

MP111E
M-687.UL XY Stage
User Manual

Version: 1.1.0

Date: 17.03.2022



This document describes the following product:

- **M-687.UL**
XY stage for inverted Leica microscopes,
135 mm × 85 mm, self-locking, PLine® linear
drives, 0.1 µm resolution



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The patents held by PI are found in our patent list:
<https://www.physikinstrumente.com/en/about-pi/patents>

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Original instructions
First printing: 17.03.2022
Document number: MP111E, CBo, Version 1.1.0

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 This manual is superseded by any new release.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.

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1 About this Document

In this Chapter

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1.1 Objective and Target Audience of this User Manual

This user manual contains the information required for using the M-687.UL as intended.

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

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

1.2 Symbols and Typographic Conventions

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

CAUTION



Dangerous situation

Failure to comply could lead to minor injury.

- Precautionary measures for avoiding the risk.

NOTICE



Dangerous situation

Failure to comply could cause damage to equipment.

- Precautionary measures for avoiding the risk.

INFORMATION

Information for easier handling, tricks, tips, etc.

Symbol/Label	Meaning
1.	Action consisting of several steps with strict sequential order
2.	
➤	Action consisting of one or more steps without relevant sequential order
▪	Bullet
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 referring to detailed information in this manual.

1.3 Definition of Terms

Term	Explanation
Positioner	Electrically driven mechanics (e. g., M-687.UL)
Electronics	Controller or amplifier that supplies the operating voltage for the connected positioner
Controller	Electronics with sensor evaluation for closed-loop operation of positioners (e. g., C-867 controller)
Amplifier	Electronics without sensor evaluation for open-loop operation of positioners
Load capacity	Maximum load capacity in the vertical direction when the M-687.UL is mounted horizontally. The contact point of the load is at the center of the motion platform.
Linear encoder	The linear encoder is an incremental sensor for detecting changes in position. Signals from the sensor are used for axis position feedback. After switching the controller on, referencing must be done before absolute target positions can be commanded and reached.

1.4 Figures

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

1.5 Other Applicable Documents

The devices and software tools from PI mentioned in this documentation are described in separate manuals.

Description	Document
C-867.2U2 PLine® controller	MS231 User Manual
PIMikroMove	SM148E Software Manual
PLine® positioners	MP121EK Short Instructions

1.6 Downloading Manuals

INFORMATION

If a manual is missing or problems occur with downloading:

- Contact our customer service department (p. 33).

Downloading Manuals

1. Open the website www.pi.ws.
2. Search the website for the product number (e.g., M-687) or the product family (e.g., PLine®).
3. Click the corresponding product to open the product detail page.
4. Click the **Downloads** tab.

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

5. Click the desired manual and fill out the inquiry form.

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

2 Safety

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2.1 Intended Use

The M-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.

According to its design, the M-687.UL is intended for positioning, adjusting, and moving loads in two axes at different velocities in interval mode. The M-687.UL is **not** intended for applications in areas where failure would be a considerable risk for people or the environment.

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

It is only possible to use the M-687.UL as intended when it is completely mounted and connected.

The M-687.UL uses PLine® ultrasonic piezo linear motors as a drive and must be operated with a suitable controller (p. 11).

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.

- Use the M-687.UL for its intended purpose only, and only when it is in perfect technical condition.
- Read the user manual.
- Eliminate any malfunctions that may affect safety immediately.

The operator is responsible for the correct installation and operation of the M-687.UL.

Piezo motors are driven by piezo actuators. Piezo actuators can remain electrically charged for several hours after disconnecting the electronics. Temperature changes can also induce charges in piezo actuators. Touching the contacts in the connection sockets of the M-687.UL (or in the connectors of the connected cables) could lead to minor injuries from electric shock. In addition, the piezo actuators could be destroyed by an abrupt contraction.

- Do **not** open the M-687.UL.
- Do **not** touch the contacts in the connection sockets of the M-687.UL.
- If an adapter or connecting cable is connected to the M-687.UL, do **not** touch the contacts in the connector.
- Do **not** pull the connectors out of the electronics during operation. If possible, use screws to secure the connectors against being pulled out of the electronics.

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 there are touch voltages, touching the M-687.UL can result in minor injuries from electric shock.

- Connect the M-687.UL to a protective earth conductor (p. 16) before starting.
- 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 restarting.

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. 35).

2.3 Organizational Measures

User manual

- Always keep this user manual together 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 a third party, include this user manual as well as other relevant information provided by the manufacturer.
- Do the work only if the user manual is complete. Missing information due to an incomplete user manual can result in minor injury and damage to equipment.
- Install and operate the M-687.UL only after you have read and understood this user manual.

Personnel qualification

The M-687.UL may only be installed, started, operated, maintained, and cleaned by authorized and appropriately qualified personnel.

3 Product Description

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3.1 Product View

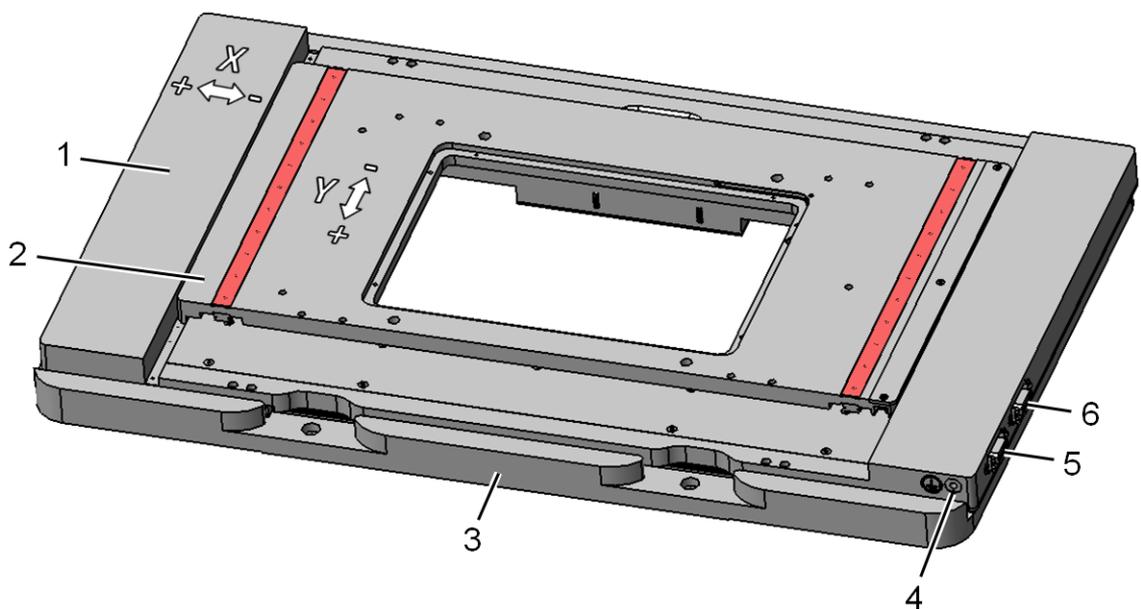


Figure 1: M-687.UL product view

- 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

Labeling	Description
M-687.UL	Product number (example), the digits after the period refer to the model
123456789	Serial number (example), individual for each M-687.UL Meaning of each position (from the left): 1 = internal information 2 and 3 = year of manufacture 4 to 9 = consecutive number
	Manufacturer's logo
	Warning sign "Pay attention to the manual!"
	Old equipment disposal (p. 41)
Country of origin: Germany	Country of origin
WWW.PI.WS	Manufacturer's address (website)
	CE conformity mark
PILine®	Brand name
	Symbol for the protective earth conductor, marks the protective earth connector of the M-687.UL (p. 16)
Axis X	Connection socket for controller cable (X axis)
Axis Y	Connection socket for controller cable (Y axis)

3.3 Scope of Delivery

Product number	Quantity	Description
M-687.UL	1	XY stage for inverted Leica microscopes, 135 mm × 85 mm, self-locking, PILINE® linear drives, 0.1 µm resolution
000036450	1	M4 screw set for protective earth, consisting of: <ul style="list-style-type: none"> ▪ One flat-head screw with cross recess, M4x8, ISO 7045 ▪ 2 lock washers ▪ 2 flat washers
000041912	1	Screw set for mounting the M-687.UL, consisting of: <ul style="list-style-type: none"> ▪ 4 socket head screws, M4×16 ISO 4762 ▪ 1 hex key
MP121EK	1	Short instructions for PILINE® positioners

Also included in the scope of delivery when the M-687.UL is part of the U-780.DLS system:

Product number	Quantity	Description
C-867.2U2	1	Piezo motor controller for PLine® systems, 2 axes, USB, RS-232, TCP/IP, SPI, I/O, analog or digital joystick, networkable via daisy chain (for scope of delivery, refer to the documentation for the controller)
U-600.AMD	2	PLine® adapter cable MDR 14 (m) to D-sub 15 (m), 1.5 m, for connecting the XY stage to the controller
C-819.JD	1	Digital joystick for 2 axes, 3 programmable buttons

3.4 Suitable Controllers

Product number	Description
C-867.2U2	Piezo motor controller for PLine® systems, 2 axes, USB, RS-232, TCP/IP, SPI, I/O, analog or digital joystick, networkable via daisy chain

- To order, contact our customer service department (p. 33).

3.5 Accessories

Order number	Description
P-561, P-562, P-563	PIMars XYZ nanopositioner with up to 300 µm travel range
P-541.2, P-542.2	Flat XY nanopositioner with large aperture
P-541.Z	Flat nanopositioner Z stage with large aperture
P-545.2R8S	PI nano® XY piezo system, clear aperture for microscope slides, 200 µm × 200 µm, piezoresistive sensors, with USB digital controller
P-545.3R8S	PI nano® XYZ piezo system, clear aperture for microscope slides, 200 µm × 200 µm × 200 µm, piezoresistive sensors, with USB digital controller
P-737.1SL	PIFOC® nanofocus positioner for microscope sample holders, 100 µm, DMS, LEMO connector
P-737.2SL	PIFOC® nanofocus positioner for microscope sample holders, 250 µm, DMS, LEMO connector
M-687.AP1	Universal holder for microscope slide and Petri dishes for PI stages with 160 mm × 110 mm clear aperture

You can find more information about accessories in our BRO70E brochure "Microscope Stage Configurator" (<https://www.physikinstrumente.com/stage-configurator>).

- To order, contact our customer service department (p. 33).

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. 35).

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.

Refer to "Limit Switch Specifications" (p. 36) for more information.

3.6.3 Reference Switch

The M-687.UL is equipped with one direction-sensing reference 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 switch.

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

Refer to "Reference Switch Specifications" (p. 36) for more information.

4 Unpacking

NOTICE

**Platform slips and hits the hard stop!**

When the M-687.UL is aligned vertically, the platforms can slip and hit the hard stop. The impact of a platform on the hard stop could 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 platforms against slipping.

1. Unpack the M-687.UL with care.
2. Compare the contents with the scope of delivery according to the contract and the delivery note.
3. Inspect the contents for signs of damage. If any parts are damaged or missing, contact our customer service department (p. 33) immediately.
4. Keep all packaging materials in case the product needs to be returned.

5 Installation

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5.1 General Notes on Installing

CAUTION



Dangerous voltage and residual charge in piezo actuators!

Piezo motors are driven by piezo actuators. Piezo actuators can remain electrically charged for several hours after disconnecting the electronics. Temperature changes can also induce charges in piezo actuators. Touching the contacts in the connection sockets of the M-687.UL (or in the connectors of the connected cables) could lead to minor injuries from electric shock. In addition, the piezo actuators could be destroyed by an abrupt contraction.

- Do **not** open the M-687.UL.
- Do **not** touch the contacts in the connection sockets of the M-687.UL.
- If an adapter or connecting cable is connected to the M-687.UL, do **not** touch the contacts in the connector.
- Do **not** pull the connectors out of the electronics during operation. If possible, use screws to secure the connectors against being pulled out of the electronics.

NOTICE



Lubricants, dirt, condensation!

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

- Make sure that the piezo motors 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. 33).

INFORMATION

When moving the platform in a power off state manually, differences in the holding force may be noticeable across the travel range.

There are mechanical reasons for fluctuations in the holding force and they have no influence on the function of the XY stage.

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

INFORMATION

- Pay attention to the applicable standards for connecting the protective earth conductor.

INFORMATION

- If there is any vibration in your application, secure the screw connection for the protective earth conductor in a suitable manner (e.g., with conductive liquid adhesive) to prevent it from unscrewing by itself. If this is not possible, check the screw connection at regular intervals and retighten the screw if necessary.

There is an M4 hole in the M-687.UL for connecting the protective earth. This hole is marked with the symbol for the protective earth conductor . The position of the hole is shown in the product view (p. 9).

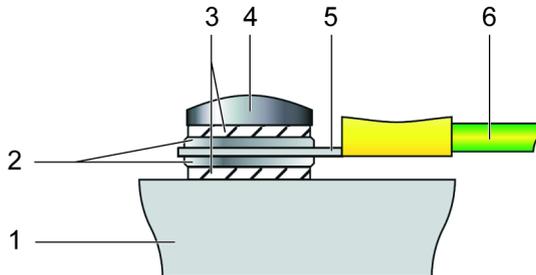


Figure 2: Connecting the protective earth conductor (profile view)

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

Requirements

- ✓ You have read and understood the general notes on installing (p. 15).
- ✓ The M-687.UL is **not** connected to the controller.

Tools and accessories

- Suitable protective earth conductor: Cross-sectional area of the cable $\geq 0.75 \text{ mm}^2$
- M4 screw set supplied for connecting the protective earth conductor (p. 10)
- 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 flat and lock washers) to attach the cable lug of the protective earth conductor to the threaded hole in 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 $< 0.1 \Omega$ 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.

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

NOTICE

**Warping the base body!**

Incorrect mounting can warp the base body. A warped base body will increase wear and reduce accuracy.

- Mount the M-687.UL onto a flat surface. The recommended flatness of the surface is 5 μm .
- For applications with large temperature fluctuations:
Only fix 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 M-687.UL's directions of motion are indicated in the product view (p. 9).

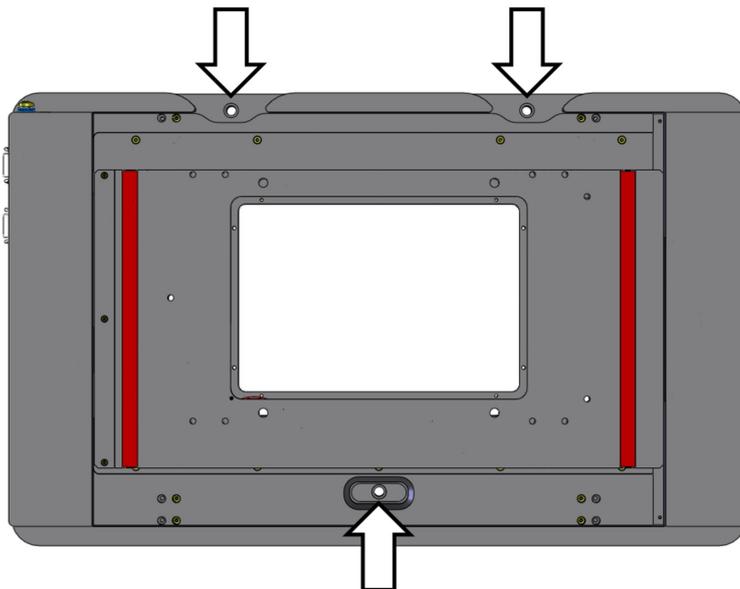


Figure 3: M-687.UL: Mounting holes in the base body

The exact position of the holes is specified in the dimensional drawing in the "Dimensions" (p. 38) section.

Requirements

- ✓ You have read and understood the general notes on installing (p. 15).
- ✓ The M-687.UL is **not** connected to the controller.

Tools and accessories

- 000041912 screw set (p. 10)

Mounting the M-687.UL onto a surface

1. Move the motion platforms of the M-687.UL by hand until all countersunk holes in the base body are accessible (refer to illustration above).
2. Fix the M-687.UL with three of the M4 screws supplied.
3. Make sure that the screw heads are fully countersunk.

5.4 Mounting a Positioner on 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, pay attention to the maximum permissible forces that, according to the specification (p. 35), are allowed to act on the platforms.

NOTICE**Excessively long screws!**

The M-687.UL can be damaged by excessively long screws.

- Pay attention to the depth of the mounting holes in the upper platform (p. 38).
- Only use screws of the correct length for the respective mounting holes.

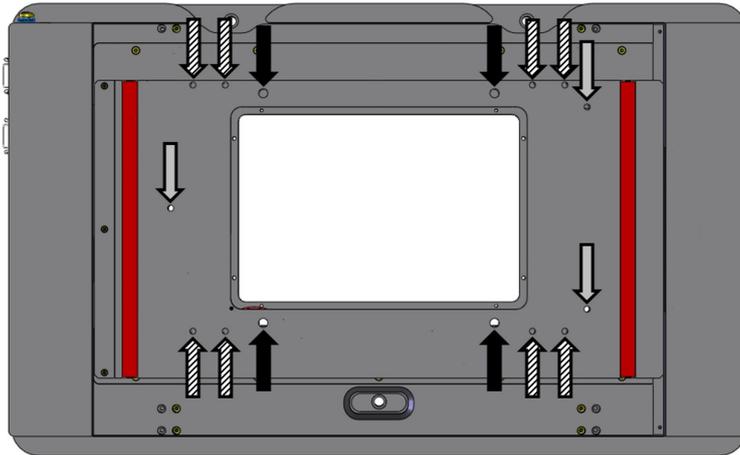


Figure 4: M-687.UL: Threaded holes in the upper platform (hatched arrows = 8 × M4; black arrows = 4 × M6; gray arrows = 3 × M4)

Requirements

- ✓ You have read and understood the general notes on installing (p. 15).
- ✓ The M-687.UL and the positioner to be mounted are **not** connected to the respective controller.

Tools and accessories

- Screws of suitable size and length:

Positioner	Suitable screws
P-561, P-562, P-563	M6x30
P-541.2, P-542.2	M6x16
P-541.Z	M6x16
P-545.2R8S	M4x20
P-545.3R8S	M4x20
P-737.1SL	M2.5x10
P-737.2SL	M2.5x10

- Suitable tool for tightening the screws

Mounting a positioner on the M-687.UL

1. Select the mounting position so that the threaded holes in the upper platform (refer to figure above) can be used for fixing the positioner.
2. Fix the positioner to the threaded holes with the specified screws (refer to "Tools and accessories"). Depending on the positioner model to be mounted, use three or four screws.

5.5 Inserting and Removing the M-687.AP1 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 5: M-687.AP1 universal holder for microscope slides and Petri dishes



Figure 6: M-687.UL: Clip spring in aperture

Tools and accessories

- M-687.AP1 universal holder (p. 11)

Inserting the M-687.AP1 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 (refer to figure 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 M-687.AP1 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 installing (p. 15).
- ✓ You have read and understood the user manual for the controller (p. 3).
- ✓ The controller is **switched off**.
- ✓ You have connected the M-687.UL to the protective earth conductor (p. 16).

Tools and accessories

- Two U-600.AMD adapter cables (p. 10)

Connecting the M-687.UL to the controller

1. Connect the MDR connector of the first cable to the **Axis X** socket of the M-687.UL.
2. Connect the D-sub connector (m) on the other end of the cable to the **Axis 1** socket of the controller.
3. Connect the MDR connector of the second cable to the **Axis Y** socket of the M-687.UL.
4. Connect the D-sub connector (m) on the other end of the cable to the **Axis 2** socket of the controller.

6 Starting and Operating

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6.1 General Notes on Starting and Operating

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 there are touch voltages, touching the M-687.UL can result in minor injuries from electric shock.

- Connect the M-687.UL to a protective earth conductor (p. 16) before starting.
- 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 restarting.

NOTICE



Destruction of the piezo motor due to electric flashovers!

Using the M-687.UL in environments that increase the electrical conductivity could lead to the destruction of the piezo motor by electric flashovers. Electric flashovers can be caused by moisture, high humidity, liquids, and conductive materials (e.g., metal dust). In addition, electric flashovers are also possible as a result of increased conductivity in certain air pressure ranges.

- Avoid operating the M-687.UL in environments that can increase the electrical conductivity.
- Operate the M-687.UL only under permissible ambient conditions and classifications (p. 37).

NOTICE



Damage if the wrong controller is connected!

Connecting an XY stage to an unsuitable controller can damage the XY stage or controller.

- Connect an XY stage with PLine® ultrasonic piezo motors only to a PLine® controller (p. 11).

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.

- Operate the M-687.UL only with controllers/drivers and original accessories from PI.
- Do **not** exceed the operating voltage range (p. 36) for which the M-687.UL is specified.
- Operate the M-687.UL only when the operating voltage is properly connected; refer to "Pin Assignment" (p. 39).

NOTICE**Short-circuiting due to condensation!**

Condensation can lead to short-circuiting and failure of the M-687.UL.

- Wait for a sufficient period of time to allow the M-687.UL to reach room temperature in the following cases:
 - After unpacking or before starting for the first time
 - If the M-687.UL has been brought from a cold into a warm environment or from a warm into a cold environment
- Keep the M-687.UL free of condensation.

NOTICE**Unintentional motion!**

The M-687.UL may move unintentionally when connecting it to the controller. Faulty software and incorrect operation of the software may also cause unintended movements.

- Do not place any objects in areas where they can be caught by moving parts.
- Before connecting the M-687.UL, check whether a macro is defined as the startup macro in the controller and cancel the selection of the startup macro if necessary.

NOTICE**Damage due to collisions!**

Collisions can damage the M-687.UL, the load to be moved, and the surroundings.

- Make sure that no collisions are possible between the M-687.UL, the load to be moved, and the surroundings in the motion range of the M-687.UL.
- 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.

NOTICE**Impact of platforms on the hard stop!**

The impact of the M-687.UL's platforms on the hard stop could lead to damage or considerable wear on the M-687.UL.

- Avoid motion in open-loop operation.
- If motion in open-loop operation is necessary with the C-867 controller:
 - Set the control value with the `SMO` command so that the axes move at 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.
- Make sure that the end of the travel range is approached at low velocity.
- Make changes to the velocity, acceleration, deceleration, and load in small steps only.
- Do **not** deactivate the limit switches in the software.
- Test the function of the limit switches at low velocities only.
- Stop motion immediately if the limit switches malfunction.

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 switch is always approached from the same side. Controllers from PI fulfill this requirement due to the automatic direction sensing for reference moves to the reference switch.

INFORMATION

For maximum force generation, it is necessary to run the M-687.UL in when starting and after longer downtimes; refer also to "Influence of Downtimes on the Static Holding Force" (p. 37). The M-687.UL will generate its maximum dynamic force after running in.

- Command several motion cycles at low velocity (<50 mm/s) over the entire travel range to run in.

INFORMATION

The M-687.UL's directions of motion are indicated in the product view (p. 9).

6.2 Starting and Operating the M-687.UL with the C-867 Controller

NOTICE**Wrong parameter settings!**

If you use the software that is included in the scope of delivery of the controller (p. 11), the operating parameters of the M-687.UL can be loaded from a positioner database. The positioner database contains the default parameter values of your XY stage for doing initial motion testing during starting. 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: Start without a load first.
- Perform initial startup at a low velocity (<50 mm/s).
- Always install the latest version of the positioner database onto your PC.

For starting with a load:

- Before starting, make sure that the M-687.UL has been properly installed (p. 15).
- For optimal performance of the moving axis, adjust the operating parameters of the controller (e.g., P term, I term, D term, acceleration, velocity; refer to the controller manual).
- Save the new parameter values to a positioner database on the PC or to the nonvolatile memory of the controller for future use (refer to the controller manual and the 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 positioner type with specially adapted parameters is available in the positioner database from which the operating parameters can be loaded.

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

Default configuration when the C-867.2U2 controller is used:

- For controller axis 1 (**Axis 1** socket), the parameter set for axis X of the XY stage is stored in the controller.
- For controller axis 2 (**Axis 2** socket), the parameter set for axis Y of the XY stage is stored in the controller.
- Connect the M-687.UL and the controller using the cables so that the assignment specified by the parameter sets stored in the controller is adhered to.

Requirements

- ✓ You have read and understood the general notes on starting and operating (p. 23).
- ✓ You have read and understood the user manual for the controller (p. 3).
- ✓ The M-687.UL is properly installed (p. 15).
- ✓ The controller (p. 11) and the required software have been installed. All connections on the controller have been made (refer to the controller manual).

Starting and operating the M-687.UL with the C-867 controller

- Operate one axis of the M-687.UL (refer to controller manual), and repeat the sequence for the second axis.

Starting and operating comprises the following steps:

- Selecting the positioner type
- Referencing the axis
- Commanding initial motion in closed-loop operation for testing and for running the mechanics in

The controller manual describes starting and operating using the PIMikroMove program.

7 Maintenance

In this Chapter

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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-687.UL.

- Loosen screws only when instructed in this manual.
- Make sure that the piezo motors of the M-687.UL do not come into contact with lubricants.

7.2 Doing 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 done to distribute the existing lubricant on the guides of the M-687.UL.

- To evenly distribute the existing lubricant on the stage guides, do a maintenance run across the entire travel range after 500 hours of operation, or at least after 1 year.
- If you move the M-687.UL over a small travel range (<20 % of the entire travel range) in continuous industrial operation, do 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. 33).
- Ensure that the piezo motors of the M-687.UL do not come into contact with lubricants.

7.3 Cleaning the M-687.UL**Requirements**

- ✓ You have disconnected the M-687.UL from the controller.

Cleaning the M-687.UL

- If necessary, clean the M-687.UL surface using a cloth dampened with a mild cleanser or disinfectant.

8 Troubleshooting

Problem	Possible causes	Solution
Noise during operation	Uncontrolled oscillation of the M-687.UL	<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.
Inaccurate positioning	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. Refer to the controller 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. Refer to the controller manual (p. 3) for details.
Increased wear Reduced accuracy	Warped base body	<ul style="list-style-type: none"> ➤ Mount the M-687.UL onto a flat surface. The recommended flatness of the surface is 5 µm. ➤ For applications with large temperature fluctuations: 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).
Axis does not reach the commanded position	The values of the travel range parameters in the controller do not match with the connected axis of the XY stage	<ul style="list-style-type: none"> ➤ Select the suitable positioner type in the PC software (separate parameter sets for the X and Y axes of the XY stage). If the M-687.UL is part of a preconfigured system: ➤ Connect the M-687.UL and the controller using the cables so that the assignment specified by the parameter sets stored in the controller is adhered to.

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. 33).

9 Customer Service

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

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

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

10 Technical Data

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

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10.1 Specifications

10.1.1 Data Table

	M-687.UL	Unit	Tolerance
	XY Stage for Inverted Leica Microscopes		
Active axes	X, Y		
Motion and positioning			
Travel range	135 mm × 85 mm		
Integrated sensor	Linear encoder		
Sensor resolution	0.1	µm	
Pitch / yaw	±300	µrad	Typ.
Velocity	120	mm/s	Max.
Reference switch	Optical, 1 µm repeatability		
Limit switch	Hall effect		
Mechanical properties			
Load capacity	25	N	Max.
Drive properties			
Motor type	PILine® ultrasonic piezo motor, performance class 2		
Connectors			
Motor / sensor	2 × MDR14 (f)		

	M-687.UL XY Stage for Inverted Leica Microscopes	Unit	Tolerance
Miscellaneous			
Operating temperature range	20 to 40	°C	
Material	Aluminum (black anodized)		
Mass	4.2	kg	±5 %
Recommended electronics	C-867.2U2		

10.1.2 Limit Switch Specifications

Type	Magnetic (Hall effect) sensor
Supply voltage	+5 V / GND, supply via the motor socket
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 Switch Specifications

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

10.1.4 Maximum Ratings

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

Maximum operating voltage	Operating frequency	Maximum power consumption
		
200 V _{pp} or 71 V _{eff}	152 to 165 kHz	60 W

10.2 Ambient Conditions and Classifications

Pay attention to the following ambient conditions and classifications for the M-687.UL:

Area of application	For indoor use only
Maximum altitude	2000 m
Air pressure	1100 hPa to 0.1 hPa
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 40 °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 Influence of Downtimes on the Static Holding Force

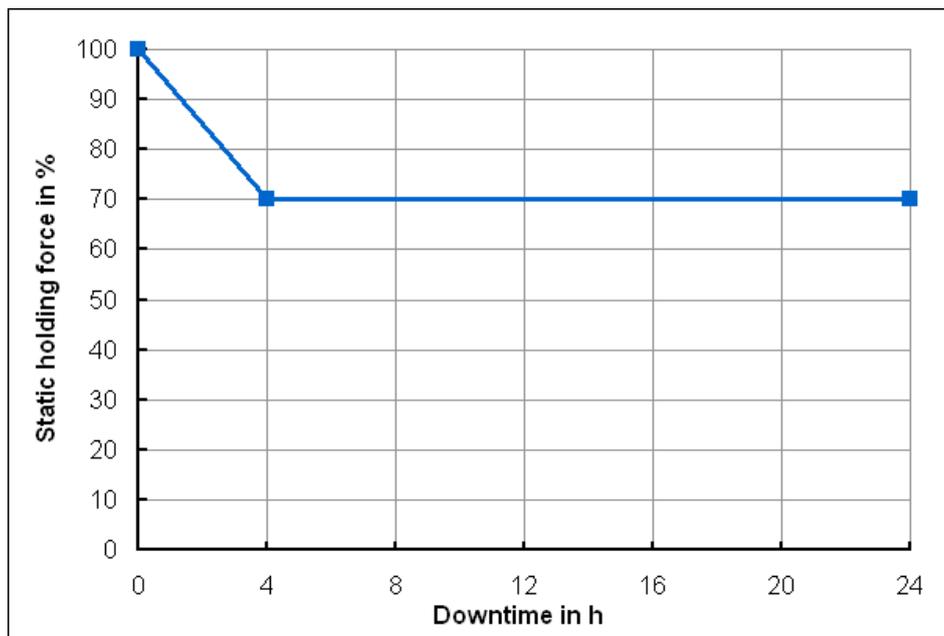


Figure 7: Static holding force of the M-687.UL depending on the downtime of the motor

10.4 Dimensions

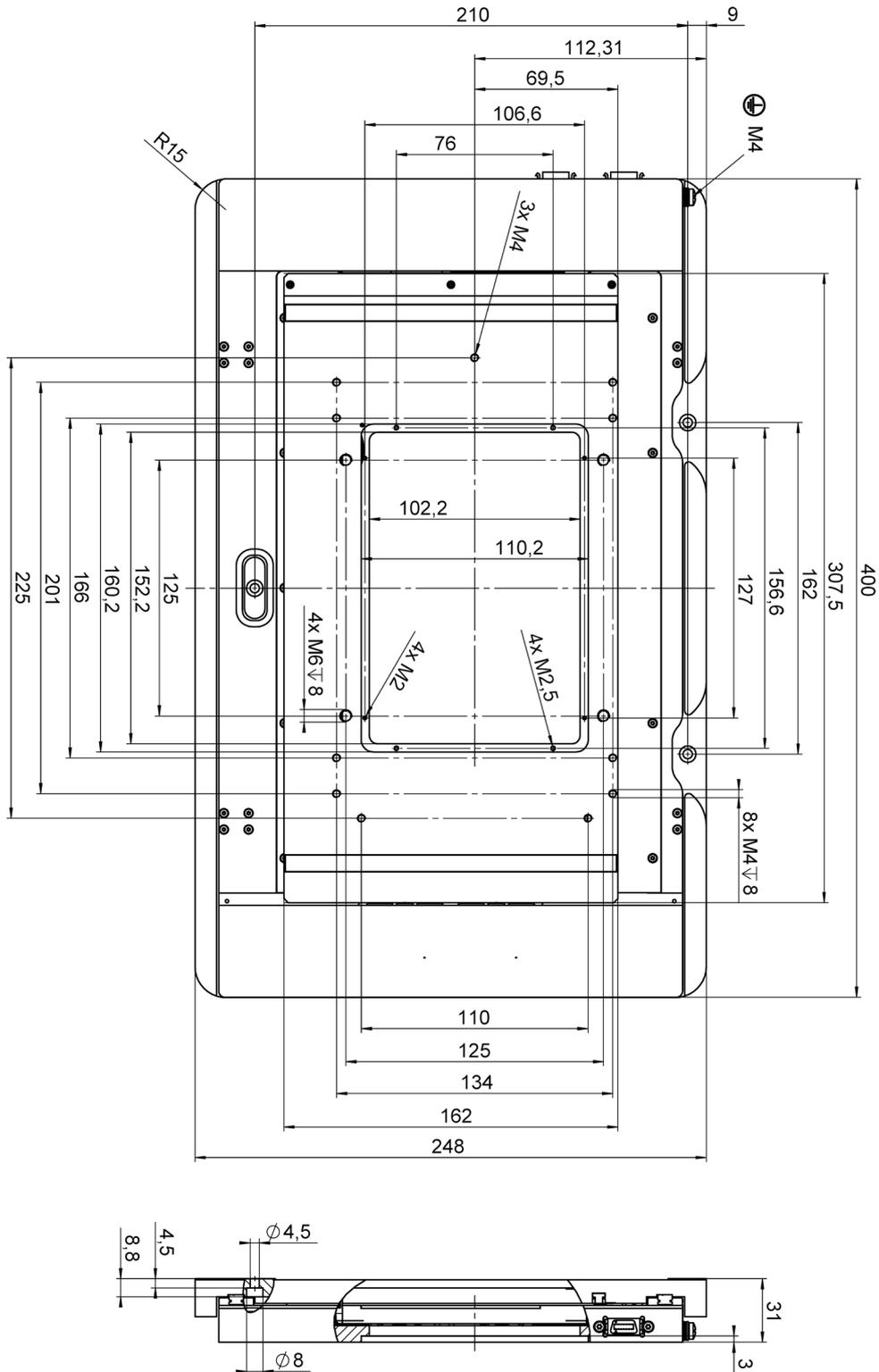


Figure 8: M-687.UL XY stage, dimensions in mm. Note that a comma is used in the drawings instead of a decimal point.

10.5 Pin Assignment

MDR14 connection socket for controller cable

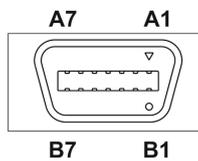


Figure 9: Front view of the MDR14 socket

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 switch, TTL, positive
A5	NC	Not connected
A6	VDD	Input: +5 V
A7	USM_P1	Input: Piezo voltage ground
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	REFSWITCH -	Output: Reference switch, TTL, negative

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

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

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



12 European Declarations of Conformity

For the M-687.UL, declarations of conformity were issued according to the following European statutory requirements:

Low Voltage Directive

EMC Directive

RoHS Directive

The standards applied for certifying conformity are listed below.

Safety (Low Voltage Directive): EN 61010-1

EMC: EN 61326-1

RoHS: EN IEC 63000

