This document describes the following product:

- **M-687.UL**
  XY stage for inverted Leica microscopes, 135 mm × 85 mm, self-locking, PILine® linear drives, 0.1 µm resolution
The following company names and brands are registered trademarks of Physik Instrumente (PI) GmbH & Co. KG:

PI®, NanoCube®, PICMA®, PIFOC®, PILine®, NEXLINE®, PiezoWalk®, PicoCube, PiezoMove, PIMikroMove, NEXACT®, Picoactuator®, Plnano®, NEXSHIFT, PITOUCH, PIMag®, PIHera, Q-Motion®

PI owns the following patents or patent applications in the field of ultrasonic piezo motor technology (PILine®):


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


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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 This manual is superseded by any new release.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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1.1 Objective and Target Audience of this User Manual

This manual contains information necessary for the intended use of the M-687.UL.
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.
1 About this Document

---

INFORMATION

Information for easier handling, tricks, tips, etc.

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

1.3 Definition

<table>
<thead>
<tr>
<th>Term</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load capacity</td>
<td>Maximum load capacity in the vertical direction when the XY stage is mounted horizontally. The contact point of the load is in the center of the platform.</td>
</tr>
<tr>
<td>Linear encoder</td>
<td>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.</td>
</tr>
</tbody>
</table>

1.4 Figures

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

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

<table>
<thead>
<tr>
<th>Description</th>
<th>Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-867.1U PILine® controller</td>
<td>MS223E user manual</td>
</tr>
<tr>
<td>PI MikroMove</td>
<td>SM148E software manual</td>
</tr>
<tr>
<td>PILine® stage</td>
<td>MP121EK short instructions</td>
</tr>
</tbody>
</table>

1.6 Downloading Manuals

**INFORMATION**

If a manual is missing or problems occur with downloading:

- Contact our customer service department (p. 31).

**INFORMATION**

For products that are supplied with software (CD in the scope of delivery), access to the manuals is protected by a password. Protected manuals are only displayed on the website after entering the password.

The password is included on the CD of the product.

**For products with CD: Identify the password**

1. Insert the product CD into the PC drive.
2. Switch to the Manuals directory on the CD.
3. In the Manuals directory, open the Release News (file including `releasenews` in the file name).
4. Find the user name and the password in the section "User login for software download" in the Release News.

**Downloading manuals**

1. Open the website [www.pi.ws](http://www.pi.ws).
2. If access to the manuals is protected by a password:
   a) Click Login.
   b) Log in with the user name and password.
3. Click *Search*.  
4. Enter the product code up to the period (e.g., P-882) or the product family (e.g., PICMA® Bender) into the search field.  
5. Click *Start search* or press the *Enter* key.  
6. Open the corresponding product detail page in the list of search results:  
   a) If necessary: Scroll down the list.  
   b) If necessary: Click *Load more results* at the end of the list.  
   c) Click the corresponding product in the list.  
7. Scroll down to the *Downloads* section on the product detail page.  
   The manuals are displayed under *Documentation*.  
8. Click the desired manual and save it to the hard disk of your PC or to a data storage medium.
2 Safety

In this Chapter

Intended Use.................................................................................................................................. 5
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2.1 Intended Use

The M-687.UL is a laboratory device as defined by DIN EN 61010-1. 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-687.UL is intended for positioning, adjusting and moving loads on two axes at different velocities in interval operation. The M-687.UL is not intended for applications in areas, in which a failure would present severe risks to human beings or the environment.

The M-687.UL is only intended for horizontal mounting.

The intended use of the M-687.UL is only possible when completely mounted and connected.

The M-687.UL PILine® uses ultrasonic piezo linear motors as a drive and must be operated with a suitable controller (p. 9).

2.2 General Safety Instructions

The M-687.UL 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-687.UL.

- Only use the M-687.UL 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-687.UL.
Piezomotors are driven by piezo actuators. After disconnection from the electronics, piezo actuators can remain electrically charged for several hours. Temperature changes can also induce charges in piezo actuators. Touching charged parts of the M-687.UL can result in minor injuries from electric shock.

- Do not open the M-687.UL.
- Do not touch the contacts in the connection sockets of the M-687.UL.
- If a connecting cable is connected to the M-687.UL, do not touch the contacts in the connection plug.

If a protective earth conductor is not or not properly connected, dangerous touch voltages can occur on the M-687.UL in the case of malfunction or failure of the system. If touch voltages exist, touching the M-687.UL can result in minor injuries from electric shock.

- Connect the M-687.UL to a protective earth conductor (p. 14) 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-687.UL to the protective earth conductor before starting it up again.

Mechanical forces can damage or misalign the M-687.UL.

- Avoid impacts that affect the M-687.UL.
- Do not drop the M-687.UL.
- Do not exceed the maximum permissible stress and load capacities (p. 33).

### 2.3 Organizational Measures

#### User manual

- Always keep this user manual available with the M-687.UL. The latest versions of the user manuals are available for download (p. 3) on our website.
- Add all information from the manufacturer to the user manual, for example supplements or technical notes.
- If you give the M-687.UL to other users, also include 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 damage to equipment.
- Only install and operate the M-687.UL after you have read and understood this user manual.

#### Personnel qualification

The M-687.UL 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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Scope of Delivery .................................................................................................................................. 8
Suitable Controllers ............................................................................................................................ 9
Accessories......................................................................................................................................... 9
Technical Features ............................................................................................................................. 10

3.1 Product View

Figure 1: M-687.UL product view

1 Lower platform (X axis)
2 Upper platform (Y axis)
3 Base body
4 Protective earth connection
5 Connection socket for controller cable (Y axis)
6 Connection socket for controller cable (X axis)

X Directions of motion of the X axis
Y Directions of motion of the Y axis
### 3.2 Product Labeling

<table>
<thead>
<tr>
<th>Labeling</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axis X</td>
<td>Connection socket for controller cable (X axis)</td>
</tr>
<tr>
<td>Axis Y</td>
<td>Connection socket for controller cable (Y axis)</td>
</tr>
<tr>
<td>Symbol</td>
<td>Symbol for the protective earth conductor, marks the protective earth connection of the M-687.UL (p. 14)</td>
</tr>
<tr>
<td>PILine®</td>
<td>Brand name</td>
</tr>
<tr>
<td>M-687.UL</td>
<td>Product name</td>
</tr>
<tr>
<td>116054306</td>
<td>Serial number (example), individual for each M-687.UL</td>
</tr>
<tr>
<td></td>
<td>Meaning of the places (counting from left):</td>
</tr>
<tr>
<td></td>
<td>1 = internal information</td>
</tr>
<tr>
<td></td>
<td>2 and 3 = year of manufacture</td>
</tr>
<tr>
<td></td>
<td>4 to 9 = consecutive numbers</td>
</tr>
</tbody>
</table>

PI Branding, Manufacturer's logo

⚠️ Warning sign "Observe manual!"

 gammes Old equipment disposal (p. 39)

Country of origin: Germany Country of origin

WWW.PI.WS Manufacturer's address (website)

CE CE conformity mark

### 3.3 Scope of Delivery

<table>
<thead>
<tr>
<th>Item number</th>
<th>Quantity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-687.UL</td>
<td>1</td>
<td>XY stage for inverted Leica microscopes, 135 mm × 85 mm, self-locking, PILine® linear drives, 0.1 µm resolution</td>
</tr>
<tr>
<td>000036450</td>
<td>1</td>
<td>M4 screw set for protective earth, consisting of:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 flat-head screw with cross recess, M4x8 ISO 7045</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 safety washers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 flat washers</td>
</tr>
<tr>
<td>000041912</td>
<td>1</td>
<td>Screw set for mounting the M-687.UL, consisting of:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 socket head cap screws, M4x16 ISO 4762</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 hex key</td>
</tr>
<tr>
<td>MP121EK</td>
<td>1</td>
<td>Short instructions for the PILine® stage</td>
</tr>
</tbody>
</table>
Also in the scope of delivery when the M-687.UL is part of the U-780.DLS system:

<table>
<thead>
<tr>
<th>Item number</th>
<th>Quantity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-867.2U2</td>
<td>1</td>
<td>Piezomotor controller / driver, networkable, 2 channels, for PILine® systems (for scope of delivery, see documentation of the controller)</td>
</tr>
<tr>
<td>U-600.AMD</td>
<td>2</td>
<td>PILine® adapter cable MDR 14 (m) to Sub-D 15 (m), 1.5 m, for connecting the XY stage to the controller</td>
</tr>
<tr>
<td>C-819.JD</td>
<td>1</td>
<td>Digital joystick for 2 axes, 3 programmable buttons</td>
</tr>
</tbody>
</table>

### 3.4 Suitable Controllers

<table>
<thead>
<tr>
<th>Product code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-867.2U2</td>
<td>Piezomotor controller / driver, networkable, 2 channels, for PILine® systems</td>
</tr>
</tbody>
</table>

➢ To order, contact our customer service department (p. 31).

### 3.5 Accessories

<table>
<thead>
<tr>
<th>Order number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-561 to P-563</td>
<td>PIMars XYZ nanopositioning systems with up to 300 µm travel</td>
</tr>
<tr>
<td>P-541.2 and P-542.2</td>
<td>Low-profile XY scanners for microscopy</td>
</tr>
<tr>
<td>P-541.Z</td>
<td>Low-profile Z tip/tilt piezo nanopositioning stages for microscopy</td>
</tr>
<tr>
<td>P-545.2R8S</td>
<td>PInano® XY piezo system, clear aperture for microscope slides, 200 µm × 200 µm, piezoresistive sensors, with USB digital controller</td>
</tr>
<tr>
<td>P-545.3R8S</td>
<td>PInano® XYZ piezo system, clear aperture for microscope slides, 200 µm × 200 µm × 200 µm, piezoresistive sensors, with USB digital controller</td>
</tr>
<tr>
<td>P-737.1SL</td>
<td>PIFOC® nanofocusing stage for microscope sample holder, 100 µm, SGS, LEMO connector(s)</td>
</tr>
<tr>
<td>P-737.2SL</td>
<td>PIFOC® nanofocusing stage for microscope sample holder, 250 µm, SGS, LEMO connector(s)</td>
</tr>
<tr>
<td>M-687.AP1</td>
<td>Universal holder for microscope slides and Petri dishes for PI stages with 160 mm × 110 mm clear aperture</td>
</tr>
</tbody>
</table>

➢ To order, contact our customer service department (p. 31).
3.6 Technical Features

3.6.1 Linear Encoder

The M-687.UL is equipped with one optical linear encoder per axis. For the encoder resolution, refer to the table in the "Specifications" section (p. 33).

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-687.UL 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 XY stage runs into the hard stop.

See "Limit Switch Specifications" (p. 34) for more information.

3.6.3 Reference Point Switch

The M-687.UL 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 that make use of the reference point signal.

For more information, see "Reference Point Switch Specifications" (p. 34).
4 Unpacking

**NOTICE**

Motion platform slips and collides with the hard stop!
When the M-687.UL is oriented vertically, the motion platforms can slip and collide with the hard stop. A collision of a motion platform with the hard stop can cause damage to the M-687.UL.

- Make sure that the M-687.UL is always horizontal.
- If the M-687.UL must be brought to a vertical position during installation, secure the motion platforms against slipping.

1. Unpack the M-687.UL with care.
2. Compare the contents with the items listed in the contract and the packing list.
3. Inspect the contents for signs of damage. If parts are missing or you notice signs of damage, contact PI immediately.
4. Keep all packaging materials in case the product needs to be returned.
5 Installation

In this Chapter

General Notes on Installation ................................................................. 13
Connecting the M-687.UL to the Protective Earth Conductor ....................... 14
Mounting the M-687.UL on a Surface ....................................................... 15
Affixing a Stage to the M-687.UL .............................................................. 17
Inserting and Removing the Universal Holder ........................................... 18
Connecting the M-687.UL to the Controller ............................................ 19

5.1 General Notes on Installation

CAUTION

Dangerous voltage and residual charge in piezo actuators!
Piezomotors are driven by piezo actuators. After disconnection from the electronics, piezo actuators can remain electrically charged for several hours. Temperature changes can also induce charges in piezo actuators. Touching or short-circuiting the contacts in the connection sockets of the M-687.UL can lead to minor injuries from electric shock.

➢ Do not touch the contacts in the connection sockets of the M-687.UL.
➢ If a connecting cable is connected to the M-687.UL, do not touch the contacts in the connection plug.

NOTICE

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

➢ Ensure that the piezomotors of the M-687.UL do not come into contact with lubricants.
➢ Keep the M-687.UL free from dirt and condensation.

NOTICE

Heating up of the M-687.UL during operation!
The heat produced during operation of the M-687.UL can affect your application.

➢ Install the M-687.UL so that your application is not affected by the dissipating heat.
NOTICE

Unsuitable cables!
Unsuitable cables can cause damage to the controller and affect the performance of the M-687.UL.

- Only use genuine PI parts to connect the M-687.UL to the controller.
- If you need longer cables, contact our customer service department (p. 31).

5.2 Connecting the M-687.UL to the Protective Earth Conductor

INFORMATION

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

There is an M4 hole in the M-687.UL for connecting the protective earth conductor. This hole is marked with the protective earth symbol ⬤. The position of the hole is shown in the product view (p. 7).

![Diagram](image1.png)

Figure 2: Connecting the protective earth conductor (profile view)

1 Lower platform of the M-687.UL
2 Flat washer
3 Safety washer
4 Screw
5 Cable lug
6 Protective earth conductor

Requirements

- You have read and understood the general notes on installation (p. 13).
- The M-687.UL is not connected to the controller.
Tools and accessories

- Suitable protective earth conductor: Cross-sectional area of the cable ≥0.75 mm²
- M4 screw set supplied for the connecting the protective earth conductor (p. 8)
- Suitable screwdriver

Connecting the M-687.UL to the protective earth conductor

1. If necessary, attach a suitable cable lug to the protective earth conductor.
2. Use the M4 screw (together with the washers and self-locking washers) to affix the cable lug of the protective earth conductor to the protective earth connection of the M-687.UL 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 connecting the protective earth conductor is <0.1 Ω at 25 A.

5.3 Mounting the M-687.UL onto a Surface

**NOTICE**

Protruding screw heads!
Protruding screw heads can damage the M-687.UL.
- Ensure that the screw heads do not protrude from countersunk 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-687.UL on an even surface. The recommended evenness of the surface is 5 µm.
- For applications with large temperature changes:
  Only affix the M-687.UL to surfaces that have the same or similar thermal expansion properties as the M-687.UL (e.g., surfaces made of aluminum).

**INFORMATION**

The directions of motion of the M-687.UL are indicated in the product view (p. 7).
Figure 3: M-687.UL: Mounting holes in the base body

The exact position of the holes is specified in the dimensional drawing in the "Dimensions" (p. 36) section.

Requirements

✓ You have read and understood the general notes on installation (p. 13).

Tools and accessories

- 000041912 screw set (p. 8)

Mounting the M-687.UL on a surface

1. Move the motion platforms of the M-687.UL by hand until all countersunk holes in the base body are accessible (see figure above).
2. Affix the stage with three of the M4 screws supplied.
3. Make sure that the screw heads do not protrude from the countersunk holes.
5.4 Affixing a Stage to the M-687.UL

**NOTICE**

**Impermissibly high load on the XY stage!**
An impermissibly high load impairs the motion of the platforms and can damage the XY stage.
- For mounting type and mass of the load, observe the maximum permissible forces that, according to the specification (p. 33), are allowed to act on the motion platforms.

**NOTICE**

**Screws that are too long!**
The M-687.UL can be damaged by screws that are too long.
- Note the depth of the mounting holes in the upper platform (p. 36).
- Only use screws of the correct length for the respective mounting holes.

**Requirements**

- You have read and understood the general notes on installation (p. 13).
- The M-687.UL and the stage to be mounted are **not** connected to the respective controller.

**Tools and accessories**

- Screws of appropriate size and length:

<table>
<thead>
<tr>
<th>Stage</th>
<th>Suitable screws</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-561 to P-563</td>
<td>M6x30</td>
</tr>
<tr>
<td>P-541.2 and P-542.2</td>
<td>M6x16</td>
</tr>
<tr>
<td>P-541.Z</td>
<td>M6x16</td>
</tr>
<tr>
<td>P-545.2R8S</td>
<td>M4x20</td>
</tr>
<tr>
<td>P-545.3R8S</td>
<td>M4x20</td>
</tr>
<tr>
<td>P-737.1SL</td>
<td>M2.5x10</td>
</tr>
<tr>
<td>P-737.2SL</td>
<td>M2.5x10</td>
</tr>
</tbody>
</table>

- Suitable tools for tightening the screws
Mounting a stage on the M-687.UL

1. Select the mounting position so that the threaded holes in the upper platform (see figure above) can be used for affixing the stage.

2. Affix the stage to the threaded holes with the specified screws (see "Tools and accessories"). Depending on the stage model to be mounted, use three or four screws.

5.5 Inserting and Removing the Universal Holder

The M-687.AP1 universal holder for microscope slides and Petri dishes can be inserted into the clear aperture (160 mm × 110 mm) of the M-687.UL.

Figure 4: M-687.UL: Threaded holes in the upper platform (hatched arrows = 8 × M4; black arrows = 4 × M6; gray arrows = 3 × M4)

Figure 5: M-687.AP1 universal holder
Tools and accessories
- M-687.AP1 universal holder, available as optional accessory (p. 9)

Inserting the universal holder into the aperture
1. Align the universal holder so that the red dot on the holder points in the direction of the clip spring of the aperture (see figures above).
2. On the side of the clip spring, place the short edge of the universal holder at a flat angle in the middle of the aperture so that it makes contact on two sides.
3. Slowly slide the universal holder towards the clip spring until it reaches the edge and the clip spring is compressed.
4. On the opposite side, press the universal holder slowly down until it snaps in completely.
   The universal holder is now clamped firmly.

Removing the universal holder from the aperture
> Slowly pull the universal holder on one side upwards until it releases.

5.6 Connecting the M-687.UL to the Controller

Requirements
✓ You have read and understood the general notes on installation (p. 13).
✓ You have read and understood the user manual of the controller (p. 3).
✓ The controller is *switched off*.
✓ You have connected the M-687.UL to the protective earth conductor (p. 14).

Tools and accessories
- Two U-600.AMD adapter cables (p. 8)
Connecting the M-687.UL to the controller

1. Connect the MDR connector (m) of the first cable to the Axis X socket of the XY stage.
2. Connect the Sub-D connector (m) at the other end of the cable to the Axis 1 socket of the controller.
3. Connect the MDR connector (m) of the second cable to the Axis Y socket of the XY stage.
4. Connect the Sub-D connector (m) at the other end of the cable with the Axis 2 socket of the controller.
6 Start-Up and Operation

In this Chapter

General Notes on Start-Up and Operation ........................................................................................................... 21
Starting Up the M-687.UL with the C-867 Controller .......................................................................................... 24

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-687.UL in the case of malfunction or failure of the system. If touch voltages exist, touching the M-687.UL can result in minor injuries from electric shock.

- Connect the M-687.UL to a protective earth conductor (p. 14) 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-687.UL 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-687.UL.

- Only operate the M-687.UL with controllers/drivers and original accessories from PI.
- Do not exceed the operating voltage range (p. 34) for which the M-687.UL is specified.
- Only operate the M-687.UL when the operating voltage is properly connected; see "Pin Assignment" (p. 37).
6 Start-Up and Operation

NOTICE

Unintentional motion!
Unintentional motion of the stage is possible when connecting the M-687.UL to the controller. Defective software or wrong operation of the software can also result in unintentional motion.

➢ Do not place any objects in areas where they can be caught by moving parts.
➢ Before connecting the M-687.UL, 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 due to collisions!
Collisions can damage the XY stage, the load to be moved, and the surroundings.

➢ Make sure that no collisions are possible between the XY stage, the load to be moved, and the surroundings in the motion range of the XY stage.
➢ 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

Uncontrolled oscillation!
Your application can be damaged by uncontrolled oscillation of the M-687.UL. 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.
6 Start-Up and Operation

**NOTICE**

Collision of the motion platforms with the hard stop!

Collision of the motion platforms of the M-687.UL with the hard stop can lead to damage or considerable wear on the M-687.UL.

- 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.

**INFORMATION**

Although the M-687.UL operates quietly in theory, noise levels of up to 50 dB (A) are possible during operation. The ultrasonic drive of the M-687.UL 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 due to the automatic direction sensing for reference moves to the reference point switch.

**INFORMATION**

For maximum force generation, a run-in procedure is necessary during the start-up of the M-687.UL and after longer downtimes; see also "Influence of Downtimes on the Static Holding Force" (p. 35). The M-687.UL will generate its maximum dynamic force after the run-in procedure.

- For run-in, command a few motion cycles at low velocity (<50 mm/s) over the entire travel range.

**INFORMATION**

The directions of motion of the M-687.UL are indicated in the product view (p. 7).
6.2 Starting Up the M-687.UL with the C-867 Controller

**NOTICE**

Incorrect parameter settings!

If you use the software that is included in the scope of delivery of the controller (p. 9), the operating parameters of the M-687.UL can be loaded from a stage database. The stage database contains the standard parameter values of the 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 cause damage to the XY stage, especially when operated with heavy loads.

- If possible: Perform the first start-up without a load.
- Perform initial start-up at a low velocity (<50 mm/s).
- Always install the latest version of the stage database on your PC.

For start-up with a load:

- Before start-up, make sure that the M-687.UL has been properly installed (p. 13).
- For optimum performance of the moving axis, adjust the operating parameters of the controller (e.g., P term, I term, D term, acceleration, velocity; see controller manual).
- Save the new parameter values to a stage database on the PC or to the nonvolatile memory of the controller for future use (see controller manual and PIMikroMove manual).

**INFORMATION**

The X and Y axes of the M-687.UL XY stage have different travel ranges. Therefore, for each axis a separate stage type with specially adapted parameters is available in the stage database from which the operating parameters can be loaded.

- In the PC software, assign the suitable stage type to the axes. The cable connections between the XY stage and the controller determine the assignment of the stage type.

If the M-687.UL is part of a preconfigured system, suitable parameter sets are already stored in the controller. In this case, it is not necessary to assign a stage type in the PC software. Default configuration when the C-867.2U2 controller is used:

- For axis 1 of the controller (Axis 1 socket), the parameter set for axis X of the XY stage is stored in the controller.
- For axis 2 of the controller (Axis 2 socket), the parameter set for axis Y of the XY stage is stored in the controller.

- Connect the M-687.UL to the controller with the cables according to the assignments specified in the parameter sets stored in the controller.
6 Start-Up and Operation

Requirements

✓ You have read and understood the general notes on start-up and operation (p. 21).
✓ You have read and understood the user manual of the controller (p. 3).
✓ The M-687.UL is properly installed (p. 13).
✓ The controller (p. 9) and the required software have been installed. All connections on
the controller have been set up (see controller manual).

Starting up the M-687.UL with the C-867 controller

➢ Start up one axis of the M-687.UL (see controller manual) and repeat the procedure for
the second axis.
Start-up involves the following steps:
− Selecting the stage type
− Defining the reference point of the axis
− Commanding initial motion in closed-loop operation for testing and for run-in of the
mechanical system

The controller manual describes start-up using the PIMikroMove program.
7 Maintenance

In this Chapter

General Notes on Maintenance................................................................. 27
Performing a Maintenance Run................................................................. 27
Cleaning the XY Stage ............................................................................. 28

7.1 General Notes on Maintenance

NOTICE

Damage due to improper maintenance!
Improper maintenance can result in the failure of the M-687.UL.
- Only loosen screws according to the instructions in this manual.
- Ensure that the piezomotors of the M-687.UL 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-687.UL, the following maintenance measures are required:

Maintenance run
The maintenance run is performed to distribute the existing lubricant on the guides of the M-687.UL.
- To evenly distribute the existing lubricant on the stage guides, 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-687.UL over a small travel range (<20% of the entire travel range) in continuous industrial operation, perform a maintenance run across the entire travel range every 5000 motion cycles.
Lubrication

Under laboratory conditions, the guides of the M-687.UL only need to be lubricated in exceptional cases. For continuous industrial use, the lubrication intervals must be defined individually.

- Do not lubricate the guides of the M-687.UL without consulting our customer service department (p. 31).
- Ensure that the piezomotors of the M-687.UL do not come into contact with lubricants.

7.3 Cleaning the XY Stage

Requirements

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

Cleaning the XY stage

- ✔ When necessary, clean the surface of the XY stage with a cloth dampened lightly with a mild cleanser or disinfectant.
# 8 Troubleshooting

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible causes</th>
<th>Solution</th>
</tr>
</thead>
</table>
| Noise during operation                       | Uncontrolled oscillation of the M-687.UL                  | ➢ 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  | ➢ 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                               | Warped base body                                          | ➢ Mount the M-687.UL on an even surface. The recommended evenness of the surface is 5 µm.  
➤ For applications with large temperature changes: Only mount the M-687.UL on surfaces that have the same or similar thermal expansion properties as the M-687.UL (e.g., surfaces made of aluminum). |
| Reduced accuracy                             |                                                           |                                                                                                                                          |
| Axis does not reach the commanded position   | The values of the travel range parameters in the controller do not match the connected axis of the XY stage| ➢ Select the suitable stage type in the PC software (separate parameter sets for the axes X and Y of the XY stage).  
If the M-687.UL is part of a preconfigured system:  
➤ Connect the M-687.UL to the controller with the cables according to the assignments specified in the parameter sets stored in the controller. |

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. 31).
9 Customer Service

For inquiries and orders, contact your PI sales engineer or send us an email (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)
- If possible: Take photographs or make videos of your system that can be sent to our customer service department if requested.

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

### In this Chapter

<table>
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<th>Page</th>
</tr>
</thead>
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<td>Ambient Conditions and Classifications</td>
<td>35</td>
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<td>Influence of Downtimes on the Static Holding Force</td>
<td>35</td>
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<tr>
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<td>37</td>
</tr>
</tbody>
</table>

### 10.1 Specifications

#### 10.1.1 Data Table

<table>
<thead>
<tr>
<th>M-687.UL XY stage for inverted Leica microscopes</th>
<th>Unit</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active axes X, Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Motion and positioning</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Travel range 135 mm x 85 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated sensor Linear encoder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensor resolution 0.1 µm</td>
<td>µm</td>
<td></td>
</tr>
<tr>
<td>Pitch / yaw ±300 µrad</td>
<td>µrad</td>
<td>typ.</td>
</tr>
<tr>
<td>Velocity 120 mm/s max.</td>
<td>mm/s</td>
<td></td>
</tr>
<tr>
<td>Reference point switches Optical, 1 µm repeatability</td>
<td>Hall effect</td>
<td></td>
</tr>
<tr>
<td>Limit switches Hall effect</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mechanical properties</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load capacity 25 N max.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Drive properties</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor type PILine® ultrasonic piezomotor,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>performance class 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Connectors</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor / sensor 2 x MDR14 (f)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Miscellaneous</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating temperature range 20 to 40 °C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material Al (black anodized)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass 4.2 kg ±5 %</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
10.1.2 Limit Switch Specifications

<table>
<thead>
<tr>
<th>Type</th>
<th>Magnetic (Hall effect) sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage</td>
<td>+5 V / GND, supply via the motor socket</td>
</tr>
<tr>
<td>Signal output</td>
<td>TTL level</td>
</tr>
<tr>
<td>Signal logic</td>
<td>Active high. When the limit switch is passed, the signal level changes:</td>
</tr>
<tr>
<td></td>
<td>Normal motor operation: low (0 V)</td>
</tr>
<tr>
<td></td>
<td>Limit switch reached: high (+5 V)</td>
</tr>
</tbody>
</table>

10.1.3 Reference Point Switch Specifications

<table>
<thead>
<tr>
<th>Type</th>
<th>Optical sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage</td>
<td>+5 V / GND, supply via the motor socket</td>
</tr>
<tr>
<td>Signal output</td>
<td>TTL level</td>
</tr>
<tr>
<td>Signal logic</td>
<td>Direction sensing by means of different signal levels on the left and right side of the reference point switch: The signal level changes from 0 to +5 V when the reference point switch is passed.</td>
</tr>
</tbody>
</table>

10.1.4 Maximum Ratings

M-687.UL XY stages are designed for the following operating data:

<table>
<thead>
<tr>
<th>Maximum operating voltage</th>
<th>Operating frequency</th>
<th>Maximum power consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="icon_warning.png" alt="Warning" /></td>
<td><img src="icon_warning.png" alt="Warning" /></td>
<td><img src="icon_warning.png" alt="Warning" /></td>
</tr>
<tr>
<td>200 V_{pp} or 71 V_{eff}</td>
<td>152 to 165 kHz</td>
<td>60 W</td>
</tr>
</tbody>
</table>
10.2 Ambient Conditions and Classifications

The following ambient conditions and classifications for the M-687.UL must be observed:

<table>
<thead>
<tr>
<th>Area of application</th>
<th>For indoor use only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum altitude</td>
<td>2000 m</td>
</tr>
<tr>
<td>Air pressure</td>
<td>1100 hPa to 0.1 hPa</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>Highest relative humidity 80 % for temperatures up to 31 °C Decreasing linearly to 50 % relative humidity at 40 °C</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>20 °C to 40 °C</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>-20 °C to 75 °C</td>
</tr>
<tr>
<td>Transport temperature</td>
<td>-20 °C to 75 °C</td>
</tr>
<tr>
<td>Overvoltage category</td>
<td>II</td>
</tr>
<tr>
<td>Protection class</td>
<td>I</td>
</tr>
<tr>
<td>Degree of pollution</td>
<td>1</td>
</tr>
<tr>
<td>Degree of protection</td>
<td>IP20</td>
</tr>
</tbody>
</table>

10.3 Influence of Downtimes on the Static Holding Force

Figure 7: Static holding force of the M-687.UL 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 8: M-687.UL XY stage
10.5 Pin Assignment

MDR14 connection socket for controller cable

![Front view of the MDR14 socket](image)

Figure 9: Front view of the MDR14 socket

<table>
<thead>
<tr>
<th>Pin</th>
<th>Signal</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>GND</td>
<td>0 V</td>
</tr>
<tr>
<td>A2</td>
<td>PSWITCH</td>
<td>Output: Positive-end limit switch, active-high</td>
</tr>
<tr>
<td>A3</td>
<td>NSWITCH</td>
<td>Output: Negative-end limit switch, active-high</td>
</tr>
<tr>
<td>A4</td>
<td>REFSWITCH+</td>
<td>Output: Reference point switch, TTL, positive</td>
</tr>
<tr>
<td>A5</td>
<td>NC</td>
<td>Not connected</td>
</tr>
<tr>
<td>A6</td>
<td>VDD</td>
<td>Input: +5 V</td>
</tr>
<tr>
<td>A7</td>
<td>USM_P1</td>
<td>Input: Piezo 71 VAC (RMS)</td>
</tr>
<tr>
<td>B1</td>
<td>USM_P2</td>
<td>Input: Piezo 71 VAC (RMS)</td>
</tr>
<tr>
<td>B2</td>
<td>USM_P3</td>
<td>Input: Piezo 71 VAC (RMS)</td>
</tr>
<tr>
<td>B3</td>
<td>ENCA+</td>
<td>Output: Encoder channel A, RS-422</td>
</tr>
<tr>
<td>B4</td>
<td>ENCA-</td>
<td>Output: Encoder channel A (inverted), RS-422</td>
</tr>
<tr>
<td>B5</td>
<td>ENCB+</td>
<td>Output: Encoder channel B, RS-422</td>
</tr>
<tr>
<td>B6</td>
<td>ENCB-</td>
<td>Output: Encoder channel B (inverted), RS-422</td>
</tr>
<tr>
<td>B7</td>
<td>REFSWITCH-</td>
<td>Output: Reference point switch, TTL, negative</td>
</tr>
</tbody>
</table>
11 Old Equipment Disposal

In accordance with EU law, electrical and electronic equipment may not be disposed of in EU member states via the municipal residual waste.

Dispose of your old equipment according to international, national, and local rules and regulations.

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

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

Physik Instrumente (PI) GmbH & Co. KG
Auf der Roemerstr. 1
D-76228 Karlsruhe, Germany
For the M-687.UL, an EC Declaration of Conformity has been issued in accordance with the following European directives:

Low Voltage Directive
EMC Directive
RoHS Directive

The applied standards certifying the conformity are listed below.
Safety (Low Voltage Directive): EN 61010-1
EMC: EN 61326-1
RoHS: EN 50581