MS198E

H-810 Hexapod Microrobot

User Manual

Version: 1.2.0 Date: 03.06.2013

This document describes the following product:

- **H-810.D1**
  Miniature-Hexapod Microrobot, Direct Drive, 2.5 mm/s, 5 kg Load, 2 m Cable

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Contents

1 About this Document

In this Chapter

1.1 Goal and Target Audience of this User Manual

This manual contains information on the intended use of the H-810.

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

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

1.2 Symbols and Typographic Conventions

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

CAUTION

Dangerous situation

If not avoided, the dangerous situation will result in minor injury.

➢ Actions to take to avoid the situation.

NOTICE

Dangerous situation

If not avoided, the dangerous situation will result in damage to the equipment.

➢ Actions to take to avoid the situation.

INFORMATION

Information for easier handling, tricks, tips, etc.

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

1.3 Other Applicable Documents

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

Description	Document
C-887 Hexapod controller	MS204E User Manual
C-887 Hexapod controller	MS204Equ User Manual Short Version

1.4 Downloading Manuals

INFORMATION

If a manual is missing on our website or if there are problems in downloading:

➢ Contact our customer service department (p. 41).

The current versions of the manuals are found on our website. To download a manual, proceed as follows:

1. Open the website **http://www.pi-portal.ws**.
2. Click ***Downloads***.
3. Click the corresponding category (e. g. ***H-Hexapods***).
4. Click the corresponding product code (e. g. ***H-810***).

   An overview of the available file types is shown for the selected product.
5. If ***(0 Files)*** is shown in the ***Documents*** line, log in as follows to display and download the documents:

   a) Insert the product CD in the corresponding PC drive.
   b) Open the ***Manuals*** directory.
   c) Open the Release News (e. g. ***C-887_Releasenews_V_x_x_x.pdf***) on the CD of the product.
   d) Find the user name and password in the **User login for software download** section in the Release News.
   e) In the ***User login*** area on the left margin in the website, enter the user name and the password in the corresponding fields.
   f) Click ***Login***.

   If ***Documents (0 Files)*** is still being displayed, no manuals are available:

   – Contact our customer service department (p. 41).
6. Click ***Documents***.
7. Click the desired manual and save it on the hard disk of your PC or on a data storage medium.

2 Safety

In this Chapter

2.1 Intended Use

The Hexapod microrobot (in short: "Hexapod") is a laboratory device in accordance with DIN EN 61010-1. It is intended to be used in interior spaces and in an environment that is free of dirt, oil and lubricants.

Based on its design and realization, the Hexapod is intended for positioning, adjusting and shifting of loads in six axes at various velocities.

The Hexapod is part of a Hexapod system. The intended use of the Hexapod is only possible in connection with the Hexapod controller, which is part of the Hexapod system and coordinates all motions of the Hexapod.

2.2 General Safety Instructions

The H-810 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 H-810.

- Only use the H-810 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 H-810.

2.3 Organizational Measures

User manual

- Always keep this user manual available by the H-810.
  The latest versions of the user manuals are available for download (p. 3) on our website.
- Add all information given by the manufacturer to the user manual, for example supplements or Technical Notes.
- If you pass the H-810 on to other users, also turn over this user manual as well as other relevant information provided by the manufacturer.
- Only use the device on the basis of the complete user manual. Missing information due to an incomplete user manual can result in minor injury and property damage.
- Only install and operate the H-810 after having read and understood this user manual.

Personnel qualification

The H-810 may only be started up, operated, maintained and cleaned by authorized and qualified staff.

3 Product Description

In this Chapter

3.1 Features and Applications

The H-810 Hexapod achieves a velocity of up to 2.5 mm/s. It can be loaded with a maximum of 5 kg in a vertical orientation and with a maximum of 2.5 kg in any other orientation.

The parallel kinematics structure and the free choice of the pivot point offer the following advantages:

- Positioning operations in six independent axes (three translational axes, three rotational axes) with short settling times
- Pivot point is maintained for rotations and moves along with linear motions
- High accuracy and step resolution in all axes
- No addition of the errors of individual axes
- No friction and torques from moving cables

The Hexapod is controlled with the Hexapod controller, which is part of the Hexapod system. The position commands to the Hexapod controller are entered in Cartesian coordinates.

3.2 Model Overview

Hexapod and Hexapod controller are only available together as a system.

Possible system components

Standard version of the H-810 Hexapod:

Model	Name
H-810.D1	Miniature-Hexapod Microrobot, Direct Drive, 2.5 mm/s, 5 kg Load, 2 m Cable (permanently installed)

Standard versions of the C-887 Hexapod controller:

Model	Name
C-887.11	6-D Hexapod Controller, Control of 2 Additional Servo-Motor Axes Included, TCP/IP and RS-232 Interface, 19" Chassis
C-887.21	6-D Hexapod Controller, TCP/IP and RS-232 Interface, Bench-Top

Available Hexapod systems

The following Hexapod systems are available as combinations of Hexapod and Hexapod controller:

System	Hexapod including cable set	Hexapod Controller	
–	H-810.D1	C-887.11	C-887.21
H-810.D11	**X**	**X**	**–**
H-810.D12	**X**	**–**	**X**

3.3 Product View

Figure 1: Product view

1 Moving platform
2 Strut
3 Power supply cable
4 Data transmission cable
5 Base plate

3.4 Scope of Delivery

The following table contains the scope of delivery of the Hexapod.

The scope of delivery of the Hexapod controller is listed in the user manual of the Hexapod controller.

Order Number	Items
H-810	Hexapod according to your order (p. 8), including cable set (permanently installed)
000015165	Steward snap-on ferrite suppressor
Packaging, consisting of:	
	▪ Outer box ▪ Inner box ▪ Top and bottom ring-shaped pad for securing the inner box ▪ Foam cover for the inner box ▪ Foam insert for the inner box ▪ Transport lock, consisting of three corrugated plastic sheets ▪ Pallet
Documentation, consisting of:	
H810T0001	Technical Note on unpacking the Hexapod
MS198E	User manual for the Hexapod (this document)
Screw set:	
000020110	Mounting accessories: ▪ 6 M4x25 hex-head cap screws ISO 4762 ▪ 1 Allen wrench 3.0 DIN 911

3.5 Technical Features

3.5.1 Struts

The Hexapod has six adjustable-length struts. Each strut carries out linear motions. Each set of settings of the six struts defines a position of the moving 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 moving platform

The actuator contains a direct drive, consisting of DC motor with rotary encoder and drive screw.

3.5.2 Reference Point Switch and Limit Switches

The reference point 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.

3.5.3 Control

The Hexapod is intended for operation with the Hexapod controller which belongs to the Hexapod system. The Hexapod 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 Hexapod 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 in such a way that all struts start and stop at the same time.

After the Hexapod controller has been switched on or restarted, the Hexapod has to complete a reference move in which each strut moves to its reference point switch. After the reference move, the moving platform is in the reference position and can be commanded to move to absolute target positions.

For more information, see the user manual of the Hexapod controller.

3.5.4 Motion

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

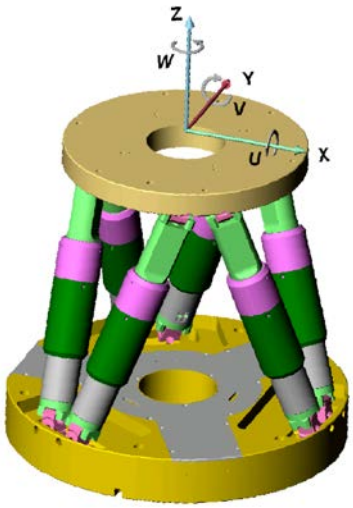


Figure 2: XYZ coordinate system and rotations to the rotation coordinates U, V and W. The coordinate system is depicted above the platform for better clarity.

Translation

Translations are described in the spatially-fixed XYZ coordinate system. The translational axes meet at the origin of the XYZ coordinate system (0,0,0). For more information, see the glossary (p. 55).

Rotation

Rotations take place around the rotational axes U, V and W. The rotational axes meet at the pivot point. For more information on the pivot point, see the glossary (p. 55).

In contrast to the spatially-fixed translational axes, the rotational axes and thus the pivot point as well move along with the platform (see also the example below for consecutive rotations).

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

INFORMATION

The dimensional drawing (p. 46) contains the following:

- Alignment of the XYZ coordinate system
- Position of the pivot point after the reference move, when the standard settings of the Hexapod controller are used

Example: Consecutive rotations

INFORMATION

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

- Round platform replaced by T-shaped platform
- XYZ coordinate system shown shifted
- Pivot point 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.

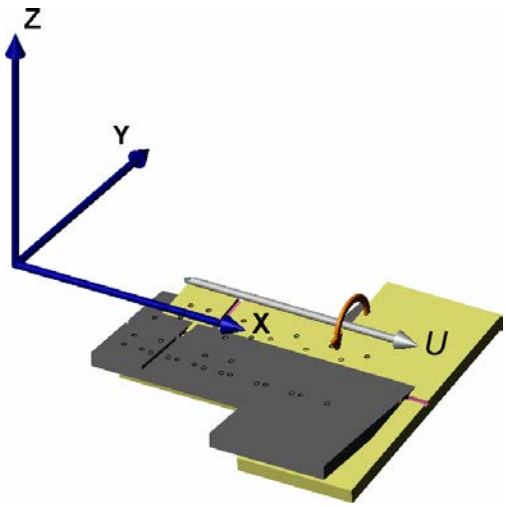


Figure 3: Rotation around the U axis

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.

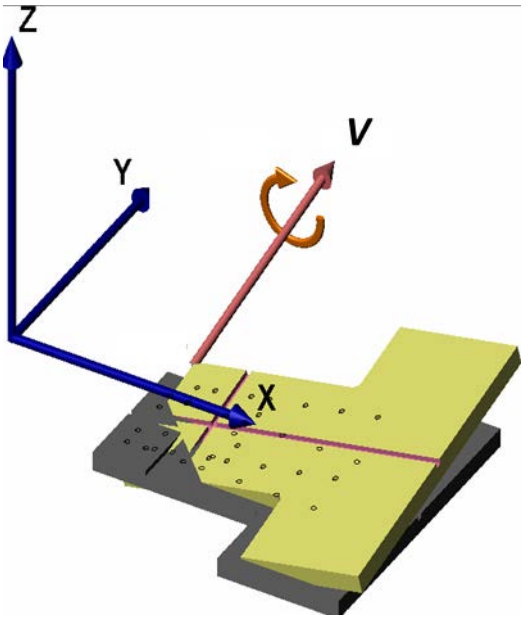


Figure 4: Rotation around the V axis

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.

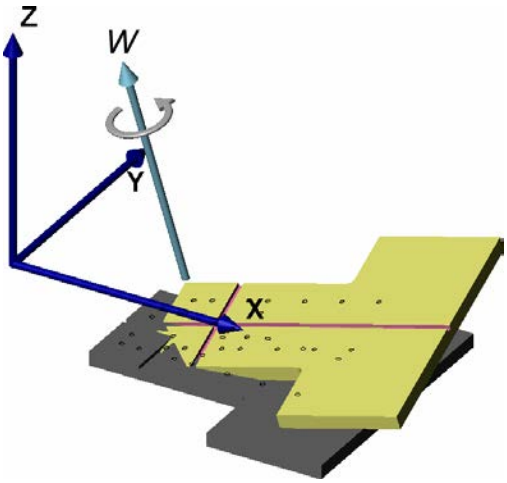


Figure 5: Rotation around the W axis

- 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 more data on the travel ranges, see the "Specifications" section (p. 43).

4 Unpacking

The Hexapod is delivered in a special packaging with adapted foam inserts.

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 base plate.

Unpacking the Hexapod

1. Open the outer box.

2. Remove the top ring-shaped pad from the inner box.
3. Lift the inner box out of the outer box.

4. Open the inner box.

5. Remove the foam cover.

6. Hold the Hexapod by the base plate and take it out of the foam insert together with the connection cables.
7. Remove the plastic foil from the Hexapod.
8. Compare the contents against the items covered by the contract and against the packing list. If parts are incorrectly supplied or missing, contact PI immediately.
9. Inspect the Hexapod for signs of damage. If you notice signs of damage, contact PI immediately.

10. Remove the transport lock:
    - Pull the three corrugated plastic sheets that are clamped between the base plate and the moving platform of the Hexapod.

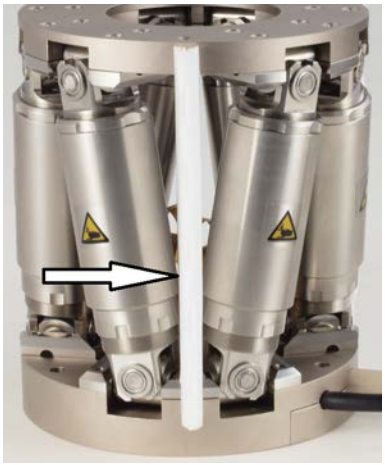


Figure 6: Hexapod with transport lock, one of three corrugated plastic sheets visible and marked with an arrow

11. Keep all packaging materials in case the product needs to be transported again later.

5 Installation

In this Chapter

5.1 General Notes on Installation

NOTICE

Impermissible mechanical load and collisions!

Impermissible mechanical load and collisions between the Hexapod, the load to be moved, and the environment can damage the Hexapod.

- Only hold the Hexapod by the base plate.
- Before installing the load, determine the limit value for the load of the Hexapod with a simulation program (p. 22).
  The limit values determined with the simulation program are only valid when the Hexapod controller has the servo mode switched on for the axes of the moving platform of the connected Hexapod.
- Before installing the load, determine the work space of the Hexapod with a simulation program (p. 22).
  The limits of the work space vary depending on the current position of the Hexapod (translational and rotational coordinates) and the current coordinates of the pivot point.
- If you do **not** mount the Hexapod with a horizontally oriented base plate but in any other orientation:
  - Suitably support the moving platform or the load when the servo mode or the Hexapod controller is switched off.
- Avoid high forces and torques on the moving platform during installation.
- Ensure an uninterruptible power supply in order to prevent an unintentional deactivation of the Hexapod system and resulting unintentional position changes of the Hexapod.
- Make sure that no collisions between the Hexapod, the load to be moved and the environment are possible in the work space of the Hexapod.

INFORMATION

The optionally available PIVeriMove software for collision checking can be used to mathematically check possible collisions between the Hexapod, the load and the environment. 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 regarding the activation and configuration of the PIVeriMove software for collision checking, see Technical Note C887T0002 (included in the scope of delivery of the software).

5.2 Determining the Permissible Load and Working Space

Tools and accessories

- PC with Windows operating system on which the simulation program Hexapod Simulation Software is installed. For more information, see the manual of the Hexapod controller.

Determining the working space and permissible load of the Hexapod

➢ Follow the instructions in the manual of the Hexapod controller to determine the working space 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 XYZ coordinate system (0,0,0).

	Servo mode switched on for Hexapod – max. load capacity		**Servo mode switched off for Hexapod – max. holding force**	
Mounting position of the base plate	Mounted horizontally	Mounted as desired	Mounted horizontally	Mounted as desired*
H-810.D1	5 kg	2.5 kg	15 N	–

* The struts of the Hexapod have a very low self-locking when the servo mode or the Hexapod controller is switched off.

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

➢ Contact our customer service department (p. 41).

5.3 Attaching the snap-on ferrite suppressor

Figure 7: Power supply cable of the Hexapod with snap-on ferrite suppressor

1 Power supply cable of the Hexapod
2 Snap-on ferrite suppressor 000015165
3 Connector M 12 (for connection to the controller)

INFORMATION

The snap-on ferrite suppressor 000015165 is included in the scope of delivery of the Hexapod system. The snap-on ferrite suppressor is for permanent attachment to the power supply cable of the Hexapod. The snap-on ferrite suppressor ensures the electromagnetic compatibility of the Hexapod system.

- ➢ When attaching the snap-on ferrite suppressor, make sure that it is correctly positioned on the cable. The snap-on ferrite suppressor can only be removed with special tools (not included in the scope of delivery).
- ➢ Attach the snap-on ferrite suppressor to the power supply cable of the Hexapod before you connect the Hexapod to the Hexapod controller for the first time.

Tools and accessories

- Snap-on ferrite suppressor 000015165, in the scope of delivery (p. 10)

Permanently attaching the snap-on ferrite suppressor

1. Place the power supply cable of the Hexapod close behind the M12 connector, that is intended for connection to the controller, into the opened snap-on ferrite suppressor (see figure).
2. Close the snap-on ferrite suppressor:
   a) Align the cable so that it is not squeezed when the snap-on ferrite suppressor is closed.
   b) Carefully press the two halves of the snap-on ferrite suppressor around the cable until the lock engages.

5.4 Grounding the Hexapod

If a functional grounding is required for potential equalization:

1. Connect the base plate to the grounding system:
   - Use one of the mounting holes with Ø 4.5 mm (p. 24) for connection.
2. Connect the moving platform to the grounding system:
   - Use one of the mounting holes in the moving platform (p. 46) for connection.
     or
   - If the moving platform and the load are conductively connected with each other, connect the load to the grounding system.

5.5 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 of the base plate!

Incorrect mounting can warp the base plate. Warping of the base plate reduces the accuracy.

➢ Mount the Hexapod on an even surface. The recommended evenness of the surface is 100 µm.

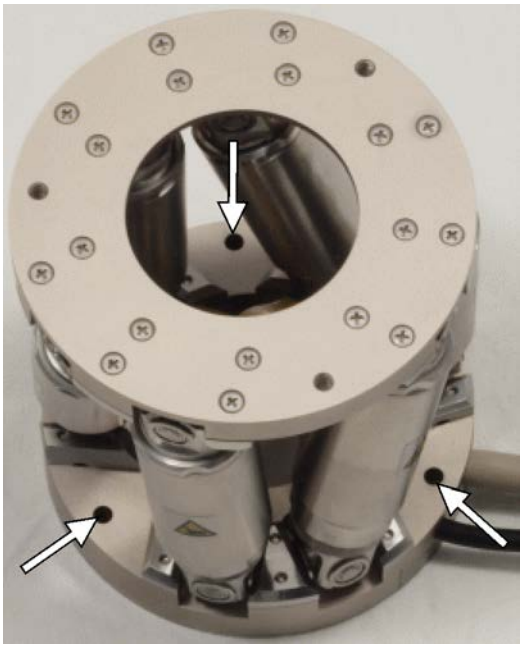


Figure 8: Mounting holes in the base plate

Prerequisite

✓ You have read and understood the General Notes on Installation (p. 21).

Tools and accessories

- Allen wrench 3.0 and three of the supplied M4x25 screws (p. 10)

Mounting the Hexapod

1. Insert three M4 threaded holes in the surface for mounting with M4x25 screws.
   The three mounting holes in the base plate of the Hexapod have a rotationally symmetric arrangement.
   They are offset by 60° to the mounting holes in the moving platform and are located on a circle with a diameter of 88 mm (see arrows in figure and p. 46).
2. Mount the Hexapod on the three mounting holes in the base plate using the included M4x25 screws.

5.6 Affixing 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 environment can damage the Hexapod.

- Make sure that the installed load observes the limit value resulting from the load test (p. 22).
- Avoid high forces and torques on the moving platform during installation.
- Make sure that no collisions between the Hexapod, the load to be moved and the environment are possible in the work space of the Hexapod.

NOTICE

Screws that are too long!

The Hexapod can be damaged by excessively long screws.

- When selecting the screw length, observe the thickness of the moving platform or the depth of the mounting holes (p. 46) together with the load to be mounted.
- Only use screws that do not project under the moving platform after being screwed in.
- Only mount the Hexapod and the load on the mounting fixtures (holes) intended for this purpose.

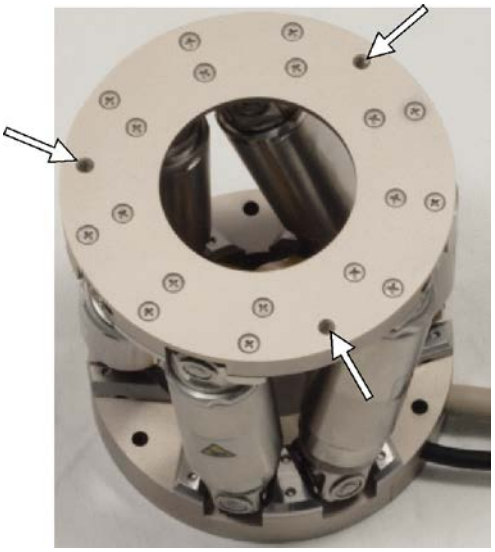


Figure 9: M4 mounting holes in the moving platform

Prerequisites

- ✓ You have read and understood the General Notes on Installation (p. 21).
- ✓ You have determined the permissible load and the work space of the Hexapod (p. 22).
- ✓ You have designed the load and the environment of the Hexapod so that the permissible load of the Hexapod is observed and no collisions can occur.

Tools and accessories

- 3 suitably long M4 screws
- Suitable tools for fastening the screws

Affixing the Load

1. If you have **not** mounted the Hexapod with a horizontally oriented base plate but in any other orientation, compensate for the low self-locking of the Hexapod struts:

   a) Connect the Hexapod to the Hexapod controller (see manual of the Hexapod controller).
   b) Switch on the servo mode for the axes of the moving platform by switching on the Hexapod controller (see manual of the Hexapod controller).

   or

   – Support the moving platform or the load in a suitable way.

2. Choose the mounting position so that the selected M4 holes in the moving platform (see top figure and p. 46) can be used for affixing the load.
3. Affix the load to the moving platform using the screws.

6 Start-Up

In this Chapter

6.1 General Notes on Start-Up

CAUTION

Risk of crushing by moving parts!

There is a risk of minor injuries caused by crushing which can occur between the moving parts of the Hexapod and a stationary part or obstacle.

- ➢ Keep your fingers away from areas where they can get caught by moving parts.

NOTICE

Incorrect configuration of the Hexapod controller!

The configuration data used by the Hexapod 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 motions or collisions. The configuration data is adapted before delivery.

- ➢ Check whether the Hexapod controller matches the Hexapod. A label on the rear panel of the controller indicates for which Hexapod the controller is intended.
- ➢ When you have established the communication via TCP/IP or RS-232 or use the user interface of the C-887, send the `CST?` command. The response shows the Hexapod to which the controller is adapted.
- ➢ Only operate the Hexapod with a Hexapod controller whose configuration data is adapted to the Hexapod.

NOTICE

Damage from collisions!

Collisions can damage the Hexapod, the load to be moved, and the environment.

- ➢ Make sure that no collisions between the Hexapod, the load to be moved and the environment are possible in the work space of the Hexapod.
- ➢ Do not place any objects in areas where they can get caught by moving parts.
- ➢ If the Hexapod controller malfunctions, stop the motion immediately.

NOTICE

Damage from unintentional position changes!

The self-locking of the Hexapod struts is very low. Although the installed load observes the limit value resulting from the load test (p. 22), it can cause an unintentional position change of the Hexapod when the servo mode or the Hexapod controller is switched off and one of the following conditions is also fulfilled:

- The Hexapod is **not** mounted with a horizontally oriented base plate but in any other orientation.
- The Hexapod is mounted with a horizontally oriented base plate and is **not** in the reference position.

As a result of unintentional position changes, the actuators in the Hexapod struts can be damaged, and collisions between the Hexapod, the load to be moved and the environment are possible. Collisions can damage the Hexapod, the load to be moved, or the environment.

- ➢ Suitably support the moving platform or the load when the servo mode or the Hexapod controller is switched off.

6.2 Starting Up the Hexapod System

Prerequisite

- ✓ You have read and understood the General Notes on Start-Up (p. 29).
- ✓ The Hexapod has been correctly installed (p. 21).
- ✓ You have read and understood the user manual of the Hexapod controller.

Accessories

- Hexapod controller belonging to the Hexapod system
- PC with suitable software (see user manual of the Hexapod controller)

Starting up the Hexapod system

1. Connect the Hexapod to the Hexapod controller (see user manual of the Hexapod controller).
2. Start up the Hexapod controller (see user manual of the Hexapod controller).
3. Operate a few motion cycles for testing purposes (see user manual of the Hexapod controller).

7 Maintenance

In this Chapter

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. 43).

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

Depending on the operational conditions and the period of use of the Hexapod, the following maintenance measures are required.

7.1 Carrying out a Maintenance Run

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

- Carry out a maintenance run over the entire travel range at regular intervals (see user manual of the Hexapod controller). The more often motions are carried out over a limited travel range, the shorter the time between the maintenance runs has to be.

7.2 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 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.

NOTICE

Cable break!

A cable break leads to a failure of the Hexapod.

- ➢ Pack the Hexapod as to ensure that the cables are not bent or squeezed too severely.

Accessories

- Original packaging (p. 10)
- Transport lock (p. 10)
- 4 cable ties

Packing the Hexapod

1. Command a motion of the Hexapod to the transport position:

   X = Y = Z = U = V = W = 0

2. Uninstall the Hexapod system:

   a) Remove the load from the moving platform of the Hexapod.
   b) Power down the Hexapod controller.

c) Remove the data transmission cable and the power supply cable from the Hexapod controller.
d) Loosen the three M4x25 screws with which the Hexapod is mounted on the surface.
e) Remove the three M4x25 screws.

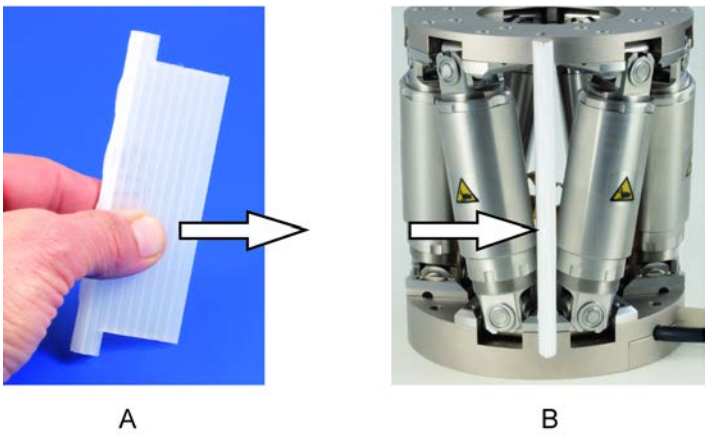


Figure 10: Inserting the corrugated plastic sheet of the transport lock into the Hexapod

A Transport lock: one of three corrugated plastic sheets
B Hexapod with transport lock

3. Place the transport lock between the base plate and the moving platform:
   - Insert the three corrugated plastic sheets between the strut pairs that are arranged in a V-shape (see figure above).
4. Prepare the cables on the Hexapod for packing. Do **not** bend the cables:
   - Wind the power supply cable with a diameter of approx. 15 cm and secure it with two cable ties.
   - Wind the data transmission cable with a diameter of approx. 15 cm and secure it with two cable ties.
5. Wrap the Hexapod in a plastic foil to protect it against dirt.
6. Open the outer box.
7. Remove the top ring-shaped pad from the inner box.
8. Lift the inner box out of the outer box.
9. Open the inner box.
10. Remove the foam cover.

11. Hold the Hexapod by the base plate and place the Hexapod and the cables in the corresponding recesses in the foam insert of the inner box.

12. Place the foam cover in the inner box so that the Hexapod fits in the corresponding recess of the cover and the cables are not squeezed.
13. Close the inner box.
14. Make sure that the bottom ring-shaped pad is in the outer box. The feet of the ring-shaped pad must be facing downwards.
15. Place the inner box in the ring-shaped pad in the outer box.

16. Place top ring-shaped pad on the inner box.
17. Close the outer box.
18. Secure the box on the pallet.

7.3 Cleaning the Hexapod

Prerequisites

✓ You have disconnected the Hexapod from the controller.

Cleaning the Hexapod

➢ When necessary, clean the Hexapod surface with a towel lightly dampened with a mild cleanser or disinfectant.

➢ Do **not** use any organic solvents.

8 Troubleshooting

Problem	Possible Causes	Solution
Unexpected Hexapod behaviour.	▪ Cable broken ▪ Connector or soldered joints loosened	➢ Check the data transmission and power supply cables. ➢ Contact our customer service department (p. 41).
The Hexapod does not achieve the specified accuracy.	Warped base plate	➢ Mount the Hexapod on an even surface (p. 24). The recommended evenness of the surface is 100 µm.
	Increased wear due to small motions over a long period of time	➢ Carry out a maintenance run over the entire travel range (p. 33).
The Hexapod does not move.	▪ Worn drive screw ▪ Foreign body has entered the drive screw ▪ Faulty motor ▪ Blocked or broken joint ▪ Dirty encoder	➢ Carry out a strut test (see user manual of the Hexapod 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. 41).

If the problem with your Hexapod is not listed in the table or it cannot be solved as described, contact our customer service department (p. 41).

9 Customer Service

For inquiries and orders, contact your PI sales engineer or send us an e-mail (mailto:info@pi.ws).

If you have questions concerning your system, have the following information ready:

- Product codes and serial numbers of all products in the system
- Firmware version of the controller (if present)
- Version of the driver or the software (if present)
- Operating system on the PC (if present)

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

10 Technical Data

In this Chapter

10.1 Specifications

10.1.1 Data Table

	H-810.D1x	Unit	Tolerance
Active axes	X, Y, Z, θ_X, θ_Y, θ_Z		
Motion and positioning			
Travel range* X, Y	±20	mm	
Travel range* Z	±6.5	mm	
Travel range* θ_X, θ_Y	±10	°	
Travel range* θ_Z	±30	°	
Single-actuator design resolution	40	nm	
Min. incremental motion X, Y	1	µm	typ.
Min. incremental motion Z	0.5	µm	typ.
Min. incremental motion θ_X, θ_Y, θ_Z	10	µrad	typ.
Backlash X, Y	3	µm	typ.
Backlash Z	0.5	µm	typ.
Backlash θ_X, θ_Y	15	µrad	typ.
Backlash θ_Z	75	µrad	typ.
Repeatability X, Y	±1	µm	typ.
Repeatability Z	±0.1	µm	typ.
Repeatability θ_X, θ_Y	±3	µrad	typ.
Repeatability θ_Z	±15	µrad	typ.
Max. velocity X, Y, Z	2.5	mm/s	
Max. velocity θ_X, θ_Y, θ_Z	60	mrad/s	

Typ. velocity X, Y, Z	2	mm/s	
Typ. velocity θ_X, θ_Y, θ_Z	30	mrad/s	
Mechanical properties			
Stiffness X, Y	0.1	N/µm	
Stiffness Z	4	N/µm	
Load (base plate horizontal / any orientation)	5 / 2.5	kg	max.
Holding force (base plate horizontal)	15	N	max.
Motor type	Brushless DC motor		
Miscellaneous			
Operating temperature range	0 to 50	°C	
Material	Stainless steel, aluminum		
Mass	1.7	kg	±5%
Cable length	2	m	±10 mm

Order as a system including controller and software. Add number 1 or 2 to the order number: H-810.xx1 for C-887.11; H-810.xx2 for C-887.21.

Technical data specified at 20±3°C.

Ask about custom designs!

* The travel ranges of the individual coordinates (X, Y, Z, θ_X, θ_Y, θ_Z) are interdependent. The data for each axis in this table shows its maximum travel, where all other axes are at their zero positions. If the other linear or rotational coordinates are not zero, the available travel may be less.

10.1.2 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

10.2 Ambient Conditions and Classifications

Degree of pollution:	2
Transport temperature:	–25°C to +85°C
Storage temperature:	0 °C to 70 °C
Humidity:	Maximum relative humidity of 80% at temperatures of up to 31°C, linearly decreasing until 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

All figues show the Hexapod in the reference position. Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.

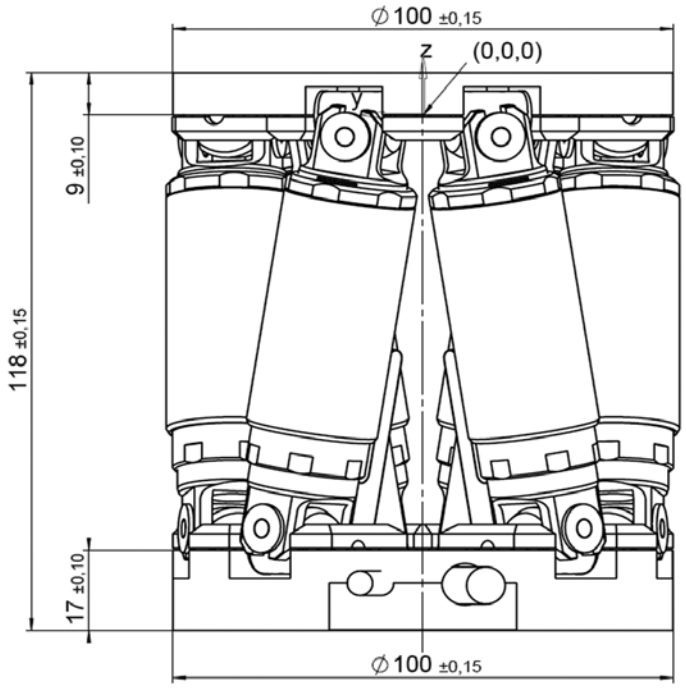


Figure 11: H-810.00 miniature Hexapod, front view (dimensions in mm)

The (0,0,0) coordinates refer to the origin of the XYZ coordinate system. When the standard settings of the Hexapod controller are used, the origin of the XYZ coordinate system in the reference position corresponds to the pivot point.

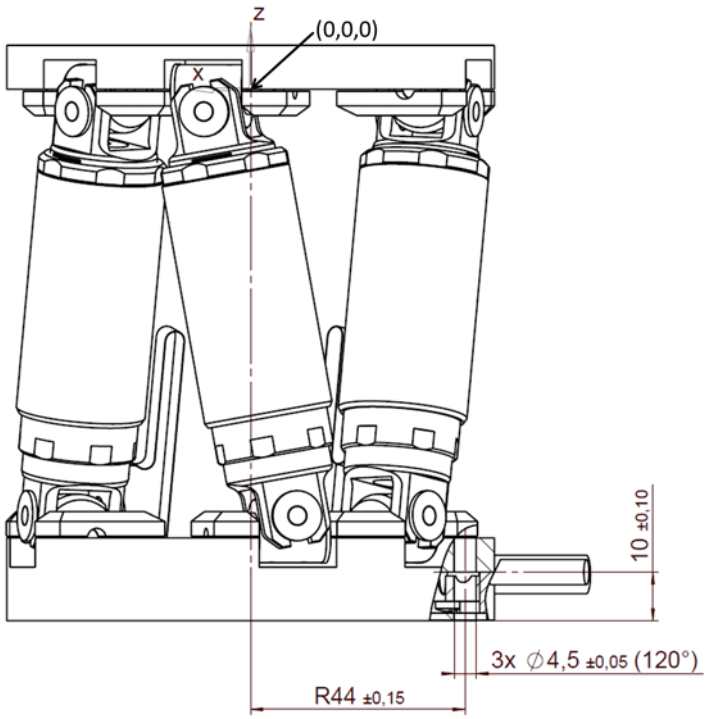


Figure 12: H-810.00 miniature Hexapod, side view (dimensions in mm)

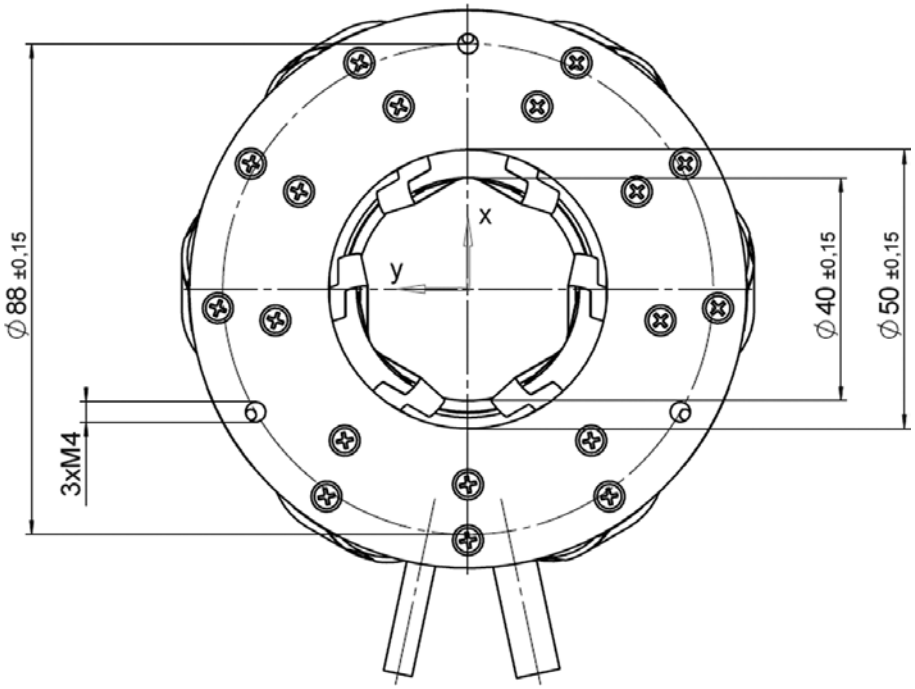


Figure 13: H-810.00 miniature Hexapod, top view (dimensions in mm)

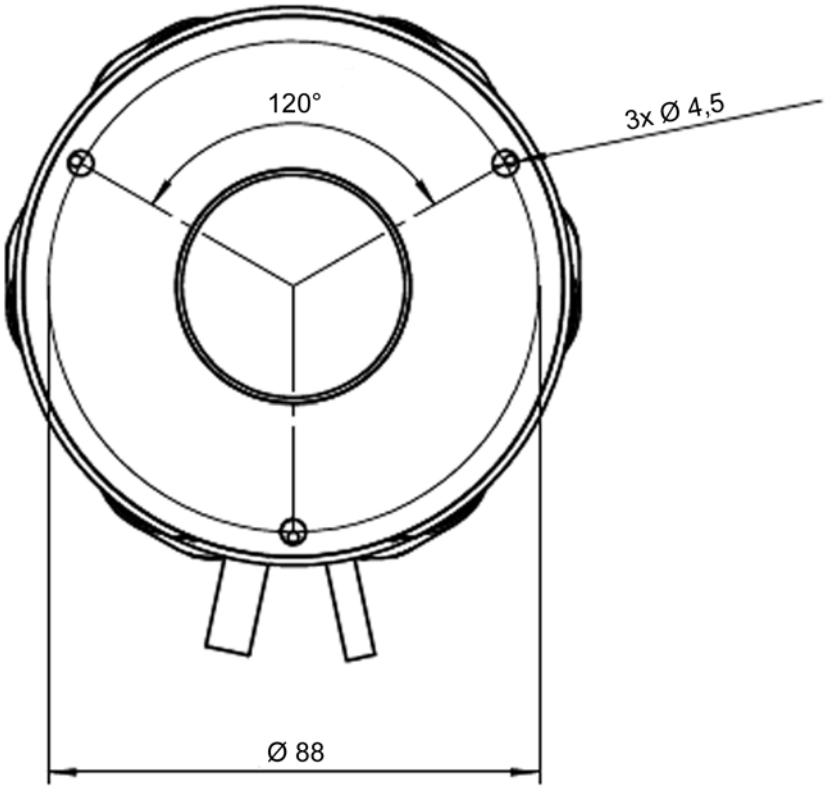


Figure 14: Base plate of the H-810 Hexapod with mounting holes, top view (dimensions in mm)

10.4 Pin Assignment

10.4.1 Power Source Connection

Power supply to the motors via 4-pin, A-coded M12 connector

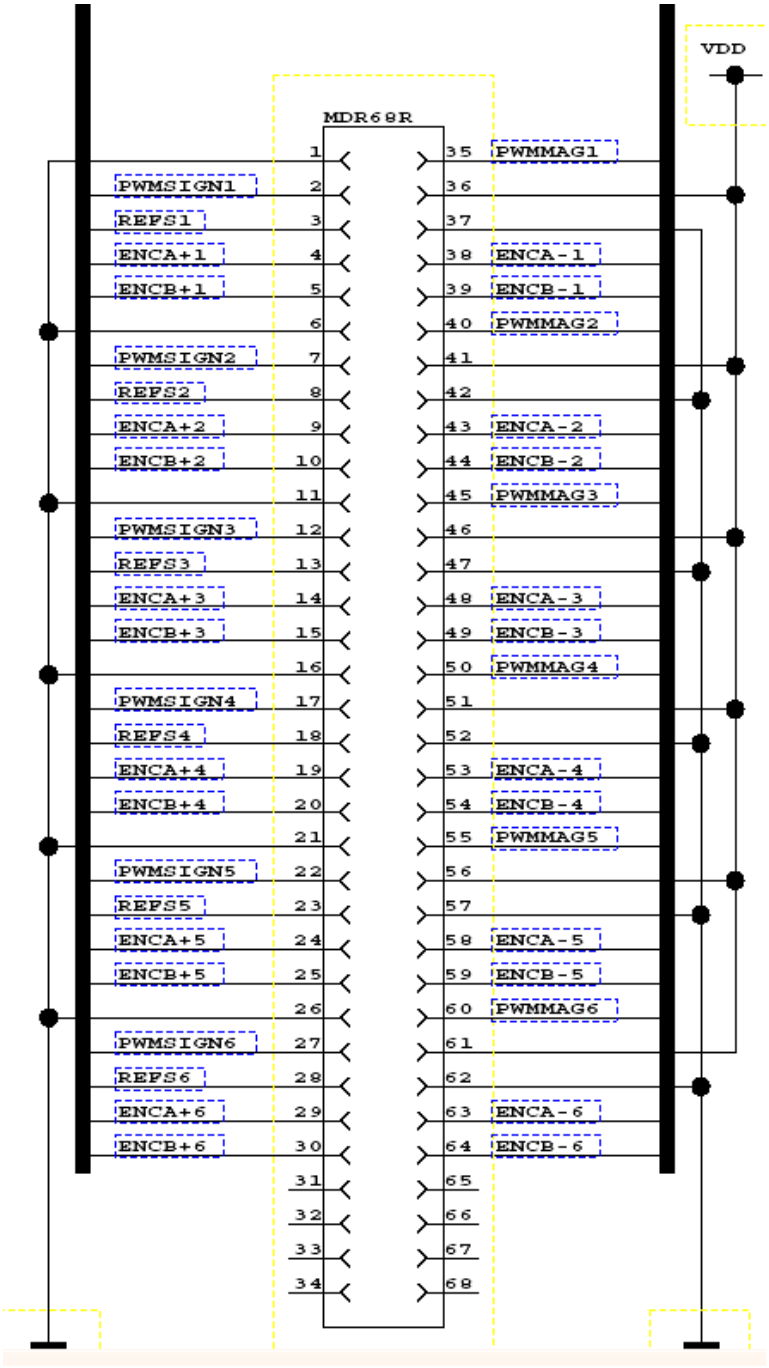
Pin	Function	
1	GND	
2	GND	
3	24 V DC	
4	24 V DC	

10.4.2 Data Transmission Connection

Data transmission between the H-810 and the Hexapod controller via MDR68 connector

Function	Connector
All signals: TTL	

Pin assignment



11 Old Equipment Disposal

In accordance with the applicable EU law, electrical and electronic equipment may not be disposed of with unsorted municipal wastes in the member states of the EU.

When disposing of your old equipment, observe the international, national and local rules and regulations.

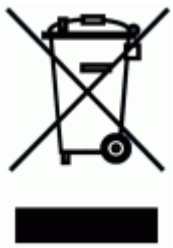
To meet the manufacturer's product responsibility with regard to this product, Physik Instrumente (PI) GmbH & Co. KG ensures environmentally correct disposal of old PI equipment that was first put into circulation after 13 August 2005, free of charge.

If you have old PI equipment, you can send it postage-free to the following address:

Physik Instrumente (PI) GmbH & Co. KG

Auf der Römerstr. 1

D-76228 Karlsruhe, Germany



12 Glossary

Work space

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

The work space can be limited by the following external factors:

- Installation space
- Dimensions and position of the load

Pivot point

The pivot point describes the center of rotation (intersection of the rotational axes U, V and W). When the standard settings for the pivot point coordinates are used, the pivot point is located at the origin of the XYZ coordinate system after a reference move, see the dimensional drawing (p. 46) for more information.

The pivot point is shifted along with the platform during translations. Rotations do not change the position of the pivot point. The pivot point coordinates remain unchanged in both cases.

The pivot point coordinates can be changed in the Hexapod controller.

XYZ coordinate system

The position and orientation of the Cartesian XYZ coordinate system cannot be changed, which is why the system is referred to as spatially fixed. The axes X, Y and Z are referred to as translational axes.

The intersection of the axes of the spatially-fixed Cartesian XYZ coordinate system (0,0,0) is referred to as the origin.

The Z axis is always perpendicular to the base plate of the Hexapod.

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

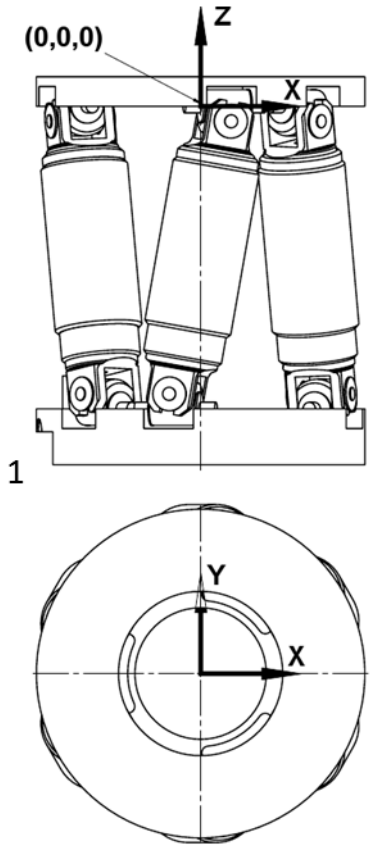


Figure 15: H-810 Hexapod in the reference position.

1 Cable outlet

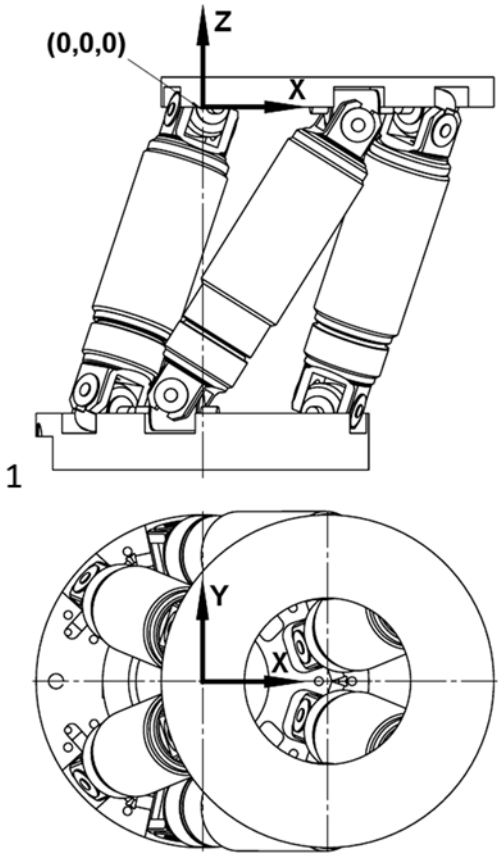


Figure 16: H-810 Hexapod, the platform of which has been moved in X.

1 Cable outlet

13 Appendix

In this Chapter

13.1 Explanations of the Performance Test Sheet

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

The following figure shows the test setup used.

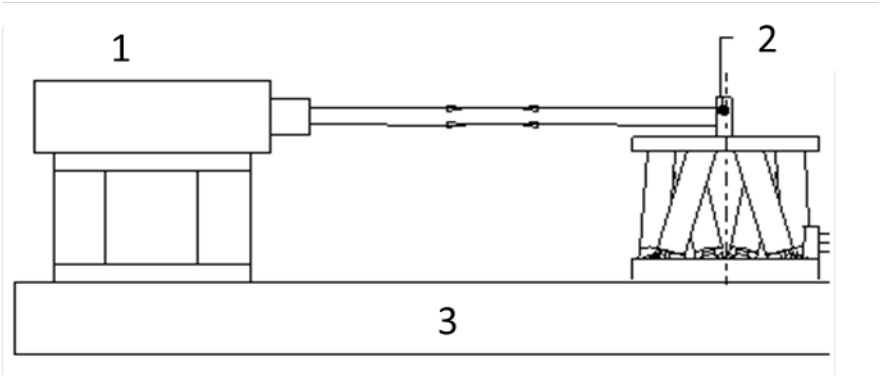


Figure 17: Test setup for measuring the X or Y axis.

1 Laser interferometer
2 Mirror
3 Bench

The following test cycles are performed:

- Movement over the entire travel range with at least 20 measuring points, in at least five cycles.
- Movement over partial sections, e. g. ±1 mm in increments of e. g. 10 µm

13.2 EC Declaration of Conformity

PI

Declaration of Conformity

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

Manufacturer:	**Physik Instrumente (PI) GmbH & Co. KG**
Manufacturer's Address:	Auf der Roemerstrasse 1 D-76228 Karlsruhe, Germany

CE

The manufacturer hereby declares that the product

Product Name: **Miniature-Hexapod Microrobot**

Model Numbers: **H-810**

Product Options: **all**

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

The applied standards certifying the conformity are listed below.

Safety of Machinery:	EN 12100:2010
Electrical Safety:	EN 61010-1:2010
Electromagnetic Emission:	EN 61000-6-3:2007, EN 55011:2009
Electromagnetic Immunity:	EN 61000-6-1:2007

The person authorized to compile the technical file is: Dr. Christian Rudolf
Address: see manufacturer's address

November 20, 2012
Karlsruhe, Germany

Norbert Ludwig
Managing Director

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