MP96E

M-664 Linear Stage

User Manual

Version: 1.2.0 Date: 13.02.2014

This document describes the following product:

- **M-664.164**
  PILine® Low-Profile Micropositioning Stage with P-664 Piezo Linear Motor, 25 mm, 2.5 N

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PI owns the following patents or patent applications for the technology field Ultrasonic Piezo Motors (PILine®):

Germany: DE102004024656A1, DE102004044184B4, DE102004059429B4, DE102005010073A1, DE102005039357B4, DE102005039358A1, DE102006041017B4, DE102008012992A1, DE102008023478A1, DE102008058484A1, DE102010022812A1, DE102010047280A1, DE102010055848, DE102011075985A1, DE102011082200A1, DE102011087542B3, DE102011087542B3, DE102011087801B4, DE102011108175, DE102012201863B3, DE19522072C1, DE19938954A1

Europe: EP0789937B1 EP1210759B1, EP1267425B1, EP1581992B1, EP1656705B1, EP1747594B1, EP1812975B1, EP1861740B1, EP1915787B2, EP1938397B1, EP2095441B1, EP2130236B1, EP2153476B1, EP2164120B1, EP2258004B1, EP2608286A2

USA: US2010/0013353A1, US5872418A, US6765335B2, US6806620B1, US6806620B1, US7218031B2, US7598656B2, US7737605B2, US7795782B2, US7834518B2, US7973451B2, US8253304B2, US8344592B2, US8482185B2

Japan: JP2011514131, JP2011522506, JP3804973B2, JP4377956, JP4435695, JP4477069, JP4598128, JP4617359, JP4620115, JP4648391, JP4860862, JP4914895, JP2013539346

China: ZL200380108542.0, ZL200580015994.3, ZL200580029560.9, ZL200580036995.6, ZL200680007223.4, ZL200680030007.1, ZL200680042853.5

International patent applications: WO2009059939A2, WO2010121594A1, WO2012048691A2, WO2012113394A1, WO2012155903A1, WO2013034146A3, WO2013117189A2

Original instructions
First printing: 13.02.2014
Document number: MP96E, CBo, version 1.2.0

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 This manual is superseded by any new release.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.

Contents

1 About this Document

In this Chapter

1.1 Goal and Target Audience of this User Manual

This manual contains information on the intended use of the M-664.

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

1.3 Definition

Term	Explanation
Load capacity	Maximum load capacity in the vertical direction when the stage is mounted horizontally. The contact point of the load is in the center of the platform.
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 PILine® controller	MS185E User Manual
C-867.260 PILine® controller	MS189E User Manual
C-867.OE PILine® controller	MS195E User Manual
PIMikroMove	SM148E Software Manual
PILine® 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. 39).

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-664***).
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

2.1 Intended Use

The M-664 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-664 is intended for single-axis positioning, adjusting and shifting of loads at various velocities in interval operation. The M-664 is **not** intended for applications in areas in which a failure would present severe risks to human beings or the environment.

The intended use of the M-664 is only possible when completely mounted and connected.

The M-664 uses a PILine® ultrasonic piezo linear motor as a drive and has to be operated with a suitable controller (p. 11). The controller is not included in the scope of delivery of the M-664.

2.2 General Safety Instructions

The M-664 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-664.

- Only use the M-664 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-664.

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-664 can cause slight injuries from electric shock.

- Do **not** open the M-664.
- Do **not** touch the contacts in the connector of the M-664.

If a protective earth conductor is not or not properly connected, dangerous touch voltages can occur on the M-664 in the case of malfunction or failure of the system. If touch voltages exist, touching the M-664 can result in minor injuries from electric shock.

- Connect the M-664 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-664 to the protective earth conductor before starting it up again.

Mechanical forces can damage or misalign the M-664.

- Avoid impacts that affect the M-664.
- Do **not** drop the M-664.
- Do **not** exceed the maximum permissible stress and load capacities according to the specifications (p. 41).

2.3 Organizational Measures

User manual

- Always keep this user manual available by the M-664.
  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-664 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-664 after having read and understood this user manual.

Personnel qualification

The M-664 may only be installed, started up, operated, maintained and cleaned by authorized and appropriately qualified personnel.

3 Product Description

In this Chapter

3.1 Product View

Figure 1: M-664.164 product view

1 Moving platform
2 Cable for connecting to the controller
3 Base body
x Positive direction of motion of the stage

3.2 Product Labeling

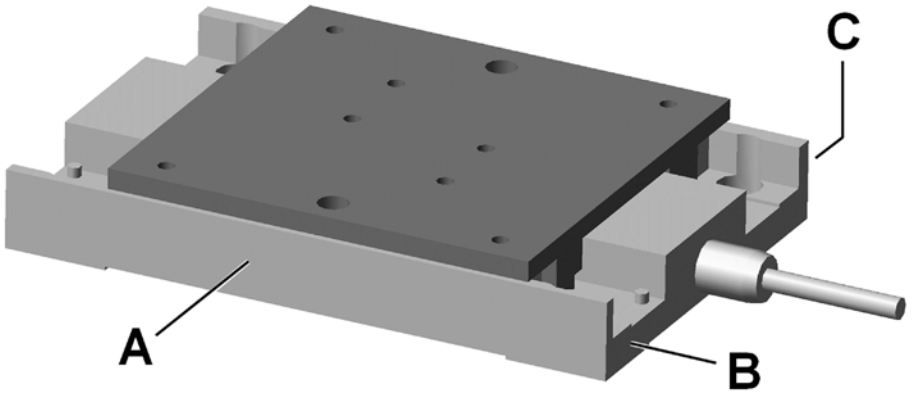


Figure 2: M-664: Position of the product labeling (example view)

Position	Labeling	Description
A	PI	Manufacturer's logo
A	M-664.164	Product name
A	113068527	Serial number (example), individual for each M-664 Meaning of the places (counting from left): 1 = internal information 2 and 3 = manufacturing year 4 to 9 = consecutive numbers
A	Country of origin: Germany	Country of origin
A	WWW.PI.WS	Manufacturer's address (website)
A and C	⏚	Symbol for the protective earth conductor, marks the position of the holes via which the M-664 is to be connected to the protective earth conductor
B		Old equipment disposal (p. 51)
B	CE	CE conformity mark
B	⚠	Warning sign "Observe manual!"

3.3 Scope of Delivery

Item ID	Quantity	Items
M-664.164	1	PILine® low-profile micropositioning stage with P-664 piezo linear motor, 25 mm, 2.5 N
3487	1	Screw set for fastening the M-664, consisting of: ▪ 6 M3x6 socket-head cap screws ISO 4762 ▪ 1 Allen wrench
MP121EK	1	Short instructions for PILine® stages

3.4 Suitable Controllers

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

➢ To order, contact our customer service department (p. 39).

3.5 Accessories

Order Number	Description
M-664.AP1	▪ Adapter plate for XY mounting of M-664, 4 mm high, including screw set no. 000031236: – 5 M3x4 hex-head cap screws, DIN 7984 – 1 Allen wrench
M-663.AB	▪ Adapter box, MDR to 15-pin Sub-D, for PILine® stages with long cables ▪ M663T0015 Technical Note for adapter box
Extension cables for use with the M-663.AB adapter box:	
M-663.A01 M-663.A03 M-663.A05	Extension cable for PILine®, MDR to 15-pin Sub-D, 1 m Extension cable for PILine®, MDR to 15-pin Sub-D, 3 m Extension cable for PILine®, MDR to 15-pin Sub-D, 5 m Longer cables available on request.

➢ To order, contact our customer service department (p. 39).

3.6 Technical Features

3.6.1 Linear Encoder

The M-664 is equipped with an optical linear encoder. For the resolution, refer to the table in the "Specifications" section (p. 41).

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-664 is equipped with non-contact, Hall-effect limit switches.

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

See "Limit Switch Specifications" (p. 42) for more information.

3.6.3 Reference Point Switch

The M-664 is equipped with a direction-sensing reference point switch, which is located at about the midpoint of the travel range. This sensor transmits a TTL signal that indicates whether the stage is on the positive or negative side of the reference point switch.

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. 42).

4 Unpacking

1. Unpack the M-664 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

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-664 can lead to minor injuries from electric shock.

- Do **not** touch the contacts in the connector of the M-664.

NOTICE

Lubricants, dirt, condensation!

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

- Ensure that the piezomotor of the M-664 does not come into contact with lubricants.
- Keep the M-664 free from dirt and condensation.

NOTICE

Heating up of the M-664 during operation!

The heat produced during operation of the M-664 can affect your application.

- Install the M-664 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-664.

- ➢ Only use original PI parts to connect the M-664 to the controller.
- ➢ If you need longer cables, use the M-663.AB adapter box and an extension cable from PI (p. 27).

INFORMATION

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

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

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

For more information about operational conditions, refer to the "Motor Power" section (p. 44).

5.2 Mounting the M-664 on a Surface and Connecting It to a Protective Earth Conductor

NOTICE

Protruding screw heads!

Protruding screw heads can damage the M-664.

- ➢ 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-664 on an even surface. The recommended evenness of the surface is 10 µm.
- ➢ For applications with great temperature changes:
  Only fasten the M-664 to surfaces that have the same or similar thermal expansion properties as the M-664 (e.g. surfaces made of aluminum).

INFORMATION

The contact of the M-664 with the protective earth conductor is made as follows:

- Four mounting holes in the base body of the M-664, marked with the ⏚ symbol for the protective earth conductor
- Suitable conductive screws (p. 11)
- Protective earth conductor connected to the surface on which the M-664 is mounted

INFORMATION

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

INFORMATION

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

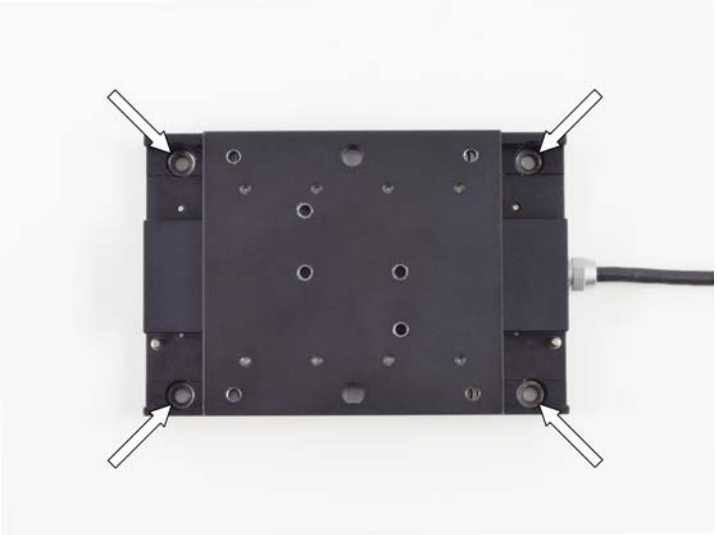


Figure 3: M-664.164: Counter-sunk holes in the base body (see arrows)

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. 48).
  - The surface must be connected to the protective earth conductor.
  - Four M3 holes are present.
  - The holes for accommodating the screws have to be sufficiently conductive to ensure the proper functioning of the protective earth conductor.
  - The evenness of the surface is ≤10 µm.
  - For applications with great temperature changes: The surface should have the same or similar thermal expansion properties as the M-664 (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-664 is **not** connected to the controller.

Tools and accessories

- Suitable protective earth conductor: Cross-sectional area of the cable ≥0.75 mm^2
- Mounting accessories in the scope of delivery (p. 11):
  - 4 M3x6 screws
  - Allen wrench

Mounting the M-664 on a surface and connecting it to the protective earth conductor

1. Manually displace the moving platform of the M-664 until the four counter-sunk holes in the base body are accessible (see figure).
2. Align the M-664 on the surface so that the corresponding holes in the M-664 and the surface overlap.
3. Introduce the four screws into the counter-sunk holes in the base body of the M-664.
4. Tighten the screws with a torque of 120 Ncm each.
5. Ensure that the screw heads do not protrude from the counter-sunk holes.
6. Make sure that the contact resistance is <0.1 Ω at 25 A at all connection points relevant for mounting the protective earth conductor.
7. Check that the M-664 fits on the surface without backlash.
8. If necessary, secure the screws with a thread-locking adhesive.

5.3 Affixing the Load to the M-664

NOTICE

Impermissibly high forces and torques!

Impermissibly high forces and torques that are applied to the moving platform can damage the stage.

- ➢ For affixing type and mass of the load, observe the maximum permissible forces according to the specifications (p. 41).
- ➢ When the motion axis of the stage is oriented vertically, ensure that the installed load is lower than the holding force of the drive (see "Data Table" (p. 41) and "Influence of Downtimes on the Static Holding Force", p. 47).
- ➢ Avoid tilting torques at the moving platform.

NOTICE

Screws that are too long!

The M-664 can be damaged by screws that are too long.

- ➢ Note the depth of the mounting holes in the moving platform (p. 48).
- ➢ Only use screws of the correct length for the respective mounting holes.

INFORMATION

With a vertically oriented motion axis, the M-664 can reliably move a maximum load of 100 g without gravity compensation. The velocity is correspondingly reduced; see "Velocity and Dynamic Force" (p. 45).

For operating M-664 with a vertically oriented motion axis and load >100 g:

- ➢ Mount a suitable gravity compensation. Contact our customer service department (p. 39) for details on gravity compensation.

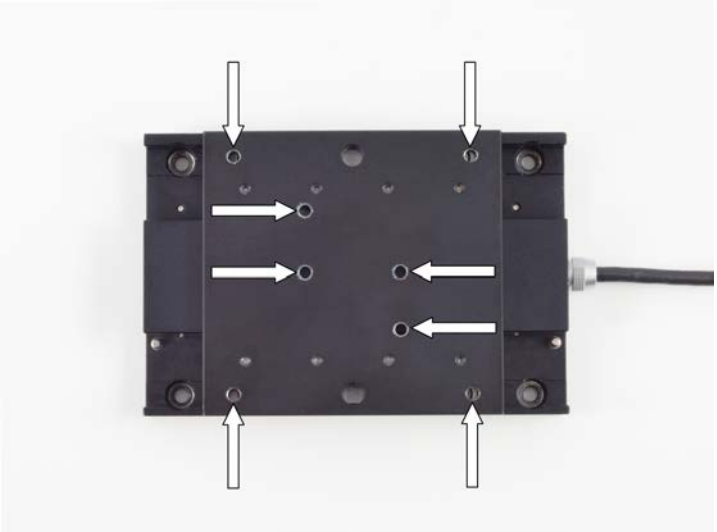


Figure 4: M-664.164: M3 holes for affixing a load (see arrows)

Prerequisite

- ✓ You have read and understood the General Notes on Installation (p. 17).
- ✓ You have properly mounted the M-664 on a surface.
- ✓ The M-664 is **not** connected to the controller.
- ✓ You have prepared the load so that it can be affixed to the mounting holes on the moving platform:
  - The distance between the center of gravity of the load and the center of the moving platform is as small as possible in all directions.
  - At least three points are provided for affixing the load on the moving platform.

Tools and accessories

- At least three M3 screws of suitable length (p. 48)
- Suitable tools for fastening the screws

Affixing the load

1. Align the load on the M-664 so that the mounting holes in the load and the moving platform overlap.
2. Affix the load with at least three screws.
3. Check that the load fits on the moving platform of the M-664 without backlash.

5.4 Setting Up a Multi-Axis System

Two M-664 can be used in multi-axis systems.

Typical combinations:

- XY system (p. 25) as a stacked system

➢ For combination possibilities with other stages, contact our customer service department (p. 39).

5.4.1 General Information on Setting Up a Multi-Axis System

NOTICE

Impermissibly high forces and torques!

Impermissibly high forces and torques that are applied to the moving platforms of the stages in a multi-axis system can damage the stages.

➢ Include the masses of the moved stages and the mounting adapters (p. 12) in the calculation of the load to be moved.

➢ For the mounting type and mass of the load, observe the maximum permissible forces according to the specifications for the individual stages.

➢ Avoid tilting torques on the moving platforms: Make sure that 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 for the individual stages.

➢ When the motion axis of the stage is oriented vertically, ensure that the installed load is lower than the holding force of the drive.

NOTICE

Screws that are too long!

Screws that are inserted too deeply can damage the lower stage.

➢ Observe the depth of the mounting holes in the moving platform of the lower stage.

➢ Only use screws of the correct length for the respective mounting holes.

➢ 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. 39).

5.4.2 Setting Up an XY System

Two linear positioning stages can be stacked to form an XY system as shown below:

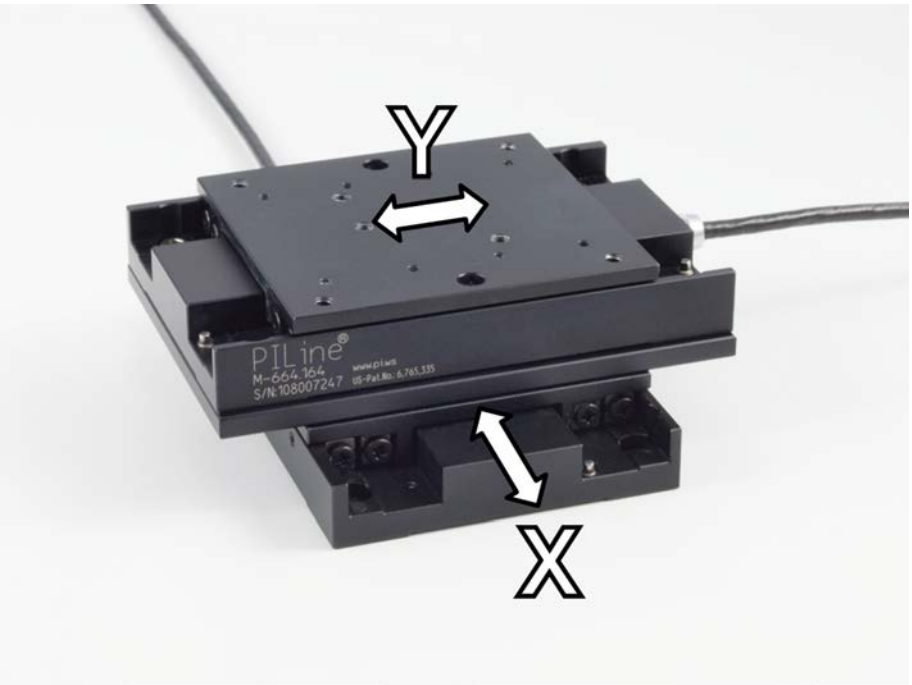


Figure 5: Stacked XY system, consisting of two M-664.164 and an M-664.AP1 adapter plate

Prerequisite

- ✓ You have read and understood the General Notes on Installation (p. 17).
- ✓ You have read and understood the general notes on setting up a multi-axis system (p. 24).

Tools and accessories for combining two M-664

- M-664.AP1 adapter plate and 4 included M3x4 screws (p. 12)
- Mounting accessories in the scope of delivery of the M-664 (p. 11):
  - 4 M3x6 screws
  - Allen wrench

Affixing an M-664 to an M-664

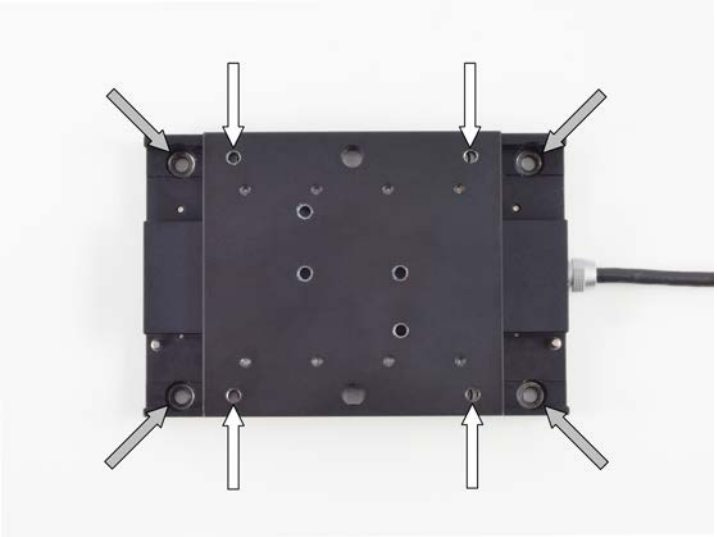


Figure 6: Threaded holes for affixing the adapter plate (white arrows) and counter-sunk holes in the base body (gray arrows)

Figure 7: M-664.164 with affixed M-664.AP1 adapter plate

1. Affix the adapter plate to the lower M-664:
   a) Position the adapter plate on the moving platform of the lower M-664:
   – Orientation as in the figure
   – Counter-sunk holes in the adapter plate and corresponding holes in the moving platform (see white arrows in the figure) overlap
   b) Introduce the four M3x4 screws into the counter-sunk holes of the adapter plate.
   c) Tighten the screws.
   d) Ensure that the screw heads do not protrude from the counter-sunk mounting holes.
2. Affix the upper M-664 to the adapter plate:
   a) If necessary: Manually displace the moving platform of the upper M-664 until all four counter-sunk holes in the base body are accessible (see gray arrows in the figure).
   b) Position the upper M-664 on the adapter plate so that the corresponding holes in the stage and the adapter plate overlap. For a different orientation of the cable exit, it is possible to rotate the stage by 180°.
   c) Introduce the four M3x6 screws into the counter-sunk holes in the base body of the upper M-664.
   d) Tighten the screws.
   e) Ensure that the screw heads do not protrude from the counter-sunk mounting holes.

5.5 Connecting the Extension Cable

Prerequisites

- ✓ You have read and understood the General Notes on Installation (p. 17).
- ✓ The controller is **switched off**.
- ✓ You have connected the M-664 to the protective earth conductor (p. 19).

Tools and accessories

- M-663.AB adapter box*, MDR14 to Sub-D 15-pin, for PILine® stages with long cable
- Extension cable* for PILine®, MDR14 to Sub-D 15-pin, 1 to 5 m

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

Connecting the extension cable

- Connect the M-664 ("stage") and controller via the adapter box and the extension cable as shown in the connection diagram below.
  - Observe the assignment that is given by the labeling on the sockets, connectors and cables.

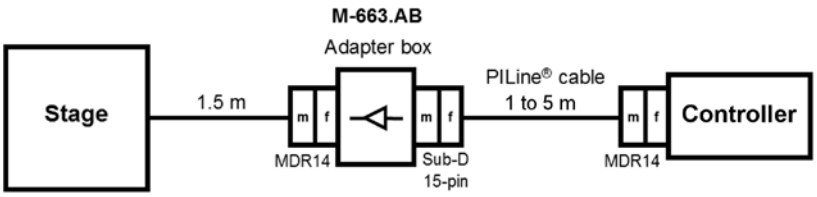


Figure 8: Connection of an extension cable

6 Start-Up and Operation

In this Chapter

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-664 in the case of malfunction or failure of the system. If touch voltages exist, touching the M-664 can result in minor injuries from electric shock.

- Connect the M-664 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-664 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-664.

- Only operate the M-664 with controllers/drivers and original accessories from PI.
- Do **not** exceed the operating voltage range (p. 43) for which the M-664 is specified.
- Only operate the M-664 when the operating voltage is properly connected; see "Pin Assignment" (p. 50).

NOTICE

Unintentional motions!

When the M-664 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-664, 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 stage, the load to be moved and the environment.

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

NOTICE

Uncontrolled oscillation!

Your application can be damaged by uncontrolled oscillation of the M-664.
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 platform with the hard stop!

The collision of the moving platform of the M-664 with the hard stop can lead to damage or considerable wear on the M-664.

- 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 axis moves with low velocity.
  - Stop the axis 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-664 may overheat during continuous operation.

- Observe the recommended motor power depending on the duty cycle and the ambient temperature (p. 46).

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. 44).

INFORMATION

Although in theory the M-664 operates quietly, noise levels of up to 50 dB (A) are possible during operation. The ultrasonic drive of the M-664 can also generate higher noise levels at frequencies between 100 and 500 kHz.

INFORMATION

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

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-664 and after longer downtimes; see also "Influence of Downtimes on the Static Holding Force" (p. 47). After run-in, the M-664 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. 44).

6.2 Starting Up the M-664 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-664 can be loaded from a stage database. The stage *PIStages2.dat* database contains the default parameter values of your 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 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-664 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. 29).
- ✓ 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-664 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-664 with the C-867 controller

- Start up the axis (see C-867 User Manual).
  The start-up involves the following steps:
  - Selecting the stage type
  - 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.

7 Maintenance

In this Chapter

7.1 General Notes on Maintenance

NOTICE

Damage due to improper maintenance!

Improper maintenance can result in the failure of the M-664.

- Only loosen screws according to the instructions in this manual.
- Ensure that the piezomotor of the stage does 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-664, the following maintenance measures are required:

Maintenance run

The maintenance run is performed to distribute the existing lubricant on the guidings of the M-664.

- To evenly distribute the existing lubricant on the stage guidings, perform a run across the entire travel range after 500 hours of operation or after 1 year at the latest.
- If you move the M-664 continuously over a small working range (<20 % of the entire travel range) in industrial operation, perform a run across the entire travel range every 5000 motion cycles.

Lubrication

Under laboratory conditions, the guidings of the M-664 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-664 without consulting our customer service department (p. 39).
- To lubricate the guidings, follow the instructions given in the maintenance manual which you can obtain from our customer service department.
- Ensure that the piezomotor of the M-664 does not come into contact with lubricants.

7.3 Cleaning the M-664

Prerequisites

- ✓ You have disconnected the stage from the controller.

Cleaning the stage

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

8 Troubleshooting

Problem	Possible Causes	Solution
Noise during operation	Uncontrolled oscillation of the M-664	➢ Immediately switch off the servo-control system of the affected axes. ➢ Check the settings of the servo-control parameters.
stage positions inaccurately	Settling window around the target position is too large	➢ 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	➢ 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	➢ Mount the M-664 on an even surface. The recommended evenness of the surface is 10 µm. ➢ For applications with great temperature changes: Only mount the M-664 on surfaces that have the same or similar thermal expansion properties as the M-664 (e.g. surfaces made of aluminum).
With a vertically oriented motion axis: No or limited motion	Excessive load	➢ Reduce the load to a maximum of 100 g. For operating M-664 with a vertically oriented motion axis and load >100 g: ➢ Mount a suitable gravity compensation. Contact our customer service department (p. 39) for details on gravity compensation.

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. 39).

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

10.1 Specifications

10.1.1 Data Table

	M-664.164	Tolerance
Active axes	X	
Motion and positioning		
Travel range	25 mm	
Integrated sensor	Linear encoder	
Sensor resolution	0.1 µm	
Min. incremental motion	0.6 µm	typ.
Bidirectional repeatability	±1 µm	typ.
Unidirectional repeatability	±0.2 µm	typ.
Pitch	±75 µrad	typ.
Yaw	±50 µrad	typ.
Velocity	400 mm/s	max.
Reference point switch repeatability	1 µm	typ.
Mechanical properties		
Load capacity	25 N	max.
Push / pull force	2.5 N	max.
Holding force	2.5 N	max.
Drive properties		
Motor type	P-664 PILine® Ultrasonic Piezo Drive	
Limit and reference point switches	Hall-effect	

Miscellaneous	M-664.164	Tolerance
Operating temperature range	0 to 50 °C	
Material	Al (black anodized)	
Dimensions	90 mm x 60 mm x 15 mm	
Mass	0.225 kg	±5 %
Cable length	1.5 m	±10 mm
Connector	MDR, 14-pin	
Recommended controller / driver	C-867 controller / driver	

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: – Normal motor operation: low (0 V) – Limit switch reached: high (+5 V)

10.1.3 Reference Point Switch Specifications

Type	Magnetic (Hall-effect) 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 0.4 mm (when arriving from the positive or negative direction)

10.1.4 Maximum Ratings

M-664 stages are designed for the following operating parameters:

Device	Maximum Operating Voltage 	Operating Frequency 	Maximum Power Consumption 
M-664	200 V_{pp} or 71 V_{rms}	152 to 165 kHz	15 W

10.2 Ambient Conditions and Classifications

The following ambient conditions and classifications must be observed for the M-664:

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	0 °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-664. 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-664 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. 11) used to operate the M-664.

10.3.2 Velocity and Dynamic Force

The following figure can be used to estimate the velocity and force of the M-664 with different motor power levels.

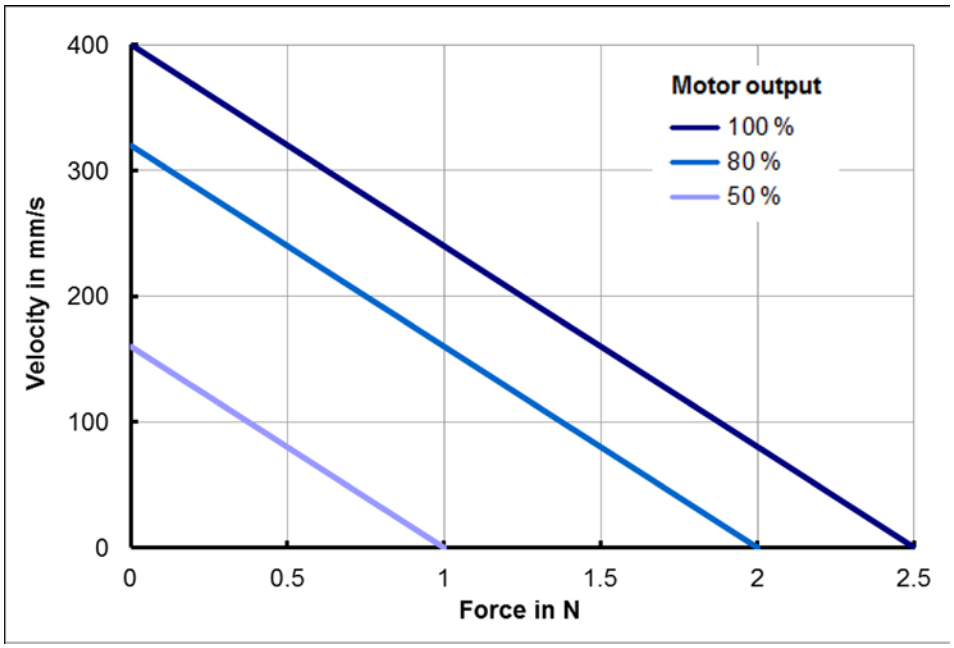


Figure 9: Velocity of the M-664 vs. dynamic force (push/pull force) with different motor power levels

10.3.3 Motor Power and Lifetime

Motor power, duty cycle and ambient temperature influence the lifetime of the 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.

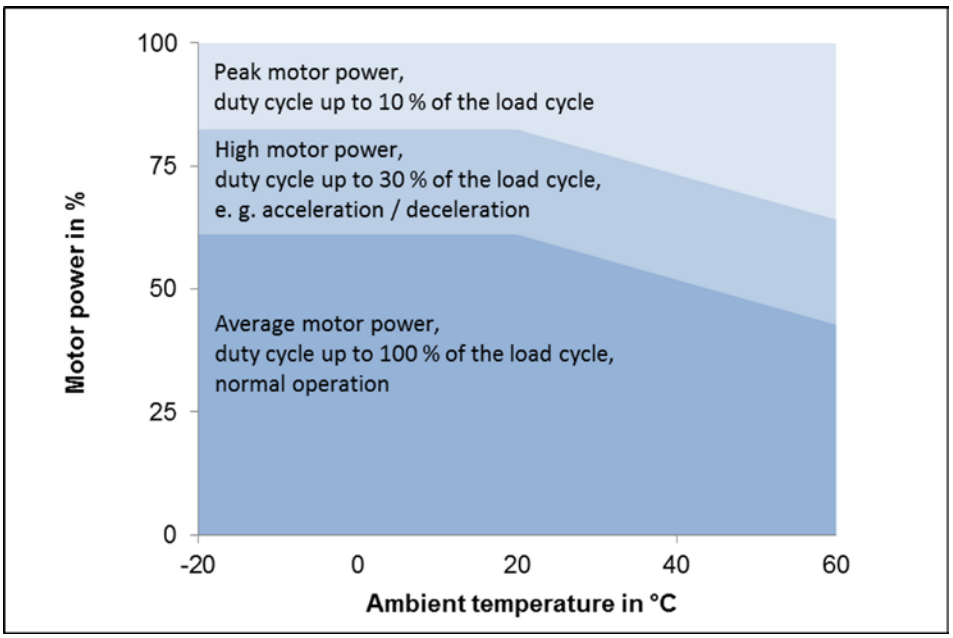


Figure 10: M-664: Recommended duty cycle and motor power depending on the ambient temperature

10.3.4 Influence of Downtimes on the Static Holding Force

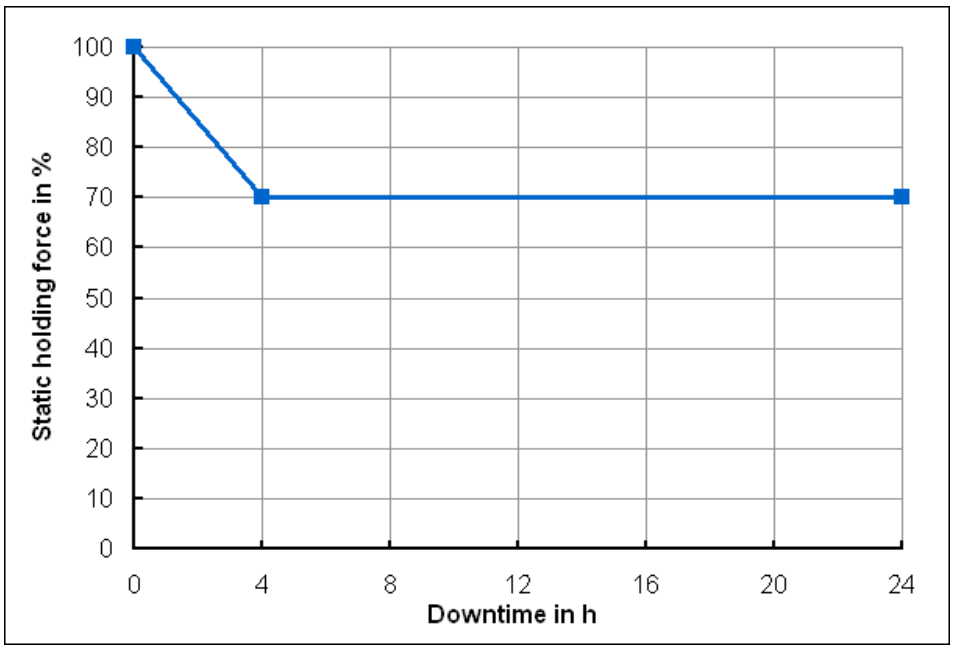


Figure 11: Static holding force of the M-664 depending on the downtime of the motor

10.4 Dimensions

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

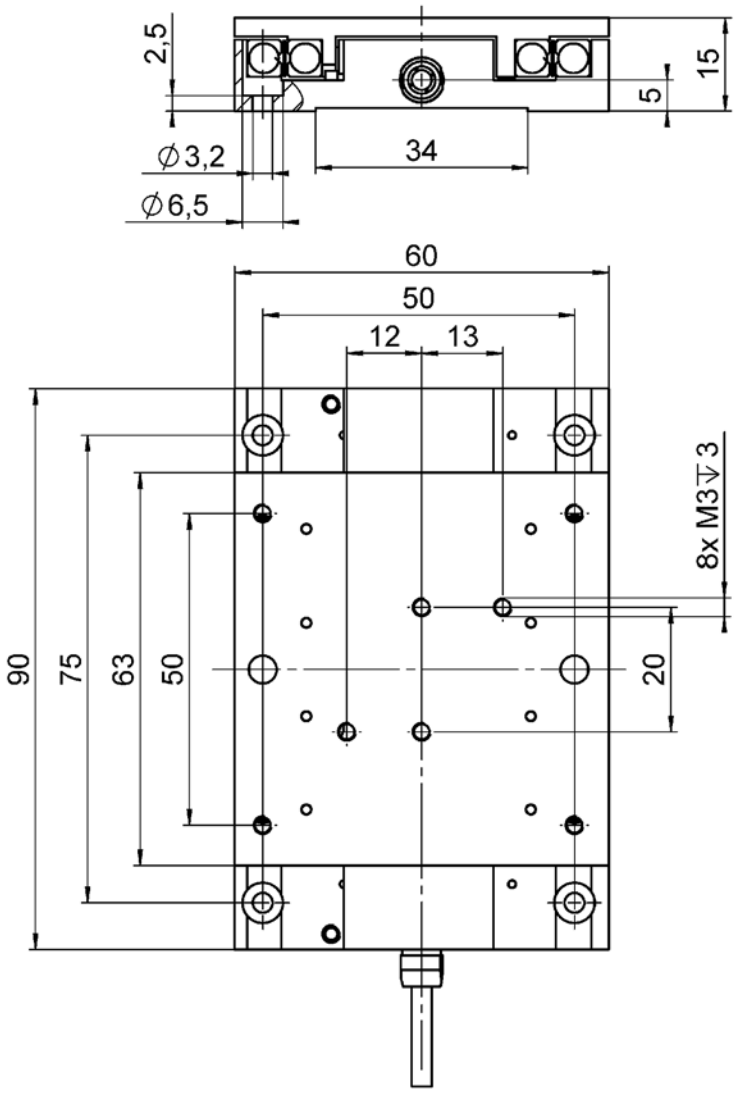


Figure 12: M-664.164

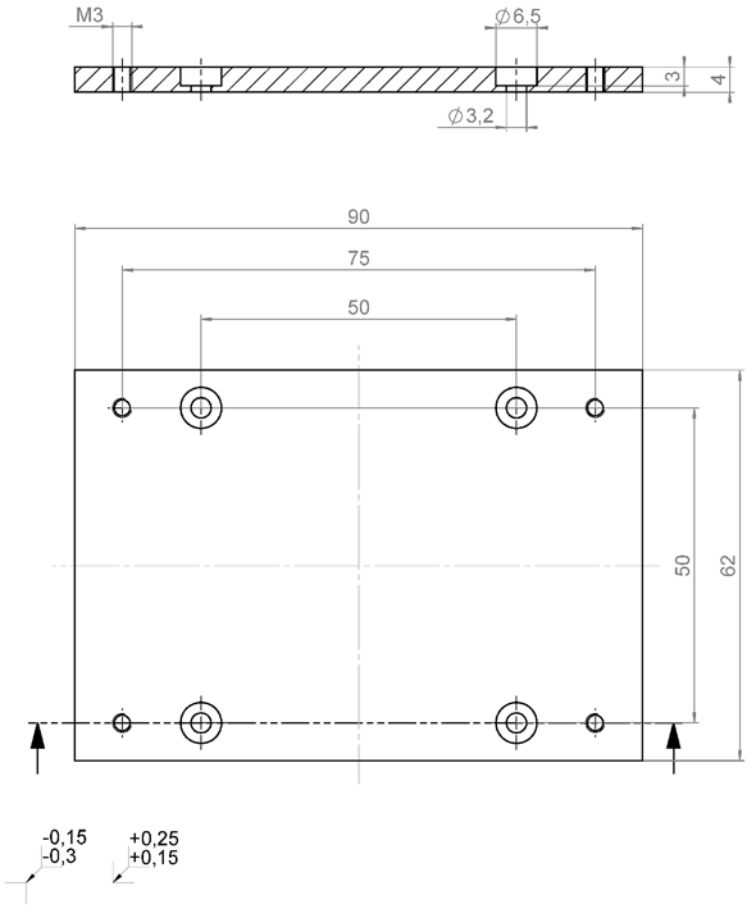


Figure 13: M-664.AP1 adapter plate

10.5 Pin Assignment

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

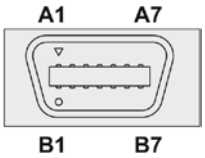


Figure 14: Front view of the MDR14 connector

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.

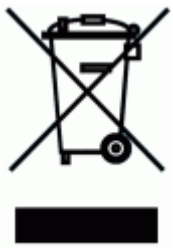
To meet the manufacturer's product responsibility with regard to this product, Physik Instrumente (PI) GmbH & Co. KG ensures environmentally correct disposal of old PI equipment that was first put into circulation after 13 August 2005, free of charge.

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

PI

Declaration of Conformity

according to DIN EN ISO/IEC 17050-1:2005

Manufacturer: **Physik Instrumente (PI) GmbH & Co. KG**

Manufacturer's Address: Auf der Roemerstrasse 1
D-76228 Karlsruhe,
Germany

CE

The manufacturer hereby declares that the product

Product Name: **PILine® Micropositioning Stage**

Model Numbers: **M-664**

Product Options: **all**

complies with all relevant provisions of the **Machinery Directive (2006/42/EC)**.
Furthermore, it complies with all provisions of the **EMC Directive (2004/108/EC)** as well as the **RoHS Directive (2011/65/EC)**.

The applied standards certifying the conformity are listed below.

Safety of Machinery:	EN 12100:2010
Electrical Safety:	EN 61010-1:2010
EMC:	EN 61326-1:2013
RoHS:	EN 50581:2012

The person authorized to compile the technical file is: Martin Schmack
Address: see manufacturer's address

November 20, 2013
Karlsruhe, Germany

Norbert Ludwig
Managing Director

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