PI

User Manual

H-850 Hexapod-Mikroroboter

This document describes the following products:

- H-850.H2A
- H-850.H2V
- H-850.H2IV
- H-850.G2A
- H-850.G2V

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Subject to change. This document is superseded by any new release. The latest respective release is available for download on the PI website.

Contents

1 Other applicable documents

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

Product	Document	Content
C-887.5xx	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	Hexapod motion; Position and orientation in space, center of rotation
PIVirtualMove	SM163E	Determining the valid poses of the hexapod by simulation
PC software included in the scope of delivery of the controller	Various	See user manual of the C-887.5xx controller

You can download the current versions of the documents from www.pi.ws (p. 7).

2 Downloading manuals

Information

If a manual is missing or problems occur while downloading:

➢ Contact the PI customer service (p. 70).

Downloading manuals

1. Open the website www.pi.ws.
2. Search the website for the product number (e.g., H-850).
3. Select the corresponding product to open the product page.
4. Select the **Downloads** tab.

   → The manuals are shown under **Documentation**. Software manuals are shown under **General Software Documentation**.
5. Select **ADD TO LIST** for the desired manual and then select **REQUEST**.
6. Fill out the request form and select **SEND REQUEST**.

→ The download link will then be sent to the entered e-mail address.

3 About this document

3.1 Objective and target group of this user manual

This user manual contains the information necessary for using the H-850 as intended.

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

3.2 Symbols and typographic conventions

The following symbols and markings are used in the user manuals of PI.

DANGER

Immediate threat of danger

Failure to comply can result in death or serious injuries.

➢ Precautions to avoid the risk.

WARNING

Possibly hazardous situation

Failure to comply can result in serious injuries.

➢ Precautions to avoid the risk.

CAUTION

Dangerous situation

Failure to comply can result in minor injuries.

➢ Precautions to avoid the risk.

NOTICE

Dangerous situation

Failure to comply could result in damage to the equipment.

➢ Precautions to avoid the risk.

Information

Information for the user

Tips and additional information

Warning signs can be placed on PI products which refer to detailed information in this manual. The following symbols and markings are used in the user manuals of PI.

 Warning of general danger

 Warning of laser beams

 Warning of strong magnetic fields

 Warning of electrical voltage

 Warning of hot surfaces

 Warning of sharp objects or sharp edges

 Warning of crush injuries

 Warning of pull-in hazard due to counter-rotating rollers

 Prohibition of pacemakers and implanted defibrillators

3.3 Figures

For better clarity, the illustrations can vary in color, proportions, and level of detail compared to actual circumstances. Photographic illustrations can also differ and must not be seen as guaranteed properties.

4 Safety

4.1 Intended use

The H-850 is a laboratory device according to DIN EN 61010-1. The H-850 is intended for indoor use in an environment that is free from dirt, oil, and lubricants.

In accordance with its design, the hexapod is intended for positioning, adjusting, and shifting of loads in 6 axes at various velocities.

The hexapod can only be used as intended in conjunction with a suitable controller available from PI that coordinates all motion of the hexapod (▸Suitable controllers (p. 20)).

4.2 General safety instructions

The H-850 is built according to state-of-the-art technology and recognized safety standards. Improper use of the H-850 might result in personal injury and/or damage to the H-850.

- Only use the H-850 for its intended purpose, and only if 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 the correct installation and operation of the H-850.

4.3 Organizational measures

User manual

- Always keep this user manual together with the H-850. The latest versions of the documents are available for download on www.pi.ws ▸ (p. 7).
- Add all information from the manufacturer to the user manual, for example, supplements or technical notes.
- If you give the H-850 to a third party, include this user manual as well as other relevant information provided by the manufacturer.
- Install and operate the H-850 only after you have read and understood this user manual.

Personnel qualification

The H-850 may only be installed, operated, maintained, and cleaned by authorized and appropriately qualified personnel.

4.4 Measures for handling vacuum-compatible products

Attention must be paid to appropriate cleanliness when handling the vacuum version of the H-850. All parts are cleaned at PI before assembly. Powder-free gloves are worn during assembly and calibration. Afterwards, the H-850 is wipe-cleaned again and then shrink wrapped twice in vacuum-compatible film.

➢ Touch the H-850 only when wearing powder-free gloves.

➢ If necessary, wipe the H-850 clean after unpacking.

4.5 European declarations of conformity

For this product, declarations of conformity were issued according to the following European statutory requirements:

- EMC Directive
- RoHS Directive

The applied standards certifying the conformity are listed below.

- Electrical safety: EN 61010-1
- EMC: EN 61326-1
- RoHS: EN IEC 63000

5 Product description

5.1 Model overview

Model	Designation
H-850.H2A	Precision hexapod; brushless DC gear motor; absolute encoder, 250 kg payload; 0.5 mm/s maximum velocity. Connecting cables are not included in the scope of delivery and must be ordered separately.
H-850.H2V	Precision hexapod; DC gear motor; rotary encoder; 80 kg payload; 0.15 mm/s maximum velocity; vacuum compatible to 10^{-6} hPa; cable set 2 m on the vacuum side; feedthrough. Air-side connecting cables are not included in the scope of delivery and must be ordered separately.
H-850.H2IV	Precision hexapod; DC gear motor; rotary encoder; 80 kg payload; 0.15 mm/s maximum velocity; vacuum compatible to 10^{-6} hPa; cable set 2 m on the vacuum side; feedthrough. Air-side connecting cables are not included in the scope of delivery and must be ordered separately.
H-850.G2A	Precision hexapod; brushless DC gear motor; absolute encoder, 50 kg payload; 8 mm/s maximum velocity. Connecting cables are not included in the scope of delivery and must be ordered separately.
H-850.G2V	Precision hexapod; DC gear motor; rotary encoder; 25 kg payload; 2.5 mm/s maximum velocity; vacuum compatible to 10^{-6} hPa; cable set 2 m on the vacuum side; feedthrough. Air-side connecting cables are not included in the scope of delivery and must be ordered separately.

5.2 Product view

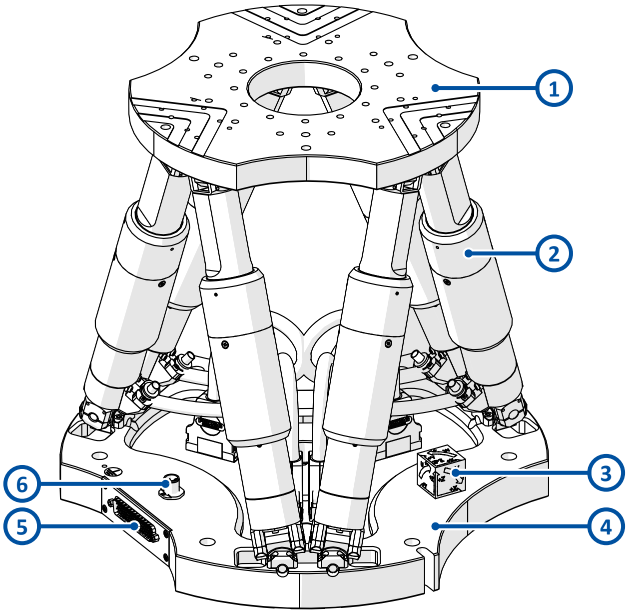


Fig. 1: Product view

1	Motion platform	**2**	Strut
3	Coordinate cube	**4**	Base plate
5	Panel plug for data transmission cable	**6**	Panel plug for power supply cable

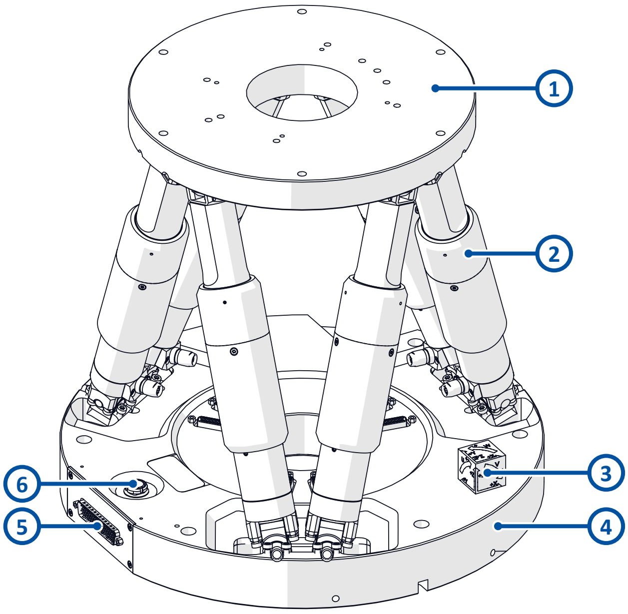


Fig. 2: Product view H-850.H2V

1	Motion platform	**2**	Strut
3	Coordinate cube	**4**	Base plate
5	Panel plug for data transmission cable	**6**	Panel plug for power supply cable

5.3 Technical features

5.3.1 Struts

The hexapod has 6 adjustable-length struts. Each strut carries out linear motion. Each set of settings of the 6 struts defines a position of the motion platformin 6 degrees of freedom (3 translational axes and 3 rotational axes).

Each strut is equipped with the following components:

– Actuator

– Reference switch and limit switch

– Joints for connecting to the base plate and motion platform

5.3.2 Actuator

The actuator contains the following components:

– H-850.G2V, .H2V, .H2IV: DC motor with incremental rotary encoder

– H-850.G2A, .H2A: brushless DC motor, absolute measuring encoder

– Gearhead

– Drive screw

5.3.3 Reference switch and limit switch

The reference switch of a strut works independently of teh angular positions of the strut ends end the lengths of 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.

5.3.4 ID chip

The H-850 has an ID chip that contains data on the type of hexapod, its serial number, and the manufacturing date. 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 H-850 is stored at the factory in every standard controller (e.g., geometry data and control parameters). The configuration data for customized H-850 is only stored on the controller if the H-850 and controller are delivered together, or if PI was correspondingly informed before delivery of the controller.

For further information and application notes, refer to the documentation for the controller.

5.4 Control and motion

5.4.1 Controller

The hexapod is intended for operation with a suitable controller form PI (Suitable controllers (p. 20)). With the controller, it is possible to command motion of individual axes, combinations of axes or all six axes at the same time in a single motion command.

Teh controller calculates the configuration of the individual struts from the target positions specified 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 H-850 equipped with incremental encoders is switched on or rebooted, it must complete a referencing move, in which each strut moves to its reference switch. After the referencing move, the motion platform is in the reference position and can be commanded to move to absolute target positions.

A referencing move is not required for a hexapod with absolute measuring encoders.

Please find further information in the user manual of the controller.

5.4.2 Motion

The platform moves along the translational axes and around the rotational axes.

The translational axes are labeled X, Y, and Z.

The rotational axes can have the following designations:

Application	Rotation around X	Rotation around Y	Rotation around Z
Controller, PIHexapodEmulator, PIVirtual-Move, manuals If available: Coordinate cube	U	V	W
Data table of the hexapod	θX	θY	θZ
Measurement report of the hexapod, figures of the coordinate system	A A (rot X)	B B (rot Y)	C C (rot Z)

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 user manual.

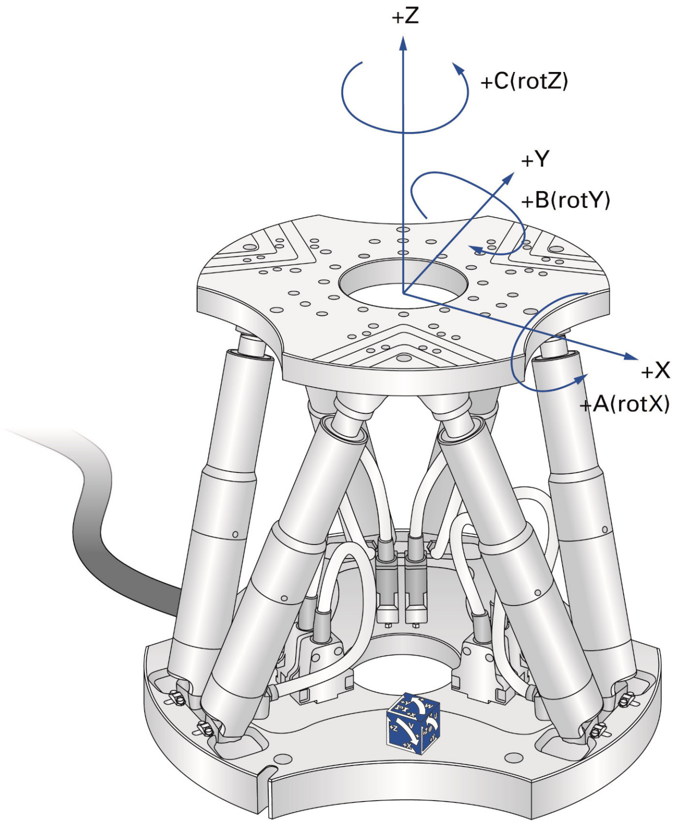


Fig. 3: Coordinate system of a hexapod

For better clarity, the coordinate system is depicted above the platform.

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).

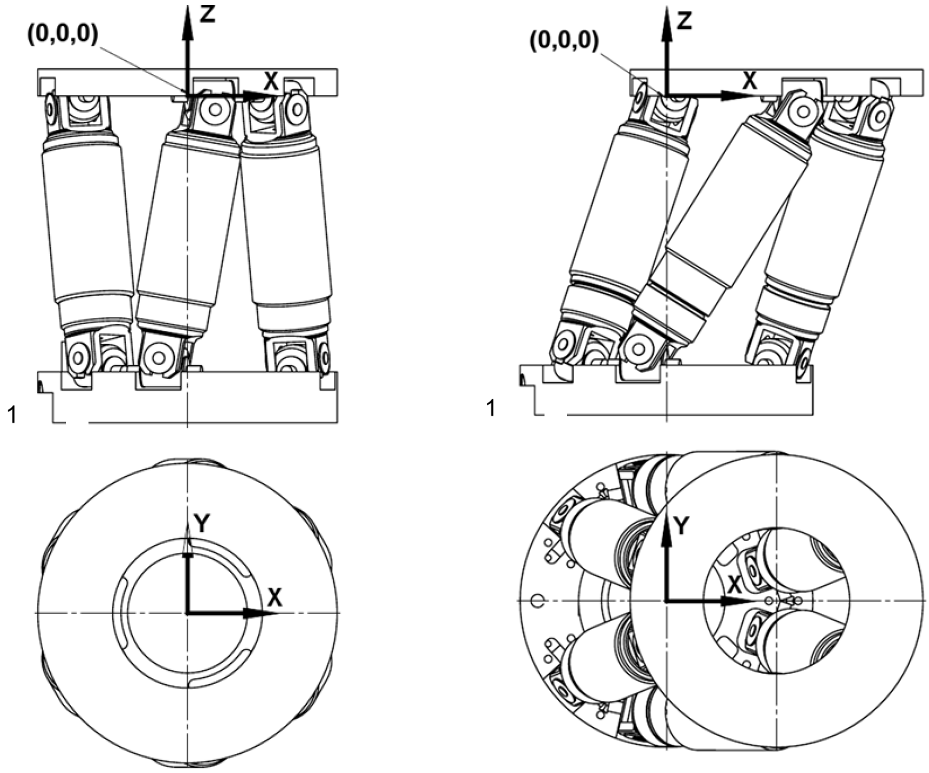


Fig. 4: Hexapod in reference position (left), Hexapod, the platform of which has been moved in X (right)

Rotation

Rotations take place around the rotational axes U, V, and W. Teh 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 specified rotation in space is calculated from the individual rotations in the order U > V > W.

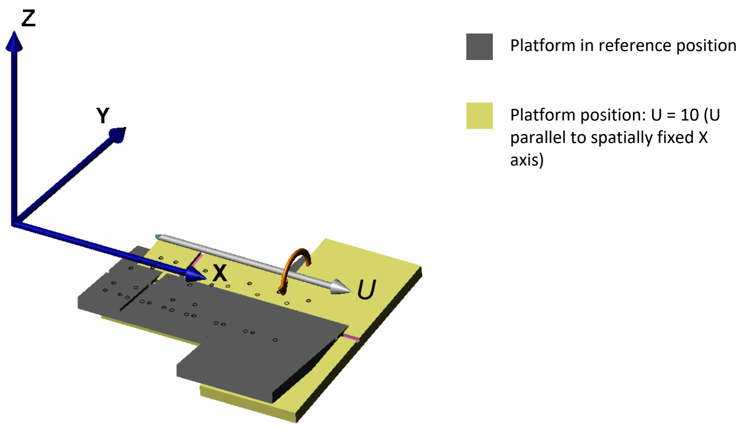
Example: Consecutive rotations

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

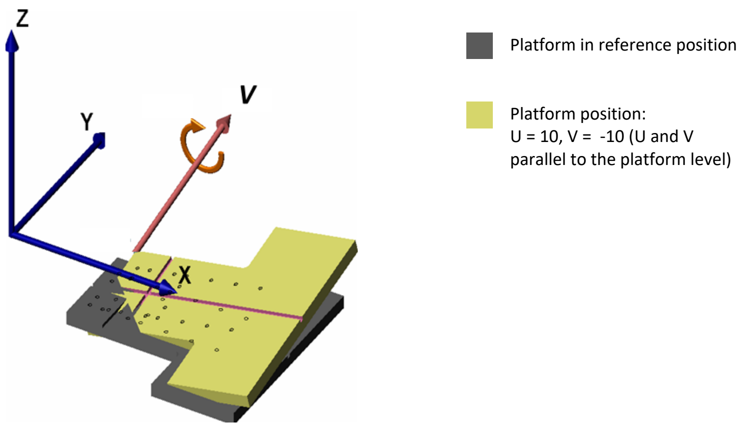
The U axis is commanded to move to position 10.

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



The V axis is commanded to move to position –10.

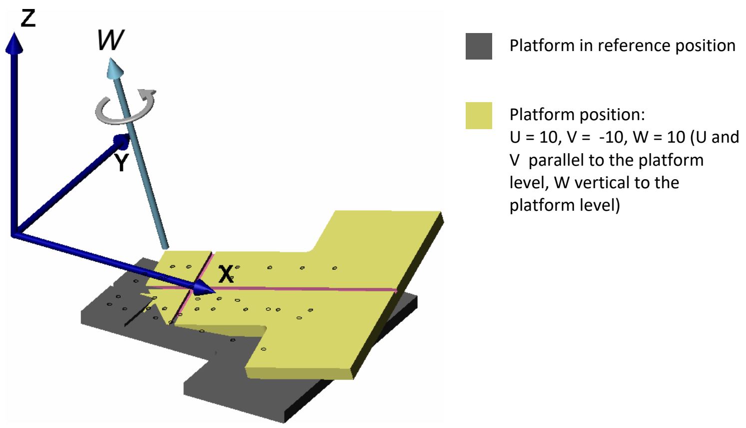
The rotation takes place around rotational axis V, which was tilted during the previous rotation. The rotation around the V axis tilts the rotational axes U and W.



The W axis is commanded to move to position 10.

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

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



For further information on the travel ranges, see Specifications (p. 49).

5.5 Suitable controllers

Product number	Description
C-887.5220	6-axis controller for hexapods, TCP/IP, RS-232, benchtop device, incl. control or 2 additional axes, motion stop
C-887.5230	6-axis controller for hexapods, TCP/IP, RS-232, benchtop device, incl. control of 2 additional axes, motion stop, analog inputs
C-887.5330	6-axis controller for hexapods, TCP/IP, RS-232, benchtop device, incl. control of 2 additional axes, EtherCAT interface, motion stop, analog inputs

➢ To order, visit the PI website (www.pi.ws) or send an e-mail to info@pi.de.

5.6 Accessories

The following items are not included in the scope of delivery of the H-850 and must be ordered separately if required.

Data transmission cable

Order number	Data transmission cables, 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/w, 10 m
C-815.82D20	Data transmission cable for hexapods, drag-chain compatible, HD D-sub 78 m/f, 20 m

Power supply cable

Order number	Power supply cables, available lengths
C-815.82P02A	Power supply cable for hexapods, drag-chain compatible, M12 m/f angled, 2 m

Order number	Power supply cables, available lengths
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, visit the PI website (www.pi.ws) or send an e-mail to info@pi.de.

6 Unpacking

6.1 Unpacking the hexapod

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

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.

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.

Unpacking the product

- Proceed as described in H850T0001 (Scope of delivery (p. 22)).

Keeping the packaging

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

6.2 Scope of delivery

Information

For the 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.

Order number	Part
H-850	Product according to order (▸ Model overview (p. 12)).
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 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 box and outer box – Foam and corrugated cardboard cushions – Palett
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 protective earth system: – 1 flat-head screw with cross recess M4x8 ISO 7045 – 2 lock washers shape A-4,3 DIN 7090 – 2 flat washers Schnorr Ø 4 mm N0110
H850T0001	Instructions on unpacking the hexapod
MS247EK	Short instructions for hexapod systems

Adapter cables to connect the H-850 to the electronics must be ordered separately.

➢ To order, visit the PI website (www.pi.ws) or send an e-mail to info@pi.de.

6.3 Removing the transport safeguard

6.3.1 Removing the transport safeguard for the H-850.x2A models

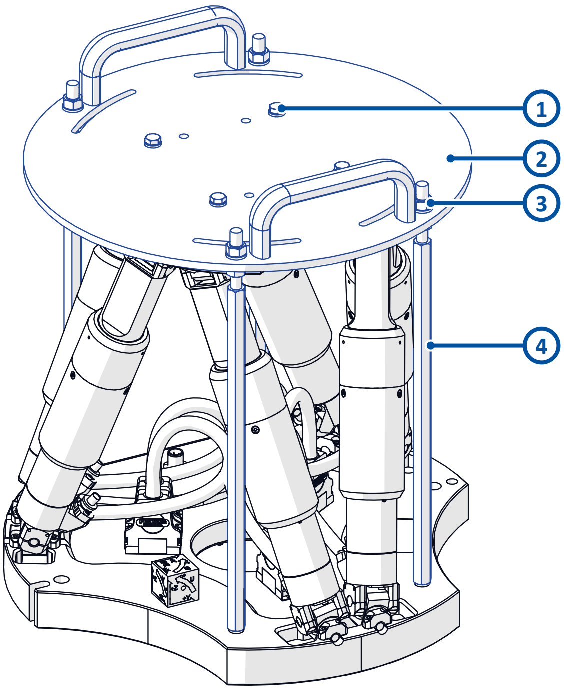


Fig. 5: Transport safeguard components

1	M6x16 screw	**2**	Cover
3	M8 nut	**4**	Strut

Tools and accessories

- Open-end wrench SW 10
- Open-end wrench SW 13

Removing the transport safeguard

1. Loosen the 4 nuts (M8) used for securing the transport safeguard's cover to the struts.
2. Remove the nuts and the corresponding flat washers.
3. Loosen the 4 screws (M6x16) used for holding the transport safeguard's cover on the motion platform.
4. Remove the loosened screws and the corresponding flat washers.
5. Remove the lid of the transport safeguard.
6. Unscrew the 4 struts of the transport safeguard from the hexapod's base plate (M8 thread).

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

6.3.2 Removing the transport safeguard for the H-850.x2V models

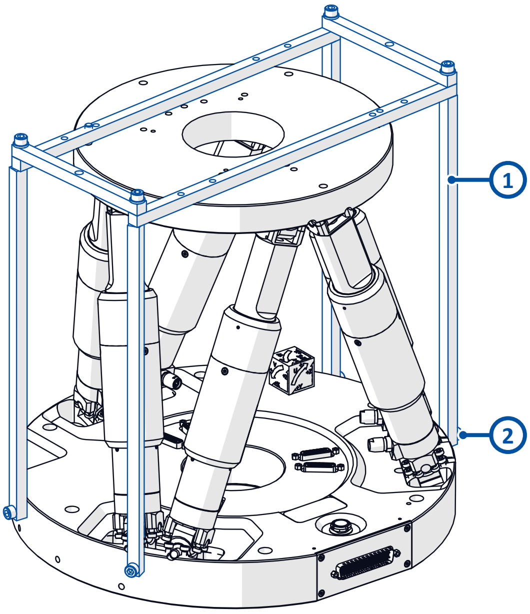


Fig. 6: Transport safeguard components

1 Transport safeguard

2 Mounting screws

Tools and accessories

– Hex key 5.0 from the supplied screw set (Scope of delivery (p. 22))

Removing the transport safeguard

1. Use the hex key to loosen the 4 screws (M6x20) used for securing the transport safeguard to the side of the base plate.
2. Use the hex key to loosen the 2 screws (M6x30) used for securing the transport safeguard to the motion platform. The screw heads are located on the underside of the motion platform.
3. Remove the 6 loosened screws and the corresponding flat washers.
4. Remove the transport safeguard.
5. Keep the transport safeguard in case the product needs to be transported later.

7 Installation

7.1 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 hexapod and load: Determine the valid poses using the PIVirtualMove simulation program. Definition of a valid pose: Determining valid poses (p. 27).
- If you change the hexapod type and before any change to the installation position, load to be moved, external forces and torques, or the used coordinate system: Repeat determining the valid poses.
- If you define your own coordinate system and use it instead of teh factory-set coordinate system: The PIVirtualMove simulation program calculates narrower travel range limits thant the controller when using user-defined coordinate systems. If you define your own coordinate system and use it instead of the factory-set coordinate system: The PIVirtualMove simulation program calculates narrower travel range limits than the controller when using user-defined coordinate systems. To avoid commanding poses that lie outside the travel range limits calculated by PIVirtualMove, use the `TRA?` command to determine if poses can be commanded that lie outside the travel range limits.
  If necessary, set the soft limits in the controller according to the travel range limits calculated by PIVirtualMove (commands`NLM` and `PLM`).
- While installing the hexapod and load: Make sure that the actual system setup corresponds to the system setup for which you determined the valid poses in the PIVirtualMove simulation program.
- 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.

NOTICE

Damage or malfunction due to disconnection of connectors

For hexapod models with absolute measuring encoders, the following applies:

Removing the hexapod leg connectors from the base plate of the hexapod may damage the absolute measuring encoders or render them inoperable. This applies whether the hexapod is operational or powered-off.

➢ Do **not** disconnect the leg connectors from the hexapod base plate.

7.2 Determining valid poses

To avoid damaging the hexapod, only valid poses may be commanded. The PIVirtualMove simulation program is intended for determining the valid poses according to the following definition.

A pose is valid if it can be reached by all 6 axes X, Y, Z, U, V, W with the used coordinate system and the used system setup (installation position of the hexapod, load to be moved, external forces and torques) **and** the permissible load of the struts is **not** exceeded.

Tools and accessories

– PC with a Windows operating system on which the PIVirtualMove simulation program is installed.

Determining valid poses of the hexapod

➢ Follow the instructions in the user manual of PIVirtualMove (SM163E).

Information

The PIVirtualMove simulation program calculates the valid poses based on the maximum payload of the hexapod (= limit value when servo mode is switched on). With the servo mode switched off, the maximum holding force is based on the self-locking of the actuators in the hexapod struts and is lower than the maximum payload.

Information

The load of the hexapod struts varies depending on the following factors:

- Activation state of the servo mode in the controller
- Installation position of the hexapod
- Load to be moved: mass and position of the center of mass on the motion platform
- Forces and torques acting on the motion platform
- Poses to be approached by the motion platform during operation (coordinates for translation and rotation)

7.3 Mounting the hexapod onto 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 could warp the base plate. Warping of the base plate reduces the accuracy.

➢ Mount the H-850 on a flat surface. The recommended flatness of the surface is 300 µm.

Requirements

- You have read and understood the general notes on installation (General notes on installation (p. 26)).
- You have obtained the arrangement of the mounting holes as well as the locating holes in the hexapod's base plate (Dimensions (p. 55)).

Tools and accessories

- 6 M6x30 screws (Scope of delivery (p. 22))
- Hex key 5.0
- *Optional*: 2 locating pins for easy alignment of the hexapod, suitable for holes with Ø 8 mm H7, not included in the scope of delivery

Mounting the hexapod

1. Drill 6 M6 threaded holes into the surface for mounting with M6x30 screws.
2. *If you use locating pins:*: Drill 2 locating holes with Ø 8 mm H7 into the surface to accommodate the locating pins.
3. *If you use locating pins:*: Insert the locating pins into the locating holes in the hexapod or surface.
4. *If you use locating pins:*: Put the hexapod onto the surface so that the locating pins are inserted into the corresponding locating holes on the other side.
5. Mount the hexapod on the 6 mounting holes in the base plate with the included screws.

7.4 Grounding the hexapod

If a functional grounding is required for potential equalization:

Information

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

Requirements

– You have read and understood the general notes on installation (▸General notes on installation (p. 26)).

– You have identified the position of the holes marked with the grounding symbol from the ▸Dimensions (p. 55).

Tools and accessories

– Suitable screwdriver

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 and the M4 hole marked with the ground connection symbol (▸Scope of delivery (p. 22), ▸Dimensions (p. 55)).
2. Connect the motion platform to the grounding system:
   Use one of the mounting holes in the motion platform for connection (▸Dimensions (p. 55)).
   - or -
   If the motion platform and the load are connected conductively to each other: Connect the load to the grounding system.

7.5 Attaching 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.

- While installing the hexapod and the load, make sure that the actual system setup corresponds to the system setup for which you determined the valid poses in the PIVirtualMove simulation program.
- 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 screwsSchrauben

The H-850 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 together with the load to be mounted (Dimensions (p. 55)).
- Only use screws that do not project under the motion platform after being screwed in.
- Only mount the H-850 and the load on the mounting fixtures (holes) intended for this purpose.

Requirements

- You have read and understood the general notes on installation (General notes on installation (p. 26)).
- You have determined the valid poses of the hexapod (Determining valid poses (p. 27)).
- 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.
- You have obtained the arrangement of the mounting holes and the locating holes in the hexapod's base plate as well as the tolerance specifications from the dimensional drawing (Dimensions (p. 55)).

Tools and accessories

- Screws of suitable length. Options depend on the model, see dimensional drawing (Dimensions (p. 55)):
  - M4 screws
  - M6 screws

- M8 screws
- Suitable tool for tightening the screws
- *Optional*: 2 locating pins for easy alignment of the load on the hexapod. Hole diameter depends on the model, see dimensional drawing (Dimensions (p. 55)). Locating pins not including in the scope of delivery.

Fixing the load

1. Align the load so that the selected mounting holes in the platform can be used to fix it.
2. *If you use locating pins to align the load:*: Drill 2 locating holes in the load to accommodate the locating pins.
3. *If you use locating pins to align the load:*: Insert the locating pins into the locating holes in the platform or in the load.
4. *If you use locating pins to align the load:*: Put the load on the platform so that the locating pins are inserted into the corresponding locating holes on the other side.
5. Use the screws to fix the load to the selected mounting holes in the platform.

7.6 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

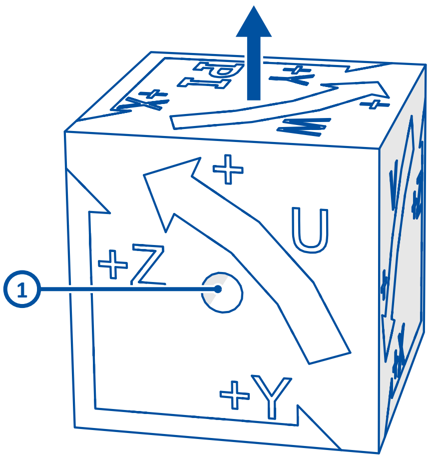


Fig. 7: Removing the coordinate cube

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

7.7 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 (Accessories (p. 20))

Connecting the hexapod to the controller

➤ Pay attention to the assignment specified on the labeling of the sockets, plug connectors, and cables.

➤ Pay attention to the mechanical coding of the connectors and sockets.

➤ Do not use force.

➤ Use the integrated screws to secure the connections against accidental disconnection.

Standard cabling

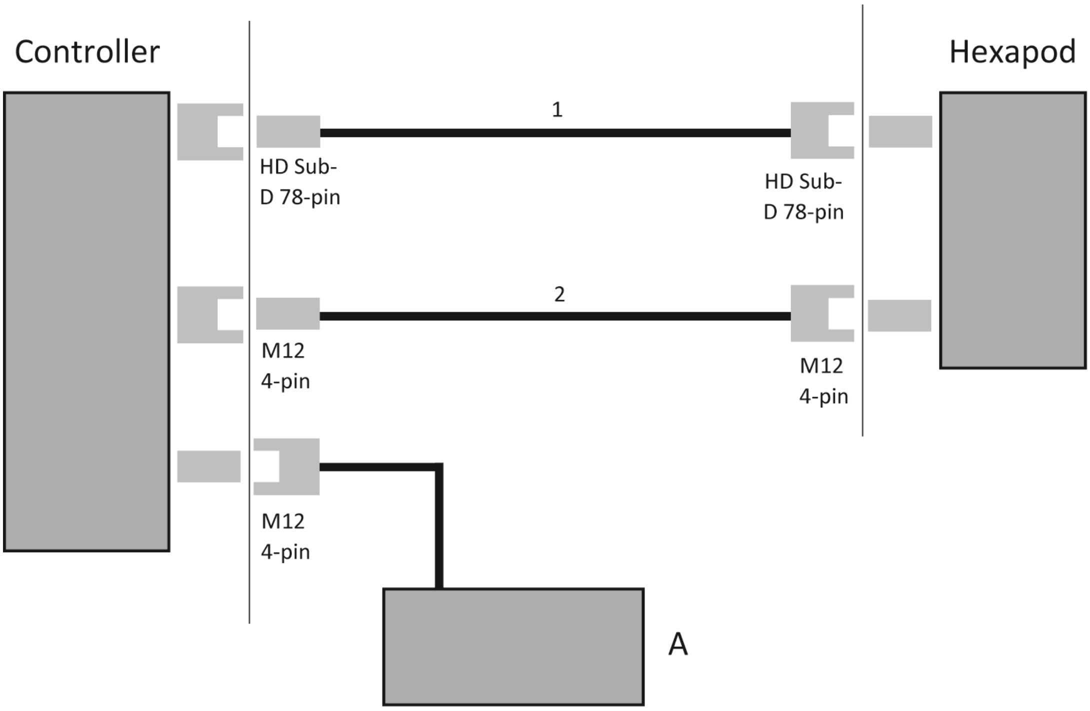


Fig. 8: Connection diagram

(panel plug symbol)	Panel plug / connector, male
(socket symbol)	Socket / connector, female
Controller	Suitable controllers (p. 20)

Hexapod	H-850
A	Power adapter from the scope of delivery of the controller, 24 V DC output
1	Data transmission cable
2	Power supply cable

7.8 Connecting the vacuum-compatible the hexapod to the controller

NOTICE

Cable break due to bent or crushed cable

A cable break leads to failure of the H-850.

- In your application, make sure that the cables permanently installed to the H-850 is **not** subject to tensile stress.
- In your application, make sure that the cables permanently installed to the H-850 are **not** moved.
- Secure the cables in a suitable manner.
- Fix the permanently installed data transmission cable onto the surface using the connector holder supplied.

Requirements

- The controller is switched off, i.e., the on/off switch is in the position O.
- You have attached the installed data transmission cable to the surface with the connector holder supplied (Mounting the hexapod onto a surface (p. 28)).

Tools and accessories

- Data transmission cable and power supply cable (available as Accessories (p. 20))
- Vacuum feedthrough (included in the scope of delivery (p. 22))
- Suitable tools for installing the vacuum feedthrough

Installing the vacuum feedthrough

1. Install the vacuum feedthrough for data transmission (4668) so that the HD D-sub 78 socket is in the vacuum chamber.
2. Install the vacuum feedthrough for the power supply (C887B0002) so that the 2-pole LEMO connection is in the vacuum chamber.

Connecting the hexapod to the controller

1. Connect the hexapod to the controller.
2. Use the integrated screws to secure the connectors against accidental disconnection.

Cabling for vacuum

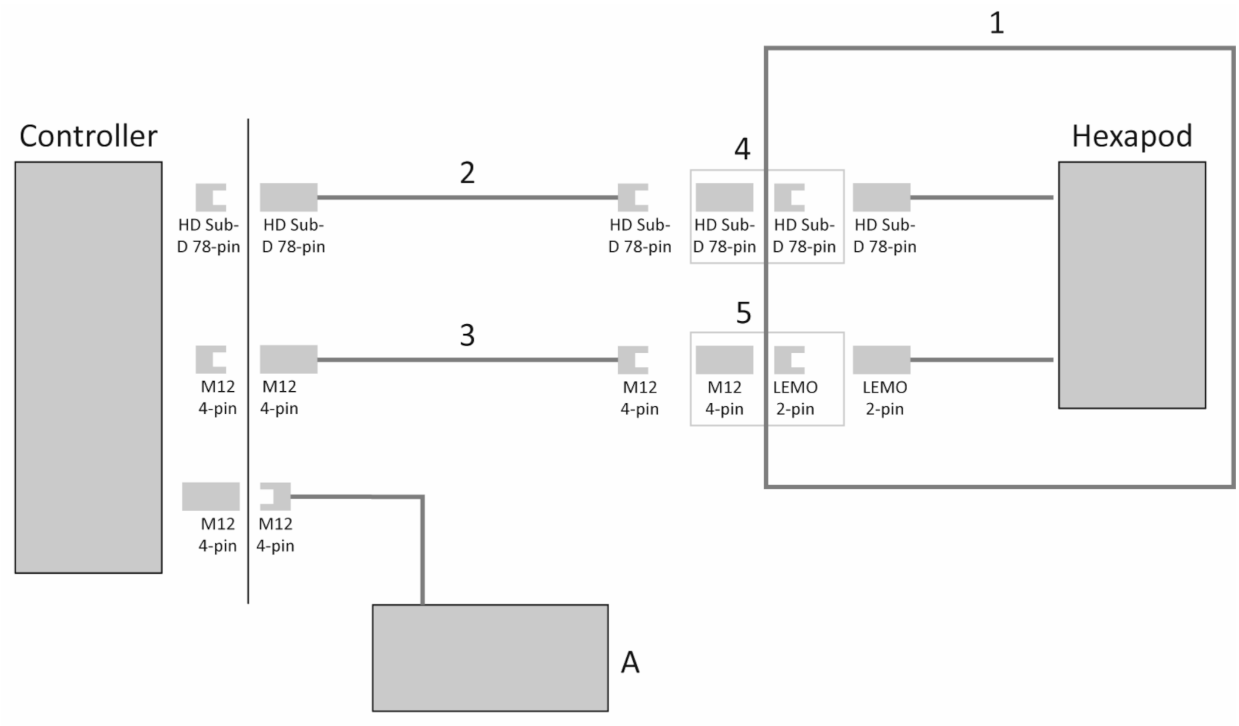


Fig. 9: Connection diagram of the cable set for the vacuum-compatible hexapod

Panel plug / connector, male

Socket / connector, female

Controller ▸Suitable controllers (p. 20)

HEXAPOD H-850

a Power adapter, from the controller's scope of delivery, 24 V DC output

1 Vacuum chamber

2 Data transmission cable

3 Power supply cable

4 Vacuum feedthrough for data transmission

5 Vacuum feedthrough for power supply

8 Starting and operating

8.1 Allgemeine Hinweise zur Inbetriebnahme

CAUTION

Risk of crushing by moving parts

Risk of minor injuries from crushing between the moving parts of the H-850 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., geometry data and control parameters) must be adapted to the H-850. If incorrect configuration data is used, the H-850 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.
- Operate the H-850 only with a controller whose configuration data is adapted to the H-850.

NOTICE

Damage due to collisions

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

- Make sure that no collisions between the hexapod, the load to be moved, and the surroundings are possible in the workspace of the hexapod.
- Do not place any objects in areas where they can be caught by moving parts.
- Only command valid poses (Determining valid poses (p. 27)).
- Stop the motion immediately if a controller malfunction occurs.

NOTICE

Damage due to transport safeguard not being removed

If the transport safeguard of the H-850 has not been removed and a motion is ccommanded, damage to the hexapod can occur.

➢ Remove the transport safeguard before starting up the hexapod system (Removing the transport safeguard (p. 24)).

8.2 Starting up the hexapod system

Requirements

- You have read and understood the General Notes on Startup (p. 35).
- You have installed the H-850 correctly (Installation (p. 26)).
- If necessary: You have removed the transport safeguard (p. 24).
- The controller and, if necessary, the PC software have been installed (refer to the user manual for the controller).
- You have read and understood the user manual for the controller.

Starting up the H-850

1. Start up the controller (see user manual for the controller).
2. Start a few motion cycles for testing purposes (refer to the user manual for the controller).

8.3 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 H-850. Uneven distribution of the lubricant can lead to failure of the H-850.

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 H-850 to the controller (Connecting the hexapod to the controller (p. 32)).
- You have performed a test run of the hexapod system at least once (Starting up the hexapod system (p. 36)).

Baking out vacuum-compatible models

1. Bake out the H-850 at **maximum** 80 °C (176 °F).
2. Perform a maintenance run over the entire travel range during the bakeout and cooling process at least once a day (Performing a maintenance run (p. 38)).

9 Maintenance

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

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

Contact you PI representative to learn more about the wraparound service benefits from PI.

NOTICE

Damage due to incorrect maintenance

The H-850 can be misaligned by incorrect maintenance. The specifications can change as a result (▸Specifications (p. 49)).

➢ 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.

9.1 Performing a maintenance run

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

➢ Perform maintenance runs 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.

9.2 Cleaning the hexapod

Requirements

- You have removed the cables for data transmission and the power supply from the H-850.

Cleaning the hexapod

Only if the H-850 is **not**used in vacuum:

➢ If necessary, clean the surfaces of the H-850 with a cloth that is dampened with a mild cleanser or disinfectant.

If the H-850 is used **in vacuum**:

1. Touch the H-850 only with powder-free gloves.
2. If necessary, wipe the H-850 clean.

9.3 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 base plate.

9.3.1 Uninstalling the Hexapod

Uninstalling the Hexapod

1. Command hexapod motion to the transport position: X = Y = U = V = 0; Z = -23, W = -6
2. Remove the load from the motion platform of the hexapod.
3. Switch off the controller.
4. Remove the data transmission cable and the power supply cable from the controller.
5. Loosen connections between the cables permanently attached to the hexapod and the cable set used, and remove the cables from all attachments (for example, connector holders).
6. Remove the hexapod from the surface.

9.3.2 Mounting the transport safeguard for all models (except .H2V)

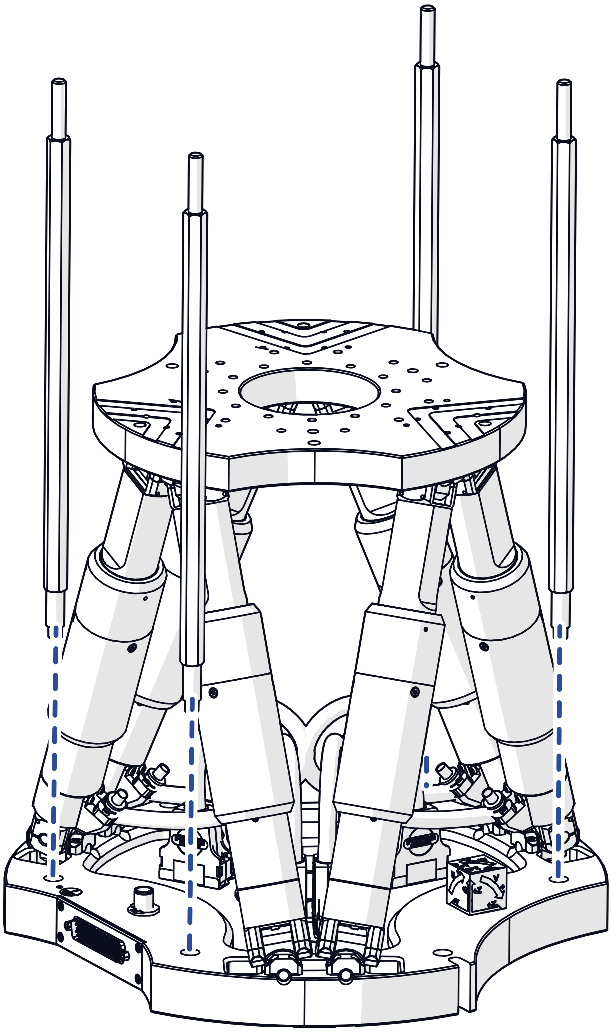
Tools and accessories

- Open-end wrench SW 10
- Open-end wrench SW 13
- Suitable screwdriver

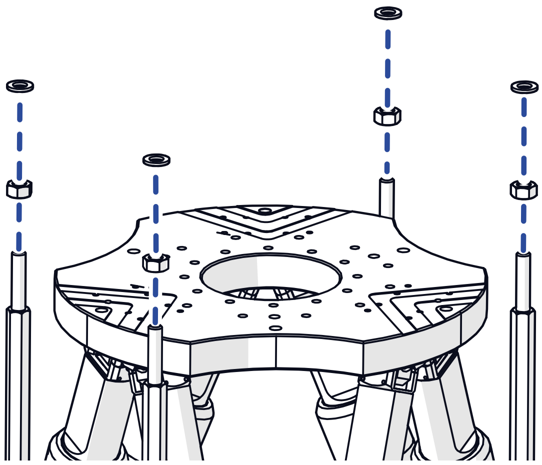
Mounting the transport safeguard

1. Screw the struts with the shorter thread into the base plate of the H-850.

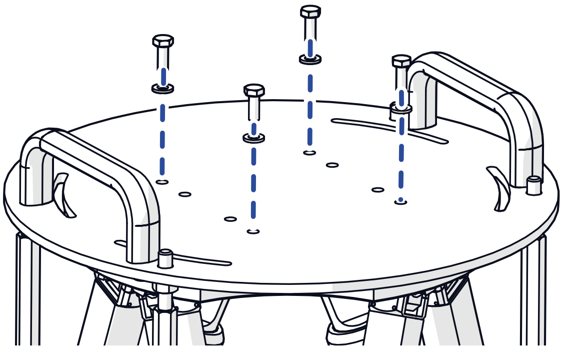
2. Tighten the struts hand-tight.



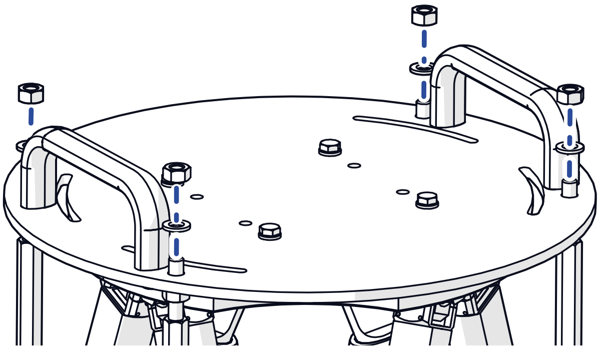
3. On each strut, screw an M8 nut down to the thread end.
4. Put an 8.4 flat washer onto each nut.



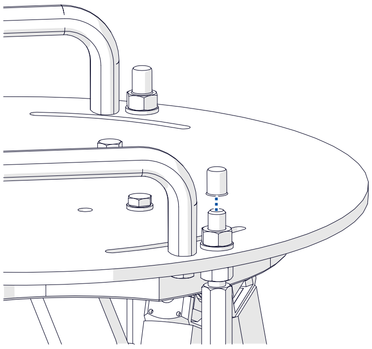
5. Put the cover onto the motion platform so that the ends of the 4 struts protrude through the corresponding holes in the cover.
6. Attach the cover to the motion platform using the 4 M6x16 screws that you previously pushed a 6.4 flat washer onto.



7. Push an 8.4 flat washer onto each strut.
8. Place an M8 nut on each strut and hand-tighten them.



9. Lock each nut above with the nut below the cover for each strut.
10. Put thread protection caps onto the strut ends.



9.3.3 Mounting the transport safeguard for the H-850.H2V

Tools

- Open-end wrench SW 10
- Open-end wrench SW 13
- Suitable screwdriver

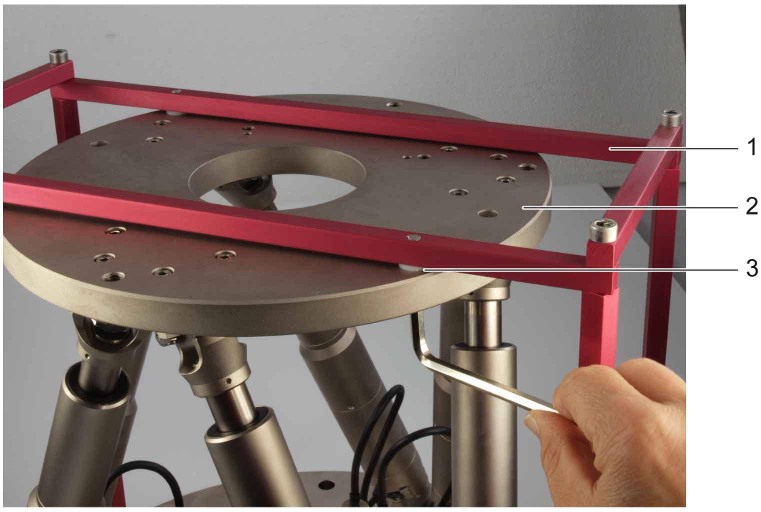


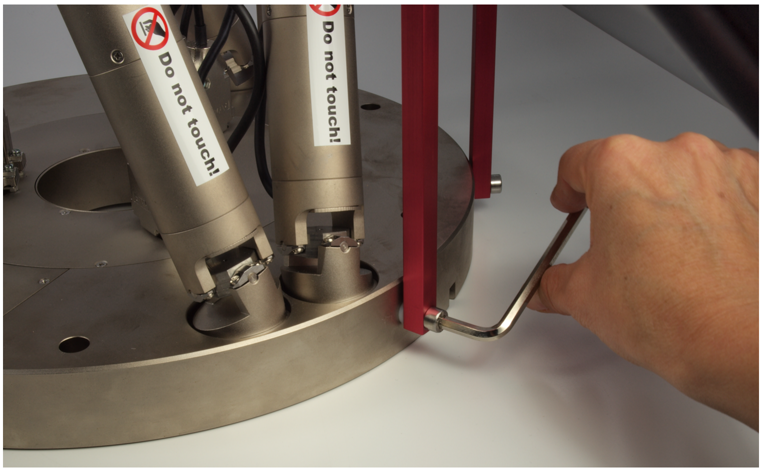
Fig. 10: Transport safeguard on the motion platform

1	Transport safeguard
2	Motion platform
3	Plastic flat washer

Mounting the transport safeguard

1. Position the transport safeguard (1) on the hexapod so that the holes in the struts of the transport safeguard are in line with the corresponding holes in the motion platform (2) and the base plate of the hexapod (see figures in Removing the transport safeguard for the H-850.x2V models (p. 25)).
   If the hexapod system is defective, the holes in the hexapod and transport safeguard may not be congruent because the hexapod has not reached the transport position. Do not attach the transport safeguard, and continue with Packing the Hexapod (p. 43).
2. Push the plastic flat washers (3) between the holes in the hexapod and the transport safeguard.

3. Fasten the transport safeguard with 2 screws (M6x30) to the motion platform. The screw heads must be located on the underside of the motion platform.



4. Fasten the transport safeguard with 4 screws (M6x20) on the side of the base plate (see figure).

9.3.4 Packing the Hexapod

Accessories

- Original packaging (Scope of delivery (p. 22))
- Instructions on unpacking the hexapod (H850T0001, Scope of delivery (p. 22))

Packing the Hexapod

- Proceed as described in H850T0001.

10 Troubleshooting

Unexpected behavior of the H-850	
– Defective cable – Bent pin – Connector or soldered joints loosened	➢ Check the connecting cables. ➢ Replace the cables by cables of the same type and test the function of the hexapod. ➢ Contact the ▸PI customer service (p. 70).

The H-850 does not achieve the specified repeatability.	
– Motion platform is warped – Warped base plate	➢ Mount the H-850 on an even surface (▸Mounting the hexapod onto a surface (p. 28)). ➢ Only mount loads with a flat surface. The recommended flatness of the surface is 300 µm.
– Poor lubrication because of small motions over a long period of time	➢ Perform a maintenance run over the entire travel range (▸Performing a maintenance run (p. 38)).
– External disturbances	➢ Make sure that no vibrations are transmitted to the system. ➢ Make sure that forces, e.g., also through dragged cables, do not affect the movement of the motion platform. ➢ Make sure that the system is in a thermal equilibrium.

Travel accuracy is poor	
– Unsuitable control parameters for the application – The system behavior has changed due to an increasing ease of operation.	➢ Carry out a tuning of the parameters. ➢ Contact the ▸PI customer service (p. 70).

H-850 does not move	
– Foreign body has entered the drive spindle – Motor defective – Sensor defective – Blocked or broken joint – Load too heavy	➢ Test a strut (refer to the user manual for the controller). The strut test should be carried out in the zero position of the factory coordinate sys-

H-850 does not move	
	tem, unless the malfunction occurs at the maximum or minimum displacement of the motion platform in Z. ➢ Contact the PI customer service (p. 70).

– The hexapod is not supplied with voltage.	➢ Check the power supply cable.
	➢ If available: Check the power adapter.
	➢ Check the Power Good signal of the H-850. To check the signal, open the ***Diagnostic Information*** window in PIMikroMove by selecting the ***C-887*** > ***Show diagnostic information...*** menu item - *or* -send the `DIA?` command.
	Meaning of the displayed information:
	– 1 (Hexapod Powered):
	  – = 1: power supply for the hexapod drives exists
	  – = 0: power supply for the hexapod drives has been interrupted
	– 2 (Controller E-Stop Activated):
	  – = 1: 24-V output of the C-887.5xx controller is active
	  – = 0: 24-V output of the C-887.5xx controller is inactive
	– 3 (Temperature):
	  – = <Temperature value>
	– 5 (Faulty Point in Waveform):
	  – = 1: Faulty point in waveform
	– For further information, see the user manual for the C-887.5xx controller.

– Servo mode was switched off automatically	1. Send the `SVO?` command to check the activation state of the servo mode. 2. Send the `ERR?` command and check the error code that is returned. For more information on possible error codes and their causes, see "Protective Functions of the C-887" in the user manual of the C-887.5xx controller.

H-850 does not move	
– Controller with **E-Stop** socket: Connection of the E-Stop socket prevents motion from being triggered	➢ Connect the E-Stop socket with external hardware according to the requirements of your application, e.g., with the C887B0038 shorting plug. For more information, see "Using the E-Stop Socket" in the user manual of the C-887.5xx controller. ➢ Check the Power Good signal and the activation state of the 24-V output for the hexapod (24 V Out 7 A). Options: ➢ In PIMikroMove®, open the Diagnostic Information window by selecting the C-887 > Show diagnostic information... menu item. ➢ Send the `DIA?` command. Meaning of the displayed information: ➢ 1 (Hexapod Powered): = 1 - Power supply for the hexapod drives exists – = 0 - Power supply for the hexapod drives has been interrupted ➢ 2 (Controller E-Stop Activated): = 1 - 24-V output of the C-887.5xx controller is active = 0 - 24-V output of the C-887.5xx controller is inactiveFor further information, see the user manual for the C-887.5xx controller.
– Incorrect or missing configuration data	➢ Connect the hexapod only when the controller is switched off. ➢ When the firmware has finished booting, send the `CST?` command to check whether the installed configuration has to be activated by rebooting the controller. A reboot is necessary when the response is "NOSTAGE" for the axes X, Y, Z, U, V, and W. The controller can be rebooted with the `RBT` command. ➢ Send the `ERR?` command. If the response to `ERR?` contains the error code 233 or 211, the controller does not have the configuration file for the hexapod. Contact PI cus-

H-850 does not move	
	tomer service to receive a suitable configuration file. For the installation of the new configuration file, refer to "Updating firmware and configuration files". ➢ Send the VER? command to check the information for the hexapod type, serial number, and manufacturing date saved on the ID chip. Example of the response: IDChip: H-811.F2 SN123456789 20/1/2016 Send the CST? command. The response shows the hexapod, to which the controller is adapted. ➢ If the hexapod does not have an ID chip, you will need to load the suitable configuration manually, if needed. For further information, see the user manual for the C-887.5xx controller.
– The motion platform is located at a position outside the travel range limits. Commanding a permitted target position generates error code 7 ("Position out of limits").	➢ Send the ERR? command and check the error code that is returned. ➢ Send the POS? command to check the current position of the motion platform. If error code 7 is returned and the current position is outside the travel range limits for at least one axis, the following steps are necessary depending on the sensor type of the hexapod (incremental or absolute measuring). If the hexapod is equipped with incremental sensors: ➢ Check your system and make sure that all axes can be moved safely. ➢ Start a referencing move for the hexapod.

H-850 does not start a referencing move	
– The hexapod is equipped with absolute-measuring encoders.	➢ The FRF command does not start a referencing move for axes with absolute-measuring sensors but sets the target positions to the current position values.

H-850 does not start a referencing move	
– Motion is generally not possible	➢ Check if one of the causes mentioned in the "H-850 does not move." section applies to your problem

If the problem that occurred with your system is not listed in the table above or cannot be solved as described, contact the PI customer service (p. 70).

11 Specifications

Subject to change. You can find the latest product specifications on the product web page at www.pi.ws.

11.1 Technical data

11.1.1 H-850.X2A

Subject to change. You can find the latest product specifications on the product web page at www.pi.ws.

Motion	Unit		H-850.G2A	H-850.H2A
Active axes			X | Y | Z | θX | θY | θZ	X | Y | Z | θX | θY | θZ
Travel range in X	mm		±50	±50
Travel range in Y	mm		±50	±50
Travel range in Z	mm		±25	±25
Rotation range in θX	°		±15	±15
Rotation range in θY	°		±15	±15
Rotation range in θZ	°		±30	±30
Maximum velocity in X	mm/s		8	0.5
Recommended velocity in X	mm/s		5	0.3
Maximum velocity in Y	mm/s		8	0.5
Recommended velocity in Y	mm/s		5	0.3
Maximum velocity in Z	mm/s		8	0.5
Recommended velocity in Z	mm/s		5	0.3
Maximum angular velocity in θX	mrad/s		120	6
Recommended angular velocity in θX	mrad/s		75	3
Maximum angular velocity in θY	mrad/s		120	6
Recommended angular velocity in θY	mrad/s		75	3
Maximum angular velocity in θZ	mrad/s		120	6
Recommended angular velocity in θZ	mrad/s		75	3

Positioning	Unit	Tolerance	H-850.G2A	H-850.H2A
Minimum incremental motion in X	µm	Typ.	1	0.3
Minimum incremental motion in Y	µm	Typ.	1	0.3
Minimum incremental motion in Z	µm	Typ.	0.5	0.2
Minimum incremental motion in θX	µrad	Typ.	7.5	3
Minimum incremental motion in θY	µrad	Typ.	7.5	3
Minimum incremental motion in θZ	µrad	Typ.	15	5
Unidirectional repeatability in X	µm	Typ.	±0.5	±0.6
Unidirectional repeatability in Y	µm	Typ.	±0.5	±0.6
Unidirectional repeatability in Z	µm	Typ.	±0.2	±0.2
Unidirectional repeatability in θX	µrad	Typ.	±3	±3
Unidirectional repeatability in θY	µrad	Typ.	±3	±3
Unidirectional repeatability in θZ	µrad	Typ.	±7.5	±9
Backlash in X	µm	Typ.	6	4
Backlash in Y	µm	Typ.	6	4
Backlash in Z	µm	Typ.	1.5	0.5
Backlash in θX	µrad	Typ.	25	7.5
Backlash in θY	µrad	Typ.	25	7.5
Backlash in θZ	µrad	Typ.	90	60
Integrated sensor			Absolute rotary encoder, multi-turn	Absolute rotary encoder, multi-turn

Drive Properties			H-850.G2A	H-850.H2A
Drive type			Brushless DC gear motor	Brushless DC gear motor

Mechanical Properties	Unit		H-850.G2A	H-850.H2A
Stiffness in X	N/µm		7	7
Stiffness in Y	N/µm		7	7
Stiffness in Z	N/µm		100	100
Maximum load capacity, base plate horizontal	kg		50	250
Maximum load capacity, base plate in any orientation	kg		20	50
Maximum holding force, base plate horizontal	N		250	2000
Maximum holding force, base plate in any orientation	N		85	500
Overall mass	kg		17	17
Material			Aluminum	Aluminum

Miscellaneous	Unit		H-850.G2A	H-850.H2A
Operating temperature range	°C		-10 to 50	-10 to 50
Connector for data transmission			HD D-sub 78 (m)	HD D-sub 78 (m)
Connector for supply voltage			M12 4-pole (m)	M12 4-pole (m)
Recommended controllers/drivers			C-887.5xx	C-887.5xx

Connecting cables are not included in the scope of delivery and must be ordered separately.
Ask about customized versions.
When measuring position specifications, typical velocity is used. The data is included in the delivery of the product in the form of a measurement report and is stored at PI.
The maximum travel ranges of the individual coordinates (X, Y, Z, θX, θY, θZ) 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 in use, or rather when the pivot point is set to 0,0,0.

At PI, technical data is specified at 22 ±3 °C. Unless otherwise stated, the values are for unloaded conditions. Some properties are interdependent. The designation "typ." indicates a statistical average for a property; it does not indicate a guaranteed value for every product supplied. During the final inspection of a product, only selected properties are analyzed, not all. Please note that some product characteristics may deteriorate with increasing operating time.

11.1.2 H-850.X2V

Subject to change. You can find the latest product specifications on the product web page at www.pi.ws.

Motion	Unit		H-850.G2V	H-850.H2V
Active axes			X | Y | Z | θX | θY | θZ	X | Y | Z | θX | θY | θZ
Travel range in X	mm		±50	±50
Travel range in Y	mm		±50	±50
Travel range in Z	mm		±25	±25
Rotation range in θX	°		±15	±15
Rotation range in θY	°		±15	±15
Rotation range in θZ	°		±30	±30
Maximum velocity in X	mm/s		2.5	0.15
Recommended velocity in X	mm/s		2	0.1
Maximum velocity in Y	mm/s		2.5	0.15
Recommended velocity in Y	mm/s		2	0.1
Maximum velocity in Z	mm/s		2.5	0.15
Recommended velocity in Z	mm/s		2	0.1
Maximum angular velocity in θX	mrad/s		30	1.8
Recommended angular velocity in θX	mrad/s		25	1.2
Maximum angular velocity in θY	mrad/s		30	1.8
Recommended angular velocity in θY	mrad/s		25	1.2
Maximum angular velocity in θZ	mrad/s		30	1.8
Recommended angular velocity in θZ	mrad/s		25	1.2

Positioning	Unit	Tolerance	H-850.G2V	H-850.H2V
Minimum incremental motion in X	µm	Typ.	1	0.3
Minimum incremental motion in Y	µm	Typ.	1	0.3
Minimum incremental motion in Z	µm	Typ.	0.5	0.2
Minimum incremental motion in θX	µrad	Typ.	7.5	3
Minimum incremental motion in θY	µrad	Typ.	7.5	3
Minimum incremental motion in θZ	µrad	Typ.	15	5
Unidirectional repeatability in X	µm	Typ.	±0.5	±0.5
Unidirectional repeatability in Y	µm	Typ.	±0.5	±0.5
Unidirectional repeatability in Z	µm	Typ.	±0.2	±0.2
Unidirectional repeatability in θX	µrad	Typ.	±3	±3
Unidirectional repeatability in θY	µrad	Typ.	±3	±3
Unidirectional repeatability in θZ	µrad	Typ.	±7.5	±9
Backlash in X	µm	Typ.	8	8
Backlash in Y	µm	Typ.	8	8
Backlash in Z	µm	Typ.	1.5	1
Backlash in θX	µrad	Typ.	25	7.5
Backlash in θY	µrad	Typ.	25	7.5
Backlash in θZ	µrad	Typ.	90	60
Integrated sensor			Incremental rotary encoder	Incremental rotary encoder

Drive Properties	Unit		H-850.G2V	H-850.H2V
Drive type			DC gear motor with ActiveDrive	DC gear motor with ActiveDrive
Nominal voltage	V		24	24

Mechanical Properties	Unit		H-850.G2V	H-850.H2V
Stiffness in X	N/µm		7	7
Stiffness in Y	N/µm		7	7
Stiffness in Z	N/µm		100	100
Maximum load capacity, base plate horizontal	kg		25	80
Maximum load capacity, base plate in any orientation	kg		10	40
Maximum holding force, base plate horizontal	N		250	2000
Maximum holding force, base plate in any orientation	N		85	500
Drive screw type			Ball screw	Ball screw
Overall mass	kg		17	17
Material			Aluminum	Aluminum

Miscellaneous	Unit		H-850.G2V	H-850.H2V
Operating temperature range	°C		-10 to 50	-10 to 50
Vacuum class	hPa		10^{-6}	10^{-6}
Maximum bakeout temperature	°C		80	80
Connector for data transmission			HD D-sub 78 (m)	HD D-sub 78 (m)
Connector for supply voltage			M12 4-pole (m)	M12 4-pole (m)
Cable length	m		2	2
Recommended controllers/drivers			C-887.5xx	C-887.5xx

Air-side connecting cables are not included in the scope of delivery and must be ordered separately.
With continuous operation in a vacuum, heat generation may necessitate limiting the operating parameters.
When measuring position specifications, typical velocity is used. The data is included in the delivery of the product in the form of a measurement report and is stored at PI.
The maximum travel ranges of the individual coordinates (X, Y, Z, θX, θY, θZ) 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 in use, or rather when the pivot point is set to 0,0,0.

At PI, technical data is specified at 22 ±3 °C. Unless otherwise stated, the values are for unloaded conditions. Some properties are interdependent. The designation "typ." indicates a statistical average for a property; it does not indicate a guaranteed value for every product supplied. During the final inspection of a product, only selected properties are analyzed, not all. Please note that some product characteristics may deteriorate with increasing operating time.

11.2 Technical data data transmission cable and power supply cable

The following table lists the technical data of all optionally available cable sets, irrespective of whether they are suitable for the H-850. For a selection of suitable cable sets, see Accessories (p. 20).

Data transmission cable	Power supply cable, single-side angled connector	Power supply cable, straight connectors
All hexapod types	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
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:

- Cable type
- Length
- Connector type (power cables only)

These features are coded in the product number by the characters 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 cables 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

* Cables longer than 20 m require additional power drivers.

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

Power supply cable, straight connectors		Unit
Minimum bending radius in a drag chain	49	mm
Minimum bending radius in a fixed installation	24.5	mm

Power supply cable, straight connectors		Unit
Outer diameter	4.9	mm
Connector	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 in a fixed installation	36	57	mm
Outer diameter	7.2	7.5	mm
Connector	M12 m/f		

11.3 Specifications for 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 in a fixed installation	47	mm
Outer diameter	9.3	mm
Connector	HD D-sub78 m/f	

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

11.4 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

11.5 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)
Relative humidity	Maximum relative humidity 80 % for temperatures up to 31 °C Decreasing linearly to 50 % relative humidity at 40 °C
Degree of protection according to IEC 60529	IP20
Area of application	For indoor use only
Maximum altitude	2000 m

11.6 Dimensions

If the controller's factory settings are used for the coordinate system and the center of rotation, the pictured hexapod corresponds to the position X=Y=Z=U=V=W=0.

The (0,0,0) coordinates indicate the origin of the coordinate system. The center of rotation is at the origin of the coordinate system when the factory settings for the coordinate system and center of rotation are used, and the hexapod is at position X=Y=Z=U=V=W=0.

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

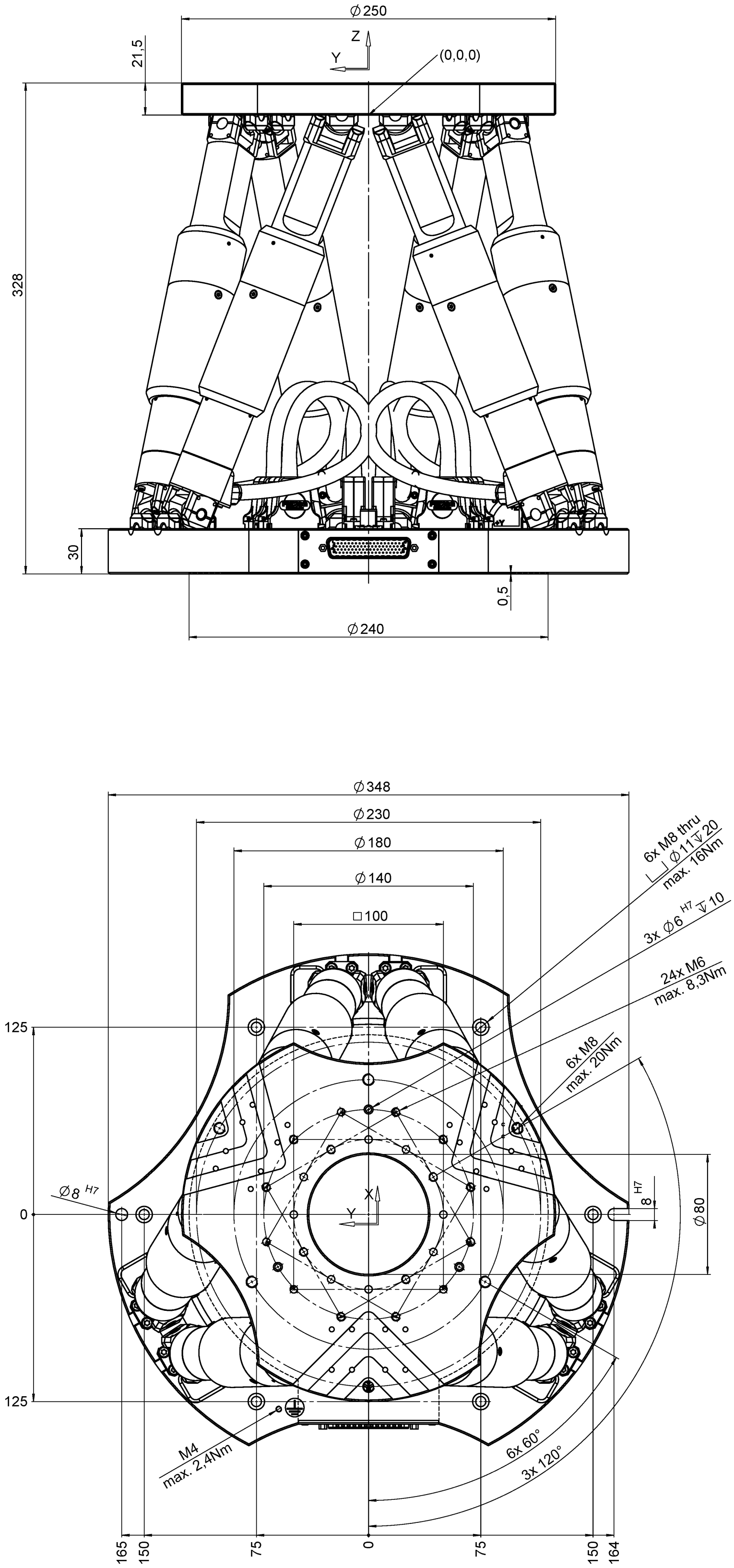


Fig. 11: H-850.x2A, at the zero position of the nominal travel range

11.7 Load Curves

The load curves in the following figures only apply when the hexapod is connected to the controller and the servo mode is switched on.

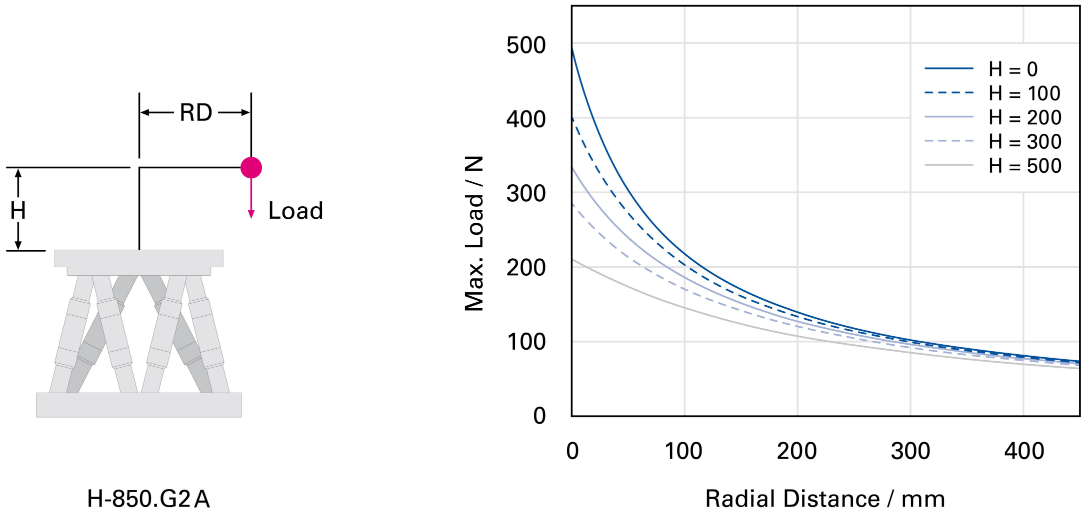


Fig. 12: Maximum loads on the H-850.G2A when mounted horizontally

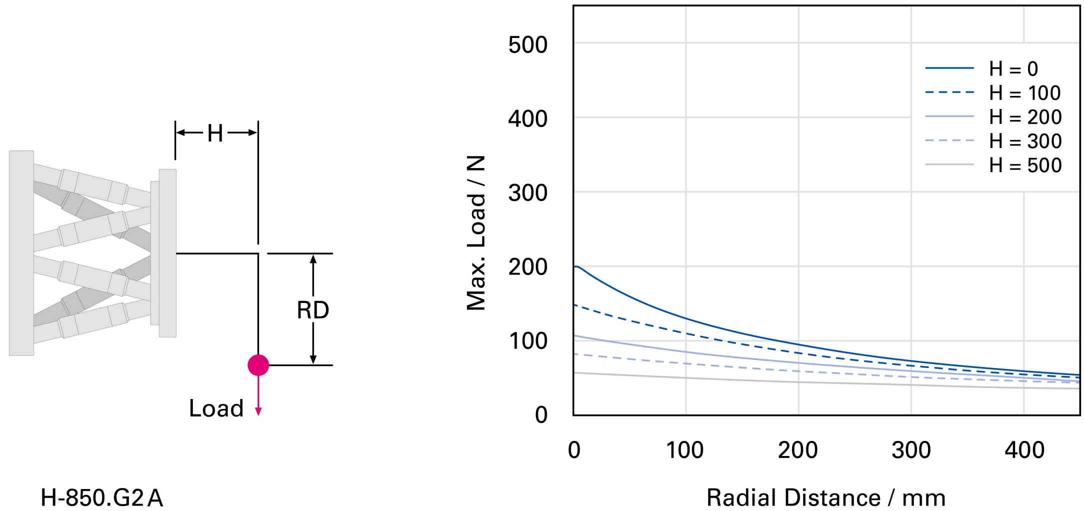


Fig. 13: Maximum loads on the H-850.G2A when mounted vertically

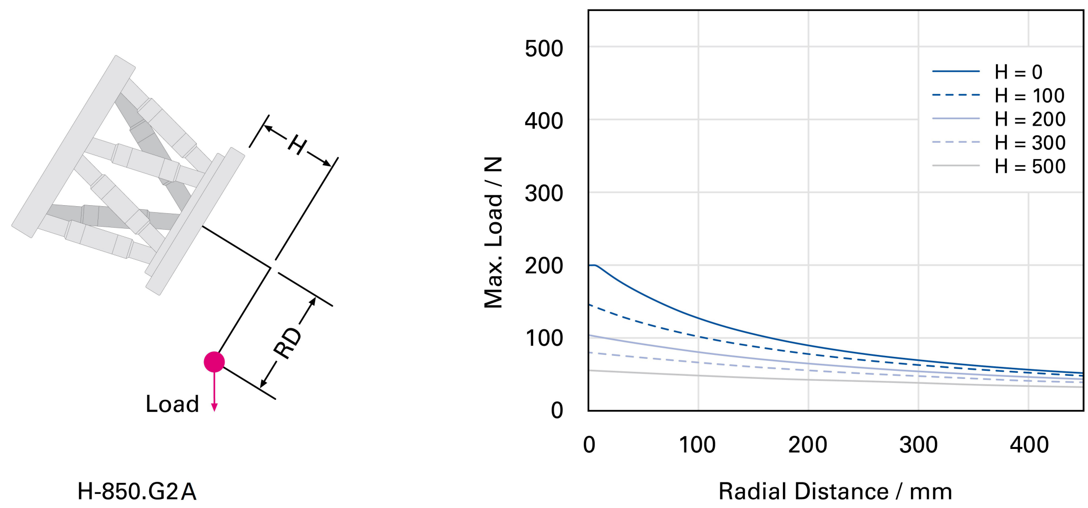


Fig. 14: Maximum loads on the H-850.G2A when mounted at the most unfavorable angle

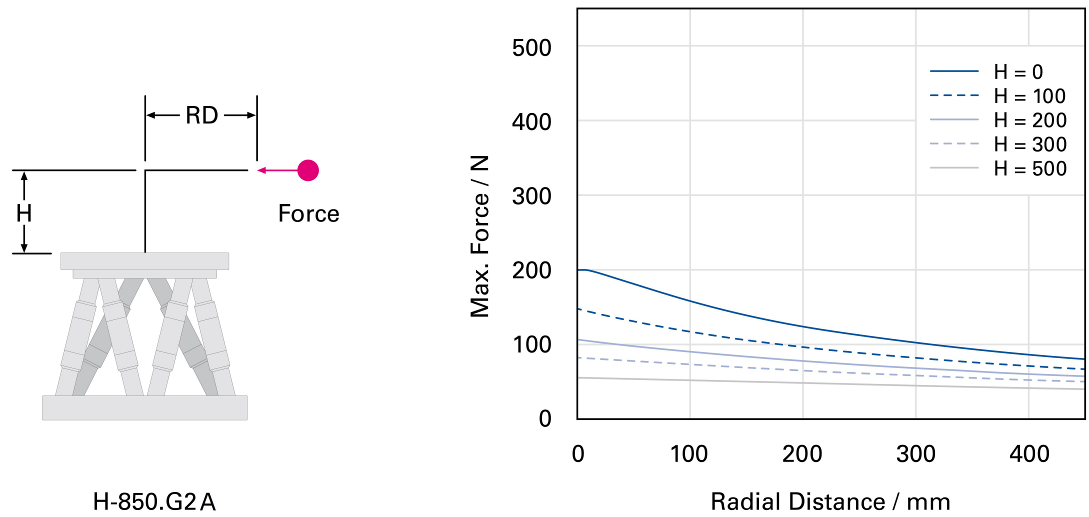


Fig. 15: Maximum permissible force acting on the H-850.G2A when mounted horizontally

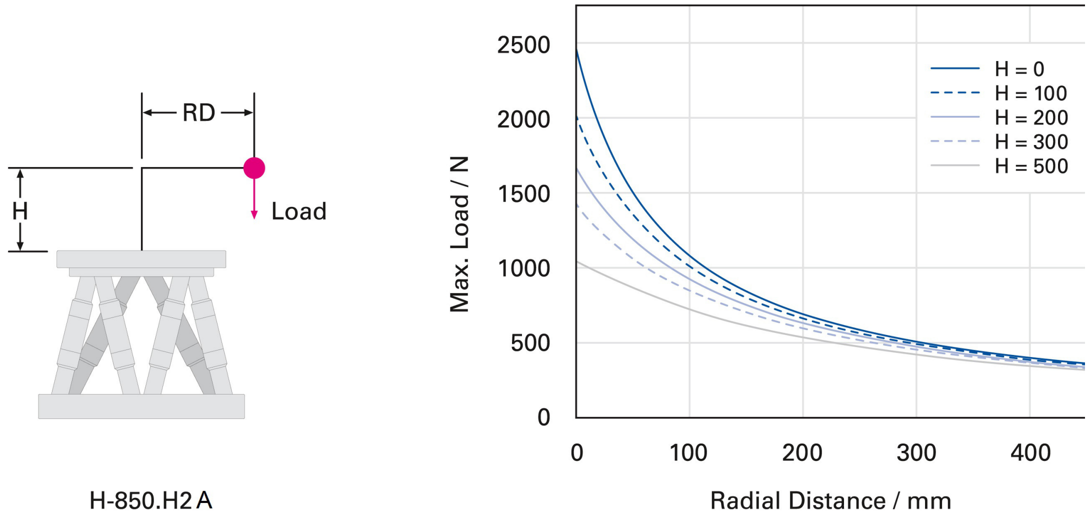


Fig. 16: Maximum loads on the H-850.H2A when mounted horizontally

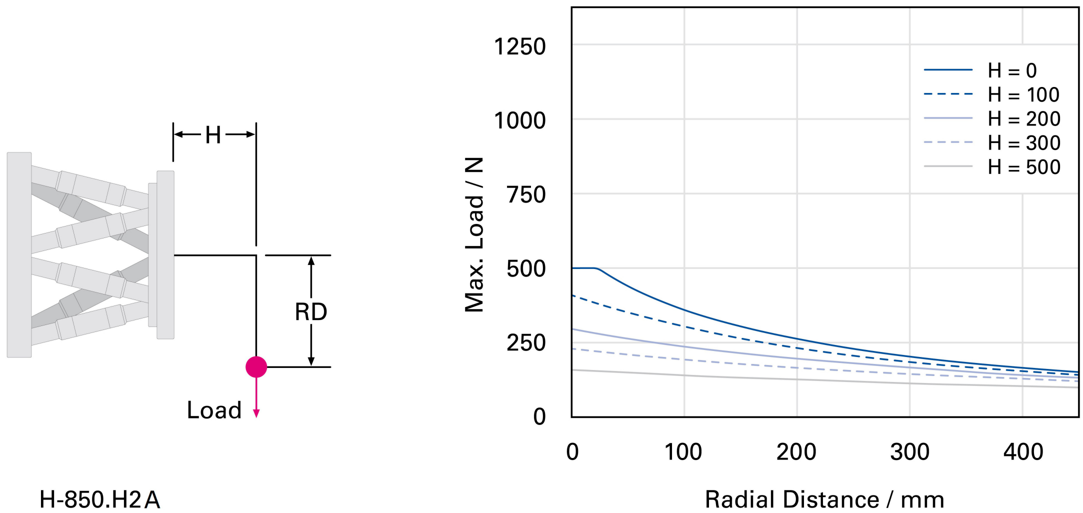


Fig. 17: Maximum loads on the H-850.H2A when mounted vertically

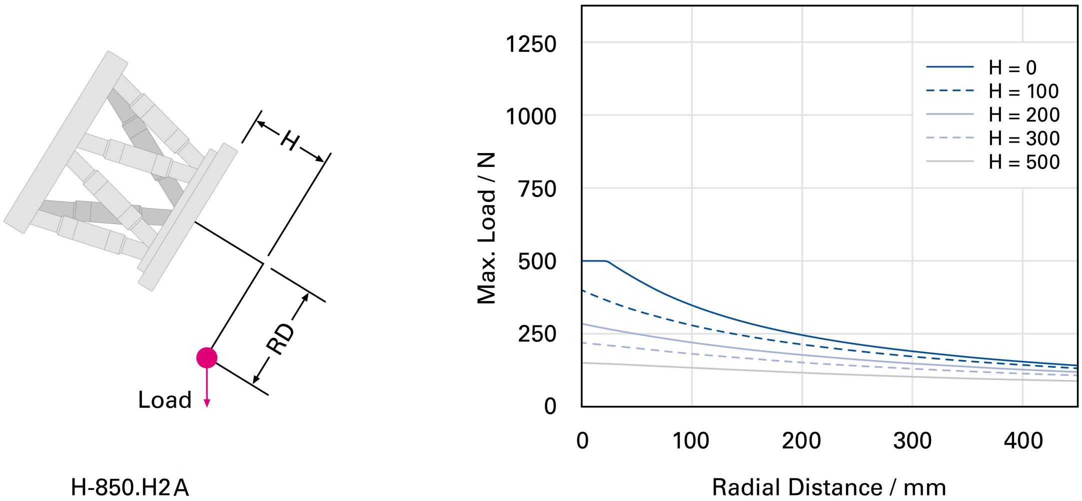


Fig. 18: Maximum loads on the H-850.H2A when mounted at the most unfavorable angle

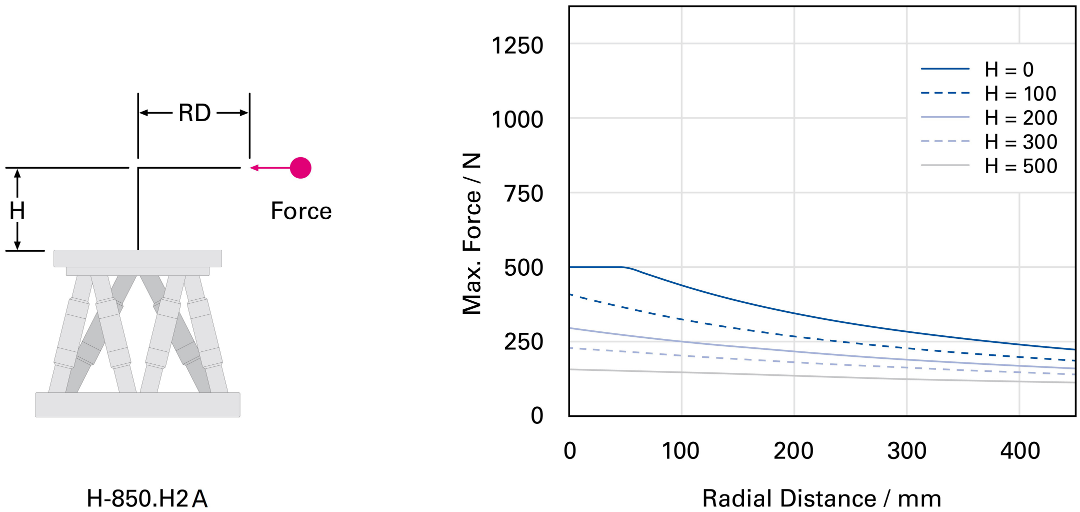


Fig. 19: Maximum permissible force acting on the H-850.H2A when mounted horizontally

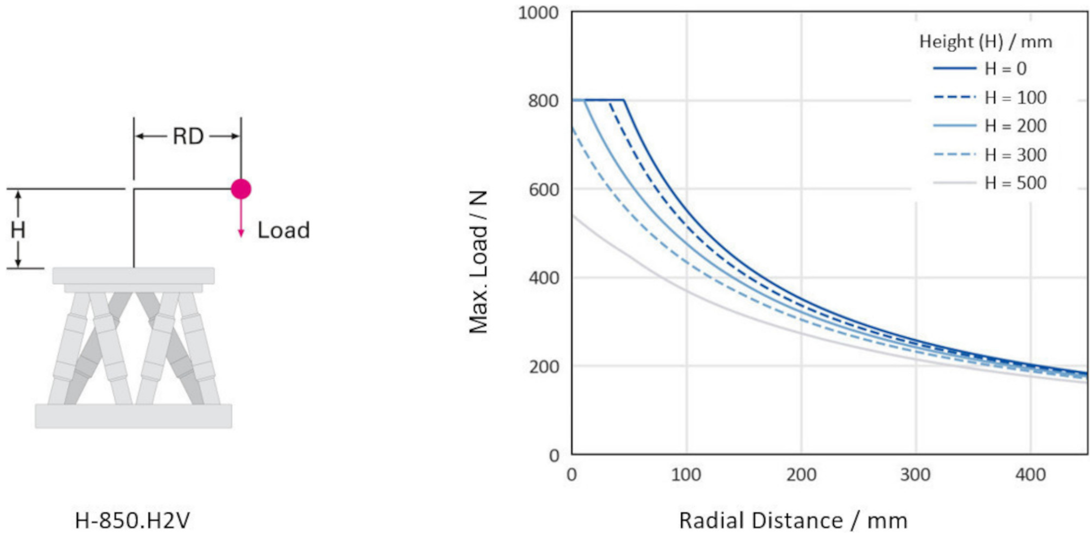


Fig. 20: Maximum loads on the H-850.H2V when mounted horizontally

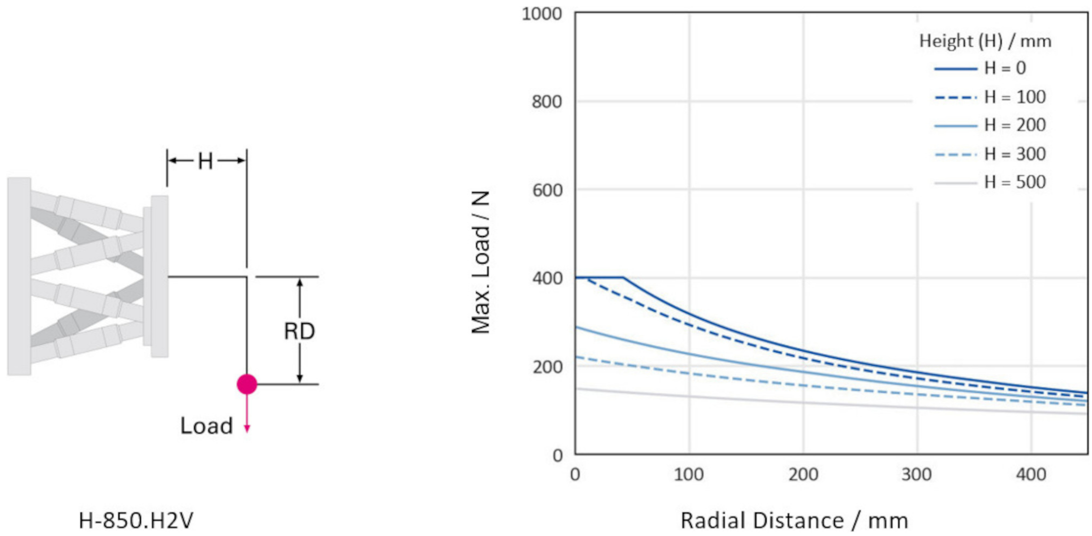


Fig. 21: Maximum loads on the H-850.H2V when mounted vertically

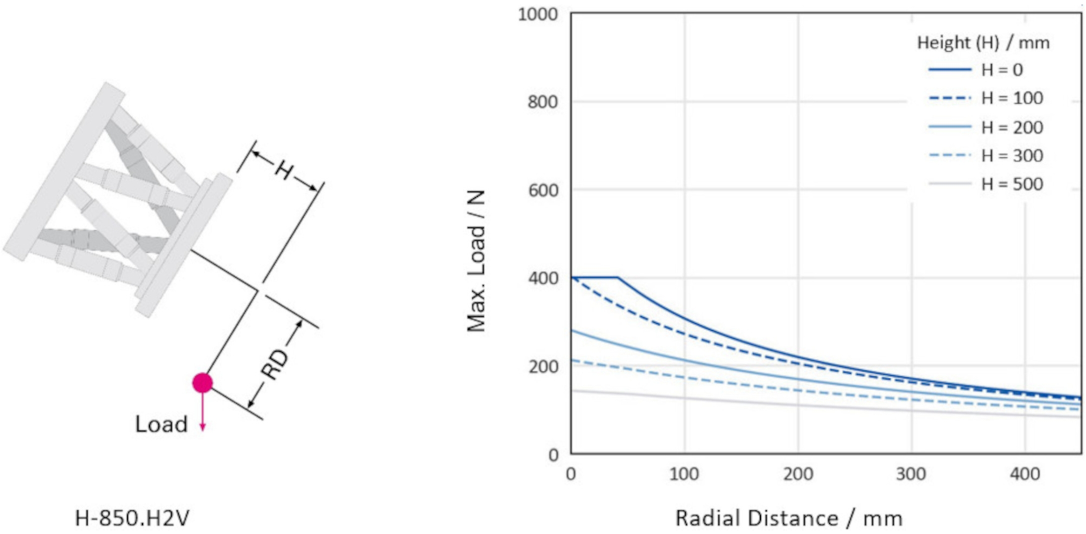
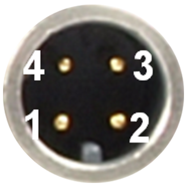


Fig. 22: Maximum loads on the H-850.H2V when mounted at the most unfavorable angle

11.8 Pin assignment

11.8.1 Power supply connector

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



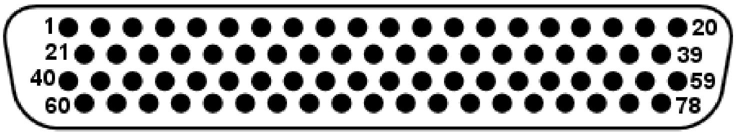
Pin	Function
1	GND
2	GND
3	24 V DC
4	24 V DC

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

Pin	Function
1	GND
2	24 V DC

11.8.2 Data transmission connector

Data transmission between hexapod and controller: HD D-sub 78 panel plug



Function
All signals: TTL

Pin assignment

Pin	Signal	Pin	Signal
1	CH1 Sign IN	**40**	CH1 MAGN IN
2	nc	**41**	CH1 LimN OUT
3	CH1 A- OUT	**42**	CH1 B- OUT
4	CH2 Sign IN	**43**	CH2 MAGN IN
5	nc	**44**	CH2 LimN OUT
6	CH2 A- OUT	**45**	CH2 B- OUT
7	CH3 Sign IN	**46**	CH3 MAGN IN
8	nc	**47**	CH3 LimN OUT
9	CH3 A- OUT	**48**	CH3 B- OUT
10	CH4 Sign IN	**49**	CH4 MAGN IN
11	nc	**50**	CH4 LimN OUT
12	CH4 A- OUT	**51**	CH4 B- OUT
13	CH5 Sign IN	**52**	CH5 MAGN IN
14	nc	**53**	CH5 LimN OUT
15	CH5 A- OUT	**54**	CH5 B- OUT
16	CH6 Sign IN	**55**	CH6 MAGN IN
17	nc	**56**	CH6 LimN OUT
18	CH6 A- OUT	**57**	CH6 B- OUT
19	ID chip	**58**	Brake/Enable drive

Pin	Signal	Pin	Signal
20	24 V input	**59**	Power Good 24 V output
21	CH1 Ref OUT	**60**	CH1 LimP OUT
22	CH1 A+ OUT	**61**	CH1 B+ OUT
23	GND	**62**	GND
24	CH2 Ref OUT	**63**	CH2 LimP OUT
25	CH2 A+ OUT	**64**	CH2 B+ OUT
26	GND	**65**	GND
27	CH3 Ref OUT	**66**	CH3 LimP OUT
28	CH3 A+ OUT	**67**	CH3 B+ OUT
29	GND	**68**	GND
30	CH4 Ref OUT	**69**	CH4 LimP OUT
31	CH4 A+ OUT	**70**	CH4 B+ OUT
32	GND	**71**	GND
33	CH5 Ref OUT	**72**	CH5 LimP OUT
34	CH5 A+ OUT	**73**	CH5 B+ OUT
35	GND	**74**	GND
36	CH6 Ref OUT	**75**	CH6 LimP OUT
37	CH6 A+ OUT	**76**	CH6 B+ OUT
38	GND	**77**	GND
39	GND	**78**	GND

11.9 Explanations for 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 used test setup.

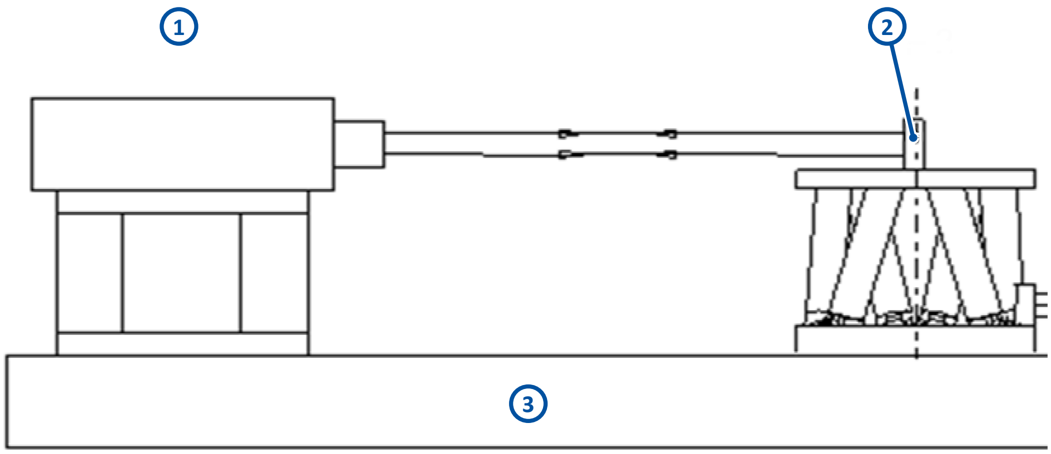


Fig. 23: Test setup for measuring the X axis or the Y axis

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 5 cycles

– Motion over partial sections, for example, ±1 mm in increments of for example, 100 µm

12 Glossary

12.1 User-defined coordinate systems

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

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

12.2 Workspace

The entirety of all poses that the hexapod can approach from its current position is referred to as workspace.

The workspace can be limited by the following external factors:

- Installation space
- Dimensions and position of the load

To avoid subjecting the hexapod to an impermissible mechanical load, the forces acting on the hexapod struts at the poses must be taken into consideration in addition to the workspace. Valid poses can be calculated with the PIVirtualMove simulation program.

12.3 Center of rotation

The center of rotation describes the intersection of rotational axes U, V, and W. If the default settings for the coordinate system and the center of rotation are used, the center of rotation after the referencing move is located at the origin of the coordinate system (0,0,0), see the dimensional drawing of the hexapod (Dimensions (p. 55)).

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 systemin 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".

12.4 Hexapod system

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

12.5 Pose

The spatial position of the hexapod, i.e. the combination of its pose and orientation in the three-dimensional space is referred to as "pose". The pose of a hexapod is defined by 6 coordinates in relation to a right-handed Cartesian coordinate system:

- Translational axes (also referred to as "linear axes"): X, Y, Z
- Rotational axes: U, V, W

A pose is valid if it can be reached by all 6 axes X, Y, Z, U, V, W with the used coordinate system and the used system setup (installation position of the hexapod, load to be moved, external forces and torques) **and** the permissible load of the struts is **not** exceeded.

Valid poses can be calculated with the PIVirtualMove simulation program.

For other possible designations of the U, V, and W axes: Motion (p. 16)

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

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

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

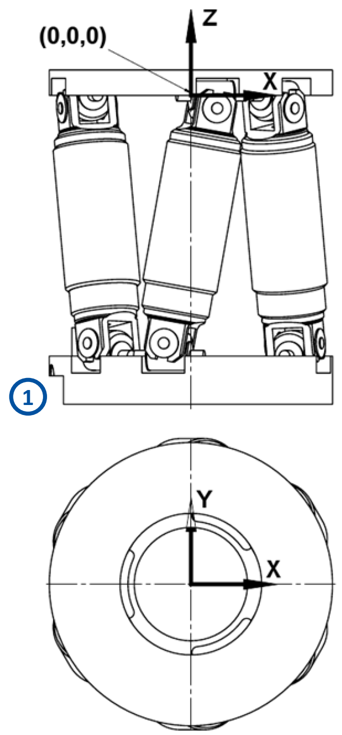


Fig. 24: Hexapod in reference position

1 Cable exit

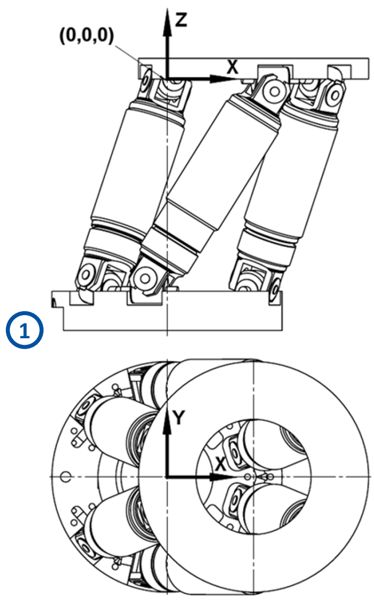


Fig. 25: Hexapod, the platform of which has been moved in X

1 Cable exit

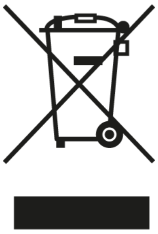
13 Old equipment disposal

In accordance with EU law, electrical and electronic equipment may not be disposed of in EU member states via the municipal residual waste. This refers to devices which are labeled with the symbol for the separate collection of waste electrical and electronic equipment.

If you are established in a member state of the European Union and have an old device from PI, Physik Instrumente (PI) SE & Co. KG will take care of the environmentally friendly disposal of this old device free of charge. You can send the old PI device free of charge to the following address:

Physik Instrumente (PI) SE & Co. KG
Auf der Römerstraße 1
76227 Karlsruhe
Germany

If you are not established in a member state of the European Union: Dispose of your old device according to the national and local rules and regulations.



14 Customer service

If you have any questions or problems, contact the PI customer service or send us an e-mail: service@pi.de

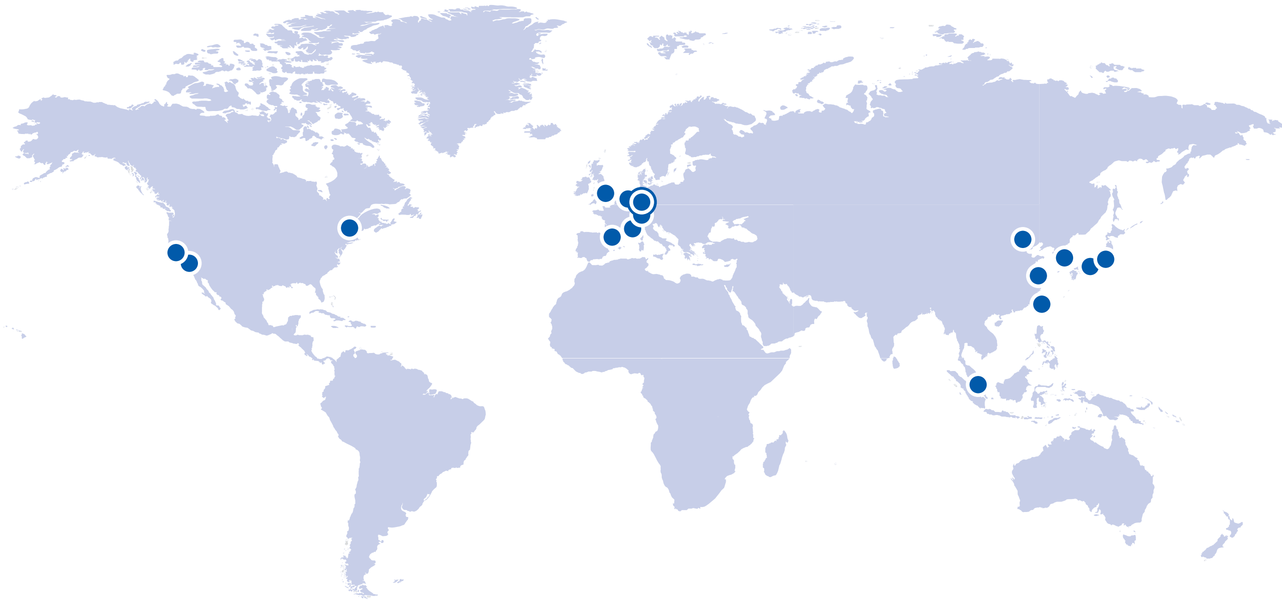
If you have questions regarding your system, provide us the following information:

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

If possible, take photographs or make videos of your system that can be sent to the PI customer service if requested.

Customer service address:

Physik Instrumente (PI) SE & Co. KG
Auf der Römerstraße 1
76227 Karlsruhe
Germany



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