

MS204Equ C-887 Hexapod Controller / Digital Motion Controller Short Version of the User Manual

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This document describes the following products:

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

**The detailed version of this user manual is
included as a PDF file on the product CD.**



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1 About this Document

In this Chapter

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1.1 Goal and Target Audience of this User Manual

The short version of the MS204E user manual includes the following information on the intended use of the C-887:

- Product description and technical data of the C-887
- Installation instructions for the C-887 and the Hexapod
- Start-up instructions of the C-887 with the Hexapod
- Command Overview for the GCS syntax version 2.0
- Cleaning instructions for the C-887
- Overview for troubleshooting

In the detailed MS204E user manual, which is included as a PDF file on the product CD, you can find all other information and instructions regarding installation, start-up, operation, and maintenance as well as command and parameter descriptions. This short version refers to information that is only included in the detailed version of the user manual.

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

For updated releases of the user manuals, or if you have any questions, contact our customer service department (p. 103).

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 property damage.

- Actions to take to avoid the situation.

INFORMATION

Information for easier handling, tricks, tips, etc.

Symbol	Meaning
1.	Action consisting of several steps whose sequential order must be observed
2.	
➤	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)
Start > Settings	Menu path in the PC software (example: to open the menu, the Start and Settings buttons must be clicked in succession)
<code>SVO?</code>	Command line or a command from PI's General Command Set (GCS) (example: command to get the servo mode).

Symbol	Meaning
Device S/N	Parameter name (example: parameter where the serial number is stored)
5	Value that must be entered or selected via the PC software

1.3 Definition

PC software	Software that is installed on the PC.
Firmware	Software that is installed on the controller.
Volatile memory	RAM module in which the controller parameters are saved when the controller is switched on (working memory).
Non-volatile memory	CF card from which, e.g., settings for communication are loaded to the volatile memory when the controller is started.
Axis	Also referred to as the "logical axis". Logical axes reproduce the translations and rotations of the moving platform of the Hexapod and the motions of the optionally usable stages in the firmware of the C-887. Each direction of motion corresponds to a logical axis. Further information on translations and rotations can be found in the manual of the Hexapod. All motion commands of the C-887 refer to logical axes.
Hexapod strut	In order to move a logical axis of the moving platform, several Hexapod struts must be moved. The C-887 calculates the target positions for the individual struts from the target positions given for the translation and rotation axes. The velocities and accelerations of the struts are calculated in such a way that all struts start and stop at the same time.
Motion profile	Also referred to as a "trajectory". Comprises the target position, velocity, and acceleration of the axis calculated for each point in time of the motion. The calculated values are called "commanded values". The source of the motion profile can be selected for the Hexapod (p. 30).

XYZ coordinate system	<p>The position and orientation of the Cartesian XYZ coordinate system in which the translations of the moving platform of the Hexapod take place cannot be changed, which is why the system is referred to as spatially fixed. The axes X, Y and Z are referred to as translation axes.</p> <p>The intersection of the axes of the spatially fixed Cartesian XYZ coordinate system (0,0,0) is referred to as the origin.</p> <p>The Z axis is always perpendicular to the base plate of the Hexapod.</p>
Pivot point	<p>The intersection of the rotational axes U, V and W of the moving platform of the Hexapod.</p> <p>When the default settings for the pivot point coordinates are used, the pivot point is located at the origin of the XYZ coordinate system after a reference move. See the dimensional drawing in the manual of the Hexapod that belongs to the Hexapod system.</p> <p>The pivot point is displaced along with the platform during translations. Rotations do not change the position of the pivot point. The pivot point coordinates remain unchanged in both cases.</p> <p>The pivot point coordinates can be changed with the <code>SPI</code> command.</p>
Work space	<p>The entirety of all combinations of translations and rotations that the Hexapod can approach from the current position is referred to as the work space.</p> <p>The work space can be limited by the following external factors:</p> <ul style="list-style-type: none"> ▪ Installation space ▪ Dimensions and position of the load
Digital Motion Controller	<p>Labeling on the C-887 front panel. The C-887 is referred to as "Hexapod controller" in this manual.</p>

1.4 Other Applicable Documents

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

For the latest versions of the user manuals contact our customer service department (p. 103).

Description	Document
Detailed user manual for the C-887	MS204E User Manual
C-887 GCS LabVIEW	MS209E Software Manual
PI GCS 2 DLL for the C-887	MS210E Software Manual
PIMikroMove	SM148E Software Manual
GCS Data	SM146E Software Manual
Simulation of the Controller and Hexapod	C887T0001 Technical Note
Updating PI Software	A000T0032 Technical Note
PI Update Finder	A000T0028 Technical Note
LabVIEW with Linux	A000T0021 Technical Note

Depending on the Hexapod system ordered, one of the following user manuals for the Hexapod microrobot is included in the scope of delivery.

Model family	Document
H-206 Hexapod for 6D Alignment and Micromanipulation	MS203E
H-811 Miniature Hexapod Microrobot	MS199E
H-820 Hexapod Microrobot	MS207E
H-824 Compact Hexapod Microrobot	MS200E
H-840 Hexapod Microrobot	MS201E
H-850 Hexapod Microrobot	MS202E

2 Safety

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2.1 Intended Use

The C-887 is a laboratory device as defined by DIN EN 61010-1. It is intended to be used in interior spaces and in an environment which is free of dirt, oil and lubricants.

In accordance with its design, the C-887 is intended for closed-loop driving of a Hexapod Microrobot from PI equipped with DC servo motors.

The C-887 must not be used for purposes other than those named in this user manual.

The C-887 may only be used in compliance with the technical specifications and instructions in this user manual. The user is responsible for process validation.

2.2 General Safety Instructions

The C-887 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 C-887.

- Only use the C-887 for its intended purpose, and only use it if it is in a good working order.
- Read the user manual.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for the correct installation and operation of the C-887.

2.2.1 Organizational Measures

User Manual

- Always keep this user manual next to the C-887.
If the user manual is lost or damaged, contact our customer service department (p. 103).
- Add all information given by the manufacturer to the user manual, for example supplements or Technical Notes.
- Only use the device on the basis of the complete user manual. Missing information due to an incomplete user manual can lead to minor injury as well as property damage.
- Only install and operate the C-887 after having read and understood this user manual.

Personnel Qualification

The C-887 may only be started up, operated, maintained and cleaned by authorized and qualified staff.

2.2.2 Safety Measures during Installation

- Install the C-887 near the power source so that the power plug can be quickly and easily disconnected from the mains.
- Use the supplied power cord to connect the C-887 to the power source.
- If the supplied power cord must be replaced, use a power cord with sufficient ratings.

High temperatures can overheat the C-887.

- Set up the C-887 with a distance of at least 10 cm to the front and rear panels and at least 5 cm to the sides. If this is not possible, make sure that the area is cooled sufficiently.
- Ensure sufficient ventilation at the place of installation.
- Keep the ambient temperature to a non-critical level (<40° C).
- Make sure that the ventilation holes of the case are always free.
- Clean the air filter in the front panel of the case if necessary (p. 95).

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

- Only hold the Hexapod by the base plate.
- Before installing the load, determine the limit value for the load of the Hexapod with a simulation program (p. 46).
- Before installing the load, determine the work space of the Hexapod with a simulation program (p. 46).
- Make sure that the installed load observes the limit value determined with the simulation program.
- Avoid high forces and torques on the moving platform during installation of the Hexapod and the load.
- Ensure an uninterruptible power supply in order to prevent an unintentional deactivation of the Hexapod system and resulting unintentional position changes of the Hexapod.
- Make sure that no collisions between the Hexapod, the load to be moved and the environment are possible in the work space of the Hexapod.

The C-887 and the optionally available add-on cards contain electrostatic-sensitive devices (ESD) and can be damaged if handled improperly.

- Avoid touching assemblies, pins and PCB traces.
- Before you touch the C-887 or the add-on cards, discharge yourself of any electric charges:
 - Wear an antistatic wrist strap
or
 - Before touching an electronic component, briefly touch a conducting, grounded object.
- Only handle and store the C-887 and the add-on cards in environments that dissipate existing static charges to earth in a controlled way and prevent electrostatic charges (ESD protected workstation or electrostatically protected area, in short EPA).

The P-611.3SF NanoCube® stage of the F-206.NCU option is driven by piezo actuators. Temperature changes and compressive stresses can induce charges in piezo actuators. After being disconnected from the electronics, piezo actuators can also stay charged for several hours. Touching or short-circuiting the contacts in the connector of the P-611.3SF NanoCube® stage can lead to minor injuries. In addition, the piezo actuators can be destroyed by an abrupt contraction.

- Do **not** pull out the connector from the electronics during operation.
- Do **not** touch the contacts in the connector.
- Secure the connector of the stage with screws against being pulled out of the controller.

2.2.3 Measures during Start-Up and Operation

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

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

When the communication between the C-887 and the PC is established via TCP/IP, the PC software offers all controllers present in the same network for selection. After a C-887 has been selected for the connection, all commands are sent to this controller. If the wrong controller is selected, the operating and maintenance staff of the connected Hexapod are at risk of slight injury from crushing due to unexpectedly supplied motion commands.

- If several C-887 are displayed in the PC software, make sure that you select the right C-887.

If a protective earth conductor is not or not properly connected, dangerous touch voltages can occur and there is a risk of electric shock. In the case of a malfunction or failure of the system, touching the P-611.3SF NanoCube® stage of the F-206.NCU option can result in slight injuries.

- Connect the P-611.3SF NanoCube® stage to a protective earth conductor before start-up. Follow the instructions in the Technical Note F206T0021 (included in the scope of delivery of the F-206.NCU option).
- Do **not** remove the protective earth conductor during operation.

- If the protective earth conductor has to be temporarily removed (e.g. for modifications), reconnect the P-611.3SF NanoCube® stage to the protective earth conductor before starting it up again.

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.
- Only operate the Hexapod with a Hexapod controller whose geometrical data is adapted to the Hexapod.

Damage can occur to the Hexapod if the transport lock of the Hexapod has been not removed and a motion is commanded.

- Remove the transport lock before you start up the Hexapod system.

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

General measures for avoiding collisions:

- Make sure that no collisions between the Hexapod, the load to be moved and the environment are possible in the work space of the Hexapod.
- Do not place any objects in areas where they can get caught by moving parts.
- If the Hexapod controller malfunctions, stop the motion immediately.
- Please note that the Hexapod moves unpredictably during a reference move and **no** collision check or prevention occurs.

Depending on the source of the motion profile, the platform of the Hexapod can move along an undefined path under certain conditions. As a result, collisions are possible between the Hexapod, the load to be moved and the environment.

When the motion profile is determined by the trajectory generator of the C-887 (default):

- Avoid sending new target positions while the Hexapod (axes X, Y, Z, U, V, W) is still moving.

- If new target positions have to be sent while the Hexapod is still moving (axes X, Y, Z, U, V, W): Only use motion commands to set target positions that maximally deviate from the current position by the value of the **Path Control Step Size** parameter (ID 0x19001504).

When the motion profile is determined by consecutive **MOV** commands:

- Only set target positions whose distance from each other is maximally as large as the value of the **Path Control Step Size** parameter (ID 0x19001504) with consecutive **MOV** commands.

When an E-760 controller card is installed in the C-887.11, unintentional motions can be caused by a lack of signal transmission. As a result, collisions are possible between the Hexapod, the load to be moved, and the environment.

- Before switching on or rebooting the C-887.11, make sure that the P-611.3SF NanoCube® stage is connected to the E-760 controller card via the Sub-D 25 (f) socket (p. 55).

When the actual load of the moving platform of the Hexapod exceeds the maximum holding force based on the self-locking of the actuators, switching off the servo mode for the axes of the moving platform of the Hexapod can cause unintentional position changes of the Hexapod. As a result, collisions between the Hexapod, the load to be moved and the environment are possible, and the scanning procedure can end with an unsatisfactory result. Measures for avoiding tipping:

- Select suitable values for paths and angles. For the Hexapod models H-810, H-811 and H-206, 0.2 mm or 0.2 degrees should not be exceeded; for other Hexapod models, the ideal values must be determined experimentally.
- Suitably align the moving platform before the scanning procedure.
- Use suitable holders for the inputs and/or outputs of the optical element to be aligned on the moving platform so that the motion during the scanning procedure only takes place over short distances or angles.

During a scanning procedure started with the FSA command, the scanning area can increase up to double the original area. As a result, collisions are possible between the Hexapod, the load to be moved and the environment.

- Make sure that the platform can safely move outside of the originally specified scanning area as well.

When the actual load of the moving platform of the Hexapod exceeds the maximum holding force based on the self-locking of the actuators, switching off the servo mode for the axes of the moving platform of the Hexapod can cause unintentional position changes of the Hexapod. As a result, collisions are possible between the Hexapod, the load to be moved, and the environment.

- Make sure that the actual load of the moving platform of the Hexapod does not exceed the maximum holding force based on the self-locking of the actuators before you switch off the servo mode, reboot or switch off the C-887.
- Ensure an uninterruptible power supply in order to prevent an unintentional deactivation of the Hexapod system and resulting unintentional position changes of the Hexapod.

Unsuitable parameter settings can lead to improper operation or damage to the connected mechanical system.

- Only change parameters after careful consideration.

2.2.4 Safety Measures during Maintenance

The C-887 contains electrostatic-sensitive devices (ESD) that can be damaged in the case of short circuits or flashovers.

- Before cleaning the case and the air filter, disconnect the C-887 from the power source by pulling the power plug.

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

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

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

During a strut test, the Hexapod moves unpredictably. **No** collision check or prevention takes place, even when a configuration for collision prevention has been stored on the C-887 with the PIVeriMove Software for the Collision Check. Soft limits that have been set for the moving platform of the Hexapod with the `NLM` and `PLM` commands are ignored during a strut test. As a result, collisions are possible between the Hexapod, the load to be moved, and the environment.

- Make sure that no collisions are possible between the Hexapod, the load to be moved and the environment during a strut test of the Hexapod.
- Do not place any objects in areas where they can get caught by moving parts during a strut test.
- Observe the Hexapod during a strut test in order to be able to intervene quickly in the case of malfunctions.

During a strut test, the Hexapod strut can reach a limit switch. As a result, the servo mode is automatically switched off for the axes of the moving platform of the Hexapod. Switching off the servo mode can cause unintentional position changes of the Hexapod. As a result, collisions are possible between the Hexapod, the load to be moved, and the environment.

- Make sure that the actual load of the moving platform of the Hexapod does not exceed the maximum holding force based on the self-locking of the actuators before you start a strut test.

3 Product Description

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3.1 Features and Applications

General

The C-887 Hexapod controller is used to control a Hexapod in six degrees of freedom with a very high positioning accuracy.

The controller forms a Hexapod system together with a cable set and a Hexapod. A Hexapod system offers translations in the direction of the X, Y and Z axes as well as rotations around each of these three axes.

The C-887 drives the DC motors of the six Hexapod struts in closed-loop operation. The Hexapod struts carry the moving platform and bring it into the desired position.

Positioning commands use Cartesian coordinates. The C-887 converts these into the respective positions and velocities of the Hexapod struts before the moving platform moves to the desired position.

The product features of the C-887 include:

- TCP/IP and RS-232 interface for communication
- Four USB connections, e.g., for the C-887.MC operating unit (available as an accessory), a keyboard or a mouse
- Communication is also possible via a connected keyboard and connected VGA monitor without connecting the C-887 to a PC
- Parameters for configuring the properties of the C-887
- Non-volatile macro memory
- Data Recorder

- Comprehensive software package available, including the Hexapod Simulation Software program for determining the work space and the maximum loads of the Hexapod
- Real-time operating system
- Command set available in GCS syntax version 1.0 for downwards compatibility and in the current GCS syntax version 2.0 (default)
- Available in two versions:
 - in a 19" case including the control of two additional axes and extendable by add-on cards (C-887.11) (p. 24)or
 - as a compact bench-top (C-887.21)

Simple system connection

Parameters can be set and checked with the PC software. The start-up and system configuration takes place via the PIMikroMove program included in the scope of delivery. Connection to the customer's software is possible via LabView driver and shared library. The programming of the system is identical for all PI controllers. The combined control of different controllers is therefore easily possible.

Data recorder

The current position and the target position for the Hexapod axes, among others, can be recorded over time with the data recorder. The recorded values are saved in data recorder tables and can be conveniently read out, e.g., with PIMikroMove.

Furthermore, the velocities and the accelerations commanded by C-887 for the individual struts of the Hexapod, and if present, for the axes A and B, for example, can be calculated from the recorded data with PIMikroMove.

Operating system

The C-887 uses a real-time operating system.

Further software

The Hexapod Simulation Software program is included on the supplied C-887.CD. This program can be used to calculate, e.g., the load of the individual struts for the Hexapod depending on the mounted load and the Hexapod position. This prevents the Hexapod from being overloaded.

The controller itself and the connected Hexapod can be simulated on a PC with Windows operating system using various other programs from the supplied C-887.CD.

The PIVeriMove Software for the Collision Check can be ordered as an optional accessory. With PIVeriMove the environment and the load on the moving platform of the Hexapod can be defined and simulated. This configuration can be stored on the controller. Thus the controller can prevent collisions independently of the PC by calculating all distances between the defined components and comparing them with a given safety distance online after it has received move commands.

3.2 Model Overview

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

Possible system components

Standard versions of the C-887 Hexapod controller:

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

Standard versions of the Hexapod:

Model family	Name
H-206	Hexapod for 6D alignment and micromanipulation
H-811	Miniature Hexapod microrobot, direct drive, vacuum-compatible version available
H-820	Hexapod microrobot, basic model
H-824	Compact Hexapod microrobot, versions with gearhead and direct drive each also available with vacuum compatibility
H-840	Hexapod microrobot, versions with gearhead and direct drive available
H-850	Hexapod microrobot with excellent repeatability, gearhead; versions available for higher loads or higher velocities, each also available with vacuum compatibility

For detailed lists of the available models, see the manual of the respective Hexapod model family.

Standard cable sets:

Model	Name
C-887.A03	Hexapod cable set 3 m, consisting of: <ul style="list-style-type: none"> Data transmission cable, MDR68 to MDR68, 1:1 (K040B0034) Power supply cable, M12m 180° to M12f 90° (K060B0111)
C-887.V02	Hexapod cable set 2 m on the vacuum side, vacuum feedthrough, 3 m on the air side, consisting of: <ul style="list-style-type: none"> Data transmission cable on the vacuum side, MDR68m to HD Sub-D 78m, 2 m (M824B0010) Power supply cable on the vacuum side, LEMO 2-pin to LEMO 2-pin, 2 m (K060B0132) Vacuum feedthrough for data transmission, HD Sub-D 78m/f (4668) Vacuum feedthrough for power source, LEMO 2-pin to M12m (C887B0002) Data transmission cable on the air side, HD Sub-D 78f to MDR68m, 3 m (K040B0092) Power supply cable on the air side, M12m to M12f, 3 m (K060B0112)

Available Hexapod systems

A Hexapod system consists of a Hexapod controller, a Hexapod and a cable set. The order number of the system reflects which system components are combined in the system.

For detailed lists of the available Hexapod systems, see the manual of the respective Hexapod model family. The following table is for general orientation:

System order number	Description
H-xxx.x11	Hexapod system with C-887.11 controller and C-887.A03 cable set; Hexapod not vacuum-compatible
H-xxx.x12	Hexapod system with C-887.21 controller and C-887.A03 cable set; Hexapod not vacuum-compatible
H-xxx.xV1	Hexapod system with C-887.11 controller and C-887.V02 cable set; Hexapod vacuum-compatible
H-xxx.xV2	Hexapod system with C-887.21 controller and C-887.V02 cable set; Hexapod vacuum-compatible

3.3 Product View

3.3.1 Front Panel

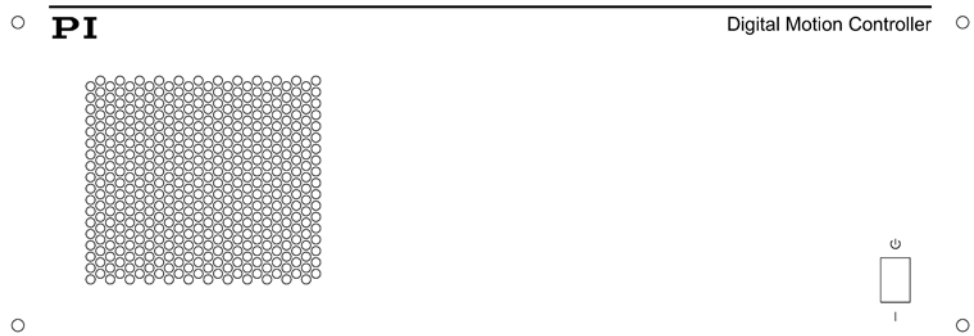


Figure 1: C-887.11 front panel

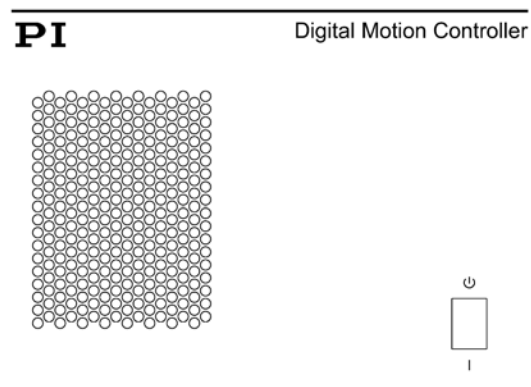













Figure 2: C-887.21 front panel

Labeling	Function
	Standby switch: <ul style="list-style-type: none">  position: C-887 is switched off, various internal components remain in standby mode  position: C-887 is switched on

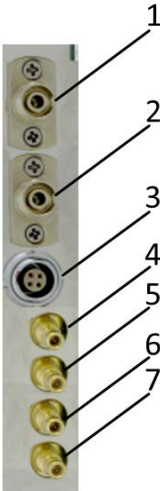
3.3.2 Rear Panel

All C-887 models			
	Labeling	Type, pin assignment	Function
	2x 24 VDC Power Out	A-coded, 4-pin M12 socket (f) (p. 111)	<p>Two connections:</p> <ul style="list-style-type: none"> Power source connection for Hexapod Only when a cable set with line driver boxes is used: power source connection for line driver box <p>The connections can be assigned as desired.</p>
	Universal serial bus	USB type A	Four USB interfaces for connecting peripheral devices, e.g., for keyboard, mouse, or C-887.MC control unit
	VGA	Mini-HD Sub-D 15 (f)	VGA connection for monitor
	LAN	RJ45 socket	Network connection via TCP/IP (p. 34)
	RS-232	Sub-D 9 (m) (p. 113)	Serial connection to PC (p. 34)
	Hexapod	MDR68 (f) (p. 111)	Connection for data transmission between Hexapod and controller

Only C-887.11:			
	Labeling	Type, pin assignment	Function
	A, B	Sub-D 15(f) (p. 113)	<p>Two connections for stages. Only for DC motors!</p> <ul style="list-style-type: none"> Output of PWM signals for the stage Input of the signals of the incremental position sensor Input of the reference switch signal

Only C-887.11 and only when the E-760.3S0 controller card (F-206.NCU option) is installed:			
	Labeling	Type, pin assignment	Function
	Nanocube	Sub-D 25 (f) (p. 114)	<p>Connection for P-611.3SF NanoCube® stage:</p> <ul style="list-style-type: none"> Output of the operating voltage for the 3 piezo actuators, -20 V to +120 V Input of the signals of the 3 strain gauge sensors
		RJ45 socket (p. 115)	Connection for an analog input line
		FC with protective cap	Reserved (photodiode not populated)

Only C-887.11 and only when at least one photometer card (F-206.VVU and F-206.iiU options) is installed. Connections per photometer card:

	No.	Labeling, when pre- installed	Type	Function
	1	FC1	FC	Connection for optical input signal 1: for processing with the C-887 the signal must be fed through analog output 1 to analog input 1 (p. 55).
	2	FC2	FC	Connection for optical input signal 2: for processing with the C-887 the signal must be fed through analog output 2 to analog input 2 (p. 55).
	3	-	LEMO 4 (f)	Reserved
	4	IN	SMB socket	Analog input 1, 0 to 10 V (p. 108), can be used as: <ul style="list-style-type: none"> Input for converted signal of optical input 1 or <ul style="list-style-type: none"> Input for the analog signal of an external sensor
	5	IN	SMB socket	Analog input 2, 0 to 10 V (p. 108), can be used as: <ul style="list-style-type: none"> Input for converted signal of optical input 2 or <ul style="list-style-type: none"> Input for the analog signal of an external sensor
	6	OUT	SMB socket	Analog input 1: <ul style="list-style-type: none"> Output of the converted signal of optical input 1; 0 to 10 V (p. 108)
	7	OUT	SMB socket	Analog input 2: <ul style="list-style-type: none"> Output of the converted signal of optical input 2; 0 to 10 V (p. 108)

3.4 Scope of Delivery

The following table contains the scope of delivery of the Hexapod controller. The scope of delivery of the Hexapod and the cable set of the Hexapod system is listed in the user manual of the Hexapod.

Order Number	Items
C-887	Hexapod controller according to your order
3763	Power cord
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
36711	US keyboard with USB connection
3683	Torx screwdriver for opening the case
	Only C-887.21: 2 mounting brackets for fastening the case on a surface
Documentation, consisting of:	
MS204Equ	Short version of the user manual for the C-887
C-887.CD	CD with PC software and documentation
A000T0028	Technical Note on Using the PI Update Finder
A000T0032	Technical Note on Updating the PI Software using the PI Update Finder
Packaging material	

3.5 Accessories

3.5.1 Overview

Order Number	Description
C-887.A20	Hexapod cable set 20 m, consisting of: <ul style="list-style-type: none"> ▪ Line driver box for data transmission cable, controller-side (C030B0011) ▪ Line driver box for data transmission cable, Hexapod-side (C030B0012) ▪ 2 data transmission cables, MDR68 to MDR68, 1:1, 3 m (K040B0034) ▪ Data transmission cables, MDR68 to MDR68, 1:1, 3 m (K040B0034) ▪ Power supply cable for line driver box, with M12 coupling/M12 connector, 17 m (K060B0126) ▪ Power supply cable for Hexapod, with M12 coupling/M12 connector, 20 m (K060B0127)
C-887.MC	<ul style="list-style-type: none"> ▪ Hexapod Control Unit, USB Connector, 3 m Cable ▪ Technical Note C887T0003
C-887.VM1	<ul style="list-style-type: none"> ▪ PIVeriMove Software for the Collision Check ▪ Technical Note C887T0002
F-311.LV	PIMotion&Vision LabVIEW Driver Set

Only for C-887.11:

Order Number	Description
M-0xx, M-1xx, M-2xx, M-4xx, M-5xx	Stages from the PI product area of micropositioning technology that are equipped with a DC motor and PWM amplifier. Information on suitable models on request.

Order Number	Description
F-206.iiU	<ul style="list-style-type: none"> ▪ Photometer Card, IR Range, 2 Channels ▪ 2 SMB/SMB cables for connecting an analog output with the corresponding analog input ▪ Technical Note F206T0020 for the photometer card
F-206.VVU	<ul style="list-style-type: none"> ▪ Photometer Card, Visible Range, 2 Channels ▪ 2 SMB/SMB cables for connecting an analog output with the corresponding analog input ▪ Technical Note F206T0020 for the photometer card
F-206.NCU	<ul style="list-style-type: none"> ▪ Rapid 3-Axis Piezo Nanopositioning System for Use in Combination with Hexapod Systems. Consists of P-611.3SF NanoCube® XYZ Nanopositioning System, 100 x 100 x 100 µm, Strain Gauge Sensors with Integrated Fiber Adapter Interface and E-760.3S0 NanoCube® Piezo Controller Board, ISA Bus ▪ Mounting bracket for P-611.3SF NanoCube® (F20601127) ▪ Extension cable 1.5 m (P-611K006) ▪ Technical note F206T0021 on handling the piezo nanopositioning system

➤ To order, contact our customer service department (p. 103).

3.5.2 C-887.VM1 PIVeriMove as an Option for Collision Checking - See detailed user manual

You can find information on this topic in the detailed MS204E user manual which is included as a PDF file on the product CD.

3.5.3 F-206.VVU and F-206.iiU Photometer Cards - See detailed user manual

You can find information on this topic in the detailed MS204E user manual which is included as a PDF file on the product CD.

3.5.4 F-206.NCU Piezo Nanopositioning System - See detailed user manual

You can find information on this topic in the detailed MS204E user manual which is included as a PDF file on the product CD.

3.6 Functional Principles

3.6.1 Commandable Items

The following table contains the items that can be accessed with commands of the GCS (p. 87).

Item	Number	Identifier	Description
Logical axis	6	X, Y, Z, U, V, W	The logical axes X to W reproduce the translations and rotations of the moving platform of the Hexapod in the firmware of the C-887. Translation axes: X, Y and Z Rotation axes: U, V and W
Logical axis	2	A, B	Only C-887.11: The logical axes A and B reproduce the motion of additional stages with DC motors in the firmware of the C-887.
Logical axis	3	K, L, M	Only C-887.11 and only when the E-760 controller card (F-206.NCU option) is installed: The logical axes K, L and M reproduce the motion of the P-611.3SF NanoCube® in the firmware of the C-887.
Hexapod strut	6	1 to 6	The Hexapod struts are not accessible for motion commands but can be selected as data sources for recording with the data recorder for diagnostic purposes, see also DRC and HDR? .

Item	Number	Identifier	Description
Input signal channels (optional)	Maximum of 6	1 to 6	<p>Only C-887.11 and only when at least one photometer card (F--206.iiU and F-206.VVU options) and/or the E-760.3S0 controller card (F-206.NCU option) is installed:</p> <p>Channels of the analog inputs; the identifier is assigned to the input signal channels in the following order:</p> <ul style="list-style-type: none"> ▪ 1 and 2: first photometer card ▪ 3 and 4: second photometer card ▪ E-760.3S0 controller card: <ul style="list-style-type: none"> – 2 when no photometer card is installed – 4, when only one photometer card is installed – 6, when two photometer cards are installed <p>The TAC? command gets the number of installed analog inputs.</p>
Data recorder table	16	1 to 16	<p>The data recorder tables contain the recorded data. The C-887 has 16 data recorder tables (query with TNR?) with max. 10,240 data points per table.</p> <p>The number of points per data recorder table can be set with the Data Recorder Points Per Table parameter (ID 0x16000201).</p>
Overall system	1	1	C-887 as an overall system.

3.6.2 Important Components of the Firmware

The firmware of the C-887 provides the following functional units:

Firmware component	Description
ASCII commands	<p>The communication with the C-887 can be carried out with the commands of the PI General Command Set (GCS; syntax version 2.0 or syntax version 1.0). The GCS is independent of the hardware (controller, connected Hexapod). Examples of the use of GCS:</p> <ul style="list-style-type: none"> ▪ Starting motions of the Hexapod ▪ Getting system and motion values <p>The available commands are listed in "Overview of Commands for GCS 2.0" (p. 89).</p>
Configuration files, stage databases, parameters	<p>The settings that are used to adapt the C-887, e.g., to the properties of the connected mechanical system or the communication interfaces used are determined by:</p> <ul style="list-style-type: none"> ▪ Configuration files and stage databases: Only accessible for the customer service department (p. 103) ▪ Interface parameters: Adaptation in the non-volatile memory possible, further information in "Establishing Communication via the TCP/IP Interface" (p. 69) and "Establishing Communication via the RS-232 Interface" (p. 79) ▪ Volatilely configurable parameters: further information in "Adjusting Settings" (p. 93)
Data recorder	<p>The C-887 contains a real-time data recorder. This can record different input and output signals (e.g. current position, commanded position) from different data sources (e. g. logical axes, input signal channels) (p. 85).</p>
Macros	<p>The C-887 can save macros. Command sequences can be defined and permanently stored via the macro function. A start-up macro can be defined that is executed each time that the C-887 is switched on or rebooted. This simplifies operation without a connected PC. For more information, see "Controller Macros" (p. 85).</p>
User interface	<p>The user interface of the C-887 can be used to get and set the system configuration as well as for test purposes (p. 64).</p>

The firmware can be updated with a tool (p. 97).

3.6.3 Triggering Motions

Motions are triggered by move commands. Possibilities for sending motion commands:

- Direct entry of commands or usage of control elements in the user interface of the C-887 (p. 64)
- Direct entry of commands or usage of control elements in the PC software (connected via TCP/IP or RS-232 interface)
- Control unit C-887.MC for the axes of the moving platform of the Hexapod (X, Y, Z, U, V, W)
- Controller macros (p. 85) with motion commands : Any commands can be sent via the communication interfaces of the C-887 when a macro is running on the controller. The macro content and move commands received via the communication interfaces may overwrite each other.

Commands	Description
MOV	Motion to absolute target position
MVR	Motion to relative target position Is sent by the C-887.MC control unit. In this case, the step size of the motion equates the setting made with the SST command.
IMP	Starts an impulse and triggers data recording
STE	Starts a step and triggers data recording
FRF	Starts a reference move Can also be sent by the C-887.MC control unit.
AAP, FIO, FLM, FLS, FSA, FSC, FSM	Starting of scanning procedures

INFORMATION

For the axes of the moving platform of the Hexapod (X, Y, Z, U, V, W) and axes A and B, motions can only be commanded after a successful reference move (also referred to as "initialization").

3.6.4 Motions of the Hexapod

Rotations

Rotations take place around the pivot point. The coordinates of the pivot point are determined with the **SPI** command. A given rotation in space is calculated from the individual rotations in the order U -> V -> W. This takes place regardless of whether the values for U, V and W were explicitly given with the current command or result from the previous commands.

Further information can be found in the manual of the Hexapod.

Motion profile

Depending on the parameter setting, the motion profile (p. 3) for the axes of the Hexapod (X, Y, Z, U, V, W) is specified by one of the two following sources:

- Trajectory generator of the C-887
- Consecutive MOV commands

The motion profile is configured with the following parameters:

Parameter	Description and possible values
Maximum System Velocity (Phys. Unit/s) 0x19001500	Maximum system velocity This parameter is write-protected and is adapted to the Hexapod of the Hexapod system before delivery. Upper limit of the velocity for the moving platform of the Hexapod that can be set with VLS .
Minimum System Velocity (Phys. Unit/s) 0x19001501	Minimum system velocity This parameter is write-protected and is adapted to the Hexapod of the Hexapod system before delivery. Depends on the smallest step size of the Hexapod. Lower limit of the velocity for the moving platform of the Hexapod that can be set with VLS .
Maximum System Acceleration (Phys. Unit/s²) 0x19001502	Maximum system acceleration This parameter is write-protected and is adapted to the Hexapod of the Hexapod system before delivery.

Parameter	Description and possible values
Path Control Step Size (mm) 0x19001504	<p>Step size for the trajectory calculation of the platform motion</p> <p>This parameter is write-protected and is adapted to the Hexapod of the Hexapod system before delivery.</p> <p>This parameter is only evaluated when the parameter 0x19001900 has the value 0.</p> <p>If the parameter 0x19001900 has the value 1: The distance of the target positions set with consecutive MOV commands to each other may only be maximally as large as the value of the parameter 0x19001504, in order to avoid tilting the Hexapod.</p>
Trajectory Source 0x19001900	<p>Source of the motion profile</p> <p>0 = Motion profile is determined by the trajectory generator (default). During a motion, any given new motion command sets the target position to a new value and the moving platform immediately approaches the new target position on an undefined path.</p> <p>1 = Motion profile is determined by consecutive MOV commands. Other motion commands (e.g., MVR, IMP and STE, commands for starting scanning procedures) are not permitted.</p>
Trajectory Execution 0x19001901	<p>Execution of the motion profile</p> <p>Determines how the motion profile defined by consecutive MOV commands is executed:</p> <p>0 = Motion profile is immediately executed (default)</p> <p>1 = Motion profile is stored in a buffer before execution</p> <p>This parameter is only evaluated when the parameter 0x19001900 has the value 1.</p>
Maximum Number of Trajectory Points 0x19001902	<p>Maximum number of motion profile points</p> <p>Indicates the maximum size of the buffer.</p> <p>This parameter is write-protected and only evaluated when the parameters 0x19001900 and 0x19001901 both have the value 1.</p>

Parameter	Description and possible values
Threshold for Trajectory Execution 0x19001903	Threshold value for executing the motion profile Determines how many motion profile points have to be stored in the buffer (by consecutive MOV commands) until the execution of the motion profile begins. This parameter is only evaluated when the parameters 0x19001900 and 0x19001901 both have the value 1.
Current Number Threshold for Trajectory Execution 0x19001904	Shows the current number of motion profile points in the buffer. The parameter value is always 0 when the motion profile is determined by the trajectory generator or the motion profile defined by consecutive MOV commands is immediately executed. This parameter is write-protected.

The motion profile is configured with the following commands:

Command	Syntax	Function
SCT	SCT "T" <CycleTime>	Determines the cycle time for executing a motion profile. The setting is only in effect when the Trajectory Source parameter (ID 0x19001900) has the value 1. The cycle time is used to calculate the velocity during the motion so that the specified points of the motion profile are each reached precisely at the end of the time interval (where possible with regard to the velocity and acceleration limits).
VLS	VLS <SystemVelocity>	Sets the velocity for the moving platform of the Hexapod. Limits the velocities of the individual struts when the Trajectory Source parameter (ID 0x19001900) has the value 1.

The **#11** command gets the free memory space of the buffer, the contents of which determine the motion profile of the Hexapod, when the parameters 0x19001900 and 0x19001901 both have the value 1.

INFORMATION

When the **Trajectory Execution** parameter (ID 0x19001900) has the value 1: For PC's with a Windows operating system, it is not ensured that consecutive **MOV** commands are sent in the required time unit, due to the lack of real-time capability of the operating system.

- If the motion profile is already determined, store it in a buffer before execution, in order to ensure that the cycle time is observed. For this purpose, use **SPA** to set the **Trajectory Execution** parameter (ID 0x19001901) to the value 1.
- For a meaningful use of the buffer, increase the value of the **Threshold for Trajectory Execution** parameter (0x19001903) with **SPA** (default = 1).

Checking the motion profile created by the trajectory generator

When the motion profile for the Hexapod is created by the trajectory generator (parameter 0x19001900 has the value 0), a check is carried out before the start of each motion whether the moving platform can actually reach the nodes of the calculated trajectory and the commanded target position. If a node or the target position cannot be reached, the motion is not executed. The following is checked:

- Are the nodes and the target position outside of the travel range limits that can be queried with **TMN?** and **TMX?**?
- Have the soft limits set with **NLM** and **PLM** been activated with **SSL**, and if yes, are the nodes and the target position outside of these soft limits?
- Are the individual struts able to move the platform to the specified position?
- When a configuration for collision avoidance has been stored on the C-887 with the optionally available PIVeriMove Software for the Collision Check: Do collisions occur between the following groups?
 - Environment incl. base plate of the Hexapod
 - Hexapod struts
 - Moving platform of the Hexapod incl. load

The **VMO?** command queries whether a specified target position can be reached.

3.7 Communication Interfaces

Available communication interfaces

The C-887 can be controlled with ASCII commands via the following interfaces:

- From the PC:
 - TCP/IP
 - Serial RS-232 connection
- User interface, accessible via keyboard, mouse, and monitor connection directly on the C-887
- C-887.MC Hexapod Control Unit (available as accessory), connected directly to the C-887

3.8 Overview of PC Software

The following table shows the PC software that is included in the C-887 CD. The given operating systems stand for the following versions:

- Windows: XP, Vista, and 7
- Linux: Kernel 2.6, GTK 2.0, glibc 2.4

PC software	Supporting operating system	Short description	Recommended use
Dynamic program library for GCS	Windows, Linux	Allows software programming for the C-887 with programming languages such as C++. The functions in the dynamic program library are based on the PI General Command Set (GCS).	For users who would like to use a dynamic program library for their application.

PC software	Supporting operating system	Short description	Recommended use
LabVIEW driver	Windows, Linux	LabVIEW is a software for data acquisition and process control (must be ordered separately from National Instruments). The C-887 LabVIEW software is a collection of virtual instrument drivers (VI drivers) for the C-887 controller. These drivers support GCS.	For users who want to use LabVIEW to program their application.
PIMikroMove	Windows	<p>Graphic user interface for Windows with which the C-887 and other controllers from PI can be used.</p> <ul style="list-style-type: none"> ▪ The system can be started without programming effort ▪ Graphic representation of the motions ▪ Macro functionality for storing command sequences on the PC (host macros) ▪ Complete environment for command entry, for testing different commands <p>No command knowledge is necessary to operate the PIMikroMove. PIMikroMove uses the dynamic program library to supply commands to the controller.</p>	For users who want to perform simple automation tasks or test their equipment before or instead of programming an application. A log window showing the commands sent makes it possible to learn how to use the commands.
PITerminal	Windows	Simple graphic user interface for Windows that can be used for nearly all PI controllers (see PIMikroMove user manual).	For users who want to send GCS commands directly to the controller.
PI Update Finder	Windows	Checks the PI software installed on the PC. If more current versions of the PC software are available on the PI server, downloading is offered.	For users who want to update the PC software.

PC software	Supporting operating system	Short description	Recommended use
Hexapod Simulation Software	Windows	Simulation program with which the work space and the load of the Hexapod must be calculated before the Hexapod is installed.	For all users.
Simulation of the controller and Hexapod	Windows	Program with which the C-887 and the connected Hexapod as well as the axes A, B, K, L and M can be simulated. The simulated Hexapod system can be operated with PIMikroMove, for example.	For users who would like to test the behavior of the Hexapod systems when the Hexapod controller and/or the Hexapod are not available.
PI Hexapod Controller Update Wizard	Windows	Program for updating the firmware of the C-887.	For users who want to update the firmware.

INFORMATION

The separately available manuals for PC software are listed in "Other Applicable Documents" (p. 5) and are found on the product CD.

4 Unpacking

1. Unpack the C-887 with care.
2. Compare the contents against the items covered by the contract and against the packing list.
3. Inspect the contents for signs of damage. If parts are missing or you notice signs of damage, contact PI immediately.
4. Keep all packaging materials in case the product needs to be returned.

5 Installation

In this Chapter

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5.1 General Notes on Installation

The Hexapod can be mounted in any orientation.

NOTICE**Impermissible mechanical load and collisions!**

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

- Only hold the Hexapod by the base plate.
- Before installing the load, determine the limit value for the load of the Hexapod with a simulation program (p. 46).
The limit values determined with the simulation program are only valid when the Hexapod controller has the servo mode switched on for the axes of the moving platform of the connected Hexapod.
- Before installing the load, determine the working space of the Hexapod with a simulation program (p. 46).
The limits of the working space vary depending on the current position of the Hexapod (translation and rotation coordinates) and the current coordinates of the pivot point.
- Avoid high forces and torques on the moving platform during installation.
- Ensure an uninterruptible power supply in order to prevent an unintentional deactivation of the Hexapod system and resulting unintentional position changes of the Hexapod.
- Make sure that no collisions between the Hexapod, the load to be moved and the environment are possible in the working space of the Hexapod.

5.2 Ensuring Ventilation

High temperatures can overheat the C-887.

- Set up the C-887 with a distance of at least 10 cm to the front and rear panels and at least 5 cm to the sides. If this is not possible, make sure that the area is cooled sufficiently.
- Ensure sufficient ventilation at the place of installation.
- Keep the ambient temperature to a non-critical level (<40° C).
- Make sure that the ventilation holes of the case are always free.
- Clean the air filter in the front panel of the case if necessary (p. 95).


5.3 Installing the PC Software

5.3.1 Performing the Initial Installation

Accessories

- PC with a Windows operating system (XP, Vista, 7) or Linux operating system
- For installation from CD: product CD (included in the scope of delivery)

Installing the PC software on Windows

1. Start the installation wizard by double-clicking the  icon or the **setup.exe** file in the installation directory (root directory of the CD).
2. Follow the instructions on the screen.
You can choose between the default installation (typical) or the user-defined installation (customized). With the default installation (recommended), the following components are installed among others:
 - LabVIEW drivers
 - Dynamic program library for GCS
 - PIMikroMove
 - Hexapod Simulation Software simulation program
 - Program for updating the firmware of the C-887

Installing the PC software on Linux

1. Unpack the tar archive from the /linux directory of the product CD to a directory on your PC.
2. Open a terminal and go to the directory to which you have unpacked the tar archive.
3. Log on as a superuser (root rights).
4. Enter `./INSTALL` to start the installation.
Pay attention to lower and upper case when entering commands.
5. Follow the instructions on the screen.

You can select individual components for installation.

5.3.2 Installing Updates

Since the PC software is continually improved by PI, your product CD may no longer be up-to-date upon delivery.

- Always install the latest version of the PC software, provided that this makes sense for your application.

Prerequisite

- ✓ Active connection of the PC to the Internet.
 - If your PC does **not** have an Internet connection:
You have the Technical Note "Updating PI Software" (A000T0032) at hand. You can find the document either on the product CD or at <http://www.update.pi-portal.ws> in the zip file for the PI Update Finder.
- ✓ If your PC uses a Windows operating system:
 - If the PI Update Finder program is not on your product CD:
You have downloaded the PI Update Finder from <http://www.update.pi-portal.ws> and unpacked it from the zip file into a directory on your PC.
 - You have the Technical Note "PI Update Finder" (A000T0028) at hand. You can find the document either on the product CD or on in the zip file that you have downloaded for the PI Update Finder.
- ✓ If your PC uses a Linux operating system:
 - You have the user name and password for the C-887 at hand. Both of these can be found in the file "C-887 Releasenews_V_x_x_x.pdf" (x_x_x: version number of the CD) in the \Manuals folder on the product CD.

Updating the PC software on Windows

- Follow the instructions in the Technical Note for the PI Update Finder (A000T0028).
- If your PC does **not** have an Internet connection: Follow the instructions in the Technical Note "Updating PI Software" (A000T0032) as well.

Updating the PC software on Linux

1. Open the PI website (<http://www.pi.ws>).
2. In the **Resources** area on the start page, click **Manuals, Software, ISO Statements** on the left margin.
A selection list appears.
3. In the selection list, click **Software & Manuals on PI Support Server**.

4. In **User login** area on the left margin, enter your user name and password from the "xxx Releasenews.pdf" file from the product CD.
5. Click **Login**.
6. Click the category **C Motion Controllers / Hexapod Controllers**.
7. Click **C-887 > Software** (if you click **Documents** the latest versions of the corresponding manuals are displayed).
8. Underneath the latest CD mirror, click the **Download** button (also contains the manuals).
9. Save the downloaded archive file on the PC.
10. Unpack the file to a separate installation directory.
11. In the directory with the unpacked files, go to the linux subdirectory.
12. Unpack the archive file in the linux directory by entering the command `tar -xvpf <Name of the archive file>` on the console.
13. Read the accompanying information (readme file) on the software updating.
14. Log onto the PC as a superuser (root rights).
15. Only install the update if it is a good idea for your application.

5.4 Installing an Add-on Card in the C-887 - See detailed user manual

You can find information on this topic in the detailed MS204E user manual which is included as a PDF file on the product CD.

5.5 Fastening the Mounting Brackets on the C-887.21

INFORMATION

Mounting brackets for fastening the case to a surface are included in the scope of delivery of the C-887.21 model. The arrangement and the dimensions of the mounting holes in the mounting brackets can be found in the dimensional drawing (p. 109).

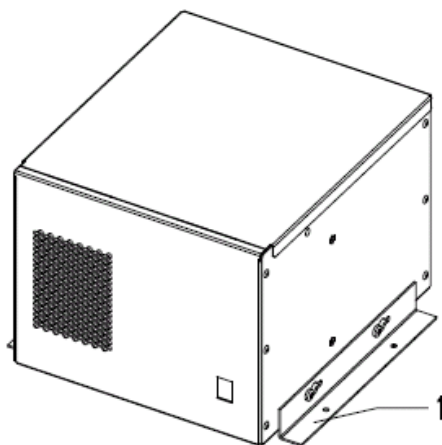


Figure 3: C-887.21 with mounting brackets

1 Mounting bracket

INFORMATION

The C-887.21 can also be mounted on a wall with a horizontal orientation of the mounting brackets, see the following figure.

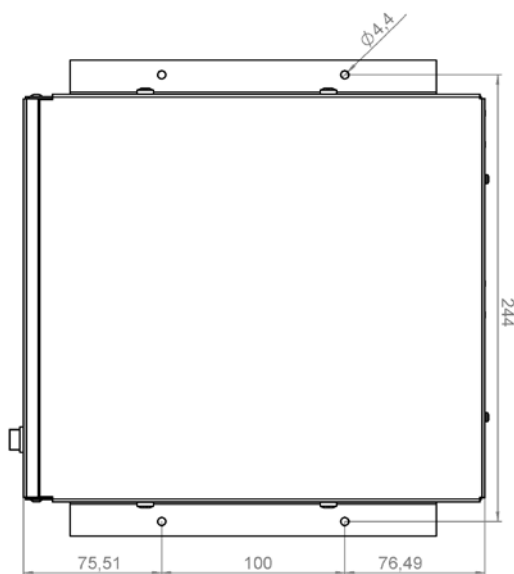


Figure 4: Vertical orientation of the C-887.21 for wall mounting

Prerequisite

- ✓ The C-887.21 is **not** connected to the power socket via the power cord.

Tools and accessories


- Two mounting brackets (included in the scope of delivery)
- Suitable Phillips-head screwdriver

Fastening the mounting brackets on the C-887.21

1. Loosen the two cross-head screws in the lower area of the side panel of the case until the screw heads protrude by approx. 2 mm.
2. Place the mounting bracket on the side panel of the case so that the screw heads protrude through the two longitudinal holes of the mounting bracket.
3. Push the mounting bracket onto the screws in the direction of the front panel or the rear panel of the case until the correct mounting position has been achieved.
4. Tighten the two screws.
5. Perform steps 1 to 4 for the other side panel of the case.

5.6 Connecting the C-887 to the Power Source

Prerequisites

- ✓ The C-887 is switched off, i.e., the standby switch is in the  position.
- ✓ The C-887 is installed near the power source so that the power plug can be quickly and easily disconnected from the mains.

Tools and accessories

- Supplied power cord
- Alternatively: power cord with sufficient ratings

Connecting the C-887 to the power source

1. Connect the power cord to the panel plug in the rear panel of the C-887.
2. Connect the C-887 to the power socket with the power cord.

5.7 Installing the Hexapod

5.7.1 Determining the Work Space and the Permissible Load of the Hexapod

INFORMATION

The limit value for the load of the Hexapod determined with the simulation program is only valid when the servo mode is switched on for the axes of the moving platform. The maximum holding force when the servo mode is switched off is based on the self-locking of the actuators in the Hexapod struts and is lower than the limit value when the servo mode is switched on (see manual of the Hexapod).

INFORMATION

The limit value for the load of the Hexapod varies depending on the following factors:

- Activation state of the servo mode
- Installation position of the Hexapod
- Load to be moved: mass and position of the center of mass
- Position (translation and rotation coordinates) of the moving platform of the Hexapod
- Forces and moments that are applied to the moving platform of the Hexapod.

INFORMATION

The limits of the work space vary depending on the current position of the Hexapod (translation and rotation coordinates) and the current coordinates of the pivot point.

INFORMATION

In the simulation program, the direction of the applied forces and moments corresponds to the axes of an absolute reference coordinate system (also referred to as the "world coordinate system"). The XYZ coordinate system of the Hexapod can deviate from the absolute reference coordinate system depending on the mounting position of the base plate.

Prerequisite

- ✓ The following data for the configuration of your Hexapod system is known:
 - Planned installation position of the Hexapod

- Load to be moved: mass and position of the center of mass on the moving platform
 - Forces and moments applied to the moving platform
 - Positions and orientations to be approached from the moving platform of the Hexapod during operation (translation and rotation coordinates)
- ✓ The PC is switched on.

Tools and accessories

- PC with Windows operating system on which the Hexapod Simulation Software simulation program is installed. For further information, see "Installing the PC Software" (p. 41).

Determining the work space and the permissible load of the Hexapod

1. Start the simulation program on the PC with the Start menu item **Programs > PI > C-887 > Hexapod Simulation Software**.
2. Load the geometrical data of the Hexapod for which you want to determine the permissible load:
 - a) In the main window, select the menu item **Main > Load Geometry**.
 - b) In the file selection window, go to the directory \PI\C-887\HexapodSimulation. The path in which the \PI directory is located was determined during the installation of the PC software, normally C:\Programs.
 - c) In the file selection window, select the file with the extension .dat that corresponds to your Hexapod.
 - d) In the file selection window, click **Open**.

The Hexapod is displayed in the main window.

3. If you do **not** use the default settings for the pivot point coordinates ($R = S = T = 0$): enter values for the pivot point coordinates R, S and T in the **Position** area.
4. In the **Position** area, enter the target positions for the axes X to W that correspond to a position of the moving platform to be approached during operation.

When the **LIMIT** display has a red background:

The moving platform **cannot** approach the position resulting from the given target position values.

- Change the target positions for the axes X to W until the **LIMIT** display has a green background.
5. Select the **Forces** tab in the main window.
 6. On the **Forces** tab, enter the values for the load and the position of the center of mass as well as the applied forces and moments:
 - **M**: mass of the load on the moving platform, in kg
 - **rx M, ry M, rz M**: Position of the center of mass of the load, in relation to the origin of the XYZ coordinate system of the Hexapod (0,0,0), in mm
 - **Fx, Fy, Fz**: applied force in the respective axis relative to the absolute reference coordinate system, in N.
 - **rx F, ry F, rz F**: Position of the application point of the force in relation to the origin of the XYZ coordinate system of the Hexapod (0,0,0), in mm
 - **Mx, My, Mz**: applied torque in the respective axis of the absolute reference coordinate system, in Nm.
 7. On the **Forces** tab, select the mounting position of the Hexapod in the **Mounting** area. The values for X, Y and Z refer to the XYZ coordinate system of the Hexapod.
 8. Read the result of the load calculation:

The simulation calculates the following values from your entries and displays them on the **Forces** tab underneath the **Mounting** area:

 - **F1 to F6**: forces that are applied to the individual struts of the Hexapod, in N
 - **Fres**: resulting force in the axes X, Y and Z of the absolute reference coordinate system, in N.
 - **Mres**: resulting moment in the axes X, Y and Z of the absolute reference coordinate system, in Nm.
 9. Evaluate the result of the load calculation (see also the two following figures):

Is at least one of the values for **F1** to **F6** shown in red?

If so:

- The permissible load of the Hexapod has been exceeded by the values that you have entered. The configuration for the installation of the Hexapod is **not** permissible for the current position of the moving platform. Change the values for the load and/or the position of the center of mass and/or the applied forces and moments and evaluate the result of the load calculation again.

If not:

- The load and the position of the center of mass as well as the applied forces and moments are permissible for the current position of the moving platform.

10. In the main window of the simulation program, select the **Workspace** tab.

11. Check the available work space from the current position:

- On the **Workspace** tab, click the **Workspace Reserve** button to find out the maximum distances that the axes can still move from the current position. The values are shown in the field to the right of the list of extreme values.
- On the **Workspace** tab, click the **Workspace XYZ** button to graphically display the available work space for the axis combination XYZ from the current position in the main window.
- On the **Workspace** tab, click the **Workspace UVW** button to graphically display the available work space for the axis combination UVW from the current position in the main window.

12. Repeat steps 4 to 11 for other positions of the moving platform to be approached during operation.

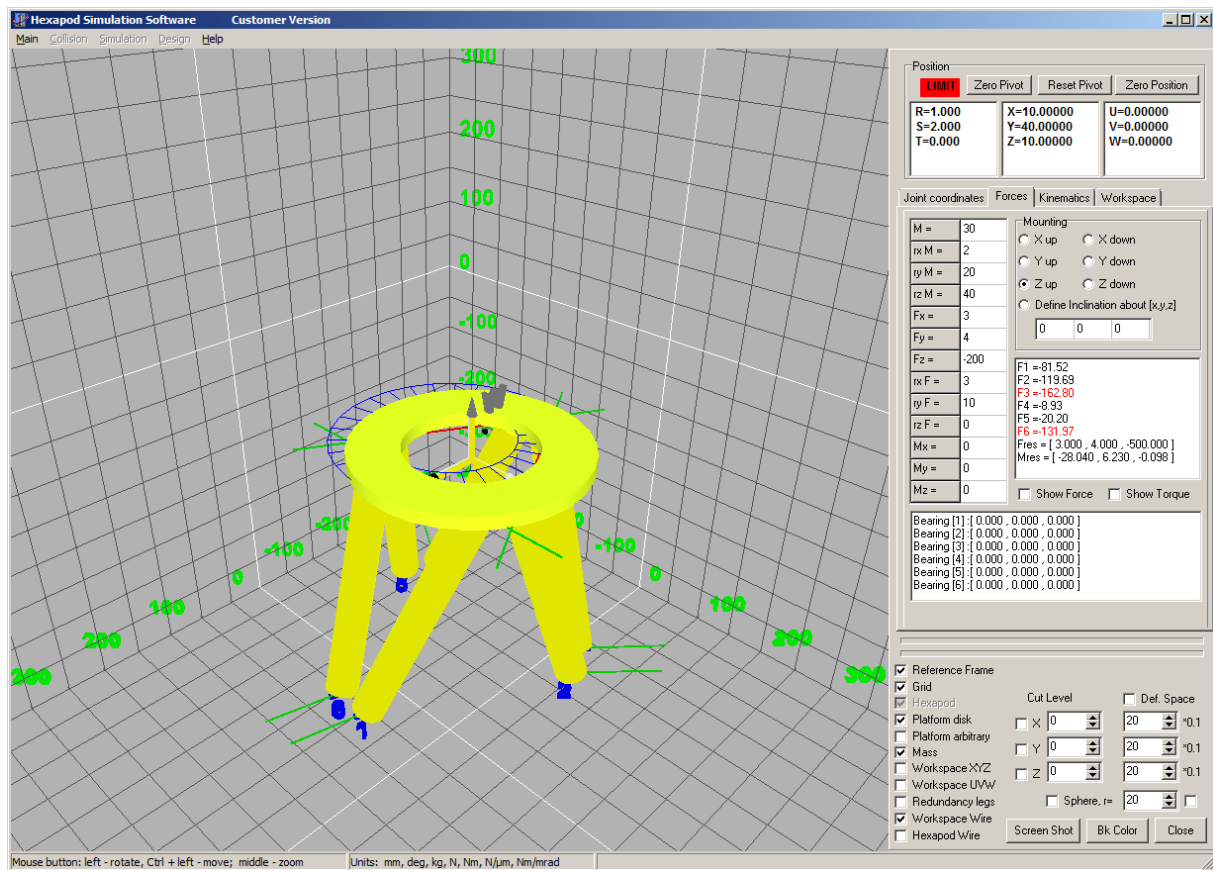


Figure 5: Position cannot be approached

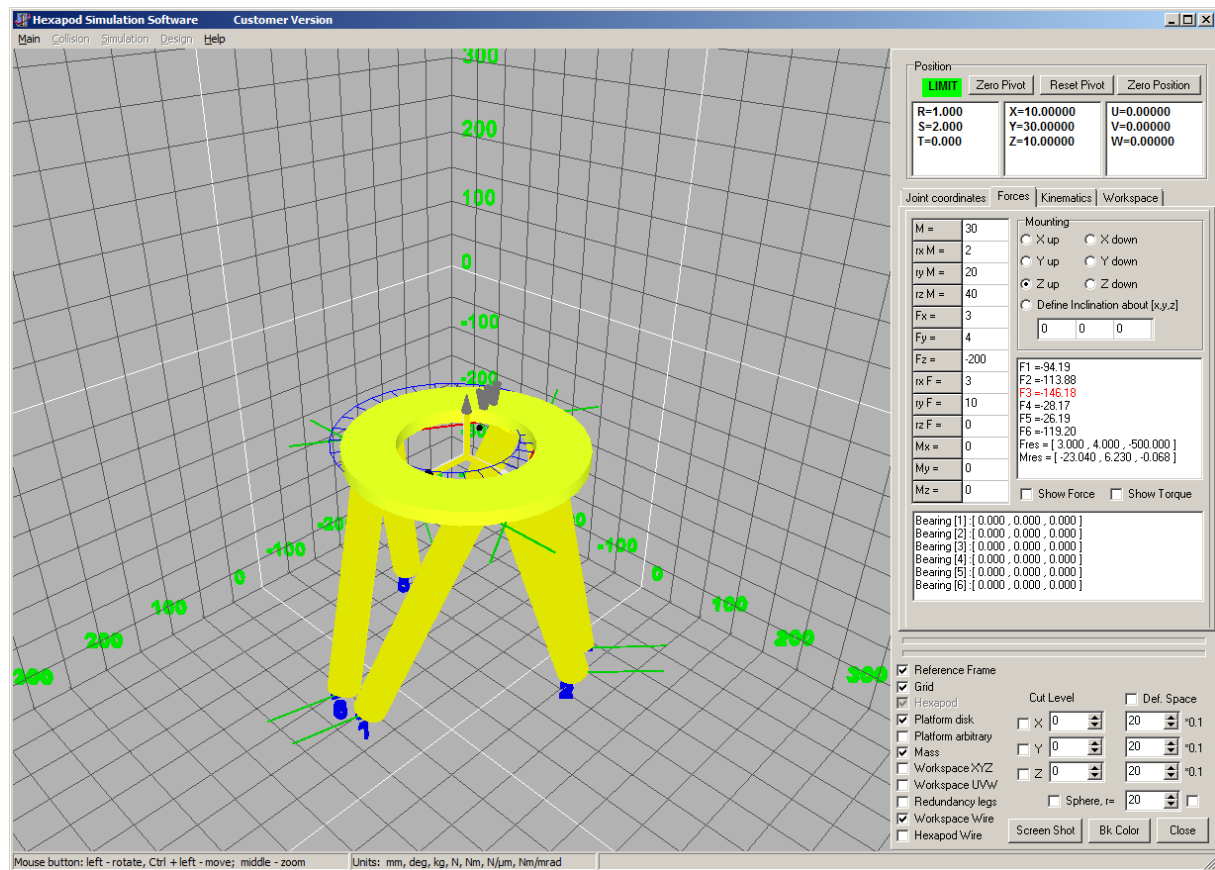


Figure 6: Permissible load for strut 3 of the Hexapod exceeded; configuration not permissible

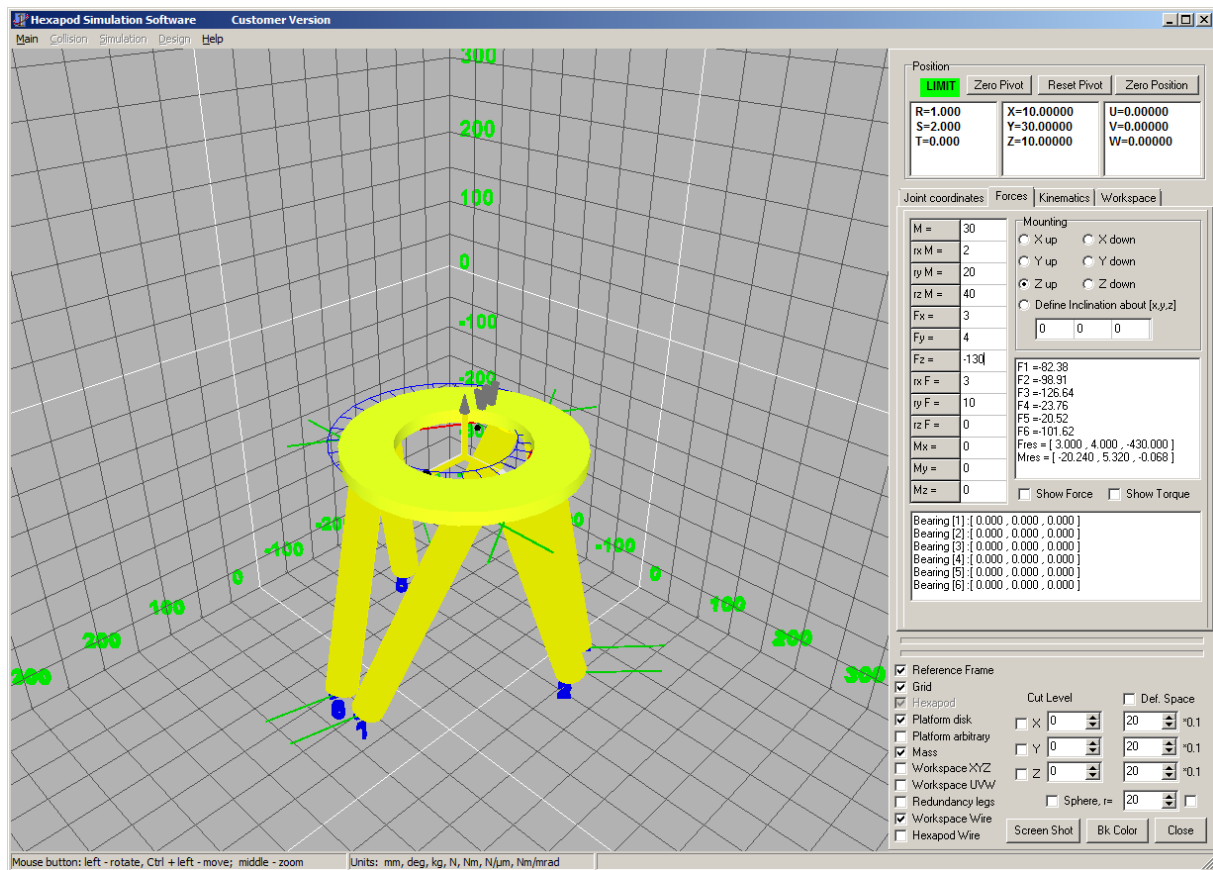


Figure 7: Configuration permissible, limit values for the load not exceeded

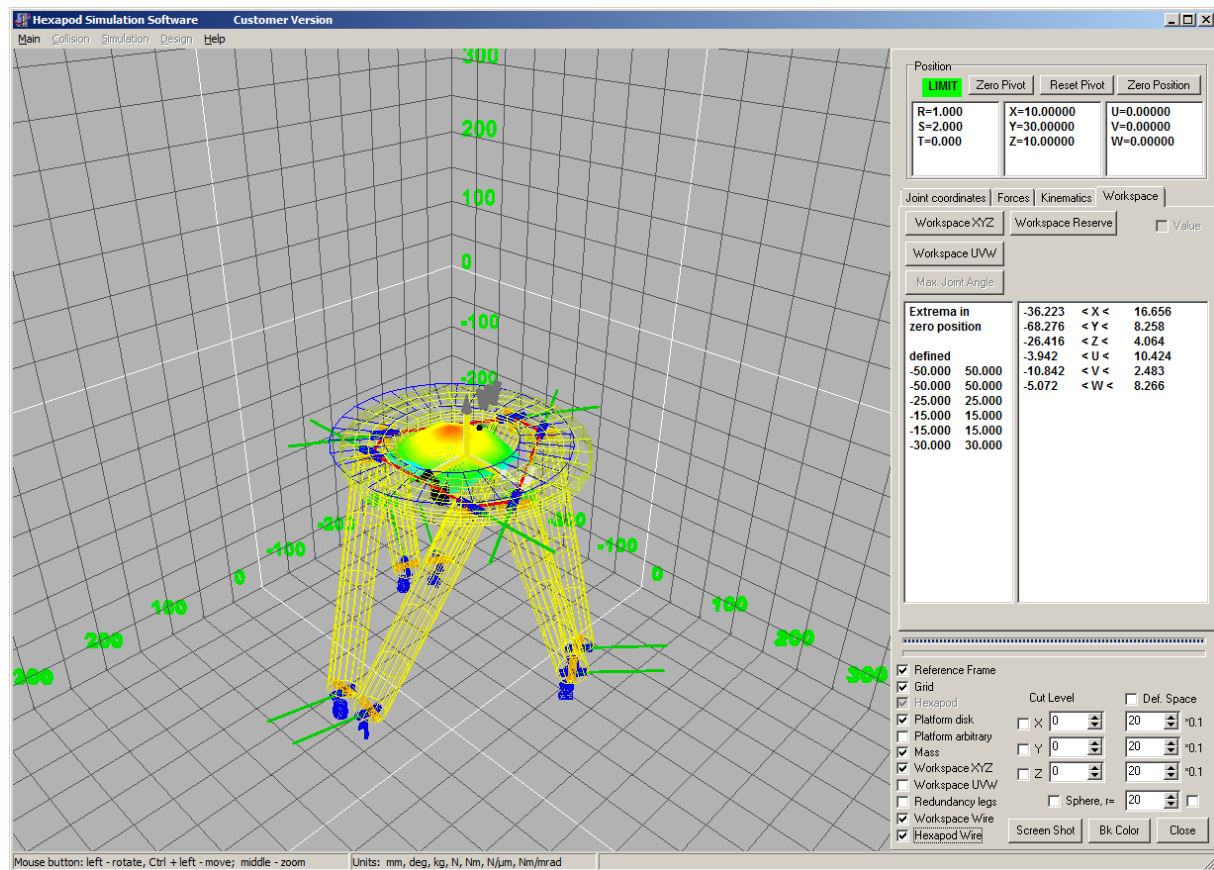


Figure 8: Available work space for the axis combination XYZ graphically displayed

INFORMATION

The optionally available PIVeriMove Software for the Collision Check makes it possible to mathematically check possible collisions between the Hexapod, load and environment. The use of the software is recommended when the Hexapod is located in a limited installation space and/or operated with a spatially limiting load. For details on the release and configuration of the PIVeriMove Software for the Collision Check see Technical Note C887T0002 (included in the scope of delivery of the software).

5.7.2 Grounding the Hexapod

- Follow the instructions in the manual of the Hexapod.

5.7.3 Mounting the Hexapod on a Surface


- Follow the instructions in the manual of the Hexapod.

5.7.4 Affixing the Load on the Hexapod

- Follow the instructions in the manual of the Hexapod.

5.8 Connecting the Hexapod to the C-887 with the Cable Set

Prerequisite

- ✓ The C-887 is switched off, i. e., the standby switch is in the  position.
- ✓ The cable set is connected to the Hexapod; see the Hexapod manual.

Tools and accessories

- Cable set that belongs to the Hexapod system (p. 17)
- Hexapod that belongs to the Hexapod system (p. 17)

Connecting the Hexapod to the C-887 with the cable set

1. Connect the data transmission cable to the **Hexapod** MDR68 socket in the rear panel of the C-887:
 - a) Press the latches together on both sides of the connector.
 - b) Insert the connector into the socket on the C-887.
 - c) Check that the connector correctly fits.
 - d) Release the latches.
2. Connect the M12 connector of the power supply cable for the Hexapod to one of the two 4-pin M12 sockets **2x 24 VDC Power Out** in the rear panel of the C-887.
 - Observe the mechanical coding of the connector and socket.
 - Do not use force.
3. If you are using a cable set with line driver boxes: Connect the M12 connector of the power supply cable for the Hexapod-side line driver box to one of the two 4-pin M12 sockets **2x 24 VDC Power Out** in the rear panel of the C-887.
 - Observe the mechanical coding of the connector and socket.

- Do not use force

5.9 Connecting Stages for Axes A and B to the C-887.11 - See detailed user manual

You can find information on this topic in the detailed MS204E user manual which is included as a PDF file on the product CD.

5.10 Connecting the P-611.3SF NanoCube® Stage to the C-887.11 - See detailed user manual

You can find information on this topic in the detailed MS204E user manual which is included as a PDF file on the product CD.

5.11 Connecting an Optical Signal Source to the C-887.11 - See detailed user manual

You can find information on this topic in the detailed MS204E user manual which is included as a PDF file on the product CD.

5.12 Connecting an Analog Signal Source to the C-887.11 - See detailed user manual

You can find information on this topic in the detailed MS204E user manual which is included as a PDF file on the product CD.

5.13 Connecting the C-887 to a PC

The communication between the C-887 and a PC can be used to configure the C-887 and send motion commands with the commands of the GCS. The C-887 has the following interfaces for this purpose:

- TCP/IP
- RS-232 interface

In this section, you learn how to establish the corresponding cable connections between the C-887 and a PC. All further steps that are necessary for establishing communication between the C-887 and a PC can be found in "Establishing Communication via a TCP/IP Interface" (p. 69) and in "Establishing Communication via an RS-232 Interface" (p. 79).

5.13.1 Connecting the C-887 via the TCP/IP Interface

Prerequisites

- ✓ If the C-887 is to be directly connected to the PC:
The PC has a free RJ45 Ethernet connection socket.
- ✓ If the C-887 and a PC are to be operated together in a network:
A free access point to the network is available for the C-887; a suitable hub or switch is connected to the network for this purpose if necessary.

Tools and accessories

- If the C-887 is to be directly connected to the PC:
cross-over network cable (C-815.563 included in the scope of delivery)
- If the C-887 is to be connected to a network access point: straight-through network cable (C-815.553 included in the scope of delivery)

Connecting the C-887 directly to the PC

- Connect the **LAN** RJ45 socket on the rear panel of the C-887 to the RJ45 Ethernet connection socket of the PC via the cross-over network cable.

Connecting the C-887 to the network in which the PC is also located

- Connect the **LAN** RJ45 socket on the rear panel of the C-887 with the network access point via the straight-through network cable.

5.13.2 Connecting the C-887 via the RS-232 Interface

Prerequisite

- ✓ The PC has a free RS-232 interface (also called a "serial interface" or "COM port", e. g. COM1 or COM2).

Tools and accessories

- RS-232 null-modem cable (C-815.34 included in the scope of delivery)

Connecting the C-887 to the PC

- Connect the **RS-232** panel plug on the rear panel of the C-887 and the RS-232 interface of the PC (one Sub-D 9(m) panel plug) with the null-modem cable.

5.14 Connecting the Keyboard, Mouse and Monitor to the C-887

A keyboard, a mouse and a monitor can be used to work with the user interface of the C-887; for details, see "Using the User Interface of the C-887" (p. 64). The C-887 has the following peripheral interfaces for that purpose:

- VGA connection
- USB connections

Tools and accessories

- Keyboard with USB connection, included in the scope of delivery (p. 23)
- Mouse with USB connection, not included in the scope of delivery
- Monitor with VGA connection, not included in the scope of delivery

Connecting the keyboard, mouse and monitor to the C-887

- Connect the keyboard to one of the **Universal Serial Bus** USB connections on the rear panel of the C-887.
- Connect the mouse to one of the **Universal Serial Bus** USB connections on the rear panel of the C-887.
- Connect the monitor to the **VGA** socket on the rear panel of the C-887.

6 Start-Up

In this Chapter

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Using the User Interface of the C-887	64
Establishing Communication via the TCP/IP Interface.....	69
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Starting Motions of the Axes A, B, K, L and M - Only C-887.11 - See detailed user manual.....	84

6.1 General Notes on Start-Up

CAUTION



Risk of crushing by moving parts!

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

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

NOTICE



Incorrect configuration of the Hexapod controller!

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

The configuration data is adapted before delivery.

- Check whether the Hexapod controller matches the Hexapod. A label on the rear panel of the controller indicates for which Hexapod the controller is intended.
- When you have established the communication via TCP/IP (p. 69) or RS-232 (p. 79) or use the user interface of the C-887 (p. 64), send the CST? command. The response shows the Hexapod to which the controller is adapted.
- Only operate the Hexapod with a Hexapod controller whose configuration data is adapted to the Hexapod.

NOTICE**Damage from collisions!**

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

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

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

Damage can occur to the Hexapod if the transport lock (p. 37) of the Hexapod has not been removed and a motion is commanded.

- Remove the transport lock before you start up the Hexapod system.

NOTICE**Damage from unintentional position changes!**

The limit value for the load of the Hexapod determined with the simulation program is only valid when the servo mode is switched on (p. 46) for the axes of the moving platform. The maximum holding force when the servo mode is switched off is based on the self-locking of the actuators in the Hexapod struts and is lower than the limit value when the servo mode is switched on (see manual of the Hexapod).

When the actual load of the Hexapod exceeds the maximum holding force based on the self-locking of the actuators, unintentional position changes of the Hexapod can occur in the following cases:

- Switching off the C-887
- Rebooting the C-887
- Switching off the servo mode for the axes of the moving platform of the Hexapod

As a result, collisions are possible between the Hexapod, the load to be moved, and the environment. Collisions can damage the Hexapod, the load to be moved, or the environment.

- Make sure that the actual load of the moving platform of the Hexapod does not exceed the maximum holding force based on the self-locking of the actuators before you switch off the servo mode, reboot or switch off the C-887.

NOTICE**Damage from collisions during the reference move!**

During a reference move, the Hexapod moves unpredictably. **No** collision check or prevention takes place, even when a configuration for collision prevention has been stored on the C-887 with the PIVeriMove Software for the Collision Check.

As a result, collisions are possible between the Hexapod, the load to be moved, and the environment. Collisions can damage the Hexapod, the load to be moved and the environment.

- Make sure that no collisions between the Hexapod, the load to be moved and the environment are possible during the reference move of the Hexapod.
- Do not place any objects in areas where they can get caught by moving parts during the reference move.
- After a successful reference move, supply a command for the corresponding target position in order to return to the reference position (default: zero position) from any given position. Do **not** start a new reference move.

NOTICE**Damage from uncontrolled motion of the Hexapod!**

In the following cases, the velocity and acceleration of the moving platform of the Hexapod are not specified by the trajectory generator of the C-887:

- The **Trajectory Source** parameter (ID 0x19001900) has the value 1.
- The **Trajectory Source** parameter has the value 0, and the Hexapod (axes X, Y, Z, U, V, W) is still moving while a new motion command is sent. The previous target position is thereby overwritten without the velocity and acceleration of the moving platform of the Hexapod being recalculated.

The platform of the Hexapod then moves on an undefined path. On this undefined path, collisions with the environment of the Hexapod are possible. Collisions can damage the Hexapod, the load to be moved and the environment.

When the **Trajectory Source** parameter has the value 1:

- Only set target positions whose distance from each other is maximally as large as the value of the **Path Control Step Size (mm)** parameter (ID 0x19001504) with consecutive **MOV** commands.

When the **Trajectory Source** parameter has the value 0:

- Avoid sending new target positions while the Hexapod (axes X, Y, Z, U, V, W) is still moving.
- If new target positions have to be sent while the Hexapod is still moving (axes X,

Y, Z, U, V, W): Only use motion commands to set target positions that maximally deviate from the current position by the value of the **Path Control Step Size (mm)** parameter (ID 0x19001504).

NOTICE



Damage from uncontrolled motion of the Hexapod!

If an E-760 controller card is installed in the C-887.11 (F-206.NCU option), the P-611.3SF NanoCube® stage must be correctly connected in order to start the operating system and the firmware. If the P-611.3SF NanoCube® stage is not connected when the C-887.11 is switched on or rebooted, the Hexapod system can demonstrate the following behavior:

- The operating system and the firmware of the C-887.11 do not start.
- The operating system and the firmware of the C-887.11 start, and the Hexapod carries out uncontrolled motions. As a result, collisions are possible between the Hexapod, the load to be moved, and the environment. Collisions can damage the Hexapod, the load to be moved and the environment.
- Before switching on or rebooting the C-887.11, make sure that the P-611.3SF NanoCube® stage is connected to the E-760 controller card via the Sub-D 25 (f) socket (p. 55).

INFORMATION

The optionally available PIVeriMove Software for the Collision Check makes it possible to mathematically check possible collisions between the Hexapod, load and environment. The use of the software is recommended when the Hexapod is located in a limited installation space and/or operated with a spatially limiting load. For details on the release and configuration of the PIVeriMove Software for the Collision Check see Technical Note C887T0002 (included in the scope of delivery of the software).

INFORMATION

The communication between the C-887 and a PC can be used to configure the C-887 and send motion commands with the commands of the GCS.

- Communication is possible via the RS-232 interface without further settings.
- For communication via TCP/IP, it may be necessary to adjust the interface parameters accordingly once (p. 71).

INFORMATION

The communication interfaces of the C-887 (e.g. user interface, TCP/IP, and RS-232 interfaces) are active at the same time. Commands are executed in the order that the complete command lines arrive. The simultaneous use of several communication interfaces can cause problems with the PC software, however.

- Always only use one interface of the C-887.

INFORMATION

When switched on or rebooted, the C-887 automatically switches on the servo mode for all axes. When the servo mode is switched off for the axes of the moving platform of the Hexapod (X, Y, Z, U, V, W), it is automatically switched on when the reference move is started.

INFORMATION

For the axes of the moving platform of the Hexapod (X, Y, Z, U, V, W), motions can only be commanded after a successful reference move (also referred to as "initialization").


A common reference move is always performed for the axes of the moving platform of the Hexapod (X, Y, Z, U, V, W).

6.2 Switching on the C-887

Prerequisites

- ✓ You have read and understood the General Notes on Start-Up (p. 59).
- ✓ The C-887 has been installed properly (p. 39).

Switching on the C-887

- Move the standby switch on the front panel of the C-887 into the  position.

The standby switch lights up green.

The C-887 starts the operating system and the firmware. The starting procedure lasts approx. 36 seconds; the beginning and end are each indicated by a signal tone.

During the starting procedure, the C-887 performs the following actions, among others:

- Switching on the servo mode for all axes
- Activation of the factory default settings for the volatily configurable parameters
- Activation of the settings stored in the non-volatile memory for the interface parameters
- Starting the start-up macro, if present

6.3 Using the User Interface of the C-887

The user interface of the C-887 can be used for the following purposes:

- Sending commands in the **Terminal Panel** (p. 66)
- Starting motions of the Hexapod platform in the main window of the user interface (p. 67)
- Assigning a stage type for axes A and B — only C-887.11 (p. 68)
- Getting voltages at the analog inputs — only C-887.11 (p. 68)
- Performing tests for Hexapod struts (p. 69)

INFORMATION

The operating system of the C-887 may not recognize the layout of the connected keyboard until the C-887 has been rebooted or after the keyboard has been removed and reconnected while the C-887 is switched on.

- If possible, only use the US keyboard included in the scope of delivery.

INFORMATION

When the starting procedure of the C-887 has finished (p. 63), the user interface of the C-887 automatically opens.

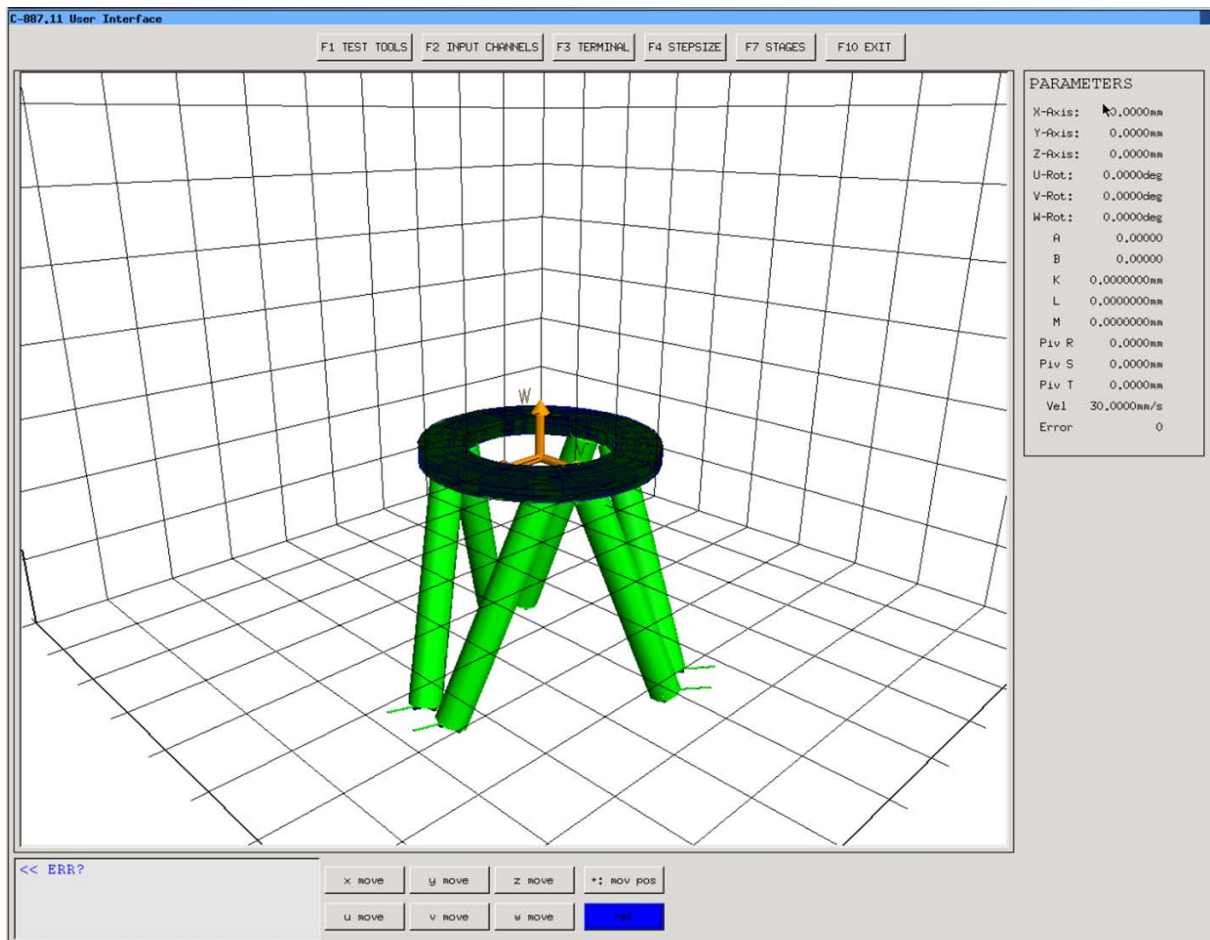


Figure 9: Main window of the user interface of the C-887

Prerequisites

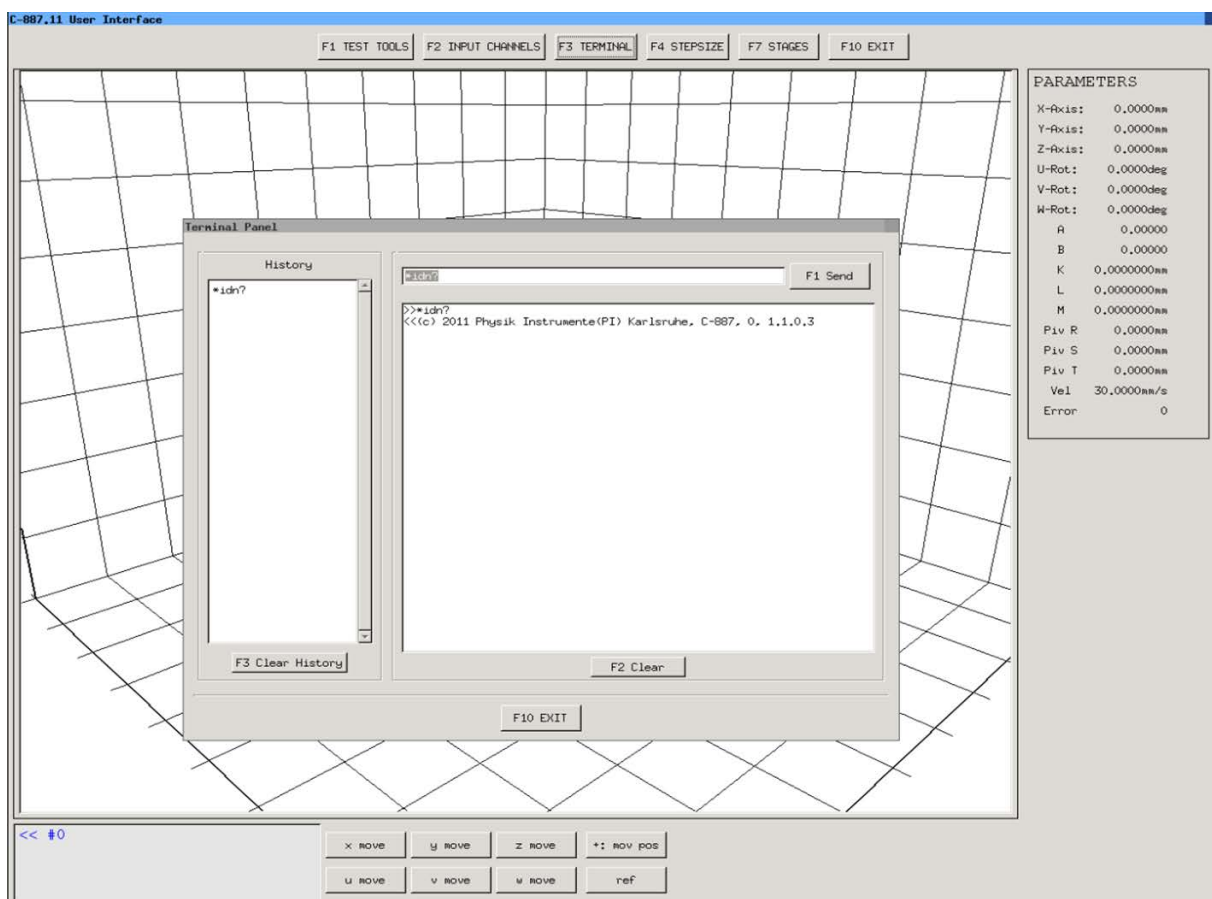
- ✓ You have read and understood the General Notes on Start-Up (p. 59).
- ✓ A keyboard and a monitor are connected to the C-887 (p. 57).
- ✓ Optional: A mouse is connected to the C-887 (p. 57).
- ✓ The C-887 is switched on and the starting procedure of the C-887 has finished (p. 63).
- ✓ The monitor is switched on and shows the main window of the user interface (see above figure).

Sending commands in the Terminal Panel window

1. Press the **F3** key on the keyboard or click the **F3 TERMINAL** button in the main window of the user interface to open the **Terminal Panel** window.

The **Terminal Panel** window contains the following elements:

- Input line for commands (on the left of the **F1 Send** button)
- Display field for sent commands and the responses of the C-887 (underneath the input line)
- **History** field with a list of sent commands (to the left of the input line and display field)



2. Send a command:
 - a) Type the command in the input line in the **Terminal Panel** window.
 - b) Press the **F1** key or **ENTER** on the keyboard or click the **F1 Send** button.

- When the sent command requires a response from the C-887: Read the response of the C-887 in the display field of the **Terminal Panel** window.

INFORMATION

Sending the following query commands in the **Terminal Panel** window gives you an overview of the system configuration:

- `*IDN?` gets the device identification string of the C-887.
- `VER?` gets the versions of the firmware components.
- `IFS?` gets the values of the interface parameters in the non-volatile memory.
- `MAC DEF?` gets the start-up macro.
- `SAI?` gets the axis identifiers.
- `CST?` gets the names of the connected stage types.
- `SVO?` gets the servo mode.
- `FRF?` gets whether the axes are referenced.

Starting motions of the Hexapod platform in the main window of the user interface

- Make sure that the main window of the user interface is displayed.
- Press the **I** or **R** button on the keyboard or click the **ref** button in the main window of the user interface to start a reference move of the Hexapod (the corresponding command is `FRF`).
- If you want to change the step size for motions of the platform of the Hexapod (default value is 0.01 mm or degrees; the corresponding command is `SST`):
 - Press the **F4** key on the keyboard or click the **F4 STEPSIZE** button in the main window of the user interface to open the **step size configuration** window.
 - Type in values for the step sizes of the individual axes. The permissible range of values for the step size is 0.0001 to 0.5 mm or degrees.
 - Return to the main window of the user interface with the **F1** key (save values) or **F10** key (do not save values).
- If you want to reverse the direction of motion of the axes: Press the **+** or **-** key on the keyboard or click the **+: mov pos** or **-: mov pos** button in the main window of the user interface (labeling of the button depends on the currently set orientation).

5. Press the **X**, **Y**, **Z**, **U**, **V**, **W** keys on the keyboard or click the **x move**, **y move**, **z move**, **u move**, **v move**, **w move** buttons in the main window of the user interface to start motions of the corresponding axis of the platform of the Hexapod (the corresponding command is **MOV**). Each press of a key or click increases the target position by the set step size.

Assigning a stage type for axes A and B — only C-887.11

If stages for the axes A and B are subsequently added to the Hexapod system, the appropriate stage types must be assigned to the axes A and B each time that the C-887.11 is switched on and rebooted; for further information see "Starting Motions of the Axes A, B, K, L and M - Only C-887.11".

1. Press the **F7** key on the keyboard or click the **F7 STAGES** button in the main window of the user interface to open the **Select additional stages** window.
2. Select the suitable stage type from the **Stage database entries** list with the arrow keys on the keyboard or by clicking.
3. Allocate the selected stage type to an axis (the corresponding command is **CST**):
 - Press the **A** key or click **'A' assign to channel A -->** for allocation to axis A.
 - Press the **B** key or click **'B' assign to channel B -->** for allocation to axis B.
4. If you want to allocate the stage type NOSTAGE to an axis and thereby deactivate the axis:
 - Press the **F1** key or click **<-- F1 disconnect channel A** to deactivate axis A.
 - Press the **F2** key or click **<-- F2 disconnect channel B** to deactivate axis B.
5. Return to the main window of the user interface with the **F10** key.

Getting voltages at the analog inputs — only C-887.11

1. Press the **F2** key on the keyboard or click the **F2 INPUT CHANNELS** button in the main window of the user interface to open the **InputChannels** window.

2. Read the voltage values for the analog inputs (the corresponding command is `TAV?`). The **InputChannels** window only displays the actually present analog input channels (p. 26).
3. Return to the main window of the user interface with the `Esc` key.

Performing tests for Hexapod struts

The **hexapod strut tests** window allows the testing of Hexapod struts 1 to 6 for error diagnosis (accessible from the main window of the user interface with the `F1` key or the **F1 TEST TOOLS** button).

- For tests of the Hexapod struts with the user interface, follow the instructions in "Carrying Out a Strut Test".

INFORMATION

When the E-760 controller card of the optional accessory F-206.NCU is installed in the C-887.11 (p. 43), measurements of the impulse response and the step response for the axes K, L, and M of the P-611.3SF NanoCube® stage can also be carried out in the **hexapod strut tests** window.

6.4 Establishing Communication via the TCP/IP Interface

Adaptation of the interface parameters

Before communication is established, it can be necessary to adapt the factory settings of the interface parameters once. The following interface parameters for the TCP/IP communication can be adapted in the non-volatile memory of the C-887 with the `IFS` command:

Interface parameter	Factory setting	Note
Default IP address (IPADR)	192.168.1.28:50000	<p>Allows the definition of a static address. This static address is not used when the C-887 is configured to obtain the IP address via a DHCP server or AutoIP (factory setting of the start-up behavior for configuration of the IP address).</p> <p>If the static address is to be used:</p> <ul style="list-style-type: none"> ▪ The start-up behavior must be changed so that the C-887 uses the IP address defined with "IPADR". ▪ The IP addresses and subnet masks of the C-887 and PC as well as all other network participants must be coordinated with each other. <p>For details, see "Preparing the PC and C-887 for Using Static IP Addresses" (p. 71).</p>
Start-up behavior for configuring the IP address for TCP/IP communication (IPSTART)	DHCP or AutoIP is used to obtain the IP address	<p>The IP address of the C-887 is obtained via DHCP or automatically configured using AutoIP with the factory setting of the start-up behavior.</p> <p>The factory setting of the start-up behavior only has to be changed if the network participants are to use static addresses instead.</p>
Subnet mask (IPMASK)	255.255.255.0	<p>The factory setting of the subnet mask may have to be changed if the network participants are to use static addresses.</p> <p>For details, see "Preparing the PC and C-887 for Using Static IP Addresses" (p. 71).</p>

After switching on or rebooting the C-887

The starting procedure of the C-887 must be finished before the communication between the C-887 and PC can be established. The starting procedure takes around 36 seconds (second signal tone indicates the end).

When the IP addresses of the network participants are configured with AutoIP, it will take up to 2 minutes after the end of the starting procedure of the C-887 (p. 63) until communication is possible via TCP/IP.

Connection of the network cable when the controller is switched on

The establishment of communication via TCP/IP can fail if the network cable was connected to the **LAN** RJ45 socket on the rear panel of the C-887 while the C-887 was switched on.

- If the establishment of communication fails, switch the C-887 off and back on again while the network cable is plugged in.

Port setting

For communication via TCP/IP, the C-887 only has a single unchangeable port (50000) available that cannot be used by more than one connection at a time.

6.4.1 Preparing the PC and C-887 for Using Static IP Addresses

If a network does not have a DHCP server or the C-887 is directly connected to the Ethernet connection socket of the PC (direct connection) **and** static IP addresses are to be used, the following adaptations of the interface parameters are necessary:

- Set the start-up behavior for configuring the IP address of the C-887 so that a static address is used
- Coordinate IP addresses and subnet masks of the C-887 and PC as well as all other network participants with each other.

To adapt IP addresses and subnet masks, you can choose one of the two following options:

- Adapt the PC settings and if necessary the settings of other network participants. The settings of the C-887 remain unchanged.
- Adapt the settings of the C-887. The PC settings and if necessary the settings of other network participants remain unchanged.

Prerequisite

- ✓ You have established communication between the C-887 and the PC via RS-232 in order to determine the settings of the C-887 and to be able to change them if necessary (p. 79).

or:

- ✓ You have made preparations for using the user interface of the C-887 (p. 64), in order to determine the settings of the C-887 and be able to change them if necessary.

Determining the IP address and subnet mask of the PC

1. Open the window in which the properties of the Internet protocol TCP/IP are displayed and set, in a suitable way on your PC. The necessary steps depend on the operating system used.

If your operating system distinguishes between Internet protocol version 4 (TCP/IPv4) and version 6 (TCP/IPv6) (e.g. Windows 7), open the window for version 4.

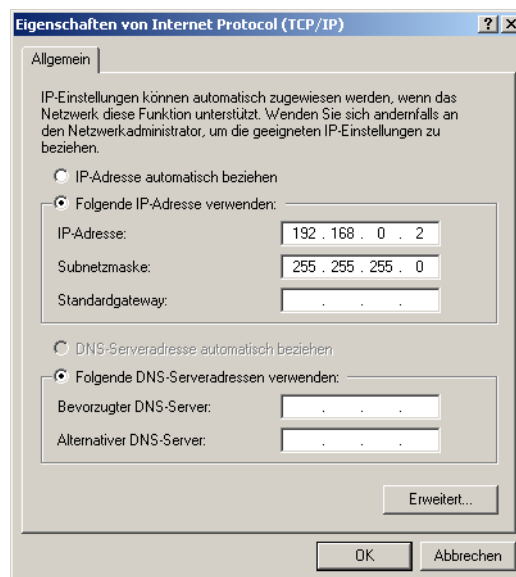


Figure 10: "Internet Protocol (TCP/IP) Properties" window with example settings (not necessarily suitable for your system)

The figure shows example settings that may not apply to your system.

2. Write down the settings.

C-887_INBE_Kommunikation_TCP-IP_vorbereiten_Adresse_und_Startverhalten_C-887_Head+

1. Prepare for entering commands:
 - If you have established communication between the C-887 and PC via the RS-232 interface, open the window for entering commands in the used program:

or

- If you use the user interface of the C-887: Press the **F3** key on the keyboard or click the **F3 TERMINAL** button in the main window of the user interface to open the **Terminal Panel** window.

2. Enter the `IFS?` command.

This command gets the values of the interface parameters in the non-volatile memory

3. Write down the settings **IPMASK** and **IPADR**.
4. Make sure that the **IPSTART** parameter is correctly set:
 - If **IPSTART** = 0 (the static IP address defined with **IPADR** is used), the setting is correct.
 - If **IPSTART** ≠ 0: Send the command `IFS 100 IPSTART 0`.

INFORMATION

In PIMikroMove, you can determine the IP address and subnet mask of the C-887 and adapt the start-up behaviour of the C-887 in the **Configure Interface** window without sending commands.

Adapting IP settings of the PC

- If you want to leave the PC settings unchanged, continue with the section "Adapting C-887 settings" (p. 74).
1. Activate **Use following IP address** in the window in which the properties of the Internet protocol TCP/IP (TCP/IPv4) are displayed and set.
 2. Adapt the IP address and the subnet mask to the settings of the C-887:
 - a) Copy the first three sections of the IP address of the C-887 for the IP address on the PC.
 - b) Make sure that the last section of the IP address on the PC differs from the last section of the IP address of the C-887 and is not "255" or "0".
 - c) Copy the subnet mask of the C-887 for the subnet mask on the PC.

Example:

New IP address of the PC: 192.168.1.29 (if the C-887 has the IP address 192.168.1.28)

New subnet mask of the PC: 255.255.255.0 (if the C-887 has the subnet mask 255.255.255.0)

3. Confirm the settings with the **OK** button.

4. If further network participants have to be adapted:
Adapt the IP addresses and subnet masks as in the previous steps.
Assign a separate, clear IP address to each network participant.
IP addresses must not occur twice in the same network.
5. If you have established communication between the C-887 and the PC via RS-232: Close the connection via the RS-232 interface, e.g., in PIMikroMove in the main window via the **Connections > Close > Hexapod** menu item.
6. Switch off the C-887.
7. Continue with the section "Establishing Communication via TCP/IP in the PC Software" (p. 75).

Adapting C-887 settings

1. Adapt the settings of the C-887 to those of the PC with the `IFS` command:
 - a) Change the subnet mask with the `IFS 100 IPMASK`
`xxx.xxx.xxx.xxx` command, whereby `xxx.xxx.xxx.xxx` is the subnet mask of the PC.
 - b) Change the IP address with the `IFS 100 IPADR`
`xxx.xxx.xxx.yyy:50000` command, whereby the following applies:
 - `xxx.xxx.xxx` matches the first three sections of the IP address of the PC
 - `yyy` differs from the last section of the IP address of the PC and every other device in the same network
 - `yyy` is not "255" and not "0" and is in the address range which is given by the last section of the subnet mask
 - The port address "50000" must not be changed

Example:
If the IP address of the PC is 192.168.0.1 and no other device has the IP address 192.168.0.2, send the `IFS 100 IPADR 192.168.0.2:50000` command.
2. If you have established communication between the C-887 and the PC via RS-232: Close the connection via the RS-232 interface, e. g. in PIMikroMove in the main window via the **Connections > Close > Hexapod** menu item.
3. Switch off the C-887.
4. Continue with the section "Establishing Communication via TCP/IP in the PC Software" (p. 75).

6.4.2 Establishing Communication via TCP/IP in the PC Software

CAUTION



Risk of crushing from unexpected motion

When the communication between the C-887 and the PC is established via TCP/IP, the PC software offers all controllers present in the same network for selection. After a C-887 has been selected for the connection, all commands are sent to this controller. If the wrong controller is selected, the operating and maintenance staff of the connected Hexapod are at risk of slight injury from crushing due to unexpectedly supplied motion commands.

- If several C-887 are displayed in the PC software, make sure that you select the right C-887.

INFORMATION

In the list of controllers found in the same network, the C-887 is **not** shown as **C-887** but as **HEXAPOD** or **F-HEX**, followed by the 9-digit serial number of the C-887.

Example of the display of a C-887 to which no connection has been established via TCP/IP yet:

HEXAPOD SN 111160398 -- listening on port 50000 -- 172.17.72.55 50000

111160398 is the serial number of the C-887 in this example.

- If several C-887 are connected with the same network via TCP/IP, identify the C-887 to be connected in the list of found controllers on the basis of its serial number. The serial number of the controller can be found on the type plate on the rear panel of the C-887.
- If you establish (p. 79) communication in advance via RS-232 or use (p. 64) the user interface of the C-887, you can also find the serial number of the C-887 in the response to the `*IDN?` command or get using the `SSN?` command.

Prerequisites

- ✓ You have read and understood the General Notes on Start-Up (p. 59).
- ✓ The C-887 is connected to the network via the **LAN** RJ45 socket on its rear panel or directly to the PC.

- ✓ If the C-887 is connected to a network:
The PC to be used for communication with the C-887 is suitably connected to the same network as the C-887.
- ✓ If the used network does not have a DHCP server or if the C-887 is directly connected to the Ethernet connection socket of the PC **and** static IP addresses are to be used:
You have set the correct start-up behavior for configuring the IP address of the C-887 by adapting the interface parameters and coordinated the IP addresses and subnet masks of the C-887 and PC as well as all other network participants with each other (p. 71).
- ✓ If several C-887's are connected to the same network via their TCP/IP interfaces: You have the serial number of the C-887 at hand with which the communication is to be established. The serial number can be found on the type plate on the rear panel of the C-887.
- ✓ The PC is switched on.
- ✓ The required software is installed on the PC (p. 41).
- ✓ You have read and understood the manual of the used PC software. The software manuals are found on the product CD.
- ✓ The C-887 is switched off.

Establishing communication via TCP/IP

The procedure for PIMikroMove is described in the following. The procedure for other PC software programs (PITerminal, LabVIEW driver) is similar.

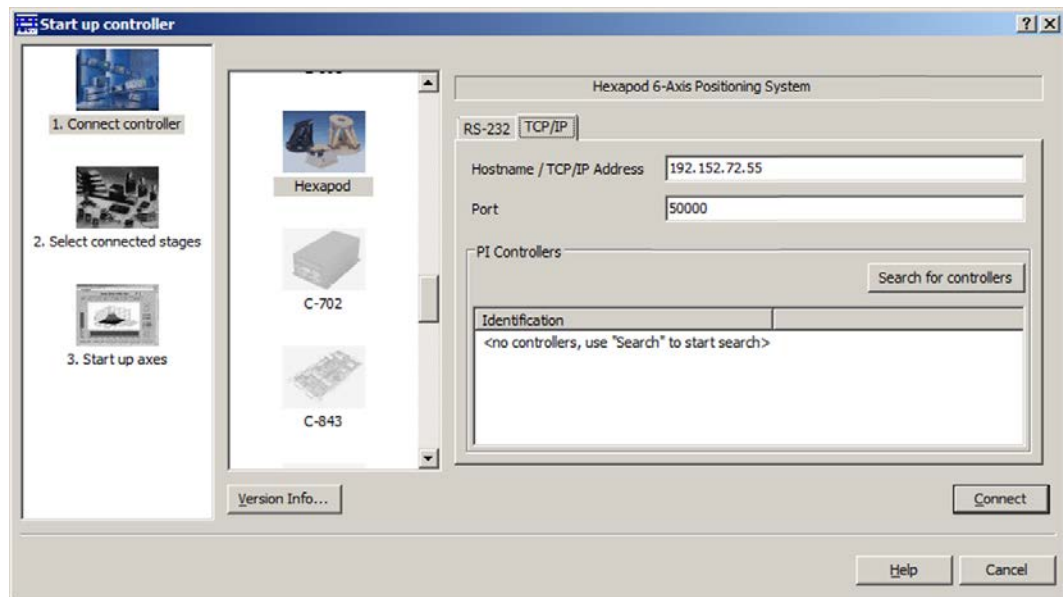
1. Switch on the C-887.

When the IP addresses of the network participants are configured with AutoIP, it will take up to 2 minutes after the end of the starting procedure of the C-887 (p. 63) until communication is possible via TCP/IP.

2. Start PIMikroMove.

The **Start up controller** window opens with the **Connect controller** step.

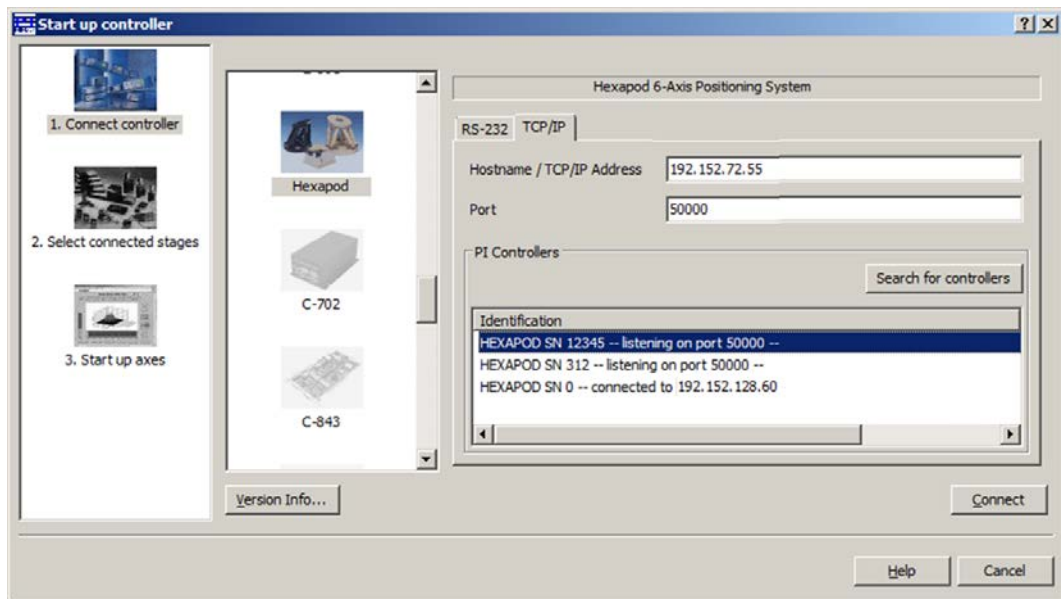
- If the **Start up controller** window does not automatically open, select the **Connections > New...** menu item in the main window.



3. Select **Hexapod** in the field for controller selection.
4. Select the **TCP/IP** tab on the right side of the window.
5. Click the **Search for controllers** button.

All controllers in the same network are shown in the field underneath the button.

6. Click the **HEXAPOD SN ...** or **F-HEX SN ...** entry in the list of controllers found (*SN* stands for *serial number*).
 - If several **HEXAPOD SN ...** or **F-HEX SN ...** entries are shown, identify your C-887 on the basis of its nine-digit serial number.
 - If the C-887 is not displayed in the list of the controllers found, check the network settings (p. 99). Consult your network administrator if necessary.



Do **not** select a controller with which a connection via TCP/IP already exists. Otherwise, an error message will be displayed as soon as you want to establish communication with this controller.

7. Check the IP address in the **Hostname / TCP/IP Address** field and the port number in the **Port** field.
8. Click the **Connect** button to establish communication.

When communication has been successfully established, the **Start up controller** window goes to the **Start up axes** step.

6.5 Establishing Communication via the RS-232 Interface

6.5.1 Changing the Baud Rate

The interface parameters for RS-232 communication are set at the factory as in the table below. The values in the non-volatile memory can be queried with the `IFS?` command.

Interface parameter	Factory setting	Note
Port for RS-232 communication (RSPORT)	1	Write-protected Indicates the port of the C-887 used for RS-232 communication.
Handshake for RS-232 communication (RSHSHK)	RTS/CTS	Write-protected Indicates the handshake setting of the C-887 for RS-232 communication.
Baud rate (RSBAUD)	115200	Indicates the baud rate of the C-887 for RS-232 communication. Further possible values are 9600, 19200, 38400, 57600. To successfully establish communication, the baud rates of the C-887 and PC must match.

Before communication is established, it can be necessary to change the factory baud rate setting of the C-887. The procedure for the user interface of the C-887 is described in the following. Alternatively, the PC software can also be used for entering commands after the communication has been established via TCP/IP or RS-232. The baud rate is changed in the non-volatile memory and does not go into effect until the C-887 is rebooted.

Prerequisite

- ✓ You have made the preparations for using the user interface of the C-887 (p. 64).

Changing the baud rate for the RS-232 connection

1. Press the `F3` key on the keyboard or click the **F3 TERMINAL** button in the main window of the user interface to open the **Terminal Panel** window.
2. Send the `IFS 100 RSBAUD xxxxxx` command, whereby xxxxxx is the new baud rate.

6.5.2 Establishing Communication via RS-232 in the PC Software

Prerequisites

- ✓ You have read and understood the General Notes on Start-Up (p. 59).
- ✓ The C-887 is connected to the RS-232 interface of the PC (p. 56)
- ✓ The C-887 is switched on and the starting procedure of the C-887 has finished (p. 63).
- ✓ The PC is switched on.
- ✓ The required software is installed on the PC.
- ✓ You have read and understood the manual of the used PC software. The software manuals are found on the product CD.

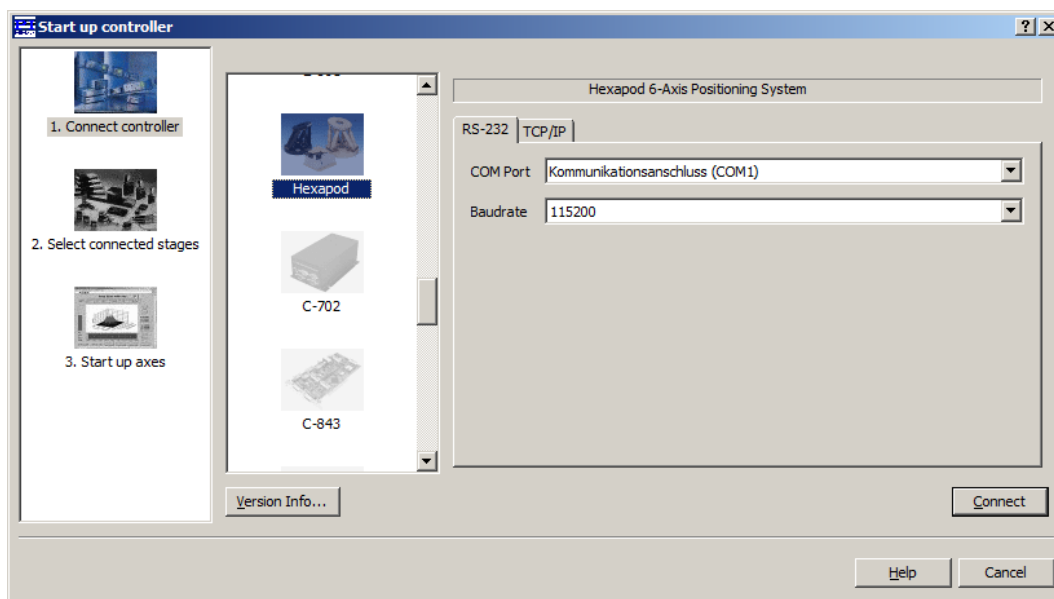
Establishing communication via RS-232

The procedure for PIMikroMove is described in the following. The procedure for other PC software programs (PITerminal, LabVIEW driver) is similar.

1. Start PIMikroMove.

The **Start up controller** window opens with the **Connect controller** step.

- If the **Start up controller** window does not automatically open, select the **Connections > New...** menu item in the main window.



2. Select **Hexapod** in the field for controller selection.

3. Select the **RS-232** tab on the right side of the window.
4. In the **COM Port** field, select the COM port of the PC to which you have connected the C-887.
5. In the **Baud rate** field, set the value 115200 (factory setting upon delivery of the C-887).

This adapts the baud rate of the PC to the baud rate of the C-887.

If you have changed the baud rate of the C-887, you have to enter the new value in the **Baud rate** field instead (p. 79).

6. Click **Connect** to establish communication.

When communication has been successfully established, the **Start up controller** window goes to the **Start up axes** step.

6.6 Starting Motions of the Platform of the Hexapod

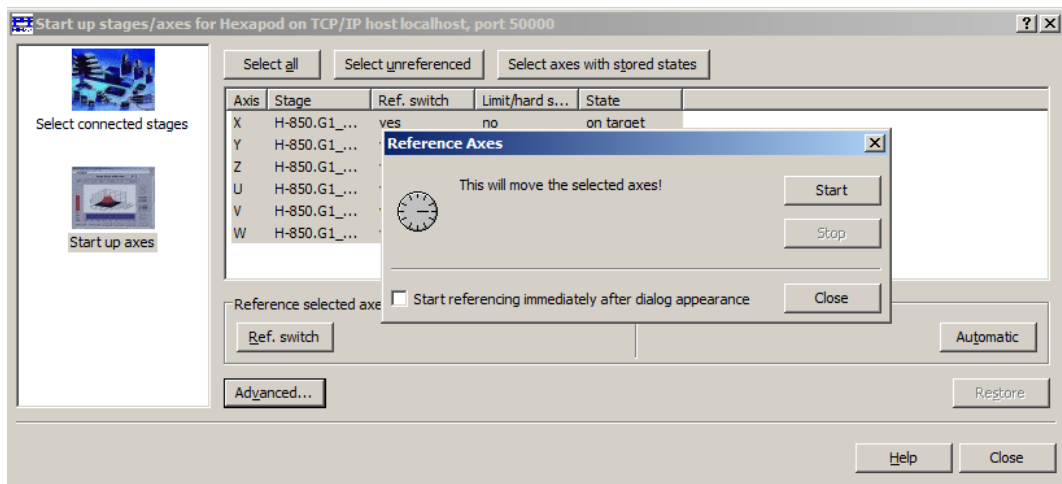
In the following, PIMikroMove is used to move the platform of the Hexapod. For starting motions with the user interface, see "Using the User Interface of the C-887" (p. 64).

Prerequisites

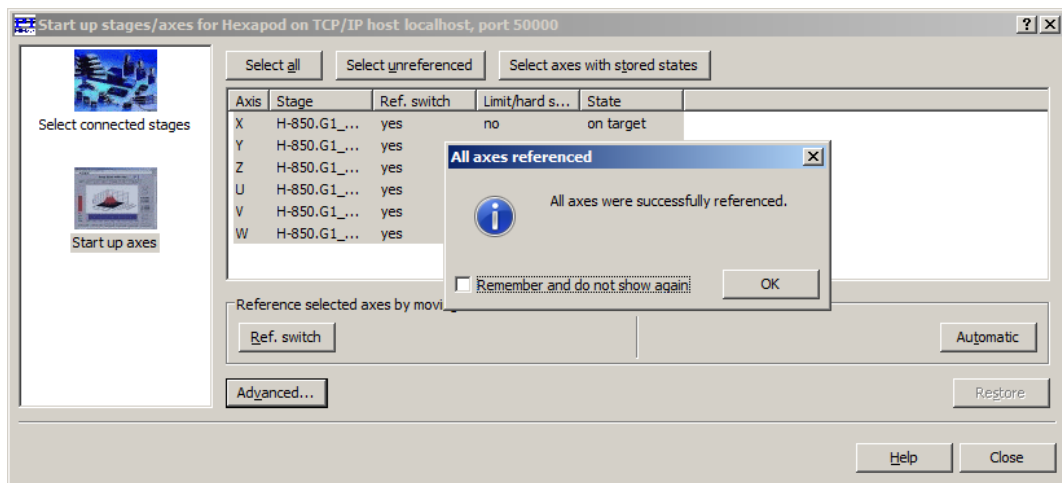
- ✓ You have read and understood the General Notes on Start-Up (p. 59).
- ✓ PIMikroMove is installed on the PC (p. 41).
- ✓ You have read and understood the PIMikroMove manual. The manual is found on the product CD.
- ✓ You have correctly installed the Hexapod system (C-887, Hexapod and cable set) (p. 39).
- ✓ You have read and understood the user manual of the Hexapod.
- ✓ You have established communication between the C-887 and the PC with PIMikroMove via the TCP/IP interface (p. 75) or the RS-232 interface (p. 80).

Starting motions of the platform of the Hexapod with PIMikroMove

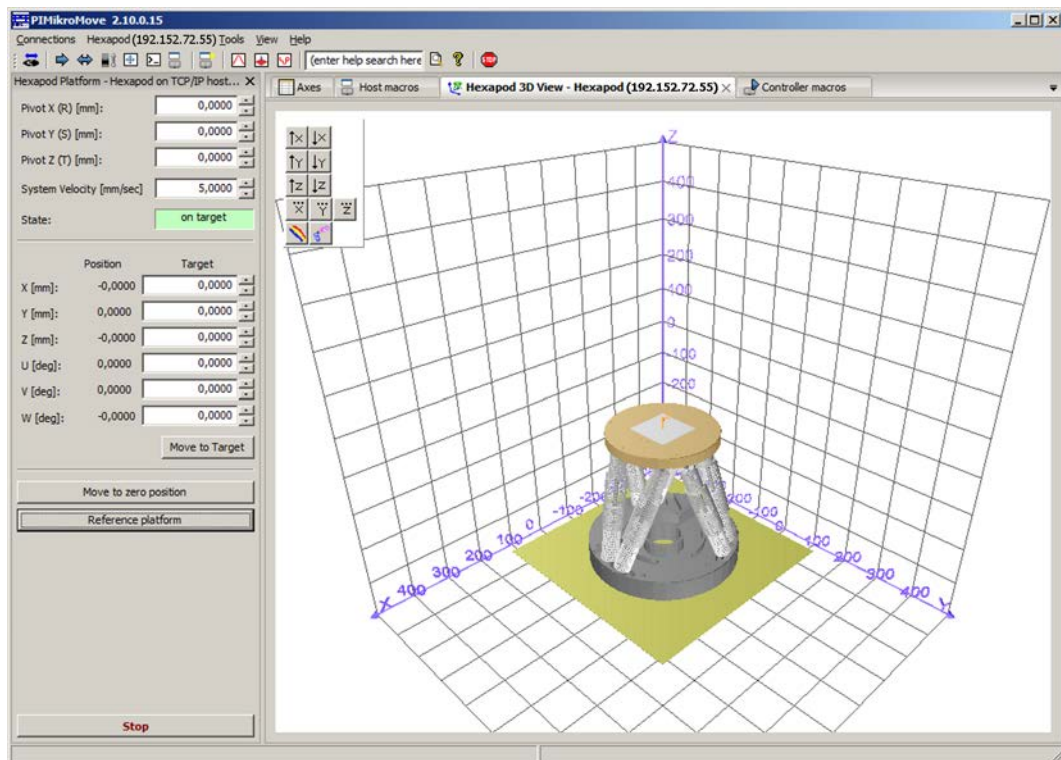
1. Carry out the reference move for the moving platform of the Hexapod in the **Start up axes** step. To do this, click **Ref.switch** or **Automatic**.



2. After a successful reference move, click **OK > Close**.



3. If the **Hexapod Platform** window (left, docked) and the **Hexapod 3D View** card are **not** displayed in the main window of PIMikroMove:
- Display the **Hexapod Platform** window with the **Hexapod > Show Hexapod platform settings** menu item.
 - Display the **Hexapod 3D View** card with the **Hexapod > Hexapod 3D View > Show** menu item.
 - If the **Hexapod 3D View** card is not displayed in the foreground, click on the corresponding tab.



4. Start a few test motions of the axes of the moving platform of the Hexapod:
 - a) In the **Hexapod Platform** window, enter a target position for at least one axis of the moving platform of the Hexapod in the corresponding **Target** field.
 - b) Click **Move to Target** to start the motion towards the given target position.
 - c) When the motion is finished, repeat steps a and b for a new target position.

If a node of the calculated trajectory or the target position cannot be reached, the motion is not executed and a window opens with an error message.

A new target position cannot be entered during a motion.

The motion is graphically displayed on the **Hexapod 3D View** card.

6.7 Starting Motions of the Axes A, B, K, L and M - Only C-887.11 - See detailed user manual

You can find information on this topic in the detailed MS204E user manual which is included as a PDF file on the product CD.

7 Operation

In this Chapter

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7.1 Data Recorder - See detailed user manual

You can find information on this topic in the detailed MS204E user manual which is included as a PDF file on the product CD.

7.2 Controller Macros - See detailed user manual

You can find information on this topic in the detailed MS204E user manual which is included as a PDF file on the product CD.

7.3 Analog Input Signals - See detailed user manual

You can find information on this topic in the detailed MS204E user manual which is included as a PDF file on the product CD.

8 GCS Commands

In this Chapter

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8.1 Selection of the GCS Syntax Version

The C-887 uses the PI General Command Set (GCS). This command set is available in two syntax versions for the C-887: GCS syntax version 1.0 (GCS 1.0) and GCS syntax version 2.0 (GCS 2.0).

When the default settings of the C-887 are used, GCS 2.0 is active. GCS 2.0 has been expanded and revised compared to GCS 1.0. GCS 2.0 is also standard for other PI controllers.

INFORMATION

The `CSV` command can be used to switch to GCS 1.0, in order to remain compatible with older Hexapod controllers. These older Hexapod controllers were sold together in a Hexapod system with one of the following Hexapod models: F-206, M-810, M-824, M-840 or M-850.

Since important syntax differences must be observed, however, it is recommended to only use GCS 1.0 when compatibility with existing Hexapod systems is necessary. For the important differences between the two syntax versions, see "Differences between GCS 2.0 and GCS 1.0" (p. 88).

The syntax and commands of GCS syntax version 2.0 are described in the detailed MS204E user manual which is included as a PDF file on the product CD.

The syntax and commands of GCS syntax version 1.0 are described in the manuals MS54E (for M-824, M-840 and M-850 Hexapod systems), MP36E (for F-206 Hexapod systems) and MS186E (for M-810 Hexapod systems). These manuals are available for downloading at www.pi.ws or can be requested from the customer service department.

INFORMATION

The communication interfaces (TCP/IP, RS-232) work independently of the selected GCS syntax version.

To select the GCS syntax version, proceed as follows:

- To activate GCS 1.0, send:

`CSV 1`

- To activate GCS 2.0, send:

`CSV 2`

The activated GCS syntax version can be determined with `CSV?`. The only possible response is "2" (for GCS 2.0). In GCS syntax version 1.0, the `CSV?` command is not present and will cause an error.

INFORMATION

A start-up macro can be used to activate GCS 1.0 during switching-on or rebooting.

8.2 GCS Syntax for Syntax Version 2.0 - See detailed user manual

You can find information on this topic in the detailed MS204E user manual which is included as a PDF file on the product CD.

8.3 Differences between GCS 2.0 and GCS 1.0 - See detailed user manual

You can find information on this topic in the detailed MS204E user manual which is included as a PDF file on the product CD.

8.4 Command Overview for GCS 2.0

The commands listed hereafter are described in the detailed MS204E user manual which is included as a PDF file on the product CD. The GCS syntax version 2.0 is activated by default after the controller is switched on or rebooted.

#3	Get Real Position
#4	Request Status Register
#5	Request Motion Status
#6	Query for Position Change
#7	Request Controller Ready Status
#8	Query if Macro is Running
#11	Get Memory Space for Trajectory Points
#24	Stop All Axes
#27	System Abort
*IDN?	Get Device Identification
AAP	Automated Alignment Part
ADD	Add and Save to Variable
CCL	Set Command Level
CCL?	Get Command Level
CPY	Copy into Variable
CST	Set Assignment of Stages to Axes
CST?	Get Assignment of Stages to Axes
CSV	Set Syntax Version
CSV?	Get Current Syntax Version
DEL	Delay the Command Interpreter
DRC	Set Data Recorder Configuration
DRC?	Get Data Recorder Configuration
DRL?	Get Number of Recorded Points
DRR?	Get Recorded Data Values
DRT	Set Data Recorder Trigger Source
DRT?	Get Data Recorder Trigger Source

ECO?	Echo a String
ERR?	Get Error Number
FIO	Fast Input-Output Alignment Procedure
FLM	Fast Line Scan to Maximum
FLS	Fast Line Scan
FRF	Fast Reference Move To Reference Switch
FRF?	Get Referencing Result
FSA	Fast Scan with Automated Alignment
FSC	Fast Scan with Abort
FSM	Fast Scan to Maximum
FSS?	Get Status of Fast Scan Routines
HDR?	Get All Data Recorder Options
HLP?	Get List of Available Commands
HLT	Halt Motion Smoothly
HPA?	Get List of Available Parameters
IFS	Set Interface Parameters as Default Values
IFS?	Get Interface Parameters as Default Values
IMP	Start Impulse and Response Measurement
JRC	Jump Relatively Depending on Condition
LIM?	Indicate Limit Switches
MAC	Call Macro Function
MAC?	List Macros
MEX	Stop Macro Execution due to Condition
MOV	Set Target Position
MOV?	Get Target Position
MVR	Set Target Relative to Current Position
NAV	Set Number of Readings to be Averaged?
NAV?	Get Number of Readings to be Averaged?
NLM	Set Low Position Soft Limit
NLM?	Get Low Position Soft Limit

ONT? Get On Target State
PLM Set High Position Soft Limit
PLM? Get High Position Soft Limit
POS? Get Real Position
PUN? Get Position Unit
RBT Reboot System
RMC? List Running Macros
RON? Get Reference Mode
RTR Set Record Table Rate
RTR? Get Record Table Rate
SAI? Get List of Current Axis Identifiers
SCT Set Cycle Time
SCT? Get Cycle Time
SGA Set Gain
SGA? Get Gain
SPA Set Volatile Memory Parameters
SPA? Get Volatile Memory Parameters
SPI Set Pivot Point
SPI? Get Pivot Point
SSL Set Soft Limit
SSL? Get Soft Limit Status
SSN? Get Device Serial Number
SST Set Step Size
SST? Get Step Size
STA? Query Status Register Value
STE Start Step and Response Measurement
STP Stop All Axes
SVO Set Servo Mode
SVO? Get Servo Mode
TAC? Tell Analog Channels

TAD? Get ADC Value of Input Signal
TAV? Get Analog Input Voltage
TMN? Get Minimum Commandable Position
TMX? Get Maximum Commandable Position
TNR? Get Number of Record Tables
TRS? Indicate Reference Switch
VAR Set Variable Value
VAR? Get Variable Value
VEL Set Closed-Loop Velocity
VEL? Get Closed-Loop Velocity
VER? Get Version
VLS Set System Velocity
VLS? Get System Velocity
VMO? Virtual Move
VST? Get Connectable Stages
WAC Wait for Condition

8.5 Error Codes - See detailed user manual

The error codes of the PI General Command Set are listed in the detailed MS204E user manual which is included as a PDF file on the product CD.

9 Adapting Settings

In this Chapter

Changing volatily configurable parameters in the C-887	93
Parameter Overview - See detailed user manual	93

9.1 Changing volatily configurable parameters in the C-887

INFORMATION

The settings that are used to adapt the C-887, e.g., to the properties of the connected mechanical system or the communication interfaces used are determined by:

- Configuration files and stage databases: only accessible for the customer service department (p. 103)
- Interface parameters: Adaptation in the non-volatile memory possible with the `IFS` command, further information in "Establishing Communication via the TCP/IP Interface" (p. 69) and "Establishing Communication via the RS-232 Interface" (p. 79)
- Volatile-configurable parameters: Information in the detailed MS204E user manual which is included as a PDF file on the product CD.

INFORMATION

After the C-887 has been switched on or rebooted, factory settings for the volatily configurable parameters will be active unless a configuration takes place with a start-up macro.

9.2 Parameter Overview - See detailed user manual

You can find information on this topic in the detailed MS204E user manual which is included as a PDF file on the product CD.

10 Maintenance

In this Chapter

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Cleaning the Air Filter	95
Updating Firmware - See detailed user manual	97
Maintaining and Checking the Hexapod - See detailed user manual	97

10.1 Cleaning the C-887

NOTICE



Pull the power plug before cleaning!

The C-887 contains electrostatic-sensitive devices (ESD) that can be damaged in the case of short circuits or flashovers.

- Before cleaning, disconnect the C-887 from the power source by pulling the power plug.

- When necessary, clean the surfaces of the C-887 case with a towel that has been lightly dampened with a mild cleanser or disinfectant.
- Do **not** use any organic solvents.

10.2 Cleaning the Air Filter

INFORMATION

The intervals for cleaning the air filter depend on the operating conditions of the C-887.

INFORMATION

The figures in the following section show a C-887.11 controller. In the case of the model C-887.21, the top of the case is fastened and removed in the same way as with the C-887.11, and the air filter is also located on the inside of the front panel of the case.

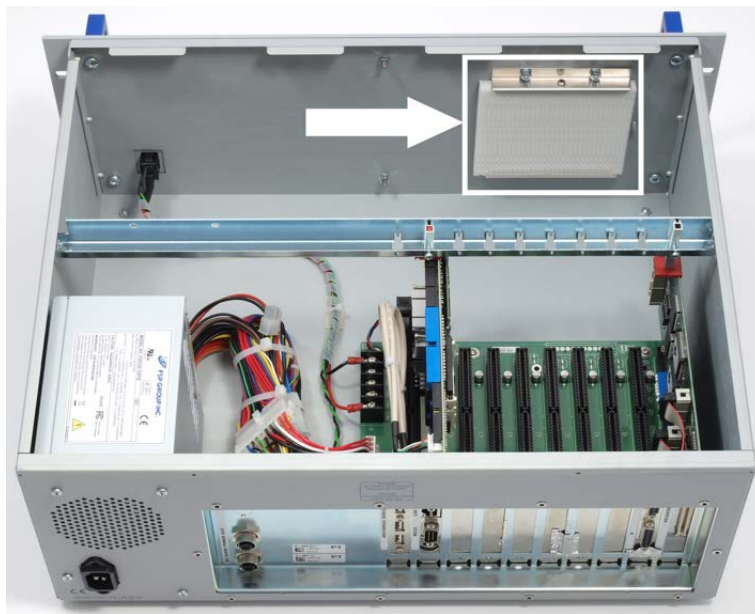


Figure 11: C-887.11 opened for air filter cleaning



Figure 12: Air filter, already moved, and ventilation holes of the C-887

Prerequisite

- ✓ The C-887 is **not** connected to the power socket via the power cord.

Tools and accessories

- Compressed air, oil-free
- Supplied Torx screwdriver

Cleaning the air filter

1. Release the two Torx screws with which the top of the case is fastened to the rear panel of the controller.
2. Carefully remove the top of the case.
3. Remove the air filter from the rails in front of the ventilation holes in the front panel of the C-887, see figures above:
 - a) Loosen the screw which locks the air filter in the upper rail.
 - b) Remove the screw.
 - c) Carefully push the air filter out of the rails.
4. Clean the air filter with oil-free compressed air.
5. Insert the air filter into the rails so that it completely covers the ventilation holes.
6. Lock the air filter in the upper rail using the screw.
7. Place the top of the case so that the locking lugs of the top and the case engage on the front panel.
8. Fasten the top of the case to the rear panel of the controller with the two Torx screws.

10.3 Updating Firmware - See detailed user manual

You can find information on this topic in the detailed MS204E user manual which is included as a PDF file on the product CD.

10.4 Maintaining and Checking the Hexapod - See detailed user manual

You can find information on this topic in the detailed MS204E user manual which is included as a PDF file on the product CD.

11 Troubleshooting

Problem	Possible Causes	Solution
Hexapod does not move	The cable is not connected correctly	➤ Check the cable connections.
	Incorrect command or incorrect syntax	➤ Send the <code>ERR?</code> command and check the error code this returns.
	Incorrect configuration	➤ Check the parameter settings in the volatile memory with the <code>SPA?</code> command. The configuration data used by the C-887 must be adapted to the Hexapod. ➤ Check with the <code>CST?</code> command whether the axes of the moving platform of the Hexapod have been assigned the correct stage type. ➤ If the stage type does not match the connected Hexapod, contact our customer service department (p. 103).
One Hexapod strut does not move or is difficult to move	Wear of the drive screw	➤ If only small motions are executed over a long period of time: Carry out a maintenance run at regular intervals.
	<ul style="list-style-type: none"> ▪ Foreign body has entered the drive screw ▪ Faulty motor ▪ Blocked joint due to wear or foreign body ▪ Wear of the drive screw 	➤ Carry out a strut test and communicate the test results to our customer service department (p. 103).
Reduced accuracy of the Hexapod	Warped base plate	➤ Mount the Hexapod on an even surface (see user manual of the Hexapod).

Problem	Possible Causes	Solution
Communication with the C-887 failed	The operating system and firmware of the C-887 do not start because the permissible operating temperature has been exceeded	<ol style="list-style-type: none"> 1. Switch off the C-887. 2. Wait a few minutes until the C-887 has cooled off. 3. Switch on the C-887. <ul style="list-style-type: none"> ➤ Ensure sufficient ventilation at the place of installation (p. 40) to prevent the C-887 from overheating in the future.
	Communication cable is incorrect or defective	<ul style="list-style-type: none"> ➤ Check the cable. <ul style="list-style-type: none"> – Use a null-modem cable for the RS-232 connection. – Use the straight-through network cable for TCP/IP connection via a hub or a router (with DHCP server). – Use the cross-over network cable for direct connection with the Ethernet connection socket of the PC. ➤ If necessary, also check whether the cable works on a fault-free system.
	Communication interface is not correctly configured	<p>When using the RS-232 interface:</p> <ul style="list-style-type: none"> ➤ Check the port settings, the baud rate and the handshake setting of the PC. <p>When using the TCP/IP connection:</p> <ul style="list-style-type: none"> ➤ Connect the controller to the network before you switch it on. Otherwise, you will have to switch the controller off and then on again. ➤ Check the network settings (p. 69). ➤ Make sure that the network is not blocked for unknown devices. ➤ Make sure that several PC software applications cannot access the C-887 at the same time. ➤ Make sure that you have selected the correct C-887 when establishing communication. ➤ If you cannot solve the problems, consult your network administrator if necessary.
	The starting procedure of the operating system and the firmware of the C-	<ol style="list-style-type: none"> 1. Wait approx. 36 seconds after switching on or rebooting the C-887 (second signal tone has been emitted). 2. Try to establish communication or send commands.

Problem	Possible Causes	Solution
	887 has not finished yet.	When the IP addresses of the network participants are configured with AutoIP, it will take up to 2 minutes after the end of the starting procedure of the C-887 (p. 63) until communication is possible via TCP/IP.
	A different program is accessing the interface	➤ Close the other program.
	Problems with special PC software	➤ Check whether the system works with different PC software, such as e. g. a terminal program or a development environment. You can test the communication by starting a terminal program (such as e. g. PI Terminal) and entering <code>*IDN?</code> or <code>HLP?</code> . ➤ Make sure that you end the command with an LF (line feed). A command is not executed until the LF has been received.
The customer software does not run with the PI drivers	Incorrect combination of driver routines/Vis	➤ Check whether the system works with a terminal program. If so: ➤ Read the information in the corresponding software manual and compare the sample code on the C-887.CD with your program code.

If the problem that occurred with your system is not listed in the table above or it cannot be solved as described, contact our customer service department (p. 103).

12 Customer Service

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

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

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

The latest versions of the relevant user manuals for your system are available for download on our website (<http://www.pi.ws>).

13 Technical Data

In this Chapter

Specifications	105
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13.1 Specifications

13.1.1 Data Table

	C-887.11	C-887.21
Function	6-D controller for Hexapods, 19", incl. control of two additional single axes, can be enhanced with many options	6-D controller for Hexapods, compact bench-top for a lower system price
Drive type	Servo motors (Hexapod and additional axes) Optional: Piezo drives	Servo motors
Motion and control		
Servo characteristics	32-bit PID filter	
Trajectory profile modes	Trapezoid, linear interpolation	
Processor	CPU: 1.8 GHz, motion control chip with 2.5 kHz servo update rate	
Encoder input	AB (quadrature) differential TTL signal, 5 MHz	
Stall detection	Servo off, triggered by position error	
Reference point switch	TTL signal	
Electrical properties		
Max. output power per channel	10-bit output for PWM drivers, 24 kHz	
Max. output voltage per channel	TTL in PWM operation for SIGN and MAGN	

Interface and operation		
Communication interfaces	TCP/IP, RS-232 VGA (monitor), USB (keyboard, mouse, manual control unit)	
Hexapod connection	MDR, 68-pin for data transmission M12 4-pin. for power supply	
Connection for additional single axes	15-pin sub-D	–
I/O ports	Optional: Analog inputs (photometer cards)	–
Command set	PI General Command Set (GCS)	
User software	PIMikroMove	
Software drivers	LabVIEW driver, shared libraries for Windows and Linux	
Manual control	Optional: C-887.MC control unit for Hexapods	
Miscellaneous		
Operating voltage	100 to 240 VAC, 50 / 60 Hz	
Operating temperature range	5 to 40°C	
Mass	11 kg	5 kg
Dimensions	395 × 483 × 185 mm	255 × 226 × 185 mm

13.1.2 Cycle times

The differences in the cycle times of axes and Hexapod struts result from the different drive concepts:

- Axes X, Y, Z, U, V and W of the moving platform of the Hexapod: Motion results from the motions of Hexapod struts 1 to 6
- Hexapod struts 1 to 6 and axes A and B: DC servo motors
- Axes K, L, M: piezo actuators

Axis	X, Y, Z, U, V, W	A, B, Hexapod struts 1 to 6	K, L, M
Cycle time in ms	1	0.403	0.02

13.1.3 Maximum Ratings

The C-887 is designed for the following maximum ratings:

Input on:	Maximum Operating Voltage	Maximum Operating Frequency (Unloaded)	Maximum Current Consumption
Power plug	100 to 240 V AC	50 to 60 Hz	6 A

Output on:	Maximum output voltage	Maximum output current	Maximum output frequency
M12 sockets	24 V DC	Σ max. 5 A	---

13.1.4 Ambient Conditions and Classifications

The following ambient conditions and classifications must be observed for the C-887:

Area of application	For indoor use only
Maximum altitude	2000 m
Relative humidity	Highest relative humidity 80% for temperatures up to 31°C Decreasing linearly to 50% relative humidity at 40°C
Storage temperature	0°C to 70°C
Transport temperature	−25°C to +85°C
Overvoltage category	II
Protection class	I
Degree of pollution	2
Measurement category	I
Degree of protection according to IEC 60529	IP20

13.1.5 Specifications of the F-206.iiU and F-206.VVU Options - See detailed user manual

You can find information on this topic in the detailed MS204E user manual which is included as a PDF file on the product CD.

13.1.6 Specifications of the F-206.NCU Option - See detailed user manual

You can find information on this topic in the detailed MS204E user manual which is included as a PDF file on the product CD.

13.2 System Requirements

The following system requirements must be met to operate the Hexapod system:

- The Hexapod of the Hexapod system to whose configuration data the controller is adapted (see sticker on the controller)
- In the case of a Hexapod without permanently installed cables: cable set of the Hexapod system
- When the C-887 is to be supplied with commands via a PC or a network:
 - PC with Windows (XP, Vista, 7) or Linux operating system
 - Communication interface to the PC:
free COM port on the PC
or
Ethernet connection in the PC and, if necessary, a free access point in the network to which the PC is connected
 - RS-232 or network cable to connect the controller with the PC or with the network
 - C-887 CD with PC software
- When the user interface of the C-887 is to be worked with:
 - Keyboard with USB connection, included in the scope of delivery (p. 23)
 - Monitor with VGA connection

13.3 Dimensions

13.3.1 C-887.11

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

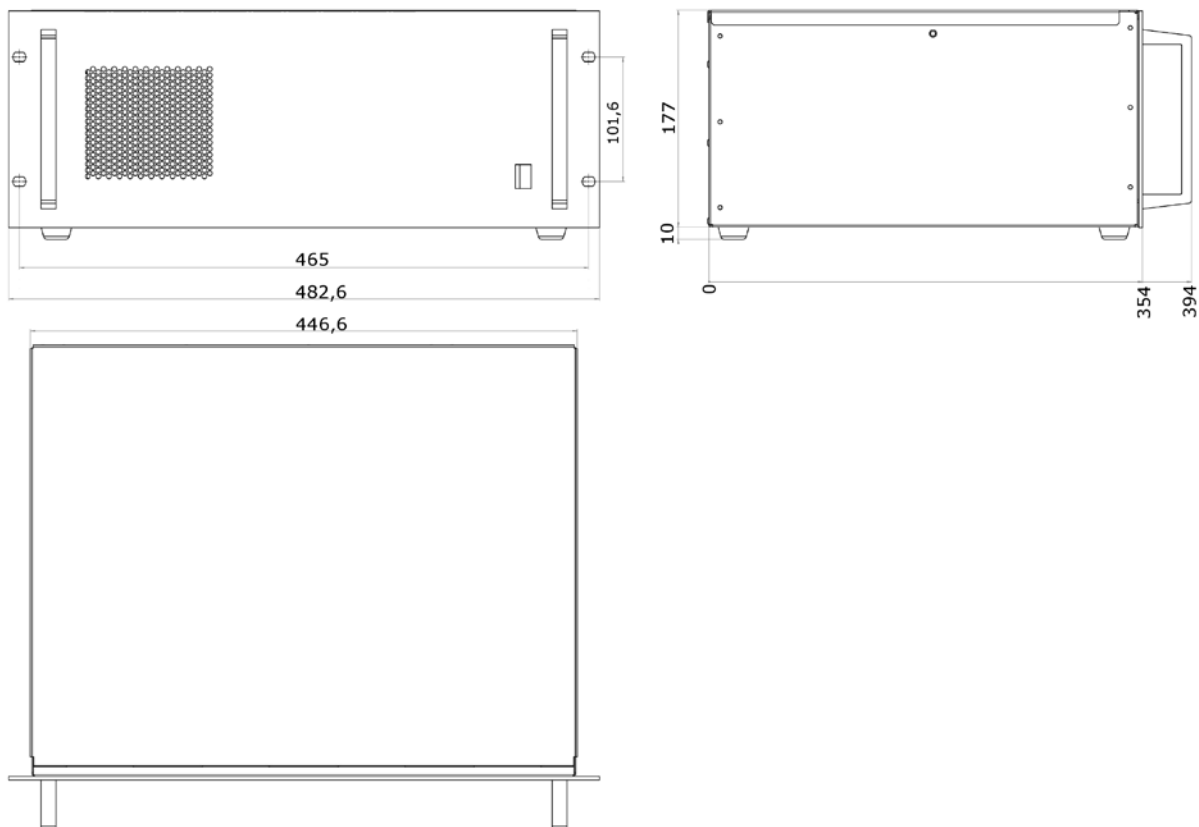


Figure 13: C-887.11

13.3.2 C-887.21

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

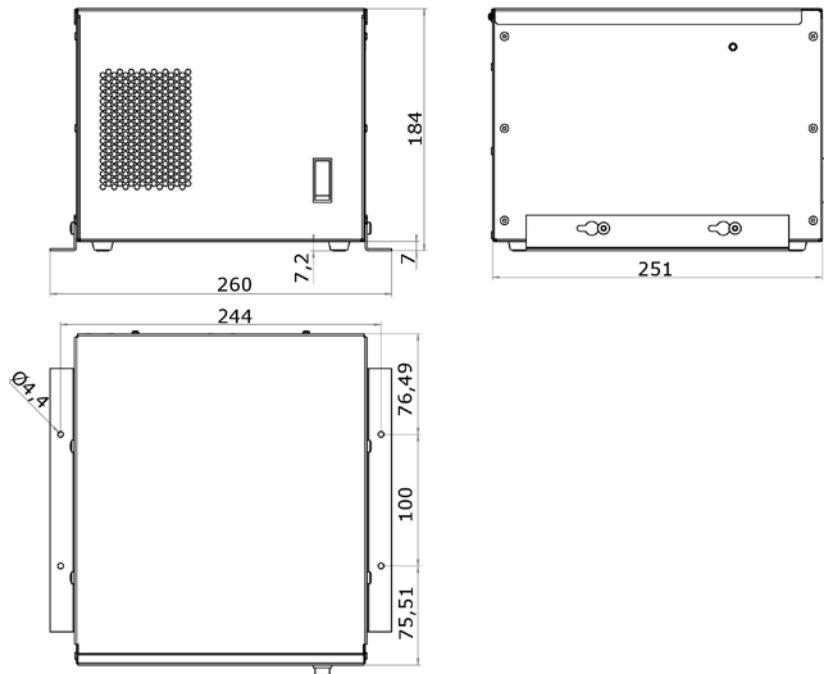


Figure 14: C-887.21

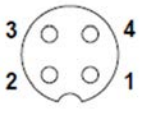
13.4 Pin Assignment

13.4.1 2x 24 VDC Power Out

The two **2x 24 VDC Power Out** connections on the rear panel of the C-887 can be used for the following purposes with any allocation:

- Power source of the Hexapod
- Only when using a cable set with line driver boxes: power source for line driver box; for further information, see the user manual of the Hexapod

A-coded, 4-pin M12 socket, female

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

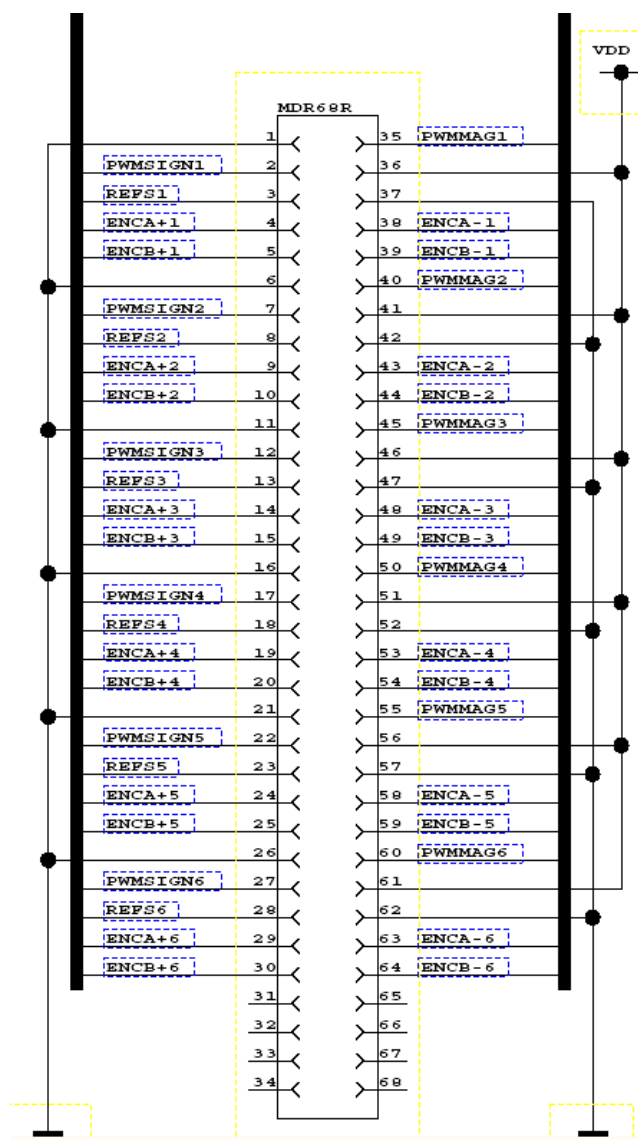
13.4.2 Hexapod

Data transmission between the Hexapod and the Hexapod controller

MDR68 socket


Function	Socket
All signals: TTL	

Pin assignment



13.4.3 RS-232

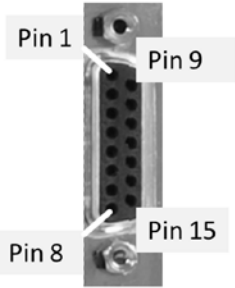
9-pin sub-D panel plug, male

Pin	Function	
1	Not connected	
2	RxD, data input	
3	TxD, data output	
4	Not connected	
5	DGND (digital mass)	
6	Not connected	
7	RTS, hardware handshake output	
8	CTS, hardware handshake input	
9	Not connected	

13.4.4 A and B - only C-887.11

The rear panel of the C-887.11 has **A** and **B** connections for optionally available stages with DC motors (p. 24).

15-pin sub-D socket, female

Pin	Function	
1	Output: +5 V for motor brake	
2	Reserved	
3	Output: MAGN (motor PWM, TTL signal)	
4	Output: +5 V, for encoder	
5	Reserved	
6	Reserved	
7	Input: encoder: A (-)	
8	Input: encoder: B (-)	
9	Reserved	
10	PWM GND	
11	Output: SIGN (direction of rotation of the motor, TTL signal)	
12	Reserved	
13	Input: REFS (reference switch, TTL signal)	
14	Input: encoder: A (+) / ENCA	
15	Input: encoder: B (+) / ENCB	

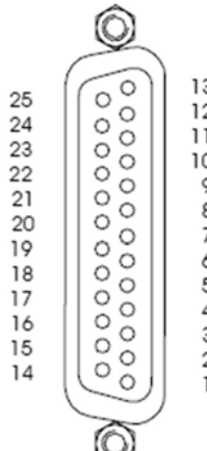
13.4.5 Nanocube - only C-887.11

If the E-760 controller card of the F-206.NCU option is installed in the C-887.11 (p. 43), the C-887.11 will have the following connections on the rear panel:

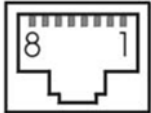
- Sub-D socket 25-pin, female for the connection of the P-611.3SF NanoCube®
- RJ45 socket for the connection of an analog input signal

The E-760 controller card is labeled with **Nanocube**.

25-pin sub-D socket, female

Pin	Function	
1	Input: B31	
2	Input: REF3	
3	Input: B21	
4	Input: REF2	
5	Input: B11	
6	Input: REF1	
7	Not connected	
8	Not connected	
9	Not connected	
10	AGND	
11	Output: PZT3 (-20 to 120 V)	
12	Output: PZT2 (-20 to 120 V)	
13	Output: PZT1 (-20 to 120 V)	
14	Input: B32	
15	AGND	
16	Input: B22	
17	AGND	
18	Input: B12	
19	AGND	
20	Not connected	
21	Not connected	
22	Reserved	
23	AGND	
24	AGND	
25	AGND	

RJ45 socket for the connection of an analog input signal

Pin	Function	
1	GND	
2	Reserved	
3	Reserved	
4	Reserved	
5	Reserved	
6	Reserved	
7	Analog input, ± 5 V, resolution: 14 bit	
8	AGND	

14 Old Equipment Disposal

Since 13 August 2005, in accordance with the EU directive 2002/96/EC (WEEE), electrical and electronic equipment can no longer be disposed of in the member states of the EU with other wastes.

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



15 Appendix

In this Chapter

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GNU General Public License.....	121

15.1 EC Declaration of Conformity

PI

Declaration of Conformity

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

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

The manufacturer hereby declares that the product

Product Name: **6D Hexapod Controller**

Model Numbers: **C-887**

Product Options: **all**

complies with the following European directives:

2006/95/EC, Low Voltage Directive (LVD)

2004/108/EC, EMC Directive

2011/65/EC, RoHS Directive

The applied standards certifying the conformity are listed below.

Electromagnetic Emission: EN 61000-6-3:2007, EN 55011:2009

Electromagnetic Immunity: EN 61000-6-1:2007

Safety (Low Voltage Directive): EN 61010-1:2010

December 05, 2012
Karlsruhe, Germany



Norbert Ludwig
Managing Director

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PIEZO NANO POSITIONING

15.2 GNU General Public License

The software included in this product contains copyrighted software that is licensed under the GNU General Public License (the GPL), or the GNU Lesser General Public License (the LGPL).

For more information about the GPL, you can access the GPL website (<http://www.gnu.org/licenses/gpl-3.0.en.html>) and download a copy of the GPL (<http://www.gnu.org/licenses/gpl.txt>).

For more information about the LGPL, you can access the GPL website (<http://www.gnu.org/licenses/gpl-3.0.en.html>) and download a copy of the LGPL (<http://www.gnu.org/licenses/lgpl.txt>).

The GPL'ed source code used falls into a number of categories:

1. The compiler toolchain used to build all the software
2. The Linux kernel, with modifications by PI
3. Other third party software (under GPL or LGPL)

