

MP73E M-403 Linear Stage User Manual

Version: 2.1.4

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This document describes the following linear stages:

- M-403.xDG:
with leadscrew and closed-loop DC gear motor
- M-403.xPD:
with leadscrew, DC motor and integrated PWM power driver
- M-403.x2S:
with leadscrew and 2-phase stepper motor



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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 This manual is superseded by any new release.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

1.1 Objective and Target Group of this User Manual

This user manual contains the information necessary for using the M-403 as intended.

We assume that the user has basic knowledge of closed-loop systems, motion control concepts, and applicable safety measures.

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 result in minor injuries.

- Precautions to avoid the risk.

NOTICE



Dangerous situation
Failure to comply could result in damage to the equipment.

- Precautions to avoid 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

**Symbol/
Label****Meaning**

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 Positionierer 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 this could limit the lifetime.
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.
Pulse width modulation (PWM)	PWM-controlled motors allow control of the motor performance with a high-frequency-signal. This means that the power signal can be separated from the digital control signal.

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. 41).

Downloading manuals

1. Open the website **www.pi.ws**.
2. Search the website for the product number (e.g., M-403).
3. In the search results, select the product to open the product detail page.
4. Select **Downloads**.

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

5. For the desired manual, select **ADD TO LIST** and then **REQUEST**.
6. Fill out the request form and select **SEND REQUEST**.

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

2 Safety

2.1 Intended Use

The M-403 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-403 is intended for single-axis positioning, adjusting and shifting of loads at different velocities. The M-403 is **not** intended for applications in areas where failure could lead to considerable risk to people or the environment.

The M-403 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-403 as intended when completely mounted and connected.

The M-403 must be operated with a suitable controller (p. 11). The controller is not included in the scope of delivery of the M-403.

2.2 General Safety Instructions

The M-403 is built according to state-of-the-art technology and recognized safety standards. Improper use of the M-403 may result in personal injury and/or damage to the M-403.

- Use the M-403 for its intended purpose only, and only when it is in perfect condition.
- Read the user manual.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for installing and operating the M-403 correctly.

Risk of minor injuries from crushing between the moving parts of the M-403 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.

2.3 Organizational Measures

User manual

- Always keep this user manual together with the M-403. The latest versions of the user manuals are available for download on our website (p. 3).

- Add all information from the manufacturer such as supplements or technical notes to the user manual.
- If you give the M-403 to other users, include this user manual as well as all 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-403 only after you have read and understood this user manual.

Personnel qualification

The M-403 may only be installed, started, operated, maintained, and cleaned by authorized and appropriately qualified personnel.

3 Product Description

3.1 Model Overview

Product number	Description
M-403.1DG	Linear stage; DC gear motor; 25 mm travel range; 200 N load capacity; 2.5 mm/s maximum velocity; trapezoidal-threaded spindle; incremental rotary encoder, 2000 counts/rev sensor resolution, A/B quadrature, RS-422
M-403.2DG	Linear stage; DC gear motor; 50 mm travel range; 200 N load capacity; 2.5 mm/s maximum velocity; trapezoidal-threaded spindle; incremental rotary encoder, 2000 counts/rev sensor resolution, A/B quadrature, RS-422
M-403.4DG	Linear stage; DC gear motor; 100 mm travel range; 200 N load capacity; 2.5 mm/s maximum velocity; trapezoidal-threaded spindle; incremental rotary encoder, 2000 counts/rev sensor resolution, A/B quadrature, RS-422
M-403.6DG	Linear stage; DC gear motor; 150 mm travel range; 200 N load capacity; 2.5 mm/s maximum velocity; trapezoidal-threaded spindle; incremental rotary encoder, 2000 counts/rev sensor resolution, A/B quadrature, RS-422
M-403.8DG	Linear stage; DC gear motor; 200 mm travel range; 200 N load capacity; 2.5 mm/s maximum velocity; trapezoidal-threaded spindle; incremental rotary encoder, 2000 counts/rev sensor resolution, A/B quadrature, RS-422
M-403.1PD	Linear stage; DC motor with ActiveDrive; 25 mm travel range; 200 N load capacity; 10 mm/s maximum velocity; trapezoidal-threaded spindle; incremental rotary encoder, 4000 counts/rev sensor resolution, A/B quadrature, RS-422
M-403.2PD	Linear stage; DC motor with ActiveDrive; 50 mm travel range; 200 N load capacity; 10 mm/s maximum velocity; trapezoidal-threaded spindle; incremental rotary encoder, 4000 counts/rev sensor resolution, A/B quadrature, RS-422
M-403.4PD	Linear stage; DC motor with ActiveDrive; 100 mm travel range; 200 N load capacity; 10 mm/s maximum velocity; trapezoidal-threaded spindle; incremental rotary encoder, 4000 counts/rev sensor resolution, A/B quadrature, RS-422
M-403.6PD	Linear stage; DC motor with ActiveDrive; 150 mm travel range; 200 N load capacity; 10 mm/s maximum velocity; trapezoidal-threaded spindle; incremental rotary encoder, 4000 counts/rev sensor resolution, A/B quadrature, RS-422
M-403.8PD	Linear stage; DC motor with ActiveDrive; 200 mm travel range; 200 N load capacity; 10 mm/s maximum velocity; trapezoidal-threaded spindle; incremental rotary encoder, 4000 counts/rev sensor resolution, A/B quadrature, RS-422

Product number	Description
	quadrature, RS-422
M-403.12S	Linear stage; 2-phase stepper motor; 25 mm travel range; 200 N load capacity; 3 mm/s maximum velocity; trapezoidal-threaded spindle
M-403.22S	Linear stage; 2-phase stepper motor; 50 mm travel range; 200 N load capacity; 3 mm/s maximum velocity; trapezoidal-threaded spindle
M-403.42S	Linear stage; 2-phase stepper motor; 100 mm travel range; 200 N load capacity; 3 mm/s maximum velocity; trapezoidal-threaded spindle
M-403.62S	Linear stage; 2-phase stepper motor; 150 mm travel range; 200 N load capacity; 3 mm/s maximum velocity; trapezoidal-threaded spindle
M-403.82S	Linear stage; 2-phase stepper motor; 200 mm travel range; 200 N load capacity; 3 mm/s maximum velocity; trapezoidal-threaded spindle

➤ Refer to the specifications (p. 43) for further technical data.

3.2 Product View

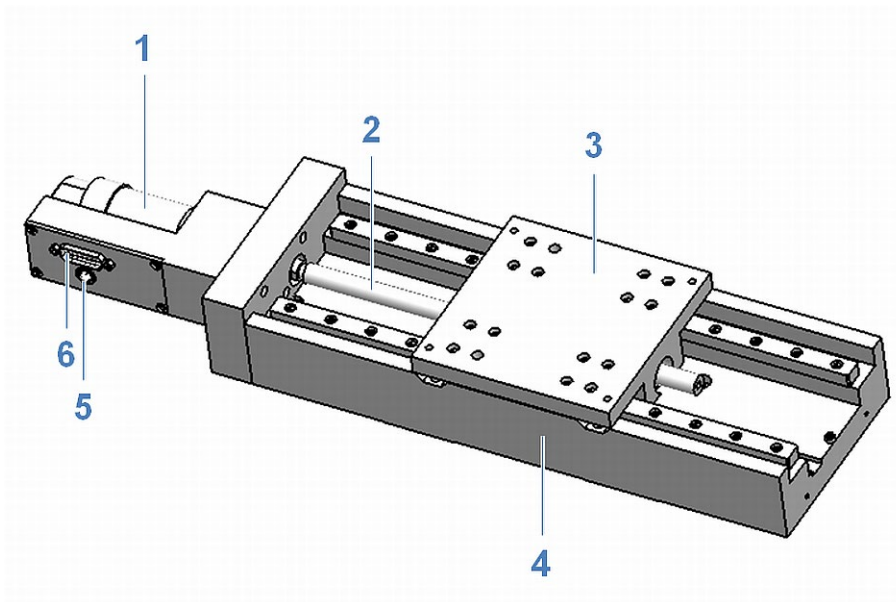


Figure 1: Elements of the M-403

1. Motor
2. Drive screw
3. Platform
4. Base body

5. M-403.xPD models only: Power adapter connector (Mini XLR 3 panel plug)
6. Controller connector: D-sub 15 (m) panel plug

3.3 Direction of Motion

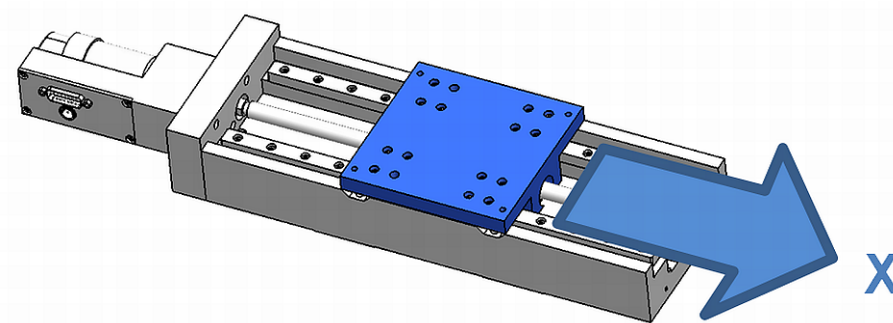


Figure 2: Direction of motion of the platform

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

3.4 Product Labeling

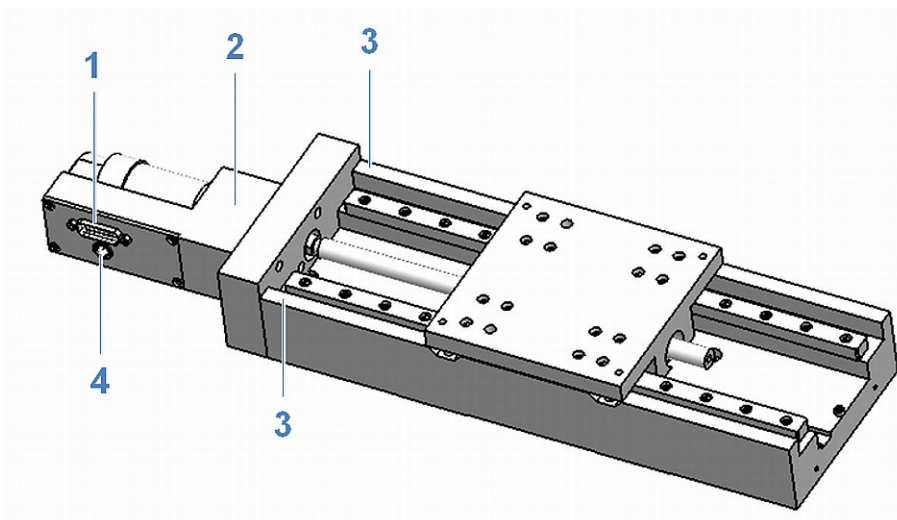







Figure 3: Position of the product labeling

Position	Labeling	Description
1	Controller	Controller connection
2		Manufacturer's logo
2		CE conformity mark
2		Warning sign "Pay attention to the manual!"
2	M-403.1DG	Product name (example), the characters following the period refer to the model
2	113050975	Serial number (example), individual for each M-403 Meaning of each position (from the left): 1 = internal information, 2 and 3 = year of manufacture, 4 to 9 = consecutive number
2	WWW.PI.WS	Manufacturer's address (website)
2		Old equipment disposal (p. 59)
2	Country of origin: Germany	Country of origin
3		Warning sign "Risk of crushing": Reference to dangerous forces (p. 29)
4	24 VDC	Power supply connection (for M-403.xPD models only)

3.5 Scope of Delivery

Item number	Component
M-403.xxx	Linear stage according to the order (p. 7)
000012703	Screw set for mounting the positioner and the load <ul style="list-style-type: none"> 6 socket head screws, M4×30 ISO 4762 6 socket head screws, M5×45 ISO 4762 4 socket head screws, M6×12 ISO 4762 Hex key AF 3 DIN 911 Hex key AF 4 DIN 911 Hex key AF 5 DIN 911
MP119EK	Short instructions for positioners with electric motors

Additionally for the M-403.xPD models:

Item number	Component
C-501.24050H	Wide input range power supply 24 V DC / 50 W
3763	Power cord
K050B0002	Adapter from 5.5 mm x 2.1 mm barrel connector to mini XLR3 (f) for the power adapter connector

3.6 Optional Accessories

Order number	Description
M-403.AP1	Adapter plate for mounting stages with standard thread pitch horizontally and for mounting rotation stages onto M-403 / M-404 stages vertically
M-403.AP2	Adapter plate for mounting M-403 / M-404 stages onto M-403 / M-404 stages vertically
M-403.AP3	Adapter plate for mounting on stages with PI standard thread pitch and mounting M-403 / 404 onto M-413 / 414, M-451, M-505 and M-511 / 521 / 531 stages horizontally

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

3.7 Suitable Controllers

The M-403 must be connected to a suitable controller. The following controllers from PI are suitable for operating the M-403:

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-403 to the electronics must be ordered separately.

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

3.8 Technical Features

3.8.1 Encoder

The M-403.xDG and M-403.xPD models are equipped with an incremental rotary encoder.

A rotary encoder, also called an incremental 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 (counts).

3.8.2 Limit Switches

The M-403 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 Positionierer runs into the hard stop.

Refer to "Limit Switch Specifications" (p. 49) for more information.

3.8.3 Reference Switch

The Positionierer 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 Positionierer is on the positive or negative side of the reference switch.

For the commands that make use of the reference point signal, refer to the controller user manual and/or associated software manuals.

3.8.4 Integrated PWM Amplifier

The M-403.xPD models with direct drive are equipped with a PWM amplifier ("ActiveDrive concept"). The PWM amplifier only receives the PWM control signals from the controller, whereas the supply voltage is provided via an external power adapter. The ActiveDrive concept allows high motor power and dynamics at low power loss.

4 Unpacking

1. Unpack the M-403 with care.
2. Compare the contents with the scope of delivery according to the contract and the delivery note.
3. Inspect the contents for signs of damage. If any parts are damaged or missing, contact our customer service department immediately (p. 41).
4. Keep all packaging materials in case the product needs to be returned.

5 Installing

5.1 General Notes on Installation

NOTICE

**Unwanted changes in position when mounted vertically!**

If the load exceeds the holding force of the M-403 when the drive is mounted vertically, unwanted changes in the position of the platform will occur. Unintentional changes in the position of the platform can damage the drive, the load or the surroundings.

- If the M-403 is mounted vertically, make sure that the installed load is lower than the holding force of the drive.

NOTICE

**Protruding screw heads!**

Protruding screw heads can damage the M-403.

- Make sure 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-403.

- Install the M-403 so that the cable is not bent too strongly or crushed.

NOTICE

**Heating up of the M-403 during operation!**

The heat produced during operation of the M-403 can affect your application.

- Install the M-403 so that your application is not affected by the dissipating heat.

NOTICE**Damage to the drive screw by foreign bodies!**

Foreign bodies and dirt penetrating the open drive screw of the M-403 could damage the drive screw and interfere with platform's motion.

- Install the M-403 so that foreign bodies and dirt cannot penetrate. If necessary, install appropriate covers.
- Remove any foreign bodies and heavy contamination immediately.

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-403 and the application.

5.2 Mounting the M-403 onto a Surface

NOTICE**Warping the M-403 when mounting onto uneven surfaces!**

The M-403 could warp if mounted on an uneven surface. Warping reduces the accuracy.

- Mount the M-403 onto a flat surface. The recommended flatness of the surface is $\leq 10 \mu\text{m}$.
- For applications with large temperature fluctuations:
Mount the M-403 only onto surfaces that have the same or similar thermal expansion properties as the M-403.

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-403.xDG models, move the platforms by hand only if it cannot be moved in any other way.

INFORMATION

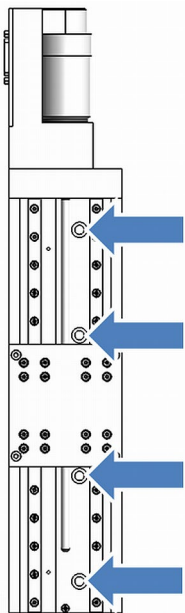
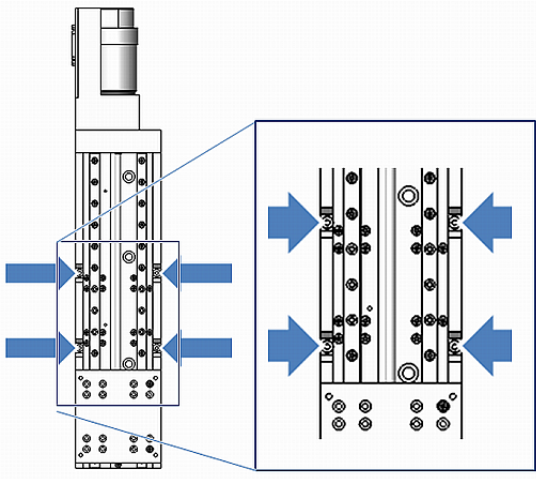
The required mounting holes are covered by the platform in the reference position, depending on the selected mounting option.

Mounting option 1: The platform must be in the reference position (delivery condition).

Mounting option 2: The platform must be moved away from the reference position (in a positive or negative direction) so that the mounting holes are accessible (see below).

INFORMATION

Depending on the M-403 model, there are 2 or 4 mounting holes for M6 screws (see table, mounting option 1).

Mounting option 1	Mounting option 2
	
Position of the mounting holes with counterbores for M6 socket head screws (schematic)	Position of the mounting holes with counterbores for M5 socket head screws (schematic)

Requirements

- ✓ You have read and understood the general notes on installation (p. 15).
- ✓ You have provided a suitable underlying surface (see "Dimensions" (p. 50) for the required position of the holes for the screws):

- For mounting option 1: There are two or four M6 threaded holes with a depth of at least 11 mm.
- For mounting option 2: There are four M5 threaded holes with a depth of at least 10 mm.
- 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-403 (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-403 accessible by moving the platform by hand: The M-403 is **not** connected to the power adapter and the controller.

Tools and accessories

- Mounting kit for mounting option 1, included in the scope of delivery (p. 10):
 - 2 or 4 M6x12 socket head screws
 - Hex key, AF 5
- Mounting kit for mounting option 2, included in the scope of delivery (p. 10):
 - 4 M5x45 socket head screws
 - Hex key, AF 4

Mounting the M-403 onto an underlying surface

1. If necessary: Give access to the mounting hole(s) in the base body of the M-403.
Possible measures:
 - Starting and operating the M-403 (p. 29) temporarily and commanding the motion platform to a suitable position
 - Moving the platform by hand (p. 36)
2. Align the M-403 on the underlying surface so that the corresponding mounting holes in the M-403 and underlying surface are in line.
3. Tighten the screws in all accessible mounting holes completely.
4. If necessary: Give access to the now concealed mounting hole(s) after tightening the first screw(s). Possible measures:
 - Starting and operating the M-403 (p. 29) temporarily and commanding the motion platform to a suitable position
 - Moving the platform by hand (p. 36)
5. If necessary: Tighten the screws completely in the now exposed mounting hole(s).
6. Check that the M-403 is fixed firmly to the underlying surface.

5.3 Fixing the Load to the M-403

NOTICE



Impermissibly high load on the Positionierer!

An impermissible high load impairs the motion of the motion platform and can damage the Positionierer.

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

Requirements

- ✓ You have read and understood the general notes on installation (p. 15).
- ✓ You have mounted the M-403 onto an underlying surface (p. 16) properly.
- ✓ The M-403 is **not** connected to the controller.
- ✓ M-403.xPD: The M-403 is **not** connected to the power adapter.
- ✓ 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 mounting the load on the platform (ideally: three attachment points).

Tools and accessories

- At least 2 M5 screws of suitable length
- Suitable tool for tightening the screws

Fixing the load

1. Align the load so that the selected mounting holes in the platform can be used to fix it.
2. Use the screws to fix the load on the selected mounting holes in the platform.
3. Check that the load is sitting firmly on the platform of the M-403.

5.4 Building a Multi-Axis System

5.4.1 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-403.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. 41).

5.4.2 Building an XY System

INFORMATION

An adapter is not required for combining M-403 and M-404 series positioners for building XY systems.

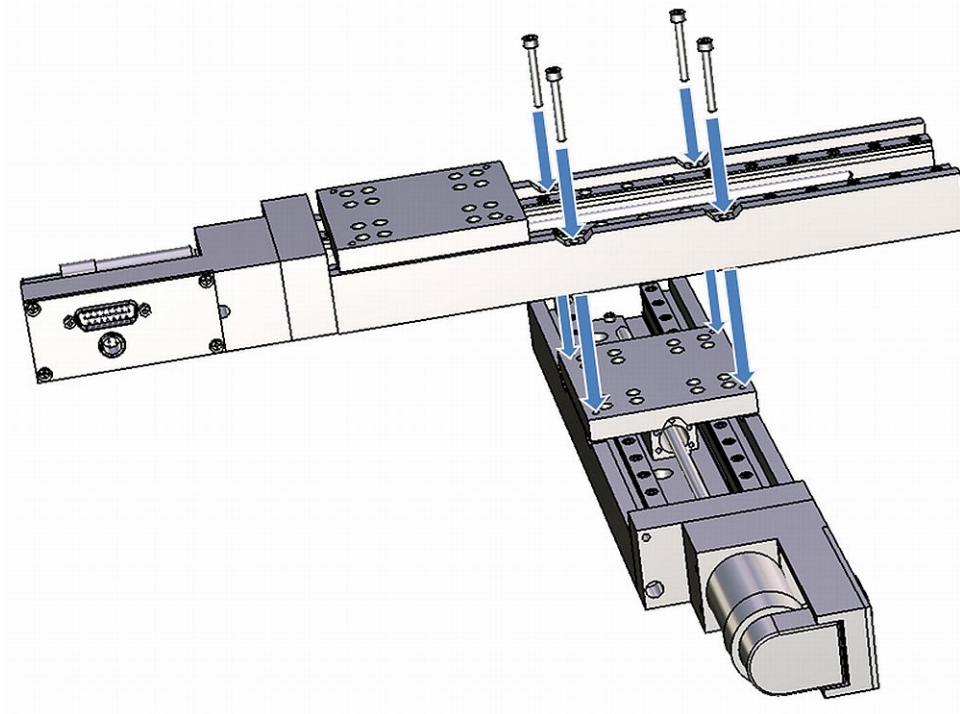


Figure 4: Building an XY system (example)

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°

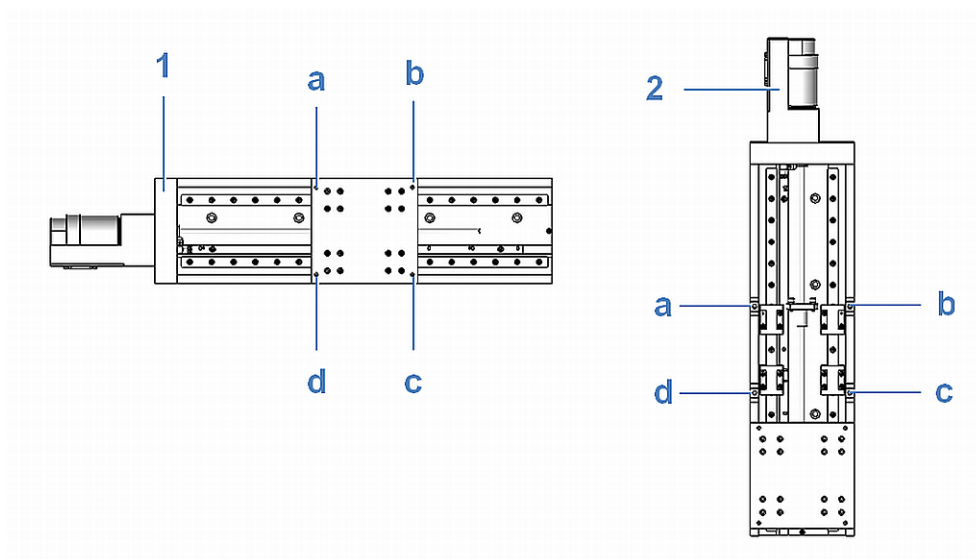


Figure 5: Building an XY system from two M-403 (schematic)

1. Lower positioner
a - d: M5 mounting holes in the platform
2. Upper positioner
a - d: Mounting holes with counterbore in the base body of the positioner for M5 socket head screws

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. 20).
- ✓ 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. 16) properly.

Tools and accessories

From the scope of delivery:

- 4 M5x45 screws
- Hex key, AF 4

Building an XY System

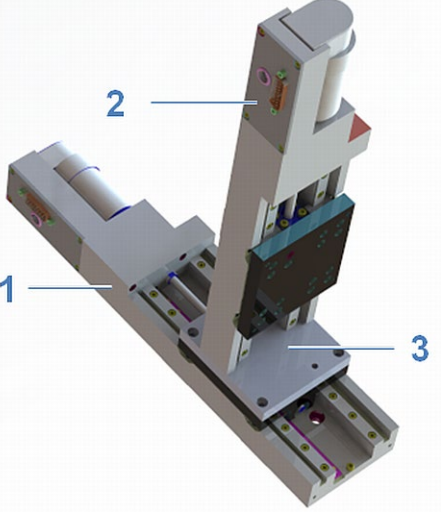
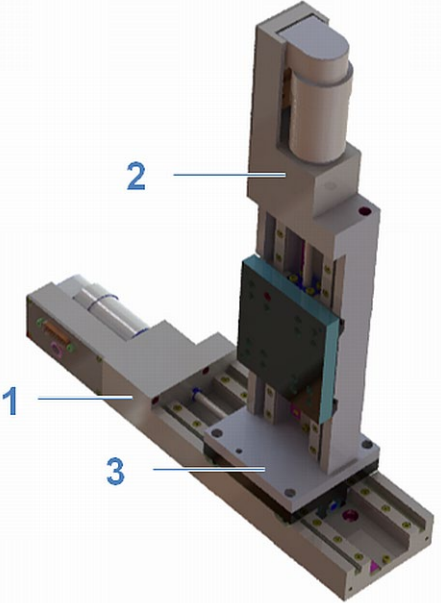
1. If necessary: Give access to mounting holes **a** and **b** in the base body of the upper positioner. Possible measures:

- Starting and operating the upper positioner (p. 29) temporarily and commanding the platform to a suitable position
 - Moving the platform of the upper positioner by hand (p. 36)
2. Position the upper positioner rotated by 90° on the platform of the lower positioner (see above figure).
 3. Align the upper positioner so that mounting holes **a** to **d** in the upper and lower the positioner are in line.
 4. Tighten an M5x45 screw completely in mounting holes **a** and **b** respectively.
 5. If necessary: Give access to mounting holes **c** and **d** in the base body of the upper positioner. Possible measures:
 - Starting and operating the upper positioner (p. 29) temporarily and commanding the platform to a suitable position
 - Moving the platform of the upper positioner by hand (p. 36)
 6. Tighten an M5x45 screw completely in mounting holes **a** and **b** respectively.
 7. Check that the upper positioner is firmly seated.

5.4.3 Setting Up a Z System

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 a mounting adapter.
- **Upper positioner:** Forms the Z axis of the multi-axis system, is mounted in a vertical alignment to the lower positioner.
- **Transverse mounting and longitudinal mounting:** See the following table for the marking of the orientation of the upper positioner.

Transverse mounting	Longitudinal mounting
	
Z system with transverse mounting (schematic)	Z system with longitudinal mounting (schematic)

1. Lower positioner
2. Upper positioner
3. Mounting adapter

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. 20).
- ✓ You have accounted for the space required to route cables without bending them and according to regulations.
- ✓ The positioners are disconnected from the controller and if applicable, the power adapter.
- ✓ If you are building an XZ combination: You have attached the lower positioner onto an underlying surface (p. 16) properly.
- ✓ If you are building an XYZ combination: You have attached the positioner for the X and Y axis (p. 20) properly.

Tools and accessories

- V-413.AP2 mounting adapter, available as optional accessory (p. 11)
- Mounting kit from the scope of delivery of the mounting adapter:
 - 2 M4x12 screws

- 4 M5x12 screws
- Hex key, AF 3
- Hex key, AF 4

Building a Z system

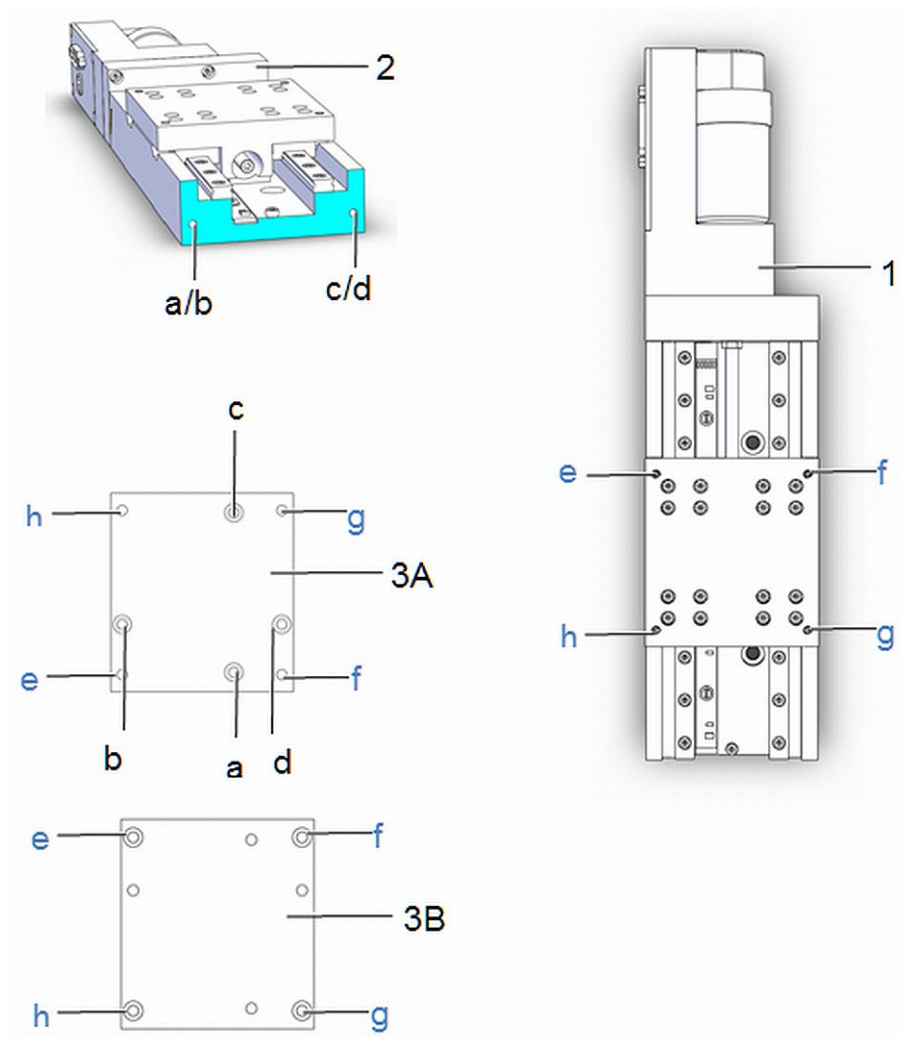


Figure 6: Building an XY system from two M-41x (schematic)

1. Lower positioner
 2. Upper positioner
 3. Mounting adapter (3A: Bottom, 3B: Top)
- a - g: Mounting holes
- a, c: For longitudinal mounting

- b, d: For transverse mounting

Holes aligned when attaching are marked with the same letter

1. Fix the mounting adapter to the upper positioner.
 - a) Align the mounting adapter on the front of the upper positioner:
 - The top of the mounting adapter points to the upper positioner.
 - For transverse mounting: Holes **b** and **d** in the upper positioner are in line with holes **b** and **d** in the adapter plate.
 - For longitudinal mounting: Holes **a** and **c** in the upper positioner are in line with holes **a** and **c** in the adapter plate.
 - b) Insert an M4x12 screw into each of the screws above-mentioned holes in the bottom of the mounting adapter.
 - c) Make sure that the screw heads do not protrude from the countersunk holes.
 - d) Check that the mounting adapter is sitting firmly on the upper positioner.
2. Fix the mounting adapter to the lower positioner (M-403):
 - a) Position the mounting adapter fixed to the upper positioner onto the platform of the lower positioner: The mounting holes required in the mounting adapter and platform of the lower positioner are in line (holes **e** to **h**).
 - b) Completely screw one M5x12 screw into each of the holes.
 - c) Check that the mounting adapter is sitting firmly on the lower positioner.

5.5 Connecting the M-403 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-403 to the controller

1. Connect the connector (f) of the motor cable to the D-sub 15 panel plug of the M-403.
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.

5.6 Connecting the Power Adapter to the M-403

Connecting a power supply is only necessary for the M-403.xPD models.

Requirements

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

Tools and accessories

- Supplied components:
 - 24 V wide-range-input power supply
 - Adapter for the power supply connection; barrel connector 5.5 mm x 2.1 mm to Mini XLR3 (f)
 - Power cord
- If one of the components supplied for connection to the power source has to be replaced: Use a sufficiently measured and certified replacement component. Details:
 - Power supply: Output 24 V DC, maximum output current 2 A
 - Power cord: Three wires, cable cross section at least 3 x 0.75 mm² (3 x AWG18), maximum length 2 m

Connecting the power supply to the M-403

- Connect the Mini XLR3 connector (f) of the adapter to the Mini XLR3 panel plug of the M-403.
- 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 Startup

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-403 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-403, the load to be moved, and the surroundings.

- Make sure that no collisions are possible between the M-403, the load to be moved, and the surroundings in the motion range of the M-403.
- 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-403 to an unsuitable controller can damage the M-403 or controller.

- Connect a M-403 with DC motor to a DC motor controller only.
- Connect a M-403 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-403.

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

Excessively high or incorrectly connected operating voltages could cause damage to the M-403.

- Do **not** exceed the operating voltage range (p. 48) specified for the M-403.
- Operate the M-403 only when the operating voltage is properly connected; see "Pin Assignment" (p. 55).

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-403 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-403, 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 Positionierer 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-403. This can have the following consequences:

- Oscillation
- Imprecise approach of the position
- Settling time is too long
- If the performance of the M-403 is not satisfactory, check the settings for the servo control parameters of your controller.

6.2 Starting and Operating the M-403

Requirements

- ✓ You have read and understood the General Notes on Startup (p. 29).
- ✓ You have installed the M-403 correctly (p. 15).
- ✓ You have connected (p. 26) the M-403 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-403

1. Only M-403.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-403 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. 32) the model of the M-403 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-403; see the overview for the operating parameters for DC motor controllers (p. 32) or stepper motor controllers (p. 32).
3. Start a few motion cycles for testing purposes (refer to the user manual for the controller).

6.2.1 M-403 Entries in the PI Positioner Database

For PI controllers, you can select the connected Positionierer 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.

Operating Parameters of the Models with DC Motor

If you are using a DC motor controller from a third-party supplier, it may be necessary to enter operating parameters to adapt to the M-403.

Parameters	M-403.xDG	M-403.xPD	Unit
I limit	2000	2000	-
Maximum acceleration	4	30	mm/s ²
Maximum velocity*	2.5	10	mm/s
Maximum velocity*	142222	40000	counts/s
Gear ratio	28.44:1	-	-
Encoder resolution	2000	4000	counts/mm
Limit switch polarity	high	high	

* Recommended for continuous operation

Operating Parameters of the Models with Stepper Motor

If you use a stepper motor controller from a third-party supplier, it may be necessary to enter operating parameters to adapt it to the M-403.

Parameters	M-403.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*	3	mm/s
Max. velocity*	1200	Full steps/s
Hardware properties:		
Limit switch polarity	low	

Parameters	M-403.x2S	Unit
Full steps	400	Steps/revolutions
Phase resistance	6.6	ohm
Max. phase current, bipolar	850	mA

* Recommended for continuous operation

7 Maintenance

7.1 General Notes on Maintenance

NOTICE

**Damage due to improper maintenance!**

Improper maintenance could lead to misalignment and failure of the M-403.

- Loosen screws only according to the instructions in this manual or the instructions of our customer service department (p. 41).

7.2 Doing a Maintenance Run

Depending on the operating conditions and the period of use of the M-403, 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-403 continuously over a short travel range (<20 % of the entire travel range) in industrial operation, do a run across the entire travel range every 15 operating hours or at least after 30 days.

Relubricating

Under laboratory conditions, it is only necessary to relubricate the M-403 in exceptional cases. For continuous industrial use, the lubrication intervals must be determined individually.

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

7.3 Cleaning the M-403

Requirements

- ✓ You have disconnected the M-403 from the controller.

Cleaning the Positionierer

- When necessary, clean the surface of the M-403 with a cloth dampened lightly with a mild cleanser or disinfectant.

7.4 Moving the Platform by Hand

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-403.xDG models, move the platforms by hand only if it cannot be moved in any other way.

INFORMATION

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

- Give access to the holes in the M-403's base body for fixing screws.
- Move the platform away from the hard stop to re-establish operational readiness of the M-403.

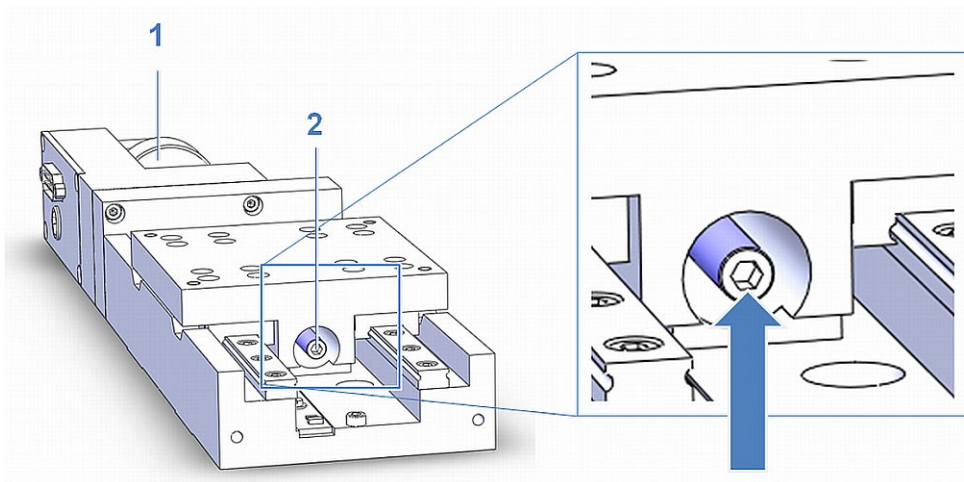


Figure 7: Position of the drive screw access (schematic)

1. Motor
2. Drive screw with hexagon socket or slot

Requirements

- ✓ The M-403 is **not** connected to the power adapter and the controller.

Tools

- Hex key, AF 4 (included in the scope of delivery)

Moving the platform by hand

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

8 Troubleshooting

8.1 Possible Causes and Correction

Problem	Possible causes	Solution
Reduced positioning accuracy	Warped base body	➤ Mount the M-403 onto a flat surface. The recommended flatness of the surface is 10 µm.
	When the M-403 is mounted vertically: The load exceeds the self-locking of the drive.	➤ Do not exceed the maximum permissible loads according to the specifications (p. 43).
	Increased wear due to small motion over a long period of time	➤ Perform a maintenance run over the entire travel range.
Function impairment after system modification	<ul style="list-style-type: none"> ▪ Controller was replaced. ▪ M-403 was replaced with another model. 	Controller from PI: ➤ Load the parameters from the positioner database that correspond to the combination of controller and M-403 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.
	When a PI controller is used: Axis motion error.	Motion error = The difference between the current position and the commanded position exceeds the specified maximum value in closed-loop operation. Motion errors can be caused for example, by malfunctions of the drive or the position sensor of the positioner. 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.

Problem	Possible causes	Solution
		Refer to the user manual for the controller for details.
	Platform has triggered the limit switch (p. 12).	If you use a controller from PI: <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.	The motor skips steps. The information on the current position is lost without the controller detecting the state. <ul style="list-style-type: none"> ➤ Use a stepper motor in the application to determine the maximum velocity for a positioner.

If the problem with your system is not listed in the table above or cannot be solved as described, contact our customer service department (p. 41).

9 Customer Service Department

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

- If you have 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)
 - PC operating system (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 on our website (p. 3).

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>).

10.1 Specifications

10.1.1 Data Table

M-403.xPD specifications

Motion	M-403.xPD	Tolerance
Active axes	X	
Travel range in X	M-403.1PD: 25 mm M-403.2PD: 50 mm M-403.4PD: 100 mm M-403.6PD: 150 mm M-403.8PD: 200 mm	
Maximum velocity in X, unloaded	10 mm/s	
Pitch (rotational crosstalk in θ_Y with motion in X)	$\pm 200 \mu\text{rad}$	Typ.
Yaw (Rotational crosstalk in θ_Z with motion in X)	$\pm 200 \mu\text{rad}$	Typ.

Positioning	M-403.xPD	Tolerance
Unidirectional repeatability in X	1 μm	Typ.
Bidirectional repeatability in X	$\pm 4 \mu\text{m}$	Typ.
Minimum incremental motion in X	0.25 μm	Typ.
Backlash in X	6 μm	Typ.
Integrated sensor	Incremental rotary encoder	
Sensor signal	A/B quadrature, RS-422	
Sensor resolution	4000 cts/rev	
Reference Switch	Hall effect	
Reference switch repeatability	1 μm	

Positioning	M-403.xPD	Tolerance
Limit switch	Hall effect	

Drive properties	M-403.xPD	Tolerance
Drive Type	DC motor with ActiveDrive	
Nominal voltage	24 V	
Drive force in X	50 N	Typ.

Mechanical properties	M-403.xPD	Tolerance
Drive screw type	Trapezoidal drive screw	
Drive screw pitch	1 mm	
Stiffness in X	3.5 N/ μ m	
Moved mass in X, unloaded	240 g	
Permissible push force in Y	100 N	Max.
Permissible push force in Z	200 N	Max.
Permissible torque in θ X	6 Nm	Max.
Permissible torque in θ Y	4 Nm	Max.
Permissible torque in θ Z	4 Nm	Max.
Overall mass	M-403.1PD: 1700 g M-403.2PD: 1800 g M-403.4PD: 2100 g M-403.6PD: 2200 g M-403.8PD: 2500 g	
Material	Aluminum, anodized	

Miscellaneous	M-403.xPD	Tolerance
Connector	D-sub 15-pole (m)	
Connector: Supply voltage	M8 4-pin (m)	
Recommended controllers / drivers	C-863 C-884 G-901 G-910 ACS modular controller	

Miscellaneous	M-403.xPD	Tolerance
Operating temperature range	-20 to 65 °C	

M-403.xDG specifications

Motion	M-403.xDG	Tolerance
Active axes	X	
Travel range in X	M-403.1DG: 25 mm M-403.2DG: 50 mm M-403.4DG: 100 mm M-403.6DG: 150 mm M-403.8DG: 200 mm	
Maximum velocity in X, unloaded	2.5 mm/s	
Pitch (rotational crosstalk in θ_Y with motion in X)	$\pm 200 \mu\text{rad}$	Typ.
Yaw (Rotational crosstalk in θ_Z with motion in X)	$\pm 200 \mu\text{rad}$	Typ.

Positioning	M-403.xDG	Tolerance
Unidirectional repeatability in X	1 μm	Typ.
Bidirectional repeatability in X	$\pm 6 \mu\text{m}$	Typ.
Minimum incremental motion in X	0.2 μm	Typ.
Backlash in X	10 μm	Typ.
Integrated sensor	Incremental rotary encoder	
Sensor signal	A/B quadrature, RS-422	
Sensor resolution	2000 cts/rev	
Reference Switch	Hall effect	
Reference switch repeatability	1 μm	
Limit switch	Hall effect	

Drive properties	M-403.xDG	Tolerance
Drive Type	DC gear motor	
Nominal voltage	12 V	

Drive properties	M-403.xDG	Tolerance
Drive force in X	50 N	Typ.
Nominal current, RMS	0.43 A	Typ.
Resistance phase-phase	9.6 Ω	Typ.
Inductance phase-phase	0.44 mH	

Mechanical properties	M-403.xDG	Tolerance
Drive screw type	Trapezoidal drive screw	
Drive screw pitch	1 mm	
Stiffness in X	3.5 N/ μ m	
Moved mass in X, unloaded	240 g	
Permissible push force in Y	100 N	Max.
Permissible push force in Z	200 N	Max.
Permissible torque in θ X	6 Nm	Max.
Permissible torque in θ Y	4 Nm	Max.
Permissible torque in θ Z	4 Nm	Max.
Overall mass	M-403.1DG: 1700 g M-403.2DG: 1800 g M-403.4DG: 2100 g M-403.6DG: 2200 g M-403.8DG: 2500 g	
Material	Aluminum, anodized	
Gear ratio i	256:9	

Miscellaneous	M-403.xDG	Tolerance
Connector	D-sub 15-pole (m)	
Recommended controllers / drivers	C-863 C-884 G-901 G-910 ACS modular controller	
Operating temperature range	-20 to 65 °C	

M-403.x2S specifications

Motion	M-403.x2S	Tolerance
Active axes	X	
Travel range in X	M-403.12S: 25 mm M-403.22S: 50 mm M-403.42S: 100 mm M-403.62S: 150 mm M-403.82S: 200 mm	
Maximum velocity in X, unloaded	3 mm/s	
Pitch (rotational crosstalk in θ_Y with motion in X)	$\pm 200 \mu\text{rad}$	Typ.
Yaw (Rotational crosstalk in θ_Z with motion in X)	$\pm 200 \mu\text{rad}$	Typ.

Positioning	M-403.x2S	Tolerance
Unidirectional repeatability in X	1 μm	Typ.
Bidirectional repeatability in X	$\pm 4 \mu\text{m}$	Typ.
Minimum incremental motion in X	0.2 μm	Typ.
Backlash in X	6 μm	Typ.
Reference Switch	Hall effect	
Reference switch repeatability	1 μm	
Limit switch	Hall effect	

Drive properties	M-403.x2S	Tolerance
Drive Type	2-phase stepper motor	
Nominal voltage	24 V	
Drive force in X	50 N	Typ.
Nominal current, RMS	1.2 A	Typ.
Resistance phase-phase	2.6 Ω	Typ.
Inductance phase-phase	1.9 mH	
Motor resolution	400 full steps/rev.	

Mechanical properties	M-403.x2S	Tolerance
Drive screw type	Trapezoidal drive screw	
Drive screw pitch	1 mm	
Stiffness in X	3.5 N/ μ m	
Moved mass in X, unloaded	240 g	
Permissible push force in Y	100 N	Max.
Permissible push force in Z	200 N	Max.
Permissible torque in θ X	6 Nm	Max.
Permissible torque in θ Y	4 Nm	Max.
Permissible torque in θ Z	4 Nm	Max.
Overall mass	M-403.12S: 1700 g M-403.22S: 1800 g M-403.42S: 2100 g M-403.62S: 2200 g M-403.82S: 2500 g	
Material	Aluminum, anodized	

Miscellaneous	M-403.x2S	Tolerance
Connector	D-sub 15-pole (m)	
Recommended controllers / drivers	C-663 G-901 G-910 ACS modular controller	
Operating temperature range	-20 to 65 °C	

Note on the velocity for M-403.xPD: Maximum recommended velocity




Note on the sensor resolution: Quadruple evaluated

Note on the permissible push force in Z: Maximum possible normal load capacity, centered, vertical load (linear stage installed horizontally)

Note on the motor resolution and drive type for M-403.x2S: Max. 0.85 A/phase; 400 full steps/rev., motor resolution with C-663 stepper motor controller

10.1.2 Maximum Ratings

The M-403 positioners are designed for the following operating data:

Device	Maximum operating voltage 	Operating frequency 	Maximum power consumption 
M-403.xDG	24 V	—	2.5 W
M-403.xPD	24 V	—	26 W
M-403.x2S	48 V	—	4.8 W

10.1.3 Ambient Conditions and Classifications

Pay attention to the following ambient conditions and classifications for the M-403:

Area of application	For indoor use only
Maximum altitude	2000 m
Relative humidity	Max. 80 % for temperatures up to 31 °C Linearly decreasing to 50 % at 40 °C
Storage temperature	-20 °C to 80 °C
Transport temperature	-20 °C to 80 °C
Supply fluctuations	Max. ± 10 % of the nominal voltage
Degree of pollution	2
Degree of protection according to IEC 60529	IP40

10.1.4 Limit Switch Specifications

Type	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

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

10.2.1 M-403

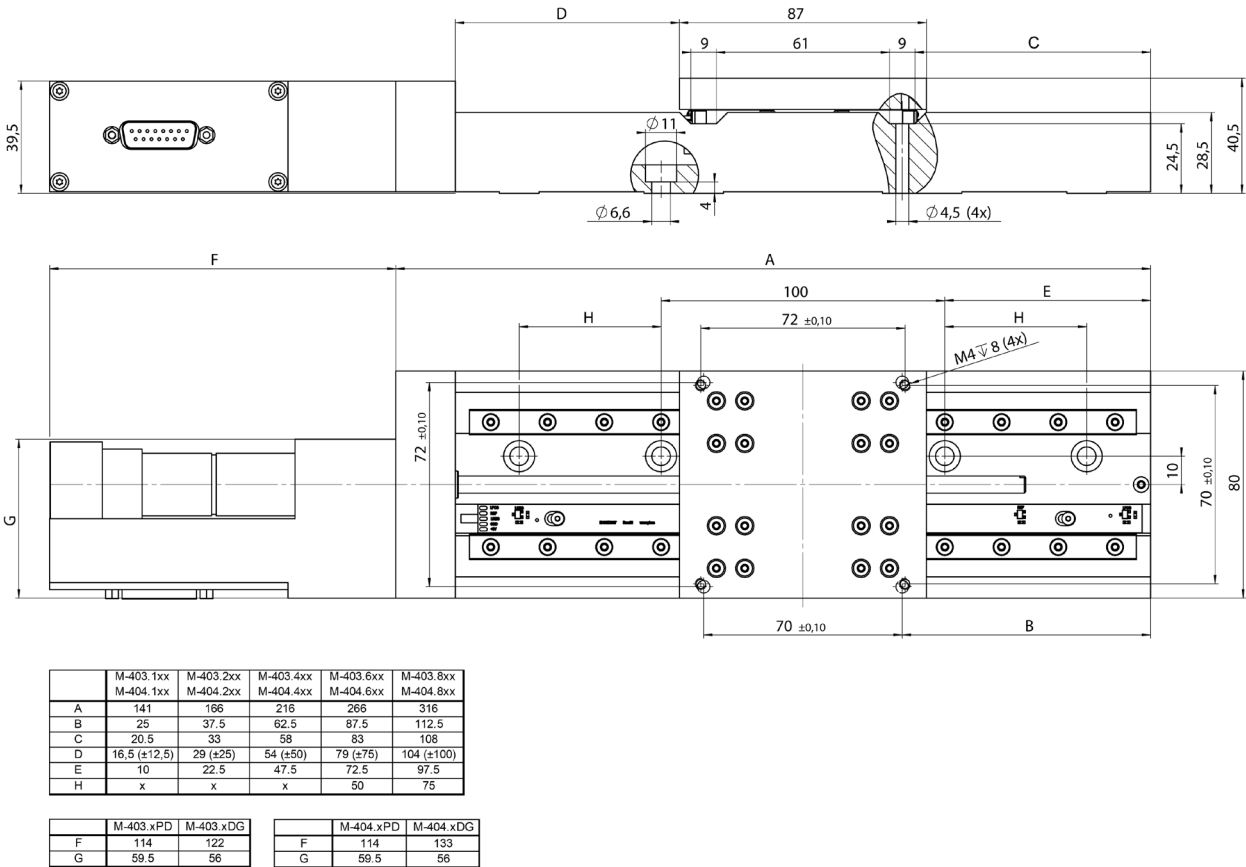


Figure 8: Dimensions of the M-403

10.2.2 M-403.AP1 Mounting Adapter

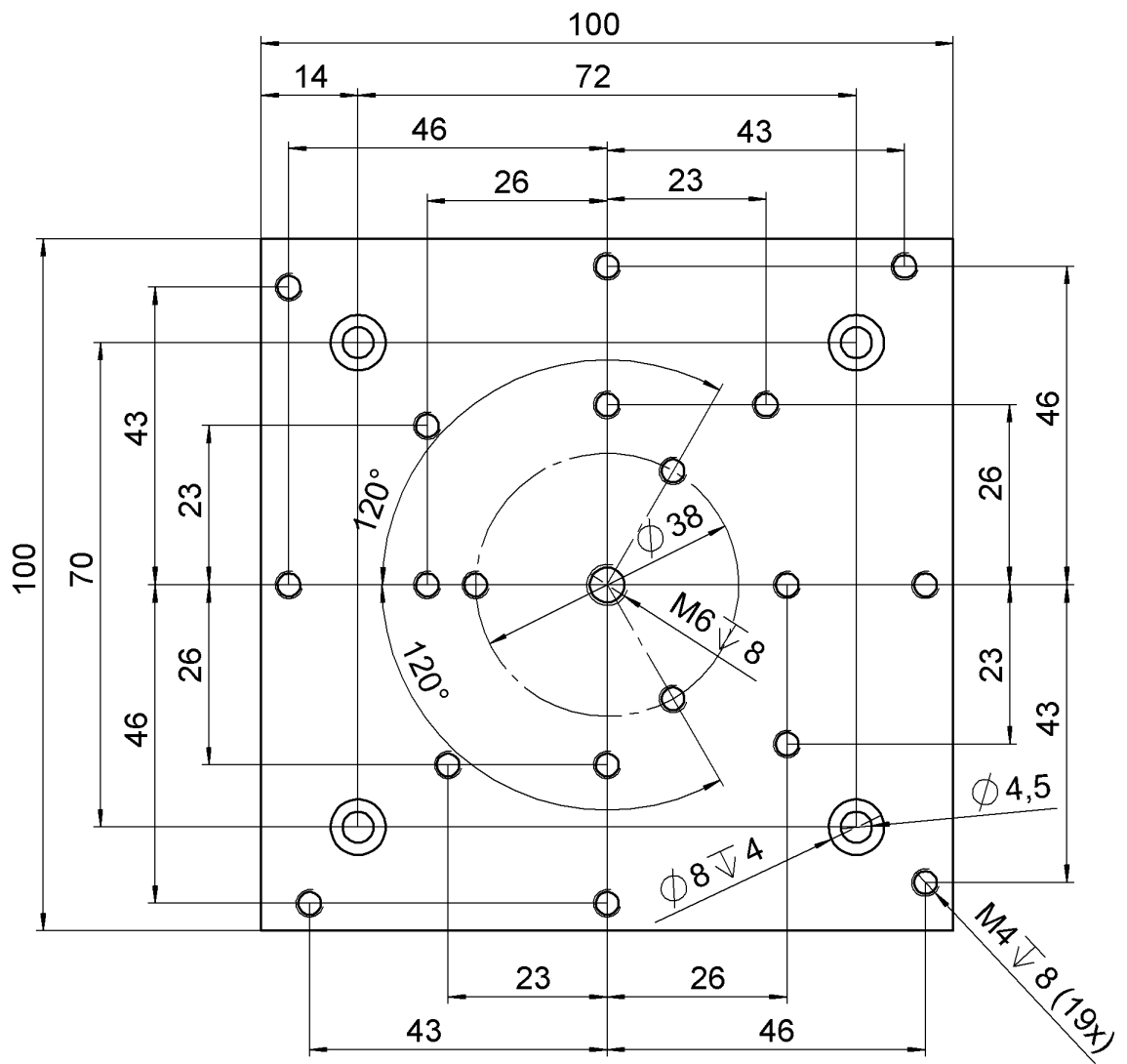


Figure 9: Dimensions of the M-403.AP1 mounting adapter

10.2.3 M-403.AP2 Mounting Adapter

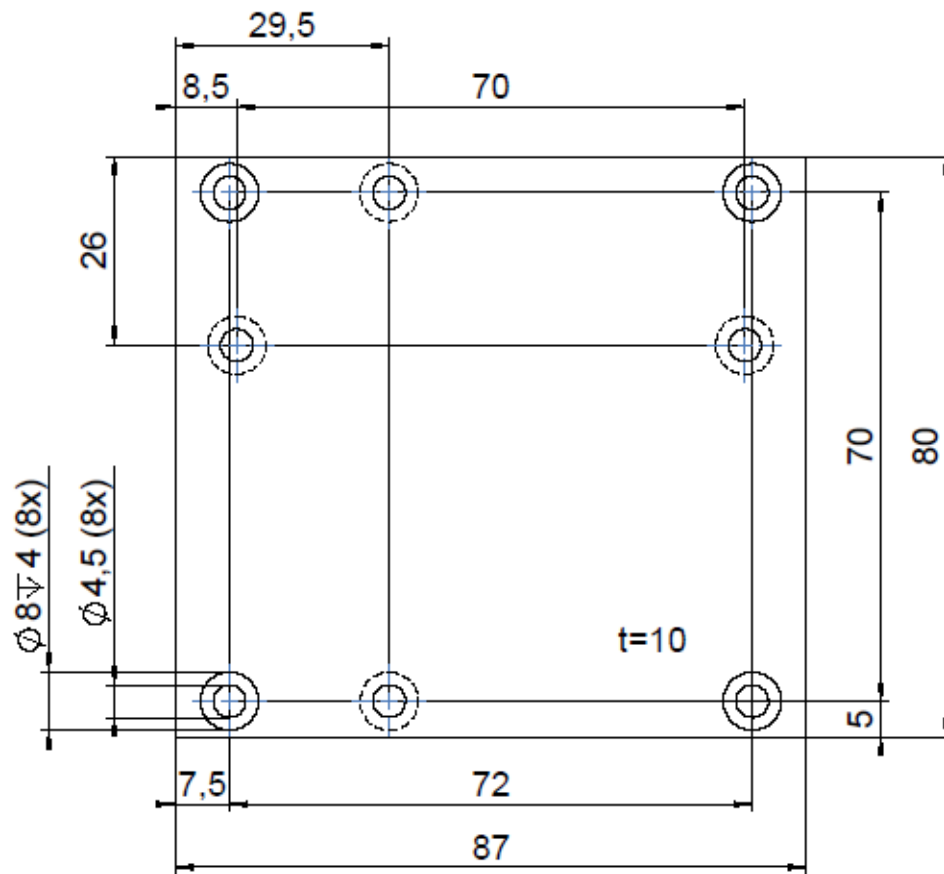


Figure 10: Dimensions of the M-403.AP2 mounting adapter

10.2.4 M-403.AP3 Mounting Adapter

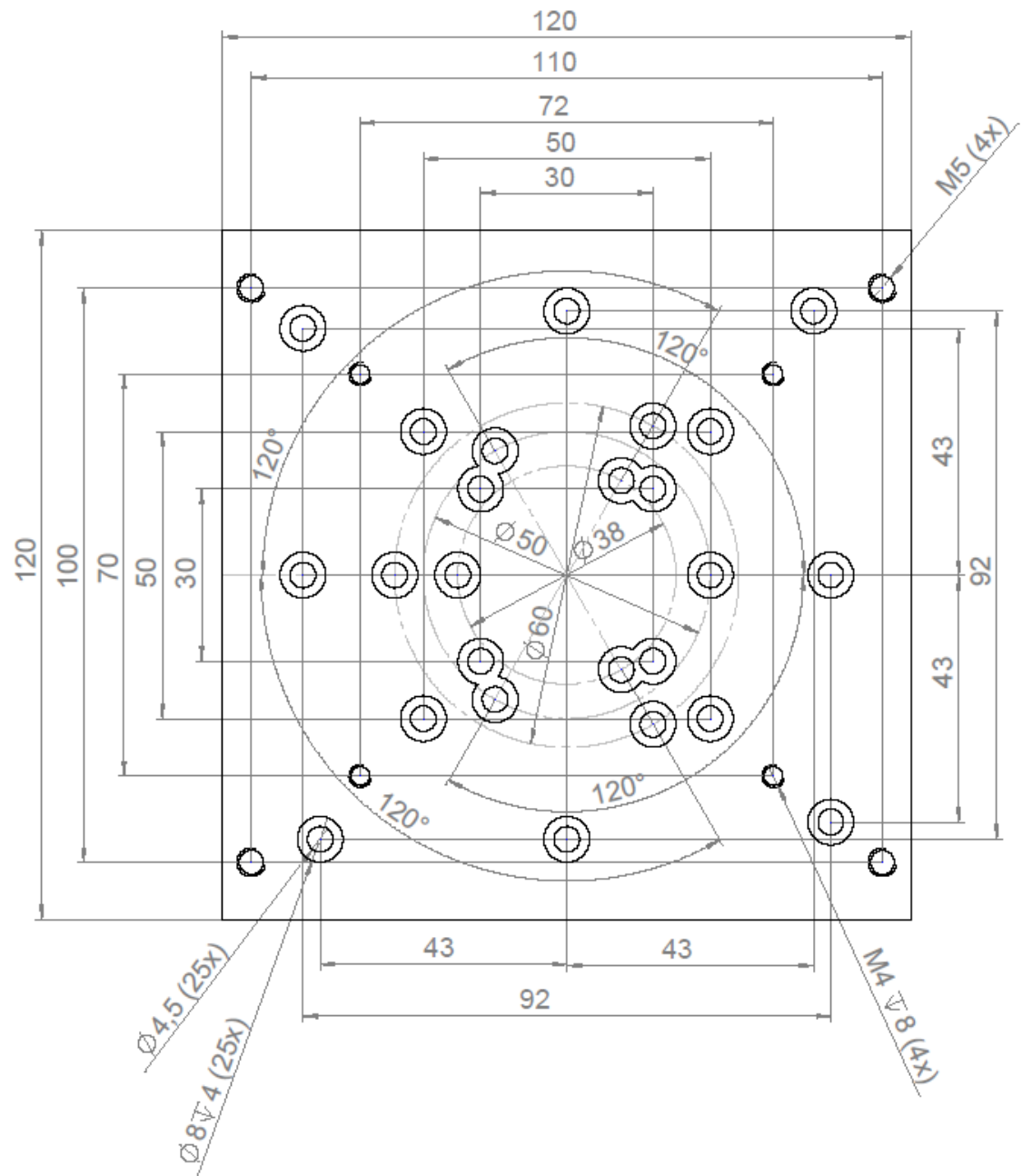


Figure 11: Dimensions of the M-403.AP3 mounting adapter

10.3 Pin Assignment

10.3.1 D-sub 15 (m) Controller Connection

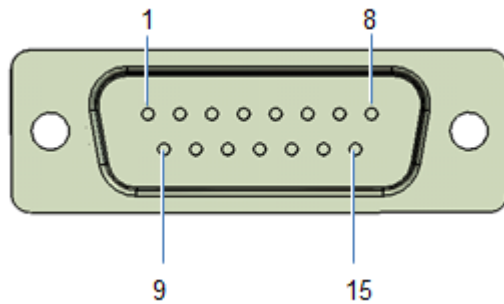


Figure 12: Sub-D 15 (m) controller connection, front view

M-403.xDG models

Pin	Signal	Direction
1	Not connected	-
9	Motor (-)	Input
2	Motor (+)	Input
10	GND	GND
3	Not connected	-
11	Not connected	-
4	+ 5 V (encoder)	Input
12	Negative limit switch	Output
5	Positive limit switch	Output
13	Reference switch	Output
6	GND	GND
14	Encoder A (+)	Output
7	Encoder A (-)	Output
15	Encoder B (+)	Output
8	Encoder B (-)	Output

M-403.xPD models

Pin	Signal	Direction
1	Brake	Input
9	Not connected	-
2	Not connected	-
10	GND	GND
3	MAGN (PWM magnitude)	Input
11	SIGN (PWM sign)	Input
4	+ 5 V	Input
12	Negative limit switch	Output
5	Positive limit switch	Output
13	Reference switch	Output
6	GND	GND
14	Encoder A (+)	Output
7	Encoder A (-)	Output
15	Encoder B (+)	Output
8	Encoder B (-)	Output

M-403.x2S models

Pin	Signal	Direction
1	Motor phase A+	Input
9	Motor phase A-	Input
2	Motor phase B+	Input
10	Motor phase B-	Input
3	Not connected	-
11	Not connected	-
4	Not connected	-
12	Not connected	-
5	Not connected	-
13	Not connected	-
6	+5 V	Input

Pin	Signal	Direction
14	Positive limit switch	Output
7	GND	GND
15	Reference switch	Output
8	Negative limit switch	Output

10.3.2 Mini XLR3 (m) Power Supply Connection

M-403.xPD models only

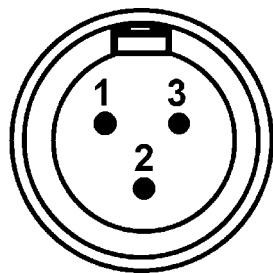


Figure 13: Mini XLR 3 (m) power supply connection, front view

Pin	Signal	Direction
1	GND	GND
2	24 V DC 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.

To fulfill the 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 Römerstraße 1
76228 Karlsruhe, Germany



12 European Declarations of Conformity

For the M-403, declarations of conformity were issued according to the following European statutory requirements:

EMC Directive

RoHS Directive

The standards applied for certifying conformity are listed below.

EMC: EN 61326-1

Safety: EN 61010-1

RoHS: EN IEC 63000