

MP123E M-406 Micropositioning Stage User Manual

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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



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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 This manual is superseded by any new release.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.

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1 About this Document

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1.1 Objective and Target Audience of this User Manual

This manual contains information on using the M-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 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.	Action consisting of several steps whose sequential order must be observed
2.	
➤	Action consisting of one or several steps whose sequential order is irrelevant
▪	List item
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.

1.3 Definition of Terms

Term	Explanation
Load capacity	Maximum load capacity in the vertical direction when the positioner is mounted horizontally. The contact point of the load is at the center of the platform.
Max. push/pull force	Maximum force in the direction of motion. Some positioners may have higher forces but with limited lifetimes. In the case of vertical mounting, the specified value (p. 51) for models without a gearhead and brake only applies when servo mode is switched on.
Incremental position sensor	Sensor (encoder) for detecting changes of position or changes of angle. Signals from the incremental position sensor are used for axis position feedback. After the controller is switched on, referencing must be done before absolute target positions can be commanded and reached.

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 from PI mentioned in this documentation are described in separate manuals.

Product	Document
Positioners with Electric Motors	MP119EK Short Instructions

1.6 Downloading Manuals

INFORMATION

If a manual is missing or problems occur with downloading:

- Contact our customer service department (p. 49).

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 the **Downloads** tab.

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

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2.1 Intended Use

The M-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 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 where failure could lead to considerable risk to people 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. 15).

It is only possible to use the M-406 as intended when completely mounted and connected.

The M-406 must be operated with a suitable controller (p. 11). 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.

- Use the M-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 M-406.

2.3 Organizational Measures

User manual

- Always keep this user manual together with the M-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 M-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 M-406 only after you have read and understood this user manual.

Personnel qualification

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

3 Product Description

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3.1 Model Overview

The positioners of the M-406.2xx, M-406.4xx and M-406.6xx series are summarized under the designation M406 in this manual.

All models are micropositioning stages with precision leadscrew. They differ with respect to:

- Travel range
- Drive type

M-406	Travel range in mm	Travel range in inches
.2xx	50	2
.4xx	100	4
.6xx	150	6

Version	Drive type		
	DC motor		Stepper motor
	Gearhead, analog	Direct drive, PWM	
.xDG	●		
.xPD		●	
.x2S			●

Detailed model overview

Product number	Description
M-406.2DG	Precision microtranslation stage, 50 mm travel range, DC gear motor
M-406.2PD	Precision microtranslation stage, 50 mm travel range, ActiveDrive DC motor, incl. 24 V power adapter
M-406.22S	Precision microtranslation stage, 50 mm travel range, 2-phase stepper motor
M-406.4DG	Precision microtranslation stage, 100 mm travel range, DC gear motor
M-406.4PD	Precision microtranslation stage, 100 mm travel range, ActiveDrive DC motor, incl. 24 V power adapter
M-406.42S	Precision microtranslation stage, 100 mm travel range, 2-phase stepper motor
M-406.6DG	Precision microtranslation stage, 150 mm travel range, DC gear motor
M-406.6PD	Precision microtranslation stage, 150 mm travel range, ActiveDrive DC motor, incl. 24 V power adapter
M-406.62S	Precision microtranslation stage, 150 mm travel range, 2-phase stepper motor

- Refer to the specifications (p. 51) for further technical data.

3.2 Product View

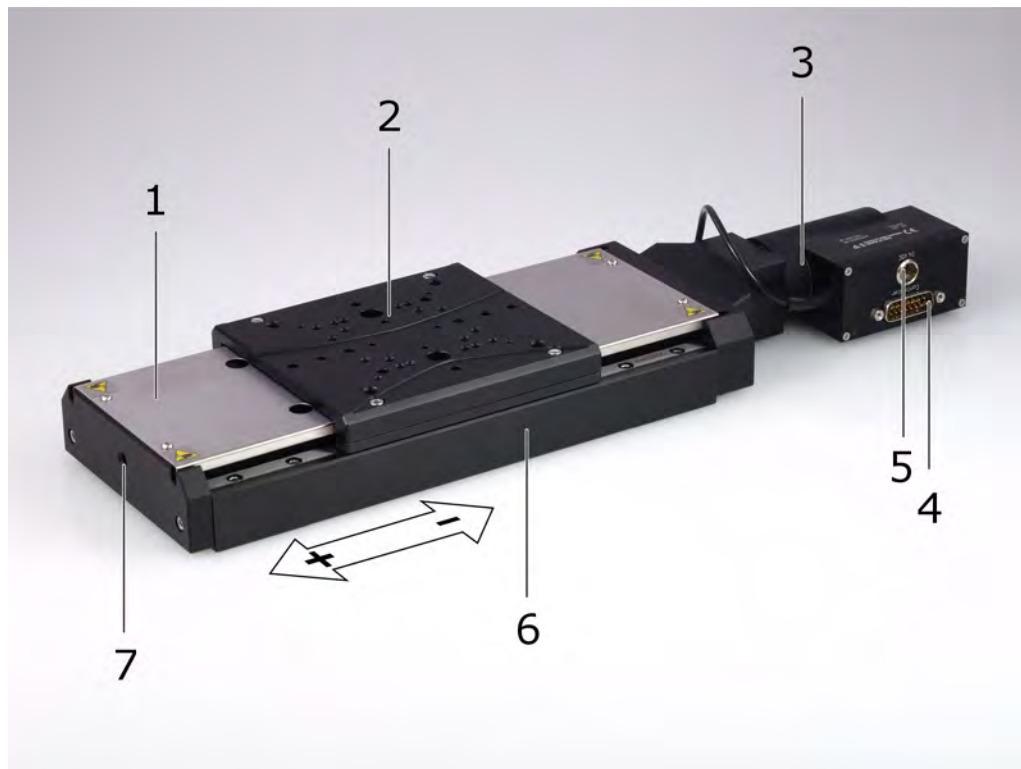


Figure 1: Positioner components (here: M-406.4PD)






1. Protective cover
2. Motion platform
3. Motor
4. Controller connection (D-sub 15 panel plug)
5. Power adapter connector (Switchcraft panel plug, 3-pole, M-406.xPD models only)
6. Base body
7. Drive screw access

The arrow shows the positive (+) and negative (-) direction of motion.

3.3 Product Labeling



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

Position	Labeling	Description
A		Warning sign "Risk of crushing": Reference to dangerous forces (p. 37)
B		Manufacturer's logo
B		CE conformity mark
B		Warning sign "Pay attention to the manual!"
B	M-406.4PD	Product name (example), the characters following the period refer to the model
B	113050975	Serial number (example), individual for each M-406 Meaning of each position (from the left): 1 = internal information, 2 and 3 = year of manufacture, 4 to 9 = consecutive number
B	WWW.PI.WS	Manufacturer's address (website)
B		Old equipment disposal (p. 59)
B	Country of origin: Germany	Country of origin
C	Controller	Controller connection
C	24 VDC	Power supply connection (only with M-406.xPD models)

3.4 Scope of Delivery

Item number	Component
M-406.xxx	Positioner according to order (p. 7)
2110	Screw set for mounting the positioner and load <ul style="list-style-type: none"> 6 socket head screws, A2 M4×8 ISO 4762 Hex key AF 3 DIN 911
MP119EK	Short instructions for positioners with electric motors
For M-406.xPD models only	
C-663.PS	Wide input range power supply 24 V/42 W
3763	Power cord
K050B0002	Adapter for the power adapter connection; barrel connector to Switchcraft 3-pole connector (f)

3.5 Optional Accessories

Order number	Description
C-815.83	Motor cable, 10 m, D-sub, 15-pole (m/f)
M-592.00	Adapter bracket for mounting M-406 stages vertically. Material: Al; mass: 0.2 kg
M-110.01	Adapter plate for mounting M-11x linear stages onto M-406 stages. Material: Al

To order, contact our customer service department (p. 49).

3.6 Suitable Controllers

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

Drive type	Controller	Axes per controller	PC interface	Multiple controllers on the same PC
DC motor	C-863	1	USB, RS-232, daisy chain network	Yes, same interface
	C-884	1 to 6	USB, RS-232, TCP/IP	Yes
Stepper motor	C-663	1	USB, RS-232, daisy chain network	Yes, same interface

PC software is included in the scope of delivery of the controllers from PI. Operating the controller is described in the associated user manuals (p. 3).

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

To order, contact our customer service department (p. 49).

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 noncontact, Hall effect limit switches.

Each limit switch sends an overrun 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 positioner runs into the hard stop.

Refer to "Limit Switch Specifications" (p. 53) for more information.

3.7.3 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.

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 PWM 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 with the scope of delivery according to the contract and the delivery note.
3. Inspect the contents for signs of damage. If any parts are damaged or missing, contact our customer service department (p. 49) immediately.
4. Keep all packaging materials in case the product needs to be returned.

5 Installation

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5.1 General Notes on Installing

NOTICE



Unwanted changes in position when mounted vertically!

If the load exceeds the holding force of the M-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.

- If the M-406 is mounted vertically, make sure that the installed load is lower than the holding force of the drive (see Data Table (p. 51)).

NOTICE



Protruding screw heads!

Protruding screw heads can damage the M-406.

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

NOTICE



Cable break!

A cable break leads to failure of the M-406.

- Install the M-406 so that the cable cannot be bent too strongly or crushed during operation.
- If necessary: Change the orientation of the M-406's connections (p. 16).

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 connected firmly together.

- If possible, simulate the motion of the positioner 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.
- In accordance with legal regulations, avoid or mark danger zones resulting from the installation of the M-406 and the application.

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

INFORMATION

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

- Check whether the connections on the M-406 are at a position suitable for your installation situation.

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

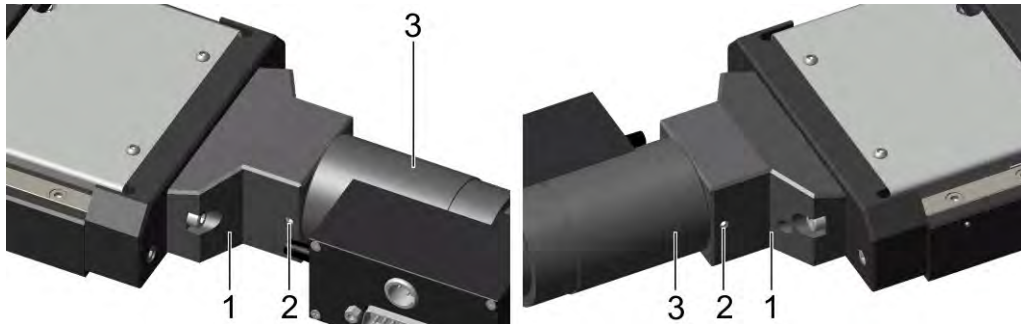


Figure 3: Position of the grub screws on the motor flange of the M-406.xDG and M-406.xPD models; left: Front view; right: Rear view

1. Motor flange
2. Grub screw
3. Motor housing

Requirements

- ✓ The M-406 is **not** mounted on an underlying surface.
- ✓ The M-406 is **not** connected to the controller and the power adapter.

Tools and accessories

- Hex key, AF 2

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

1. Loosen the two grub screws on the motor flange.
2. Rotate the motor housing with the connections to the desired orientation.
3. Make sure that the cables are not bent or crushed too strongly in the selected orientation.
4. Tighten the two grub screws on the motor flange.

5.2.2 M-406.x2S Models

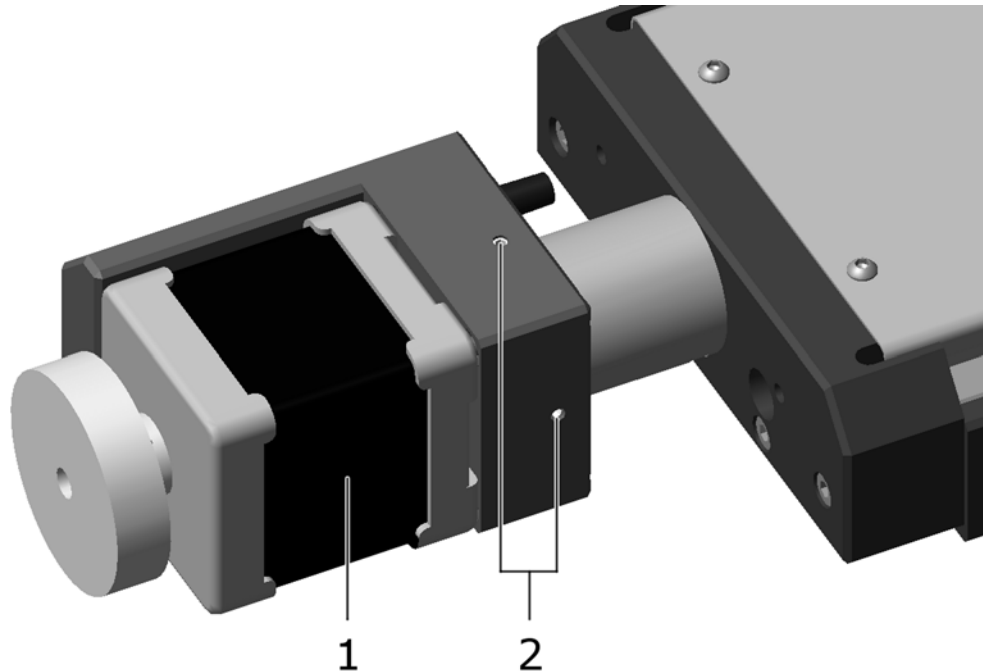


Figure 4: Position of the grub screw on the motor case of the M-406.x2S models

1. Motor housing
2. Grub screws

Requirements

- ✓ The M-406 is **not** mounted on an underlying surface.
- ✓ The M-406 is **not** connected to the controller.

Tools and accessories

- Hex key, AF 1.5

Changing the orientation for the connection on M-406.x2S models

1. Loosen the two grub screws on the motor housing.
2. Rotate the motor housing with the connections to the desired orientation.
3. Make sure that the cables are not bent or crushed too strongly in the selected orientation.
4. Tighten the two grub screws on the motor housing.

5.3 Mounting the M-406 onto a Surface

NOTICE

**Warping the M-406 when mounting onto uneven surfaces!**

The M-406 could warp if mounted on an uneven surface. Warping reduces the accuracy.

- Mount the M-406 onto a flat surface. The recommended flatness of the surface is $\leq 10 \mu\text{m}$.
- For applications with large temperature changes:
Mount the M-406 only onto surfaces that have the same or similar thermal expansion properties as the M-406.

NOTICE

**Excessively long screws!**

Mounting from below: Screws inserted too deeply could damage the M-406.

- Pay attention to the depth of the mounting holes in the base body of the M-406 (p. 54).
- Only use screws of the correct length for the respective mounting holes.

NOTICE

**Wear from moving the platform by hand!**

Moving the platform by hand increases wear in the case of positioners with a gearhead.

- In the case of M-406.xDG models, move the platforms by hand only if it cannot be moved in any other way.

INFORMATION

The positive direction of motion is in the opposite direction of the cable exit.

INFORMATION

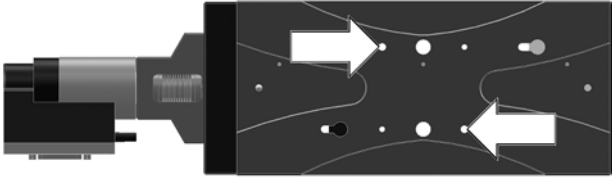
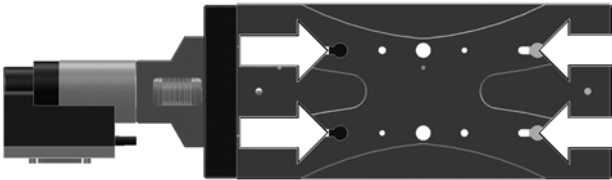
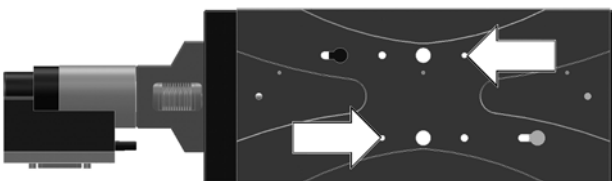
The required mounting holes may be covered by the platform, depending on which mounting option is selected.

Mounting option 1: The 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 platform.

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

- Move the platform if necessary.

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

Mounting option	Mounting type	Mounting holes, view from below, see "Dimensions" for details (p. 54).
1	Mounting from above with two M4x8 screws For example, this mounting option is used when building an XY system consisting of two M-406 (p. 25).	 <p>Figure 5: Mounting the M-406 with two M4x8 screws from above</p>
2	Mounting from above with four M4x8 screws For example, this mounting option is used when building an XZ/XYZ system consisting of two or three M-406 (p. 27).	 <p>Figure 6: Mounting the M-406 with four M4x8 screws</p>
3	Mounting from below with two M4 screws	 <p>Figure 7: Mounting the M-406 with two M4 screws from below</p>

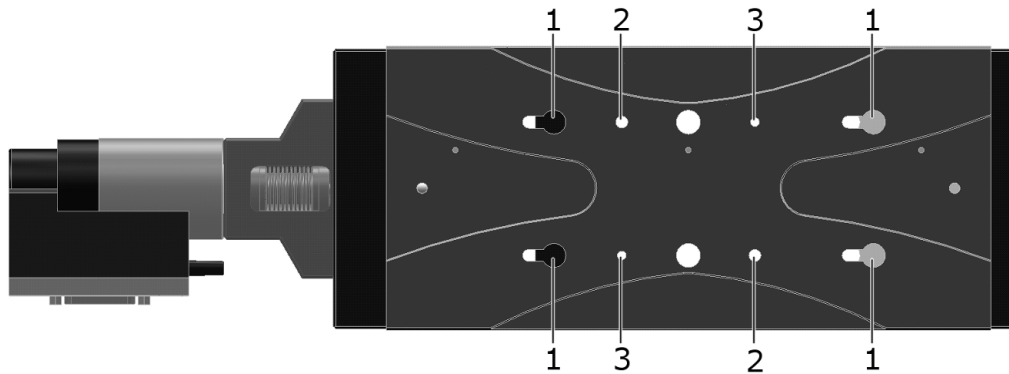


Figure 8: Mounting holes in the base body of the M-406, view from below

1. Mounting hole with slot for M4 socket head screw
2. Mounting hole with counterbore for M4 socket head screw
3. Mounting hole with M4 thread

Requirements

- ✓ You have read and understood the general notes on installation (p. 15).
- ✓ You have provided a suitable underlying surface (see "Dimensions" (p. 54) for the required position and depth of the holes for the screws):
 - For mounting from above: Two or four M4 threaded holes are provided.
 - For mounting from below: Two \varnothing 4.5 mm holes are provided.
 - The surface flatness is $\leq 10 \mu\text{m}$.
 - For applications with large temperature fluctuations: The surface should have the same thermal expansion properties as the M-406 (e.g., underlying surface made of aluminum).
- ✓ You have accounted for the space required to route cables without bending them and according to regulations.
- ✓ If you want to make the mounting holes in the base body of the M-406 accessible by moving the platform by hand: The positioner is **not** connected to the power adapter and the controller.

Tools and accessories

- Mounting kit:
 - 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. 54))
 - Hex key, AF 3

Mounting the M-406 onto an underlying surface

1. If necessary: Give access to the mounting holes in the base body of the M-406. Possible measures:
 - Temporary startup of the positioner (p. 37) and commanding the platform to a suitable position
 - Moving the platform by hand (p. 46)
2. Align the M-406 on the underlying surface so that the corresponding mounting holes in the M-406 and underlying surface are in line.
3. Tighten the screws in all mounting holes.
4. Check that the M-406 is fixed firmly to the underlying surface.

5.4 Fixing the Load to the M-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. 51).

NOTICE**Excessively long screws!**

Screws inserted too deeply can damage the M-406.

- Pay attention to the depth of the mounting holes in the platform (p. 54).
- Only use screws with the correct length for the respective mounting holes.

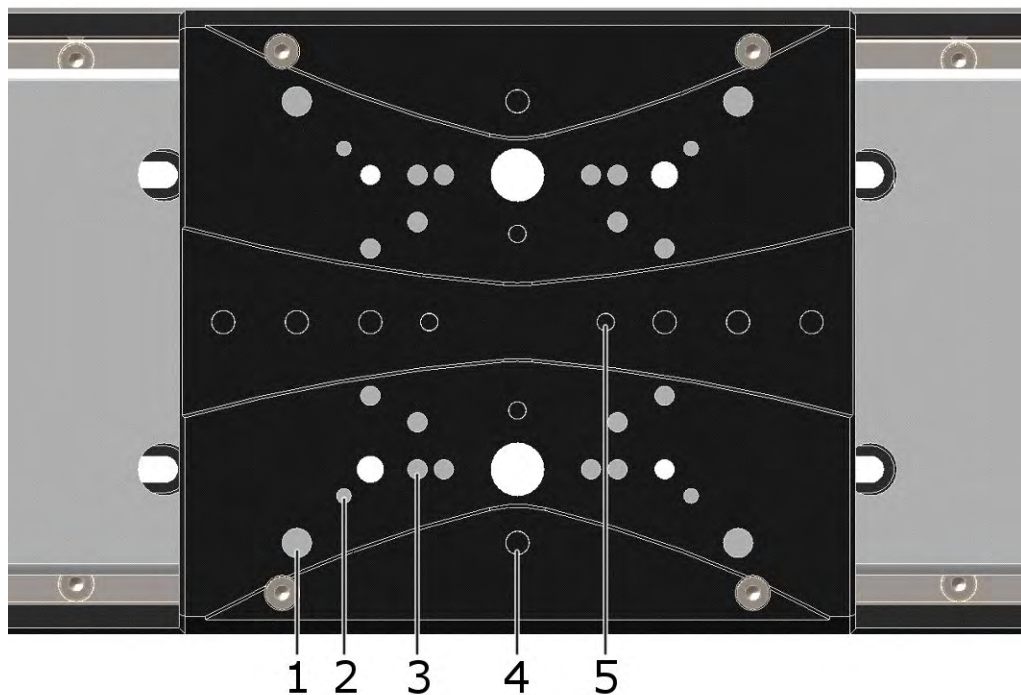


Figure 9: Holes in the platform of the M-406

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 \varnothing 4 mm H7, depth 4.1 mm (total of 8)
5. Locating hole \varnothing 3 mm H7, depth 4.1 mm (total of 4)

Requirements

- ✓ You have read and understood the general notes on installation (p. 15).
- ✓ You have mounted the positioner onto an underlying surface (p. 19) properly.
- ✓ The positioner is **not** connected to the power adapter and 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 to align the load: You have made two to four locating holes in the load with \varnothing 3 mm or 4 mm and a suitable tolerance to accommodate the locating pins.

Tools and accessories

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

Fixing the load

1. Align the load so that the selected mounting holes 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 locating holes in the platform or in the load.
 - b) Put the load onto the platform in such a way that the locating pins are inserted into the corresponding locating holes in the other side.
2. Use the screws 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 positioner.

5.5 Building 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
- Contact our customer service department (p. 49) 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.

NOTICE**Wear from moving the platform by hand!**

Moving the platform by hand increases wear in the case of positioners with a gearhead.

- In the case of M-406.xDG models, move the platforms by hand only if it cannot be moved in any other way.
-
- 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. 49).

5.5.2 Building an XY System**NOTICE****Excessively long screws!**

Screws inserted too deeply can damage the lower positioner.

- Pay attention to the depth of the mounting holes in the motion platform (p. 54) of the lower positioner.
- Only use screws 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°

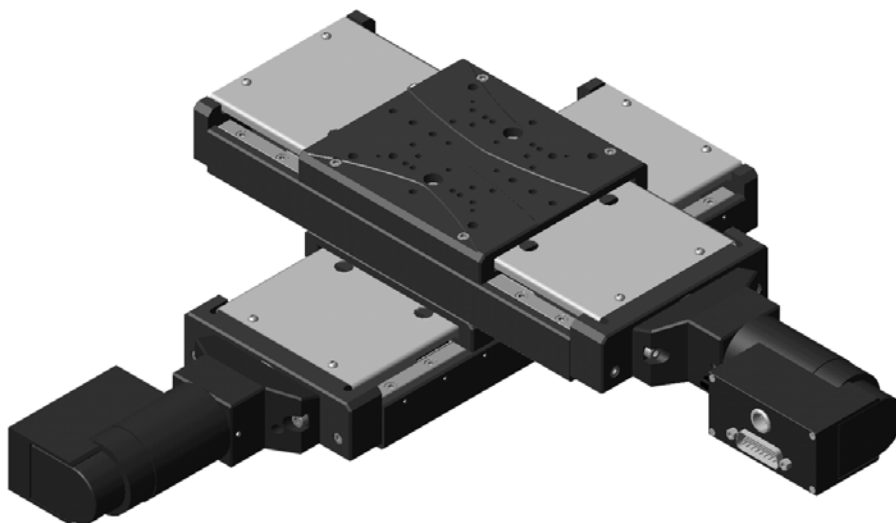


Figure 10: Example: XY system consisting of two M-406 positioners

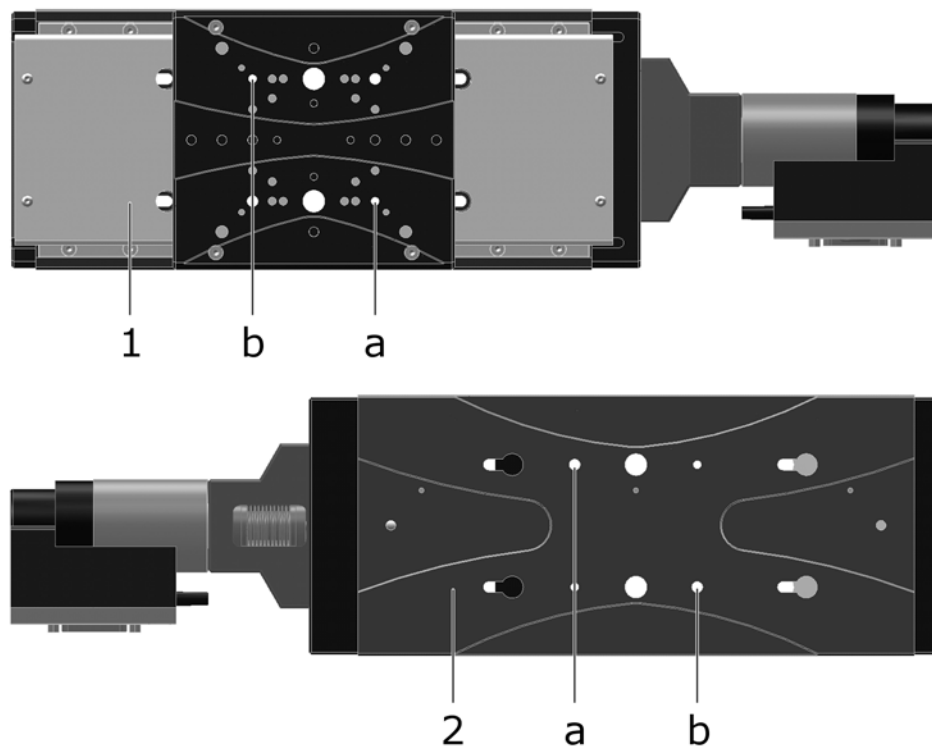


Figure 11: Setting up an XY system from two M-406

- 1 Lower positioner with
a, b) M4 mounting holes in the platform
- 2 Upper positioner (view from below) with
a, b) mounting holes with counterbore for M4 socket head screws,
in the base body of the positioner

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

Requirements

- ✓ You have read and understood the general notes on installation (p. 15).
- ✓ You have read and understood the general notes on building a multi-axis system (p. 24).
- ✓ You have accounted for the space required to route cables without bending them and according to regulations.
- ✓ The positioners are disconnected from the power adapter and controller.
- ✓ You have mounted the lower positioner onto an underlying surface (p. 19) properly.

Tools and accessories

- 2 M4 screws of suitable length from the scope of delivery of the upper positioner
 - When an M-406 is mounted to an M-406 as in the figure above: 2 M4x8 screws
- Hex key AF 3, included in the positioner's scope of delivery

Building an XY System

1. If necessary: Allow access to the first of the two mounting holes in the base body of the upper positioner. Possible measures:
 - Temporary startup of the upper positioner (p. 37) and commanding the platform to a suitable position
 - Moving the platform of the upper positioner by hand (p. 46)
2. Position the upper positioner rotated by 90° on the platform of the lower positioner (see above figure).
3. Put the upper positioner so that the corresponding mounting holes in the upper and lower positioner are in line (holes a and b in the figure above).
4. Completely screw in one M4 screw into the hole a.
5. Allow access to the second of the two mounting holes in the base body of the upper positioner. Possible measures:
 - Temporary startup of the upper positioner (p. 37) and commanding the platform to a suitable position
 - Moving the platform of the upper positioner by hand (p. 46)
6. Completely screw in one M4 screw into the hole b.
7. Check that the upper positioner is firmly seated.

5.5.3 Building a Z System with an Adapter Bracket

NOTICE



Excessively long screws!

Screws inserted too deeply can damage the lower positioner.

- Pay attention to the depth of the mounting holes in the motion platform (p. 54) of the lower positioner.
- Only use screws 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.

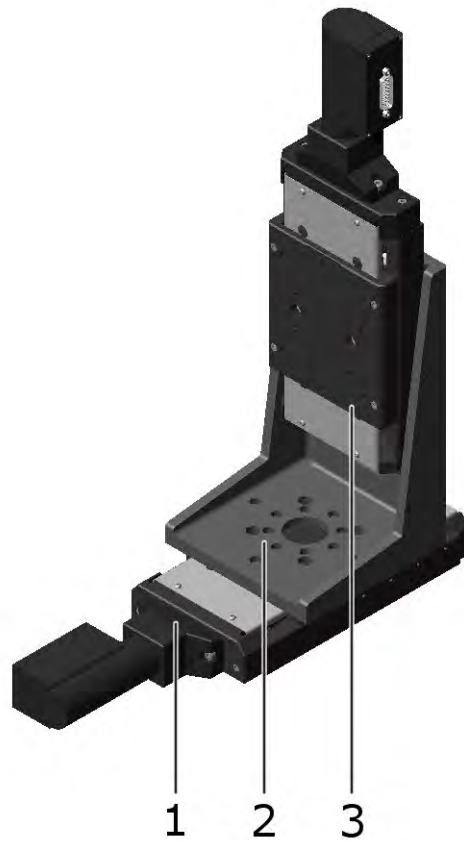


Figure 12: Example: XZ combination consisting of two M-406.2DG positioners

- 1 Lower positioner
- 2 M-592.00 adapter bracket
- 3 Upper positioner

Requirements

- ✓ You have read and understood the general notes on installation (p. 15).
- ✓ You have read and understood the general notes on building a multi-axis system (p. 24).
- ✓ You have accounted for the space required to route cables without bending them and according to regulations.
- ✓ The positioners are disconnected from the power adapter and controller.
- ✓ If you are building an XZ combination: You have attached the lower positioner onto an underlying surface (p. 19) properly.
- ✓ If you are building an XYZ combination: You have attached the positioner for the X and Y axis (p. 25) properly.

Tools and accessories

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

For attaching the Z axis to the adapter bracket: 4 M4 screws of suitable length from the scope of delivery of the upper positioner

 - 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 positioner: M4 screws of suitable length
 - When the M-592.00 adapter bracket is attached to an M-406: 4 M4x8 screws
- Hex key AF 3, included in the positioner's scope of delivery

Building a Z system

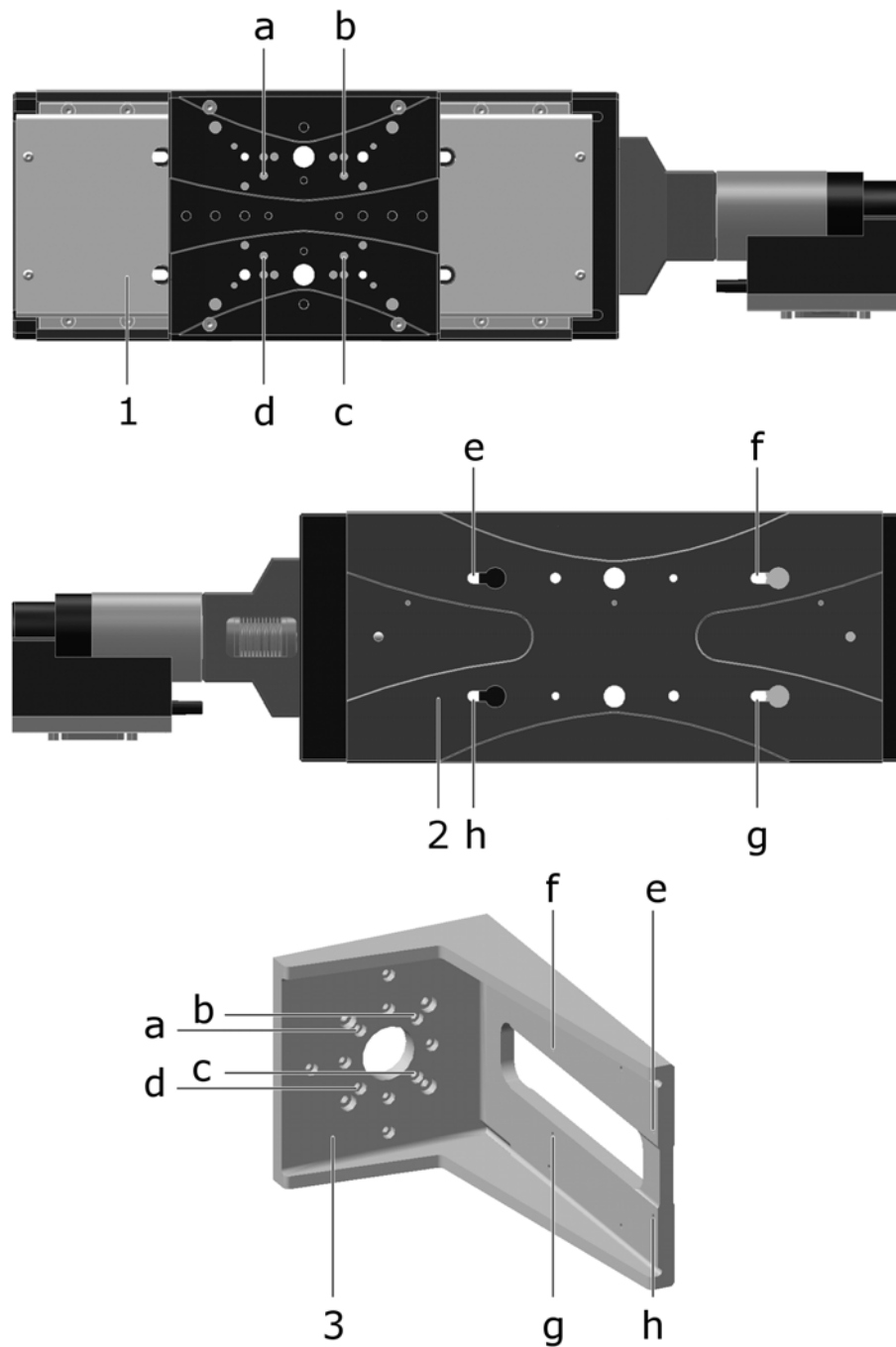


Figure 13: Example: Building an XZ combination from two M-406 positioners and M-592.00 adapter bracket

- 1 Lower positioner
- 2 Upper positioner (view from below)
- 3 M-592.00 adapter bracket
- a-h: Mounting holes:
Holes that are aligned during attachment are marked with the same letter

1. Attach the adapter bracket to the lower positioner:



Figure 14: Attaching the adapter bracket to the lower M-406

- a) Align the M-592.00 adapter bracket on the platform of the lower positioner so that mounting holes a to d in the adapter bracket and the platform are in line.
 - b) Completely screw in one screw into each mounting hole a to d.
2. Check that the adapter bracket is firmly seated.

3. Screw one screw into each of the mounting holes e to h of the adapter bracket to a depth of approx. 2 mm.

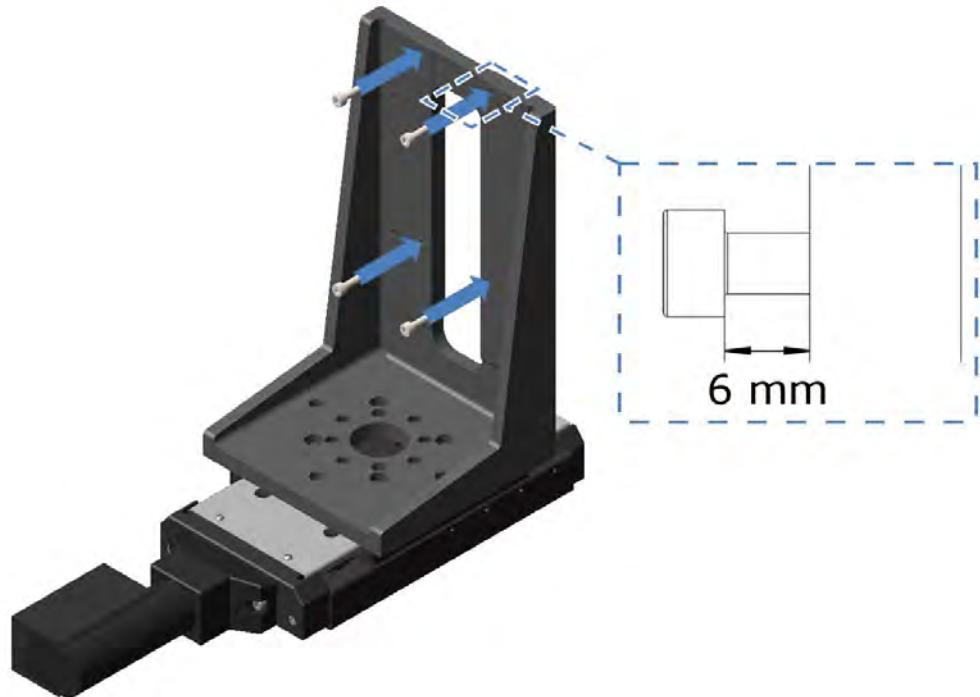


Figure 15: Screw in screws for the upper M-406 in the adapter bracket

4. Attach the upper positioner to the adapter bracket:

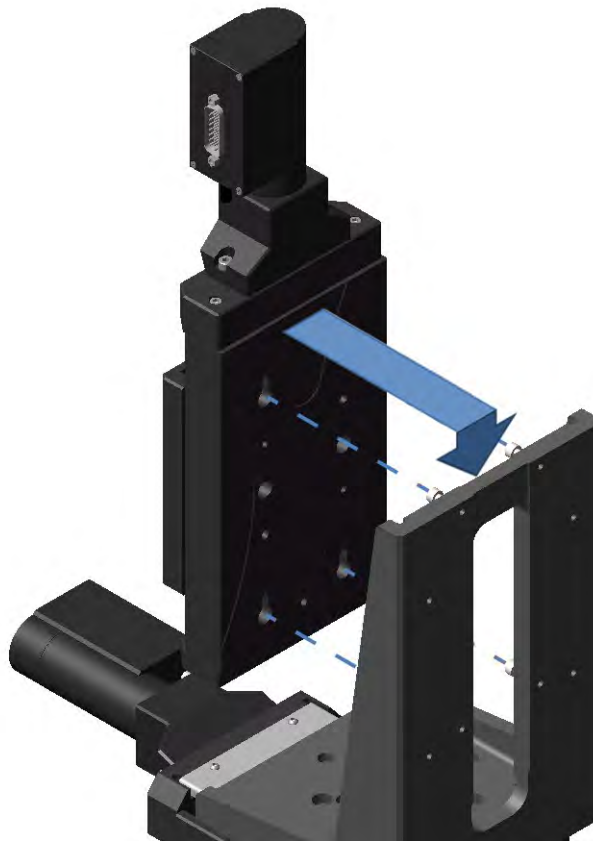


Figure 16: Attaching the upper M-406 to the adapter bracket

- a) If necessary: Allow access to two of the four mounting holes required in the base body of the positioner. Possible measures:
 - Temporary startup of the upper positioner (p. 37) and commanding the platform to a suitable position
 - Moving the platform by hand (p. 46)
- a) Position the positioner on the long surface of the adapter bracket as in the figure:
 - The positioner lies on the inside of the bracket.
 - The motor of the positioner faces the open end of the inside of the bracket (i.e., upwards in the Z system).
 - Mounting holes e to h in the positioner are aligned with the screws in the corresponding holes.
- a) Hook the positioner on the screws, located in holes e to h.
- b) Slide the positioner along the slots of holes e to h in the direction of the lower positioner until you feel resistance (approx. 10 mm).
- c) Tighten the two screws that have become accessible.
- d) Allow access to the remaining two mounting holes in the base body of the positioner. Possible measures:

- Temporary startup of the upper positioner (p. 37) and commanding the platform to a suitable position
- Moving the platform by hand (p. 46)
 - a) Tighten the two screws that have become accessible.
- 5. Check that the positioner is firmly seated.

5.6 Connecting the M-406 to the Controller

Requirements

- ✓ You have read and understood the general notes on installation (p. 15).
- ✓ You have installed the controller.
- ✓ The controller is switched off.

Tools and accessories

- Motor cable, suitable for the controller (p. 11)
- Suitable tools for tightening the screws to the connections

Connecting the M-406 to the controller

1. Connect the connector (f) of the motor cable to the D-sub 15 panel plug of the M-406.
2. Connect the other end of the motor cable to the controller's drive connector.
3. Use the integrated screws to secure the connections against accidental disconnection.

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.

Requirements

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

Tools and accessories

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

Connecting the power supply to the M-406

- Connect the adapter's Switchcraft connector (f) to the M-406's Switchcraft panel plugM-406.
- Connect the adapter's barrel connector to the power supply's barrel connector socket.
- Connect the power cord to the power supply.

6 Startup

In this Chapter

General Notes on Startup	37
Starting and Operating the M-406.....	39

6.1 General Notes on Startup

CAUTION



Risk of crushing by moving parts!

Risk of minor injuries from crushing between the moving parts of the M-406 or the load and a fixed part or obstacle.

- Use safeguards to protect limbs in areas where they could be caught by moving parts.
- Maintain the safety distances according to DIN EN ISO 13857 when installing protective structures.

NOTICE



Damage due to collisions!

Collisions can damage the M-406, the load to be moved, and the surroundings.

- Make sure that no collisions are possible between the M-406, the load to be moved, and the surroundings in the motion range of the M-406.
- 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



Damage if the wrong controller is connected!

Connecting a M-406 to an unsuitable controller can damage the M-406 or controller.

- Connect a M-406 with DC motor to a DC motor controller only.
- Connect a M-406 with stepper motor to a stepper motor controller only.
- If you are using controllers and software from other manufacturers, check their technical data to make sure that they are suitable before starting and operating the M-406.

NOTICE**Operating voltage excessively high or incorrectly connected!**

Excessively high or incorrectly connected operating voltages could cause damage to the M-406.

- Do **not** exceed the operating voltage range (p. 52) specified for the M-406.
- Operate the M-406 only when the operating voltage is properly connected; see "Pin Assignment" (p. 57).

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!**

The M-406 may move unintentionally when connecting it to the controller. Faulty software and incorrect operation of the software may also cause unintended movements.

- Do not place any objects in areas where they can be caught by moving parts.
- Before connecting the M-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 a positioner with a stepper motor should be determined in the application. If the commanded velocity is too high, the stepper motor might stop without the controller detecting this state.

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.

INFORMATION

For models with DC motors:

Unsuitable servo control parameter settings can impair the performance of the M-406. This can have the following consequences:

- Oscillation
- Imprecise approach of the position
- Settling time is too long
- If the performance of the M-406 is not satisfactory, check the settings for the servo control parameters of your controller.

6.2 Starting and Operating the M-406

Requirements

- ✓ You have read and understood the general notes on startup (p. 37).
- ✓ You have installed the M-406 correctly (p. 15).
- ✓ You have connected (p. 34) the M-406 with the controller properly.
- ✓ You have read and understood the user manual for the controller.
- ✓ The required PC software has been installed.
- ✓ You have read and understood the manual for the PC software.

Starting and operating the M-406

1. Only M-406.xPD models: Connect the power adapter's cord to the power socket.
2. Start and operate the controller (refer to the user manual for the controller).

Configure the controller during startup using the PC software for the M-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. 40) the model of the M-406 exactly.
 - If you are using a controller from another manufacturer: Enter the parameters into the corresponding PC software that fit the model of the M-406; see the overview for the operating parameters for DC motor controllers (p. 40) or stepper motor controllers (p. 40).
3. Start a few motion cycles for testing purposes (refer to the user manual for the controller).

6.2.1 M-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 loaded into the controller. You can find a detailed description in the user manual for the controller.

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 positioner.

Parameter	M-406 model		Unit
	.xDG	.xPD	
P-Term	250	250	-
I-Term	40	300	-
D-Term	800	400	-
I-Limit	2000	2000	-
Maximum acceleration	30	300	mm/s ²
Maximum velocity*	1	15	mm/s
Maximum velocity*	118568	12000	counts/s
Gear reduction	29.6:1	-	-
Encoder resolution	118568	8000	counts/mm
Limit switch polarity	Active high	Active high	-

* Recommended for continuous operation

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 positioner.

Parameter	M-406.x2S	Unit
Recommended start values:		
Holding current	200	mA
Operating current	600	mA
Holding current delay	500	ms
Max. motor current	850	mA
Max. acceleration	10	mm/s ²
Max. velocity*	2	mm/s
Max. velocity*	800	Full steps/s
Hardware properties:		
Limit switch polarity	Active low	-
Full steps	400	steps/revolution

Parameter	M-406.x2S	Unit
Phase resistance	6.6	ohm
Max. phase current, bipolar	850	mA

* Recommended for continuous operation

7 Maintenance

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7.1 General Notes on Maintenance

NOTICE



Damage due to improper maintenance!

Improper maintenance could lead to misalignment and failure of the M-406.

- Loosen screws only according to the instructions in this manual or the instructions of our customer service department (p. 49).

7.2 Doing 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 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 M-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 M-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. 49).

7.3 Cleaning the M-406

Requirements

- ✓ You have disconnected the M-406 from the controller.

Cleaning the positioner

- When necessary, clean the surface of the M-406 with a cloth dampened lightly with a mild cleanser or disinfectant.

8 Troubleshooting

In this Chapter

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8.1 Possible Causes and Correction

Problem	Possible causes	Solution
Reduced positioning accuracy	Warped base body	➤ Mount the M-406 onto a flat surface. The recommended flatness of the surface is 10 µm.
	When the M-406 is mounted vertically: The load exceeds the self-locking of the drive.	➤ Do not exceed the maximum permissible loads according to the specifications (p. 51).
	Increased wear due to small motion over a long period of time	➤ Perform a maintenance run over the entire travel range (p. 43).
Function impairment after system modification	<ul style="list-style-type: none"> ▪ Controller was replaced. ▪ M-406 was replaced with another model. 	Controller from PI: ➤ Load the parameters from the positioner database that correspond to the combination of controller and M-406 model. Controller from a third-party supplier: ➤ Check the operating parameters.
Mechanics do not move; no operating noise can be heard.	Controller and/or power adapter are connected incorrectly or defective.	➤ Check all connecting cables. ➤ Check the controller. ➤ If applicable: Check the positioner's power adapter.

Problem	Possible causes	Solution
	When a PI controller is used: Axis motion error.	<p>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 positioner.</p> <ol style="list-style-type: none"> 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. <p>Refer to the user manual for the controller for details.</p>
	Platform has triggered the limit switch (p. 12).	<p>If you use a controller from PI:</p> <ol style="list-style-type: none"> 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.
In the case of models with a stepper motor: The mechanics does not move any more but produces an operating noise.	The motor is overloaded by an external load torque or the mass to be driven in the case of strong acceleration or deceleration.	<p>The motor skips steps. The information on the current position is lost without the controller detecting the state.</p> <p>➤ Use a stepper motor in the application to determine the maximum velocity for a positioner.</p>

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. 49).

8.2 Moving the Platform by Hand

INFORMATION

In the following cases, it may be necessary to move the platform by hand:

- Give access to the holes in the M-406's base body for fixing screws.
- Move the platform away from the hard stop to re-establish operational readiness of the M-406.

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

NOTICE



Wear from moving the platform by hand!

Moving the platform by hand increases wear in the case of positioners with a gearhead.

- In the case of M-406.xDG models, move the platforms by hand only if it cannot be moved in any other way.

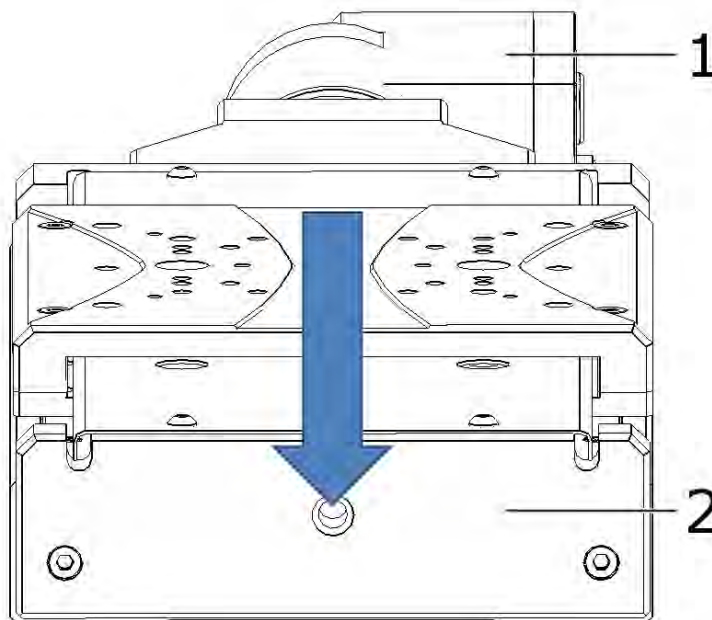


Figure 17: Position of the drive screw access on the M-406

1. Motor
2. Front face

Requirements

The positioner is **not** connected to the power adapter and the controller.

Tools and accessories

- Hex key, AF 3 (included in the scope of delivery)

Moving the platform by hand

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

Rotary motion is transferred directly to the drive screw.

8.2.2 M-406.x2S Models

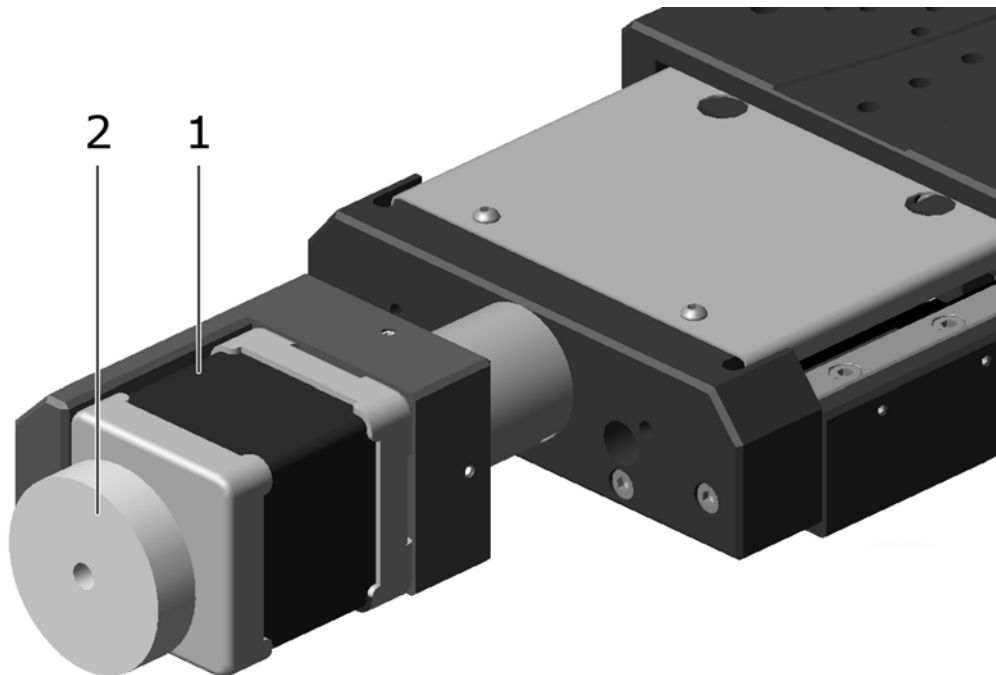


Figure 18: Position of the damper for the stepper motor on the M-406.x2S

1. Motor
2. Stepper motor damper

Requirements

The positioner is **not** connected to the controller.

Moving the platform by hand

- Turn the Stepper motor damper as far as necessary:
 - Clockwise rotation: Platform moves away from the motor
 - Counterclockwise rotation: Platform moves in the direction of the motor

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 email (service@pi.de).

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

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

10 Technical Data

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

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10.1 Specifications

10.1.1 Data Table

Motion and positioning	M-406.2DG M-406.4DG M-406.6DG	M-406.2PD M-406.4PD M-406.6PD	Unit	Tolerance
Travel range	50 / 100 / 150	50 / 100 / 150	mm	
Integrated sensor	Rotary encoder	Rotary encoder		
Sensor resolution	2000	4000	Cts./rev.	
Design resolution	0.0085	0.125	μm	
Minimum incremental motion	0.1	0.25	μm	
Unidirectional repeatability	0.2	0.2	μm	
Backlash	2	2	μm	
Crosstalk, angular error	±25 / ±50 / ±75	±25 / ±50 / ±75	μrad	
Velocity	1	15	mm/s	Max.




Mechanical properties	M-406.2DG M-406.4DG M-406.6DG	M-406.2PD M-406.4PD M-406.6PD	Unit	Tolerance
Drive screw pitch	0.5	0.5	mm	
Gear ratio	29.6:1	—		
Load capacity	200	200	N	Max.
Push/pull force	50 / 50	50 / 50	N	Max.
Lateral force	150	150	N	Max.

Drive properties	M-406.2DG M-406.4DG M-406.6DG	M-406.2PD M-406.4PD M-406.6PD	Unit	Tolerance
Motor type	DC gear motor	DC motor with PWM control		
Operating voltage	0 to ± 12	24	V	
Motor power	3	30	W	
Reference and limit switches	Hall effect	Hall effect		

Miscellaneous	M-406.2DG M-406.4DG M-406.6DG	M-406.2PD M-406.4PD M-406.6PD	Unit	Tolerance
Operating temperature range	-20 to 65	-20 to 65	°C	
Material	Aluminum, steel	Aluminum, steel		
Mass	2.1 / 2.4 / 2.8	2.1 / 2.4 / 2.8	kg	
Connector	D-sub 15 (m)	D-sub 15 (m)		
Recommended controllers	C-863 C-884	C-863 C-884		

10.1.2 Maximum Ratings

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

Device	Maximum operating voltage 	Operating frequency 	Maximum power consumption 
M-406.xDG	12 V	0 Hz	3 W
M-406.xPD	24 V	0 Hz	30 W
M-406.x2S	24 V	0 Hz	$U \cdot 0.85 \text{ A/phase}$

10.1.3 Ambient Conditions and Classifications

Pay attention to the following ambient conditions and classifications for the M-406:

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

10.1.4 Limit Switch Specifications

Type	Magnetic (Hall effect) sensor
Supply voltage	+5 V/ground
Signal output	TTL level
Signal logic	<p>The signal level changes when passing the limit switch. The signal logic depends on the model type:</p> <ul style="list-style-type: none"> ▪ Models with DC motor: active high. That means: <ul style="list-style-type: none"> – Normal motor operation: low (0 V) – Limit switch reached: high (+5 V) ▪ Models with stepper motor: active low. That means: <ul style="list-style-type: none"> – Normal motor operation: high (+5 V) – Limit switch reached: low (0 V)

10.1.5 Reference Switch Specifications

Type	Magnetic (Hall effect) sensor
Supply voltage	+5 V/GND
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 M-406

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

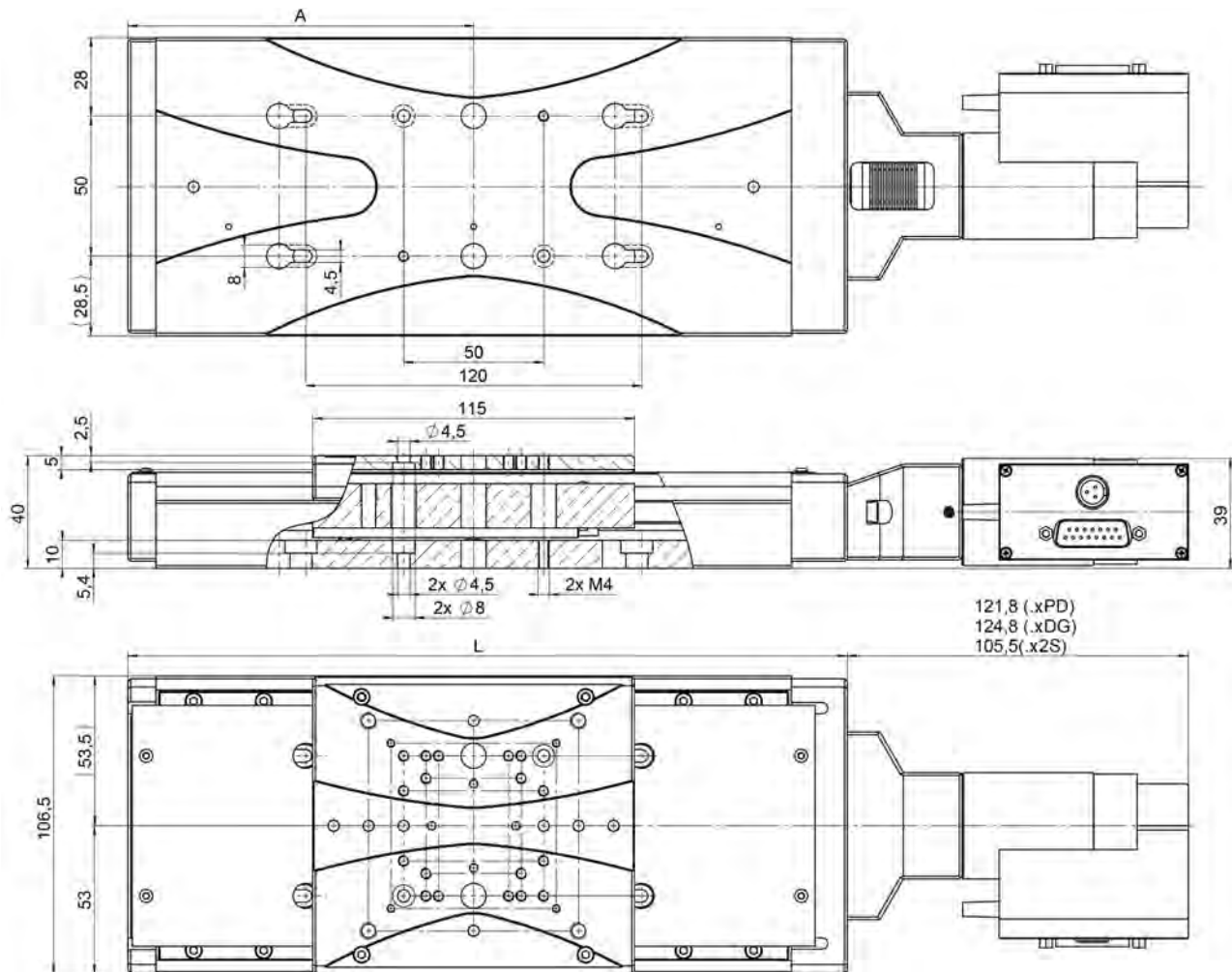


Figure 19: Dimensions for the M-406 series, see table for the values of the variables

Models	L	A
M-406.2xx	207	98.5
M-406.4xx	257	123.5
M-406.6xx	307	98

10.2.2 Hole pattern for the M-406's Platform

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

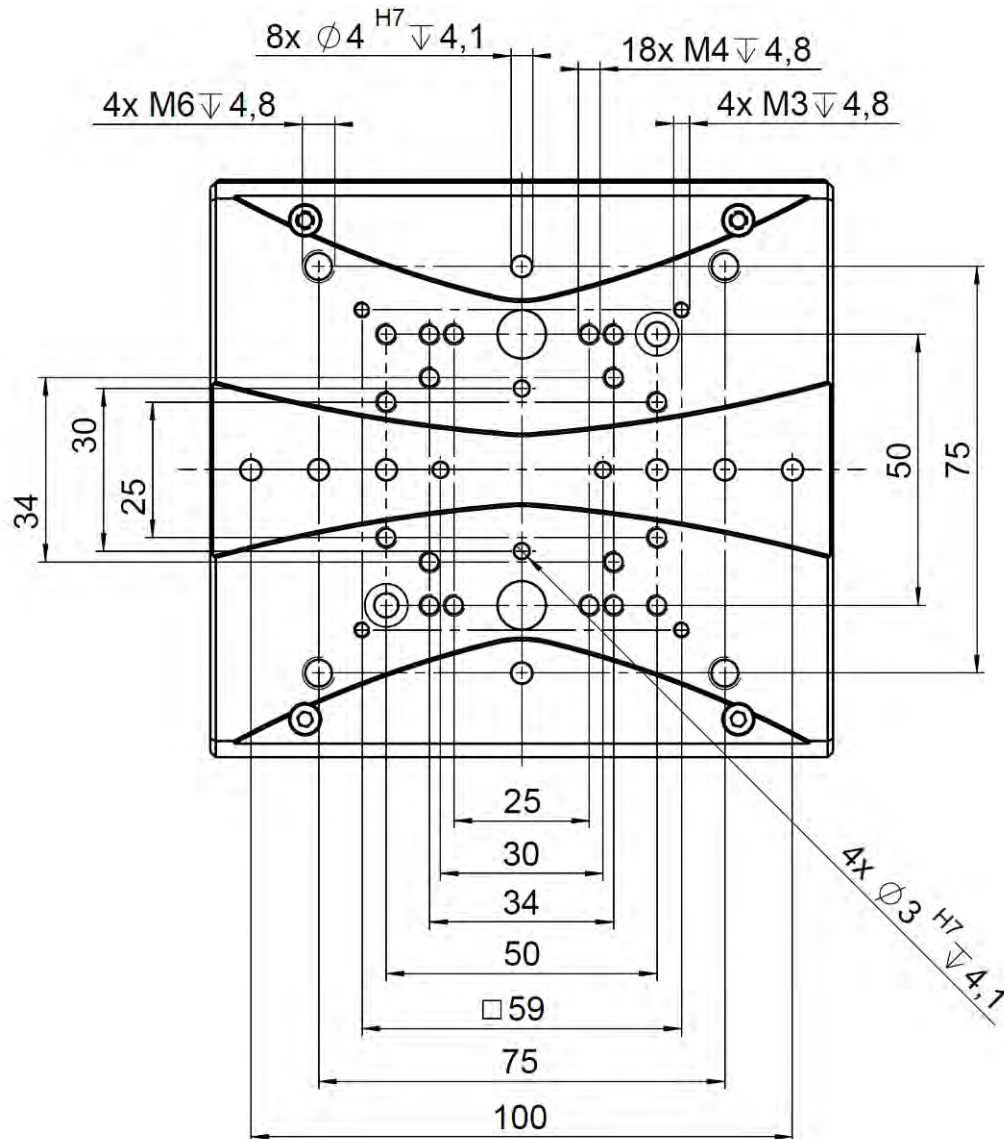


Figure 20: Hole pattern of the platform for the M-406 series

10.2.3 M-592.00 Adapter Bracket

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

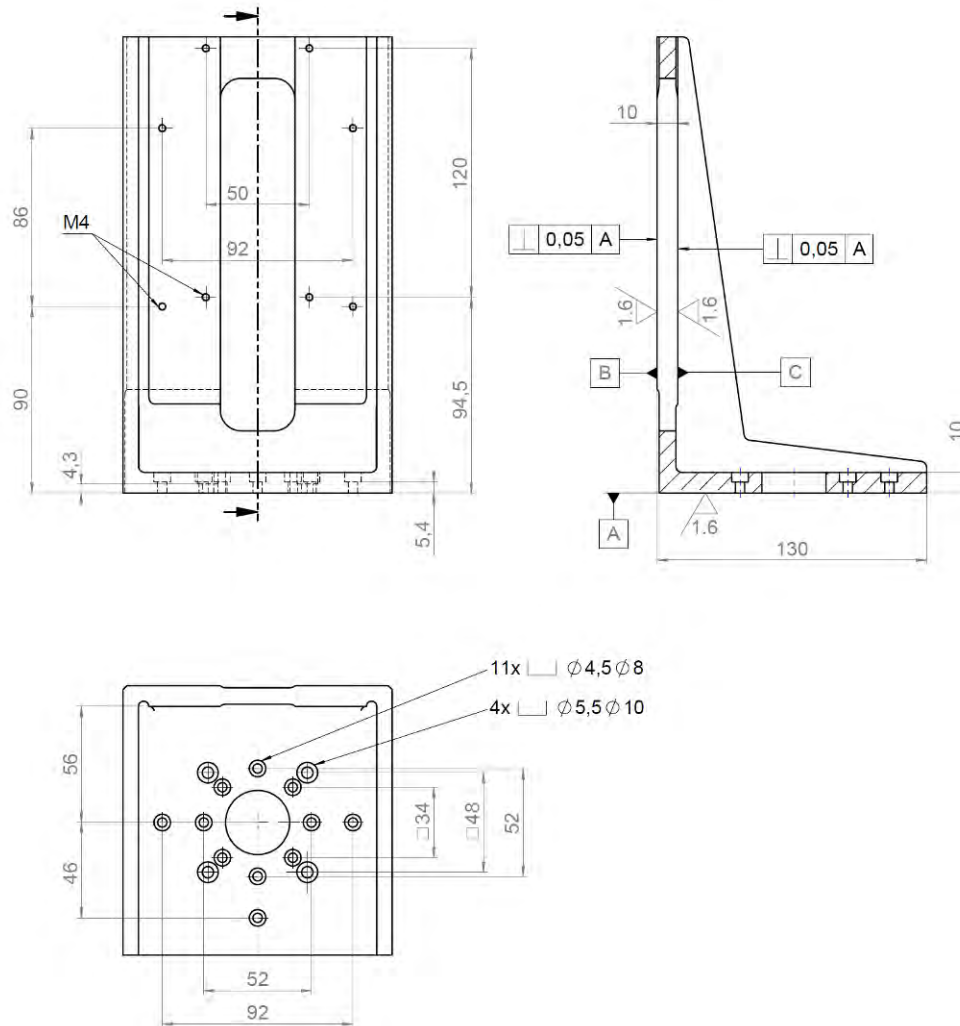


Figure 21: M-592.00 adapter bracket

10.3 Pin Assignment

10.3.1 Sub-d 15 (m) Controller Connection

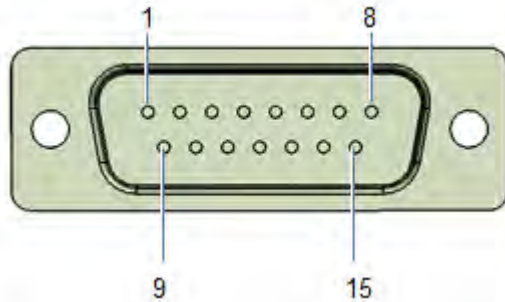


Figure 22: Sub-D 15 (m) controller connection, front view

Models with DC motor

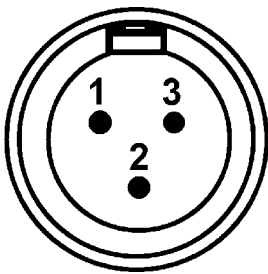
Pin	Signal	Direction
1	Internal	Input
9	M-406.xDG: Motor (-) M-406.xPD: Internal; must not be connected	Input
2	M-406.xDG: Motor (+) M-406.xPD: Internal; must not be connected	Input
10	GND	GND
3	M-406.xDG: Internal; must not be connected M-406.xPG: MAGN (PWM magnitude)	Input
11	M-406.xDG: Internal; must 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

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

10.3.2 Switchcraft 3-Pin Power Supply Connector

Connecting a power adapter is only necessary for the M-406.xPD models.



Pin	Signal	Direction
1	GND	GND
2	24 VDC supply voltage	Input
3	Not connected	-

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 its responsibility as the product manufacturer, Physik Instrumente (PI) GmbH & Co. KG undertakes environmentally correct disposal of all old PI equipment made available on the market after 13 August 2005 without charge.

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

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



12 European Declarations of Conformity

For the M-406, declarations of conformity were issued according to the following European statutory requirements:

EMC Directive

RoHS Directive

The applied standards certifying the conformity are listed below.

EMC: EN 61326-1

Safety: EN 61010-1

RoHS: EN IEC 63000

