This document describes the following micropositioning stages:

- **M-406.xDG:**
  With DC motor, rotary encoder

- **M-406.xPD:**
  With ActiveDrive DC motor, PWM, rotary encoder

- **M-406.x2S:**
  With 2-phase stepper motor

**x stands for travel range:**
- 2 = 50 mm
- 4 = 100 mm
- 6 = 150 mm
Contents

1 About this Document
   1.1 Goal and Target Audience of this User Manual ............................................. 1
   1.2 Symbols and Typographic Conventions ............................................................. 2
   1.3 Definition ............................................................................................................... 3
   1.4 Figures .................................................................................................................... 3
   1.5 Other Applicable Documents ................................................................................ 3
   1.6 Downloading Manuals .......................................................................................... 3

2 Safety
   2.1 Intended Use .......................................................................................................... 5
   2.2 General Safety Instructions .................................................................................... 5
   2.3 Organizational Measures ....................................................................................... 6

3 Product Description
   3.1 Model Overview ...................................................................................................... 7
   3.2 Product View .......................................................................................................... 9
   3.3 Product Labeling .................................................................................................... 10
   3.4 Scope of Delivery .................................................................................................... 11
   3.5 Accessories ............................................................................................................ 11
   3.6 Suitable Controllers ............................................................................................... 12
   3.7 Technical Features .................................................................................................. 12
       3.7.1 Encoder ........................................................................................................... 12
       3.7.2 Limit Switches ............................................................................................... 12
       3.7.3 Reference Point Switch .................................................................................. 13
       3.7.4 Integrated PWM Amplifier ............................................................................. 13

4 Unpacking

5 Installation
   5.1 General Notes on Installation ............................................................................... 17
   5.2 Optional: Modifying the Connection Orientation on the M-406 ............................. 18
       5.2.1 M-406.xDG and M-406.xPD Models .............................................................. 19
       5.2.2 M-406.x2S Models ....................................................................................... 20
   5.3 Mounting the M-406 on a Surface .......................................................................... 21
   5.4 Affixing the Load to the M-406 ............................................................................. 24
   5.5 Setting Up a Multi-Axis System ............................................................................ 27
       5.5.1 General Information on Setting Up a Multi-Axis System ................................. 27
       5.5.2 Setting Up an XY System .............................................................................. 28
5.5.3 Setting Up a Z System with an Adapter Bracket ......................31
5.6 Connecting the Motor Cable to the M-406 ................................38
5.7 Connecting the Power Supply to the M-406 .............................39

6 Start-Up 41
6.1 General Notes on Start-Up ..................................................41
6.2 Starting up the Stage ..........................................................43
  6.2.1 M-406 Entries in the Stage Database of PI .........................44
  6.2.2 Operating Parameters of the Models with DC Motor ............44
  6.2.3 Operating Parameters of the Models with Stepper Motor .......45

7 Maintenance 47
7.1 General Notes on Maintenance .............................................47
7.2 Performing a Maintenance Run ............................................47
7.3 Cleaning the M-406 ...........................................................48

8 Troubleshooting 49
8.1 Possible Causes and Correction ...........................................49
8.2 Manually Moving the Moving Platform .................................51
  8.2.1 M-406.xDG and M-406.xPD Models ...............................51
  8.2.2 M-406.x2S Models .....................................................52

9 Customer Service 55

10 Technical Data 57
10.1 Specifications .................................................................57
  10.1.1 Data Table ..............................................................57
  10.1.2 Maximum Ratings .....................................................58
  10.1.3 Ambient Conditions and Classifications ...........................59
  10.1.4 Limit Switch Specifications .........................................59
  10.1.5 Reference Point Switch Specifications .............................60
10.2 Dimensions .......................................................................61
  10.2.1 M-406 Stage .............................................................61
  10.2.2 Hole Pattern of the Moving Platform of the M-406 ............62
  10.2.3 M-592.00 Adapter Bracket .........................................63
10.3 Pin Assignment ...................................................................64
  10.3.1 Sub-D 15 (m) Controller Connection .............................64
  10.3.2 Switchcraft 3-Pin Power Supply Connector .......................65
1 About this Document

In this Chapter

Goal and Target Audience of this User Manual .................................................. 1
Symbols and Typographic Conventions .............................................................. 1
Definition ........................................................................................................... 2
Figures ............................................................................................................... 3
Other Applicable Documents ............................................................................... 3
Downloading Manuals ......................................................................................... 3

1.1 Goal and Target Audience of this User Manual

This manual contains information on the intended use of the M-406.
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 Symbols and Typographic Conventions

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

CAUTION

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

Actions to take to avoid the situation.

NOTICE

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

Actions to take to avoid the situation.
**INFORMATION**

Information for easier handling, tricks, tips, etc.

<table>
<thead>
<tr>
<th>Symbol/Label</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Action consisting of several steps whose sequential order must be observed</td>
</tr>
<tr>
<td>2.</td>
<td>Action consisting of one or several steps whose sequential order is irrelevant</td>
</tr>
<tr>
<td>•</td>
<td>List item</td>
</tr>
<tr>
<td>p. 5</td>
<td>Cross-reference to page 5</td>
</tr>
<tr>
<td>RS-232</td>
<td>Labeling of an operating element on the product (example: socket of the RS-232 interface)</td>
</tr>
</tbody>
</table>

Warning sign on the product which refers to detailed information in this manual.

### 1.3 Definition

<table>
<thead>
<tr>
<th>Term</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load capacity</td>
<td>Maximum load capacity in the vertical direction when the stage is mounted horizontally. The contact point of the load is in the center of the platform.</td>
</tr>
<tr>
<td>Max. push/pull force</td>
<td>Maximum force in the direction of motion. Some stages may have higher forces but with limited lifetimes. In the case of vertical mounting, the specified value (p. 57) for models without a gearhead and brake only applies when the servo mode is on.</td>
</tr>
<tr>
<td>Incremental position sensor</td>
<td>Sensor (encoder) for capturing changes of position or changes of angle. Signals from the incremental position sensor are used for axis position feedback. After switching on the controller a reference point definition must be performed before absolute target positions can be commanded and reached.</td>
</tr>
</tbody>
</table>
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.

1.5 Other Applicable Documents

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

<table>
<thead>
<tr>
<th>Product</th>
<th>Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-863.11 DC Motor Controller</td>
<td>MS205E User Manual</td>
</tr>
<tr>
<td>C-663.11 Stepper Motor Controller</td>
<td>MS208E User Manual</td>
</tr>
<tr>
<td>C-843 DC Motor Controller PCI Board</td>
<td>MS77E User Manual</td>
</tr>
<tr>
<td>C-884 DC Motor Controller</td>
<td>MS213E User Manual</td>
</tr>
<tr>
<td>Stages with electric motors</td>
<td>MP119EK Short Instructions</td>
</tr>
</tbody>
</table>

1.6 Downloading Manuals

INFORMATION
If a manual is missing on our website or if there are problems in downloading:
- Contact our customer service department (p. 55).

The current versions of the manuals are found on our website. For some products (e.g. Hexapod systems and electronics that are delivered with a CD), access to the manuals is password-protected. The password is stored on the CD.

Download freely accessible manuals
2. Click Downloads.
3. Click the corresponding category (e.g. M Products)
4. Click the corresponding product code (e.g. M-406).
5. Click **Documents**.
   The available manuals are displayed.
6. Click the desired manual and save it on the hard disk of your PC or on a data storage medium.

**Download password-protected manuals**
1. Carry out steps 1 to 5 of the download process for freely accessible manuals.
2. Insert the product CD in the PC drive.
3. Switch to the **Manuals** directory on the CD.
4. In the **Manuals** directory, open the Release News (file including `releasenews` in the file name).
5. Find the user name and password in the **User login for software download** section in the Release News.
6. In the **User login** area on the left margin in the website, enter the user name and the password in the corresponding fields.
7. Click **Login**.
   The available manuals are displayed.
8. Click the desired manual and save it on the hard disk of your PC or on a data storage medium.
2 Safety

In this Chapter

Intended Use ........................................................................................................................................... 5
General Safety Instructions ................................................................................................................... 5
Organizational Measures ...................................................................................................................... 6

2.1 Intended Use

The M-406 is a laboratory device as defined by DIN EN 61010. It is intended to be used in interior spaces and in an environment which is free of dirt, oil and lubricants.

In accordance with its design and realization, the M-406 is intended for single-axis positioning, adjusting and shifting of loads at different velocities. The M-406 is not intended for applications in areas in which a failure would present severe risks to human beings or the environment.

The M-406 is intended for horizontal or vertical mounting. For the load limits with vertical mounting, see "General Notes on Installation" (p. 17).

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

The M-406 must be operated with a suitable controller (p. 12). The controller is not included in the scope of delivery of the M-406.

2.2 General Safety Instructions

The M-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 M-406.

- Only use the M-406 for its intended purpose, and only use it if it is in a good working order.
- Read the user manual.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for the correct installation and operation of the M-406.
2.3 Organizational Measures

User manual

- Always keep this user manual available by the M-406. The latest versions of the user manuals are available for download (p. 3) on our website.
- Add all information given by the manufacturer to the user manual, for example supplements or Technical Notes.
- If you pass the M-406 on to other users, also turn over this user manual as well as other relevant information provided by the manufacturer.
- Only use the device on the basis of the complete user manual. Missing information due to an incomplete user manual can result in minor injury and property damage.
- Only install and operate the M-406 after having read and understood this user manual.

Personnel qualification

The M-406 may only be installed, started up, operated, maintained and cleaned by authorized and appropriately qualified personnel.
3 Product Description

3.1 Model Overview

Classification of the stages

The stages of the M-406.2xx, M-406.4xx and M-406.6xx series are summarized under the designation M-406 in this manual.

All models are micropositioning stages with precision leadscrew. They differ in terms of:

- Travel range
- Drive type

<table>
<thead>
<tr>
<th>M-406</th>
<th>Travel range in mm</th>
<th>Travel range in inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>.2xx</td>
<td>50</td>
<td>2</td>
</tr>
<tr>
<td>.4xx</td>
<td>100</td>
<td>4</td>
</tr>
<tr>
<td>.6xx</td>
<td>150</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Version</th>
<th>Drive type</th>
<th>DC motor</th>
<th>Stepper motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>.xDP</td>
<td>Gearhead, analog</td>
<td>Direct drive, PWM</td>
<td></td>
</tr>
<tr>
<td>.x2S</td>
<td>Direct drive, PWM</td>
<td>Stepper motor</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Technical Features of M-406 Series
Detailed model overview

<table>
<thead>
<tr>
<th>Order Number</th>
<th>Product Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-406.2DG</td>
<td>Precision Translation Stage, 50 mm, DC Gear Motor</td>
</tr>
<tr>
<td>M-406.2PD</td>
<td>Precision Translation Stage, 50 mm, ActiveDrive DC Motor, includes 24 V Power Supply</td>
</tr>
<tr>
<td>M-406.22S</td>
<td>Precision Translation Stage, 50 mm, 2-Phase Stepper Motor</td>
</tr>
<tr>
<td>M-406.4DG</td>
<td>Precision Translation Stage, 100 mm, DC Gear Motor</td>
</tr>
<tr>
<td>M-406.4PD</td>
<td>Precision Translation Stage, 100 mm, ActiveDrive DC Motor, includes 24 V Power Supply</td>
</tr>
<tr>
<td>M-406.42S</td>
<td>Precision Translation Stage, 100 mm, 2-Phase Stepper Motor</td>
</tr>
<tr>
<td>M-406.6DG</td>
<td>Precision Translation Stage, 150 mm, DC Gear Motor</td>
</tr>
<tr>
<td>M-406.6PD</td>
<td>Precision Translation Stage, 150 mm, ActiveDrive DC Motor, includes 24 V Power Supply</td>
</tr>
<tr>
<td>M-406.62S</td>
<td>Precision Translation Stage, 150 mm, 2-Phase Stepper Motor</td>
</tr>
</tbody>
</table>

- For further technical data, see the specifications (p. 57).
3.2 Product View

Figure 1: Components of the stage (in this case: M-406.4PD)

1  Protective cover
2  Moving platform
3  Motor
4  Controller connection (Sub-D 15 panel plug)
5  Power supply connector (Switchcraft panel plug, 3-pin, only with M-406.xPD models)
6  Base body
7  Drive screw access
### 3.3 Product Labeling

![Diagram of product labeling](image)

Figure 2: M-406: Position of the product labeling

<table>
<thead>
<tr>
<th>Position</th>
<th>Labeling</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td><img src="image" alt="Warning sign" /></td>
<td>Warning sign &quot;Risk of crushing&quot;: Reference to dangerous forces (p. 41)</td>
</tr>
<tr>
<td>B</td>
<td><img src="image" alt="PI" /></td>
<td>Manufacturer's logo</td>
</tr>
<tr>
<td>B</td>
<td><img src="image" alt="CE" /></td>
<td>CE conformity mark</td>
</tr>
<tr>
<td>B</td>
<td><img src="image" alt="Warning" /></td>
<td>Warning sign &quot;Observe manual!&quot;</td>
</tr>
<tr>
<td>B</td>
<td>M-406.4PD</td>
<td>Product name (example), the places after the point refer to the model</td>
</tr>
</tbody>
</table>
| B        | 113050975 | Serial number (example), individual for each M-406  
Meaning of the places (counting from left): 1 = internal information, 2 and 3 = manufacturing year, 4 to 9 = consecutive numbers |
| B        | WWW.PI.WS | Manufacturer's address (website) |
| B        | ![Old equipment disposal](image) | Old equipment disposal (p. 67) |
| B        | Country of origin: Germany | Country of origin |
### 3.4 Scope of Delivery

<table>
<thead>
<tr>
<th>Item ID</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-406.xxx</td>
<td>Stage according to order (p. 7)</td>
</tr>
<tr>
<td>2110</td>
<td>Screw set for mounting the stage and load</td>
</tr>
<tr>
<td></td>
<td>▪ 6 M4x8-A2 hex-head cap screws ISO 4762</td>
</tr>
<tr>
<td></td>
<td>▪ Allen wrench AF 3 DIN 911</td>
</tr>
<tr>
<td>C-815.38</td>
<td>Motor cable, 3 m, Sub-D 15 (m/f)</td>
</tr>
<tr>
<td>MP119EK</td>
<td>Short instructions for stages with electric motors</td>
</tr>
<tr>
<td></td>
<td><strong>Only with M-406.xPD models</strong></td>
</tr>
<tr>
<td>C-663.PS</td>
<td>Wide-range-input power supply 24 V/42 W</td>
</tr>
<tr>
<td>3763</td>
<td>Power cord</td>
</tr>
<tr>
<td>K050B0002</td>
<td>Adapter for the power supply connection; barrel connector to Switchcraft 3-pin connector (f)</td>
</tr>
</tbody>
</table>

### 3.5 Accessories

<table>
<thead>
<tr>
<th>Order Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-815.83</td>
<td>Motor cable, 10 m, Sub-D, 15-pin (m/f)</td>
</tr>
<tr>
<td>M-592.00</td>
<td>Angle bracket for the vertical mounting of M-406 stages. Material: Al; mass: 0.2 kg</td>
</tr>
<tr>
<td>M-110.01</td>
<td>Adapter plate for mounting M-11x linear positioning stages on M-406 stages. Material: Al</td>
</tr>
</tbody>
</table>

To order, contact our customer service department (p. 55).
3.6 Suitable Controllers

The M-406 must be connected to a suitable controller. The following controllers from PI are suitable for the operation of the M-406:

<table>
<thead>
<tr>
<th>Drive type</th>
<th>Controller</th>
<th>Axes per controller</th>
<th>PC interface</th>
<th>Multiple controllers on the same PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC motor</td>
<td>C-843</td>
<td>2 or 4</td>
<td>Internal (PCI bus)</td>
<td>Yes, separate boards</td>
</tr>
<tr>
<td></td>
<td>C-863</td>
<td>1</td>
<td>USB, RS-232, daisy chain</td>
<td>Yes, same interface</td>
</tr>
<tr>
<td></td>
<td>C-884</td>
<td>1 to 4</td>
<td>USB, RS-232, TCP/IP</td>
<td>Yes</td>
</tr>
<tr>
<td>Stepper motor</td>
<td>C-663</td>
<td>1</td>
<td>USB, RS-232, daisy chain</td>
<td>Yes, same interface</td>
</tr>
</tbody>
</table>

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.

3.7 Technical Features

3.7.1 Encoder

The M-406.xPD and M-406.xDG 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. To determine the relative position, the controller counts the encoder signals (impulses).

3.7.2 Limit Switches

The M-406 is equipped with non-contact, Hall-effect limit switches.

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

See "Limit Switch Specifications" (p. 59) for more information.
3.7.3 Reference Point Switch

The stage is equipped with a direction-sensing reference point switch that is located approximately in the middle of the travel range. This sensor transmits a TTL signal that indicates whether the stage is on the positive or negative side of the reference point switch.

The commands that use the reference signal are described in the user manual of the controller and/or in the corresponding software manuals.

3.7.4 Integrated PWM Amplifier

The M-406.xPD models with direct drive are equipped with a PWM amplifier ("ActiveDrive concept"). The motor and PWM amplifier are installed in a common case and thus optimally integrated and shielded. The PWM amplifier only receives the control signals from the controller, whereas the supply voltage is provided via an external power supply. The ActiveDrive concept allows a high motor power and dynamics with a low loss of power.
4 Unpacking

1. Unpack the M-406 with care.
2. Compare the contents against the items covered by the contract and against the packing list.
3. Inspect the contents for signs of damage. If parts are missing or you notice signs of damage, contact PI immediately.
4. Keep all packaging materials in case the product needs to be returned.
5 Installation

In this Chapter

General Notes on Installation ................................................................. 17
Optional: Modifying the Connection Orientation on the M-406 .................... 18
Mounting the M-406 on a Surface ............................................................ 21
Affixing the Load to the M-406 ............................................................... 24
Setting Up a Multi-Axis System ................................................................ 27
Connecting the Motor Cable to the M-406 ................................................ 38
Connecting the Power Supply to the M-406 .............................................. 39

5.1 General Notes on Installation

NOTICE

Unintentional changes in position with vertical mounting!
If the load exceeds the self-locking of the drive when the stage is mounted vertically, unintentional changes in the position of the moving platform occur. Unintentional changes in position of the moving platform can damage the drive, the load or the environment.

➢ When a stage is mounted vertically, make sure that the installed load is lower than the self-locking of the drive (see "Data Table" (p. 57)).

NOTICE

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

➢ Ensure that the screw heads do not protrude from counter-sunk holes so that they do not interfere with the stage motion.
NOTICE

Cable break!
A cable break leads to a failure of the stage.

- Install the stage so that the cable is not bent or crushed too severely during operation.
- If necessary: Modify the connection orientation of the stage (p. 18).

NOTICE

Heating up of the M-406 during operation!
The heat produced during operation of the M-406 can affect your application.

- Install the M-406 so that your application is not affected by the dissipating heat.

INFORMATION

For optimum repeatability, all components must be affixed without backlash.

- Make sure that the stage, load and - if present - the mounting adapter are affixed without backlash.

- If possible, perform a simulation of the stage motions with a mounted load or suitable calculations in order to identify collisions or unfavorable center of gravity constellations.
- If necessary, take suitable constructive measures to avoid collisions and instabilities in the overall system.
- Avoid or mark danger zones that result from the installation of the stage and the application, in accordance with the legal regulations.

5.2 Optional: Modifying the Connection Orientation on the M-406

INFORMATION

Motor and connections of the M-406 can be rotated around the axis of the motor and fixed in any position.

- Check whether the connections of the M-406 are in a position that is suitable for your installation situation.
5.2.1 M-406.xDG and M-406.xPD Models

Figure 3: Position of the grub screws on the motor flange of the M-406.xDG and M-406.xPD models; left: Front view; right: Rear view

1 Motor flange
2 Grub screw
3 Motor case

Prerequisites

- The stage is not mounted on a surface.
- The stage is not connected to the controller and the power supply.

Tools and accessories

- Allen wrench AF 2

Modifying the connection orientation on the M-406.xDG and M-406.xPD models

1. Loosen the two grub screws on the motor flange.
2. Rotate the motor case with the connections into the desired orientation.
3. Make sure that the cables are not bent or crushed too severely in the selected orientation.
4. Tighten the two grub screws on the motor flange.
5.2.2 M-406.x2S Models

Figure 4: Position of the grub screw on the motor case of the M-406.x2S models

1 Motor case
2 Grub screws

Prerequisites

✓ The stage is not mounted on a surface.
✓ The stage is not connected to the controller.

Tools and accessories

- Allen wrench AF 1.5

Modifying the connection orientation on the M-406.x2S models

1. Loosen the two grub screws on the motor case.
2. Rotate the motor case with the connections into the desired orientation.
3. Make sure that the cables are not bent or crushed too severely in the selected orientation.
4. Tighten the two grub screws on the motor case.
5.3 Mounting the M-406 on a Surface

**NOTICE**

Warping of the M-406 due to mounting on uneven surfaces!
Mounting the M-406 on an uneven surface can warp the M-406. Warping reduces the accuracy.

- Mount the M-406 on an even surface. The recommended evenness of the surface is ≤10 µm.
- For applications with great temperature changes:
  Only mount the M-406 on surfaces that have the same or similar thermal expansion properties as the M-406.

---

**NOTICE**

Screws that are too long!
Mounting from below: Screws that are inserted too deeply can damage the M-406.

- Observe the depth of the mounting holes in the base body of the M-406 (p. 61).
- Only use screws of the correct length for the respective mounting holes.

---

**NOTICE**

Wear from manually moving the moving platform!
Manually moving the moving platform increases wear in the case of stages with a gearhead.

- With the M-406.xDG models, only move the platform manually if there is no other possibility for motion.

---

**INFORMATION**

The positive direction of motion is away from the cable exit side.
INFORMATION

The required mounting holes may be covered by the moving platform, depending on which mounting option is selected.

**Mounting option 1:** The moving platform must be moved 25 mm away from the reference position (in positive or negative direction) in order to be able to reach the mounting holes through the auxiliary holes in the moving platform.

**Mounting option 2:** The moving platform must be in the reference position (delivery state).

- Move the moving platform if necessary.

The mounting holes of the M-406 are intended for the following mounting options:

<table>
<thead>
<tr>
<th>Mounting option</th>
<th>Mounting method</th>
<th>Mounting holes, view from below, for details see &quot;Dimensions&quot; (p. 61)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong></td>
<td>Mounting from above with two M4x8 screws</td>
<td><img src="image" alt="Figure 5: Mounting the M-406 with two M4x8 screws from above" /></td>
</tr>
<tr>
<td></td>
<td>This mounting option is used e.g. when setting up an XY system consisting of two M-406 stages (p. 28).</td>
<td></td>
</tr>
<tr>
<td><strong>2</strong></td>
<td>Mounting from above with four M4x8 screws</td>
<td><img src="image" alt="Figure 6: Mounting the M-406 with four M4x8 screws" /></td>
</tr>
<tr>
<td></td>
<td>This mounting option is used e.g. when setting up an XZ/XYZ system consisting of two or three M-406 stages (p. 31).</td>
<td></td>
</tr>
<tr>
<td><strong>3</strong></td>
<td>Mounting from below with two M4 screws</td>
<td><img src="image" alt="Figure 7: Mounting the M-406 with two M4 screws from below" /></td>
</tr>
</tbody>
</table>
Prerequisites

✓ You have read and understood the general notes on installation (p. 17).
✓ You have provided a suitable surface (for the required position and depth of the holes for accommodating the screws, see "Dimensions" (p. 61)):
  - For mounting from above: Two or four M4 threaded holes are provided.
  - For mounting from below: Two Ø 4.5 mm holes are provided.
  - The evenness of the surface is $\leq 10 \, \mu m$.
  - For applications with great temperature changes: The surface should have the same or similar thermal expansion properties as the M-406 (e.g. surface made of aluminum).
✓ You accounted for the space required for cable routing free of kinks and in accordance with regulations.
✓ If you want to make the mounting holes in the base body of the M-406 accessible by moving the moving platform manually: The stage is not connected to the power supply and the controller.
Tools and accessories

- Mounting accessories:
  - For mounting from above: 2 or 4 M4x8 screws, included in the scope of delivery (p. 11)
  - For mounting from below: 2 M4 screws of suitable length (for the depth of the threaded holes in the base body of the M-406, see "Dimensions" (p. 61))
  - Allen wrench AF 3

Mounting the stage on a surface

1. If necessary: Make the mounting holes in the base body of the stage accessible. Possible measures:
   - Temporary start-up of the stage (p. 41) and commanding the platform to a suitable position
   - Manually moving the moving platform (p. 51)
2. Align the stage on the surface so that the corresponding mounting holes in the stage and surface overlap.
3. Completely screw in the screws into all mounting holes.
4. Check that the stage fits on the surface without backlash.

5.4 Affixing the Load to the M-406

**NOTICE**

**Impermissibly high load on the stage!**
An impermissibly high load interferes with the motion of the moving platform and can damage the stage.

- In respect to the mass and mounting type of the load, observe the maximum permissible forces that are allowed to act on the moving platform according to the specification (p. 57).
**NOTICE**

**Screws that are too long!**
Screws that are inserted too deeply can damage the M-406.

- Observe the depth of the mounting holes in the moving platform.
- Only use screws of the correct length for the respective mounting holes.

---

*Figure 9: Holes in the moving platform of the M-406*

1. M6 mounting hole, depth 4.8 mm (total of 4)
2. M3 mounting hole, depth 4.8 mm (total of 4)
3. M4 mounting hole, depth 4.8 mm (total of 18)
4. Locating hole Ø 4 mm H7, depth 4.1 mm (total of 8)
5. Locating hole Ø 3 mm H7, depth 4.1 mm (total of 4)

**Prerequisites**

- You have read and understood the general notes on installation (p. 17).
- You have properly mounted the stage on a surface (p. 21).
- The stage is **not** connected to the power supply and the controller.
You have prepared the load so that it can be affixed to the mounting holes on the moving platform:

- The distance between the center of gravity of the load and the center of the moving platform is as small as possible in all directions.
- At least two points are provided for affixing the load to the moving platform (ideally: three or four attachment points).
- If you use locating pins to align the load: You have made two to four locating holes in the load with Ø 3 mm or 4 mm and a suitable tolerance for accommodating locating pins.

Tools and accessories

- At least 2 screws of suitable length. Options:
  - M3 screws
  - M4 screws
  - M6 screws
- Suitable tools for fastening the screws
- Optional: 2 to 4 locating pins for easy alignment of the load on the M-406, suitable for holes with Ø 3 mm or 4 mm; for tolerance data, see figure of the holes in the moving platform; locating pins not included in the scope of delivery

Affixing the load

1. Align the load so that the selected mounting holes in the moving platform can be used for affixing it.
   
   If you use locating pins to align the load:
   
   a) Insert the locating pins into the locating holes in the moving platform or the load.
   
   b) Place the load on the moving platform in such a way that the locating pins are inserted into the corresponding locating holes on the other side.

2. Affix the load to the selected mounting holes in the moving platform using the screws.

3. Check that the load fits on the moving platform of the stage without backlash.
5.5 Setting Up a Multi-Axis System

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

Typical combinations:
- XY system
- Z system (XZ or XYZ combination) with adapter bracket
  - For combination possibilities with other stages, contact our customer service department (p. 55).

5.5.1 General Information on Setting Up a Multi-Axis System

**NOTICE**

**Impermissibly high load on the stages!**

In a multi-axis system, also the stage used for the Y and/or Z axis must be moved. Impermissibly high loads interfere with the motion and can damage the stages.

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

**NOTICE**

**Wear from manually moving the moving platform!**

Manually moving the moving platform increases wear in the case of stages with a gearhead.

- With the M-406.xDG models, only move the platform manually if there is no other possibility for motion.

- Only install and operate the multi-axis system after you have read and understood the user manuals of all components of the multi-axis system.
- If you require special mounting adapters, contact our customer service department (p. 55).
5.5.2 Setting Up an XY System

**NOTICE**

Screws that are too long!
The lower stage can be damaged by screws that are inserted too deeply.

- Observe the depth of the mounting holes in the moving platform of the lower stage.
- Only use screws of the correct length for the respective mounting holes.

Designations in these instructions:

- **Lower stage**: Forms the basis of the multi-axis system (X-axis), is attached to a surface
- **Upper stage**: Forms the Y-axis of the multi-axis system, is attached to the lower stage rotated by 90°

*Figure 10: Example: XY system consisting of two M-406 stages*
Figure 11: Setting up an XY system from two M-406

1. Lower stage with
   a, b) M4 mounting holes in the platform

2. Upper stage (view from below) with
   a, b) mounting holes with counterbore for M4 hex-head cap screws, in
   the base body of the stage

Holes that overlap during attachment are marked with the same letter.

Prerequisites

✓ You have read and understood the general notes on installation (p. 17).
✓ You have read and understood the general notes on setting up a multi-axis
  system (p. 27).
✓ You accounted for the space required for cable routing free of kinks and in
  accordance with regulations.
- The used stages are disconnected from the power supply and controller.
- You have properly attached the lower stage to a surface (p. 21).

### Tools and accessories

- 2 M4 screws of suitable length from the scope of delivery of the upper stage
  - When an M-406 is mounted to an M-406 as in the figure above: 2 M4x8 screws
- Allen wrench AF 3, in the scope of delivery of the stages

### Setting up an XY system

1. If necessary: Make the first of the two mounting holes in the base body of the upper stage accessible. Possible measures:
   - Temporary start-up of the upper stage (p. 41) and commanding the platform to a suitable position
   - Manually moving the moving platform of the upper stage (p. 51)
2. Position the upper stage rotated by 90° on the moving platform of the lower stage (see above figure).
3. Align the upper stage so that the corresponding mounting holes in the upper and lower stage overlap (holes a and b in the figure above).
4. Completely screw in one M4 screw into the hole a.
5. Make the second of the two mounting holes in the base body of the upper stage accessible. Possible measures:
   - Temporary start-up of the upper stage (p. 41) and commanding the platform to a suitable position
   - Manually moving the moving platform of the upper stage (p. 51)
6. Completely screw in one M4 screw into the hole b.
7. Check that the upper stage fits without backlash.
5.5.3 Setting Up a Z System with an Adapter Bracket

**NOTICE**

**Screws that are too long!**

The lower stage can be damaged by screws that are inserted too deeply.

- Observe the depth of the mounting holes in the moving platform of the lower stage.
- Only use screws of the correct length for the respective mounting holes.

Designations in these instructions:

- **Lower stage**: X axis in an XZ combination; Y axis in an XYZ combination. The stage to which the upper stage is attached with an adapter bracket.
- **Upper stage**: Forms the Z axis of the multi-axis system, is mounted in a vertical alignment to the lower stage with an adapter bracket.
Prerequisites

✓ You have read and understood the general notes on installation (p. 17).
✓ You have read and understood the general notes on setting up a multi-axis system (p. 27).
✓ You accounted for the space required for cable routing free of kinks and in accordance with regulations.
The used stages are disconnected from the power supply and controller.

If you set up an XZ combination: You have properly attached the lower stage to a surface (p. 21).

If you set up an XYZ combination: You have properly attached the stages for the X and Y axis (p. 28).

**Tools and accessories**

- Suitable adapter bracket, available as an optional accessory (p. 11):
  - M-592.00 when an M-406 stage is used as Z axis

- For attaching the Z axis to the adapter bracket: Four M4 screws of suitable length from the scope of delivery of the upper stage
  - When an M-406 is used as Z axis as in the figure above: 4 M4x8 screws

- For attaching the adapter bracket to the lower stage: M4 screws of suitable length
  - When the M-592.00 adapter bracket is attached to an M-406: 4 M4x8 screws

- Allen wrench AF 3, in the scope of delivery of the stage
Setting up a Z system

Figure 13: Example: Setting up an XZ combination from two M-406 stages and M-592.00 adapter bracket

1 Lower stage
2 Upper stage (view from below)
3 M-592.00 adapter bracket

a-h: mounting holes:
Holes that overlap during attachment are marked with the same letter
1. Attach the adapter bracket to the lower stage:

   a) Align the M-592.00 adapter bracket on the moving platform of the lower stage so that mounting holes a to d in the adapter bracket and the moving platform overlap.

   b) Completely screw in one screw into each mounting hole a to d.

2. Check that the adapter bracket fits without backlash.
3. Screw one screw into each of the mounting holes e to h of the adapter bracket to a depth of approx. 2 mm.

Figure 15: Screw in screws for the upper M-406 in the adapter bracket
4. Attach the upper stage to the adapter bracket:

![Attaching the upper stage](image)

**Figure 16: Attaching the upper M-406 to the adapter bracket**

a) If necessary: Make two of the four required mounting holes in the base body of the stage accessible. Possible measures:

- Temporary start-up of the upper stage (p. 41) and commanding the platform to a suitable position
- Manually moving the moving platform (p. 51)

b) Position the stage on the long surface of the adapter bracket as in the figure:

- The stage lies on the inside of the bracket.
- The motor of the stage faces the open end of the inside of the bracket (i.e. upwards in the Z system).
- Mounting holes e to h in the stage overlap with the screws in the corresponding holes.

c) Hook the stage on the screws, located in holes e to h.
d) Slide the stage along the slots of holes e to h in the direction of the lower stage until you feel resistance (approx. 10 mm).

e) Tighten the two screws that have become accessible.

f) Make the remaining two mounting holes in the base body of the stage accessible. Possible measures:
   - Temporary start-up of the upper stage (p. 41) and commanding the platform to a suitable position
   - Manually moving the moving platform (p. 51)

g) Tighten the two screws that have become accessible.

5. Check that the stage fits without backlash.

### 5.6 Connecting the Motor Cable to the M-406

**Prerequisites**

- You have read and understood the general notes on installation (p. 17).
- The motor cable is not connected to the controller.

**Tools and accessories**

- Suitable motor cable from PI, e.g.:
  - Motor cable C-815.38, 3 m, Sub-D, 15-pin (m/f), in the scope of delivery (p. 11).
  - Motor cable C-815.83, 10 m, Sub-D, 15-pin (m/f), available as optional accessory (p. 11).

**Connecting the motor cable to the M-406**

1. Connect the connector (f) of the motor cable to the Sub-D 15-pin panel plug (m) of the stage.

2. Secure the connector (f) with the two integrated screws against being unintentionally pulled out of the stage.
5.7 Connecting the Power Supply to the M-406

Connecting a power supply is only necessary with the M-406.2PD, .4PD and .6PD models.

Prerequisites

✓ The power cord is not connected to the power socket.

Tools and accessories

- Included 24 V wide-range-input power supply (for line voltages between 100 and 240 VAC at 50 or 60 Hz)
- Alternatively: Sufficiently dimensioned power supply that provides 24 VDC with a maximum of 2.0 ampere
- Included adapter for the power supply connector; barrel connector to Switchcraft 3-pin connector (f)
- Alternatively: Sufficiently dimensioned adapter
- Included power cord
- Alternatively: Sufficiently dimensioned power cord

Connecting the power supply to the M-406

- Connect the Switchcraft connector (f) of the adapter to the Switchcraft panel plug of the M-406.
- Connect the barrel connector of the adapter to the barrel connector socket of the power supply.
- Connect the power cord to the power supply.
6 Start-Up

In this Chapter

General Notes on Start-Up ................................................................. 41
Starting up the Stage......................................................................... 43

6.1 General Notes on Start-Up

CAUTION
Risk of crushing by moving parts!
There is a risk of minor injury from crushing between the movable parts of the stage
or the load and a fixed part or obstacle.
➢ Use protective structures to keep limbs away from areas in which they could be
seized by moving parts.
➢ Observe the safety distances in accordance with DIN EN ISO 13857 when
installing protective structures.

NOTICE
Damage from collisions!
Collisions can damage the stage, the load to be moved and the environment.
➢ Make sure that no collisions are possible between the stage, the load to be
moved and the environment in the motion range of the stage.
➢ Do not place any objects in areas where they can get 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

Damage if an incorrect controller is connected!
Connecting a stage to an unsuitable controller can cause damage to the stage or controller.

- Connect a stage with DC motor to a DC motor controller only.
- Connect a stage with stepper motor to a stepper motor controller only.
- If you use controllers and software from other manufacturers, check their technical data to make sure that they are suitable before starting up the stage!

NOTICE

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

- Do not exceed the operating voltage range (p. 58) for which the M-406 is specified.
- Only operate the M-406 when the operating voltage is properly connected; see "Pin Assignment" (p. 64).

NOTICE

Damage or considerable wear from 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 motions!
When the M-406 is being connected to the controller, it can carry out unintentional motions. Defective software or wrong operation of the software can also result in unintentional motions.

- Do not place any objects in areas where they can get caught by moving parts.
- Before connecting the M-406, check whether a macro is defined as the start-up macro in the controller, and cancel the selection of the start-up macro if necessary.
6.2 Starting up the Stage

Prerequisites

✓ You have read and understood the General Notes on Start-Up (p. 41).
✓ For starting up with a load or in a multi-axis system: You have properly installed the stage (p. 27).
✓ You have read and understood the user manual of the used controller.
✓ You have read and understood the manual of the used PC software.
✓ The controller and the required PC software have been installed. All connections on the controller have been set up (see user manual of the controller; the stage is connected via the motor cable).
Starting up the stage

1. Only M-406.xPD models: Connect the power cord of the power supply with the power socket.

2. Start up the controller (see user manual of the controller).
   
   Configure the controller during the start-up using the PC software for the used stage (see user manual of the controller and of the PC software):
   
   - If you use a controller from PI: Select the entry in the stage database that precisely fits the used stage model (p. 44).
   - If you use a controller from another manufacturer: Enter the parameters that precisely fit the used stage model in the corresponding PC software; see the overview of the operating parameters for DC motor controllers (p. 44) or stepper motor controllers (p. 45).

3. Start a few motion cycles for testing purposes (see user manual of the controller).

6.2.1 M-406 Entries in the Stage Database of PI

For controllers from PI, you can select the connected stage from a stage database in the corresponding PC software. The appropriate operating parameters are thus 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.

6.2.2 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 used stage.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>M-406 model</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.xDG</td>
<td>.xPD</td>
</tr>
<tr>
<td>P-Term</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>I-Term</td>
<td>40</td>
<td>300</td>
</tr>
<tr>
<td>D-Term</td>
<td>800</td>
<td>400</td>
</tr>
<tr>
<td>I-Limit</td>
<td>2000</td>
<td>2000</td>
</tr>
<tr>
<td>Maximum acceleration</td>
<td>30</td>
<td>300</td>
</tr>
<tr>
<td>Maximum velocity*</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Maximum velocity*</td>
<td>118568</td>
<td>12000</td>
</tr>
</tbody>
</table>
### 6.2.3 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 for adaptation to the used stage.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>M-406.x2S</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recommended start values:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Holding current</td>
<td>200</td>
<td>mA</td>
</tr>
<tr>
<td>Operating current</td>
<td>600</td>
<td>mA</td>
</tr>
<tr>
<td>Holding current delay</td>
<td>500</td>
<td>ms</td>
</tr>
<tr>
<td>Max. motor current</td>
<td>850</td>
<td>mA</td>
</tr>
<tr>
<td>Max. acceleration</td>
<td>10</td>
<td>mm/s²</td>
</tr>
<tr>
<td>Max. velocity*</td>
<td>2</td>
<td>mm/s</td>
</tr>
<tr>
<td>Max. velocity*</td>
<td>800</td>
<td>Full steps/s</td>
</tr>
<tr>
<td><strong>Hardware properties:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limit switch polarity</td>
<td>Active low</td>
<td>-</td>
</tr>
<tr>
<td>Full steps</td>
<td>400</td>
<td>steps/revolution</td>
</tr>
<tr>
<td>Phase resistance</td>
<td>6.6</td>
<td>ohm</td>
</tr>
<tr>
<td>Max. phase current, bipolar</td>
<td>850</td>
<td>mA</td>
</tr>
</tbody>
</table>

* Recommended for continuous operation
7 Maintenance

In this Chapter

General Notes on Maintenance................................................................. 47
Performing a Maintenance Run................................................................. 47
Cleaning the M-406 .................................................................................. 48

7.1 General Notes on Maintenance

NOTICE

Damage due to improper maintenance!

Improper maintenance can lead to misalignment and failure of the M-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 M-406, the following maintenance measures are required:

Maintenance run

The maintenance run serves to distribute the lubricant that is present.

- After 500 operating hours or at least after 1 year, carry out a maintenance run over the entire travel range, in order for the lubricant present to be equally distributed.
- If you operate your stage continuously over only a small working range (<20% of the entire travel range), perform a run across the entire travel range approximately every 2000 motion cycles.

Lubrication

Under laboratory conditions, the stage needs extra lubrication in exceptional cases only. For continuous industrial use, the lubrication intervals must be defined individually.
➢ Do not lubricate the M-406 without consulting our customer service department (p. 55).

➢ To lubricate, follow the instructions given in the maintenance manual which you can obtain from our customer service department.

7.3 Cleaning the M-406

Prerequisites

✓ You have disconnected the stage from the controller.

Cleaning the stage

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

➢ Do not use any organic solvents.
# 8 Troubleshooting

## In this Chapter

Possible Causes and Correction ................................................................. 49  
Manually Moving the Moving Platform ....................................................... 51

## 8.1 Possible Causes and Correction

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible Causes</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced positioning accuracy</td>
<td>Warped base body</td>
<td>- Mount the M-406 on an even surface. The recommended evenness of the surface is 10 µm.</td>
</tr>
<tr>
<td></td>
<td>When the M-406 is mounted vertically: The load exceeds the self-locking of the drive.</td>
<td>- Do not exceed the maximum permissible stress and load capacities according to the specifications (p. 57).</td>
</tr>
<tr>
<td></td>
<td>Increased wear due to small motions over a long period of time</td>
<td>- Carry out a maintenance run over the entire travel range (p. 47).</td>
</tr>
</tbody>
</table>
| Functional impairment after system modification | • Controller has been replaced.  
• M-406 has been replaced with another model. | Controller from PI:  
- Load the parameters from the stage database that correspond to the combination of controller and M-406 model.  
Controller from a third-party supplier:  
- Check the operating parameters. |
| Mechanical system does not move; no operating noise can be heard. | Controller and/or power supply are incorrectly connected or defective. | - Check all connection cables.    
- Check the controller.  
- If present: Check the power supply of the stage. |
|                                  | When a PI controller is used: A motion error of the axis is present. | 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 |
## Troubleshooting

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible Causes</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>caused, for example, by malfunctions of the drive or the position sensor of the stage. 1. Read out the error code of the controller in the PC software. If a motion error is present, the error code -1024 is output. 2. Check your system and make sure that all axes can be moved safely. 3. Switch on the servo mode for the affected axis in the PC software. For details, see the user manual of the controller.</td>
<td></td>
</tr>
<tr>
<td>Moving platform has triggered the limit switch p. 12.</td>
<td>If you use a controller from PI: 1. Switch on the servo mode for the affected axis again in the PC software. 2. Command an axis motion away from the limit switch in the PC software.</td>
<td></td>
</tr>
<tr>
<td>In the case of models with a stepper motor: The mechanical system does not move any more but produces an operating noise.</td>
<td>The motor is overloaded by an external load torque or by the mass to be driven with a strong acceleration or deceleration.</td>
<td>The motor skips steps. The information on the current position is lost without the controller recognizing this state.  ▶ Determine the maximum velocity for a stage with a stepper motor in the application.</td>
</tr>
</tbody>
</table>

If the problem that occurred with your system is not listed in the table above or cannot be solved as described, contact our customer service department (p. 55).
8.2 Manually Moving the Moving Platform

**INFORMATION**

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

- Make mounting holes for M4 screws accessible in the base body of the stage.
- Move the moving platform away from the hard stop in order to make the stage operational again.

8.2.1 M-406.xDG and M-406.xPD Models

**NOTICE**

Wear from manually moving the moving platform!

Manually moving the moving platform increases wear in the case of stages with a gearhead.

- With the M-406.xDG models, only move the platform manually if there is no other possibility for motion.

![Diagram of drive screw access on M-406 stage](image)

*Figure 17: Position of the drive screw access on the M-406*

1. Motor
2. Front face
Prerequisites
The stage is not connected to the power supply and the controller.

Tools and accessories
- Allen wrench AF 3 (in the scope of delivery)

Manually moving the moving platform
1. Introduce the Allen wrench into the drive screw access in the front face of the stage until you feel resistance.
2. Rotate the Allen wrench as far as necessary:
   - Clockwise rotation: Platform moves towards the motor
   - Counter-clockwise rotation: Platform moves away from the motor

The rotary motion is transferred directly to the drive screw.

8.2.2 M-406.x2S Models

Figure 18: Position of the damper for the stepper motor on the M-406.x2S

1. Motor
2. Damper for stepper motor
Prerequisites
The stage is not connected to the controller.

Manually moving the moving platform
- Rotate the damper for the stepper motor as far as necessary:
  - Clockwise rotation: Platform moves away from the motor
  - Counter-clockwise rotation: Platform moves in the direction of the motor

The rotary motion is transferred directly to the drive screw.
9 Customer Service

For inquiries and orders, contact your PI sales engineer or send us an e-mail (mailto:info@pi.ws).

If you have questions concerning your system, have the following information ready:

- Product codes and serial numbers of all products in the system
- Firmware version of the controller (if present)
- Version of the driver or the software (if present)
- Operating system on the PC (if present)

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

In this Chapter

Specifications ........................................................................................................................................... 57
Dimensions ............................................................................................................................................... 61
Pin Assignment ....................................................................................................................................... 64

10.1 Specifications

10.1.1 Data Table

<table>
<thead>
<tr>
<th>Preliminary data</th>
<th>M-406.2DG / M-406.4DG / M-406.6DG</th>
<th>M-406.2PD / M-406.4PD / M-406.6PD</th>
<th>M-406.22S / M-406.42S / M-406.62S</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motion and positioning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Travel range</td>
<td>50 / 100 / 150</td>
<td>50 / 100 / 150</td>
<td>50 / 100 / 150</td>
<td>mm</td>
</tr>
<tr>
<td>Integrated sensor</td>
<td>Rotary encoder</td>
<td>Rotary encoder</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Design resolution</td>
<td>0.0085</td>
<td>0.125</td>
<td>0.0781</td>
<td>µm</td>
</tr>
<tr>
<td>Min. incremental motion</td>
<td>0.1</td>
<td>0.25</td>
<td>0.1</td>
<td>µm</td>
</tr>
<tr>
<td>Unidirectional repeatability</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>µm</td>
</tr>
<tr>
<td>Backlash</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>µm</td>
</tr>
<tr>
<td>Crosstalk, angular error</td>
<td>±25 / ±50 / ±75</td>
<td>±25 / ±50 / ±75</td>
<td>±25 / ±50 / ±75</td>
<td>µrad</td>
</tr>
<tr>
<td>Max. velocity</td>
<td>1</td>
<td>15</td>
<td>3.5</td>
<td>mm/s</td>
</tr>
<tr>
<td>Mechanical properties</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thread pitch</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>mm</td>
</tr>
<tr>
<td>Gear ratio</td>
<td>29.6:1</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Max. load</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>N</td>
</tr>
<tr>
<td>Max. push / pull force</td>
<td>50 / 50</td>
<td>50 / 50</td>
<td>50 / 50</td>
<td>N</td>
</tr>
<tr>
<td>Max. lateral force</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>N</td>
</tr>
</tbody>
</table>
Technical Data

Version: 1.3.0
MP123E
M-406 Stage

Preliminary data

<table>
<thead>
<tr>
<th>Preliminary data</th>
<th>M-406.2DG / M-406.4DG / M-406.6DG</th>
<th>M-406.2PD / M-406.4PD / M-406.6PD</th>
<th>M-406.22S / M-406.42S / M-406.62S</th>
<th>Unit</th>
</tr>
</thead>
</table>

Drive properties

<table>
<thead>
<tr>
<th>Motor type</th>
<th>DC gear motor</th>
<th>DC motor with PWM control</th>
<th>2-phase stepper motor*</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Operating voltage</th>
<th>0 to ±12</th>
<th>24 (PWM)</th>
<th>24</th>
<th>V</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Motor power</th>
<th>3</th>
<th>30</th>
<th>-</th>
<th>W</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Motor resolution</th>
<th>Hall effect</th>
<th>Hall effect</th>
<th>Hall effect</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Reference point and limit switches</th>
<th>Hall effect</th>
</tr>
</thead>
</table>

| Miscellaneous |
|------------------|-----------------------------------|

<table>
<thead>
<tr>
<th>Operating temperature range</th>
<th>-20 to 65</th>
<th>-20 to 65</th>
<th>-20 to 65</th>
<th>°C</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Material</th>
<th>Aluminum, steel</th>
<th>Aluminum, steel</th>
<th>Aluminum, steel</th>
</tr>
</thead>
</table>

| Mass | 2.1 / 2.4 / 2.8 | 2.1 / 2.4 / 2.8 | 2.1 / 2.4 / 2.8 | kg |
|------------------|----------|-------|-------|

<table>
<thead>
<tr>
<th>Connector</th>
<th>Sub-D 15-pin, 3 m cable incl.</th>
<th>Sub-D 15-pin, 3 m cable incl.</th>
<th>Sub-D 15-pin, 3 m cable incl.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Recommended controller / driver</th>
<th>C-863 (single-axis), C-884 (up to 4 axes)</th>
<th>C-863 (single-axis), C-884 (up to 4 axes)</th>
<th>C-663 (single-axis)</th>
</tr>
</thead>
</table>

* Max. 0.85 A/phase; 400 full steps/rev., motor resolution with C-663 stepper motor controller

Ask about custom designs!

10.1.2 Maximum Ratings

M-406 stages are designed for the following operating data:

<table>
<thead>
<tr>
<th>Device</th>
<th>Maximum Operating Voltage</th>
<th>Operating Frequency</th>
<th>Maximum Power Consumption</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>M-406.xDG</th>
<th>12 V</th>
<th>0 Hz</th>
<th>3 W</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-406.xPD</td>
<td>24 V</td>
<td>0 Hz</td>
<td>30 W</td>
</tr>
<tr>
<td>M-406.x2S</td>
<td>24 V</td>
<td>0 Hz</td>
<td>U * 0.85 A/phase</td>
</tr>
</tbody>
</table>

U * 0.85 A/phase
10.1.3 Ambient Conditions and Classifications

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

<table>
<thead>
<tr>
<th>Area of application</th>
<th>For indoor use only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum altitude</td>
<td>2000 m</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>Highest relative humidity 80 % for temperatures up to 31 °C  Decreasing linearly to 50 % relative humidity at 40 °C</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>0 °C to 80 °C</td>
</tr>
<tr>
<td>Transport temperature</td>
<td>0 °C to 80 °C</td>
</tr>
<tr>
<td>Supply fluctuations</td>
<td>Not more than ±10 % of the nominal voltage</td>
</tr>
<tr>
<td>Degree of pollution</td>
<td>2</td>
</tr>
<tr>
<td>Degree of protection according to IEC 60529</td>
<td>IP40</td>
</tr>
</tbody>
</table>

10.1.4 Limit Switch Specifications

<table>
<thead>
<tr>
<th>Type</th>
<th>Magnetic (Hall-effect) sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage</td>
<td>+5 V/ground</td>
</tr>
<tr>
<td>Signal output</td>
<td>TTL level</td>
</tr>
<tr>
<td>Signal logic</td>
<td>The signal level changes when passing the limit switch. The signal logic depends on the model type:</td>
</tr>
<tr>
<td></td>
<td>▪ Models with DC motor: <strong>active high</strong>. That means:</td>
</tr>
</tbody>
</table>
|                           |     – Normal motor operation:  low (0 V)  
|                           |     – Limit switch reached: high (+5 V) |
|                           |   ▪ Models with stepper motor: **active low**. That means: |
|                           |     – Normal motor operation:  high (+5 V)  
|                           |     – Limit switch reached: low (0 V) |
### 10.1.5 Reference Point Switch Specifications

<table>
<thead>
<tr>
<th>Type</th>
<th>Magnetic (Hall-effect) sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage</td>
<td>+5 V/GND</td>
</tr>
<tr>
<td>Signal output</td>
<td>TTL level</td>
</tr>
<tr>
<td>Signal logic</td>
<td>Direction sensing by means of different signal levels on the left and right side of the reference point switch: The signal level changes from 0 to +5 V when the reference point switch is passed.</td>
</tr>
</tbody>
</table>
10.2 Dimensions

10.2.1 M-406 Stage

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

Figure 19: Dimensions for the M-406 series, see table for the values of the variables

<table>
<thead>
<tr>
<th>Models</th>
<th>L</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-406.2xx</td>
<td>207</td>
<td>98.5</td>
</tr>
<tr>
<td>M-406.4xx</td>
<td>257</td>
<td>123.5</td>
</tr>
<tr>
<td>M-406.6xx</td>
<td>307</td>
<td>98</td>
</tr>
</tbody>
</table>
10.2.2 Hole Pattern of the Moving Platform of the M-406

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

Figure 20: Hole pattern of the moving platform of the M-406 series
10.2.3 M-592.00 Adapter Bracket

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

Figure 21: M-592.00 adapter bracket
10.3 Pin Assignment

10.3.1 Sub-D 15 (m) Controller Connection

Models with DC motor

<table>
<thead>
<tr>
<th>Pin</th>
<th>Signal</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Internal</td>
<td>Input</td>
</tr>
</tbody>
</table>
| 9   | M-406.xDG: Motor (-)  
     | M-406.xPD: Internal; must not be connected | Input |
| 2   | M-406.xDG: Motor (+)  
     | M-406.xPD: Internal; must not be connected | Input |
| 10  | GND     | GND       |
| 3   | M-406.xDG: Internal; must not be connected  
     | M-406.xPG: MAGN (PWM magnitude) | Input |
| 11  | M-406.xDG: Internal; must not be connected  
     | M-406.xPD: SIGN (PWM sign) | Input |
| 4   | + 5 V   | Input     |
| 12  | Limit_N (negative limit switch) | Output |
| 5   | Limit_P (positive limit switch) | Output |
| 13  | Reference | Output |
| 6   | ID chip (for future use) | Bidirectional |
| 14  | Encoder A (+) | Output |
| 7   | Encoder A (-) | Output |
| 15  | Encoder B (+) | Output |
| 8   | Encoder B (-) | Output |
### Models with stepper motor

<table>
<thead>
<tr>
<th>Pin</th>
<th>Signal</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Motor phase 1A</td>
<td>Input</td>
</tr>
<tr>
<td>9</td>
<td>Motor phase 1B</td>
<td>Input</td>
</tr>
<tr>
<td>2</td>
<td>Motor phase 2A</td>
<td>Input</td>
</tr>
<tr>
<td>10</td>
<td>Motor phase 2B</td>
<td>Input</td>
</tr>
<tr>
<td>3</td>
<td>not connected</td>
<td>-</td>
</tr>
<tr>
<td>11</td>
<td>not connected</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>not connected</td>
<td>-</td>
</tr>
<tr>
<td>12</td>
<td>not connected</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>ID chip (for future use)</td>
<td>Bidirectional</td>
</tr>
<tr>
<td>13</td>
<td>Internal</td>
<td>Input</td>
</tr>
<tr>
<td>6</td>
<td>+5 V</td>
<td>Input</td>
</tr>
<tr>
<td>14</td>
<td>Limit_P (positive limit switch)</td>
<td>Output</td>
</tr>
<tr>
<td>7</td>
<td>GND</td>
<td>GND</td>
</tr>
<tr>
<td>15</td>
<td>Reference</td>
<td>Output</td>
</tr>
<tr>
<td>8</td>
<td>Limit_N (negative limit switch)</td>
<td>Output</td>
</tr>
</tbody>
</table>

#### 10.3.2 Switchcraft 3-Pin Power Supply Connector

Connecting a power supply is only necessary with the M-406.xPD models.

<table>
<thead>
<tr>
<th>Pin</th>
<th>Signal</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GND</td>
<td>GND</td>
</tr>
<tr>
<td>2</td>
<td>24 VDC supply voltage</td>
<td>Input</td>
</tr>
<tr>
<td>3</td>
<td>Not connected</td>
<td>-</td>
</tr>
</tbody>
</table>
11 Old Equipment Disposal

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

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

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

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

Physik Instrumente (PI) GmbH & Co. KG
Auf der Römerstr. 1
D-76228 Karlsruhe, Germany
12 EC Declaration of Conformity

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

- 2004/108/EC, EMC Directive
- 2011/65/EU, RoHS Directive

The applied standards certifying the conformity are listed below.

EMC: EN 61326-1:2013
Safety: EN 61010-1:2010
RoHS: EN 50581:2012