PI

MS201E

H-840 Hexapod Microrobot

User Manual

Version: 2.6.0 Date: 13.01.2023

This document describes the following hexapod microrobots:

- **H-840.G2A**
- **H-840.G2I**
- **H-840.G2IHP**
- **H-840.D2A**
- **H-840.D2I**

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 This manual is superseded by any new release.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

Contents

1 About this Document

In this Chapter

1.1 Objective and Target Group of this User Manual

This user manual contains the information necessary for using the H-840 as intended.

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

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

1.2 Symbols and Typographic Conventions

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

CAUTION

Dangerous situation

Failure to comply could lead to minor injury.

- ➢ Precautionary measures to avoid the risk.

NOTICE

Dangerous situation

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

- ➢ Precautionary measures to avoid the risk.

INFORMATION

Information for easier handling, tricks, tips, etc.

Symbol/ Label	Meaning
1. 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 Figures

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

1.4 Other Applicable Documents

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

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

1.5 Downloading Manuals

INFORMATION

If a manual is missing or problems occur with downloading:

➢ Contact our customer service department (p. 45).

Downloading manuals

1. Open the website **www.pi.ws**.
2. Search the website for the product number (e.g., H-840).
3. Click the corresponding product to open the product detail page.
4. Click the ***Downloads*** tab.

   The manuals are shown under ***Documentation***. Software manuals are shown under ***General Software Documentation***.
5. Click the desired manual and fill out the inquiry form.

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

2 Safety

In this Chapter

2.1 Intended Use

The hexapod microrobot (short "hexapod") is a laboratory device as defined by DIN EN 61010-1. It is built for indoor use and use in an environment which is free of dirt, oil, and lubricants.

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

The hexapod can only be used as intended in conjunction with a suitable controller available from PI (p. 15), which coordinates all motion of the hexapod.

2.2 General Safety Instructions

The H-840 is built according to state-of-the-art technology and recognized safety standards. Improper use of the H-840 may result in personal injury and/or damage to the H-840.

- ➢ Use the H-840 for its intended purpose only, and only when it is in perfect condition.
- ➢ Read the user manual.
- ➢ Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for installing and operating the H-840 correctly.

2.3 Organizational Measures

User manual

- ➢ Always keep this user manual together with the H-840. The latest versions of the user manuals are available for download on our website (p. 3).
- ➢ Add all information from the manufacturer such as supplements or technical notes to the user manual.

- If you give the H-840 to other users, include this user manual as well as all other relevant information provided by the manufacturer.
- Do the work only if the user manual is complete. Missing information due to an incomplete user manual can result in minor injury and damage to equipment.
- Install and operate the H-840 only after you have read and understood this user manual.

Personnel qualification

The H-840 may only be installed, started, operated, maintained, and cleaned by authorized and appropriately qualified personnel.

3 Product Description

In this Chapter

3.1 Features and Applications

The various models (p. 7) of the H-840 hexapod that are offered differ with respect to the sensor type, maximum velocity, and load capacity.

The parallel-kinematic design of the hexapod offers the following advantages:

- Positioning operations in six independent axes (three translational axes, three rotational axes) with short settling times
- The center of rotation moves together with the motion platform
- High accuracy and step resolution in all axes
- No accumulation of errors of individual axes
- No friction and torques from moving cables

The hexapod is controlled with a controller that can be ordered separately from PI (p. 15). The position commands to the controller are entered as Cartesian coordinates.

3.2 Model Overview

Model	Designation
H-840.G2A	Precision hexapod microrobot, brushless DC gear motor, absolute encoder, 40 kg load capacity, 2.5 mm/s velocity. Connecting cables are not included in the scope of delivery and must be ordered separately.
H-840.G2I	Precision hexapod microrobot, brushless DC gear motor, incremental rotary encoder, 40 kg load capacity, 2.5 mm/s velocity. Connecting cables are not included in the scope of delivery and must be ordered separately.
H-840.G2IHP	High-precision hexapod microrobot, minimum incremental motion X,Y 40 nm, minimum incremental motion Z 20 nm, minimum incremental motion θX, θY 0.2

Model	Designation
	µrad, minimum incremental motion θZ, 0.4 µrad, measurement log included in the scope of delivery, brushless DC gear motor, incremental rotary encoder, 40 kg load capacity, 2.5 mm/s velocity. Connecting cables are not included in the scope of delivery and must be ordered separately.
H-840.D2A	Motion hexapod microrobot, brushless DC motor, absolute encoder, 10 kg load capacity, 60 mm/s velocity. Connecting cables are not included in the scope of delivery and must be ordered separately.
H-840.D2I	Motion hexapod microrobot, brushless DC motor, incremental rotary encoder, 10 kg load capacity, 60 mm/s velocity. Connecting cables are not included in the scope of delivery and must be ordered separately.

3.3 Product View

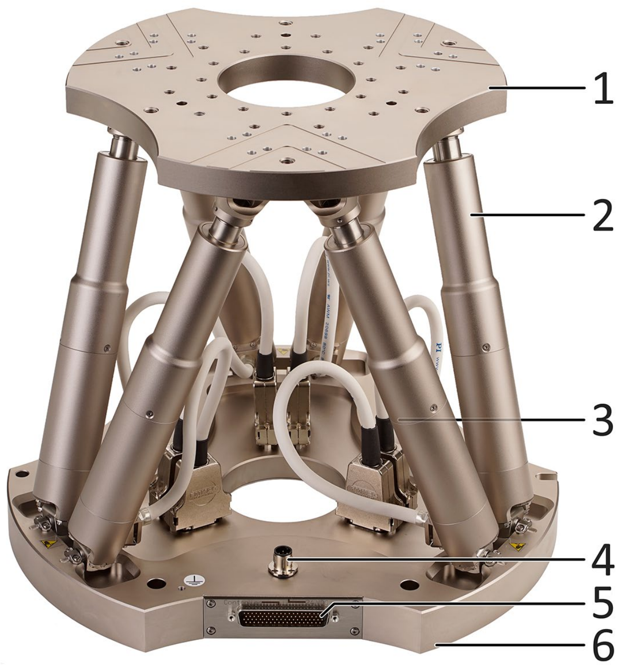


Figure 1: Elements of the H-840

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

3.4 Technical Features

3.4.1 Struts

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

Each strut is equipped with the following components:

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

The actuator contains the following components:

- H-840.G2A: Brushless DC motor with gearhead and absolute-measuring encoder, spindle
- H-840.G2I: Brushless DC motor with gearhead and incremental encoder, spindle
- H-840.G2IHP: Brushless DC motor with gearhead and incremental encoder, spindle
- H-840.D2A: Brushless DC motor with absolute-measuring encoder and spindle
- H-840.D2I: Brushless DC motor with incremental encoder and spindle

3.4.2 Reference Switch and Limit Switches

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

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

3.4.3 Control

Der hexapod is intended for operation with a suitable controller from PI (p. 15). The controller makes it possible to command motion of individual axes, combinations of axes or all six axes at the same time in a single motion command.

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

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

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

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

3.4.4 Motion

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

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

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

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

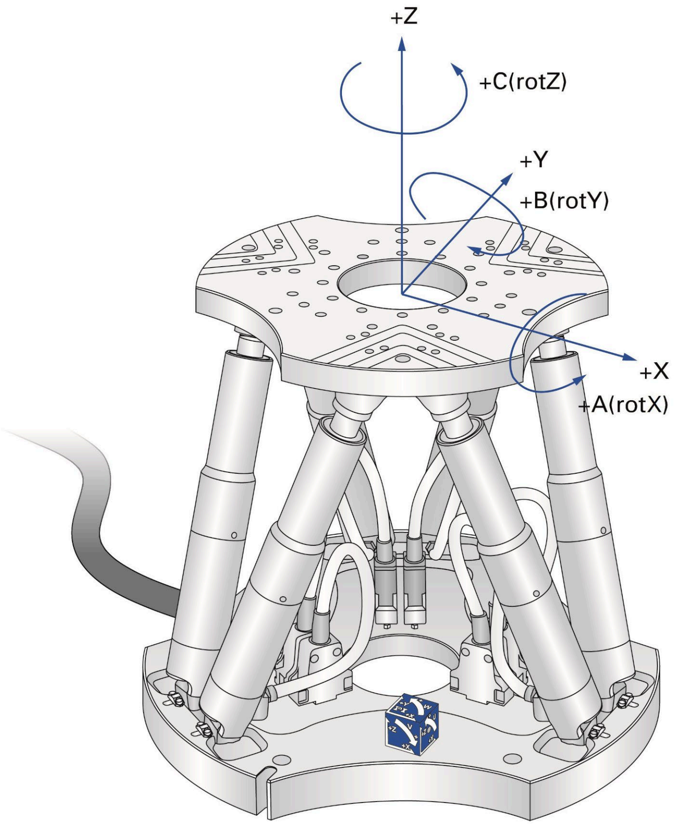


Figure 2: Coordinate system and rotations to the rotational coordinates U, V, and W. The coordinate system is depicted above the platform for better clarity

Translation

Translations are described in the spatially-fixed coordinate system. The translational axes X, Y, and Z meet at the origin of the coordinate system (0,0,0). For further information, see the glossary (p. 65).

Rotation

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

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

For further information on the center of rotation, see the glossary (p. 65).

INFORMATION

The dimensional drawing (p. 57) contains the following:

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

Example: Consecutive rotations

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

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

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

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

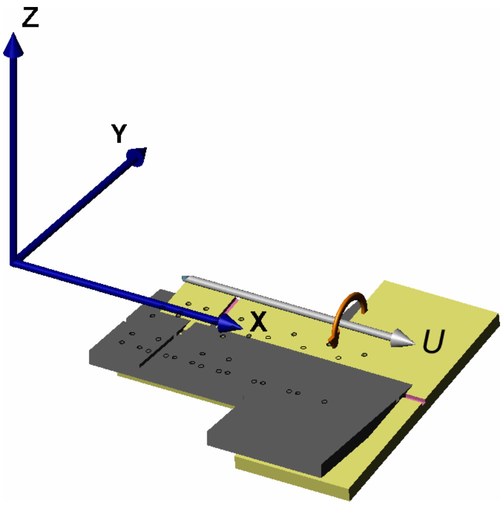


Figure 3: Rotation around the U axis

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

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.

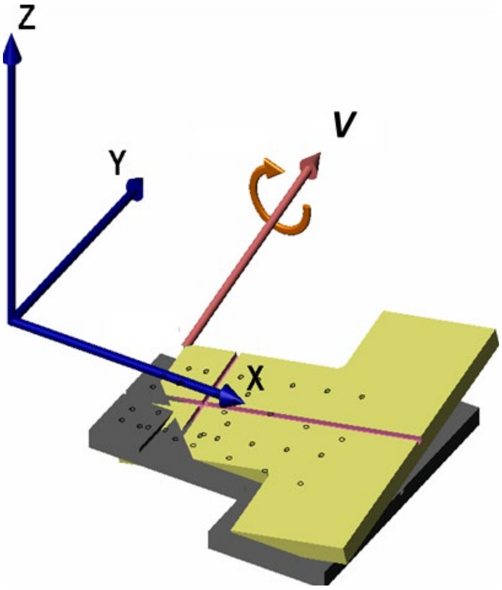


Figure 4: Rotation around the V axis

- 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.

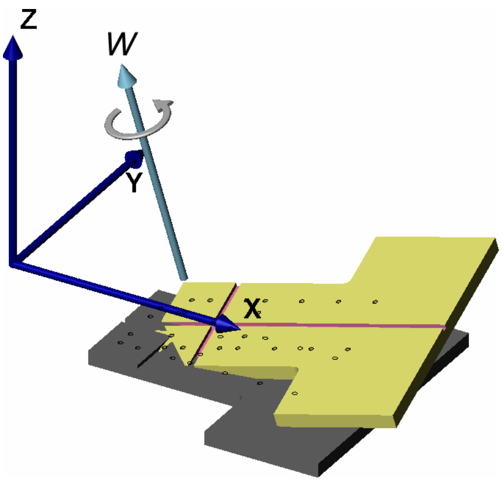


Figure 5: Rotation around the W axis

■ 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 further data on the travel ranges, see the "Specifications" section (p. 47).

3.4.5 ID Chip

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

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

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

3.5 Scope of Delivery

Order number	Components
H-840	Hexapod according to your order (p. 7)
Packaging, consisting of:	
▪ Transport safeguard with mounting kit ▪ Inner and outer box ▪ Foam and corrugated cardboard cushions ▪ Pallet	
Documentation, consisting of:	
H840T0001	Technical note on unpacking the hexapod
MS247EK	Short instructions for hexapod systems
Screw sets and tools:	
000034605	Mounting kit: ▪ 6 socket head screws, M6×30 ISO 4762 ▪ 1 hex key 5.0 DIN 911
000077312	Double open-ended wrench 10 x 13 mm DIN 895

Order number	Components
000036450	Accessories for connecting to the grounding system: ▪ 1 flat-head screw with cross recess, M4x8 ISO 7045 ▪ 2 flat washers, form A-4, 3 DIN 7090 ▪ 2 lock washers, Schnorr Ø 4 mm N0110

Note that the cables required for connecting the H-840 to the electronics must be ordered separately.

3.6 Optional Accessories

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

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

To order, contact our customer service department (p. 45).

3.7 Suitable Controllers

Model	Description
C-887.52	6-axis controller for hexapods, TCP/IP, RS-232, benchtop device, incl. control of two additional axes
C-887.521	6-axis controller for hexapods, TCP/IP, RS-232, benchtop device, incl. control of two additional axes, analog inputs
C-887.522	6-axis controller for hexapods, TCP/IP, RS-232, benchtop device, incl. control of two additional axes, motion stop
C-887.523	6-axis controller for hexapods, TCP/IP, RS-232, benchtop device, incl. control of two additional axes, motion stop, analog inputs
C-887.53	6-axis controller for hexapods, TCP/IP, RS-232, benchtop device, incl. control of two additional axes, EtherCAT interface
C-887.531	6-axis controller for hexapods, TCP/IP, RS-232, benchtop device, incl. control of two additional axes, EtherCAT interface, analog inputs
C-887.532	6-axis controller for hexapods, TCP/IP, RS-232, benchtop device, incl. control of two additional axes, EtherCAT interface, motion stop
C-887.533	6-axis controller for hexapods, TCP/IP, RS-232, benchtop device, incl. control of two additional axes, EtherCAT interface, motion stop, analog inputs

To order, contact our customer service department (p. 45).

NOTICE

Only operate H-840.G2IHP with the correct controller!

Please consult our customer service department before operating the H-840.G2IHP with a different controller to the ones specified.

Without prior briefing from our customer service department, do not operate the H-840.G2IHP with a C-887.5x[x] controller that is already being used for other hexapods.

➢ Contact our customer service department if you want to operate the H-840.G2IHP with a different controller to the ones specified.

➢ Contact our customer service department if you want to operate the H-840.G2IHP with a C-887.5x[x] controller that is already being used for other hexapods.

4 Unpacking

In this Chapter

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

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

NOTICE

Impermissible mechanical load!
An impermissible mechanical load can damage the hexapod.

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

4.1 Unpacking the Hexapod

1. Open the outer box.
2. Remove the foam cover.
3. Open the inner box.
4. Remove the foam cover.
5. Grip the hexapod's transport safeguard and take it out of the foam insert.
6. Compare the contents with the items listed in the contract and the packing list. If any of the parts are wrong or are missing, contact PI immediately.
7. Inspect the hexapod for signs of damage. If there is any sign of damage, contact PI immediately.
8. Remove the transport safeguard according to the instructions (p. 18) that apply to your hexapod model.

4.2 Removing the Transport Safeguard

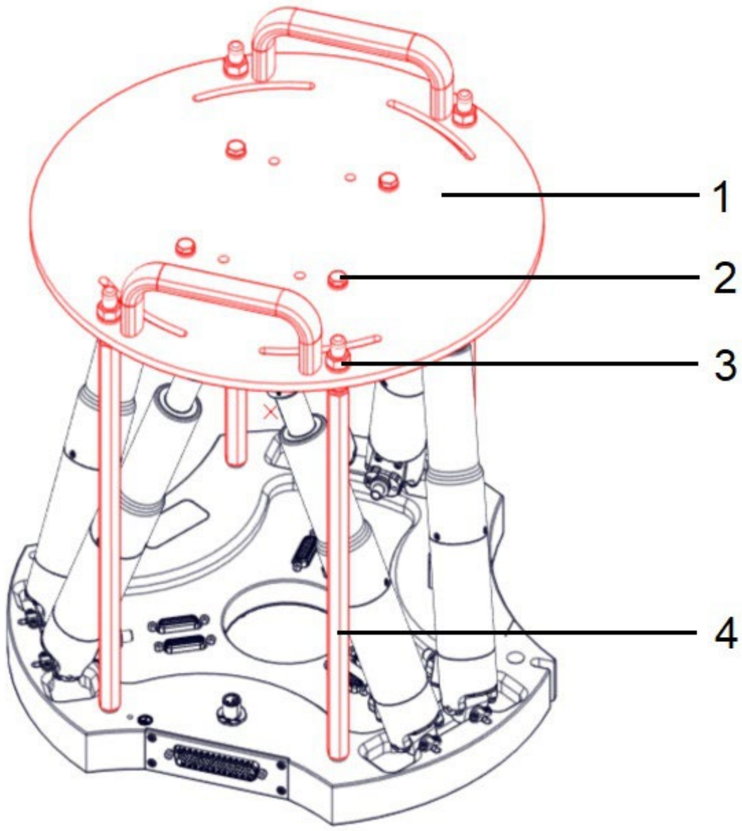


Figure 6: Transport safeguard components

1 Cover
2 M6x16 screw
3 M8 nut
4 Strut

Tools and accessories

- Open-end wrench AF 10
- Open-end wrench AF 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 screws and the corresponding flat washers.

5. Remove the transport safeguard's cover.
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.

5 Installing

In this Chapter

5.1 General Notes on Installation

The hexapod can be mounted in any orientation.

NOTICE

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

- Only hold the hexapod by the base plate.
- Before installing the load, determine
  the limit value for the load and
  the workspace of the hexapod
  with a simulation program (p. 22).
- 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.

For variants with absolute encoder:

NOTICE

Sensor malfunction due to unplugging connectors!
Unplugging the D-sub connectors between the strut and the base plate leads to a shift in the sensor's zero point. When the battery discharges, the sensor also goes into an error mode.

- Do not unplug the D-sub connectors between the strut and the base plate of the hexapod.

INFORMATION

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

5.2 Determining the Permissible Load and Workspace

Tools and Accessories

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

Determining the workspace and the permissible load of the hexapod

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

The limit values in the following table serve as a guide. They only apply when the center of mass is at the origin of the default 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 in any direction	Mounted horizontally	Mounted in any direction
H-840.G2A, .G2I, .G2IHP	30 kg	10 kg	100 N	25 N
H-840.D2A, .D2I	10 kg	3 kg	15 N	5 N

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

➢ Contact our customer service department (p. 45).

5.3 Grounding the Hexapod

INFORMATION

- If there is any vibration in your application, secure the screw connection for the protective earth conductor in a suitable manner (e.g., with conductive liquid adhesive) to prevent it from unscrewing by itself.

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

1. Connect the base plate to the grounding system:
   - For connection, use the supplied accessories (p. 13) and the M4 hole with an 8 mm depth marked with the ground connection symbol (p. 57).
2. Connect the motion platform to the grounding system:
   - Use one of the mounting holes in the motion platform (p. 57) for connection. or
   - If the motion platform and the load are connected conductively to each other, connect the load to the grounding system.

5.4 Mounting the Hexapod on a Surface

NOTICE

Impermissible mechanical load!
An impermissible mechanical load can damage the hexapod.

- Only hold the hexapod by the base plate.

NOTICE

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

- Mount the hexapod onto a flat surface. The recommended flatness of the surface is 300 µm.

Requirements

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

Tools and accessories

- Hex key 5.0 and six of the supplied screws (p. 13).
- Optional: two locating pins for easy alignment of the hexapod, suitable for holes with Ø 8 mm H7, not in the scope of delivery

Mounting the hexapod

1. Bore the required holes into the surface:
   - Six M6 threaded holes for mounting with M6x30 screws
   - Optional: Two locating holes with Ø 8 mm H7 for accommodating locating pins.

   The arrangement of the six mounting holes as well as the two locating holes in the base plate of the hexapod can be found in the dimensional drawing (p. 57).
2. If you use locating pins to align the hexapod:
   a) Insert the locating pins into the locating holes in the hexapod or the surface.
   b) Place the hexapod on the surface so that the locating pins are inserted into the corresponding locating holes on the other side.
3. Mount the hexapod on the six mounting holes in the base plate using the included screws.

5.5 Fixing the Load to the Hexapod

NOTICE

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

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

NOTICE

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

- When selecting the screw length, observe the thickness of the motion platform or the depth of the mounting holes (p. 57) together with the load to be mounted.
- Only use screws that do not project under the motion platform after being screwed in.
- Only mount the hexapod and the load on the mounting fixtures (holes) intended for this purpose.

Requirements

- ✓ You have read and understood the General Notes on Installation (p. 21).
- ✓ You have determined the permissible load and the workspace of the hexapod (p. 22).
- ✓ You have designed the load and the surroundings of the hexapod so that the permissible load of the hexapod is adhered to and no collisions can occur.

Tools and accessories

- Screws of suitable length. For model-dependent options, see dimensional drawing (p. 57):
  - M4 screws
  - M6 screws
  - M8 screws
- Suitable tool for tightening the screws
- Optional: Two locating pins for easy alignment of the load on the hexapod. Hole diameter depends on the model, see dimensional drawing (p. 57). Locating pins are not in the scope of delivery.

Fixing the load

1. Align the load so that the selected mounting holes in the motion platform can be used to fix it.

   If you use locating pins to align the load:

   a) Drill two locating holes into the load to accommodate the locating pins.

   b) Insert the locating pins into the locating holes in the motion platform or in the load.

   c) Place the load on the motion platform so that the locating pins are inserted into the corresponding locating holes on the other side.

   The layout of the mounting and locating holes in the motion platform of the hexapod as well as the tolerance values can be found in the dimensional drawing (p. 57).
2. Use the screws to fix the load to the selected mounting holes in the motion platform.

5.6 Optional: Removing the Coordinate Cube

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

Tools and accessories

- Hex key AF 2.0

Removing the coordinate cube

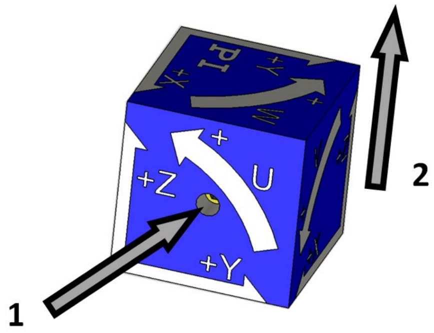


Figure 7: Removing the Coordinate Cube

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

5.7 Connecting the Hexapod to the Controller

Requirements

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

Tools and accessories

- Data transmission cable and power supply cable, available as accessories (p. 14)

Connecting the hexapod to the controller

➢ Connect the hexapod and the controller to each other:

- Pay attention to the assignment specified on the labeling of the sockets, plug connectors, and cables.
- Pay attention to the mechanical coding of connectors and sockets.
- Do not use force.

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

Standard Cabling

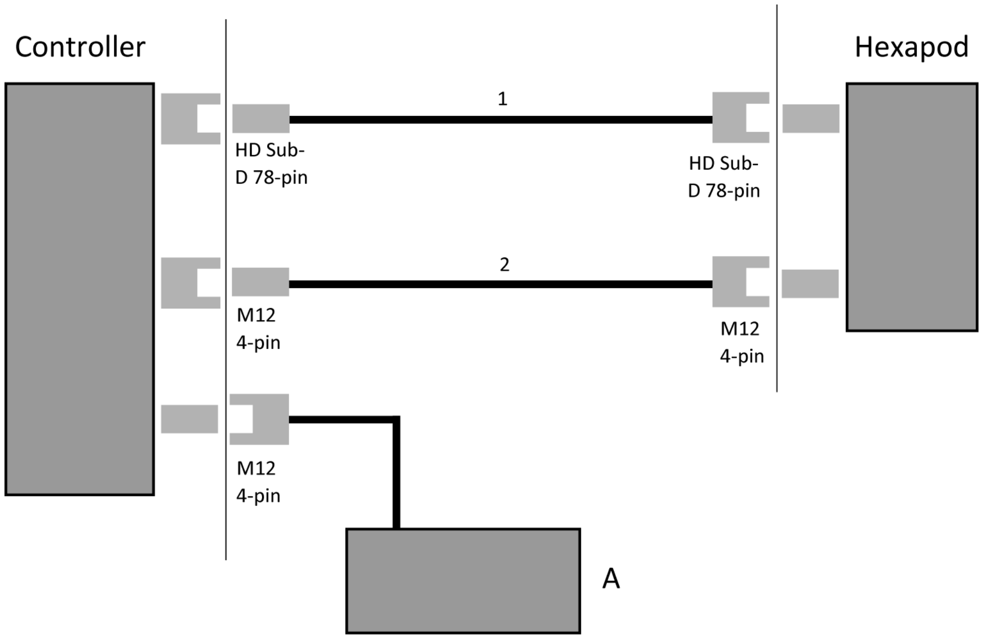


Figure 8: Connection diagram

	Panel plug / connector, male
	Socket / connector, female
Controller	Refer to "Suitable Controllers" (p. 15)
Hexapod	H-840
A	Power adapter, from the scope of delivery of the controller, 24 V DC output
1	Data transmission cable*
2	Power supply cable*

* Must be ordered separately.

6 Startup

In this Chapter

6.1 General Notes on Startup

CAUTION

Risk of crushing by moving parts!

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

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

NOTICE

Incorrect configuration of the controller!

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

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

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

NOTICE

Damage due to collisions!

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

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

NOTICE

Damage from transport safeguard that has not been removed!
Damage can occur to the hexapod if the transport safeguard (p. 17) of the hexapod has not been removed and a motion is commanded.

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

6.2 Starting Up the Hexapod System

Requirements

✓ You have read and understood the General Notes on Startup (p. 29).

✓ You have correctly installed the hexapod, i.e., you have mounted the hexapod onto a surface, fixed the load to the hexapod and connected the hexapod to the controller according to the instructions in "Installation" (p. 21).

✓ You have read and understood the user manual of the controller.

Accessories

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

Starting up the hexapod system

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

7 Maintenance

In this Chapter

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

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

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

NOTICE

Damage due to improper maintenance!
The hexapod can become misaligned as a result of improper maintenance. The specifications can change as a result (p. 47).

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

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

7.1 Performing a Maintenance Run

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

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

7.2 Cleaning the Hexapod's Pushers

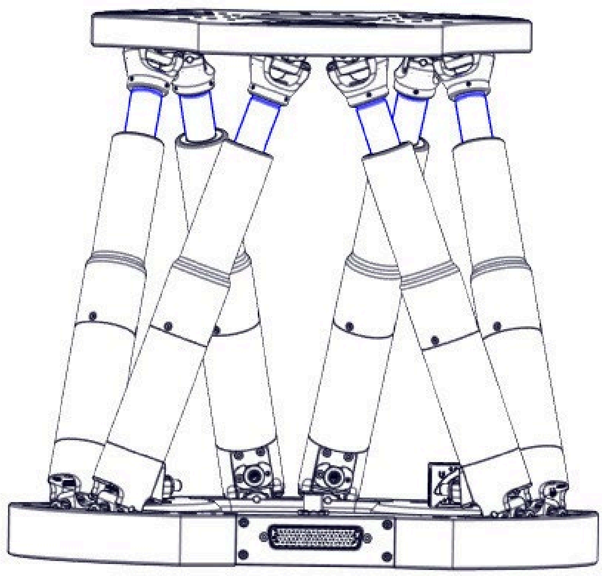


Figure 9: Position of the pushers of the H-840

Clean the pushers of the H-840 (shown in blue in the figure) after a maximum of 15 million cycles or when you can see visible contamination.

One cycle corresponds to *one* point-to-point motion (= *one* Move command = 1/2 sinus)

Preparing H-840 for cleaning

- Completely extend the struts of the hexapod by moving the H-840 to the maximum permissible z position.
- Remove the data transmission and power supply cables from the H-840.

Cleaning the pushers

- Put some isopropyl alcohol onto a lint-free cloth and use it to wipe down the pusher of the H-840.

  Carry out the cleaning along the direction of motion of the pusher so that as little radial force or torques as possible are applied to the struts.

  Make sure that no fluid gets into the struts.

7.3 Cleaning the Hexapod

Requirements

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

Cleaning the hexapod

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

7.4 Packing the Hexapod for Transport

NOTICE

Impermissible mechanical load!

An impermissible mechanical load can damage the hexapod.

➢ Only send the hexapod in the original packaging.

➢ Only hold the hexapod by the transport safeguard or the base plate.

NOTICE

Damage from applying high forces!

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

➢ If one or more struts of the hexapod are blocked, do **not** move the hexapod by hand.

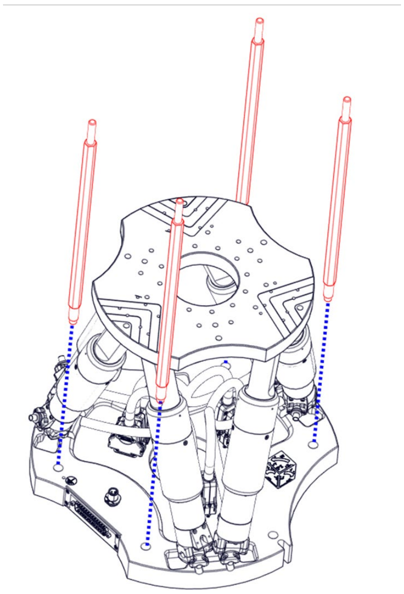
➢ If you move the hexapod by hand, do not use high forces.

Accessories

- Transport safeguard (p. 17)
- Original packaging (p. 13)
- Electrostatic dissipative film
- Strapping band
- Stretch film

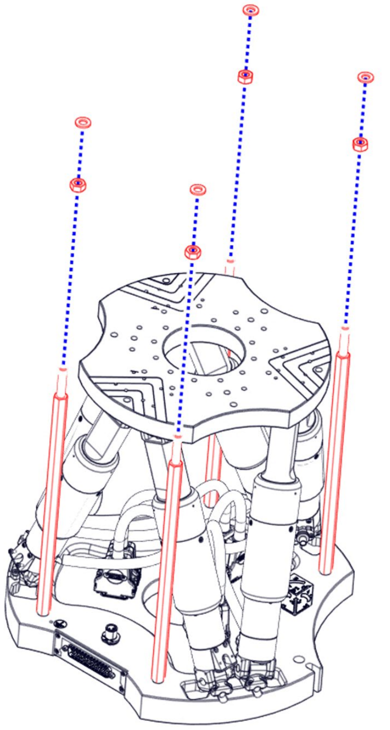
7.4.1 Attaching the Transport Safeguard

1. Command a hexapod motion to the transport position:
   X = Y = Z = U = V = W = 0
2. Uninstall the hexapod system:
   a) Remove the load from the motion platform of the hexapod.
   b) Switch the controller off.
   c) Remove the data transmission cable and the power supply cable from the controller and the hexapod.
   d) Loosen the six M6x30 screws, with which the hexapod is mounted on the underlying surface.
   e) Remove the six M6x30 screws.
3. Secure the transport safeguard:



Screw in the struts of the transport safeguard:

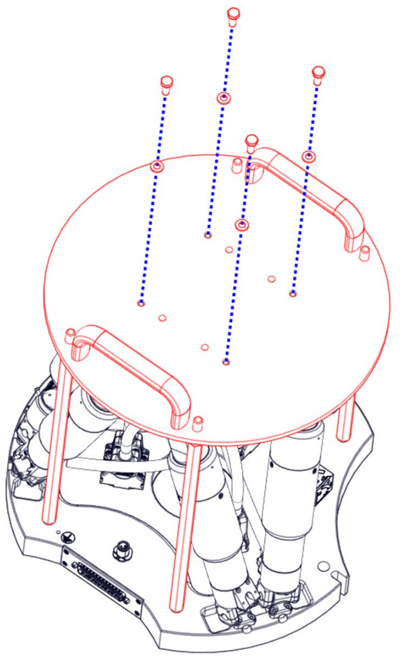
a) Screw the struts with the shorter thread into the hexapod's base plate as shown in the figure.
b) Tighten the struts by hand.



Securing nuts and flat washers:

a) Screw an M8 nut onto each strut up to the end of the thread.

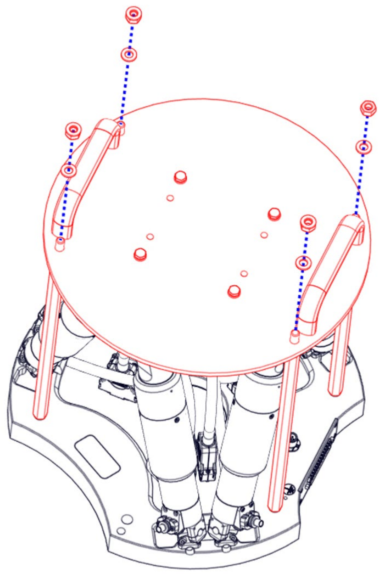
b) Put an 8.4 flat washer onto each nut.



Attaching the cover to the motion platform

a) Put the cover onto the motion platform so that the ends of the 4 struts protrude through the corresponding holes in the cover.

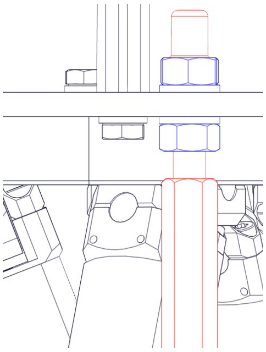
b) Attach the cover to the motion platform using the four M6x16 screws that you previously pushed a 6.4 flat washer onto.



Attaching the cover to the struts:

a) Push an 8.4 flat washer onto each strut.

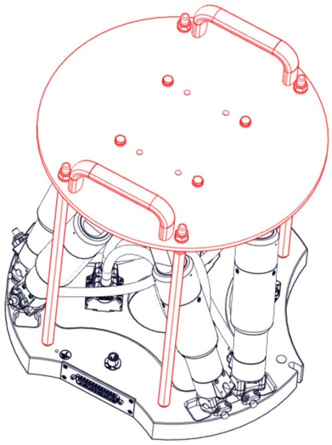
b) Screw an M8 nut onto each strut and tighten by hand.



Securing the cover with counternuts:

a) Lock each nut above and below the cover for each strut.

b) Put thread protection caps onto the strut ends.



Installation is now complete

7.4.2 Packing the Hexapod

1. Attach the transport safeguard to the hexapod. Follow the instructions (p. 34).
2. Pack the hexapod in electrostatic dissipative film to protect against dirt.
3. If necessary, prepare the original packaging, see figures:
   a) Put the outer box onto the pallet.
   b) Lay a 740 x 740 x 130 mm foam cushion into the outer box. Make sure that the recess for the inner box points upwards, while the "feet" point downwards.
   c) Insert the inner box into the outer box.
   d) If corrugated cardboard blanks are part of the original packaging: Place the blanks in the inner box.
   e) Place the foam insert for the hexapod's base plate into the inner box. Pay attention to the appropriate orientation of the insert.
4. Grip the hexapod's transport safeguard or base plate and place it into the foam insert of the inner box.

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

Step 3 a

Step 3 b

Step 3 e
The appropriate orientation of the foam insert depends on the hexapod model.

Step 5
The appropriate orientation of the foam cover depends on the hexapod model.

Step 6
Only necessary when a cushion made of folded corrugated cardboard is part of the original packaging.

Step 8

Step 9

Step 11
The upper box contains the controller.

8 Troubleshooting

Problem	Possible causes	Solution
Unexpected hexapod behavior.	▪ Defective cable ▪ Bent pin ▪ Connector or soldered joints loosened	➢ Check the data transmission and power supply cables. ➢ Replace the cables by cables of the same type and test the function of the hexapod. ➢ Contact our customer service department (p. 45).
The hexapod does not achieve the specified repeatability.	▪ Warped base plate ▪ Cover plate is warped	➢ Mount the hexapod onto a flat surface (p. 23). ➢ Only mount loads with a flat footprint surface. The recommended flatness of the surface is 300 µm.
	▪ Poor lubrication because of small movements over a long period of time.	➢ Do a maintenance run over the entire travel range (p. 31).
	▪ External disturbances	➢ Make sure that no vibrations are not transmitted to the system. ➢ Make sure that forces, e.g., also through dragged cables, do not affect the movement of the cover plate. ➢ Make sure that the system is in a thermal equilibrium.
The trajectory accuracy is poor.	▪ 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 our customer service department (p. 45).
The hexapod does not move.	▪ Foreign body has entered the drive spindle ▪ Faulty motor ▪ Sensor defective ▪ Blocked or broken joint	➢ Carry out a strut test (refer to the user manual for the controller). The strut test should be carried out in the reference position, unless the malfunction occurs with maximum or minimum displacement of the platform in Z. ➢ Contact our customer service department (p. 45).

Problem	Possible causes	Solution
	▪ Load too big	
The hexapod does not move.	▪ The mechanics is not supplied with voltage.	➢ Check the power supply cable. ➢ If applicable, check the power adapter of the mechanics. ➢ Check if power is being supplied to the hexapod with the command `DIA?` dia? 1= 1 {Hexapod powered} 2= 1 {E-stop activated} 3= +33.0 {Temperature} 4= -1 {Faulty point in waveform} or using the diagnostic information in PIMikroMove.
The hexapod does not move.	▪ The power-good check was not switched off when connecting an old hexapod (e.g., H-811.D1) to a controller with current firmware.	➢ Check if error 500 - (error 500 - "The "red knob" is still set and disables system") or 66 - Voltage out of limits has occurred. Deactivate the power-good check using parameter 0x19004000. ➢ Contact our customer service department (p. 45).
The hexapod does not move.	▪ The servo was switched off by a malfunction.	➢ Query the servo status using `SVO?`. If SVO 0 is answered, ensure that the malfunction has been corrected. Activate the servo using SVO X 1.
The hexapod does not move.	Controller with **E-Stop** socket: ▪ Nothing connected to **E-Stop** ▪ "Break contact" is active on **E-Stop** In both cases, the **24 V Out 7 A** output of the controller is disabled.	Controllers with the **E-Stop** socket support the "Motion Stop" functionality, with which the hexapod Motion can be stopped with external devices (pushbuttons, switches). ➢ Check the state of the e-stop function: `dia?` 1= 1 {Hexapod powered} 2= 1 {E-stop activated} 3= +33.0 {Temperature} 4= -1 {Faulty point in waveform} or using the diagnostic information in PIMikroMove. If you do **not** use the "Motion Stop" functionality: ➢ Make sure that the C887B0038 shorting plug from the scope of delivery of the controller is inserted in the **E-Stop** socket. If you use the "Motion Stop" functionality:

Problem	Possible causes	Solution
		1. Check your system and make sure that the hexapod can be moved safely. 2. Activate the **24 V Out 7 A** output with "Make contact" (for details, refer to the user manual for the controller). If you use the C-887.MSB motion-stop-box from PI: Press the mushroom button first to unlock it, then press the green pushbutton. 3. Switch the servo mode on for the hexapod axes. Use the SVO command or the corresponding operating elements in the PC software. Note: A new reference move is not necessary
The hexapod does not move.	▪ Incorrect or missing configuration data	➢ Send the `CST?` command. The response shows the hexapod, to which the controller is adapted. ➢ Set the correct hexapod using `DBG?` choosehexapod {type of hexapod} ➢ Send the `ERR?` command. Error code "233" in the answer indicates that the configuration data for the hexapod is missing on the controller. Contact our customer service department (p. 45) in order to receive valid configuration data.
The hexapod does not move. Error: (Position out of limit)	▪ The hexapod is outside of the permissible range of movement ▪ A reference move is not possible for hexapods with absolute-measuring sensors.	➢ Create a KSD coordinate system that does not take the Cartesian limits into consideration, and increase the struts' travel ranges to get back into a permissible range of motion: Query the current limits: SPA? 1 0x30 (neg) SPA? 1 0x15 (pos) Multiply the answer by 1.5, and later set this value as described below (for example, here 30 / -30) ksd limit z 0 ken limit spa 1 0x30 -30 2 0x30 -30 3 0x30 -30 4 0x30 -30 5 0x30 -30 6 0x30 -30 spa 1 0x15 30 2 0x15 30 3 0x15 30 4 0x15 30 5 0x15 30 6 0x15 30

Problem	Possible causes	Solution
		svo x 1 mov z -5 or mov z 5 depending on the final position of the hexapod (above or below). KEN 0 When the hexapod has moved towards the middle again, restart the system (rbt).
The hexapod does not start a reference move.	▪ The hexapod is equipped with absolute-measuring encoders.	The FRF command does not start a reference move for axes with absolute-measuring sensors but sets the target positions to the current position values.
The hexapod does not start a reference move.	▪ Motion is generally not possible.	➢ Check if one of the causes mentioned in the "Hexapod does not move" section applies to your problem.

If the problem with your hexapod is not listed in the table or cannot be solved as described, contact our customer service department (p. 45).

9 Customer Service Department

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

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

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

10 Technical Data

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

In this Chapter

10.1 Specifications

10.1.1 Data Table

H-840.X2A

Motion	H-840.D2A	H-840.G2A	Tolerance
Active axes	X, Y, Z, θX, θY, θZ	X, Y, Z, θX, θY, θZ	
Travel range in X	± 50 mm	± 50 mm	
Travel range in Y	± 50 mm	± 50 mm	
Travel range in Z	± 25 mm	± 25 mm	
Rotation range in θX	± 15 °	± 15 °	
Rotation range in θY	± 15 °	± 15 °	
Rotation range in θZ	± 30 °	± 30 °	
Maximum velocity in X	60 mm/s	2.5 mm/s	
Maximum velocity in Y	60 mm/s	2.5 mm/s	
Maximum velocity in Z	60 mm/s	2.5 mm/s	
Maximum angular velocity in θX	700 mrad/s	30 mrad/s	
Maximum angular velocity in θY	700 mrad/s	30 mrad/s	
Maximum angular velocity in θZ	700 mrad/s	30 mrad/s	
Typical velocity in X	40 mm/s	2 mm/s	
Typical velocity in Y	40 mm/s	2 mm/s	
Typical velocity in Z	40 mm/s	2 mm/s	
Typical angular velocity in θX	480 mrad/s	25 mrad/s	

Motion	H-840.D2A	H-840.G2A	Tolerance
Typical angular velocity in θY	480 mrad/s	25 mrad/s	
Typical angular velocity in θZ	480 mrad/s	25 mrad/s	
Amplitude-frequency product in X	23.6 mm·Hz		
Amplitude-frequency product in Y	23.6 mm·Hz		
Amplitude-frequency product in Z	8 mm·Hz		
Amplitude-frequency product in θX	5.1 °·Hz		
Amplitude-frequency product in θY	5.1 °·Hz		
Amplitude-frequency product in θZ	14 °·Hz		
Amplitude-frequency² product in X	65.9 mm·Hz²		
Amplitude-frequency² product in Y	65.9 mm·Hz²		
Amplitude-frequency² product in Z	22.5 mm·Hz²		
Amplitude-frequency² product in θX	14.7 °·Hz²		
Amplitude-frequency² product in θY	14.7 °·Hz²		
Amplitude-frequency² product in θZ	41 °·Hz²		
Amplitude error	10 %		max.
Phase error	60 °		max.
Maximum frequency	30 Hz		

Positioning	H-840.D2A	H-840.G2A	Tolerance
Integrated sensor	Absolute rotary encoder, multi-turn	Absolute rotary encoder, multi-turn	
Unidirectional repeatability in X	± 0.3 µm	± 0.3 µm	typ.
Unidirectional repeatability in Y	± 0.3 µm	± 0.3 µm	typ.
Unidirectional repeatability in Z	± 0.1 µm	± 0.1 µm	typ.
Unidirectional repeatability in θX	± 1.5 µrad	± 2.5 µrad	typ.
Unidirectional repeatability in θY	± 1.5 µrad	± 2.5 µrad	typ.
Unidirectional repeatability in θZ	± 3 µrad	± 3 µrad	typ.
Minimum incremental motion in X	1.5 µm	0.3 µm	typ.
Minimum incremental motion in Y	1.5 µm	0.3 µm	typ.
Minimum incremental motion in Z	1 µm	0.2 µm	typ.
Minimum incremental motion in θX	10 µrad	2 µrad	typ.
Minimum incremental motion in θY	10 µrad	2 µrad	typ.
Minimum incremental motion in θZ	2 µrad	4 µrad	typ.
Backlash in X	1.5 µm	2 µm	typ.
Backlash in Y	1.5 µm	2 µm	typ.

Positioning	H-840.D2A	H-840.G2A	Tolerance
Backlash in Z	0.2 µm	0.3 µm	typ.
Backlash in θX	4 µrad	5 µrad	typ.
Backlash in θY	4 µrad	5 µrad	typ.
Backlash in θZ	8 µrad	10 µrad	typ.

Drive properties	H-840.D2A	H-840.G2A	Tolerance
Drive type	Brushless DC motor	Brushless DC gear motor	

Mechanical properties	H-840.D2A	H-840.G2A	Tolerance
Maximum holding force, base plate in any orientation	5 N	25 N	
Maximum holding force, base plate horizontal	15 N	100 N	
Maximum load capacity, base plate in any orientation	3 kg	15 kg	
Maximum load capacity, base plate horizontal	10 kg	40 kg	
Overall mass	12 kg	12 kg	
Material	Aluminum, steel	Aluminum, steel	

Miscellaneous	H-840.D2A	H-840.G2A	Tolerance
Connector for supply voltage	M12 4-pin (m)	M12 4-pin (m)	
Recommended controllers / drivers	C-887.5xx	C-887.5xx	
Operating temperature range	-10 to 50 °C	-10 to 50 °C	
Connector for data transmission	HD D-sub 78-pin (m)	HD D-sub 78-pin (m)	

H-840.X2I

Motion	H-840.D2I	H-840.G2I	Tolerance
Active axes	X, Y, Z, θX, θY, θZ	X, Y, Z, θX, θY, θZ	
Travel range in X	± 50 mm	± 50 mm	
Travel range in Y	± 50 mm	± 50 mm	
Travel range in Z	± 25 mm	± 25 mm	
Rotation range in θX	± 15 °	± 15 °	
Rotation range in θY	± 15 °	± 15 °	

Motion	H-840.D2I	H-840.G2I	Tolerance
Rotation range in θZ	± 30 °	± 30 °	
Maximum velocity in X	60 mm/s	2.5 mm/s	
Maximum velocity in Y	60 mm/s	2.5 mm/s	
Maximum velocity in Z	60 mm/s	2.5 mm/s	
Maximum angular velocity in θX	700 mrad/s	30 mrad/s	
Maximum angular velocity in θY	700 mrad/s	30 mrad/s	
Maximum angular velocity in θZ	700 mrad/s	30 mrad/s	
Typical velocity in X	40 mm/s	2 mm/s	
Typical velocity in Y	40 mm/s	2 mm/s	
Typical velocity in Z	40 mm/s	2 mm/s	
Typical angular velocity in θX	480 mrad/s	25 mrad/s	
Typical angular velocity in θY	480 mrad/s	25 mrad/s	
Typical angular velocity in θZ	480 mrad/s	25 mrad/s	
Amplitude-frequency product in X	23.6 mm·Hz		
Amplitude-frequency product in Y	23.6 mm·Hz		
Amplitude-frequency product in Z	8 mm·Hz		
Amplitude-frequency product in θX	5.1 °·Hz		
Amplitude-frequency product in θY	5.1 °·Hz		
Amplitude-frequency product in θZ	14 °·Hz		
Amplitude-frequency^2 product in X	65.9 mm·Hz^2		
Amplitude-frequency^2 product in Y	65.9 mm·Hz^2		
Amplitude-frequency^2 product in Z	22.5 mm·Hz^2		
Amplitude-frequency^2 product in θX	14.7 °·Hz^2		
Amplitude-frequency^2 product in θY	14.7 °·Hz^2		
Amplitude-frequency^2 product in θZ	41 °·Hz^2		
Amplitude error	10 %		max.
Phase error	60 °		max.
Maximum frequency	30 Hz		

Positioning	H-840.D2I	H-840.G2I	Tolerance
Integrated sensor	Incremental rotary encoder	Incremental rotary encoder	
Unidirectional repeatability in X	± 0.3 µm	± 0.3 µm	typ.
Unidirectional repeatability in Y	± 0.3 µm	± 0.3 µm	typ.
Unidirectional repeatability in Z	± 0.1 µm	± 0.1 µm	typ.
Unidirectional repeatability in θX	± 1.5 µrad	± 2.5 µrad	typ.

Positioning	H-840.D2I	H-840.G2I	Tolerance
Unidirectional repeatability in θY	± 1.5 µrad	± 2.5 µrad	typ.
Unidirectional repeatability in θZ	± 3 µrad	± 3 µrad	typ.
Minimum incremental motion in X	0.5 µm	0.25 µm	typ.
Minimum incremental motion in Y	0.5 µm	0.25 µm	typ.
Minimum incremental motion in Z	0.25 µm	0.15 µm	typ.
Minimum incremental motion in θX	3 µrad	2 µrad	typ.
Minimum incremental motion in θY	3 µrad	2 µrad	typ.
Minimum incremental motion in θZ	5 µrad	4 µrad	typ.
Backlash in X	1.5 µm	2 µm	typ.
Backlash in Y	1.5 µm	2 µm	typ.
Backlash in Z	0.25 µm	0.3 µm	typ.
Backlash in θX	4 µrad	5 µrad	typ.
Backlash in θY	4 µrad	5 µrad	typ.
Backlash in θZ	8 µrad	10 µrad	typ.

Drive properties	H-840.D2I	H-840.G2I	Tolerance
Drive type	Brushless DC motor	Brushless DC gear motor	

Mechanical properties	H-840.D2I	H-840.G2I	Tolerance
Maximum holding force, base plate in any orientation	5 N	25 N	
Maximum holding force, base plate horizontal	15 N	100 N	
Maximum load capacity, base plate in any orientation	3 kg	15 kg	
Maximum load capacity, base plate horizontal	10 kg	40 kg	
Overall mass	12 kg	12 kg	
Material	Aluminum, steel	Aluminum, steel	

Miscellaneous	H-840.D2I	H-840.G2I	Tolerance
Connector for supply voltage	M12 4-pin (m)	M12 4-pin (m)	
Recommended controllers / drivers	C-887.5xx	C-887.5xx	
Operating temperature range	-10 to 50 °C	-10 to 50 °C	
Connector for data transmission	HD D-sub 78-pin (m)	HD D-sub 78-pin (m)	

H-840.G2IHP

Motion	H-840.G2IHP	Tolerance
Active axes	X, Y, Z, θX, θY, θZ	
Travel range in X	± 50 mm	
Travel range in Y	± 50 mm	
Travel range in Z	± 25 mm	
Rotation range in θX	± 15 °	
Rotation range in θY	± 15 °	
Rotation range in θZ	± 30 °	
Maximum velocity in X	2.5 mm/s	
Maximum velocity in Y	2.5 mm/s	
Maximum velocity in Z	2.5 mm/s	
Maximum angular velocity in θX	30 mrad/s	
Maximum angular velocity in θY	30 mrad/s	
Maximum angular velocity in θZ	30 mrad/s	
Typical velocity in X	2 mm/s	
Typical velocity in Y	2 mm/s	
Typical velocity in Z	2 mm/s	
Typical angular velocity in θX	25 mrad/s	
Typical angular velocity in θY	25 mrad/s	
Typical angular velocity in θZ	25 mrad/s	

Positioning	H-840.G2IHP	Tolerance
Integrated sensor	Incremental rotary encoder	
Unidirectional repeatability in X	± 0.3 µm	typ.
Unidirectional repeatability in Y	± 0.3 µm	typ.
Unidirectional repeatability in Z	± 0.1 µm	typ.
Unidirectional repeatability in θX	± 2.5 µrad	typ.
Unidirectional repeatability in θY	± 2.5 µrad	typ.
Unidirectional repeatability in θZ	± 3 µrad	typ.
Minimum incremental motion in X	0.04 µm	typ.
Minimum incremental motion in Y	0.04 µm	typ.
Minimum incremental motion in Z	0.02 µm	typ.
Minimum incremental motion in θX	0.2 µrad	typ.
Minimum incremental motion in θY	0.2 µrad	typ.
Minimum incremental motion in θZ	0.4 µrad	typ.
Backlash in X	2 µm	typ.

Positioning	H-840.G2IHP	Tolerance
Backlash in Y	2 µm	typ.
Backlash in Z	0.3 µm	typ.
Backlash in θX	5 µrad	typ.
Backlash in θY	5 µrad	typ.
Backlash in θZ	10 µrad	typ.

Drive properties	H-840.G2IHP	Tolerance
Drive type	Brushless DC gear motor	
Nominal voltage	24 V	

Mechanical properties	H-840.G2IHP	Tolerance
Maximum holding force, base plate in any orientation	25 N	
Maximum holding force, base plate horizontal	100 N	
Maximum load capacity, base plate in any orientation	15 kg	
Maximum load capacity, base plate horizontal	40 kg	
Overall mass	12 kg	
Material	Aluminum/steel	

Miscellaneous	H-840.G2IHP	Tolerance
Connector for supply voltage	M12 4-pin (m)	
Recommended controllers / drivers	C-887.5xx	
Operating temperature range	-10 to 50 °C	
Connector for data transmission	HD D-sub 78-pin (m)	

Technical data specified at 22±3 °C.

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 used, or when the pivot point is set to 0/0/0.

Connecting cables are not in the scope of delivery and must be ordered separately.

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	

10.1.3 Specifications for Data Transmission and Power Supply Cables

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

Data Transmission and Power Supply Cables

Data transmission cable	Power supply cable, single-side angled connector	Power supply cable, straight connectors
Alle Hexapodtypen	H-820, H-824, H-825, H-840, H-850	H-810, H-811, H-206
C-815.82D02	C-815.82P02A	C-815.82P02E
C-815.82D03	C-815.82P03A	C-815.82P03E
C-815.82D05	C-815.82P05A	C-815.82P05E
C-815.82D07	C-815.82P07A	C-815.82P07E
C-815.82D10	C-815.82P10A	C-815.82P10E
C-815.82D20	C-815.82P20A	C-815.82P20E

The models differ with respect to the following features:

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

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

Character following the C-815.82	Meaning	Possible values
First character	Cable type	D – Data transmission cable P – Power supply cable
Second character	Length	02 – 2 m 03 – 3 m

Character following the C-815.82	Meaning	Possible values
		05 – 5 m 07 – 7.5 m 10 – 10 m 20 – 20 m
Third character	Connector type (power supply cable only)	A – Angled connector E – Straight connector

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

Power supply cable, straight connectors		Unit
Minimum bending radius in a drag chain	49	mm
Minimum bending radius with the fixed installation	25	mm
Outer diameter	4.9	mm
Connectors	M12 m/f	

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

Data transmission cable		Unit
Minimum bending radius in a drag chain	107	mm
Minimum bending radius with the fixed installation	81	mm

Data transmission cable		Unit
Outer diameter	10.7	mm
Connectors	HD D-sub 78 m/f	

10.2 Ambient Conditions and Classifications

Degree of pollution	2
Air pressure	1100 hPa to 780 hPa
Transport temperature	–25 °C to +85 °C
Storage temperature	0 °C to 70 °C
Humidity	Highest relative humidity of 80% at temperatures of up to 31°C, decreasing linearly to a relative humidity of 50% at 40°C
Degree of protection according to IEC 60529	IP20
Area of application	For indoor use only
Maximum altitude	2000 m

10.3 Dimensions

Dimensions in mm. Note that a comma is used in the drawings instead of a decimal point.

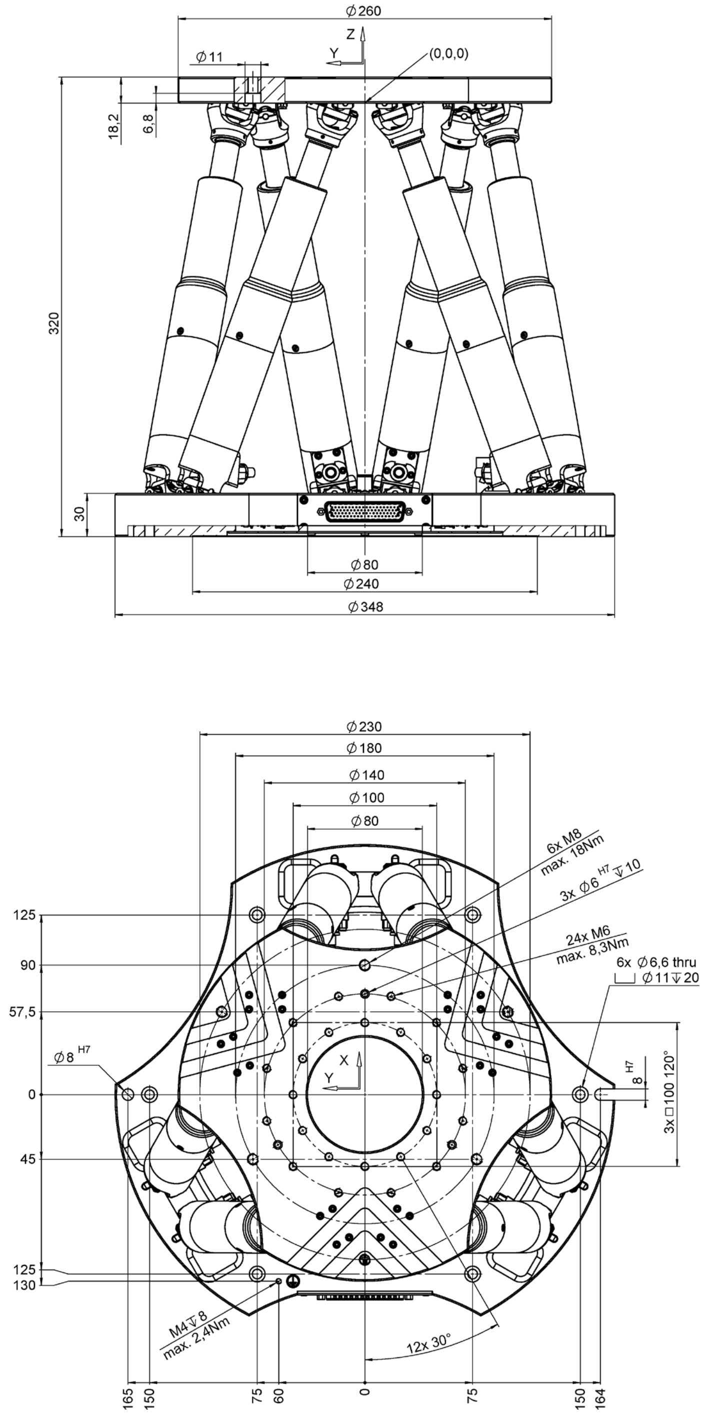


Figure 10: H-840.G2A, .G2I, .D2A, .D2I hexapod models, at zero position of nominal travel range

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

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

10.4 Dynamic Operational Area of the H-840

Die Diagramme kennzeichnen den dynamischen Arbeitsbereich des H-840.D2x. Dabei gelten die folgenden Voraussetzungen:

- Eine kompakte Last wird zentrisch montiert.
- Die Grundpatte des Hexapoden befindet sich in der horizontalen Montagestellung.
- Es wird immer eine einachsige Bewegung beschrieben.

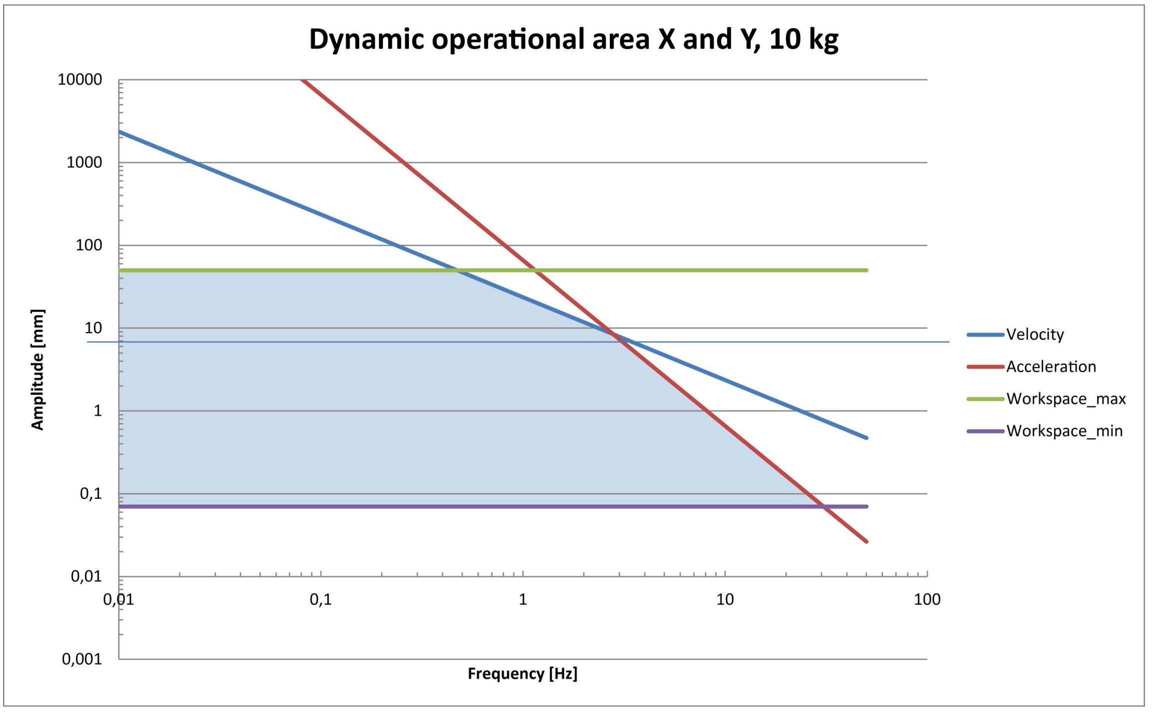


Figure 11: Dynamic working range of the H-840.D2x, X and Y, 10 kg

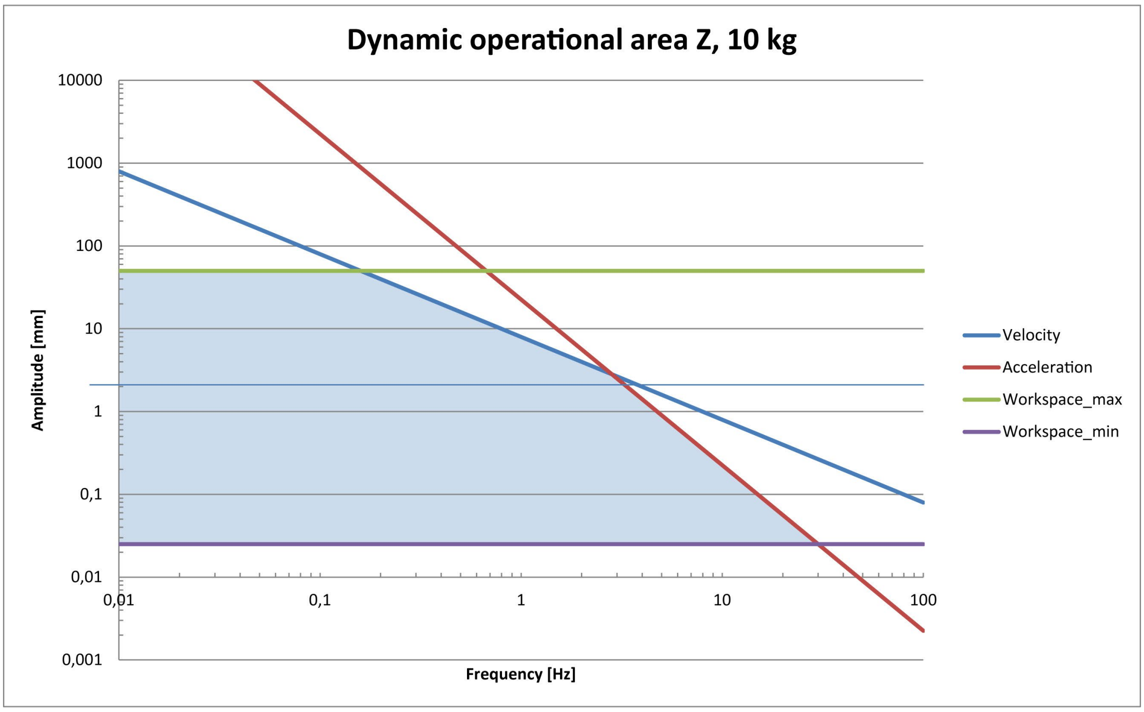


Figure 12: Dynamic working range of the H-840.D2x, Z, 10 kg

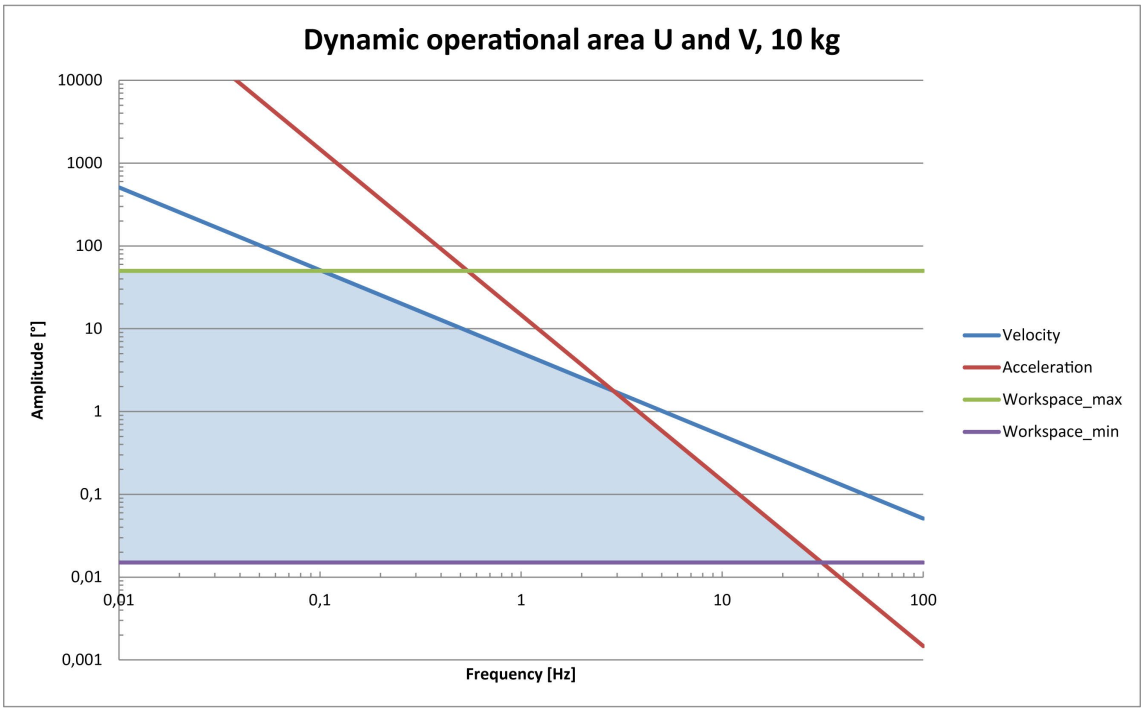


Figure 13: Dynamic working range of the H-840.D2x, U and V, 10 kg

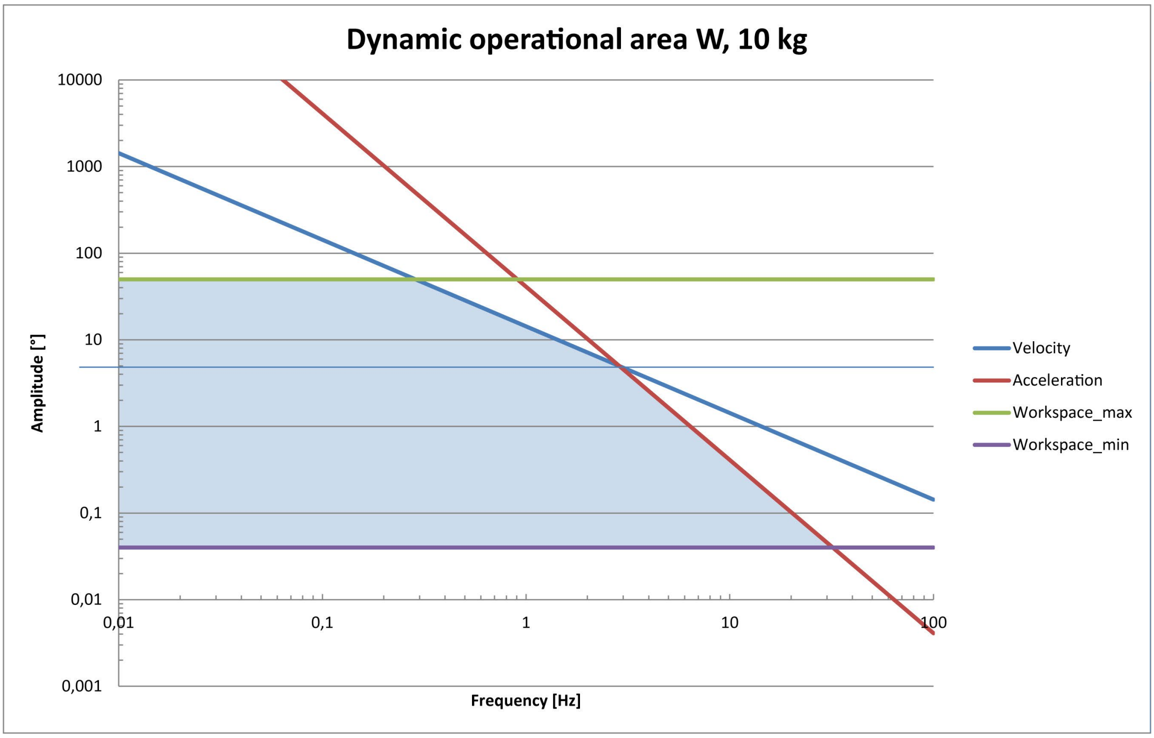
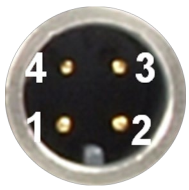


Figure 14: Dynamic working range of the H-840.D2x, W, 10 kg

10.5 Pin Assignment

10.5.1 Power Supply Connection

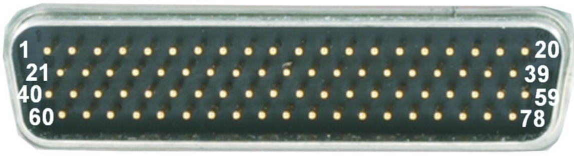
Power supply via 4-pin M12 panel plug

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

10.5.2 Data Transmission Connection

Data transmission between hexapod and controller

panel plug HD Sub-D 78 m

Function	
All signals: TTL	

Pin Assignment

Pin	Pin	Signal
1		CH1 Sign IN
	21	CH1 Ref OUT
2		nc
	22	CH1 A+ OUT
3		CH1 A- OUT
	23	GND
4		CH2 Sign IN
	24	CH2 Ref OUT
5		nc
	25	CH2 A+ OUT
6		CH2 A- OUT
	26	GND
7		CH3 Sign IN
	27	CH3 Ref OUT
8		nc
	28	CH3 A+ OUT
9		CH3 A- OUT
	29	GND
10		CH4 Sign IN
	30	CH4 Ref OUT
11		nc

Pin	Pin	Signal
40		CH1 MAGN IN
	60	CH1 LimP OUT
41		CH1 LimN OUT
	61	CH1 B+ OUT
42		CH1 B- OUT
	62	GND
43		CH2 MAGN IN
	63	CH2 LimP OUT
44		CH2 LimN OUT
	64	CH2 B+ OUT
45		CH2 B- OUT
	65	GND
46		CH3 MAGN IN
	66	CH3 LimP OUT
47		CH3 LimN OUT
	67	CH3 B+ OUT
48		CH3 B- OUT
	68	GND
49		CH4 MAGN IN
	69	CH4 LimP OUT
50		CH4 LimN OUT

Pin	Pin	Signal
	31	CH4 A+ OUT
12		CH4 A- OUT
	32	GND
13		CH5 Sign IN
	33	CH5 Ref OUT
14		nc
	34	CH5 A+ OUT
15		CH5 A- OUT
	35	GND
16		CH6 Sign IN
	36	CH6 Ref OUT
17		nc
	37	CH6 A+ OUT
18		CH6 A- OUT
	38	GND
19		ID Chip
	39	GND
20		24 V input

Pin	Pin	Signal
	70	CH4 B+ OUT
51		CH4 B- OUT
	71	GND
52		CH5 MAGN IN
	72	CH5 LimP OUT
53		CH5 LimN OUT
	73	CH5 B+ OUT
54		CH5 B- OUT
	74	GND
55		CH6 MAGN IN
	75	CH6 LimP OUT
56		CH6 LimN OUT
	76	CH6 B+ OUT
57		CH6 B- OUT
	77	GND
58		Brake/Enable drive
	78	GND
59		Power Good 24 V output

11 Old Equipment Disposal

In accordance with EU law, electrical and electronic equipment may not be disposed of in EU member states via the municipal residual waste.

Dispose of your old equipment according to international, national, and local rules and regulations.

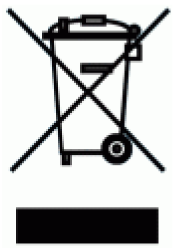
To fulfill the responsibility as the product manufacturer, Physik Instrumente (PI) GmbH & Co. KG undertakes environmentally correct disposal of all old PI equipment made available on the market after 13 August 2005 without charge.

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

Physik Instrumente (PI) GmbH & Co. KG

Auf der Roemerstrasse 1

76228 Karlsruhe, Germany



12 Glossary

User-defined coordinate system

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

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

Workspace

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

The workspace can be limited by the following external factors:

- Installation space
- Dimensions and position of the load

Center of rotation

The center of rotation describes the intersection of the rotational axes U, V, and W. When the default settings for the coordinate system and the center of rotation are used, the center of rotation after a reference move is located at the origin of the coordinate system (0,0,0), see the dimensional drawing of the hexapod (p. 57).

The center of rotation always moves together with the platform.

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

Hexapod system

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

Default coordinate system

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

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

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

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

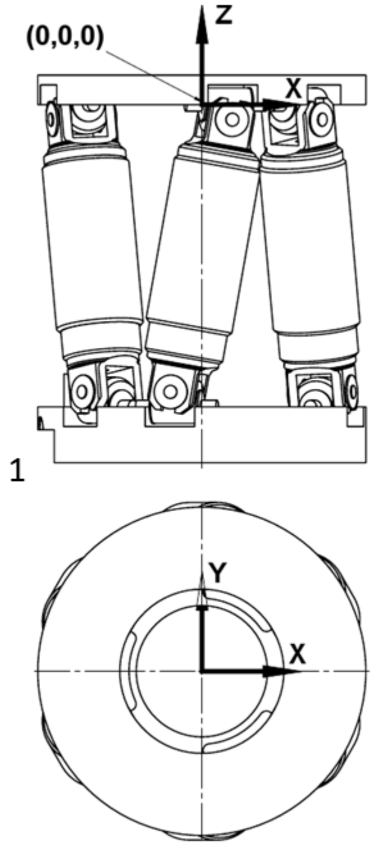


Figure 15: H-810 hexapod in the reference position.

1 Cable exit

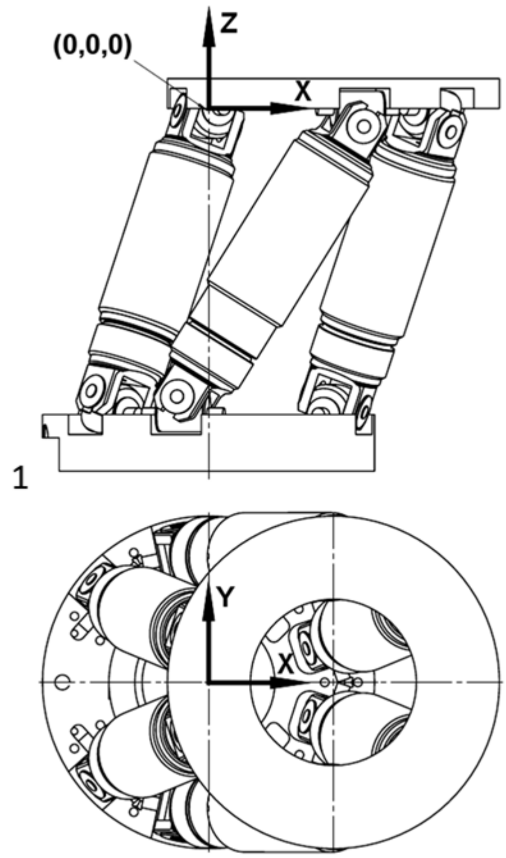


Figure 16: H-810 hexapod, the platform of which has been moved in X.

1 Cable exit

13 Appendix

In this Chapter

13.1 Explanations of the Performance Test Sheet

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

The following figure shows the test setup used.

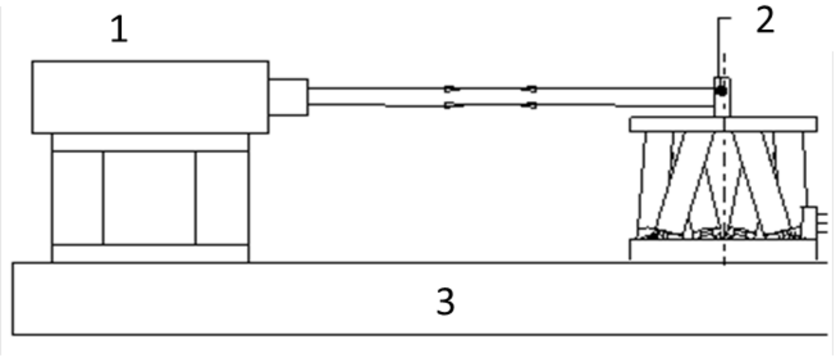


Figure 17: Test setup for measuring the X or Y axis.

1 Laser interferometer
2 Mirror
3 Bench

The following test cycles are performed:

- Motion over the entire travel range with at least 20 measuring points, in at least five cycles.
- Motion over partial sections, e.g., ±1 mm in increments of for example, 100 µm

13.2 European Declarations of Conformity

For the H-840, declarations of conformity were issued according to the following European statutory requirements:

EMC Directive

RoHS Directive

The standards applied for certifying conformity are listed below.

EMC: EN 61326-1

Safety: EN 61010-1

RoHS: EN IEC 63000

13.3 CIPA Certificate

The models H-840.D2x have been from the Camera & Imaging Products Association (CIPA) was certified as vibration equipment according to the CIPA DC-011 Measurement and Description Method for Image Stabilization Performance of Digital Camera (Optical System) standard.

Certificate of Registration of Vibratory Apparatus

This Certificate of Registration of Vibratory Apparatus is provided by the Camera & Imaging Products Association (CIPA), a general incorporated association registered under the laws of Japan and having its principal office at MA Shibaura Build., 3-8-10, Manato-ku, Tokyo 108-0023, Japan.

Issued to

Company Name:	Image Engineering GmbH & Co. KG
Company Address:	Augustinusstr. 9D, 50676 Köln, Germany
Name of Contact:	Philipp Feldker (R&D Engineer)
Access ID of Contact:	UXqll9
Date Issued:	July 28, 2015

This is to certify that the below apparatus has been registered with CIPA as a vibratory apparatus following the submission of measurement data conforming with CIPA DC-011 Measurement and Description Method for Image Stabilization Performance of Digital Cameras (Optical System).

Product

Registration Number: BLR-VA-2015-030

☑ *Developed In-House* ☐ *Purchased Certified Apparatus*

Apparatus Name and Model Number: Physik Instrumente GmbH & Co. KG
6-Axis Hexapod
Motion: H-840 Controller: C-887
(Max.: 6000g, Min.: 0g, Case: C)

N.B. This certificate of registration is not a guarantee of the accuracy of the measurement data.

Masashi Ogawa, Secretary General,
Camera & Imaging Products Association