

MP67E M-686 XY Stage User Manual

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This document describes the following product:

- **M-686.D64**
XY Stage with PLine® Piezo Motor Drives,
25 mm x 25 mm, 7 N, 0.1 µm Linear
Encoder



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Germany: DE102004024656A1, DE102004044184B4, DE102004059429B4,
DE102005010073A1, DE102005039357B4, DE102005039358A1,
DE102006041017B4, DE102008012992A1, DE102008023478A1,
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EP1747594B1, EP1812975B1, EP1861740B1, EP1915787B2, EP1938397B1,
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USA: US2010/0013353A1, US5872418A, US6765335B2, US6806620B1,
US6806620B1, US7218031B2, US7598656B2, US7737605B2, US7795782B2,
US7834518B2, US7973451B2, US8253304B2, US8344592B2, US8482185B2

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JP4914895, JP2013539346

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ZL200580036995.6, ZL200680007223.4, ZL200680030007.1, ZL200680042853.5

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WO2012048691A2, WO2012113394A1, WO2012155903A1, WO2013034146A3,
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Subject to change without notice. This manual is superseded by any new release. The latest release is available for download (p. 3) on our website.

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1 About this Document

In this Chapter

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1.1 Goal and Target Audience of this User Manual

This manual contains information on the intended use of the M-686.

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

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

1.2 Symbols and Typographic Conventions

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

CAUTION



Dangerous situation

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

- Actions to take to avoid the situation.

NOTICE




Dangerous situation

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

- Actions to take to avoid the situation.

INFORMATION

Information for easier handling, tricks, tips, etc.

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

Term	Explanation
Load capacity	Maximum load capacity in the vertical direction when the XY stage is mounted horizontally. The contact point of the load is in the center of the platform.
Linear encoder	The linear encoder is an incremental sensor for capturing changes in position. Signals from the sensor are used for axis position feedback. After switching on the controller a reference point definition must be performed before absolute target positions can be commanded and reached.

1.4 Figures

For better understandability, the colors, proportions and degree of detail in illustrations can deviate from the actual circumstances. Photographic illustrations may also differ and must not be seen as guaranteed properties.

1.5 Other Applicable Documents

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

Description	Document
C-867.160 PLine® controller	MS185E User Manual
C-867.260 PLine® controller	MS189E User Manual
C-867.262 PLine® controller	MS196E User Manual
C-867.OE PLine® controller	MS195E User Manual
PLine® stages	MP121EK Short Instructions

1.6 Downloading Manuals

INFORMATION

If a manual is missing on our website or if there are problems in downloading:

- Contact our customer service department (p. 37).

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

Download freely accessible manuals

1. Open the website <http://www.pi-portal.ws>.
2. Click **Downloads**.
3. Click the corresponding category (e.g. **M Hexapods / Micropositioning**)
4. Click the corresponding product code (e.g. **M-686**).
5. Click **Documents**.

The available manuals are displayed.

6. Click the desired manual and save it on the hard disk of your PC or on a data storage medium.

Download password-protected manuals

1. Carry out steps 1 to 5 of the download process for freely accessible manuals.
2. Insert the product CD in the PC drive.
3. Switch to the **Manuals** directory on the CD.
4. In the **Manuals** directory, open the Release News (file including **releasenews** in the file name).
5. Find the user name and password in the **User login for software download** section in the Release News.
6. In the **User login** area on the left margin in the website, enter the user name and the password in the corresponding fields.
7. Click **Login**.

The available manuals are displayed.

8. Click the desired manual and save it on the hard disk of your PC or on a data storage medium.

2 Safety

In this Chapter

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2.1 Intended Use

The M-686 is a laboratory device as defined by DIN EN 61010-1. It is intended to be used in interior spaces and in an environment which is free of dirt, oil and lubricants.

In accordance with its design and realization, the M-686 is intended for positioning, adjusting and shifting of loads in two axes at different velocities in interval operation. The M-686 is **not** intended for applications in areas in which a failure would present severe risks to human beings or the environment.

The M-686 is only intended for horizontal mounting.

The intended use of the M-686 is only possible when completely mounted and connected.

The M-686 uses PLine® ultrasonic piezo linear motors as a drive and must be operated with a suitable controller (p. 12). The controller is not included in the scope of delivery of the M-686.

2.2 General Safety Instructions

The M-686 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-686.

- Only use the M-686 for its intended purpose, and only use it if it is in a good working order.
- Read the user manual.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for the correct installation and operation of the M-686.

Piezomotors are driven by piezo actuators. After being disconnected from the electronics, piezo actuators can stay electrically charged for several hours. Temperature changes can also induce charges in piezo actuators. Touching charged parts of the M-686 can cause slight injuries from electric shock.

- Do **not** open the M-686.
- Do **not** touch the contacts in the connector of the M-686.

If a protective earth conductor is not or not properly connected, dangerous touch voltages can occur on the M-686 in the case of malfunction or failure of the system. If touch voltages exist, touching the M-686 can result in minor injuries from electric shock.

- Connect the M-686 to a protective earth conductor (p. 19) before start-up.
- Do **not** remove the protective earth conductor during operation.
- If the protective earth conductor has to be removed temporarily (e. g. in the case of modifications), reconnect the M-686 to the protective earth conductor before starting it up again.

Mechanical forces can damage or misalign the M-686.

- Avoid impacts that affect the M-686.
- Do **not** drop the M-686.
- Do **not** exceed the maximum permissible stress and load capacities according to the specifications (p. 39).

2.3 Organizational Measures

User manual

- Always keep this user manual available by the M-686.
The latest versions of the user manuals are available for download (p. 3) on our website.
- Add all information given by the manufacturer to the user manual, for example supplements or Technical Notes.
- If you pass the M-686 on to other users, also turn over this user manual as well as other relevant information provided by the manufacturer.
- Only use the device on the basis of the complete user manual. Missing information due to an incomplete user manual can result in minor injury and property damage.
- Only install and operate the M-686 after having read and understood this user manual.

Personnel qualification

The M-686 may only be installed, started up, operated, maintained and cleaned by authorized and appropriately qualified personnel.

3 Product Description

In this Chapter

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3.1 Product View

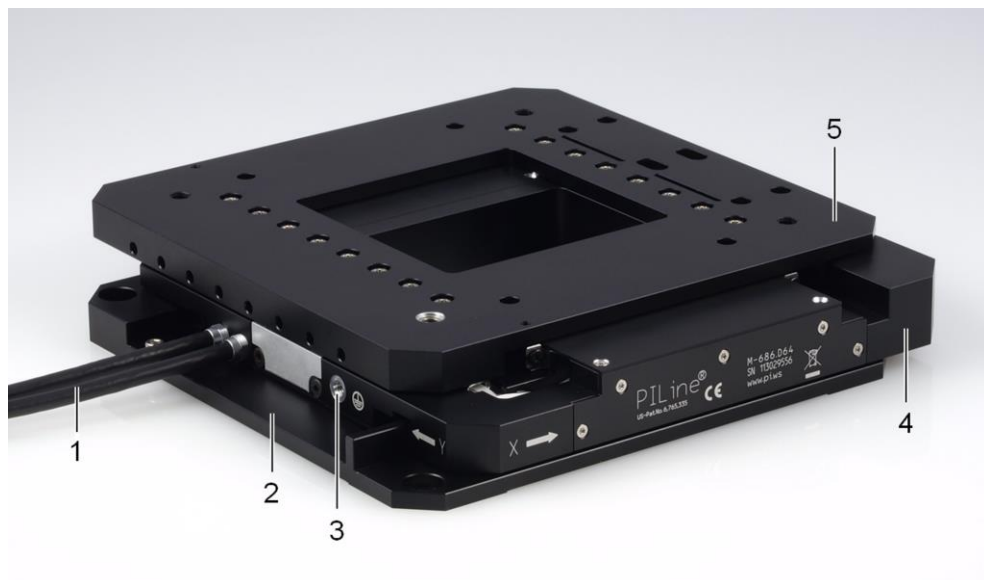


Figure 1: M-686.D64: Product view

- 1 Cable for connection to the controller
- 2 Base body
- 3 Protective earth connection
- 4 Lower platform (X axis)
- 5 Upper platform (Y axis)

3.2 Product Labeling

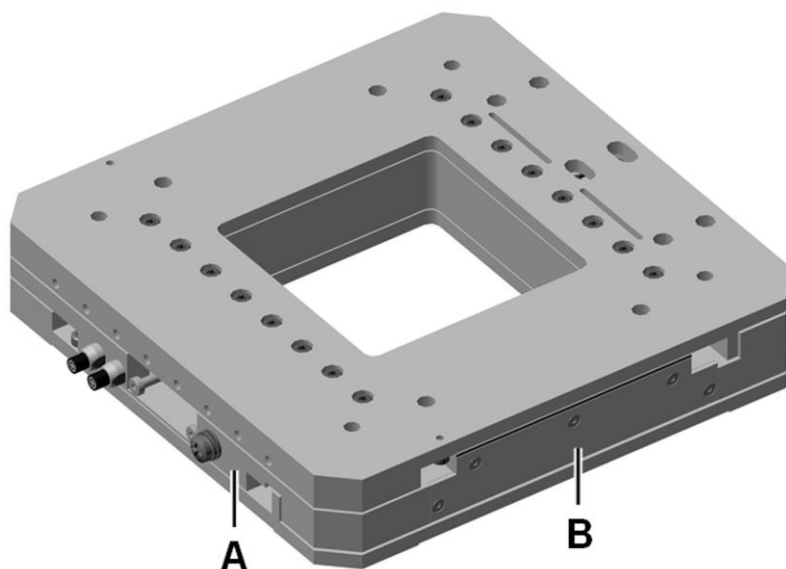




Figure 2: M-686: Position of the product labeling (example view)

Position	Labeling	Description
A		Symbol for the protective earth conductor, marks the protective earth connection of the M-686
A		Positive direction of motion of the Y axis
B		Positive direction of motion of the X axis
B	PILine®	Brand name
B	M-686.D64	Product name
B	113055789	Serial number (example), individual for each M-686 Meaning of the places (counting from left): 1 = internal information, 2 and 3 = manufacturing year 4 to 9 = consecutive numbers
B		Warning sign "Observe manual!"
B		Old equipment disposal (p. 49)

Position	Labeling	Description
B	Country of origin: Germany	Country of origin
B	WWW.PI.WS	Manufacturer's address (website)
B		Manufacturer's logo
B		CE conformity mark

3.3 Scope of Delivery

Item ID	Description
M-686.D64	XY stage with PLine® piezo motor drives, 25 mm × 25 mm, 7 N, 0.1 µm Linear Encoder
000036450	M4 screw set for protective earth, consisting of: <ul style="list-style-type: none"> ▪ 1 M4x8 flat-head screw with cross recess, ISO 7045 ▪ 2 safety washers ▪ 2 flat washers
000017714	Screw set: <ul style="list-style-type: none"> ▪ 6 M6x8 hex-head cap screws, DIN 7984 ▪ 1 Allen wrench
MP121EK	Short instructions for PLine® stages

3.4 Suitable Controllers

Order Number	Description
C-867.260	Piezomotor controller with drive electronics, 2 channels, for PLine® systems
C-867.262	High-precision piezomotor controller with drive electronics, 2 channels, for PLine® systems
C-867.160*	Piezomotor controller / driver, networkable, 1 channel, for PLine® systems
C-867.OE*	OEM driver / controller card for PLine® ultrasonic motors, 1 channel

*One controller is required per axis.

- To order, contact our customer service department (p. 37).

3.5 Accessories

Order Number	Description
P-561 to P-563	PIMars XYZ nanopositioning systems with up to 300 µm travel
P-541.2 and P-542.2	Low-profile microscopy XY scanners
P-541.Z	Low-profile Z/tip/tilt piezo nanopositioning stages for microscopy
M-663.AB	<ul style="list-style-type: none"> ▪ Adapter box, MDR to 15-pin Sub-D, for PLine® stages with long cables ▪ M663T0015 Technical Note for adapter box
Extension cables for use with the M-663.AB adapter box:	
M-663.A01	Extension cable for PLine®, MDR to 15-pin Sub-D, 1 m
M-663.A03	Extension cable for PLine®, MDR to 15-pin Sub-D, 3 m
M-663.A05	Extension cable for PLine®, MDR to 15-pin Sub-D, 5 m
Longer cables available on request.	

- To order, contact our customer service department (p. 37).

3.6 Technical Features

3.6.1 Linear Encoder

The M-686 is equipped with one optical linear encoder per axis. For the encoder resolution, refer to the table in the "Specifications" section (p. 39).

Optical linear encoders measure the actual position directly (direct metrology). Therefore, errors occurring in the drivetrain, such as nonlinearity, backlash or elastic deformation, cannot influence the measurement of the position.

3.6.2 Limit Switches

The M-686 is equipped with non-contact, Hall-effect limit switches.

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

See "Limit Switch Specifications" (p. 40) for more information.

3.6.3 Reference Point Switch

The M-686 is equipped with one direction-sensing reference point switch per axis. The switch is located at about the midpoint of the travel range. This sensor transmits a TTL signal that indicates whether the axis is on the positive or negative side of the reference point switch.

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

For more information, see "Reference Point Switch Specifications" (p. 40).

4 Unpacking

1. Unpack the M-686 with care.
2. Compare the contents against the items covered by the contract and against the packing list.
3. Inspect the contents for signs of damage. If parts are missing or you notice signs of damage, contact PI immediately.
4. Keep all packaging materials in case the product needs to be returned.

5 Installation

In this Chapter

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5.1 General Notes on Installation

CAUTION



Dangerous voltage and residual charge on piezo actuators!

Piezomotors are driven by piezo actuators. After being disconnected from the electronics, piezo actuators can stay electrically charged for several hours. Temperature changes can also induce charges in piezo actuators. Touching or short-circuiting the contacts in the connector of the M-686 can lead to minor injuries from electric shock.

- Do **not** touch the contacts in the connector of the M-686.

NOTICE



Lubricants, dirt, condensation!

Dirt, oil, lubricants and condensation will render the motor/drive inoperable.

- Ensure that the piezomotors of the M-686 do not come into contact with lubricants.
- Keep the M-686 free from dirt and condensation.

NOTICE



Heating up of the M-686 during operation!

The heat produced during operation of the M-686 can affect your application.

- Install the M-686 so that your application is not affected by the dissipating heat.

NOTICE**Unsuitable cables!**

Unsuitable cables can cause damage to the controller and can affect the performance of the M-686.

- Only use original PI parts to connect the M-686 to the controller.
- If you need longer cables, use the M-663.AB adapter boxes and extension cables from PI (p. 12).

INFORMATION

For the reproducibility of the positioning to be optimal, all components must be affixed with zero-backlash.

- Make sure that XY stage and load are affixed with zero-backlash.

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

For more information about operational conditions, refer to the "Motor Power" section (p. 42).

5.2 Connecting the M-686 to the Protective Earth Conductor

INFORMATION

- Observe the applicable standards for mounting the protective earth conductor.

An M4 hole is located on the M-686 next to the cable exit, for connecting the protective earth conductor. In the following figure, this hole is marked with an arrow.

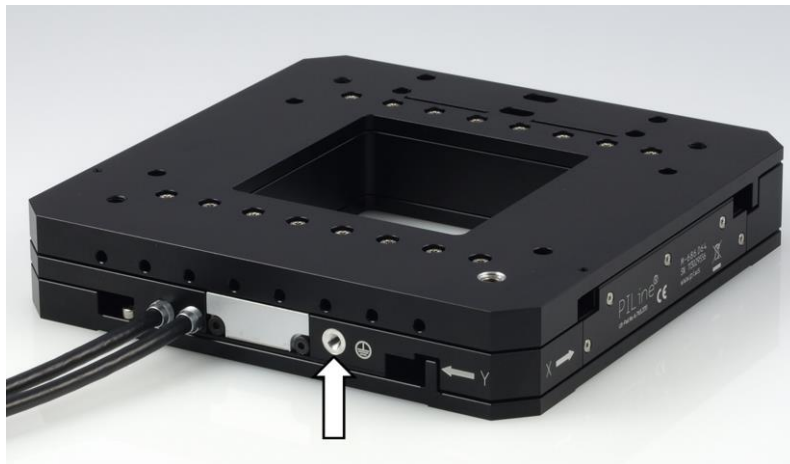


Figure 3: M-686.D64: Protective earth connection

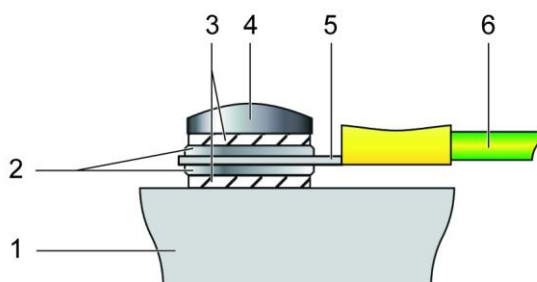


Figure 4: Mounting of the protective earth conductor (profile view)

- 1 Lower platform of the M-686
- 2 Flat washer
- 3 Safety washer
- 4 Screw
- 5 Cable lug
- 6 Protective earth conductor

Prerequisite

- ✓ You have read and understood the General Notes on Installation (p. 17).
- ✓ The M-686 is **not** connected to the controller.

Tools and accessories

- Suitable protective earth conductor: Cross-sectional area of the cable $\geq 0.75 \text{ mm}^2$
- Supplied M4 screw set for protective earth (p. 11) for mounting a protective earth conductor
- Suitable screwdriver

Connecting the M-686 to the protective earth conductor

1. If necessary, fasten a suitable cable lug to the protective earth conductor.
2. Fasten the cable lug of the protective earth conductor using the M4 screw on the protective earth connection of the M-686 as shown in the profile view.
3. Tighten the M4 screw with a torque of 1.2 Nm to 1.5 Nm.
4. Make sure that the contact resistance at all connection points relevant for mounting the protective earth conductor is $< 0.1 \Omega$ at 25 A.

5.3 Mounting the M-686 on a Surface

NOTICE



Protruding screw heads!

Protruding screw heads can damage the M-686.

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

NOTICE



Warping of the base body!

Incorrect mounting can warp the base body. Warping of the base body will increase wear and reduce accuracy.

- Mount the M-686 on an even surface. The recommended evenness of the surface is 5 μm .
- For applications with great temperature changes:
Only fasten the M-686 to surfaces that have the same or similar thermal expansion properties as the M-686 (e.g. surfaces made of aluminum).

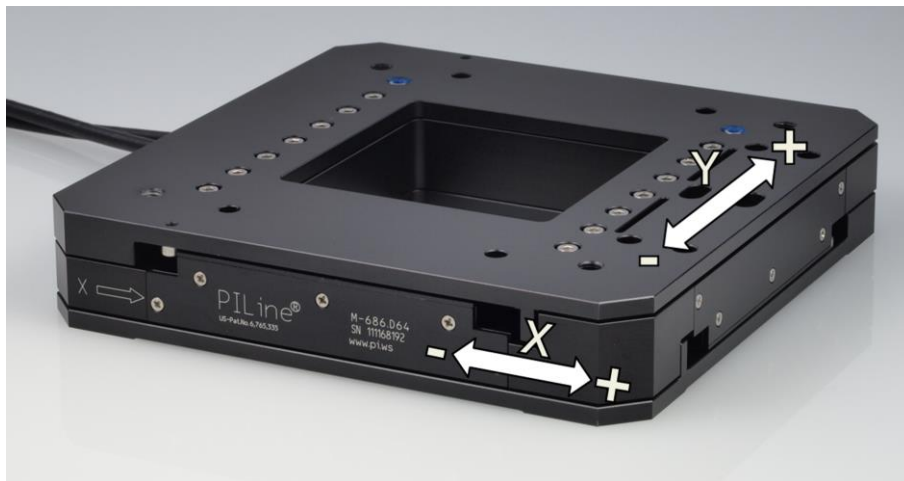


Figure 5: M-686.D64: Directions of motion of the X axis and Y axis



Figure 6: One of four M6 counter-sunk holes in the base body

Prerequisite

- ✓ You have read and understood the General Notes on Installation (p. 17).
- ✓ You have provided a suitable surface (for the required position and depth of the holes for accommodating the screws, see "Dimensions", p. 46).
 - Four M6 holes are present.
 - The evenness of the surface is $\leq 5 \mu\text{m}$.
 - For applications with great temperature changes: The surface should have the same or similar thermal expansion properties as the M-686 (e.g. surface made of aluminum).
- ✓ You accounted for the space required for cable routing free of kinks and in accordance with regulations.
- ✓ The M-686 is **not** connected to the controller.

Tools and accessories

- Mounting accessories in the scope of delivery (p. 11):
 - 4 M6x8 screws
 - Allen wrench

Mounting the M-686 on a surface

1. Manually displace the lower platform (X axis) of the M-686 until two of the four counter-sunk holes in the base body are accessible (see figure).
2. Align the M-686 on the surface so that the corresponding holes in the M-686 and the surface overlap.
3. Mount the M-686 with two screws.
4. Ensure that the screw heads do not protrude from the counter-sunk holes.
5. Manually displace the lower platform (X axis) of the M-686 until the other two counter-sunk holes in the base body are accessible.
6. Mount the M-686 with two screws.
7. Ensure that the screw heads do not protrude from the counter-sunk holes.
8. Check that the M-686 fits on the surface without backlash.

5.4 Affixing the Load to the M-686

NOTICE



Impermissibly high load on the XY stage!

An impermissibly high load interferes with the motion of the moving platform and can damage the XY stage.

- In respect to the mass and mounting type of the load, observe the maximum permissible forces that are allowed to act on the moving platform according to the specification (p. 39).

NOTICE



Screws that are too long!

The M-686 can be damaged by screws that are too long.

- Note the depth of the mounting holes in the upper platform (p. 46).
- Only use screws of the correct length for the respective mounting holes.

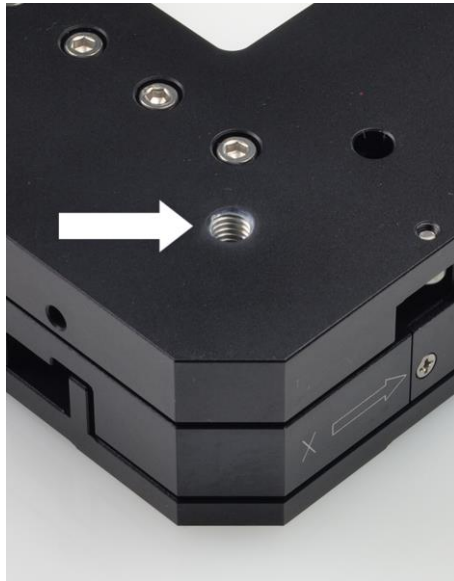


Figure 7: M-686: One of four M6 mounting holes in the upper platform (see arrow)

Prerequisite

- ✓ You have read and understood the General Notes on Installation (p. 17).
- ✓ You have properly mounted the M-686 on a surface (p. 21).
- ✓ The M-686 is **not** connected to the controller.
- ✓ You have prepared the load so that it can be affixed to the mounting holes on the upper platform:
 - The distance between the center of gravity of the load and the center of the moving platform is as small as possible in all directions.
 - At least three points are provided for affixing the load on the moving platform.

Tools and accessories

- At least three M6 screws of suitable length (p. 46)
- Suitable tools for fastening the screws

Affixing the load

1. Align the load on the M-686 so that the mounting holes in the load and the upper platform overlap.
2. Affix the load with at least three screws.
3. Check that the load fits on the upper platform of the M-686 without backlash.

5.5 Connecting the Extension Cables

Prerequisites

- ✓ You have read and understood the General Notes on Installation (p. 17).
- ✓ The controller is **switched off**.
- ✓ You have connected the M-686 to the protective earth conductor (p. 19).

Tools and accessories

- Two M-663.AB* adapter boxes, MDR14 to Sub-D 15, for PILine® stages with a long cable
- Two extension cables* for PILine®, MDR14 to Sub-D 15, 1 to 5 m

*Not in the scope of delivery; see "Accessories" (p. 12).

Connecting the extension cables

- Connect the M-686 ("stage") and controller via the adapter boxes and extension cables as shown in the connection diagram below.
 - Observe the assignment that is given by the labeling on the sockets, connectors and cables.

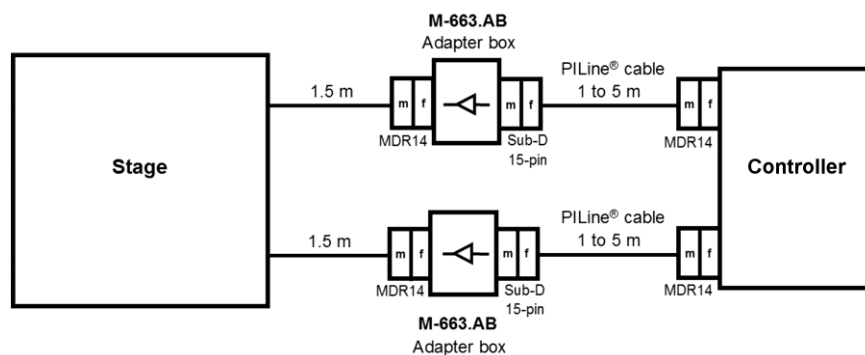


Figure 8: Connection of extension cables to the standard version of the XY stage

6 Start-Up and Operation

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M-686 Entries in the Stage Database of PI	32

6.1 General Notes on Start-Up and Operation

CAUTION



Risk of electric shock if the protective earth conductor is not connected!

If a protective earth conductor is not or not properly connected, dangerous touch voltages can occur on the M-686 in the case of malfunction or failure of the system. If touch voltages exist, touching the M-686 can result in minor injuries from electric shock.

- Connect the M-686 to a protective earth conductor (p. 19) before start-up.
- Do **not** remove the protective earth conductor during operation.
- If the protective earth conductor has to be removed temporarily (e. g. in the case of modifications), reconnect the M-686 to the protective earth conductor before starting it up again.

NOTICE



Operating voltage too high or incorrectly connected!

Operating voltages that are too high or incorrectly connected can cause damage to the M-686.

- Only operate the M-686 with controllers/drivers and original accessories from PI.
- Do **not** exceed the operating voltage range (p. 41) for which the M-686 is specified.
- Only operate the M-686 when the operating voltage is properly connected; see "Pin Assignment" (p. 47).

NOTICE**Unintentional motions!**

When the M-686 is being connected to the controller, it can carry out unintentional motions. Defective software or wrong operation of the software can also result in unintentional motions.

- Do not place any objects in areas where they can get caught by moving parts.
- Before connecting the M-686, check whether a macro is defined as the start-up macro in the controller, and cancel the selection of the start-up macro if necessary.

NOTICE**Damage from collisions!**

Collisions can damage the XY stage, the load to be moved and the environment.

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

NOTICE**Uncontrolled oscillation!**

Your application can be damaged by uncontrolled oscillation of the M-686.
If you encounter noise during operation:

- Immediately switch off the servo-control system of the affected axes.
- Check the settings of the servo-control parameters.

NOTICE**Collision of the moving platforms with the hard stop!**

Collision of the moving platforms of the M-686 with the hard stop can lead to damage or considerable wear on the M-686.

- Prevent motions in open-loop operation.
- If motions in open-loop operation are necessary with the C-867 controller:
 - Set the control value with the `SMO` command so that the axes move with low velocity.
 - Stop the axes in time. For this purpose, use the `#24`, `STP` or `HLT` command, or set the control value to zero with the `SMO` command.
- Ensure that the end of the travel range is approached at low velocity.
- Only make changes to the velocity, acceleration, deceleration and load in small steps.
- Do **not** deactivate the limit switches in the software.
- Test limit switch operation at low velocities only.
- In the event of a malfunction of the limit switches, stop the motion immediately.

NOTICE**Overheating during continuous operation!**

The highest dynamic force and holding force are achieved at maximum motor power; however, the M-686 may overheat during continuous operation.

- Observe the recommended motor power depending on the duty cycle and the ambient temperature (p. 44).

NOTICE**Damage or considerable wear from high accelerations!**

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

- Stop the motion immediately if a controller malfunction occurs.
- Determine the maximum velocity for your application.
- Observe the information in the "Motor Power" section (p. 42).

INFORMATION

Although in theory the M-686 operates quietly, noise levels of up to 50 dB (A) are possible during operation. The ultrasonic drive of the M-686 can also generate higher noise levels at frequencies between 100 and 500 kHz.

INFORMATION

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

INFORMATION

For maximum force generation, a run-in procedure is necessary during the start-up of the M-686 and after longer downtimes; see also "Influence of Downtimes on the Static Holding Force" (p. 45). After run-in, the M-686 will generate its maximum dynamic force.

- For run-in, command a few motion cycles at low velocity over the entire travel range.

For more information about operational conditions, refer to the "Motor Power" section (p. 42).

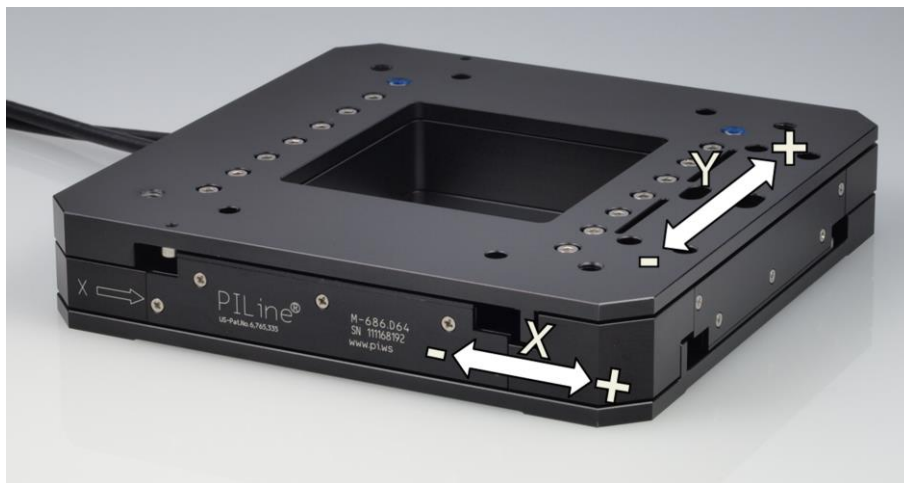


Figure 9: M-686.D64: Directions of motion of the X axis and Y axis

6.2 Starting Up the M-686 with the C-867 Controller

NOTICE



Incorrect parameter settings!

When using the software which is included in the scope of delivery of the C-867 controller, the operating parameters of the M-686 can be loaded from a stage database. The stage *PIStages2.dat* database contains the default parameter values of your XY stage for performing initial test motions during start-up. Depending on the application, using the default parameter values (e. g. for P-term, I-term, D-term, acceleration and velocity) can, however, cause damage to the XY stage, especially when operated with heavy loads.

- If possible: Perform the first start-up without a load.
- Always install the latest version of the *PIStages2.dat* stage database on your PC.

For start-up with a load:

- Before start-up, make sure that the M-686 has been properly installed (p. 17).
- For optimum performance of the moving axis, adjust the operating parameters of the C-867 (e. g. P-term, I-term, D-term, acceleration, velocity; see C-867 User Manual).
- Save the new parameter values for future use in a stage database on the PC or in the non-volatile memory of the controller (see C-867 User Manual and PIMikroMove User Manual).

Prerequisites

- ✓ You have read and understood the General Notes on Start-Up and Operation (p. 27).
- ✓ You have read and understood the user manual of the C-867 piezomotor controller/driver.
- ✓ In the case of start-up with a load: The M-686 has been properly installed (p. 17).
- ✓ The C-867 piezomotor controller/driver and the required software have been installed. All connections on the C-867 have been established (see C-867 User Manual).

Starting up the M-686 with the C-867 controller

- Start up one axis of the M-686 (see C-867 User Manual), and repeat the sequence for the second axis.

The start-up comprises the following steps:

- Selecting the stage type (p. 32)
- Defining the reference point of the axis
- Commanding initial motions in closed-loop operation for testing and for run-in of the mechanical system

The description in the C-867 User Manual assumes that you perform these steps using PIMikroMove.

6.3 M-686 Entries in the Stage Database of PI

During start-up, the M-686 must be selected from a stage database in the PC software. The appropriate operating parameters are thus loaded to the controller. You can find a detailed description in the user manual for the controller or in the manual for the PC software used.

The selection of the M-686 in the stage database depends on the controller model used; see the following table.

Controller Model Used	Entry to be Selected in the Stage Database
C-867.160 C-867.260 C-867.OE	M-686.D64_X60
C-867.262	M-686.D64_262

7 Maintenance

In this Chapter

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Performing a Maintenance Run.....	33
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7.1 General Notes on Maintenance

NOTICE



Damage due to improper maintenance!

Improper maintenance can result in the failure of the M-686.

- Only loosen screws according to the instructions in this manual.
- Ensure that the piezomotors of the M-686 do not come into contact with lubricants.

7.2 Performing a Maintenance Run

Depending on the operating conditions and the period of use of the M-686, the following maintenance measures are required:

Maintenance run

The maintenance run is performed to distribute the existing lubricant on the guidings of the M-686.

- To evenly distribute the existing lubricant on the stage guidings, perform a maintenance run across the entire travel range after 500 hours of operation, or after 1 year at the latest.
- If you move the M-686 continuously over a small working range (<20 % of the entire travel range) in industrial operation, perform a maintenance run across the entire travel range every 5000 motion cycles.

Lubrication

Under laboratory conditions, the guidings of the M-686 only need to be lubricated in exceptional cases. For continuous industrial use, the lubrication intervals must be defined individually.

- Do not lubricate the guidings of the M-686 without consulting our customer service department (p. 37).
- To lubricate the guidings, follow the instructions given in the maintenance manual which you can obtain from our customer service department.
- Ensure that the piezomotors of the M-686 do not come into contact with lubricants.

7.3 Cleaning the M-686

Prerequisites

- ✓ You have disconnected the XY stage from the controller.

Cleaning the XY stage

- When necessary, clean the XY stage surface with a cloth lightly dampened with a mild cleanser or disinfectant.
- Do **not** use any organic solvents.

8 Troubleshooting

Problem	Possible Causes	Solution
Noise during operation	Uncontrolled oscillation of the M-686	<ul style="list-style-type: none"> ➤ Immediately switch off the servo-control system of the affected axes. ➤ Check the settings of the servo-control parameters.
XY stage positions inaccurately	Settling window around the target position is too large	<ul style="list-style-type: none"> ➤ Reduce the settling window by changing the parameter values for the settling window limits on the controller. See the controller user manual (p. 3) for details.
Reaching the target position takes too long	Settling window around the target position is too small	<ul style="list-style-type: none"> ➤ Enlarge the settling window by changing the parameter values for the settling window limits on the controller. See the controller user manual (p. 3) for details.
Increased wear Reduced accuracy	Warped base body	<ul style="list-style-type: none"> ➤ Mount the M-686 on an even surface. The recommended evenness of the surface is 5 µm. ➤ For applications with great temperature changes: Only mount the M-686 on surfaces that have the same or similar thermal expansion properties as the M-686 (e.g. surfaces made of aluminum).
Functional impairment after system modification	Axes were mixed up during connection	<ul style="list-style-type: none"> ➤ Observe the assignment of the axes when connecting the XY stage to the controller. This assignment is indicated by labels on the devices.

If the problem that occurred with your system is not listed in the table above or cannot be solved as described, contact our customer service department (p. 37).

9 Customer Service

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

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

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

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

10 Technical Data

In this Chapter

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10.1 Specifications

10.1.1 Data Table

	M-686.D64	Unit	Tolerance
Active axes	XY		
Motion and positioning			
Travel range	25 mm × 25 mm		
Integrated sensor	Linear encoder		
Sensor resolution	0.1	μm	
Design resolution	0.1	μm	typ.
Min. incremental motion	0.3	μm	typ.
Bidirectional repeatability	±0.3	μm	
Pitch / yaw	±50	μrad	typ.
Velocity	100	mm/s	max.
Mechanical properties			
Load capacity*	50	N	max.
Push / pull force	7	N	max.
Holding force	6	N	max.
Drive properties			
Motor type	PILine® U-164 (dual motor)		
Reference point switch	Optical		
Limit switches	Hall-effect		

	M-686.D64	Unit	Tolerance
Miscellaneous			
Operating temperature range	-20 to 50	°C	
Material	Al (black anodized)		
Dimensions	170 mm × 170 mm × 32 mm		
Mass	1.8	kg	±5 %
Cable length	1.5	m	±10 mm
Connector	2 × MDR, 14-pin		
Recommended controller/driver	C-867 PILine® Motion Controller		

* 10 N for maximum velocity.

Ask about custom designs!

10.1.2 Limit Switch Specifications




Type	Magnetic (Hall-effect) sensor
Supply voltage	+5 V/GND, supply via the motor connector
Signal output	TTL level
Signal logic	Active high. When the limit switch is passed, the signal level changes: <ul style="list-style-type: none"> – Normal motor operation: low (0 V) – Limit switch reached: high (+5 V)

10.1.3 Reference Point Switch Specifications

Type	Optical sensor
Supply voltage	+5 V/GND, supply via the motor connector
Signal output	TTL level
Signal logic	Direction sensing by means of different signal levels on the left and right side of the reference point switch: The signal level changes from 0 to +5 V when the reference point switch is passed.
Hysteresis	0.2 to 0.4mm (when approaching from the positive or negative direction)

10.1.4 Maximum Ratings

M-686 XY stages are designed for the following operating data:

Device	Maximum Operating Voltage 	Operating Frequency 	Maximum Power Consumption 
M-686	200 V _{pp} or 71 V _{rms}	152 to 165 kHz	60 W

10.2 Ambient Conditions and Classifications

The following ambient conditions and classifications must be observed for the M-686:

Area of application	For indoor use only
Maximum altitude	2000 m
Air pressure	1100 hPa to 0.1 hPa (corresponds to roughly 825 torr to 0.075 torr)
Relative humidity	Highest relative humidity 80 % for temperatures up to 31 °C Decreasing linearly to 50 % relative humidity at 40 °C
Operating temperature	-20 °C to 50 °C
Storage temperature	-20 °C to 75 °C
Transport temperature	-20 °C to 75 °C
Overvoltage category	II
Protection class	I
Degree of pollution	1
Degree of protection according to IEC 60529	IP20

10.3 Motor Power

10.3.1 Motor Power and Operating Voltage

The following table shows the relationship between the operating voltage and the motor power of the M-686. The operating voltage is output by the C-867 controller and depends on the actual control value. The polarity sign of the control value determines the direction of motion.

Motor Power	Operating Voltage	Corresponding Control Value on the C-867*
0 %	0 V _{pp}	0
25 %	50 V _{pp}	8192 or -8192
50 %	100 V _{pp}	16384 or -16384
75 %	150 V _{pp}	24575 or -24575
100 %	200 V _{pp}	32767 or -32767

* Generated in closed-loop operation via the control algorithm or set in open-loop operation via the `SMO` command

INFORMATION

The control value and thus the output operating voltage are limited by the C-867 controller with the **Maximum Motor Output** parameter (ID 0x9). When you load the operating parameters of the M-686 from the `PIStages2.dat` stage database, this parameter is set to a suitable value.

You can check the control value of the C-867 as follows:

- Get the current control value with the `SMO?` command.
- Record the control value during the motion with the data recorder (as "motor output").

For further information, see the user manual of the controller (p. 12) used to operate the M-686.

10.3.2 Velocity and Dynamic Force

The following figure can be used to estimate the velocity and force of the M-686 with different motor powers.

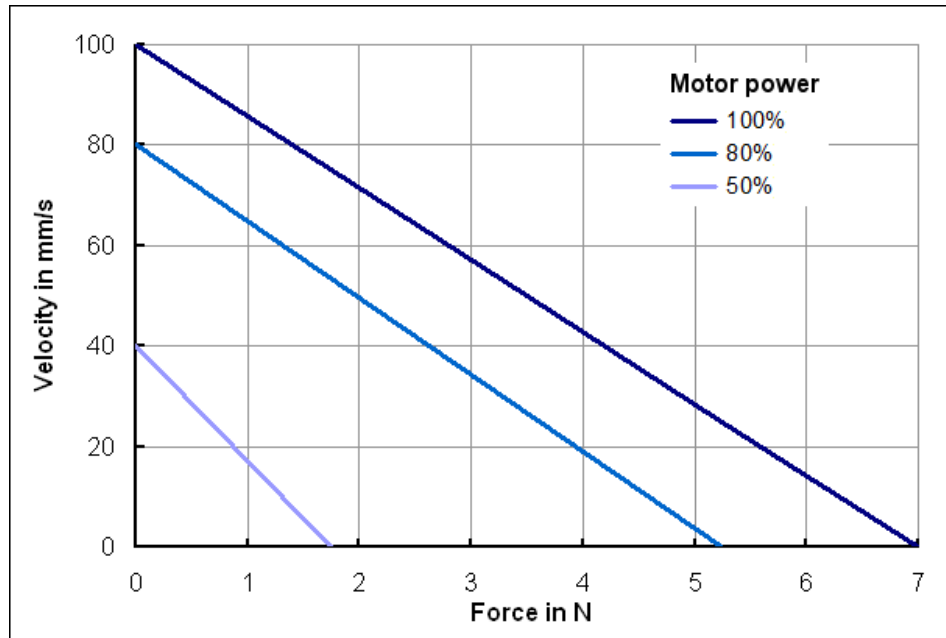


Figure 10: Velocity of the M-686 vs. dynamic force (push/pull force) with different motor powers

10.3.3 Motor Power and Lifetime

Motor power, duty cycle and ambient temperature influence the lifetime of the XY stage. In order to prevent overheating and high wear, the motor power and the duty cycle should not exceed the limits given in the following graph. A load cycle corresponds to a positioning run and includes the acceleration, motion, deceleration as well as downtime (break). The motor should only sporadically be operated at peak power; the peak power serves as a control reserve.

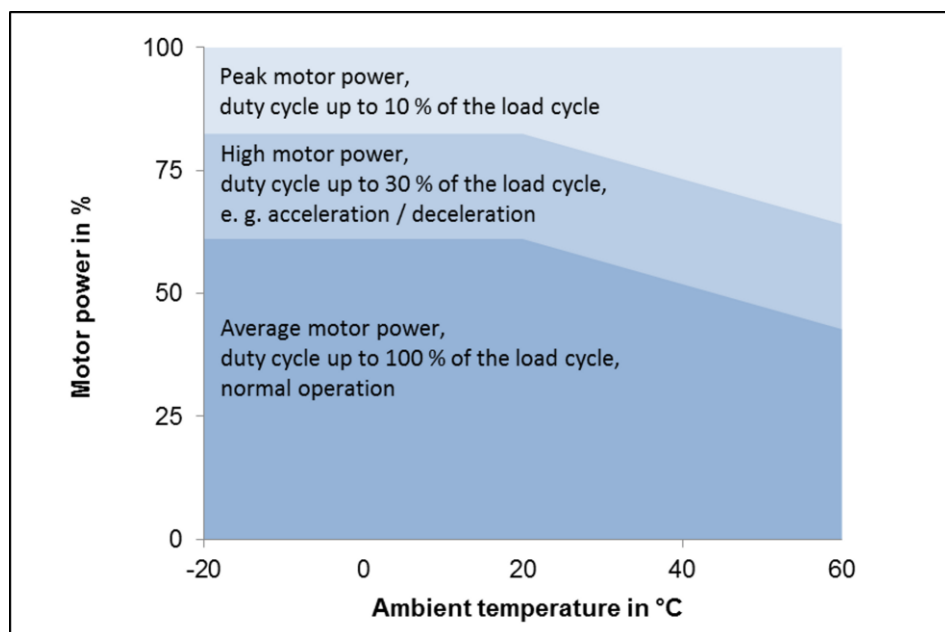


Figure 11: M-686: Recommended duty cycle and motor power depending on the ambient temperature

10.3.4 Influence of Downtimes on the Static Holding Force

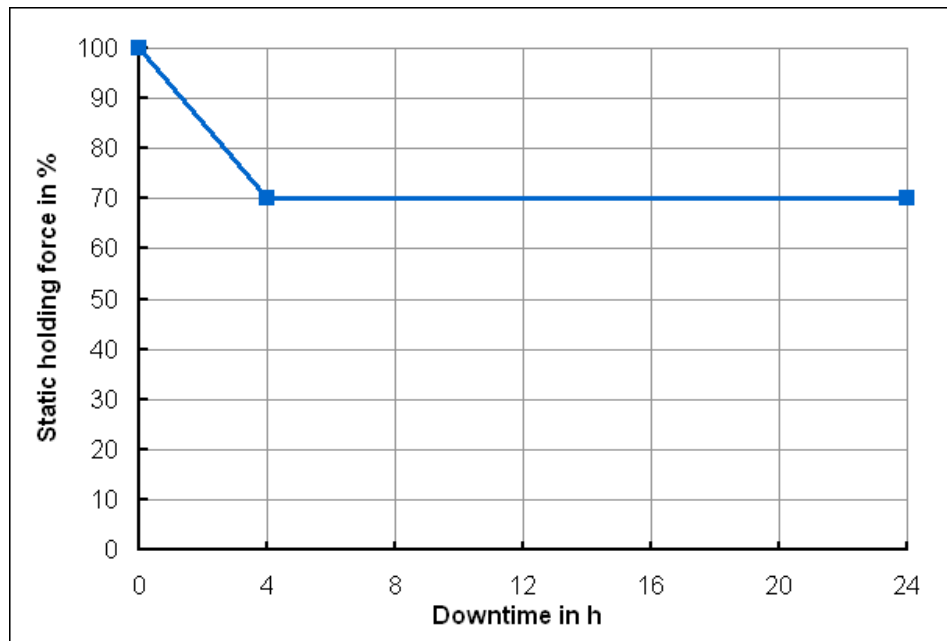


Figure 12: Static holding force of the M-686 depending on the downtime of the motor

10.4 Dimensions

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

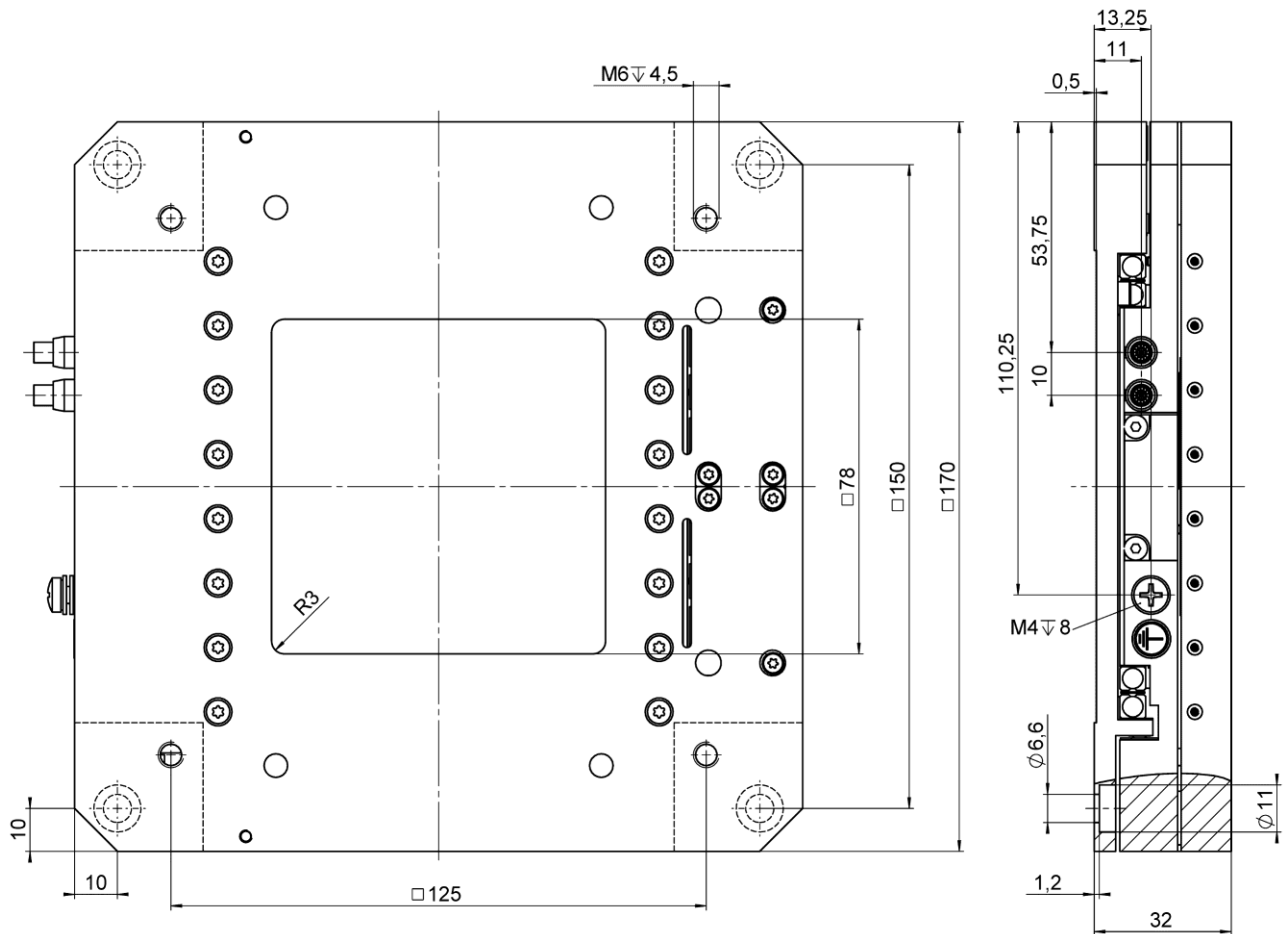


Figure 13: M-686.D64 XY stage

10.5 Pin Assignment

Connector: MDR14, N10214-52B2VC (3M)

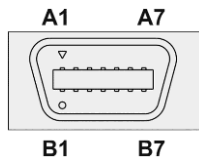


Figure 14: Front view of the MDR14 connector

Pin	Signal	Function
A1	GND	0 V
A2	PSWITCH	Output: Positive-end limit switch, active-high
A3	NSWITCH	Output: Negative-end limit switch, active-high
A4	REFSWITCH	Output: Reference point switch
A5	NC	Not connected
A6	VDD	Input: +5 V
A7	USM_P1	Input: Piezo 71 VAC (RMS)
B1	USM_P2	Input: Piezo 71 VAC (RMS)
B2	USM_P3	Input: Piezo 71 VAC (RMS)
B3	ENCA+	Output: Encoder channel A, RS-422
B4	ENCA-	Output: Encoder channel A (inverted), RS-422
B5	ENCB+	Output: Encoder channel B, RS-422
B6	ENCB-	Output: Encoder channel B (inverted), RS-422
B7	NC	Not connected

11 Old Equipment Disposal

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

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

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

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

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



12 EC Declaration of Conformity

For the M-686, an EC Declaration of Conformity has been issued in accordance with the following European directives:

2006/95/EC, Low Voltage Directive

2004/108/EC, EMC Directive

2011/65/EU, RoHS Directive

The applied standards certifying the conformity are listed below.

Electromagnetic Emission: EN 61000-6-3:2007, EN 55011:2009

Electromagnetic Immunity: EN 61000-6-1:2007

Safety (Low Voltage Directive): EN 61010-1:2010

