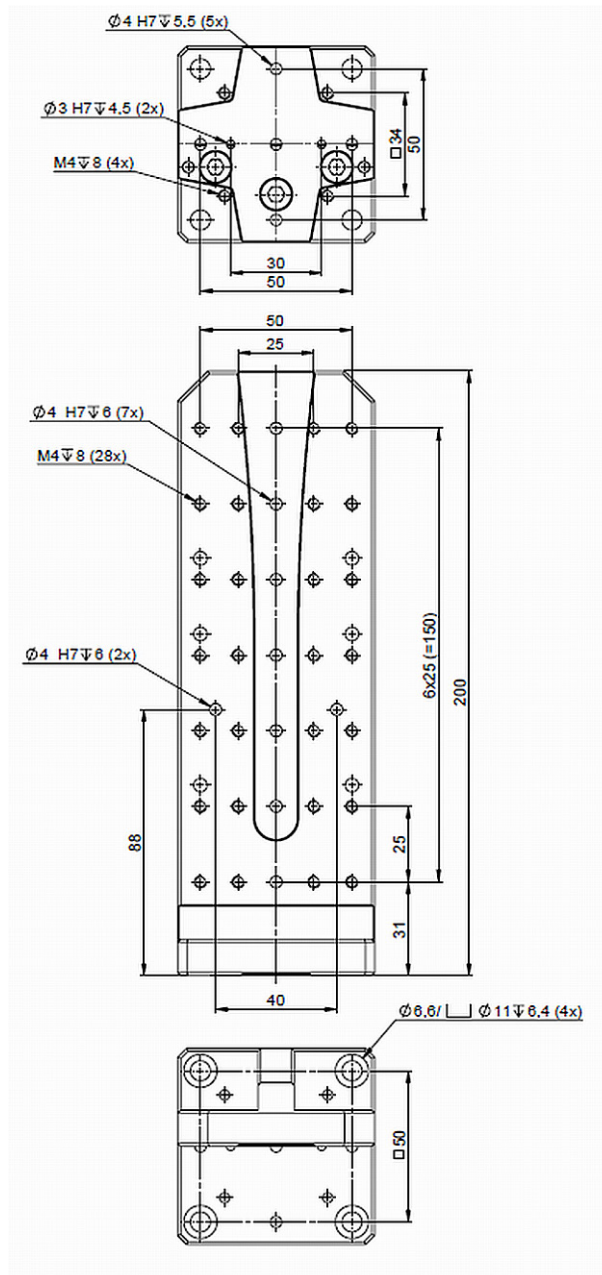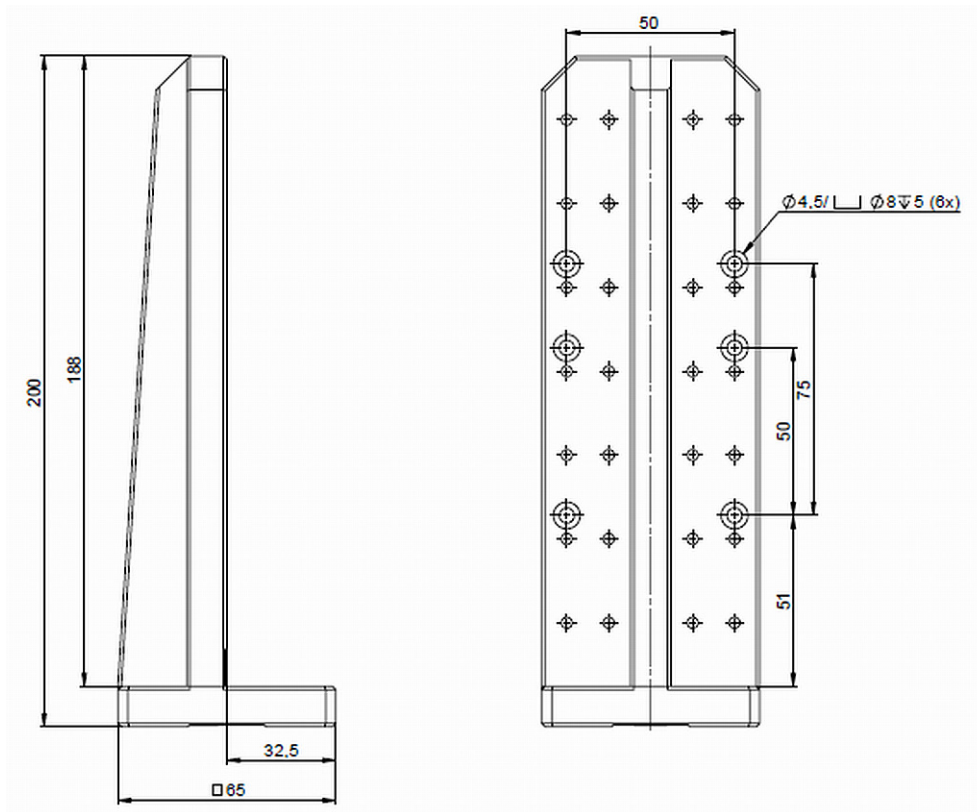

Figure 14: L-500.AV3 adapter bracket

Figure 15: L-500.AV3 adapter bracket

10.3 Tightening Torque for Screws, ISO 4762 - A2

The following tightening torques for screws according to ISO 4762 (corresponds to DIN 912) - A2 may not be exceeded.

Value	Maximum tightening torque
M3	1.5 Nm
M4	2 Nm
M5	2.5 Nm
M6	3 Nm

10.4   Pin Assignment

10.4.1   HD D-sub 26 (m)
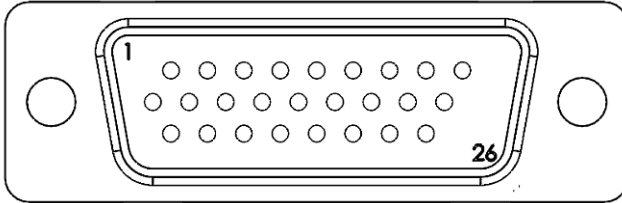
Figure 16: HD Sub-D 26 panel plug

Pin assignment for L-406.x0SD00 models

Pin	Signal	Direction
1	Motor A+	Input
2	Motor A+	Input
3	Motor A-	Input
4	Motor A-	Input
5	Motor B+	Input
6	Motor B+	Input
7	Motor B-	Input
8	Motor B-	Input
9	-	-
10	REF	Output
11	Limit E1 (neg)	Output
12	Limit E2 (pos)	Output
13	-	-
14	-	-
15	-	-
16	-	-
17	ID I/O	Bidirectional
18	Limit Power (+5 V)	Input
19	-	-
20	-	-
21	-	-
22	-	-
23	-	-

Pin	Signal	Direction
24	-	-
25	GND (limit)	GND
26	-	-

Pin assignment for L-406.x0DG10 and L-406.x0DD10 models

Pin	Signal	Direction
1	Motor +	Input
2	Motor +	Input
3	Motor -	Input
4	Motor -	Input
5	-	-
6	-	-
7	-	-
8	-	-
9	-	-
10	REF	Output
11	Limit E1 (neg)	Output
12	Limit E2 (pos)	Output
13	-	-
14	-	-
15	-	-
16	-	-
17	ID I/O	Bidirectional
18	Limit Power (+5 V)	Input
19	Encoder A+	Output
20	Encoder A-	Output
21	Encoder B+	Output
22	Encoder B-	Output
23	Encoder C+	Output
24	Encoder C-	Output
25	GND (limit, encoder)	GND
26	Encoder power (+5 V)	Input

11   Old Equipment Disposal

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

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

In order to fulfil the responsibility as the product manufacturer, PI miCos GmbH undertakes environmentally correct disposal of all old PI miCos equipment made available on the market after 13 August 2005 without charge.

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

PI miCos GmbH

Freiburger Strasse 30

79427 Eschbach, Germany

PI

12   EU Declaration of Conformity

For the L-406, an EU Declaration of Conformity has been issued in accordance with the following European directives:

EMC Directive

RoHS Directive

The applied standards certifying the conformity are listed below.

EMC: EN 61326-1

Safety: EN 61010-1

RoHS: EN 50581 or EN IEC 63000