

MP143E U-622 Rotation Stage User Manual

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Date: 18.08.2015



This document describes the following product:

- **U-622.03**
PIline® miniature rotation stage, >360° rotation range, velocity 720 °/s, incremental encoder, 175 µrad resolution, 18.5 mm diameter, piezoelectric ultrasonic motor



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

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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

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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 This manual is superseded by any new release.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.



Contents

| | | |
|----------|--|-----------|
| 1 | About this Document | 1 |
| 1.1 | Objective and Target Audience of this User Manual | 1 |
| 1.2 | Symbols and Typographic Conventions | 1 |
| 1.3 | Definition | 2 |
| 1.4 | Figures | 3 |
| 1.5 | Other Applicable Documents | 3 |
| 1.6 | Downloading Manuals | 3 |
| 2 | Safety | 5 |
| 2.1 | Intended Use | 5 |
| 2.2 | General Safety Instructions | 5 |
| 2.3 | Organizational Measures | 7 |
| 3 | Product Description | 9 |
| 3.1 | Product View | 9 |
| 3.2 | Product Labeling | 10 |
| 3.3 | Scope of Delivery | 11 |
| 3.4 | Suitable Controllers | 11 |
| 3.5 | Accessories | 12 |
| 3.6 | Technical Features | 12 |
| 3.6.1 | Rotary Encoder | 12 |
| 3.6.2 | Reference Point Switch | 12 |
| 3.6.3 | ID Chip | 12 |
| 4 | Unpacking | 13 |
| 5 | Installation | 15 |
| 5.1 | General Notes on Installation | 15 |
| 5.2 | Mounting the U-622 on a Surface and Connecting It to a Protective Earth Conductor | 17 |
| 5.3 | Affixing the Load to the U-622 | 19 |
| 6 | Start-Up and Operation | 21 |
| 6.1 | General Notes on Start-Up and Operation | 21 |
| 6.2 | Starting up the U-622 | 24 |

| | | |
|--------|--|----|
| 7 | Maintenance | 27 |
| 7.1 | General Notes on Maintenance | 27 |
| 7.2 | Performing a Maintenance Run | 27 |
| 7.3 | Cleaning the U-622 | 28 |
| 8 | Troubleshooting | 29 |
| 9 | Customer Service | 31 |
| 10 | Technical Data | 33 |
| 10.1 | Specifications | 33 |
| 10.1.1 | Data Table | 33 |
| 10.1.2 | Reference Point Switch Specifications | 34 |
| 10.1.3 | Maximum Ratings | 34 |
| 10.2 | Ambient Conditions and Classifications | 35 |
| 10.3 | Motor Power | 36 |
| 10.3.1 | Motor Power and Operating Voltage | 36 |
| 10.3.2 | Velocity and Torque | 37 |
| 10.3.3 | Motor Power and Lifetime | 38 |
| 10.3.4 | Influence of Downtimes on the Torque | 39 |
| 10.4 | Dimensions | 40 |
| 10.5 | Pin Assignment | 41 |
| 11 | Old Equipment Disposal | 43 |
| 12 | EC Declaration of Conformity | 45 |

1 About this Document

In this Chapter

| | |
|---|---|
| Objective and Target Audience of this User Manual | 1 |
| Symbols and Typographic Conventions | 1 |
| Definition | 2 |
| Figures | 3 |
| Other Applicable Documents | 3 |
| Downloading Manuals | 3 |

1.1 Objective and Target Audience of this User Manual

This manual contains information on the intended use of the U-622.

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 signs affixed to the product that refer to detailed information in this manual. |

1.3 Definition

| Term | Explanation |
|----------------|---|
| Load capacity | Maximum load capacity in the vertical direction when the rotation stage is mounted horizontally. The contact point of the load is in the center of the platform. |
| Rotary encoder | The rotary 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-867.1U PLine® controller | MS223E user manual |
| C-867.2U PLine® controller | MS231E user manual |
| C-877.1U11 PLine® controller | MS232E user manual |
| C-877.2U12 PLine® controller | MS233E user manual |
| PIMikroMove | SM148E software manual |
| PLine® stage | MP121EK short instructions |

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 **http://www.pi.ws**.
2. Click **Info**.
3. If you have a user name and password:
 - a) Click **Login**.
 - b) Log in with the user name and password.
4. Click **>> Product Downloads**.
5. In the **Product Files** area, click the corresponding product category.
6. On the right-hand side of the page, select the corresponding sub-category.
7. Navigate to the product code on the page.

The following manuals are displayed:

- Freely accessible manuals
 - Manuals that are protected by a password
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 |
| General Safety Instructions | 5 |
| Organizational Measures..... | 7 |

2.1 Intended Use

The U-622 is a laboratory device as defined by DIN EN 61010-1. It is intended for indoor and use in an environment that is free of dirt, oil and lubricants.

In accordance with its design, the U-622 is intended for single-axis positioning, adjustment and rotation of loads at different velocities in interval operation. The U-622 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 U-622 is only possible when completely mounted and connected.

The U-622 uses a PLine® ultrasonic piezomotor as drive and must be operated with a suitable controller (p. 11). The controller is not included in the scope of delivery of the U-622.

2.2 General Safety Instructions

The U-622 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 U-622.

- Only use the U-622 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 U-622.

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 U-622 can cause slight injuries from electric shock.

- Do **not** open the U-622.
- Do **not** touch the contacts in the connector of the U-622.

If a protective earth conductor is not or not properly connected, dangerous touch voltages can occur on the U-622 in the case of malfunction or failure of the system. If touch voltages exist, touching the U-622 can result in minor injuries from electric shock.

- Connect the U-622 to a protective earth conductor (p. 17) 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 U-622 to the protective earth conductor before starting it up again.

Mechanical forces can damage or misalign the U-622.

- Avoid impacts that affect the U-622.
- Do **not** drop the U-622.
- Do **not** exceed the maximum permissible stress and load capacities according to the specifications (p. 33).

2.3 Organizational Measures

User manual

- Always keep this user manual available with the U-622.
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 U-622 on 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 U-622 after you have read and understood this user manual.

Personnel qualification

The U-622 may only be installed, started up, operated, maintained and cleaned by authorized and appropriately qualified personnel.

3 Product Description

In this Chapter

| | |
|----------------------------|----|
| Product View | 9 |
| Product Labeling..... | 10 |
| Scope of Delivery | 11 |
| Suitable Controllers | 11 |
| Accessories | 12 |
| Technical Features | 12 |

3.1 Product View

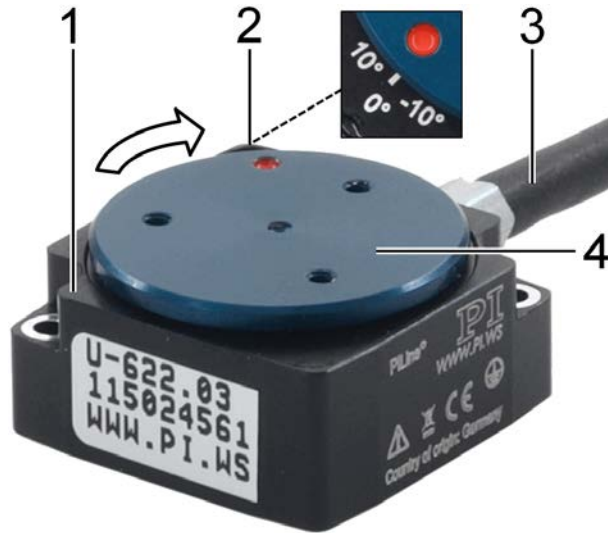


Figure 1: U-622 product view

- 1 Base body
- 2 0° mark: After a reference move of the U-622, the red dot on the moving platform is above the 0 mark in the base body.
- 3 Cable for connection to the controller
- 4 Moving platform

The arrow in the figure shows the positive direction of motion.

3.2 Product Labeling



Figure 2: U-622: Position of the product labeling (example view)

| Position | Labeling | Description |
|----------|-------------------------------|--|
| A | U-622.03 | Product name |
| A | 115024561 | Serial number (example), individual for each U-622 Meaning of the places (counting from left): 1 = internal information 2 and 3 = year of manufacture 4 to 9 = consecutive numbers |
| A, B | WWW.PI.WS | Manufacturer's address (website) |
| B | PILine® | Brand name |
| B | | Manufacturer's logo |
| B | | Warning sign "Observe manual!" |
| B | | Old equipment disposal (p. 43) |
| B | | CE conformity mark |
| B | | Symbol for the protective earth conductor (p. 17) |
| B | Country of origin: Germany | Country of origin |



Figure 3: U-622: "Residual voltage" warning sign on connector

Warning sign "Residual voltage": Notice of risk of electric shock (p. 5)

3.3 Scope of Delivery

| Item ID | Components |
|-----------|--|
| U-622.03 | PILine® miniature rotation stage, >360° rotation range, velocity 720 °/s, incremental encoder, 175 µrad resolution, 18.5 mm diameter, piezoelectric ultrasonic motor |
| 000032859 | 4 socket head cap screws M1.6x10, ISO 4762, for mounting the U-622 |
| 3109 | Allen wrench AF 1.5 |
| MP121EK | Short instructions for the PILine® stage |

3.4 Suitable Controllers

| Order Number | Description |
|--------------|---|
| C-867.1U | Piezomotor controller / driver, networkable, 1 channel, for PILine® systems with Sub-D connector(s) |
| C-867.2U | Piezomotor controller with drive electronics, networkable, 2 channels, for PILine® systems with Sub-D connector(s) |
| C-877.1U11 | Compact, cost-efficient piezomotor controller with drive electronics, 1 channel, for PILine® systems with low power consumption |
| C-877.2U12 | Compact piezomotor controller with drive electronics, 2 channels, for PILine® systems |

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

3.5 Accessories

| Order Number | Description |
|--------------|--|
| U-600.A01 | Extension cable for PLine®, 15-pin Sub-D, 1 m* |
| U-600.A03 | Extension cable for PLine®, 15-pin Sub-D, 3 m* |
| U-600.A05 | Extension cable for PLine®, 15-pin Sub-D, 5 m* |

* Other cable lengths available on request.

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

3.6 Technical Features

3.6.1 Rotary Encoder

The U-622 is equipped with an optical rotary encoder. For the encoder resolution, refer to the table in the "Specifications" section (p. 33).

Optical rotary 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 Reference Point Switch

The U-622 has an optical reference point switch (see "Reference Switch Specifications", p. 34).

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

After a reference move of the U-622, the red dot on the moving platform is above the 0° mark in the base body.

3.6.3 ID Chip

The connector of the U-622 stages contains an ID chip. Information on the stage (e.g., type, serial number, date of manufacture, version of the hardware) is stored in parameters on the ID chip.

When switched on or rebooted, controllers from PI read the data from the ID chip.

For more information on the ID chip recognition, see the manual of the controller used.

4 Unpacking

1. Unpack the U-622 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 | 15 |
| Mounting the U-622 on a Surface and Connecting It to a Protective Earth Conductor | 17 |
| Affixing the Load to the U-622 | 19 |

5.1 General Notes on Installation

CAUTION



Dangerous voltage and residual charge on 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 connector of the U-622 can lead to minor injuries from electric shock.

- Do **not** touch the contacts in the connector of the U-622.

NOTICE



Lubricants, dirt, condensation!

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

- Ensure that the piezomotor of the U-622 does not come into contact with lubricants.
- Keep the U-622 free from dirt and condensation.

NOTICE



Heating up of the U-622 during operation!

The heat produced during operation of the U-622 can affect your application.

- Install the U-622 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 U-622.

- Only use genuine PI parts to connect the U-622 to the controller.
- If you need longer cables, use extension cables from PI (p. 12).

NOTICE**Unintentional changes in position with vertical mounting!**

If the load exceeds the maximum torque of the drive when the rotation stage is mounted vertically, unintentional changes in the position of the moving platform occur. Unintentional changes in position of the moving platform can damage the drive, the load or the environment.

- When a rotation stage is mounted vertically, make sure that the installed load is lower than the maximum torque of the drive (p. 33).

INFORMATION

For optimum repeatability, all components must be firmly affixed to each other.

INFORMATION

When manually displacing the moving platform in a de-energized state, 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 stage.

- If possible, simulate the rotation stage motions with a mounted load or make 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 rotation stage and the application, in accordance with the legal regulations.

For more information on operating conditions, refer to the "Motor Power" section (p. 36).

5.2 Mounting the U-622 on a Surface and Connecting It to a Protective Earth Conductor

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 U-622 on an even surface. The recommended evenness of the surface is 10 µm.
- For applications with large temperature changes:
Only fasten the U-622 to surfaces that have the same or similar thermal expansion properties as the U-622 (e.g. surfaces made of aluminum).

INFORMATION

Contact of the U-622 with the protective earth conductor is made as follows:

- Two mounting holes in the base body of the U-622
- Suitable conductive screws (p. 11)
- Protective earth conductor connected to the surface on which the U-622 is mounted

INFORMATION

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

INFORMATION

The positive direction of motion of the U-622 is shown in the product view (p. 9).



Figure 4: Mounting holes for mounting the U-622 on a surface

Prerequisites

- ✓ You have read and understood the general notes on installation (p. 15).
- ✓ You have provided a suitable surface (for the required position of the holes for accommodating the screws, see "Dimensions" (p. 40)).
 - The surface is connected to a protective earth conductor.
 - Two M1.6 holes with a thread depth of at least 5 mm are present.
 - The holes for accommodating the screws are sufficiently conductive to ensure proper function of the protective earth conductor.
 - The evenness of the surface is $\leq 10 \mu\text{m}$.
 - For applications with large temperature changes: The surface should have the same thermal expansion properties as the U-622 (e.g., surface made of aluminum).
- ✓ You have accounted for the space required to route cables without bending and according to regulations.
- ✓ The U-622 is **not** connected to the controller.

Tools and accessories

- Suitable protective earth conductor: Cross-sectional area of the cable $\geq 0.75 \text{ mm}^2$
- Mounting accessories in the scope of delivery (p. 11):
 - 2 M1.6x10 screws
 - Allen wrench

Mounting the U-622 on a surface and connecting it to a protective earth conductor

1. Align the U-622 on the surface so that the corresponding holes in the U-622 and the surface overlap.
2. Insert the two screws into the holes in the base body of the U-622.
3. Tighten the two screws with a torque of 16 Ncm each.
4. Make sure that the contact resistance at all connection points relevant for mounting the protective earth conductor is $<0.1 \Omega$ at 25 A.
5. Check that the U-622 is affixed firmly to the surface.

5.3 Affixing the Load to the U-622

NOTICE



Impermissibly high forces and torques!

Impermissibly high forces and torques that are applied to the moving platform can damage the U-622.

- For affixing type and mass of the load, observe the maximum permissible forces according to the specifications (p. 33).
- Avoid tilting torques $>0.01 \text{ Nm}$ on the moving platform.

NOTICE



Screws that are too long!

The U-622 can be damaged by screws that are too long.

- Note the depth of the mounting holes in the moving platform (p. 40).
- Only use screws of the correct length for the respective mounting holes.

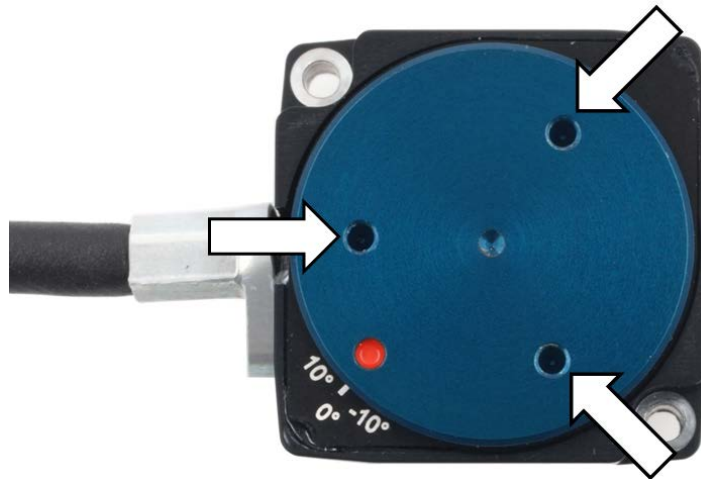


Figure 5: U-622, M1.6 holes for affixing the load

Prerequisites

- ✓ You have read and understood the general notes on installation (p. 15).
- ✓ You have properly attached the U-622 to a surface.
- ✓ The U-622 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.
 - Three points are provided for affixing the load to the moving platform.

Tools and accessories

- Three M1.6 screws of suitable length (p. 40)
- Suitable tools for tightening the screws

Affixing the Load

1. Align the load on the U-622 so that the mounting holes in the load and the holes in the moving platform overlap.
2. Affix the load using the three screws.
3. Check that the load is affixed firmly to the moving platform of the U-622.

6 Start-Up and Operation

In this Chapter

| | |
|---|----|
| General Notes on Start-Up and Operation | 21 |
| Starting up the U-622 | 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 U-622 in the case of malfunction or failure of the system. If touch voltages exist, touching the U-622 can result in minor injuries from electric shock.

- Connect the U-622 to a protective earth conductor (p. 17) 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 U-622 to the protective earth conductor before starting it up again.

NOTICE



Damage if an incorrect controller is connected!

Connecting a rotation stage to an unsuitable controller can cause damage to the rotation stage or controller.

- Only connect the rotation stage with PILine® ultrasonic piezomotors to PILine® controllers (p. 11).

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

Operating voltages that are too high or incorrectly connected can cause damage to the U-622.

- Only operate the U-622 with controllers/drivers and original accessories from PI.
- Do **not** exceed the operating voltage range (p. 34) for which the U-622 is specified.
- Only operate the U-622 when the operating voltage is properly connected; see "Pin Assignment" (p. 41).

NOTICE**Unintentional motions!**

When the U-622 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 be caught by moving parts.
- Before connecting the U-622, 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 rotation stage, the load to be moved and the environment.

- Make sure that no collisions are possible between the rotation stage, the load to be moved and the environment in the motion range of the rotation 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 U-622. 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**Overheating during continuous operation!**

The highest torque or holding force is reached at maximum motor power; however, the U-622 may overheat during continuous operation.

- Observe the recommended motor power depending on the duty cycle and the ambient temperature (p. 38).

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. 36).

INFORMATION

Although in theory the U-622 operates quietly, noise levels of up to 50 dB (A) are possible during operation. The ultrasonic drive of the U-622 can also generate higher noise levels at frequencies between 100 and 500 kHz.

INFORMATION

The positive direction of motion of the U-622 is shown in the product view (p. 9).

INFORMATION

For maximum force generation, a run-in procedure is necessary during the start-up of the U-622 and after longer downtimes; see also "Influence of Downtimes on the Torque" (p. 39). The U-622 reaches its maximum torque after the run-in procedure.

- For run-in, command a few motion cycles at low velocity. The motion cycles should comprise full revolutions if possible.

For more information on operating conditions, refer to the "Motor Power" section (p. 36).

6.2 Starting up the U-622

NOTICE**Incorrect parameter settings!**

If you use the software which is included in the scope of delivery of the controller (p. 11), the operating parameters of the U-622 can be loaded from a stage database. The *PIStages2.dat* stage database contains the default parameter values of your rotation 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 rotation 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 onto your PC.

For start-up with a load:

- Before start-up, make sure that the U-622 has been properly installed (p. 15).
- 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

If the total cable length between the stage and the controller is more than 3 m, it is necessary to adjust the parameter values in the controller for optimum motor power. The default parameter values in the *PIStages2.dat* stage database are suitable for a total cable length of 3 m.

Total cable length of 3 m to 6.5 m:

1. Adjust the value of the **Frequency Shift** parameter (ID 0x64) in the controller. Possible values: 20, 15, 10, 5, 0, -5, -10, -15, -20.
2. Repeat step 1 until the U-622 has reached optimum motor power.
3. Save the new parameter values to a stage database on the PC or the nonvolatile memory of the controller for future use (see controller manual and PIMikroMove manual).

Total cable length >6.5 m:

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

Prerequisites

- ✓ 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).
- ✓ In the case of start-up with a load: The U-622 has been properly installed (p. 15).
- ✓ The controller (p. 11) and the required software have been installed. All connections on the controller have been set up (see controller manual).

Starting up the U-622

- Start up the axis (see controller manual). 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 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 U-622..... | 28 |

7.1 General Notes on Maintenance

NOTICE



Damage due to improper maintenance!

Improper maintenance can result in the failure of the U-622.

- 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 U-622, a maintenance run may be required. The maintenance run is performed to redistribute the existing lubricant on the bearings of the U-622 and must rotate at least one full turn.

- To evenly distribute the existing lubricant on the stage bearings, perform a maintenance run after 500 hours of operation or after 1 year at the latest.
- If you operate the U-622 continuously over a small working range ($<20^\circ$), perform a maintenance run each time after 5000 motion cycles.

7.3 Cleaning the U-622

Prerequisites

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

Cleaning the rotation stage

- When necessary, clean the rotation stage surface with a cloth lightly dampened with a mild cleanser or disinfectant.

8 Troubleshooting

| Problem | Possible Causes | Solution |
|---|---|--|
| Noise during operation | Uncontrolled oscillation of the U-622 | <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. |
| Rotation stage positions inaccurately | Settling window around the target position is too large | <ul style="list-style-type: none"> ➤ Reduce the settling window by changing the parameter values for the settling window limits on the controller. See the controller user manual (p. 3) for details. |
| Reaching the target position takes too long | Settling window around the target position is too small | <ul style="list-style-type: none"> ➤ Enlarge the settling window by changing the parameter values for the settling window limits on the controller. See the controller user manual (p. 3) for details. |
| Increased wear Reduced accuracy | Warped base body | <ul style="list-style-type: none"> ➤ Mount the U-622 on an even surface. The recommended evenness of the surface is 10 µm. ➤ For applications with large temperature changes: Only mount the U-622 on surfaces that have the same or similar thermal expansion properties as the U-622 (e.g. surfaces made of aluminum). |

| Problem | Possible Causes | Solution |
|----------------------|---|---|
| No or limited motion | Excessive load | <ul style="list-style-type: none"> ➤ Reduce the load (see "Data Table", p. 33). ➤ When the rotation stage is mounted vertically, make sure that the installed load is lower than the maximum torque of the drive (p. 33). |
| | The default parameter values are not suitable for operating with high loads | <ul style="list-style-type: none"> ➤ Adjust the operating parameters according to the description in "Starting up the U-622". |
| | The default parameter values are not suitable for cables longer than 3 m | <ul style="list-style-type: none"> ➤ Adjust the operating parameters according to the description in "Starting up the U-622". |

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 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)
- 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

| | |
|--|----|
| Specifications | 33 |
| Ambient Conditions and Classifications | 35 |
| Motor Power | 36 |
| Dimensions | 40 |
| Pin Assignment..... | 41 |

10.1 Specifications

10.1.1 Data Table

| | U-622.03 | Unit | Tolerance |
|--------------------------------|---|------|-----------|
| Active axes | θ_z | | |
| Motion and Positioning | | | |
| Rotation range | >360 | ° | |
| Integrated sensor | Incremental encoder | | |
| Design resolution | 175 | μrad | |
| Min. incremental motion | 525 | μrad | typ. |
| Bidirectional repeatability | ±1050 | μrad | |
| Velocity | 720 | °/s | max. |
| Mechanical Properties | | | |
| Load capacity / axial force | 0.3 | N | max. |
| Holding torque | 0.005 | Nm | max. |
| Torque cw / ccw (θ_z) | 0.005 | Nm | max. |
| Drive Properties | | | |
| Motor type | PILine® ultrasonic piezomotor, performance class 1 | | |
| Reference point switch | Optical | | |

| | U-622.03 | Unit | Tolerance |
|-------------------------------|---|-------------|------------------|
| Miscellaneous | | | |
| Operating temperature range | 0 to 40 | °C | |
| Material | Al (black anodized) | | |
| Mass | 120 | g | ±5 % |
| Cable length | 1.5 | m | typ. |
| Connector | Sub-D connector, 15-pin (m) | | |
| Recommended controller/driver | C-877.1U11: 1 channel, affordable compact device C-877.2U12: 2 channels, affordable bench-top C-867.1U: 1 channel C-867.2U: 2 channels | | |

Ask about custom designs!

10.1.2 Reference Point Switch Specifications

| | |
|----------------|--|
| Type | Optical sensor |
| Supply voltage | +5 V/GND, supply via the motor connector |
| Signal output | TTL level |

10.1.3 Maximum Ratings

The U-622 rotation stages are designed for the following operating data:

| Maximum Operating Voltage | Operating Frequency | Maximum Power Consumption |
|--|----------------------------|----------------------------------|
| | | |
| 120 V _{pp} or 43 V _{eff} | 417 to 424 kHz | 15 W |

10.2 Ambient Conditions and Classifications

The following ambient conditions and classifications must be observed for the U-622:

| | |
|---|---|
| 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 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 Motor Power

10.3.1 Motor Power and Operating Voltage

INFORMATION

The operating voltage is limited by the controller using the **Maximum Motor Output (V)** (ID 0x7c) parameter. If you load the operating parameters of the U-622 from the *PIStages2.dat* stage database, the parameter is set to the maximum permissible value.

The following table shows the relationship between the operating voltage and the motor power of the U-622. The operating voltage is output by the controller and depends on the actual control value. The polarity sign of the control value determines the direction of motion.

| Motor Power | Operating Voltage* (Rounded) | Corresponding Control Value on the Controller** |
|-------------|---------------------------------|--|
| 0 % | 0 V _{eff} | 0 |
| 25 % | 11 V _{eff} | 8192 or -8192 |
| 50 % | 22 V _{eff} | 16384 or -16384 |
| 75 % | 32 V _{eff} | 24575 or -24575 |
| 100 % | 43 V _{eff} (max.) | 32767 or -32767 |

* Exceeding the maximum value in the **Maximum Motor Output (V)** (ID 0x7c) parameter is **not** permitted and can damage the motor.

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

For further information, see the user manual of the controller (p. 3) used to operate the U-622.

10.3.2 Velocity and Torque

The following figure can be used to estimate the velocity and torque of the U-622 with different motor powers. Motion is possible starting at a motor power of approx. 30 %.

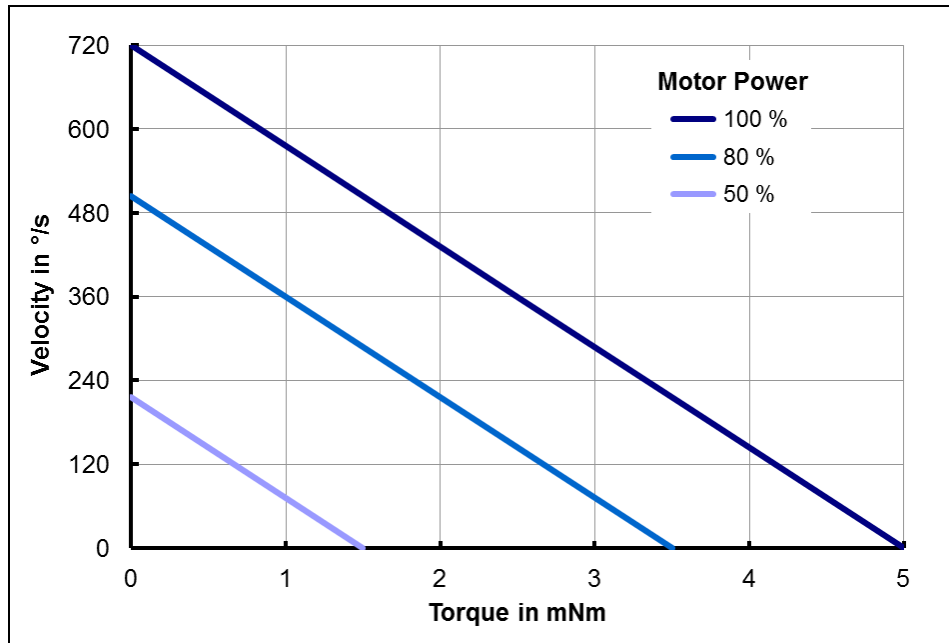


Figure 6: Relationship between velocity and torque of the U-622 with different motor power levels

10.3.3 Motor Power and Lifetime

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

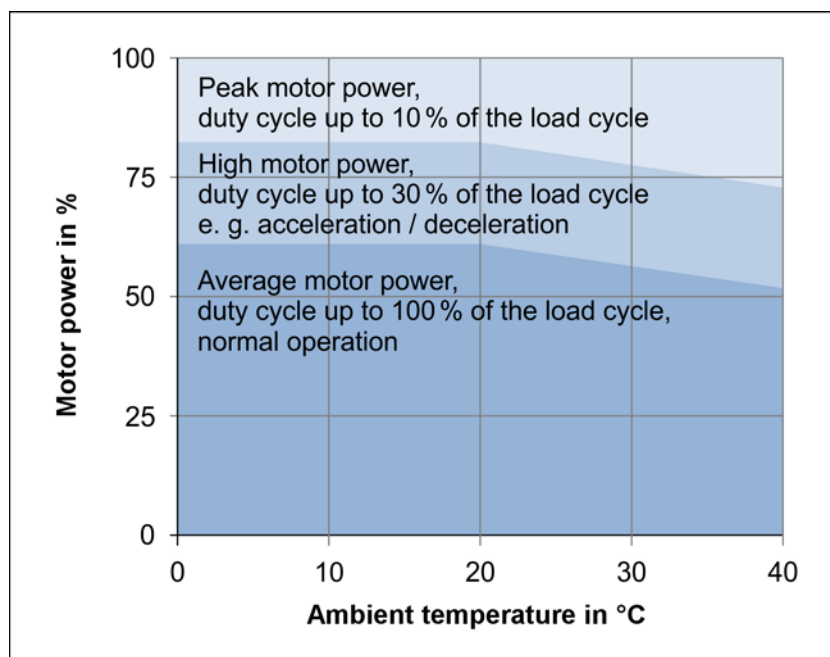


Figure 7: U-622: Recommended duty cycle and motor power depending on the ambient temperature

10.3.4 Influence of Downtimes on the Torque

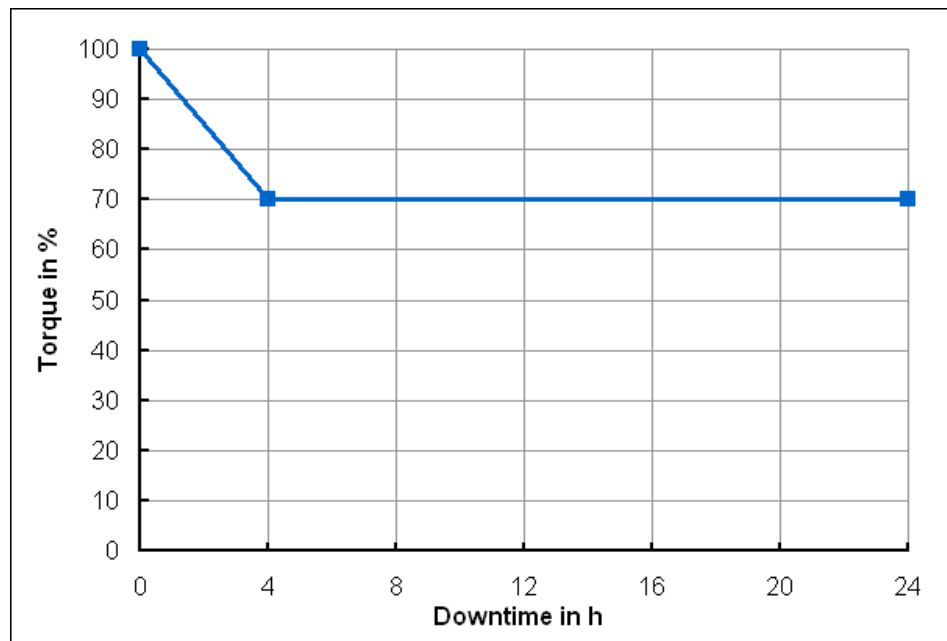


Figure 8: Torque of the U-622 depending on the downtime of the motor

10.4 Dimensions

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

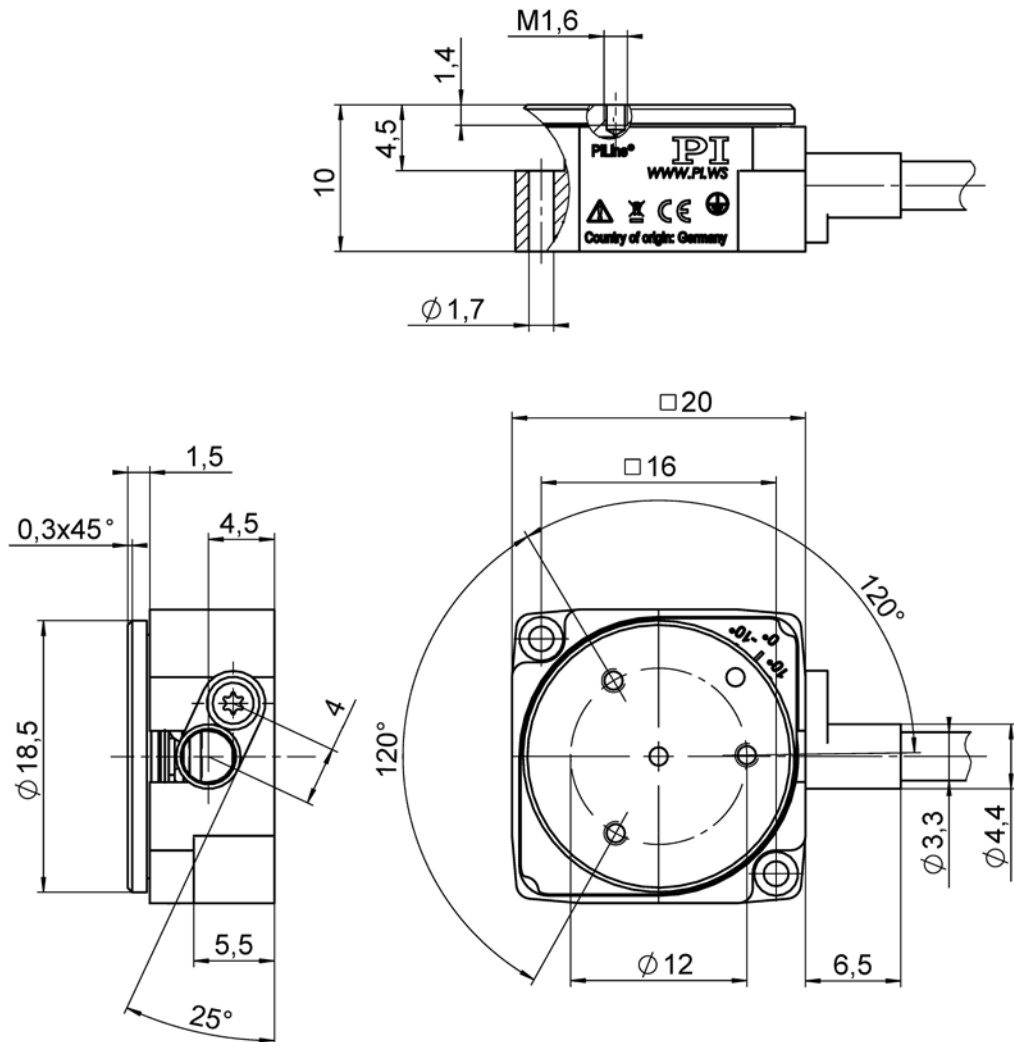


Figure 9: U-622, moving platform in reference position

10.5 Pin Assignment

Connector: Sub-D 15 (m)

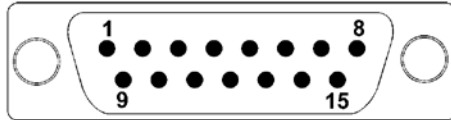


Figure 10: Front view of the Sub-D 15 connector

| Pin | Signal | Function |
|-----|-----------|--|
| 1 | NC | Not connected |
| 2 | USM_P1 | Input: Piezo 43 VAC (RMS) |
| 3 | USM_P2 | Input: Piezo 43 VAC (RMS) |
| 4 | VDD | Input: +5 V |
| 5 | NC | Not connected |
| 6 | ID_CHIP | Bidirectional: Data line for ID chip |
| 7 | ENCA- | Output: Encoder channel A (inverted), RS-422 |
| 8 | ENCB- | Output: Encoder channel B (inverted), RS-422 |
| 9 | USM_P1 | Input: Piezo 43 VAC (RMS) |
| 10 | GND | 0 V |
| 11 | USM_P3 | Input: Piezo 43 VAC (RMS) |
| 12 | NC | Not connected |
| 13 | REFSWITCH | Output: Reference point switch |
| 14 | ENCA+ | Output: Encoder channel A, RS-422 |
| 15 | ENCB+ | Output: Encoder channel B, RS-422 |

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



12 EC Declaration of Conformity

For the U-622, an EC Declaration of Conformity has been issued in accordance with the following European directives:

2006/95/EC, Low Voltage Directive

2004/108/EC, EMC Directive

2011/65/EU, RoHS Directive

The applied standards certifying the conformity are listed below.

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

EMC: EN 61326-1:2013

RoHS: EN 50581:2012

