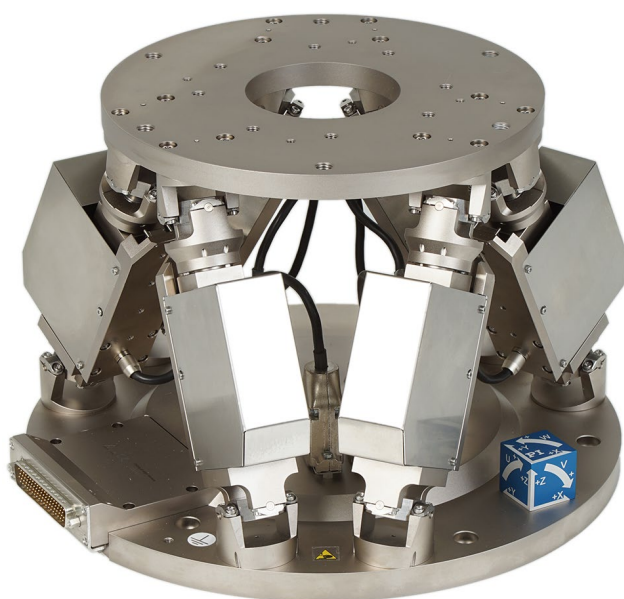


MS200E H-824 Hexapod Microrobot User Manual

Version: 2.4.0

Date: 11.01.2023



This document describes the following products:

- **H-824.G2**
Compacter Hexapod microrobot, gearhead, 10 kg load capacity, 1 mm/s velocity, D-sub connector
- **H-824.G2V**
Compacter Hexapod microrobot, gearhead, vacuum compatible to 10^{-6} hPa, 5 kg load capacity, 0.5 mm/s velocity, D-sub connector
- **H-824.D2**
Compacter Hexapod microrobot, direct drive, 5 kg load capacity, 25 mm/s velocity, D-sub connector
- **H-824.D2V**
Compacter Hexapod microrobot, direct drive, vacuum compatible to 10^{-6} hPa, 2.5 kg load capacity, 12.5 mm/s velocity, D-sub connector



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Subject to change. This manual is superseded by any new release. The latest respective release is available for download (p. 3) on our website.

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1 About this Document

In this Chapter

Objective and Target Group of this User Manual	1
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1.1 Objective and Target Group of this User Manual

This user manual contains the information necessary for using the H-824 as intended.

We assume that the user has basic knowledge of closed-loop systems, motion control concepts, and applicable safety measures.

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

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 to avoid the risk.

NOTICE




Dangerous situation

If this situation is not avoided, it will damage the equipment.

- Precautionary measures to avoid 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 points
p. 5	Cross-reference to page 5
RS-232	Label on the product indicating an operating element (example: RS-232 interface socket)
	Warning sign on the product referring to detailed information in this manual.

1.3 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.

1.4 Other Applicable Documents

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

Device/program	Document no.	Document content
C-887.5xx controller	MS247EK	Short instructions for hexapod systems
	MS244E	User manual
	C887T0011	EtherCAT interface of the C-887.53 controller series
	C887T0007	Coordinate Systems for Hexapod Microrobots
	C887T0021	Motion of the Hexapod. Position and Orientation in Space, Center of Rotation
PI Hexapod Simulation Tool	A000T0068	Determining the workspace and the permissible load of the hexapod
PC software included in the controller's scope of delivery	Various	For details, see the user manual for the C-887.5xx controller.

1.5 Downloading Manuals

INFORMATION

If a manual is missing or problems occur with downloading:

- Contact our customer service department (p. 53).

Downloading manuals

1. Open the website **www.pi.ws**.
2. Search the website for the product number (e.g., H-824).
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 hexapod microrobot (short "hexapod") is a laboratory device as defined by DIN EN 61010-1. It is built for indoor use and use in an environment which is free of dirt, oil, and lubricants.

In accordance with its design, the hexapod is intended for positioning, adjusting, and shifting of loads on six axes at various velocities.

The hexapod can only be used as intended in conjunction with a suitable controller available from PI (p. 16), which coordinates all motion of the hexapod.

2.2 General Safety Instructions

The H-824 is built according to state-of-the-art technology and recognized safety standards. Improper use of the H-824 may result in personal injury and/or damage to the H-824.

- Use the H-824 for its intended purpose only, and only when it is in perfect condition.
- Read the user manual.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for installing and operating the H-824 correctly.

2.3 Organizational Measures

User manual

- Always keep this user manual together with the H-824. The latest versions of the user manuals are available for download on our website (p. 3).
- Add all information from the manufacturer such as supplements or technical notes to the user manual.

- If you give the H-824 to other users, include this user manual as well as all 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 H-824 only after you have read and understood this user manual.

Personnel qualification

The H-824 may only be installed, started, operated, maintained, and cleaned by authorized and appropriately qualified personnel.

2.4 Measures for Handling Vacuum-Compatible Products

When handling the vacuum model of the hexapod, attention must be paid to appropriate cleanliness. At PI, all parts are cleaned before assembly. During assembly and measurement, powder-free gloves are worn. Afterwards, the hexapod is cleaned once again by wiping and shrink-wrapped twice in vacuum-compatible film.

- Touch the hexapod only with powder-free gloves.
- If necessary, wipe the hexapod clean after unpacking.

3 Product Description

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3.1 Features and Applications

Four models of the H-824 hexapod are available:

- Models for higher velocities:
 - The H-824.D2 directly driven model reaches velocities of up to 25 mm/s.
 - The vacuum-compatible H-824.D2V model reaches velocities of up to 12.5 mm/s.
- Models with a higher load capacity:
 - The H-824.G2 model equipped with DC gearhead motors reaches a load capacity of 10 kg vertically and 5 kg in any orientation.
 - The vacuum-compatible H-824.G2V model reaches a load capacity of 5 kg vertically and 2.5 kg in any orientation.

The parallel-kinematic design offers the following advantages:

- Positioning operations on six independent axes (three translational axes, three rotational axes) with short settling times
- High accuracy and step resolution on all axes
- No accumulation of errors of individual axes
- No friction and torques from moving cables

The hexapod is controlled with a controller that can be ordered separately from PI (p. 16). The position commands to the controller are entered in Cartesian coordinates.

3.2 Model Overview

Model	Description
H-824.G2	Compact hexapod microrobot, gearhead, 1 mm/s, 10 kg load, D-sub connector. Connecting cables are not in the scope of delivery and must be ordered separately.
H-824.G2V	Compact hexapod microrobot, gearhead, 0.5 mm/s, 5 kg load, vacuum compatible to 10^{-6} hPa, D-sub connector, cable set 2 m vacuum side, feedthrough. Air side connecting cables are not included in the scope of delivery and must be ordered separately.
H-824.D2	Compact hexapod microrobot, direct drive, 25 mm/s, 5 kg load, D-sub connector. Connecting cables are not in the scope of delivery and must be ordered separately.
H-824.D2V	Compact hexapod microrobot, direct drive, 12.5 mm/s, 2.5 kg load, vacuum compatible to 10^{-6} hPa, D-sub connector, cable set 2 m vacuum side, feedthrough. Air side connecting cables are not included in the scope of delivery and must be ordered separately.

3.3 Product View

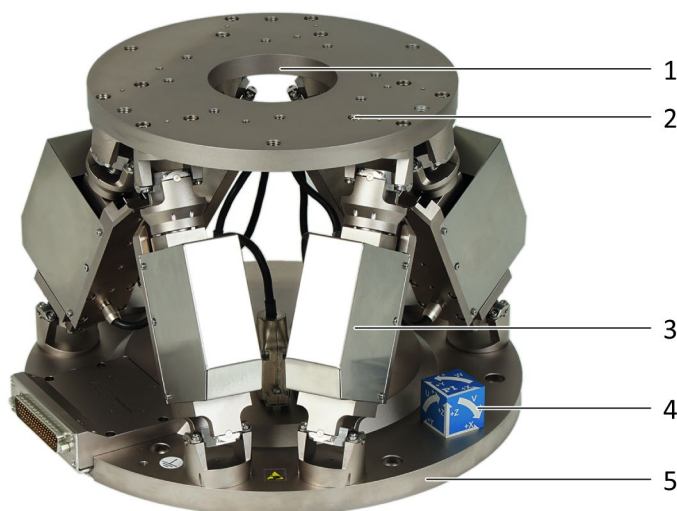


Figure 1: Product view

- 1 Clear Aperture
- 2 Motion platform
- 3 Strut
- 4 Coordinate cube
- 5 Base plate

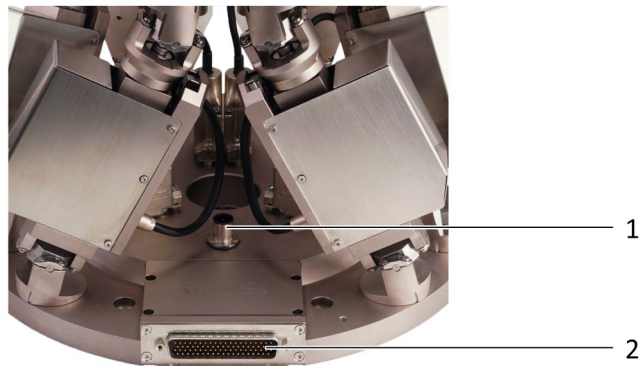


Figure 2: Connections

- 1 Panel plug for power supply cable
- 2 Panel plug for data transmission cable

3.4 Technical Features

3.4.1 Struts

The hexapod has six adjustable-length struts. Each strut carries out linear motion. Each set of settings of the six struts defines a position of the motion platform in six degrees of freedom (three translational axes and three rotational axes).

Each strut is equipped with the following components:

- One actuator
- Reference and limit switches
- Joints for connecting to the base plate and motion platform

The actuator contains the following components:

- H-824.G2, H-824.G2V:
DC motor with gearhead and rotary encoder, drive screw; folded design
- H-824.D2, H-824.D2V:
Direct drive, consisting of DC motor with rotary encoder and drive screw; folded design

3.4.2 Reference Switch and Limit Switches

The reference switch of a strut functions independently of the angular positions of the strut ends and the lengths of the other struts.

When a limit switch is activated, the power source of the motor is switched off to protect the hexapod against damage from malfunctions.

3.4.3 Control

The hexapod is intended for operation with a suitable controller from PI (p. 16). The controller makes it possible to command motion of individual axes, combinations of axes or all six axes at the same time in a single motion command.

The controller calculates the settings for the individual struts from the target positions given for the translational and rotational axes. The velocities and accelerations of the struts are calculated so that all struts start and stop at the same time.

Every time the controller of a hexapod equipped with incremental encoders is switched on or rebooted, the hexapod must complete a reference move, in which each strut moves to its reference switch. After the reference move, the motion platform is in the reference position and can be commanded to move to absolute target positions.

A reference move is not required for a hexapod with absolute-measuring sensor.

For further information, see the user manual for the controller.

3.4.4 Motion

The platform moves along the translational axes X, Y, and Z and around the rotational axes U, V, and W.

Using the controller, custom coordinate systems can be defined and used instead of the default coordinate system.

Default and user-defined coordinate systems are always right-handed systems. It is **not** possible to convert a right-handed system to a left-handed system.

The following is a description of how the hexapod behaves with the default coordinate system. Work with user-defined coordinate systems is described in the C887T0007 technical note.

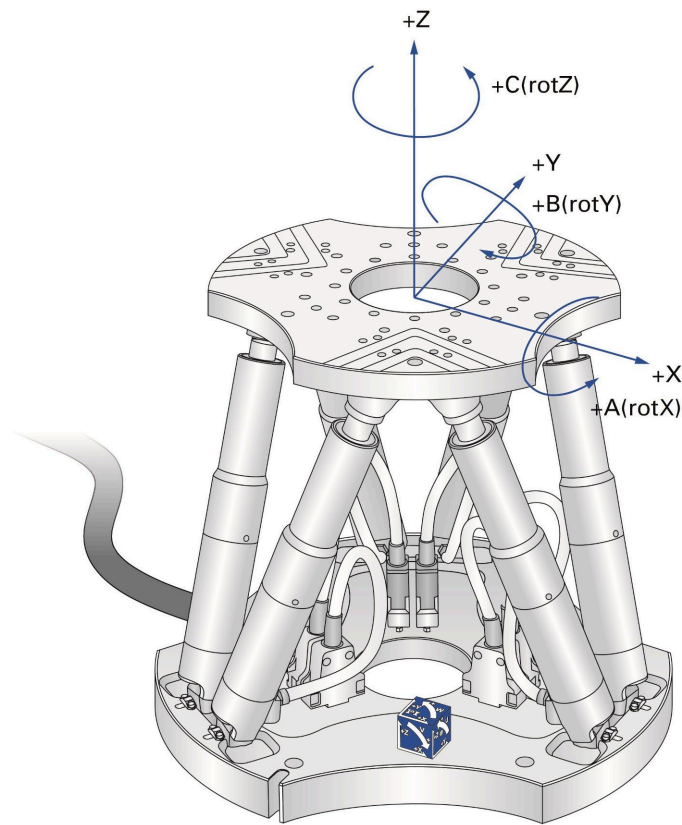


Figure 3: Coordinate system and rotations to the rotational coordinates U, V, and W. The coordinate system is depicted above the platform for better clarity

Translation

Translations are described in the spatially-fixed coordinate system. The translational axes X, Y, and Z meet at the origin of the coordinate system (0,0,0). For further information, see the glossary (p. 71).

Rotation

Rotations take place around the rotational axes U, V, and W. The rotational axes meet at the center of rotation (also referred to as "pivot point"). The rotational axes and therefore also the center of rotation always move together with the platform of the hexapod (see also the example below for consecutive rotations).

A given rotation in space is calculated from the individual rotations in the order U -> V -> W.

For further information on the center of rotation, see the glossary (p. 71).

INFORMATION

The dimensional drawing (p. 64) contains the following:

- Orientation of the default coordinate system
- Position of the default center of rotation

Example: Consecutive rotations

For a clearer view, the figures have been adapted as follows:

- Round platform replaced by T-shaped platform
- Coordinate system shown shifted
- Center of rotation in the top left corner of the platform

1. The U axis is commanded to move to position 10.

The rotation around the U axis tilts the rotational axes V and W.

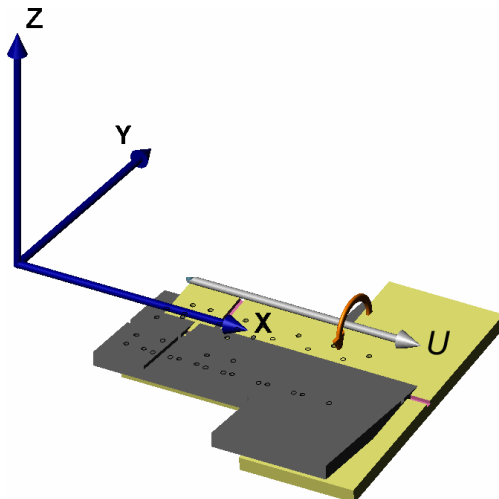


Figure 4: Rotation around the U axis

- Platform in reference position
- Platform position: $U = 10$ (U parallel to spatially-fixed X axis)

2. The V axis is commanded to move to position -10 .

The rotation takes place around rotational axis V, which was tilted during the previous rotation.

The rotation around the V axis tilts the rotational axes U and W.

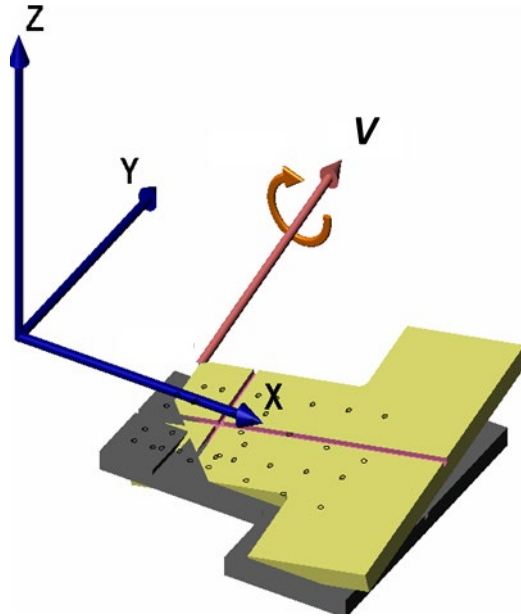


Figure 5: Rotation around the V axis

- Platform in reference position
- Platform position: $U = 10$, $V = -10$ (U and V parallel to the platform level)

3. The W axis is commanded to move to position 10.

The rotation takes place around the rotational axis W, which was tilted during the previous rotations. The W axis is always vertical to the platform level.

The rotation around the W axis tilts the rotational axes U and V.

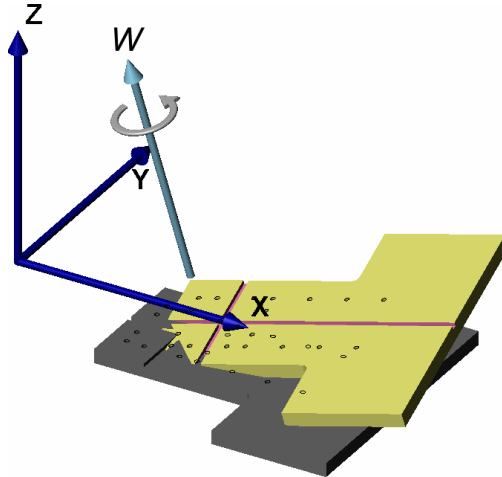


Figure 6: Rotation around the W axis

- Platform in reference position
- Platform position: $U = 10$, $V = -10$, $W = 10$ (U and V parallel to the platform level, W vertical to the platform level)

For further data on the travel ranges, see the "Specifications" section (p. 55).

3.4.5 ID Chip

The hexapod has an ID chip that contains data on the type of hexapod, its serial number, and the date of manufacture. The data is loaded from the ID chip when the controller is switched on or rebooted. Depending on the data loaded, the controller keeps the current configuration or installs a new configuration.

For simple replacement, the configuration data for all standard hexapods is stored at the factory in every standard controller (e.g., geometry data and control parameters). The configuration data for customized hexapods is only stored on the controller if the hexapod and controller are delivered together, or if PI was correspondingly informed before delivery of the controller.

For further information and application notes, see the documentation of the controller used.

3.5 Scope of Delivery

Order number	Components
H-824	Hexapod according to your order (p. 8)
For the H-824.D2V and H-824.G2V vacuum-compatible models, a 2 m cable set for the vacuum side is included in the scope of delivery. Air side connecting cables are not included in the scope of delivery and must be ordered separately.	
K040B0254	Data transmission cable on the vacuum side, HD D-sub 78 m/f, 1:1, 2 m
4668	Vacuum feedthrough for data transmission, HD D-sub 78 m/f
K060B0132	Power supply cable on the vacuum side, LEMO 2-pin (m) 180° to 2-pin (f) 90°, 2 m
C887B0002	Vacuum feedthrough for power supply, LEMO 2-pin (f) to M12 (m)
Packaging, consisting of:	
Transport safeguard with mounting kit Inner and outer box Foam and corrugated cardboard cushions Pallet	
Documentation, consisting of:	
H824T0001	Printed technical note on unpacking the hexapod
MS247EK	Short instructions for hexapod systems
Screw sets and tools:	
000034605	Mounting kit: 6 socket head screws, M6x30 ISO 4762 1 hex key 5.0 DIN 911
000077312	Double open-end wrench, 10 x 13 mm DIN 895
000036450	Accessories for connecting to the grounding system: 1 flat-head screw with cross recess, M4x8 ISO 7045 2 flat washers, form A-4.3 DIN 7090 2 safety washers, Schnorr Ø 4 mm N0110

Note that the cables required for connecting the H-824 to the electronics must be ordered separately.

3.6 Optional Accessories

Order number	Data transmission cable, available lengths
C-815.82D02	Data transmission cable for hexapods, drag chain compatible, HD D-sub 78 m/f, 2 m
C-815.82D03	Data transmission cable for hexapods, drag chain compatible, HD D-sub 78 m/f, 3 m
C-815.82D05	Data transmission cable for hexapods, drag chain compatible, HD D-sub 78 m/f, 5 m
C-815.82D07	Data transmission cable for hexapods, drag chain compatible, HD D-sub 78 m/f, 7.5 m
C-815.82D10	Data transmission cable for hexapods, drag chain compatible, HD D-sub 78 m/f, 10 m
C-815.82D20	Data transmission cable for hexapods, drag chain compatible, HD D-sub 78 m/f, 20 m

Order Number	Power Supply Cables, Available Lengths
C-815.82P02A	Power supply cable for hexapods, drag-chain compatible, M12 m/f angled, 2 m
C-815.82P03A	Power supply cable for hexapods, drag-chain compatible, M12 m/f angled, 3 m
C-815.82P05A	Power supply cable for hexapods, drag-chain compatible, M12 m/f angled, 5 m
C-815.82P07A	Power supply cable for hexapods, drag-chain compatible, M12 m/f angled, 7.5 m
C-815.82P10A	Power supply cable for hexapods, drag-chain compatible, M12 m/f angled, 10 m
C-815.82P20A	Power supply cable for hexapods, drag-chain compatible, M12 m/f angled, 20 m

To order, contact our customer service department (p. 53).

3.7 Suitable Controllers

Model	Description
C-887.52	6-axis controller for hexapods, TCP/IP, RS-232, benchtop device, incl. control of two additional axes
C-887.521	6-axis controller for hexapods, TCP/IP, RS-232, benchtop device, incl. control of two additional axes, analog inputs

Model	Description
C-887.522	6-axis controller for hexapods, TCP/IP, RS-232, benchtop device, incl. control of two additional axes, motion stop
C-887.523	6-axis controller for hexapods, TCP/IP, RS-232, benchtop device, incl. control of two additional axes, motion stop, analog inputs
C-887.53	6-axis controller for hexapods, TCP/IP, RS-232, benchtop device, incl. control of two additional axes, EtherCAT interface
C-887.531	6-axis controller for hexapods, TCP/IP, RS-232, benchtop device, incl. control of two additional axes, EtherCAT interface, analog inputs
C-887.532	6-axis controller for hexapods, TCP/IP, RS-232, benchtop device, incl. control of two additional axes, EtherCAT interface, motion stop
C-887.533	6-axis controller for hexapods, TCP/IP, RS-232, benchtop device, incl. control of two additional axes, EtherCAT interface, motion stop, analog inputs

To order, contact our customer service department (p. 53).

4 Unpacking

In this Chapter

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The hexapod is delivered in a special packaging with adapted foam inserts and with a transport safeguard installed.

- Keep **all** packaging material and the transport safeguard in case the product needs to be transported later.

NOTICE



Impermissible mechanical load!

An impermissible mechanical load can damage the hexapod.

- Only send the hexapod in the original packaging.
- Only hold the hexapod by the transport safeguard or the base plate.

INFORMATION

When handling the vacuum model of the hexapod, attention must be paid to appropriate cleanliness. At PI, all parts are cleaned before assembly. Powder-free gloves are worn during assembly and measuring. In addition, the hexapod is wipe cleaned afterwards and then shrink-wrapped twice in vacuum-compatible film.

- Touch the hexapod only with powder-free gloves.
- If necessary, wipe the hexapod clean after unpacking.

4.1 Unpacking the Hexapod

1. Open the outer box.
2. Remove the foam cover.
3. Open the inner box.
4. Remove the foam cover.
5. Grip the hexapod's transport safeguard and take it out of the foam insert.

6. Compare the contents with the items listed in the contract and the packing list. If any of the parts are wrong or are missing, contact PI immediately.
7. Inspect the hexapod for signs of damage. If there is any sign of damage, contact PI immediately.
8. Remove the transport safeguard according to the instructions (p. 20) that apply to your hexapod model.

4.2 Removing the Transport Safeguard

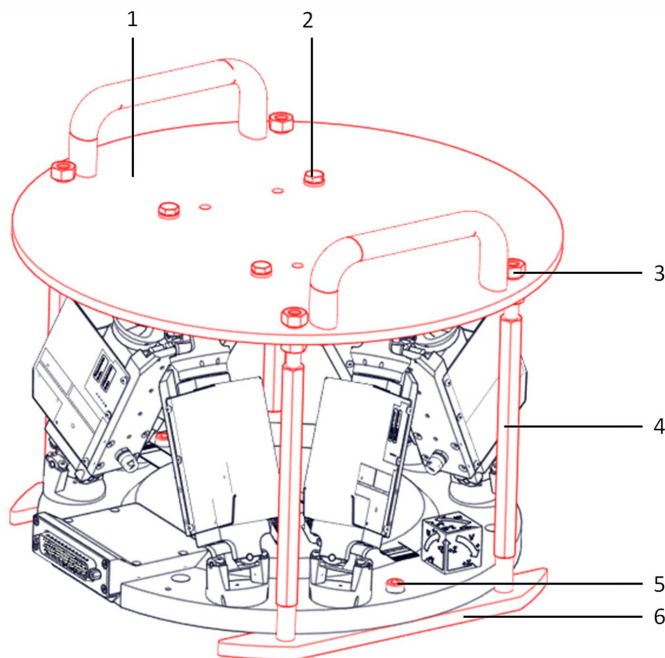


Figure 7: Hexapod with transport safeguard installed

- | | |
|---|-------------------------|
| 1 | Cover |
| 2 | M6x16 screw |
| 3 | M8 nut |
| 4 | Strut |
| 5 | M6x16 socket head screw |
| 6 | Rail |

Tools and accessories

- Open-end wrench AF 10
- Open-end wrench AF 13
- Hex key 5.0

Removing the transport safeguard

1. Use the AF 10 open-end wrench to loosen the 4 screws (M6x16) used for securing the transport safeguard's cover to the motion platform.
2. Remove the screws and the corresponding flat washers.
3. Use the AF 13 open-end wrench to loosen the 4 nuts (M8) used for securing the transports safeguard's cover to the struts.
4. Remove the nuts and the corresponding flat washers.
5. Remove the transport safeguard's cover.
6. Use the 5.0 hex key to loosen the socket head screws (M6x16) used for securing both rails of the transport safeguard to the hexapod's base plate.
7. Remove the socket head screws.
8. Grip the hexapod's baseplate and carefully pull both of the transport safeguard's rails out from under the base plate.

Store the transport safeguard

- Keep the transport safeguard as well as all screws, flat washers, and nuts in case the product needs to be transported later.

5 Installing

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5.1 General Notes on Installation

The hexapod can be mounted in any orientation.

NOTICE



Impermissible mechanical load and collisions!

Impermissible mechanical load and collisions between the hexapod, the load to be moved, and the surroundings can damage the hexapod.

- Only hold the hexapod by the base plate.
- Before installing the load, determine the limit value for the load and the workspace of the hexapod with a simulation program (p. 24).
- Avoid high forces and torques on the motion platform during installation.
- To avoid unintentional deactivation of the hexapod system and resulting position changes of the hexapod system, make sure that the power supply is not interrupted.
- Make sure that no collisions between the hexapod, the load to be moved, and the surroundings are possible in the workspace of the hexapod.

INFORMATION

The optionally available PIVeriMove hexapod software for collision checking makes it possible to check mathematically for possible collisions between the hexapod, load, and surroundings. The use of the software is recommended when the hexapod is located in a limited installation space and/or operated with a spatially limiting load. For details on activation and configuration of PIVeriMove, see the C887T0002 technical note (in the scope of delivery of the software).

5.2 Determining the Permissible Load and Workspace

Tools and Accessories

- PC with Windows operating system with the PI Hexapod Simulation Tool installed. For further information, see the A000T0068 technical note.

Determining the workspace and the permissible load of the hexapod

- Follow the instructions in the A000T0068 technical note to determine the workspace and the limit value for the load of the hexapod with the simulation program.

The limit values in the following table are for orientation. They only apply when the center of mass is at the origin of the default coordinate system (0,0,0).

Mounting position of the base plate	Servo mode switched on for hexapod – max. load capacity		Servo mode switched off for hexapod – max. holding force	
	Mounted horizontally	Mounted in any direction	Mounted horizontally	Mounted in any direction
H-824.G2	10 kg	5 kg	100 N	50 N
H-824.G2V	5 kg	2.5 kg	50 N	25 N
H-824.D2	5 kg	2.5 kg	15 N	5 N
H-824.D2V	2.5 kg	1.25 kg	15 N	5 N

If you need help in determining the limit value for the load or determining the workspace:

- Contact our customer service department (p. 53).

5.3 Grounding the Hexapod

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.

The hexapod is not grounded via the power supply cable. If a functional grounding is required for potential equalization:

1. Connect the base plate to the grounding system:
 - For connection, use the supplied accessories (p. 15) and the M4 hole with an 8 mm depth marked with the ground connection symbol (p. 64).

2. Connect the motion platform to the grounding system:

- Use one of the mounting holes in the motion platform (p. 64) for connection.
or
- If the motion platform and the load are connected conductively to each other, connect the load to the grounding system.

5.4 Mounting the Hexapod on a Surface

NOTICE



Impermissible mechanical load!

An impermissible mechanical load can damage the hexapod.

- Only hold the hexapod by the base plate.

NOTICE



Warping the base plate!

Incorrect mounting can warp the base plate. A warped base plate reduces the accuracy.

- Mount the hexapod onto a flat surface. The recommended flatness of the surface is 200 μm .

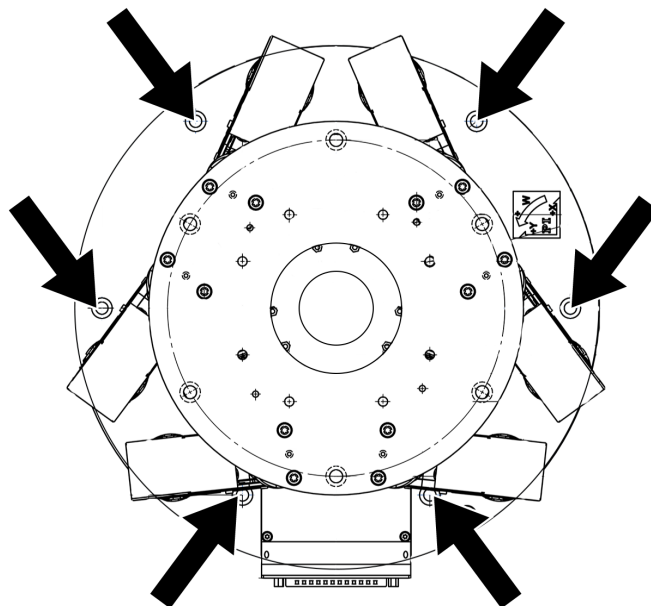


Figure 8: Mounting holes in the base plate

Requirements

- ✓ You have read and understood the General Notes on Installation (p. 23).

Tools and accessories

- Hex key 5.0 and six of the supplied screws (p. 15).

Mounting the hexapod

1. Provide six M6 threaded holes for mounting with screws M6x30 in the support. The arrangement of the six mounting holes is shown in the upper figure or in the dimensional drawing (p. 64).
2. Mount the hexapod on the six mounting holes in the base plate using the included screws.

5.5 Fixing the Load to the Hexapod

NOTICE**Impermissible mechanical load and collisions!**

Impermissible mechanical load and collisions between the hexapod, the load to be moved, and the surroundings can damage the hexapod.

- Make sure that the installed load observes the limit value resulting from the load test (p. 24).
- Avoid high forces and torques on the motion platform during installation.
- Make sure that no collisions between the hexapod, the load to be moved, and the surroundings are possible in the workspace of the hexapod.

NOTICE**Excessively long screws!**

The hexapod can be damaged by screws that are inserted too deeply.

- When selecting the screw length, observe the thickness of the motion platform or the depth of the mounting holes (p. 64) together with the load to be mounted.
- Only use screws that do not project under the motion platform after being screwed in.
- Only mount the hexapod and the load on the mounting fixtures (holes) intended for this purpose.

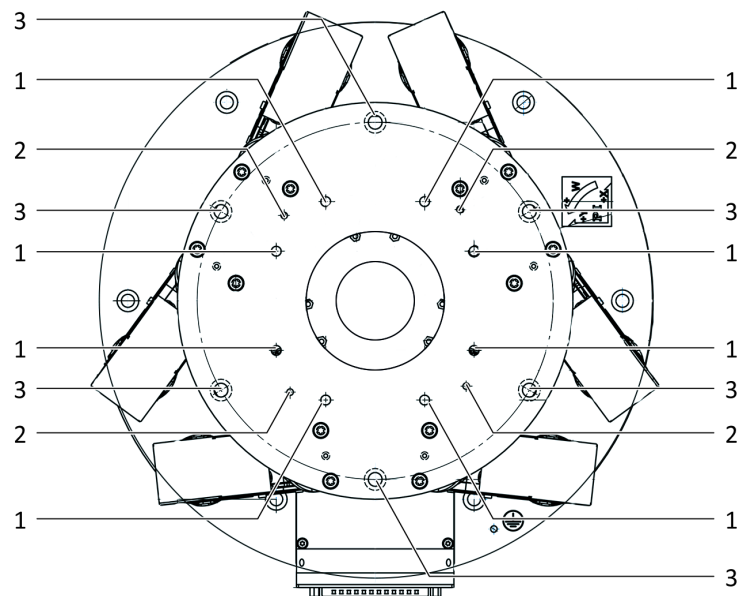


Figure 9: Mounting holes in the motion platform

- 1 8 × M6 through holes
- 2 4 × M4 through-holes with a thread depth of 8 mm
- 3 6 × M8 through holes

Requirements

- ✓ You have read and understood the General Notes on Installation (p. 23).
- ✓ You have determined the permissible load and the workspace of the hexapod (p. 24).
- ✓ You have designed the load and the surroundings of the hexapod so that the permissible load of the hexapod is adhered to and no collisions can occur.

Tools and accessories

- Screws of suitable length. Options:
 - 4 M4 screws
 - 8 M6 screws
 - 6 M8 countersunk head screws
- Suitable tool for tightening the screws

Fixing the load

1. Choose the mounting position so that the selected mounting holes in the motion platform (see upper figure and the dimensional drawing (p. 64)) can be used for fixing the load.
2. Fix the load using the screws.

5.6 Optional: Removing the Coordinate Cube

You can remove the coordinate cube from the base plate of the hexapod.

Tools and accessories

- Hex key AF 2.0

Removing the coordinate cube

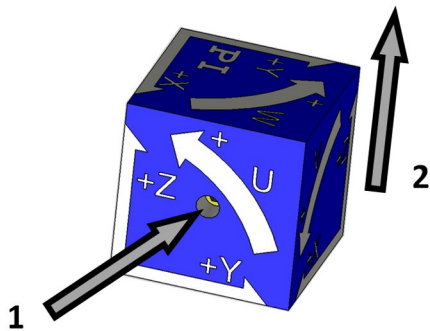


Figure 10: Removing the Coordinate Cube

1. Loosen the threaded pin M4x8.
2. Pull the coordinate cube upwards away from the base plate.

5.7 Connecting the Hexapod to the Controller

Requirements

- ✓ The controller is **switched off**, i.e., the on/off switch is in the position **O**.

Tools and accessories

- Data transmission cable and power supply cable, available as accessories (p. 15)
- If you want to operate a vacuum-compatible hexapod in a vacuum chamber: Suitable tools for installing the vacuum feedthrough

If necessary: Installing vacuum feedthroughs

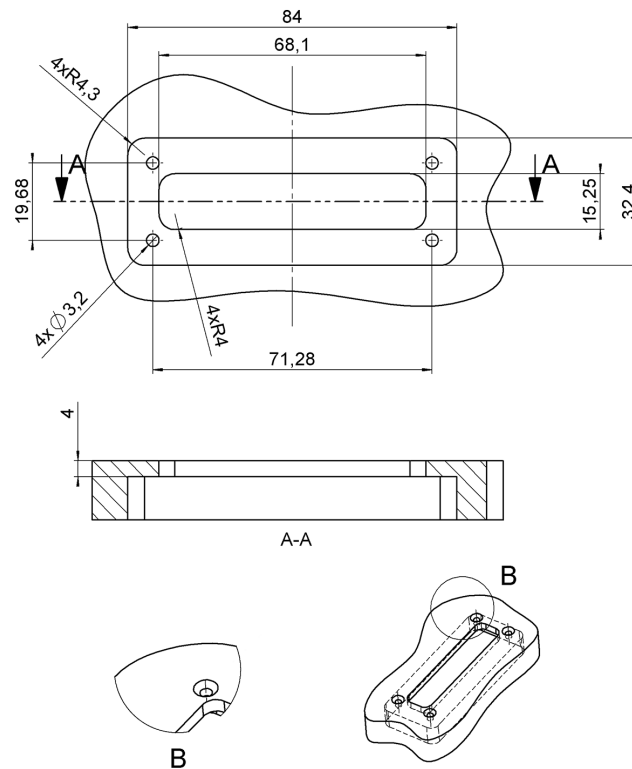


Figure 11: Vacuum feedthrough for data transmission (4668), dimensions in mm

B 4 holes, $\varnothing 6 \times 45^\circ$ for M3 countersunk screw

- Install the vacuum feedthrough for data transmission (4668) so that the HD Sub-D 78 socket (f) is in the vacuum chamber.

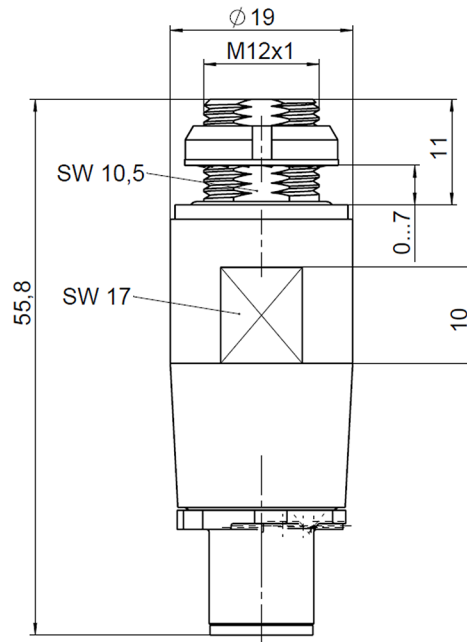


Figure 12: Vacuum feedthrough for the power supply of the hexapod (C887B0002), dimensions in mm

- Install the vacuum feedthrough for the power supply (C887B0002) so that the 2-pin LEMO connection is in the vacuum chamber.

Connecting the hexapod to the controller

- Connect the hexapod and the controller to each other:
 - Pay attention to the assignment specified on the labeling of the sockets, plug connectors, and cables.
 - Pay attention to the mechanical coding of connectors and sockets.
 - Do not use force.
 - Use the integrated screws to secure the connections against accidental disconnection.

Standard Cabling

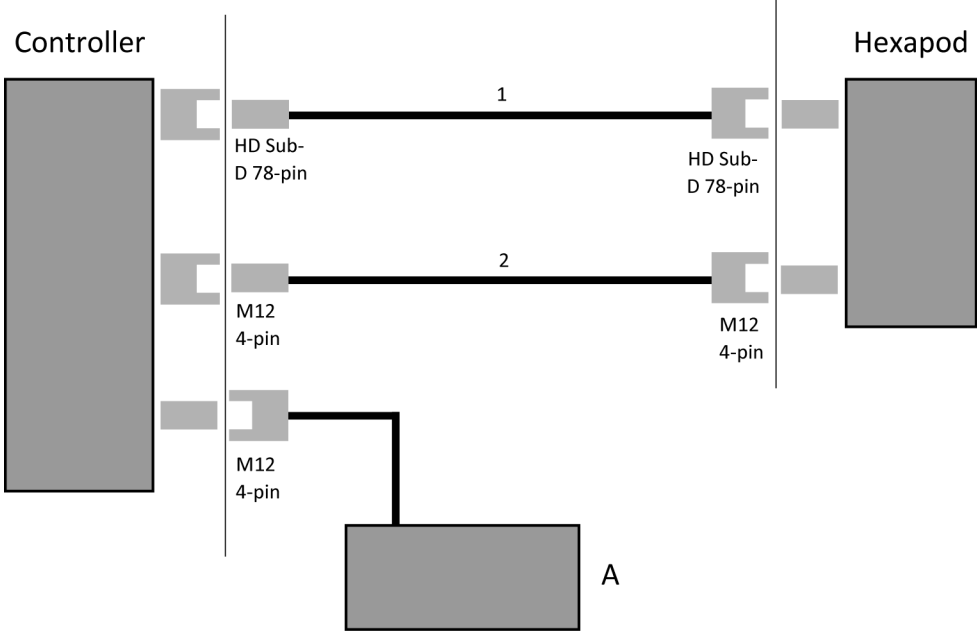




Figure 13: Connection diagram

	Panel plug / connector, male
	Socket / connector, female
Controller	Refer to "Suitable Controllers" (p. 16)
Hexapod	H-824.D2 or H-824.G2
A	Power adapter, from the scope of delivery of the controller, 24 V DC output
1	Data transmission cable*
2	Power supply cable*

* Must be ordered separately.

Cabling for vacuum

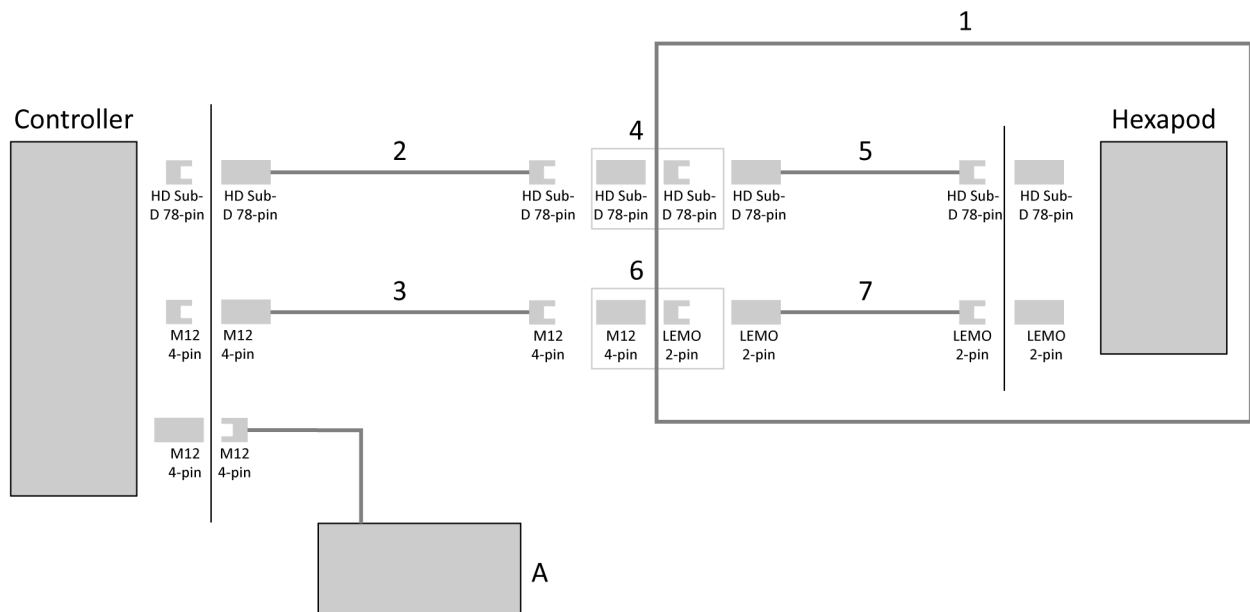




Figure 14: Connection diagram of the cable set for the vacuum-compatible hexapod

	Panel plug / connector, male
	Socket / connector, female
Controller	Refer to "Suitable Controllers" (p. 16)
Hexapod	H-824.D2V or H-824.G2V
A	Power adapter, from the scope of delivery of the controller, 24 V DC output
1	Vacuum chamber
2	Data transmission cable*
3	Power supply cable*
4	Vacuum feedthrough for data transmission**
5	Data transmission cable vacuum side**
6	Vacuum feedthrough for power supply**
7	Power supply cable, vacuum side**

* Must be ordered separately

** From the scope of delivery of the hexapod (p. 15)

6 Startup

In this Chapter

General Notes on Startup	33
Starting Up the Hexapod System	34
Baking Out Vacuum-Compatible Models.....	34

6.1 General Notes on Startup

CAUTION



Risk of crushing by moving parts!

Risk of minor injuries from crushing between the moving parts of the hexapod and a stationary part or obstacle.

- Keep your fingers away from areas where they could be caught by moving parts.

NOTICE



Incorrect configuration of the controller!

The configuration data used by the controller (e.g., geometrical data and servo control parameters) must be adapted to the hexapod. If incorrect configuration data is used, the hexapod can be damaged by uncontrolled motion or collisions.

When the controller is switched on or rebooted, the configuration data is adapted using the data that is loaded from the ID chip.

- Once you have established communication via TCP/IP or RS-232, send the `CST?` command. The response shows the hexapod, to which the controller is adapted.
- Only operate the hexapod with a controller whose configuration data is adapted to the hexapod.

NOTICE



Damage due to collisions!

Collisions can damage the hexapod, the load to be moved, and the surroundings.

- Make sure that no collisions are possible between the hexapod, the load to be moved, and the surroundings in the workspace of the hexapod.
- Do not place any objects in areas where they can be caught by moving parts.
- Stop the motion immediately if a controller malfunction occurs.

NOTICE**Damage from transport safeguard that has not been removed!**

Damage can occur to the hexapod if the transport safeguard (p. 19) of the hexapod has not been removed and a motion is commanded.

- Remove the transport safeguard before you start up the hexapod system.

6.2 Starting Up the Hexapod System

Requirements

- ✓ You have read and understood the General Notes on Startup (p. 33).
- ✓ You have correctly installed the hexapod, i.e., you have mounted the hexapod onto a surface, fixed the load to the hexapod and connected the hexapod to the controller according to the instructions in "Installation" (p. 23).
- ✓ You have read and understood the user manual of the controller.

Accessories

- PC with suitable software (refer to the user manual of the controller)

Starting up the hexapod system

1. Start up the controller (refer to the user manual of the controller).
2. Run a few motion cycles for test purposes (refer to the user manual of the controller).

6.3 Baking Out Vacuum-Compatible Models

NOTICE**Failure of the hexapod!**

The lubricant in the drivetrain can be spread unevenly during the bakeout and cooling process of the hexapod. Uneven distribution of the lubricant can lead to failure of the hexapod.

Maintenance runs that are performed over the entire travel range of the hexapod struts during the bakeout and cooling process cause the lubricant to spread evenly again. The longer the bakeout and cooling process takes, the more the maintenance runs are necessary.

- Perform a maintenance run during the bakeout and cooling process at least once a day.

Requirements

- ✓ You have connected the hexapod to the controller (p. 28).
- ✓ You have performed a test run of the hexapod system at least once (p. 34).

Baking out vacuum-compatible models

- Bake out the hexapod at maximum 80 °C (176 °F).
- Perform a maintenance run (p. 37) over the entire travel range during the bakeout and cooling process at least once a day.

7 Maintenance

In this Chapter

Performing a Maintenance Run.....	37
Packing the Hexapod for Transport	38
Cleaning the Hexapod.....	47

PI offers a range of wraparound services for all their products, many of which are designed to increase the system's lifetime and uptime:

- Remote system setup: An expert ensures that your system is optimized and runs perfectly.
- Return-to-base preventative maintenance programs: Proactive verification of your system's condition and performance.
- Customer training: Ensures that the system continues to perform optimally throughout its lifetime.

Contact your PI representative to learn more about PI's wraparound service benefits.

NOTICE



Damage due to improper maintenance!

The hexapod can become misaligned as a result of improper maintenance. The specifications can change as a result (p. 55).

- Only loosen screws according to the instructions in this manual.

Depending on the operating conditions and the period of use of the hexapod, the following maintenance measures are required.

7.1 Performing a Maintenance Run

Frequent motion over a limited travel range can cause the lubricant to be distributed unevenly on the drive screw.

- Perform a maintenance run over the entire travel range at regular intervals (see user manual of the controller). The more often motion is performed over a limited travel range, the shorter the time has to be between the maintenance runs.

7.2 Cleaning the Hexapod

Requirements

- ✓ You have removed the cables for data transmission and the power supply from the hexapod.

Cleaning the hexapod

Only when the hexapod is **not** used in vacuum:

- If necessary, clean the surfaces of the hexapod with a cloth that is dampened with a mild cleanser or disinfectant.

Only when the hexapod is used in vacuum:

- Touch the hexapod only with powder-free gloves.
- If necessary, wipe the hexapod clean.

7.3 Packing the Hexapod for Transport

NOTICE



Impermissible mechanical load!

An impermissible mechanical load can damage the hexapod.

- Only send the hexapod in the original packaging.
- Only hold the hexapod by the transport safeguard or the base plate.

NOTICE



Damage from applying high forces!

Hexapod struts with direct drive can be carefully moved by hand in the case of an error. Blocked struts can be damaged by the use of force.

- If one or more struts of the hexapod are blocked, do **not** move the hexapod by hand.
- If you move the hexapod by hand, do not use high forces.

INFORMATION

If the hexapod system is defective, the hexapod can be in a position, in which the transport safeguard cannot be attached completely. If the height of the hexapod after deactivation of the hexapod system exceeds 193 mm:

- Model with direct drive, struts not blocked: Try to move the hexapod carefully by hand so that the transport safeguard can be attached.
- Model with DC gear motor or struts blocked: Do not attach the transport safeguard.

Accessories

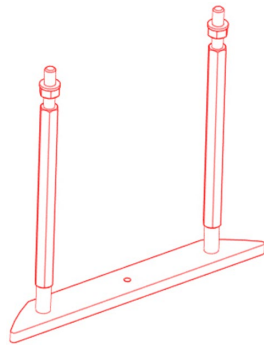
- Transport safeguard (p. 19)
- Original packaging (p. 15)
- Electrostatic dissipative film
- Strapping band
- Stretch film

7.3.1 Attaching the Transport Safeguard**Tools**

- Suitable screwdriver
- Hex key 5.0
- Open-end wrench AF 10
- Open-end wrench AF 13

Attaching the transport safeguard

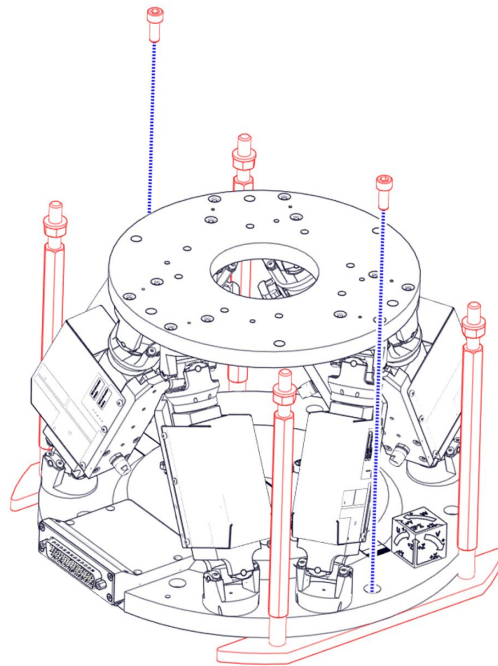
1. Command motion of the hexapod to the transport position:
xxx_Releasenews.pdf
2. Uninstall the hexapod system:
 - a) Remove the load from the motion platform of the hexapod.
 - b) Switch the controller off.
 - c) Remove the data transmission cable and the power supply cable from the controller and the hexapod.
 - d) Loosen the six M6x30 screws used to fix the hexapod on the underlying surface.
 - e) Remove the six M6x30 screws.
3. Make sure that both rails and the 4 struts of the transport safeguard are preassembled:
 - a) Screw the struts with the shorter thread into the rails as shown in the figure.
 - b) Tighten the struts by hand.
 - c) Screw an M8 nut onto each strut up to the end of the thread.
 - d) Put an 8.4 flat washer onto each nut.



Step 3
Preassembled rail
with struts, nuts,
and flat washers

Figure 15: Screw the struts into
the rail

4. Fix both preassembled rails of the transport safeguard to the hexapod's base plate, see figure:
 - a) Grip the hexapod's baseplate and carefully push both of the transport safeguard's rails under the base plate. The correct alignment of the rails can be seen in the figure.
 - b) Fix the rails to the base plate with two M6x16 socket head screws.



Step 4
Fix the
preassembled rails
to the base plate

Figure 16: Fix the rails to the base plate

5. Attach the transport safeguard's cover, see the figures also:
 - a) Place the cover onto the motion platform so that the ends of the 4 struts protrude through the corresponding holes in the cover.
 - b) Attach the cover to the motion platform using the four M6x16 screws that you previously pushed a 6.4 flat washer onto.
 - c) Push an 8.4 flat washer onto each strut.
 - d) Screw an M8 nut onto each strut and tighten by hand.
 - e) Lock each nut above and below the cover for each strut.

Steps 5 a and 5 b

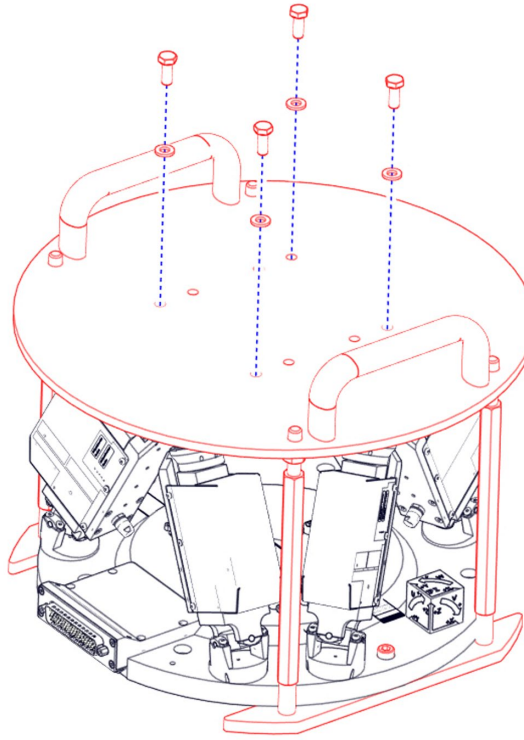


Figure 17: Fixing the cover with
M6x16 screws

Steps 5 c to 5 e

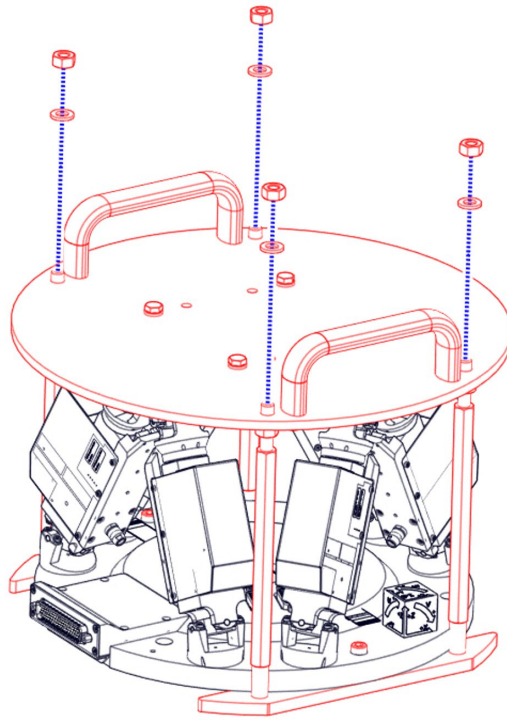
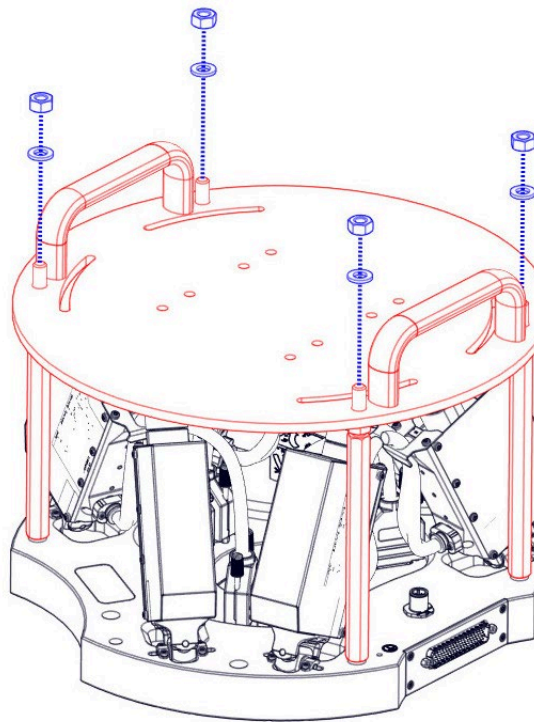


Figure 18: Fixing the cover with
M8 nuts



Installation is now complete

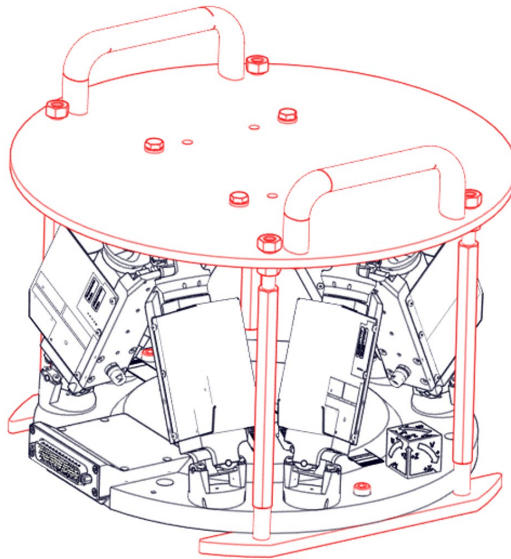


Figure 19: Transport safeguard is attached

7.3.2 Packing the Hexapod

1. Attach the transport safeguard to the hexapod. Follow the instructions (p. 39).
2. Pack the hexapod in electrostatic dissipative film to protect against dirt.
3. If necessary, prepare the original packaging, see figures:
 - a) Put the outer box onto the pallet.
 - b) Lay a 740 x 740 x 130 mm foam cushion into the outer box. Make sure that the recess for the inner box points upwards, while the "feet" point downwards.
 - c) Insert the inner box into the outer box.
 - d) If corrugated cardboard blanks are part of the original packaging: Place the blanks in the inner box.
 - e) Place the foam insert for the hexapod's base plate into the inner box. Pay attention to the appropriate orientation of the insert.
4. Grip the hexapod's transport safeguard or base plate and place it into the foam insert of the inner box.

If the transport safeguard could not be attached, stabilize the hexapod by adding additional packaging material, e.g., foam inserts.
5. Put the foam cover onto the hexapod, see figure. Pay attention to the appropriate orientation of the cover.
6. If a folded corrugated cardboard cushion is part of the original packaging: Place the cushion onto the foam cover, see figure.
7. Close the inner box.
8. Put a 740 x 740 x 130 mm foam cushion onto the inner box, see figure.
9. Put the cover onto the outer box, see figure.
10. Secure the outer box on the pallet with two parallel strapping bands.
11. Wrap the box and pallet with stretch film to protect them against moisture, see figure.



Step 3 a



Step 3 b



Step 3 e

The appropriate orientation of the foam insert depends on the hexapod model.



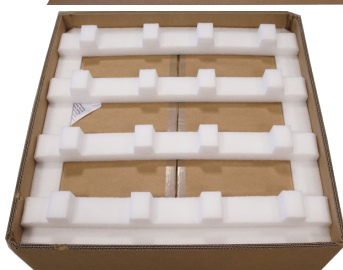
Step 5

The appropriate orientation of the foam cover depends on the hexapod model.



Step 6

Only necessary when a cushion made of folded corrugated cardboard is part of the original packaging.



Step 8



Step 9

Step 11

The upper box contains the controller.

8 Troubleshooting

Problem	Possible causes	Solution
Unexpected hexapod behavior.	<ul style="list-style-type: none"> Defective cable Bent pin Connector or soldered joints loosened 	<ul style="list-style-type: none"> ➤ Check the data transmission and power supply cables. ➤ Replace the cables by cables of the same type and test the function of the hexapod. ➤ Contact our customer service department (p. 53).
The hexapod does not achieve the specified repeatability.	<ul style="list-style-type: none"> Warped base plate Cover plate is warped 	<ul style="list-style-type: none"> ➤ Mount the hexapod onto a flat surface (p. 25). ➤ Only mount loads with a flat footprint surface. <p>The recommended flatness of the surface is 200 µm.</p>
	<ul style="list-style-type: none"> Poor lubrication because of small movements over a long period of time. 	<ul style="list-style-type: none"> ➤ Do a maintenance run over the entire travel range (p. 37).
	<ul style="list-style-type: none"> External disturbances 	<ul style="list-style-type: none"> ➤ Make sure that no vibrations are not transmitted to the system. ➤ Make sure that forces, e.g., also through dragged cables, do not affect the movement of the cover plate. ➤ Make sure that the system is in a thermal equilibrium.
The trajectory accuracy is poor.	<ul style="list-style-type: none"> Unsuitable control parameters for the application The system behavior has changed due to an increasing ease of operation. 	<ul style="list-style-type: none"> ➤ Carry out a tuning of the parameters. ➤ Contact our customer service department (p. 53).
The hexapod does not move.	<ul style="list-style-type: none"> Foreign body has entered the drive spindle Faulty motor Sensor defective Blocked or broken joint 	<ul style="list-style-type: none"> ➤ Carry out a strut test (refer to the user manual for the controller). The strut test should be carried out in the reference position, unless the malfunction occurs with maximum or minimum displacement of the platform in Z. ➤ Contact our customer service department (p. 53).

Problem	Possible causes	Solution
	<ul style="list-style-type: none"> ▪ Load too big 	
The hexapod does not move.	<ul style="list-style-type: none"> ▪ The mechanics is not supplied with voltage. 	<ul style="list-style-type: none"> ➤ Check the power supply cable. ➤ If applicable, check the power adapter of the mechanics. ➤ Check if power is being supplied to the hexapod with the command <code>DIA?</code> dia? 1= 1 {Hexapod powered} 2= 1 {E-stop activated} 3= +33.0 {Temperature} 4= -1 {Faulty point in waveform} or using the diagnostic information in PIMikroMove.
The hexapod does not move.	<ul style="list-style-type: none"> ▪ The power-good check was not switched off when connecting an old hexapod (e.g., H-811.D1) to a controller with current firmware. 	<ul style="list-style-type: none"> ➤ Check if error 500 - (error 500 - "The "red knob" is still set and disables system") or 66 - Voltage out of limits has occurred. Deactivate the power-good check using parameter 0x19004000. ➤ Contact our customer service department (p. 53).
The hexapod does not move.	<ul style="list-style-type: none"> ▪ The servo was switched off by a malfunction. 	<ul style="list-style-type: none"> ➤ Query the servo status using <code>SVO?</code>. If SVO 0 is answered, ensure that the malfunction has been corrected. Activate the servo using SVO X 1.
The hexapod does not move.	<p>Controller with E-Stop socket:</p> <ul style="list-style-type: none"> ▪ Nothing connected to E-Stop ▪ "Break contact" is active on E-Stop <p>In both cases, the 24 V Out 7 A output of the controller is disabled.</p>	<p>Controllers with the E-Stop socket support the "Motion Stop" functionality, with which the hexapod Motion can be stopped with external devices (pushbuttons, switches).</p> <ul style="list-style-type: none"> ➤ Check the state of the e-stop function: <code>dia?</code> 1= 1 {Hexapod powered} 2= 1 {E-stop activated} 3= +33.0 {Temperature} 4= -1 {Faulty point in waveform} or using the diagnostic information in PIMikroMove. <p>If you do not use the "Motion Stop" functionality:</p> <ul style="list-style-type: none"> ➤ Make sure that the C887B0038 shorting plug from the scope of delivery of the controller is inserted in the E-Stop socket. <p>If you use the "Motion Stop" functionality:</p>

Problem	Possible causes	Solution
		<ol style="list-style-type: none"> 1. Check your system and make sure that the hexapod can be moved safely. 2. Activate the 24 V Out 7 A output with "Make contact" (for details, refer to the user manual for the controller). If you use the C-887.MSB motion-stop-box from PI: Press the mushroom button first to unlock it, then press the green pushbutton. 3. Switch the servo mode on for the hexapod axes. Use the SVO command or the corresponding operating elements in the PC software. Note: A new reference move is not necessary
The hexapod does not move.	<ul style="list-style-type: none"> Incorrect or missing configuration data 	<ul style="list-style-type: none"> ➤ Send the <code>CST?</code> command. The response shows the hexapod, to which the controller is adapted. ➤ Set the correct hexapod using <code>DBG? choosehexapod {type of hexapod}</code> ➤ Send the <code>ERR?</code> command. Error code "233" in the answer indicates that the configuration data for the hexapod is missing on the controller. Contact our customer service department (p. 53) in order to receive valid configuration data.
The hexapod does not move. Error: (Position out of limit)	<ul style="list-style-type: none"> The hexapod is outside of the permissible range of movement A reference move is not possible for hexapods with absolute-measuring sensors. 	<ul style="list-style-type: none"> ➤ Create a KSD coordinate system that does not take the Cartesian limits into consideration, and increase the struts' travel ranges to get back into a permissible range of motion: Query the current limits: SPA? 1 0x30 (neg) SPA? 1 0x15 (pos) Multiply the answer by 1.5, and later set this value as described below (for example, here 30 / -30) ksd limit z 0 ken limit spa 1 0x30 -30 2 0x30 -30 3 0x30 -30 4 0x30 -30 5 0x30 -30 6 0x30 -30 spa 1 0x15 30 2 0x15 30 3 0x15 30 4 0x15 30 5 0x15 30 6 0x15 30

Problem	Possible causes	Solution
		svo x 1 mov z -5 or mov z 5 depending on the final position of the hexapod (above or below). KEN 0 When the hexapod has moved towards the middle again, restart the system (rbt).
The hexapod does not start a reference move.	<ul style="list-style-type: none"> The hexapod is equipped with absolute-measuring encoders. 	The FRF command does not start a reference move for axes with absolute-measuring sensors but sets the target positions to the current position values.
The hexapod does not start a reference move.	<ul style="list-style-type: none"> Motion is generally not possible. 	<ul style="list-style-type: none"> ➤ Check if one of the causes mentioned in the "Hexapod does not move" section applies to your problem.

If the problem with your hexapod is not listed in the table or cannot be solved as described, contact our customer service department (p. 53).

9 Customer Service Department

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

- If you have 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)
 - PC operating system (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 on our website (p. 3).

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

Motion	H-824.G2	H-824.D2	Tolerance
Active axes	X, Y, Z, θX , θY , θZ	X, Y, Z, θX , θY , θZ	
Travel range in X	± 22.5 mm	± 22.5 mm	
Travel range in Y	± 22.5 mm	± 22.5 mm	
Travel range in Z	± 12.5 mm	± 12.5 mm	
Rotation range in θX	$\pm 7.5^\circ$	$\pm 7.5^\circ$	
Rotation range in θY	$\pm 7.5^\circ$	$\pm 7.5^\circ$	
Rotation range in θZ	$\pm 12.5^\circ$	$\pm 12.5^\circ$	
Maximum velocity in X	1 mm/s	25 mm/s	
Maximum velocity in Y	1 mm/s	25 mm/s	
Maximum velocity in Z	1 mm/s	25 mm/s	
Maximum angular velocity in θX	11 mrad/s	270 mrad/s	
Maximum angular velocity in θY	11 mrad/s	270 mrad/s	
Maximum angular velocity in θZ	11 mrad/s	270 mrad/s	
Typical velocity in X	0.5 mm/s	10 mm/s	
Typical velocity in Y	0.5 mm/s	10 mm/s	
Typical velocity in Z	0.5 mm/s	10 mm/s	
Typical angular velocity in θX	5.5 mrad/s	55 mrad/s	
Typical angular velocity in θY	5.5 mrad/s	55 mrad/s	

Motion	H-824.G2	H-824.D2	Tolerance
Typical angular velocity in θZ	5.5 mrad/s	55 mrad/s	

Positioning	H-824.G2	H-824.D2	Tolerance
Unidirectional repeatability in X	$\pm 0.25 \mu\text{m}$	$\pm 0.5 \mu\text{m}$	Typ.
Unidirectional repeatability in Y	$\pm 0.25 \mu\text{m}$	$\pm 0.5 \mu\text{m}$	Typ.
Unidirectional repeatability in Z	$\pm 0.1 \mu\text{m}$	$\pm 0.15 \mu\text{m}$	Typ.
Unidirectional repeatability in θX	$\pm 2 \mu\text{rad}$	$\pm 3 \mu\text{rad}$	Typ.
Unidirectional repeatability in θY	$\pm 2 \mu\text{rad}$	$\pm 3 \mu\text{rad}$	Typ.
Unidirectional repeatability in θZ	$\pm 2 \mu\text{rad}$	$\pm 2.5 \mu\text{rad}$	Typ.
Minimum incremental motion in X	$0.3 \mu\text{m}$	$2 \mu\text{m}$	Typ.
Minimum incremental motion in Y	$0.3 \mu\text{m}$	$2 \mu\text{m}$	Typ.
Minimum incremental motion in Z	$0.3 \mu\text{m}$	$1 \mu\text{m}$	Typ.
Minimum incremental motion in θX	$3.5 \mu\text{rad}$	$12 \mu\text{rad}$	Typ.
Minimum incremental motion in θY	$3.5 \mu\text{rad}$	$12 \mu\text{rad}$	Typ.
Minimum incremental motion in θZ	$3.5 \mu\text{rad}$	$14 \mu\text{rad}$	Typ.
Backlash in X	$2 \mu\text{m}$	$1.5 \mu\text{m}$	Typ.
Backlash in Y	$2 \mu\text{m}$	$1.5 \mu\text{m}$	Typ.
Backlash in Z	$0.7 \mu\text{m}$	$1 \mu\text{m}$	Typ.
Backlash in θX	$14 \mu\text{rad}$	$15 \mu\text{rad}$	Typ.
Backlash in θY	$14 \mu\text{rad}$	$15 \mu\text{rad}$	Typ.
Backlash in θZ	$17 \mu\text{rad}$	$30 \mu\text{rad}$	Typ.

Drive properties	H-824.G2	H-824.D2	Tolerance
Drive type	DC gear motor	DC motor	
Nominal voltage	24 V	24 V	

Mechanical properties	H-824.G2	H-824.D2	Tolerance
Stiffness in X	$1.7 \text{ N}/\mu\text{m}$	$1.7 \text{ N}/\mu\text{m}$	
Stiffness in Y	$1.7 \text{ N}/\mu\text{m}$	$1.7 \text{ N}/\mu\text{m}$	
Stiffness in Z	$7 \text{ N}/\mu\text{m}$	$7 \text{ N}/\mu\text{m}$	
Maximum holding force, base plate in any orientation	50 N	5 N	
Maximum holding force, base plate horizontal	100 N	15 N	

Mechanical properties	H-824.G2	H-824.D2	Tolerance
Overall mass	8 kg	8 kg	
Material	Aluminum	Aluminum	
Maximum load capacity, base plate in any orientation	5 kg	2.5 kg	
Maximum load capacity, base plate horizontal	10 kg	5 kg	

Miscellaneous	H-824.G2	H-824.D2	Tolerance
Operating temperature range	-10 to 50 °C	-10 to 50 °C	
Connector for supply voltage	M12 4-pin (m)	M12 4-pin (m)	
Recommended controllers / drivers	C-887.5x	C-887.5x	
Connector for data transmission	HD D-sub 78-pin (m)	HD D-sub 78-pin (m)	

Technical data specified at 22±3 °C.

The maximum travel ranges of the individual coordinates (X, Y, Z, θ_X , θ_Y , θ_Z) are interdependent. The data for each axis shows its maximum travel range when all other axes are in the zero position of the nominal travel range and the default coordinate system is used, or when the pivot point is set to 0/0/0.

10.1.2 Specifications for Vacuum-Compatible Models

Motion	H-824.G2V	H-824.D2V	Tolerance
Active axes	X, Y, Z, θ_X , θ_Y , θ_Z	X, Y, Z, θ_X , θ_Y , θ_Z	
Travel range in X	± 22.5 mm	± 22.5 mm	
Travel range in Y	± 22.5 mm	± 22.5 mm	
Travel range in Z	± 12.5 mm	± 12.5 mm	
Rotation range in θ_X	± 7.5 °	± 7.5 °	
Rotation range in θ_Y	± 7.5 °	± 7.5 °	
Rotation range in θ_Z	± 12.5 °	± 12.5 °	
Maximum velocity in X	0.5 mm/s	12.5 mm/s	
Maximum velocity in Y	0.5 mm/s	12.5 mm/s	
Maximum velocity in Z	0.5 mm/s	12.5 mm/s	
Maximum angular velocity in θ_X	5.5 mrad/s	135 mrad/s	
Maximum angular velocity in θ_Y	5.5 mrad/s	135 mrad/s	
Maximum angular velocity in θ_Z	5.5 mrad/s	135 mrad/s	
Typical velocity in X	0.2 mm/s	5 mm/s	

Motion	H-824.G2V	H-824.D2V	Tolerance
Typical velocity in Y	0.2 mm/s	5 mm/s	
Typical velocity in Z	0.2 mm/s	5 mm/s	
Typical angular velocity in θX	2.3 mrad/s	28 mrad/s	
Typical angular velocity in θY	2.3 mrad/s	28 mrad/s	
Typical angular velocity in θZ	2.3 mrad/s	28 mrad/s	

Positioning	H-824.G2V	H-824.D2V	Tolerance
Unidirectional repeatability in X	$\pm 0.4 \mu\text{m}$	$\pm 0.5 \mu\text{m}$	Typ.
Unidirectional repeatability in Y	$\pm 0.4 \mu\text{m}$	$\pm 0.5 \mu\text{m}$	Typ.
Unidirectional repeatability in Z	$\pm 0.1 \mu\text{m}$	$\pm 0.15 \mu\text{m}$	Typ.
Unidirectional repeatability in θX	$\pm 2 \mu\text{rad}$	$\pm 3 \mu\text{rad}$	Typ.
Unidirectional repeatability in θY	$\pm 2 \mu\text{rad}$	$\pm 3 \mu\text{rad}$	Typ.
Unidirectional repeatability in θZ	$\pm 2 \mu\text{rad}$	$\pm 2.5 \mu\text{rad}$	Typ.
Minimum incremental motion in X	$0.3 \mu\text{m}$	$2 \mu\text{m}$	Typ.
Minimum incremental motion in Y	$0.3 \mu\text{m}$	$2 \mu\text{m}$	Typ.
Minimum incremental motion in Z	$0.3 \mu\text{m}$	$1 \mu\text{m}$	Typ.
Minimum incremental motion in θX	$3.5 \mu\text{rad}$	$12 \mu\text{rad}$	Typ.
Minimum incremental motion in θY	$3.5 \mu\text{rad}$	$12 \mu\text{rad}$	Typ.
Minimum incremental motion in θZ	$3.5 \mu\text{rad}$	$14 \mu\text{rad}$	Typ.
Backlash in X	$5 \mu\text{m}$	$3 \mu\text{m}$	Typ.
Backlash in Y	$5 \mu\text{m}$	$3 \mu\text{m}$	Typ.
Backlash in Z	$1.5 \mu\text{m}$	$1.5 \mu\text{m}$	Typ.
Backlash in θX	$30 \mu\text{rad}$	$20 \mu\text{rad}$	Typ.
Backlash in θY	$30 \mu\text{rad}$	$20 \mu\text{rad}$	Typ.
Backlash in θZ	$45 \mu\text{rad}$	$60 \mu\text{rad}$	Typ.

Drive properties	H-824.G2V	H-824.D2V	Tolerance
Drive type	DC gear motor	DC motor	
Nominal voltage	24 V	24 V	

Mechanical properties	H-824.G2V	H-824.D2V	Tolerance
Stiffness in X	$1.7 \text{ N}/\mu\text{m}$	$1.7 \text{ N}/\mu\text{m}$	
Stiffness in Y	$1.7 \text{ N}/\mu\text{m}$	$1.7 \text{ N}/\mu\text{m}$	

Mechanical properties	H-824.G2V	H-824.D2V	Tolerance
Stiffness in Z	7 N/ μ m	7 N/ μ m	
Maximum holding force, base plate in any orientation	25 N	5 N	
Maximum holding force, base plate horizontal	50 N	15 N	
Overall mass	8 kg	8 kg	
Material	Aluminum	Aluminum	
Maximum load capacity, base plate in any orientation	2.5 kg	1.25 kg	
Maximum load capacity, base plate horizontal	5 kg	2.5 kg	




Miscellaneous	H-824.G2V	H-824.D2V	Tolerance
Operating temperature range	-10 to 50 °C	-10 to 50 °C	
Connector for supply voltage	LEMO	LEMO	
Recommended controllers / drivers	C-887.5x	C-887.5x	
Connector for data transmission	HD D-sub 78-pin (m)	HD D-sub 78-pin (m)	
Vacuum class	10 ⁻⁶ hPa	10 ⁻⁶ hPa	
Maximum bake out temperature	80 °C	80 °C	

Drive and sensor	
Motor	Manufacturer: Faulhaber Motor type: DC, 2224R036SR
Gearhead	H-824.G2V only: 22/5 Reduction ratio 69:1
Encoder	Manufacturer: Faulhaber Encoder type: magnetic encoder, IE2-512
Reference switch	Magnetic, vacuum-compatible
Limit switches	Magnetic, vacuum-compatible

Materials used	
Machine-made parts	94 % of machined parts, i.e., base plate, struts, motion platform: AlMg4.5Mn0.7 (3.3547) chemically nickel-plated, stainless steel 1.4310, 1.4305 6 % of the machine parts, e.g., coupling elements: various vacuum-compatible materials
Bearing	Stainless steel
Drive elements	Drive screw: Stainless steel Drive belt: Polyurethane and Kevlar
Electrical components	Cable insulation: Teflon (PTFE, FEP) Shrink tubing: Kynar, PTFE Solder: Sn95.5Ag3.8Cu0.7 Connectors: AMP HD20, Lemo Circuit boards: Adapter board, limit switch board, PWM board
Grease	Molykote HP-300, Klüber Barrierta L55/2
Sealing compound and adhesive	Araldite 2014-1 (Huntsmann)

10.1.3 Maximum Ratings

The hexapod is designed for the following operating data:

Maximum operating voltage		Maximum operating frequency (unloaded)		Maximum current consumption	
24 V DC				5 A	

10.1.4 Specifications for Data Transmission and Power Supply Cables

The following table lists the technical data of the data transmission and power supply cables (to be ordered separately).

Data Transmission and Power Supply Cables

Data transmission cable	Power supply cable, single-side angled connector	Power supply cable, straight connectors
Alle Hexapodtypen	H-820, H-824, H-825, H-840, H-850	H-810, H-811, H-206
C-815.82D02	C-815.82P02A	C-815.82P02E
C-815.82D03	C-815.82P03A	C-815.82P03E

Data transmission cable	Power supply cable, single-side angled connector	Power supply cable, straight connectors
C-815.82D05	C-815.82P05A	C-815.82P05E
C-815.82D07	C-815.82P07A	C-815.82P07E
C-815.82D10	C-815.82P10A	C-815.82P10E
C-815.82D20	C-815.82P20A	C-815.82P20E

The models differ with respect to the following features:

1. Cable type
2. Length
3. Connector type (power cables only)

These features are coded in the product number by the character after the C-815.82 as follows:

Character following the C-815.82	Meaning	Possible values
First character	Cable type	D – Data transmission cable P – Power supply cable
Second character	Length	02 – 2 m 03 – 3 m 05 – 5 m 07 – 7.5 m 10 – 10 m 20 – 20 m
Third character	Connector type (power supply cable only)	A – Angled connector E – Straight connector

General		Unit
Cable length L	2 / 3 / 5 / 7.5 / 10 / 20	m
Maximum velocity	3	m/s
Maximum acceleration	5	m/s ²
Maximum number of bending cycles	1 million	
Operating temperature range	-10 to +70	°C

Power supply cable, straight connectors		Unit
Minimum bending radius in a drag chain	49	mm

Power supply cable, straight connectors		Unit
Minimum bending radius with the fixed installation	25	mm
Outer diameter	4.9	mm
Connectors	M12 m/f	

Power supply cable, angled connector			Unit
Cable length L	3	2 / 5 / 7.5 / 10 / 20	m
Minimum bending radius in a drag chain	72	94	mm
Minimum bending radius with the fixed installation	36	57	mm
Outer diameter	7.2	7.5	mm
Connector	M12 m/f		

Data transmission cable		Unit
Minimum bending radius in a drag chain	107	mm
Minimum bending radius with the fixed installation	81	mm
Outer diameter	10.7	mm
Connectors	HD D-sub 78 m/f	

Data Transmission and Power Supply Cables for Vacuum

Data transmission cable	Power supply cable, angled connector
K040B0254	K060B0132

General		Unit
Cable length L	2	m
Operating temperature range	-10 to +80	°C

Data transmission cable		Unit
Minimum bending radius with the fixed installation	47	mm
Outer diameter	9.3	mm

Data transmission cable		Unit
Connectors	HD D-sub78 m/f	

Power supply cable, angled connector		Unit
Minimum bending radius with the fixed installation	21	mm
Outer diameter	4.2	mm
Connectors	LEMO 2-pin m/f	

10.2 Ambient Conditions and Classifications

Degree of pollution	2
Air pressure	1100 hPa to 780 hPa Vacuum-compatible models: 1100 hPa to 10^{-6} hPa
Transport temperature	−25 °C to +85 °C
Storage temperature	0 °C to 70 °C
Bakeout temperature	Vacuum-compatible models only: 80 °C (176 °F)
Humidity:	Highest relative humidity of 80% at temperatures of up to 31°C, decreasing linearly to a relative humidity of 50% at 40°C
Degree of protection according to IEC 60529	IP20
Area of application	For indoor use only
Maximum altitude	2000 m

10.3 Dimensions

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

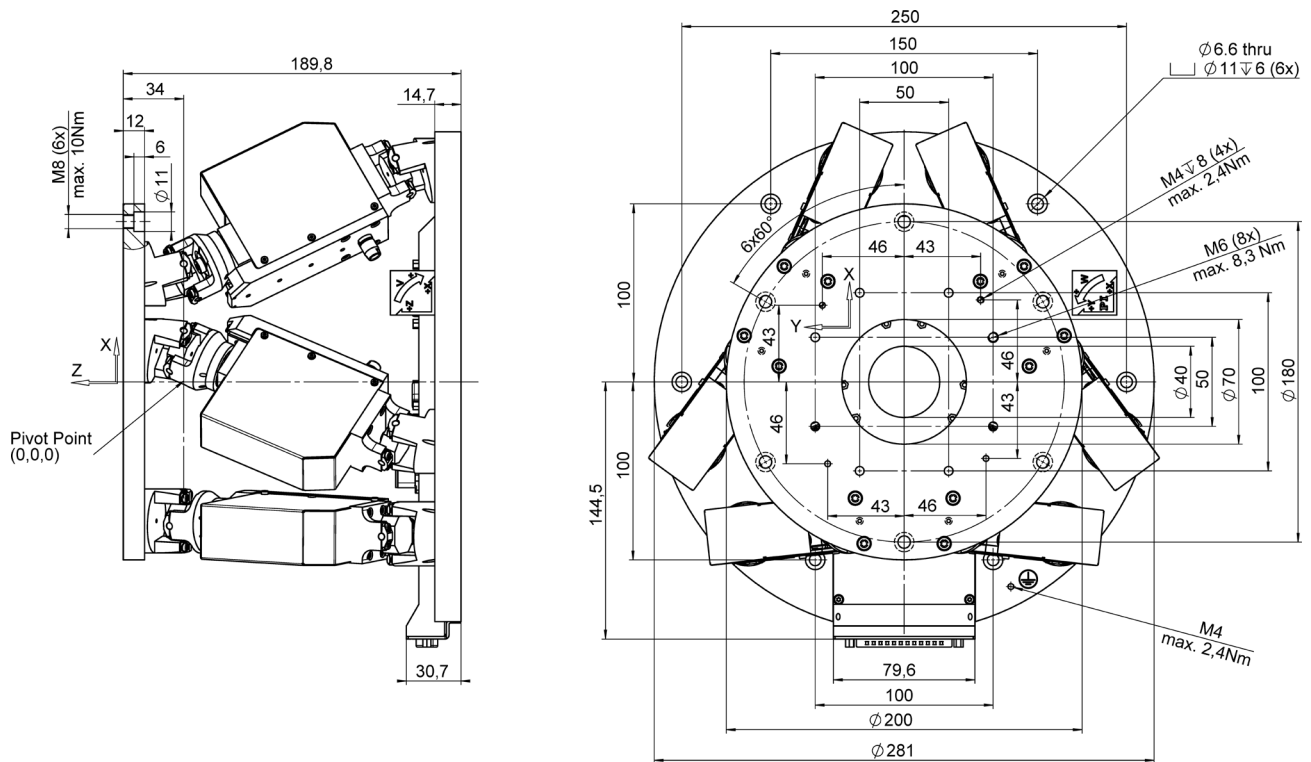
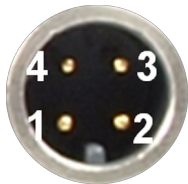


Figure 20: H-824 hexapod, at zero position of nominal travel range

10.4 Pin Assignment

10.4.1 Power Supply Connection

Not for vacuum models:
Power supply via 4-pin M12 Panel plug

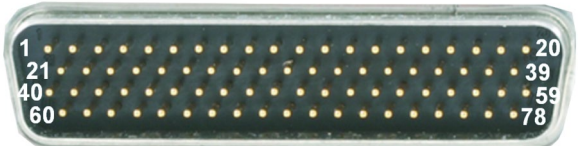
Pin	Function	
1	GND	
2	GND	
3	24 V DC	
4	24 V DC	

Only for vacuum models:
power supply via 2-pin LEMO panel plug, male, type ECJ.1B.302.CLD

Pin	Function	
1	GND	
2	24 V DC	

10.4.2 Data Transmission Connection

Data transmission between hexapod and controller
Panel plug HD Sub-D 78 m

Function	
All signals: TTL	

Pin Assignment

Pin	Pin	Signal
1		CH1 Sign IN
	21	CH1 Ref OUT
2		nc
	22	CH1 A+ OUT
3		CH1 A- OUT
	23	GND
4		CH2 Sign IN
	24	CH2 Ref OUT
5		nc
	25	CH2 A+ OUT
6		CH2 A- OUT
	26	GND
7		CH3 Sign IN
	27	CH3 Ref OUT
8		nc
	28	CH3 A+ OUT
9		CH3 A- OUT
	29	GND
10		CH4 Sign IN
	30	CH4 Ref OUT
11		nc
	31	CH4 A+ OUT
12		CH4 A- OUT
	32	GND
13		CH5 Sign IN
	33	CH5 Ref OUT
14		nc
	34	CH5 A+ OUT
15		CH5 A- OUT
	35	GND

Pin	Pin	Signal
40		CH1 MAGN IN
	60	CH1 LimP OUT
41		CH1 LimN OUT
	61	CH1 B+ OUT
42		CH1 B- OUT
	62	GND
43		CH2 MAGN IN
	63	CH2 LimP OUT
44		CH2 LimN OUT
	64	CH2 B+ OUT
45		CH2 B- OUT
	65	GND
46		CH3 MAGN IN
	66	CH3 LimP OUT
47		CH3 LimN OUT
	67	CH3 B+ OUT
48		CH3 B- OUT
	68	GND
49		CH4 MAGN IN
	69	CH4 LimP OUT
50		CH4 LimN OUT
	70	CH4 B+ OUT
51		CH4 B- OUT
	71	GND
52		CH5 MAGN IN
	72	CH5 LimP OUT
53		CH5 LimN OUT
	73	CH5 B+ OUT
54		CH5 B- OUT
	74	GND

Pin	Pin	Signal
16		CH6 Sign IN
	36	CH6 Ref OUT
17		nc
	37	CH6 A+ OUT
18		CH6 A- OUT
	38	GND
19		ID Chip
	39	GND
20		24 V input

Pin	Pin	Signal
55		CH6 MAGN IN
	75	CH6 LimP OUT
56		CH6 LimN OUT
	76	CH6 B+ OUT
57		CH6 B- OUT
	77	GND
58		Brake/Enable drive
	78	GND
59		Power Good 24 V output

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.

To fulfill the 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 Roemerstrasse 1
76228 Karlsruhe, Germany



12 Glossary

User-defined coordinate system

Using the controller, custom coordinate systems can be defined and used instead of the default coordinate systems.

Work with user-defined coordinate systems and the work-and-tool concept is described in the C887T0007 technical note.

Workspace

The entirety of all combinations of translations and rotations that the hexapod can approach from the current position is referred to as the workspace.

The workspace can be limited by the following external factors:

- Installation space
- Dimensions and position of the load

Center of rotation

The center of rotation describes the intersection of the rotational axes U, V, and W. When the default settings for the coordinate system and the center of rotation are used, the center of rotation after a reference move is located at the origin of the coordinate system (0,0,0), see the dimensional drawing of the hexapod (p. 64).

The center of rotation always moves together with the platform.

Depending on the active --> operating coordinate system, the center of rotation can be moved from the origin of the coordinate system in the X and/or Y and/or Z direction with the `SPI` command. The center of rotation that can be moved using the `SPI` command is also referred to as "pivot point".

Hexapod system

The combination of hexapod, controller, cables, and power adapter(s) is referred to as "hexapod system" in this manual.

Default coordinate system

The X, Y, and Z axes of the Cartesian coordinate system are always spatially fixed, i.e., the coordinate system does not move when the platform of the hexapod moves. The X, Y and Z axes are also referred to as translational axes.

The intersection of the axes X, Y, and Z of the spatially fixed Cartesian coordinate system (0,0,0) is referred to as the origin.

The Z axis is perpendicular to the base plate of the hexapod.

The following example figures of the H-810 hexapod show that the coordinate system does not move along with motion of the platform.

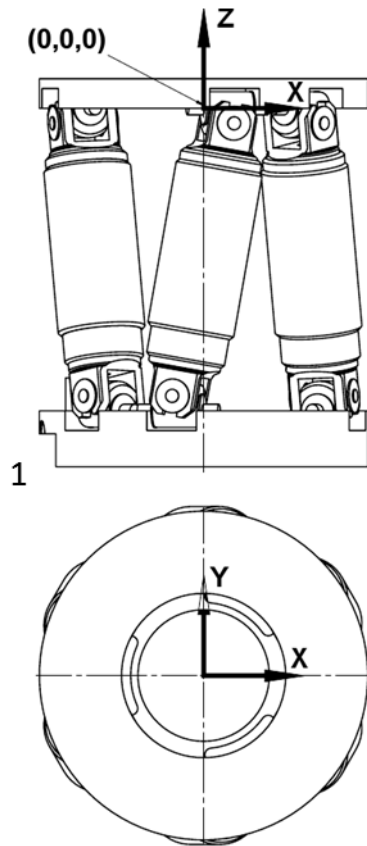


Figure 21: H-810 hexapod in the reference position.

1 Cable exit

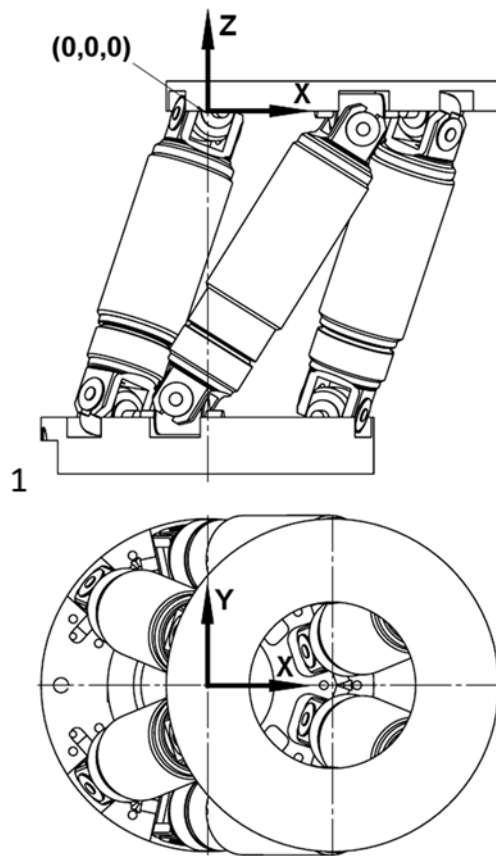


Figure 22: H-810 hexapod, the platform of which has been moved in X.

1 Cable exit

13 Appendix

In this Chapter

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13.1 Explanations of the Performance Test Sheet

The hexapod is tested for the positioning accuracy of the translation axes before delivery. The performance test sheet is included in the scope of delivery.

The following figure shows the test setup used.

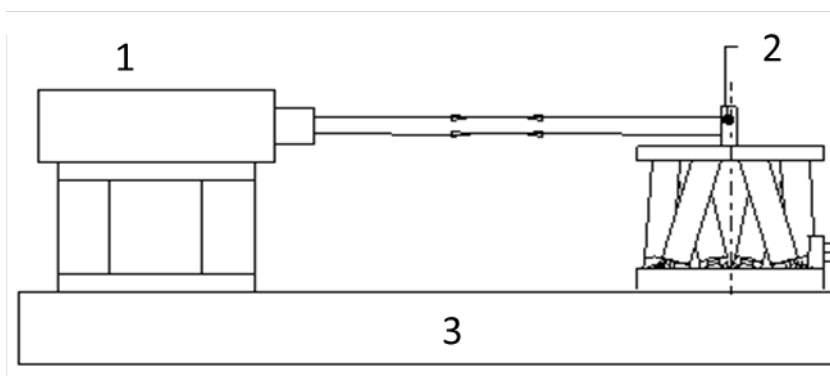


Figure 23: Test setup for measuring the X or Y axis.

- 1 Laser interferometer
- 2 Mirror
- 3 Bench

The following test cycles are performed:

- Motion over the entire travel range with at least 20 measuring points, in at least five cycles.
- Motion over partial sections, e.g., ± 1 mm in increments of for example, $100\ \mu\text{m}$

13.2 European Declarations of Conformity

For the H-824, declarations of conformity were issued according to the following European statutory requirements:

EMC Directive

RoHS Directive

The standards applied for certifying conformity are listed below.

EMC: EN 61326-1

Safety: EN 61010-1

RoHS: EN IEC 63000