MS222E

H-845 Hexapod System

User Manual

Version: 2.1.1 Date: 17.09.2019

This document describes the following products:

- **H-845.D11**
  Heavy-duty hexapod for 1000 kg load, travel ranges ±110 mm (X, Y), ±50 mm (Z), max. velocity 20 mm/s, with controller
- **H-845.D21**
  Heavy-duty hexapod for 1000 kg load, travel ranges ±170 mm (X, Y), ±105 mm (Z), max. velocity 20 mm/s, with controller
- **H-845.D31**
  Heavy-duty hexapod for 500 kg load, travel ranges ±110 mm (X, Y), ±50 mm (Z), max. velocity 40 mm/s, with controller
- **H-845.D41**
  Heavy-duty hexapod for 500 kg load, travel ranges ±170 mm (X, Y), ±105 mm (Z), max. velocity 40 mm/s, with controller
- **H-845.D51**
  Heavy-duty hexapod for 400 kg load, travel ranges ±110 mm (X, Y), ±50 mm (Z), max. velocity 50 mm/s, with controller
- **H-845.D61**
  Heavy-duty hexapod for 400 kg load, travel ranges ±170 mm (X, Y), ±105 mm (Z), max. velocity 50 mm/s, with controller

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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 This manual is superseded by any new release.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 Goal and Target Audience of this Manual

This manual contains information on the intended use of H-845 hexapod systems. It provides information about the following items:

- H845B00xx hexapod mechanics
- H845B0021 hexapod controller
- M850B0448 power supply
- Cabling

Further information on the hexapod system can be found in the documentation listed in “Other Applicable Documents” (p. 3).

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

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

1.2 Symbols and Typographic Conventions

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

CAUTION

Dangerous situation

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

➢ Actions to take to avoid the situation.

NOTICE

Dangerous situation

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

➢ Actions to take to avoid the situation.

INFORMATION

Information for easier handling, tricks, tips, etc.

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

1.3 Other Applicable Documents

Device/program	Document no.	Document content
C-887.5xx controller	MS247EK	Short instructions for hexapod systems
	MS244E	User manual
	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.

1.4 Downloading Manuals

INFORMATION

If a manual is missing or problems occur with downloading:

➢ Contact our customer service department (p. 57).

INFORMATION

For products that are supplied with software (CD in the scope of delivery), access to the manuals is protected by a password. Protected content is only displayed on the website after entering the access data.

You need the product CD to get the access data.

For products with CD: Get access data

1. Insert the product CD into the PC drive.
2. Switch to the Manuals directory on the CD.
3. In the Manuals directory, open the Release News (file including ***releasenews*** in the file name).

4. Get the access data for downloading protected content in the "User login for software download" section of the Release News. Possible methods for getting the access data:
   - Link to a page for registering and requesting the access data
   - User name and password is specified
5. If the access data needs to be requested via a registration page:
   a) Follow the link in the Release News.
   b) Enter the required information in the browser window.
   c) Click ***Show login data*** in the browser window.
   d) Note the user name and password shown in the browser window.

Downloading manuals

If you have requested access data for protected contents via a registration page (see above):

➢ Click the links in the browser window to change to the content for your product and log in using the access data that you received.

General procedure:

1. Open the website www.pi.ws.
2. If access to the manuals is protected by a password:
   a) Click ***Login***.
   b) Log in with the user name and password.
3. Click ***Search***.
4. Enter the product number up to the period (e.g., C-887) into the search field.
5. Click ***Start search*** or press the Enter key.
6. Open the corresponding product detail page in the list of search results:
   a) If necessary: Scroll down the list.
   b) If necessary: Click ***Load more results*** at the bottom of the list.
   c) Click the corresponding product in the list.
7. Click the ***Downloads*** tab.

   The manuals are shown under ***Documentation***.
8. Click the desired manual and save it to the hard disk of your PC or to a data storage medium.

2 Safety

In this Chapter

2.1 Intended Use

The 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 is part of a hexapod system. The intended use of the hexapod is only possible in conjunction with the hexapod controller, which is part of the hexapod system and coordinates all motion of the hexapod, and the hexapod power supply.

2.2 General Safety Instructions

The H-845 hexapod system is built according to state-of-the-art technology and recognized safety standards. Improper use can result in personal injury and/or damage to the hexapod system.

- Only use the hexapod system for its intended purpose, and only use it if it is in a good working order.
- Read the user manuals.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for the correct installation and operation of the hexapod system.

2.2.1 Organizational Measures

User manual

- Always keep this user manual next to the hexapod system.
  If the user manual is lost or damaged, contact our customer service department (p. 57).
- Add all information given by the manufacturer to the user manual, for example supplements or technical notes.
- If you give the hexapod system to other users, also include this user manual as well as other relevant information provided by the manufacturer.
- Only use the hexapod system on the basis of the complete user manual. Missing information due to an incomplete user manual can result in minor injury and damage to equipment.
- Only install and operate the hexapod system after you have read and understood this user manual.

Personnel qualification

The hexapod system may only be installed, started up, operated, maintained, and cleaned by authorized and appropriately qualified personnel.

2.2.2 Safety Measures during Transport

There is a risk of injuries caused by crushing since the hexapod is very heavy and capable of exerting high forces.

- Keep any part of your body away from areas where they can get caught by the hexapod.

An impermissible mechanical load can damage the hexapod.

- Only send the hexapod in the original packaging.
- Only transport the hexapod using a crane. The crane must lift the hexapod by 3 ring bolts and shackles affixed to the motion platform of the hexapod (p. 27).

2.2.3 Safety Measures during Installation

Depending on the tilting angle of the surface to which the hexapod is to be mounted, the hexapod can slip, tilt or fall from the surface. There is a risk of injuries if parts of your body get caught be the hexapod, and the hexapod can be damaged.

- Position the surface where the hexapod is to be mounted horizontally.

During positioning the hexapod on a surface there is a risk of minor injuries due to the mass of the hexapod.

- When you hold the hexapod by the base plate to position it on a surface: Ensure that your hands remain in a position where they cannot be squeezed.

If the surface where the hexapod is to be mounted cannot be positioned horizontally:

- Keep any part of your body away from areas where they can get caught by the hexapod.
- Disconnect the hexapod from the crane only when the base plate of the hexapod is securely affixed to the surface.

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

- Only lift and align the hexapod using a crane. The crane must lift the hexapod by 3 ring bolts and shackles affixed to the motion platform of the hexapod (p. 27).
- Do **not** hold the hexapod by its struts to position it on a surface.
- Before installing the load, determine the limit value for the load of the hexapod with a simulation program (p. 35).
- Before installing the load, determine the workspace of the hexapod with a simulation program (p. 35).
- Make sure that the installed load observes the limit value determined with the simulation program.
- Avoid high forces and torques on the motion platform during installation of the hexapod and the load.
- When the hexapod is mounted on a tilted surface:
  - Verify that the hexapod is lifted by the crane without the hexapod slipping from the tilted surface in a sudden motion.
  - Verify that the chain of the crane remains under slight tension. If the tension is too strong, impermissible forces can be exerted on the hexapod.
- Ensure an uninterruptible power supply in order to prevent an unintentional deactivation of the hexapod system.
- Make sure that no collisions between the hexapod, the load to be moved and the surroundings are possible in the workspace of the hexapod.
- Never cover any ventilation openings as this will impede ventilation.

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

- Mount the hexapod on an even surface. The recommended evenness of the surface is 100 µm.

The hexapod can be damaged by excessively long screws.

- When selecting the screw length, observe the thickness of the motion platform (p. 64) or the depth of the mounting holes 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 a load on the mounting fixtures (holes) intended for this purpose.

The M850B0448 power supply can be damaged due to disturbed heat dissipation.

- Install the power supply only with its bottom side (equipped with rubber feet) facing downwards.
- Place the power supply in a location with adequate ventilation to prevent internal heat build-up.
- Allow at least 15 cm clearance from the front and the rear of the unit and 1 cm from the bottom (ensured by the feet of the chassis).

2.2.4 Safety Measures during Start-Up

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

- Keep any part of your body away from areas where they can get caught by moving parts.

The geometrical data used by the hexapod controller must be adapted to the hexapod. If incorrect geometrical data is used, the hexapod can be damaged by uncontrolled motions or collisions. The geometrical data is adapted before delivery.

- Check whether the hexapod controller matches the hexapod.
  A label on the rear panel of the controller indicates for which hexapod the controller is intended.
- Use the CST? command to query for the active hexapod geometry file (see documentation of the hexapod controller). Thus you can check if the label on the rear panel is still correct.
- Only operate the hexapod with a hexapod controller whose geometrical data is adapted to the hexapod.

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 get caught by moving parts.
- Immediately stop the motion if a malfunction occurs in the hexapod controller (see user manual of the hexapod controller).

2.2.5 Safety Measures during Maintenance

The hexapod can become misaligned as a result of improper maintenance. The specifications (p. 59) can change as a result.

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

3 Product Description

In this Chapter

3.1 Features and Applications

The various models (p. 12) of the H-845 hexapod that are offered differ with respect to the 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 the hexapod controller, which is delivered with the hexapod. The position commands to the hexapod controller are entered as Cartesian coordinates.

3.2 Model Overview

Model	Designation
H-845.D11	Heavy-duty hexapod for 1000 kg load, travel ranges ±110 mm (X, Y), ±50 mm (Z), max. velocity 20 mm/s. Cable set 9 m, with 6-DOF controller for hexapods, TCP/IP and RS-232 interface
H-845.D21	Heavy-duty hexapod for 1000 kg load, travel ranges ±170 mm (X, Y), ±105 mm (Z), max. velocity 20 mm/s. Cable set 9 m, with 6-DOF controller for hexapods, TCP/IP and RS-232 interface
H-845.D31	Heavy-duty hexapod for 500 kg load, travel ranges ±110 mm (X, Y), ±50 mm (Z), max. velocity 40 mm/s. Cable set 9 m, with 6-DOF controller for hexapods, TCP/IP and RS-232 interface
H-845.D41	Heavy-duty hexapod for 500 kg load, travel ranges ±170 mm (X, Y), ±105 mm (Z), max. velocity 40 mm/s. Cable set 9 m, with 6-DOF controller for hexapods, TCP/IP and RS-232 interface
H-845.D51	Heavy-duty hexapod for 400 kg load, travel ranges ±110 mm (X, Y), ±50 mm (Z), max. velocity 50 mm/s. Cable set 9 m, with 6-DOF controller for hexapods, TCP/IP and RS-232 interface
H-845.D61	Heavy-duty hexapod for 400 kg load, travel ranges ±170 mm (X, Y), ±105 mm (Z), max. velocity 50 mm/s. Cable set 9 m, with 6-DOF controller for hexapods, TCP/IP and RS-232 interface

3.3 Product View

3.3.1 Hexapod

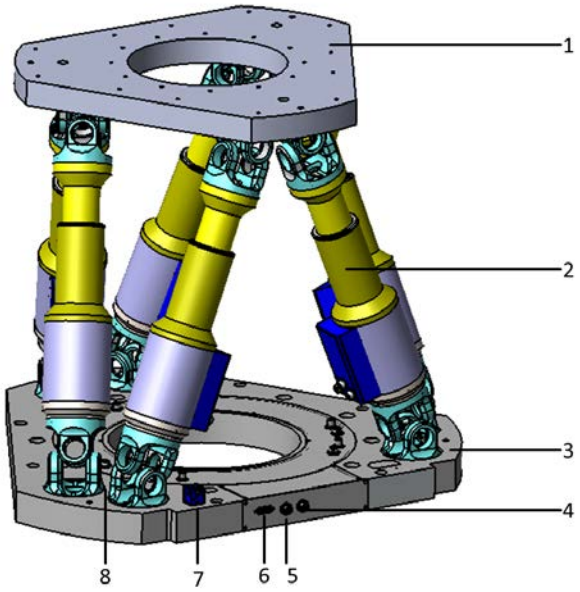


Figure 1: Hexapod

1 Motion platform
2 Strut
3 Base plate
4 Socket for data transmission cable (Controller Out)
5 Socket for data transmission cable (Controller In)
6 Panel plug for power supply cable (24 VDC)
7 Coordinate cube
8 "Risk of crushing" warning sign

Figure 2: Connections at hexapod base plate

3.3.2 Hexapod Controller

Figure 3: Front view of the hexapod controller

Element	Labeling	Type	Function
	**I/O**	HD Sub-D 26 (f) (p. 69)	Digital inputs/outputs: ▪ Outputs: Trigger external devices ▪ Inputs: Use in macros Analog inputs (multifunctional)
	**SPI Master**	Display port	For future use; currently no function.
		USB type A, high insertion and pulling force	USB interface for connecting the C-887.MC control unit from PI
		USB type A	USB interface for connecting peripheral devices
		RJ45 socket	Network connection via TCP/IP
	**SPI Slave**	Display port	For future use; currently no function.
	**RS-232**	Sub-D 9 (m)	Serial connection to PC
	**ERR**	LED red	Error indicator: ▪ Lights up continuously: Error (error code ≠ 0) ▪ Off: No error (error code = 0) The error code can be queried with the ERR? command. The query resets the error code to zero and the LED is switched off.

Element	Labeling	Type	Function
	**PWR**	LED green	Power: ▪ Lights up continuously: Booting the firmware is complete and the controller is ready for normal operation. ▪ Off: The controller is switched off or the firmware is booting.
	**STA**	LED green	State: ▪ Lights up continuously: Booting the firmware is complete and the controller is ready for normal operation. ▪ Off: The controller is switched off or the firmware is booting.
	**MAC**	LED green/red	Macro: ▪ Lights up green: Macro is running ▪ Lights up red: Macro error The error code can be queried with the `MAC ERR?` command. The query resets the error code to zero and the LED is switched off. ▪ Off: No macro is running and no macro error is present.
	**Hexapod**	HD Sub-D 78 (f)	Without function
	**24 V Out 7 A**	4-pin M12 socket (f)	Not to be used
	**24 V In 8 A**	4-pin M12 panel plug (m) (p. 70)	Connector for the supply voltage of the controller

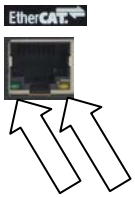
Element	Labeling	Type	Function
	**EtherCAT Port 1**	RJ45 socket with green LED and yellow LED	Connection for data transmission between hexapod (= EtherCAT slave) and controller (= EtherCAT master) Green LED: ▪ Lights up continuously: EtherCAT connection is established ▪ Off: No EtherCAT connection Yellow LED: ▪ Flickers: The EtherCAT master is sending/receiving Ethernet frames
	**EtherCAT Port 2**	RJ45 socket with green LED and yellow LED	Without function
	**RUN**	LED green	Communication status of the EtherCAT master: ▪ Off: Master is in the INIT state. ▪ Flashes (2.5 Hz): Master is in the PRE-OPERATIONAL state ▪ Flickers (10 Hz): Master is in Boot mode. ▪ Single flash: Master is in the SAFE OPERATIONAL state ▪ Lights up continuously: Master is in the OPERATIONAL state
	**ERR**	LED red	Communication status of the EtherCAT master: ▪ Off: Master has no errors ▪ On: Master has detected a communication error
	**Motor A** **Motor B**	Sub-D 15 (f)	Without function
	**E-Stop**	M12-SPEEDCON 8-pin (f)	Without function
	**-**	Toggle switch	Power on/off switch: ▪ O position: Controller is switched off* ▪ | position: Controller is switched on

Figure 4: Hexapod controller, ground connection

Labeling	Type	Function
⏚	M4 threaded pin	Ground connection If potential equalization is required, the controller can be connected to the grounding system.

3.3.3 Power Supply

Figure 5: Front panel of M850B0448 power supply

1 Power LED (Power)

Figure 6: Rear panel of M850B0448 power supply

1. *Fuse carrier for two fuses with IEC rating T8AL*
2 *Power switch:*
   position: power supply is switched off
   position: power supply is switched on
3 *Panel plug for line cord*
4 *Power LED (Power)*
5 *Fan*
6 *Sub-D 3W3 socket (Power Out 2) for 24 V DC output*
7 *Sub-D 3W3 socket (Power Out 1) for 24 V DC output*

3.4 Scope of Delivery

Hexapod

Item ID	Description
Hexapod mechanics, one of the following models (according to the order):	
H845B0008 H845B0014 H845B0024 H845B0034 H845B0016 H845B0035	System component of H-845.D11 System component of H-845.D21 System component of H-845.D31 System component of H-845.D41 System component of H-845.D51 System component of H-845.D61
Packaging of hexapod mechanics, consisting of:	
Packaging materials: ▪ Pallet ▪ Cardboard box, lower part ▪ Cardboard box, upper part ▪ Compound foil ▪ Hard foam insert for motion platform of hexapod ▪ Hard foam insert for base plate of hexapod	
Documentation, consisting of:	
H845T0001	Technical note in printed form on unpacking the hexapod
MS247EK	Short instructions for hexapod systems
Screw sets:	
	Accessories for mounting the hexapod on a surface: ▪ 6 M12x60 screws ISO 4762 ▪ 1 Allen wrench 10.0 DIN 911
000036450	Accessories for connection to the grounding system: ▪ 1 flat-head screw with cross recess M4x8 ISO 7045 ▪ 2 washers, form A-4.3 DIN 7090 ▪ 2 safety washers, Schnorr Ø 4 mm N0110

Cable set

Item ID	Description
000056207	Data transmission cable, RJ45 to M12 (m), 9 m
K060B0206	Power supply cable for hexapod controller, M12 (f) to Sub-D 3W3 (m), 3 m
K060B0060	Power supply cable for hexapod, Sub-D 3W3 (m) to Sub-D 3W3 (f), 1:1, 9 m
000015165	Snap-on ferrite suppressor

Power supply

Item ID	Description
M850B0448	Power supply for the hexapod and hexapod controller, 110 – 230 V / 24 V, 700 VA, 2 Sub-D 3W3 (f) connectors
3763	Power cord

Hexapod controller

Item ID	Description
H845B0021	Hexapod controller
C-815.563	Cross-over network cable
C-815.553	Straight-through network cable
C-815.34	Null-modem cable for connection to the PC via RS-232
C-887.CD	CD with PC software and documentation
Packaging material	

3.5 Technical Features

3.5.1 Struts

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

- Brushless DC motor with rotary encoder
- Brake
- Drive screw

3.5.2 Reference Point Switch and Limit Switches

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

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

3.5.3 Brakes

The brakes of the struts are activated by default. The brakes are deactivated only when the servo mode is switched on for the axes of the motion platform. For more information refer to “Starting Up the Hexapod System” on p. 45.

3.5.4 Control

The hexapod is intended for operation with the hexapod controller which is delivered with the hexapod. The hexapod controller makes it possible to command motion of individual axes, combinations of axes or all six axes at the same time in a single motion command. For the supported commands, see the MS244E user manual and the C887T0007 technical note.

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

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 point 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 sensors.

For more information, see the MS244E user manual.

Note that the hexapod controller in the scope of delivery provides neither data recorder nor wave generator.

3.5.5 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.

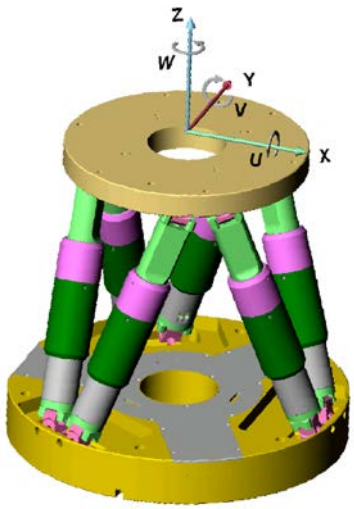


Figure 7: XYZ coordinate system and rotations to the rotational coordinates U, V and W. The coordinate system is depicted above the platform for better clarity.

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. 73).

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. 73).

INFORMATION

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

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

Example: Consecutive rotations

INFORMATION

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.

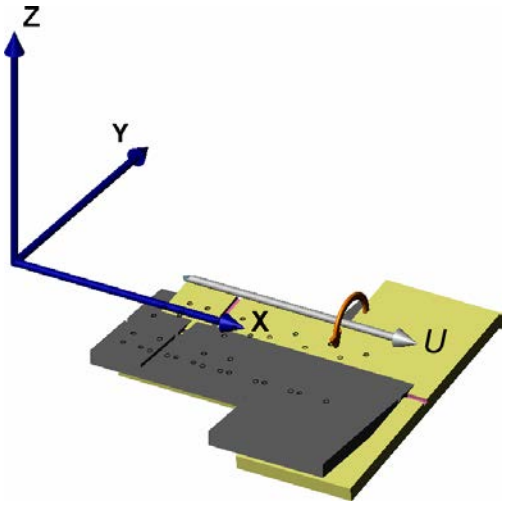


Figure 8: Rotation around the U axis

Platform in reference position

Platform position: U = 10 (U parallel to spatially fixed X axis)

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

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

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

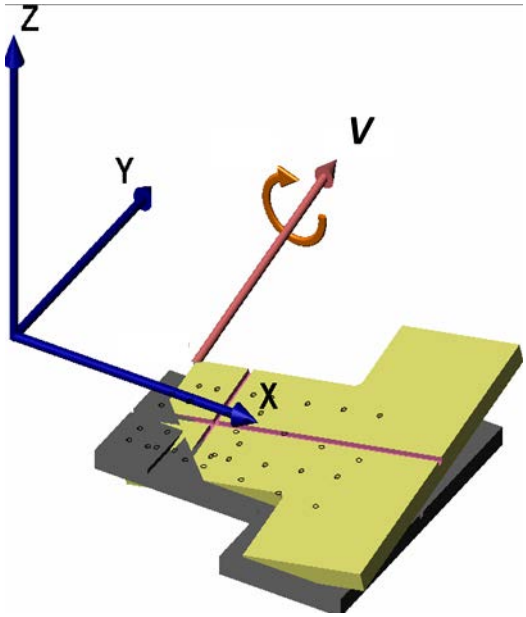


Figure 9: Rotation around the V axis

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.

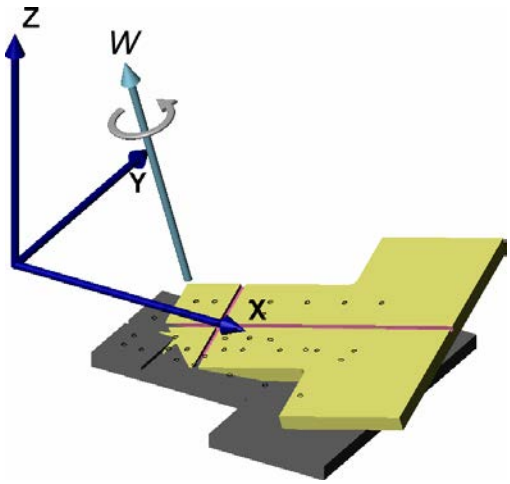


Figure 10: Rotation around the W axis

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

For more data on the travel ranges, see the "Specifications" section (p. 59).

4 Unpacking

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

CAUTION

Risk of crushing!

There is a risk of injuries caused by crushing since the hexapod is very heavy and capable of exerting high forces.

- ➢ Keep any part of your body away from areas where they can get caught by the hexapod.

NOTICE

Impermissible mechanical load!

An impermissible mechanical load can damage the hexapod.

- ➢ Only send the hexapod in the original packaging.
- ➢ Only transport the hexapod using a crane. The crane must lift the hexapod by 3 ring bolts and shackles affixed to the hexapod.
- ➢ To fix the ring bolts and shackles use the three M12 mounting holes in the motion platform of the hexapod, see Figure 15 on p. 30.

Accessories

- 3 ring bolts of appropriate size
- 3 shackles of appropriate size
- Crane appropriate to carry a load of 150 kg

Unpacking the hexapod

Figure 11: Hexapod package as delivered, with lid cardboard removed

1. Open the cardboard box, see figure above.

Figure 12: Hexapod package with upper hard foam insert removed

2. Remove the hard foam insert from the motion platform, see figure above.

Figure 13: Hexapod package with surrounding cardboard box removed

3. Remove the cardboard box that surrounds the hexapod, see figure above.

Figure 14: Unwrapped hexapod, keep the foil for repacking

4. Remove the compound foil that the hexapod is wrapped in.
   Remove the foil in a way that allows a future repacking of the hexapod.
5. Fix three ring bolts to three M12 mounting holes with 24 mm depth in the rounded edges of the motion platform, see Figure 15 below.
6. Connect each ring bolt with a shackle.

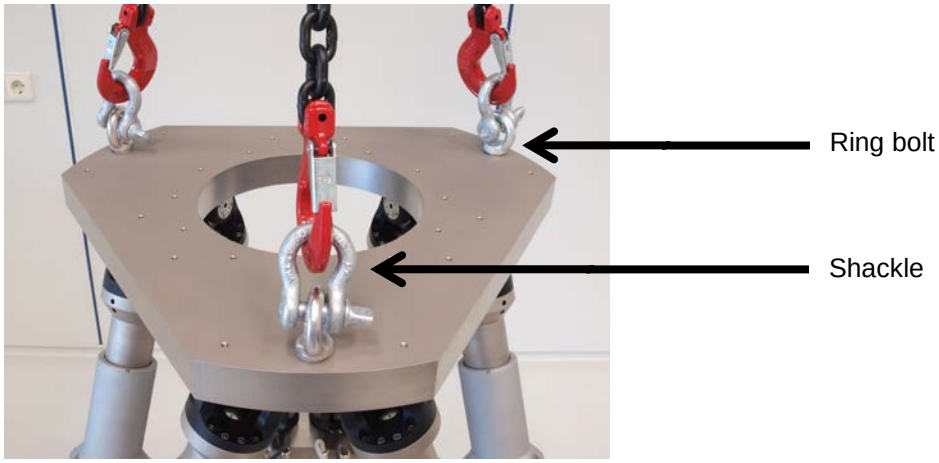


Figure 15: Lifting the hexapod at its motion platform using three ring bolts and three shackles

7. Connect the shackles to the corresponding load interfaces of the crane, see figure above.

Figure 16: Lifting the hexapod by a crane

8. Lift the hexapod out of the cardboard box.
9. Remove the hard foam insert from the base plate of the hexapod.
10. Compare the contents against the items covered by the contract and against the packing list. If parts are incorrectly supplied or missing, contact PI immediately.
11. Inspect the hexapod for signs of damage. If you notice signs of damage, contact PI immediately.
12. Keep all packaging materials in case the product needs to be transported again later.

5 Installation

In this Chapter

5.1 General Notes on Installation

The hexapod can be mounted in any orientation.

CAUTION

Risk of crushing!

Depending on the tilting angle of the surface to which the hexapod is to be mounted, the hexapod can slip, tilt or fall from the surface. There is a risk of injuries if parts of your body get caught by the hexapod, and the hexapod can be damaged.

- ➢ Position the surface where the hexapod is to be mounted horizontally.

If the surface where the hexapod is to be mounted cannot be positioned horizontally:

- ➢ Keep any part of your body away from areas where they can get caught by the hexapod.
- ➢ Disconnect the hexapod from the crane only when the base plate of the hexapod is securely affixed to the surface.

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 lift the hexapod using a crane. The crane must lift the hexapod by 3 ring bolts and shackles affixed to the motion platform of the hexapod, see Figure 16 on p. 31.
- Before installing the load, determine the limit value for the load of the hexapod with a simulation program (p. 35).
  The limit values determined with the simulation program are only valid when the hexapod controller has the servo mode switched on for the axes of the motion platform of the connected hexapod.
- Before installing the load, determine the workspace of the hexapod with a simulation program (p. 35).
  The limits of the workspace vary depending on the current position of the hexapod (translational and rotational coordinates) and the current coordinates of the center of rotation.
- Avoid high forces and torques on the motion platform during installation.
- When the hexapod is mounted on a tilted surface:
  - Verify that the hexapod is lifted by the crane without the hexapod slipping from the tilted surface in a sudden motion.
  - Verify that the chain of the crane remains under slight tension. If the tension is too strong, impermissible forces can be exerted on the hexapod.
- Ensure an uninterruptible power supply in order to prevent an unintentional deactivation of the hexapod system.
- 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 to the power supply!

The M850B0448 power supply can be damaged due to disturbed heat dissipation.

- Install the power supply only with its bottom side (equipped with rubber feet) facing downwards.
- Place the power supply in a location with adequate ventilation to prevent internal heat build-up.
- Allow at least 15 cm clearance from the front and the rear of the unit and 1 cm from the bottom (ensured by the feet of the chassis).
- Never cover any ventilation openings as this will impede ventilation.

INFORMATION

The optionally available PIVeriMove software for collision checking makes it possible to check mathematically for possible collisions between the hexapod, the 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 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	Any orientation	Mounted horizontally	Any orientation
H-845.D11, .D21	1000 kg	300 kg	10000 N	3000 N
H-845.D31, .D41	500 kg	150 kg	5000 N	1500 N
H-845.D51, .D61	400 kg	120 kg	4000 N	1200 N

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

➢ Contact our customer service department (p. 57).

5.3 Attaching the Snap-on Ferrite

INFORMATION

The 000015165 snap-on ferrite ensures the electromagnetic compatibility of the hexapod system. It is intended for permanent attachment to the power supply cable of the hexapod.

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

Tools and accessories

- 000015165 snap-on ferrite, included in the scope of delivery (p. 19)

Permanently attaching the snap-on ferrite

1. Put the power supply cable of the hexapod into the open snap-on ferrite approx. 10 to 15 cm behind the D-sub 3W3 connector (m) that is intended for connection to the power supply.
2. Close the snap-on ferrite:
   a) Align the cable so that it is not squeezed when the snap-on ferrite is closed.
   b) Carefully press the two halves of the snap-on ferrite around the cable until the lock engages.

5.4 Mounting the Hexapod on a Surface

CAUTION

Possible squeezing during mounting!

When positioning the hexapod on a surface there is a risk of minor injuries due to the mass of the hexapod.

- ➢ When you hold the hexapod by the base plate to position it on a surface: Ensure that your hands remain in a position where they cannot be squeezed.

NOTICE

Impermissible mechanical load!

An impermissible mechanical load can damage the hexapod.

- ➢ Only transport the hexapod using a crane. The crane must lift the hexapod by 3 ring bolts and shackles affixed to the motion platform of the hexapod.
- ➢ To fix the ring bolts and shackles use the three M12 holes in the motion platform of the hexapod, see Figure 15 on p. 30.
- ➢ Do **not** hold the hexapod by its struts to position it on a surface.

NOTICE

Warping of the base plate!

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

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

Requirements

- ✓ You have read and understood the General Notes on Installation (p. 33).
- ✓ If possible: Position the surface where the hexapod is to be mounted horizontally.
- ✓ You have connected the hexapod to a crane via 3 ring bolts and shackles as described in “Unpacking” (p. 27)

Tools and accessories

- 6 M12x60 screws and Allen wrench 10.0, included in the scope of delivery (p. 19)
- Alternative: 6 M16x60 screws and suitable tool, for rotationally symmetrical affixing of screws, not included in the scope of delivery

Mounting the hexapod

1. Bore the required holes into the surface:
   - 6 holes for M12x60 screws, see figure above.
   - Alternative: 6 holes for M16x60 screws, rotationally symmetrically arranged
     The arrangement of the counter-sunk holes in the base plate of the hexapod can be found in the dimensional drawing (p. 65).
2. Lift the hexapod to a suitable height.
3. Align the hexapod to the surface.

   When the hexapod is to be mounted on a tilted surface:
   - Verify that the hexapod is lifted by the crane without the hexapod slipping from the tilted surface in a sudden motion.
   - Verify that the chain of the crane remains under slight tension. If the tension is too strong, impermissible forces can be exerted on the hexapod.
4. Fasten the screws in the selected counter-sunk holes of the hexapod base plate.
5. Disconnect the hexapod from the crane:
   a) Disconnect the three shackles from the crane.
   b) Remove the three shackles from the ring bolts.
   c) Remove the three ring bolts from the hexapod.

5.5 Grounding the Hexapod and the Hexapod Controller

If a functional grounding is required for potential equalization you can ground the hexapod and the hexapod controller as follows:

1. Connect the base plate of the hexapod to the grounding system:
   - For connection, use the supplied accessories (p. 19) and the M4 hole with an 8 mm depth marked with the ground connection symbol, see dimensional drawing (p. 64).
2. Connect the motion platform to the grounding system:
   - Use one of the mounting holes in the motion platform (p. 65) for connection.
     or
   - If the motion platform and the load are connected conductively to each other, connect the load to the grounding system.

3. To connect the controller to the grounding system, use the threaded pin with the protective earth conductor symbol (see figure) on the housing of the controller.

5.6 Affixing the Load to the Hexapod

NOTICE

Impermissible mechanical load and collisions!

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

- ➢ Make sure that the installed load observes the limit value resulting from the load test (p. 35).
- ➢ Avoid high forces and torques on the motion platform during installation.
- ➢ Make sure that no collisions between the hexapod, the load to be moved, and the surroundings are possible in the workspace of the hexapod.

NOTICE

Excessively long screws!

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

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

Requirements

- ✓ You have read and understood the General Notes on Installation (p. 33).
- ✓ You have determined the permissible load and the workspace of the hexapod (p. 35).

✓ You have designed the load and the surroundings of the hexapod so that the permissible load of the hexapod is observed and no collisions can occur.

Tools and accessories

- Screws of suitable length. For options, see the dimensional drawing (p. 65).
- Suitable tool for tightening the screws

Affixing the load

1. Align the load so that the selected mounting holes in the motion platform can be used to affix it.
2. Use the screws to affix the load to the selected mounting holes in the motion platform.

5.7 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

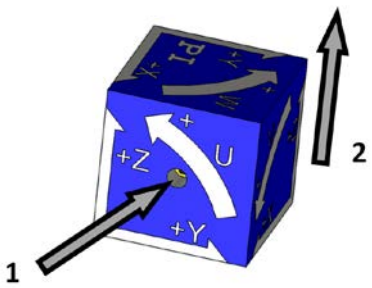


Figure 17: Removing the Coordinate Cube

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

5.8 Connecting the Hexapod System

INFORMATION

For proper data transmission, the ***Port 1 / EtherCAT*** RJ45 socket of the controller must be connected to the ***Controller In*** M12 (f) socket in the base plate of the hexapod.

Requirements

- ✓ You have read and understood the General Notes on Installation (p. 33).
- ✓ The power supply is switched off.

Tools and accessories

- Cable set that belongs to the hexapod system (p. 12)
- Power supply that belongs to the hexapod system (p. 12)

Connecting the hexapod system

1. Connect the ***Port 1 / EtherCAT*** RJ45 socket of the controller to the ***Controller In*** M12 (f) socket in the base plate of the hexapod using the 000056207 data cable.
3. Connect the ***24 V In*** M12 panel plug of the controller to one of the ***Power Out*** Sub-D 3W3 sockets of the power supply using the K060B0206 power cable.
2. Connect the ***24 V DC*** Sub-D 3W3 panel plug of the hexapod to the remaining ***Power Out*** Sub-D 3W3 socket of the power supply using the K060B0060 power cable.

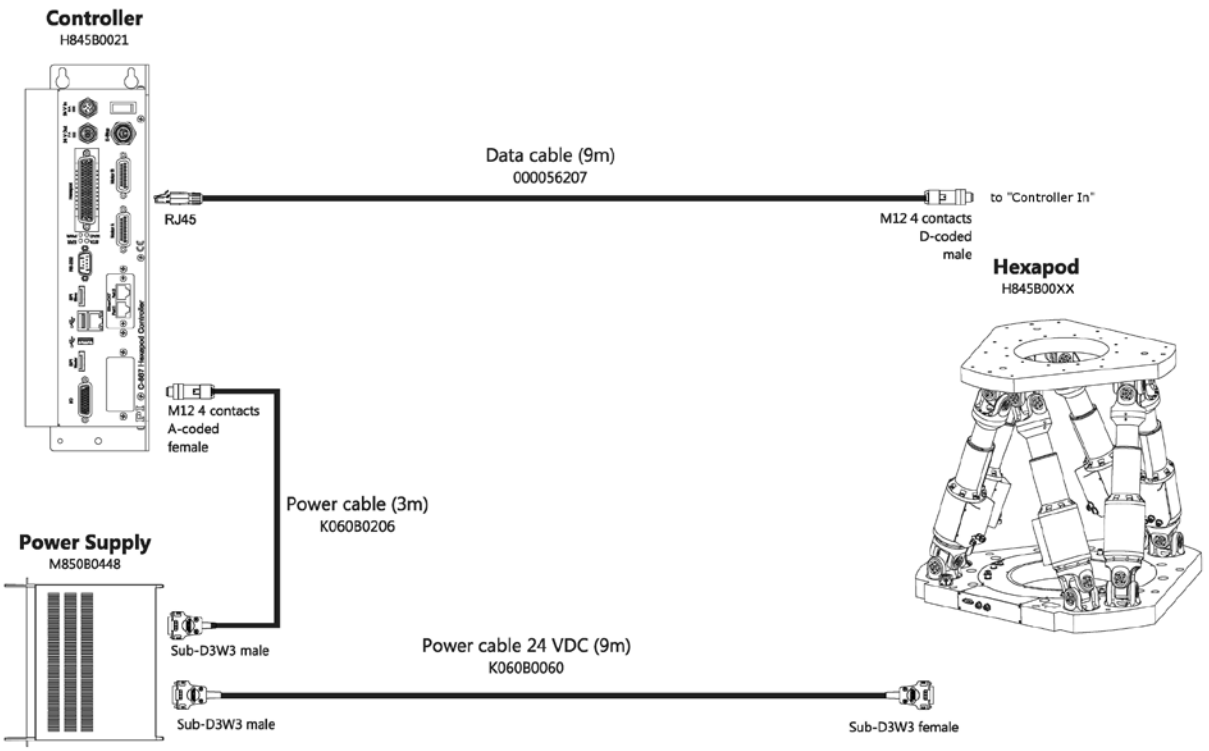


Figure 18: Connection diagram for cable set

K060B0060	*Power supply cable for hexapod, Sub-D 3W3 (m) to Sub-D 3W3 (f), 9 m*
K060B0206	*Power supply cable for controller, Sub-D 3W3 (m) to M12 (f), 3 m*
000056207	*Data transmission cable, RJ45 to M12 (m), 9 m*

6 Start-Up

In this Chapter

6.1 General Notes on Start-Up

CAUTION

Risk of crushing!

There is a risk of injuries from crushing between the moving parts of the hexapod and a stationary part or obstacle.

- ➢ Keep any part of your body away from areas where they can get caught by moving parts.

NOTICE

Incorrect configuration of the hexapod controller!

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

- ➢ Check whether the hexapod controller matches the hexapod. A label on the rear panel of the controller indicates for which hexapod the controller is intended.
- ➢ 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 hexapod 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 get caught by moving parts.
- ➢ Stop the motion immediately if a controller malfunction occurs.

INFORMATION

The output voltage of the M850B0448 power supply is decreased when the internal temperature sensor detects a temperature above 50 °C. As a result the servo mode of the controller is switched off and the system can no longer be operated in this state.

1. Ensure that the internal temperature of the power supply does not exceed 50 °C.
   - Place the power supply in a location with adequate ventilation to prevent internal heat build-up.
2. When the servo mode is switched off automatically due to overheating of the power supply:
   Wait a few minutes to let the power supply cool down.
3. Switch the power supply off and on again.

6.2 Starting Up the Hexapod System

INFORMATION

The brakes of the hexapod are activated when the hexapod controller has the servo mode switched off. The servo mode is switched off in the following cases:

- Hexapod controller is switched off
- Hexapod controller is rebooting
- Servo mode is switched off by an SVO command; for command description see the MS244 user manual of the hexapod controller
- The allowable position error of a strut is exceeded.
- At least one of the limit switches of a strut is activated.
- The output voltage of the M850B0448 power supply is below or above the permissible output voltage range.
- The M850B0448 power supply is switched off.

Requirements

✓ You have read and understood the General Notes on Start-Up (p. 43).

✓ You have correctly installed the hexapod system according to the instructions in "Installation" (p. 33).

✓ You have read and understood the documentation of the hexapod controller.

Accessories

- Hexapod controller belonging to the hexapod system
- PC with suitable software (see documentation of the hexapod controller)

Starting up the hexapod system

1. Connect the supplied power cord to the panel plug in the rear panel of the M850B0448 power supply.
2. Connect the M850B0448 power supply to the power socket with the power cord.
3. Switch on the M850B0448 power supply by moving the power switch into the ▬ position.
4. Start up the hexapod controller (see documentation of the hexapod controller).
5. Perform a few motion cycles for testing purposes (see documentation of the hexapod controller).

6.3 Switching Off the Hexapod System

1. Switch off the hexapod controller.
   Thus the servo mode is switched off and the brakes are activated.

4. Switch off the M850B0448 power supply by moving the power switch into the ○ position.

7 Maintenance

In this Chapter

NOTICE

Damage due to improper maintenance!

The hexapod can become misaligned as a result of improper maintenance. The specifications can change as a result (p. 59).

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

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

7.1 Performing a Maintenance Run

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

- Perform a maintenance run over the entire travel range at regular intervals (see documentation of the hexapod 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 Packing the Hexapod for Transport

CAUTION

Risk of crushing!

Depending on the tilting angle of the surface to which the hexapod is to be mounted, the hexapod can slip, tilt or fall from the surface. There is a risk of injuries if parts of your body get caught by the hexapod, and the hexapod can be damaged.

- ➢ Position the surface where the hexapod is mounted horizontally.

If the surface where the hexapod is mounted cannot be positioned horizontally:

- ➢ Keep any part of your body away from areas where they can get caught by the hexapod.
- ➢ Loosen the screws with which the hexapod is mounted on the surface only when the hexapod is connected to the crane by the three ring bolts and shackles.

NOTICE

Impermissible mechanical load!

An impermissible mechanical load can damage the hexapod.

- ➢ Only send the hexapod in the original packaging.
- ➢ Only transport the hexapod using a crane. The crane must lift the hexapod by 3 ring bolts and shackles affixed to the motion platform of the hexapod.
- ➢ To fix the ring bolts and shackles use the three M12 mounting holes in the motion platform of the hexapod, see Figure 15 on p. 30.

NOTICE

Sudden, impermissible forces during demounting hexapod from tilted surface!

When the hexapod slips from a tilted surface while it is connected to the crane, impermissible forces can occur which can cause damage to the hexapod.

- ➢ Position the surface where the hexapod is mounted horizontally.

If the surface where the hexapod is mounted cannot be positioned horizontally:

- ➢ Lift the crane carefully while loosening the screws with which the base plate of the hexapod is mounted to the surface.

Requirements

- If possible: You have positioned the surface where the hexapod is mounted horizontally.

Accessories

- Original packaging, including pallet, cardboard box and hard foam inserts
- 3 ring bolts of appropriate size
- 3 shackles of appropriate size
- Crane appropriate to carry a load of 150 kg

Packing the hexapod for transport

1. Command the hexapod to move to the reference position:
   X = Y = Z= U = V = W= 0
2. Prepare to uninstall the hexapod system.
   a) Power down the hexapod controller.
   b) Switch off the power supply.
   c) Remove the load from the motion platform of the hexapod.
   d) Remove the data transmission cable(s) and the power supply cable from the hexapod.
3. Fix three ring bolts to three M12 mounting holes with 24 mm depth in the rounded edges of the motion platform, see figure below.
4. Connect each ring bolt with a shackle.

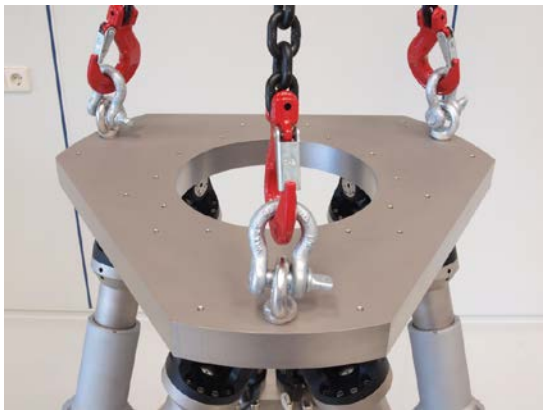


Figure 19: Lifting the hexapod at its motion platform using three ring bolts and three shackles

5. Connect the shackles to the corresponding load interfaces of the crane, see figure above.
   Verify that the chain of the crane is only slightly under tension. If the tension is too strong, impermissible forces can be exerted on the hexapod in the next step.
6. Uninstall the hexapod from the surface to which it is mounted:
   - When the hexapod is mounted on a tilted surface: Carefully lift the hexapod by the crane during the uninstalling procedure so that the chain of the crane remains under tension and the hexapod cannot slip in a sudden motion.

   a) Loosen the screws with which the hexapod is mounted on the surface.
   b) Remove the screws.

Figure 20: Lifting the hexapod by a crane

7. If required lift the hexapod to a suitable height, see figure above.
8. Pack the hexapod in a plastic foil to protect it against dirt.
   It is recommended to reuse the compound foil in which the hexapod was delivered.
9. Place the hard foam insert for the base plate of the hexapod on the pallet.

Figure 21: Hexapod wrapped in foil, with lower hard foam insert on a pallet

10. Place the hexapod into the hard foam insert on the pallet, see figure above.
11. Remove the hexapod from the crane.
12. Remove shackles and ring bolts from the motion platform of the hexapod.

Figure 22: Hexapod package with surrounding cardboard box

13. Place the cardboard box around the hexapod, see figure above.

Figure 23: Hexapod package without cardboard lid

14. Insert the hard foam insert for the motion platform of the hexapod in the cardboard box, see figure above.
15. Close the cardboard box with the cardboard lid.
16. Secure the box on the pallet.

7.3 Replacing the Fuses of the M850B0448 Power Supply

NOTICE

Damage of power supply!

The M850B0448 power supply can be damaged if unsuitable fuses are used.

➢ Check and replace **both** fuses if there is a fault.

Figure 24: Location of fuses at the rear panel of the M850B0448 power supply

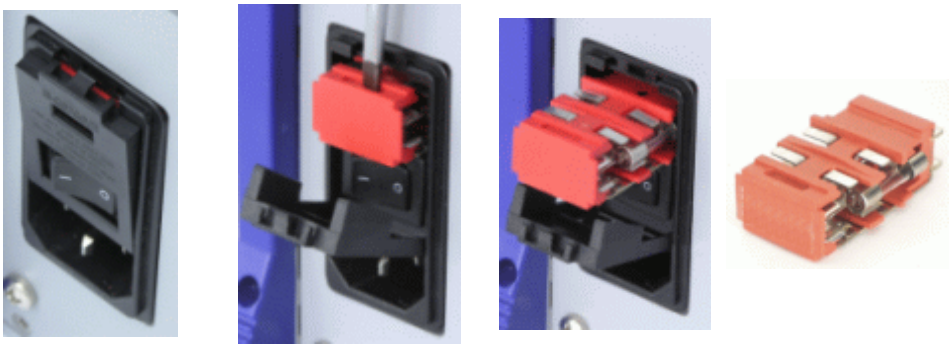


Figure 25: How to exchange fuses

Tools and accessories

- A suitable tool to pry open the fuse carrier

Replacing the fuses of the M850B0448 power supply

1. Switch off the M850B0448 power supply.
2. Disconnect the M850B0448 power supply from the power socket by pulling the power plug.
3. Wait a minute to be sure that any residual voltage has dissipated.
4. Pry open the door that covers the fuse carrier and pry out the fuse carrier (see Figure 25 above).
5. Be sure to replace both fuses with fuses of the suitable type:

   100 to 240 V ~: 2 x IEC T 8 AL (with 250 V rated voltage)

   L = Low breaking
   T = Time lag

   Note that IEC fuses are cited: other fuse standards may require higher nominal current rating.
6. Reinstall the carrier and close the door

7.4 Cleaning the Hexapod

Requirements

✓ You have disconnected the hexapod from the power supply.

Cleaning the hexapod

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

8 Troubleshooting

Problem	Possible Causes	Solution
System is not ready	M850B0448 power supply is switched off	➢ Switch on the power supply.
	Servo mode is switched off	➢ Switch on the servo mode by sending an SVO command. ➢ When servo mode cannot be switched on: The output voltage may be too low because the temperature of the power supply is above 50 °C: 1. Wait a few minutes to let the power supply cool down. 2. Switch the power supply off and on again
	At least one limit switch of a strut is activated	➢ Start a reference move by sending an FRF command.
	Impermissible load	➢ Observe the permissible load and workspace (p. 35).
	Brakes remain closed	➢ Contact our customer service department (p. 57).
Reduced accuracy	Warped base plate	➢ Mount the hexapod on an even surface (p. 36). The recommended evenness of the surface is 100 µm.
Increased wear	Only small motions over a long period of time	➢ Carry out a maintenance run over the entire travel range (p. 47).

Problem	Possible Causes	Solution
One strut does not move or is difficult to move	▪ Wear of the drive screw ▪ Foreign body has entered the drive screw ▪ Faulty motor ▪ Blocked joint due to wear or foreign body ▪ At least one of the brakes is not deactivated by activating servo control	➢ Contact our customer service department (p. 57).
Position jumps or crackling noise of the hexapod	▪ Communication error between hexapod and controller ▪ Controller busy due to communication with PC software (e.g., polling done by PIMikroMove) ▪ Power supply is undersized or reacts too slowly ▪ Faulty limit switches	➢ Check the cable connections. Tighten the M12 connections with a torque of 0.6 Nm. ➢ Use a separate power supply for the controller. ➢ Close the PC software. ➢ Send the following commands and make the response available to our customer service department (p. 57): DBG? GETETHERCATDIAG, SRG?, ERR?, DBG GETLOG, POS?

If the problem with your hexapod is not listed in the table or it cannot be solved as described, contact our customer service department (p. 57).

9 Customer Service

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

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

10 Technical Data

In this Chapter

10.1 Specifications

10.1.1 Data Table Hexapod

Motion and positioning	H-845.D11	H-845.D31	H-845.D51	H-845.D21	H-845.D41	H-845.D61	Unit	Tole-rance
Active axes	X, Y, Z, θ_X, θ_Y, θ_Z	X, Y, Z, θX, θY, θZ	X, Y, Z, θX, θY, θZ	X, Y, Z, θX, θY, θZ	X, Y, Z, θX, θY, θZ	X, Y, Z, θ_X, θ_Y, θ_Z		
Travel range* X, Y	±110	±110	±110	±170	±170	±170	mm	
Travel range* Z	±50	±50	±50	±105	±105	±105	mm	
Travel range* θ_X, θ_Y	±15	±15	±15	±20	±20	±20	°	
Travel range* θ_Z	±30	±30	±30	±30	±30	±30	°	
Actuator design resolution	0.04	0.08	0.1	0.04	0.08	0.1	µm	
Min. incremental motion X, Y	1	2	2.5	1	2	2.5	µm	typ.
Min. incremental motion Z	0.5	1	1	0.5	1	1	µm	typ.
Minimum incremental motion θ_X, θ_Y, θ_Z	15	30	30	15	30	30	µrad	typ.
Backlash X, Y	5	10	10	5	10	10	µm	typ.
Backlash Z	1	2	2	1	2	2	µm	typ.
Backlash θ_X, θ_Y	15	30	30	15	30	30	µrad	typ.
Backlash θ_Z	30	60	60	30	60	60	µrad	typ.
Repeatability X, Y	±2	±4	±5	±2	±4	±5	µm	typ.
Repeatability Z	±0.5	±1	±2	±0.5	±1	±2	µm	typ.

Motion and positioning	H-845.D11	H-845.D31	H-845.D51	H-845.D21	H-845.D41	H-845.D61	Unit	Tole-rance
Repeatability θ_X, θ_Y, θ_Z	±10	±20	±25	±10	±20	±25	µrad	typ.
Max. velocity X, Y, Z	20	40	50	20	40	50	mm/s	
Max. velocity θ_X, θ_Y, θ_Z	50	100	120	50	100	120	mrad/s	
Typ. Velocity X, Y, Z	10	20	25	10	20	25	mm/s	
Typ. Velocity θ_X, θ_Y, θ_Z	20	40	50	20	40	50	mrad/s	

Mechanical properties	H-845.D11	H-845.D31	H-845.D51	H-845.D21	H-845.D41	H-845.D61	Unit	Tole-rance
Load capacity (horizontal base plate / any orientation)	1000 / 300	500 / 150	400 / 120	1000 / 300	500 / 150	400 / 120	kg	max.
Motor type	BLDC motor	BLDC motor	BLDC motor	BLDC motor	BLDC motor	BLDC motor		

Miscellaneous	H-845.D11	H-845.D31	H-845.D51	H-845.D21	H-845.D41	H-845.D61	Unit	Tole-rance
Operating temperature range	-10 to 50	-10 to 50	-10 to 50	-10 to 50	-10 to 50	-10 to 50	°C	
Material	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum		
Mass	120	120	120	193	193	193	kg	±5 %
Cable length	9	9	9	9	9	9	m	±10 mm
Controller, in the scope of delivery	C-887	C-887	C-887	C-887	C-887	C-887		

Technical data specified at 20±3 °C.
* The travel ranges of the individual coordinates (X, Y, Z, θ_X, θ_Y, θ_Z) are interdependent. The data for each axis in this table shows its maximum travel range, where all other axes and the pivot point are at the reference position.
Ask about customized versions.

10.1.2 Maximum Ratings Hexapod

The hexapod is designed for the following operating data:

Maximum Operating Voltage	Maximum Operating Frequency (Unloaded)	Maximum Power Consumption
24 V DC	⎓	500 W

10.1.3 Data Table Hexapod Controller

	H845B0021
Function	6-axis controller for hexapods
Drive type	Servo motors
Motion and control	
Servo characteristics	32-bit PID filter
Trajectory profile modes	Jerk-limited generation of dynamics profile with linear interpolation
Processor	Intel Atom dual core (1.8 GHz)
Servo cycle time	100 µs
Encoder input	AB differential TTL signal, 50 MHz
Stall detection	Servo off, triggered by position error
Reference point switch	TTL
Interface and operation	
Communication interfaces	TCP/IP, RS-232
Hexapod connection	RJ45 socket (EtherCAT)
Supply voltage connection	M12 (m)
I/O lines	HD D-sub 26 (f): 4 × analog input (-10 to 10 V, via 12-bit A/D converter) 4 × digital input (TTL) 4 × digital output (TTL)
Command set	PI General Command Set (GCS)
User software	PIMikroMove
Software drivers	API for C / C++ / C# / VB.NET / MATLAB / Python, drivers for NI LabVIEW

Miscellaneous	H845B0021
Operating voltage	24 V, max. 8 A
Operating temperature range	5 to 40°C
Mass	2.8 kg

10.1.4 Maximum Ratings Hexapod Controller

Input on:	Maximum Operating Voltage ⚠	Operating Frequency ⚠	Maximum Current Consumption ⚠
4-pin M12 panel plug (m)	24 V	⎓	8 A

10.1.5 Data Table M850B0448 Power Supply

	M850B0448 Power Supply
Output voltage	24 V DC / 20 A max
Input voltage	110 – 230 V AC (50 – 60 Hz)
Input power	700 W
Output power	500 W
Fuses	2 x IEC T 8 AL (with 250 V rated voltage)
Dimensions	236 mm x 132 mm x 296 mm + handles
Mass	4.7 kg

10.1.6 Maximum Ratings M850B0448 Power Supply

The power supply is designed for the following operating data:

Maximum Operating Voltage ⚠	Maximum Operating Frequency (Unloaded) ⚠	Maximum Output Power ⚠
230 V AC	60 Hz	500 W

10.2 Ambient Conditions and Classifications

10.2.1 Hexapod

Degree of pollution:	2
Transport temperature:	–25 °C to +85 °C
Storage temperature:	-10 °C to 70 °C
Humidity:	Maximum relative humidity of 80% at temperatures of up to 31 °C, linearly decreasing until relative humidity of 50% at 40 °C
Degree of protection according to IEC 60529:	IP20
Area of application:	For indoor use only
Maximum altitude:	2000 m
Air pressure	1100 hPa to 780 hPa (corresponds to roughly 825 torr to 0.075 torr)

10.2.2 Hexapod Controller

Degree of pollution:	2
Transport temperature:	–25 °C to +85 °C
Storage temperature:	0 °C to 70 °C
Humidity:	Highest relative humidity 80 % for temperatures up to 31 °C Decreasing linearly to 50 % relative air humidity at 40 °C
Degree of protection according to IEC 60529:	IP20
Area of application:	For indoor use only
Maximum altitude:	2000 m
Air pressure:	1100 hPa to 0.1 hPa
Line voltage fluctuations:	Max. ±10 % of the line voltage
Overvoltage category:	II
Protection class:	I

10.2.3 M850B0448 Power Supply

Degree of pollution:	2
Transport temperature:	–25 °C to +85 °C
Storage temperature:	0 °C to 70 °C
Humidity:	Maximum relative humidity of 80% at temperatures of up to 31 °C, linearly decreasing until relative humidity of 50% at 40 °C
Degree of protection according to IEC 60529:	IP20
Area of application:	For indoor use only
Maximum altitude:	2000 m
Air pressure:	1013 hPa to 790 hPa (corresponds to roughly 760 torr to 592.5 torr)
Line voltage fluctuations:	Max. ±10 % of the line voltage
Overvoltage category:	II, transient overvoltages as typical for public power supply

10.3 Dimensions

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

If the controller's factory settings are used for the coordinate system and the center of rotation, the hexapods in the figures correspond 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.

10.3.1 Hexapod

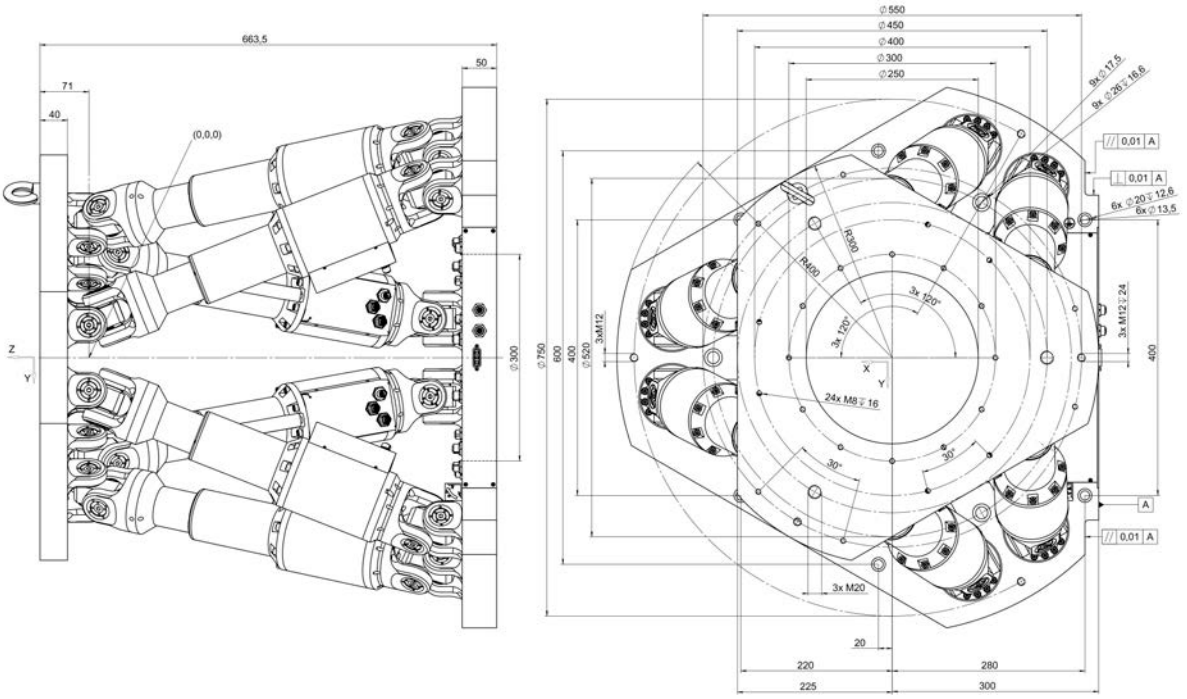


Figure 26: H-845.D11, .D31, .D51 hexapod dimensions in mm

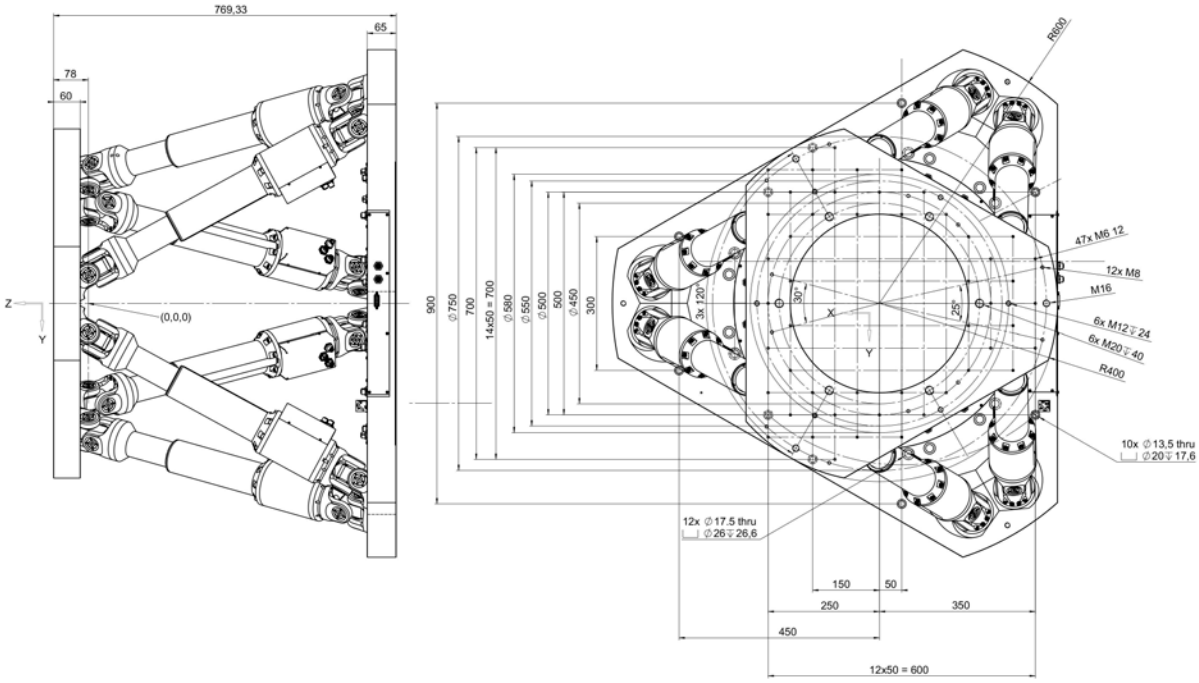


Figure 27: H-845.D21, .D41, .D61 hexapod dimensions in mm

10.3.2 Hexapod Controller

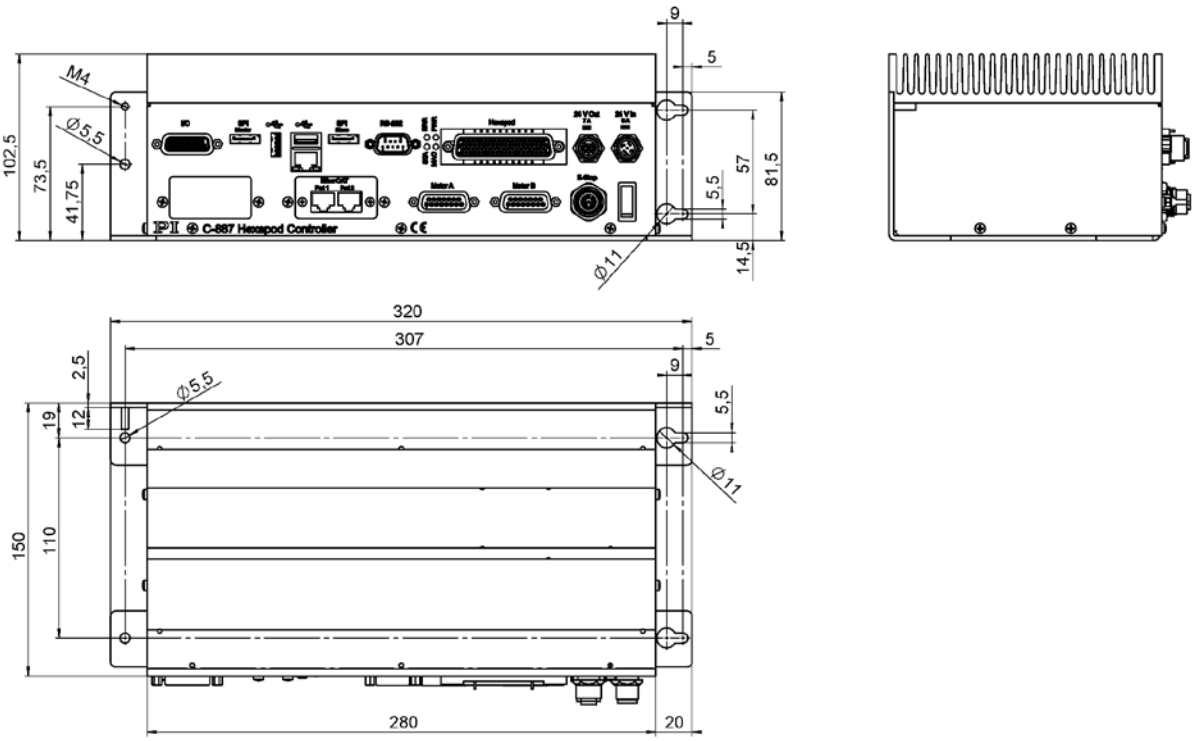


Figure 28: H845B0021 hexapod controller

10.3.3 M850B0448 Power Supply

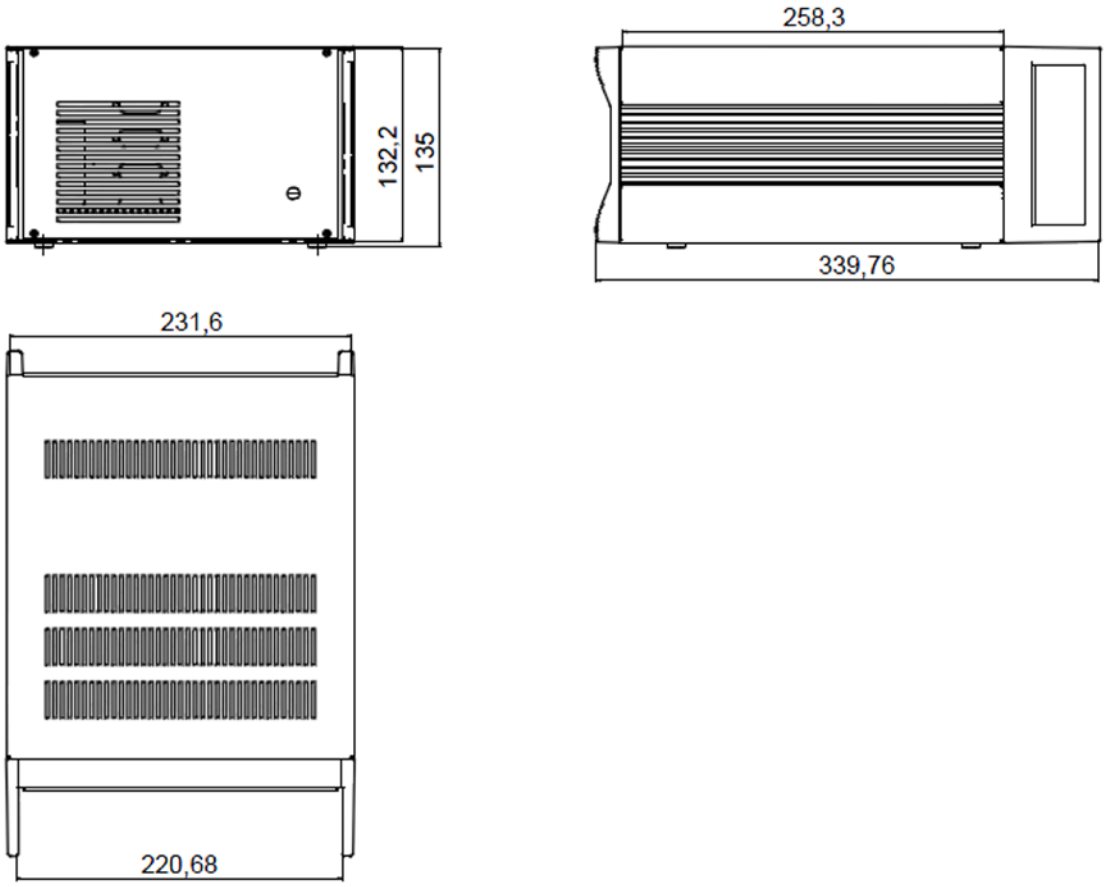
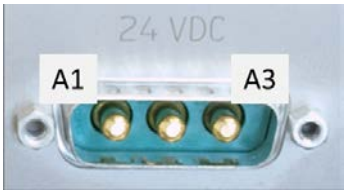


Figure 29: M850B0448 power supply

10.4 Pin Assignment Hexapod

10.4.1 Power Supply Connection

Sub-D 3W3 panel plug at base plate of hexapod

Pin	Function	
A1	GND	
A2	24 V DC	
A3	GND	
Shell	Shield	

10.4.2 Data Transmission Connection

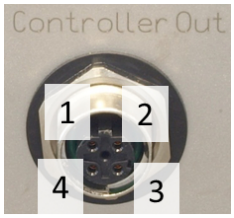
Controller In

M12 socket at base plate of hexapod

Pin	Function	
1	E_CAT_1_RD+	
2	E_CAT_1_RD-	
3	E_CAT_1_TD+	
4	E_CAT_1_TD-	

Controller Out

M12 socket at base plate of hexapod

Pin	Function	
1	E_CAT_2_RD+	
2	E_CAT_2_RD-	
3	E_CAT_2_TD+	
4	E_CAT_2_TD-	

10.5 Pin Assignment Hexapod Controller

For all connectors that are not listed below, see the user manual of the C-887.5xx controller (MS244E).

10.5.1 I/O Connection

HD D-sub 26 socket (f)

Pin	Pin	Pin	Signal	
	10		Analog input 1	
1			Analog input 2	
		19	Analog input 3	
	11		Analog input 4	
2			GND (analog)	
		20	GND	
	12		Reserved	
3			Reserved	
		21	Reserved	
	13		Reserved	
4			Reserved	
		22	GND	
	14		Reserved	
5			Reserved	
		23	Reserved	
	15		Reserved	
6			Vcc (+5 V, max. 500 mA)	
		24	GND	
	16		Digital input 4 (TTL)	
7			Digital input 3 (TTL)	
		25	Digital input 2 (TTL)	
	17		Digital input 1 (TTL)	
8			Digital output 4 (TTL)	
		26	Digital output 3 (TTL)	
	18		Digital output 2 (TTL)	
9			Digital output 1 (TTL)	

Analog inputs: -10 V to 10 V, 12-bit; 15 kΩ input impedance

Digital outputs:

Rise time and fall time = max. 500 ns

Output current = max. 10 mA per pin

Digital inputs:

Input impedance = 10 kΩ

Input voltage = 0 to 5.5 V

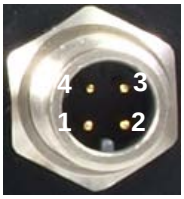
Schmitt trigger input

	min	max
V_{T+} (switching threshold with rising input voltage)	1.3 V	2.2 V
V_{T-} (switching threshold with falling input voltage)	0.6 V	1.3 V
ΔV_T (Hysteresis; V_{T+} - V_{T-})	0.4 V	1.1 V

10.5.2 Supply Power for Controller

M12 4-pin panel plug (m)

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



11 Old Equipment Disposal

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

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

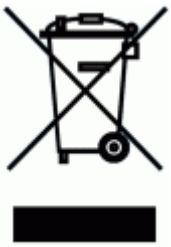
To meet the manufacturer's product responsibility with regard to this product, Physik Instrumente (PI) GmbH & Co. KG ensures environmentally correct disposal of old PI equipment that was first put into circulation after 13 August 2005, free of charge.

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

Physik Instrumente (PI) GmbH & Co. KG

Auf der Römerstr. 1

D-76228 Karlsruhe, Germany



12 Glossary

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. 65).

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".

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.

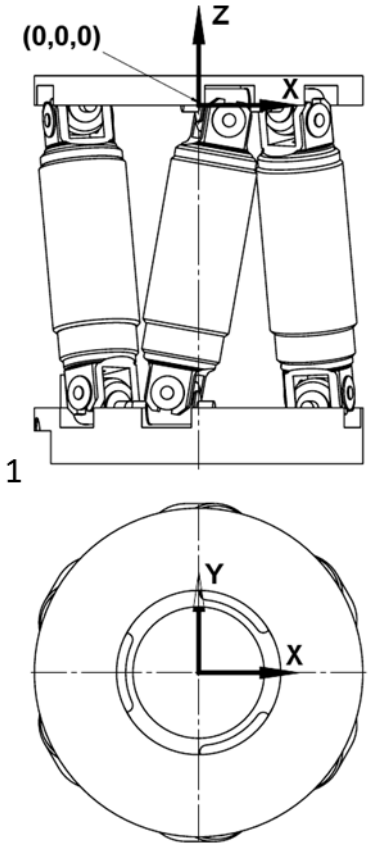


Figure 30: H-810 hexapod in the reference position.

1 Cable exit

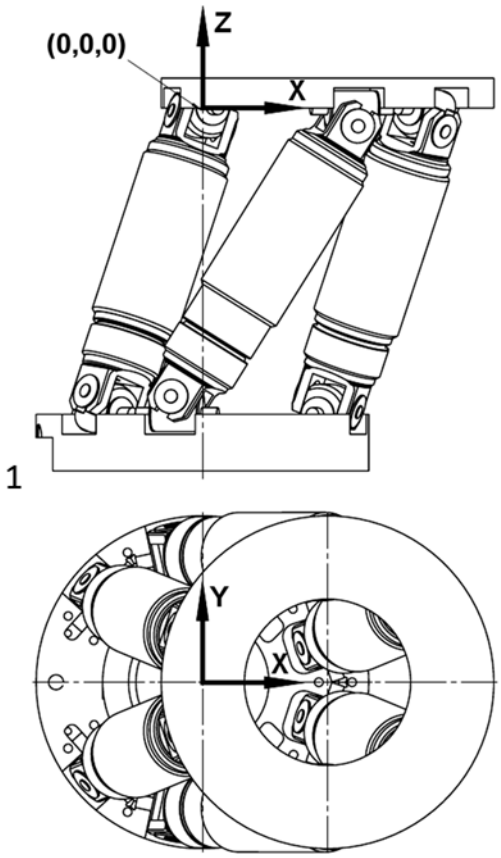


Figure 31: H-810 hexapod, the platform of which has been moved in X.

1 Cable exit

13 Appendix

13.1 Explanations of the Performance Test Sheet

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

The following figure shows the test setup used.

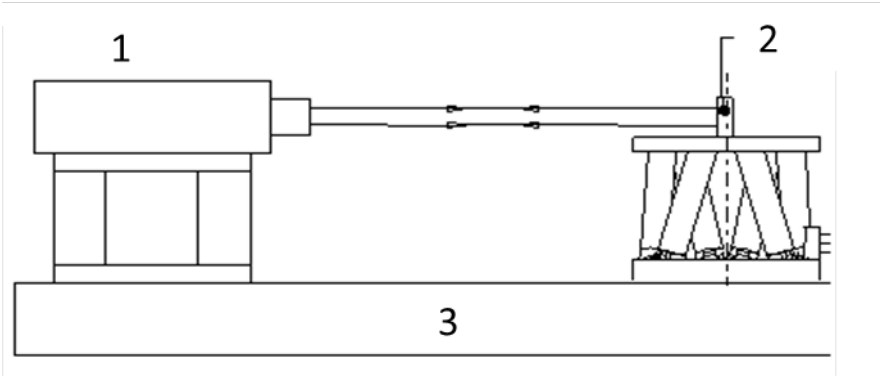


Figure 32: Test setup for measuring the X or Y axis.

1 Laser interferometer
2 Mirror
3 Bench

The following test cycles are performed:

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

13.2 EU Declaration of Conformity

For the H-845 hexapod system, an EU Declaration of Conformity has been issued in accordance with the following European directives:

EMC Directive

RoHS Directive

The applied standards certifying the conformity are listed below.

EMC: EN 61326-1

Safety: EN 61010-1

RoHS: EN 50581