Technical Note

BRo, 2015-02-11
C887T0008, valid for C-887.52

C-887.52 Hexapod Controller

Contents

Introduction

The C-887.52 Hexapod controller is intended for closed-loop driving of a Hexapod microrobot („Hexapod“) from PI equipped with DC servo motors.

The functionality of the C-887.52 controller is based on that of the C-887.21 standard model. For the most important differences between C-887.21 and C-887.52, see p. 3.

Figure 1: C-887.52 Hexapod Controller

Scope of Delivery

Item Number	Items
C-815.563	Cross-over network cable
C-815.553	Straight-through network cable
C-815.34	Null-modem cable for connection to the PC via RS-232
C-887.5PS	Wide-range-input power supply 24 V / 180 W, with line cord (item no. 3763)
C-887.CD	CD with PC software and documentation
Documentation, consisting of:	
MS204Equ	Short version of the user manual for C-887.11/.21 (detailed version is on the C-887.CD)
C887T0008	Technical Note for the C-887.52 Hexapod controller (this document)
Packaging material	

Other Applicable Documents

In general, see the MS204E user manual of the C-887.11/.21 Hexapod controller for descriptions of the commands and functionality supported by the C-887.52 Hexapod controller (important differences between the controllers are listed on p. 3).

Descriptions of commands for Hexapod coordinate systems can be found in the C887T0007 Technical Note (C887T0007_Hexapod_Coordinate_Systems_EN.pdf; on the C-887.CD).

The software tools which can be used with the C-887.52 are described in their own manuals:

Description	Document
C-887 GCS LabVIEW	MS209E Software Manual
PI GCS 2 DLL	MS210E Software Manual
PIMikroMove	SM148E Software Manual
GCS Data	SM146E Software Manual
Simulation of 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 microrobot to be operated with the C-887.52, one of the following user manuals is also valid:

Model Family	Document
H-810 Miniature Hexapod Microrobot	MS198E
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

Important Differences Between the C-887.52 and C-887.21 Models

C-887.52 differs from C-887.21 in the following points (keep the differences in mind when using the MS204E user manual of the C-887.21 Hexapod controller):

- Dimensions (p. 18), technical data (p. 16), operating elements (p. 7)
- C-887.52 is equipped with lines for digital in- and output and analog input which are available on the **I/O** socket (p. 20).
- In addition to the Hexapod, two stages equipped with DC motor and PWM amplifier can be connected to the C-887.52 (as with the C-887.11 standard model which is also described in the MS204 user manual; pinout see p. 21). The assignment of stage types for the additional stages can be saved to nonvolatile memory using the WPA command (p. 14).
- C-887.52 uses an external 24 V power supply.
- Data transmission between Hexapod and C-887.52 is done via HD Sub-D 78 connection (p. 19).
- Keyboard, mouse and monitor **cannot** be connected to the C-887.52 so that the user interface described in the MS204 user manual is **not** supported.
- C-887.52 only supports GCS syntax version 2.0.
- In addition to the commands described in the MS204 user manual and C887T0007 Technical Note, C-887.52 supports the following commands: DIO (p. 10), DIO? (p. 10), HIB? (p. 11), IFC? (p. 12), MAN? (p. 13). Using the HLP? command, you can obtain a list of supported commands.
- With C-887.52, the maximum number of points per data recorder table is 262144. For further properties of the data recorder, see the response to the HDR? command.
- With C-887.52, the volatilely configurable parameters can be saved to nonvolatile memory using the WPA command. Using the HPA? command, you can obtain a list with valid parameter IDs and parameter descriptions. See the MS204 user manual for general information on how to change parameters.

Safety

Intended Use

The C-887.52 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-887.52 is intended for closed-loop driving of a Hexapod microrobot from PI equipped with DC servo motors.

The C-887.52 must not be used for purposes other than those named in this Technical Note.

The C-887.52 may only be used in compliance with the technical specifications and instructions in this Technical Note. The user is responsible for process validation.

General Safety Instructions

The C-887.52 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 system.

- Only use the C-887.52 for its intended purpose, and only use it if it is in a good working order.
- Read the user documentation.
- 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-887.52.

Organizational Measures

User documentation

- Always keep the user documentation available by the C-887.52.
- Add all information given by the manufacturer to the user documentation, for example supplements or Technical Notes.
- If you pass the C-887.52 on to other users, also turn over the user documentation as well as other relevant information provided by the manufacturer.
- Only use the C-887.52 on the basis of the complete user documentation. Missing information due to incomplete user documentation can result in minor injury and property damage.
- Only install and operate the C-887.52 after having read and understood the user documentation.

Personnel qualification

The C-887.52 may only be installed, started up, operated, maintained and cleaned by authorized and qualified staff.

Safety Measures during Installation

- Install the C-887.52 near the power source so that the power plug can be quickly and easily disconnected from the mains.
- Use the supplied components (power supply and power cord (p. 2)) to connect the C-887.52 to the power source.
- If one of the supplied components for connecting to the power source has to be replaced, use a sufficiently dimensioned component.

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

- Make sure that the installed load observes the specified limit.
- 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.

Safety 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-887.52 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.

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 controller indicates for which Hexapod the controller is intended.
- Only operate the Hexapod with a Hexapod controller whose configuration 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 working 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.

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.

Product View

Front Panel

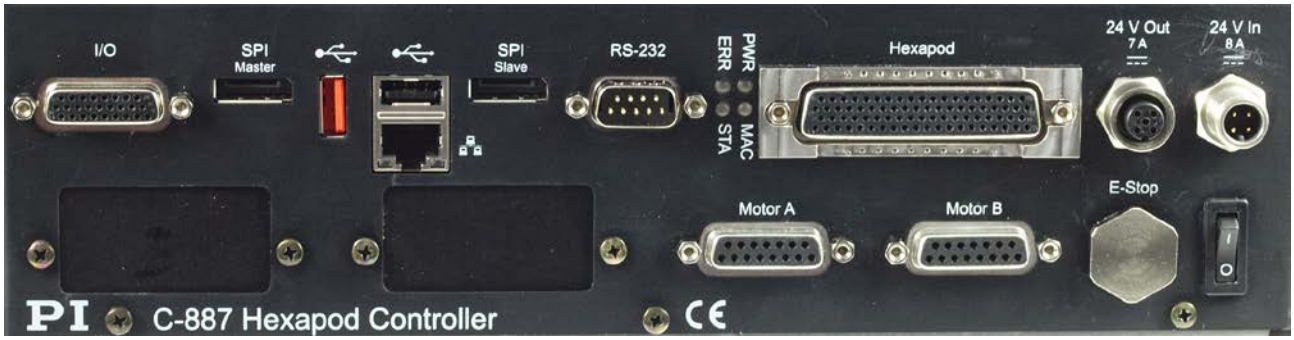


Figure 2: C-887.52 front panel

Element	Labeling	Type	Function
	**I/O**	HD Sub-D 26 (f) (p. 20)	Digital in-/outputs: ▪ Outputs: Triggering external devices ▪ Inputs: Use in macros Analog inputs (multipurpose)
	**SPI Master**	Display port	For future use; currently no function.
 		USB type A, high insertion and withdrawal force	USB interface for connecting the C-887.MC control unit from PI
 		USB type A	USB interface for connecting peripheral devices
 		RJ45 socket	Network connection via TCP/IP
	**SPI Slave**	Display port	For future use; currently no function.
	**RS-232**	Sub-D 9 (m)	Serial connection to PC
	**ERR**	LED red/off	Error indicator: ▪ Continuously lit: Error (error code ≠ 0) ▪ Off: No error (error code = 0) The error code can be queried with the ERR? command. The query resets the error code to zero and the LED is deactivated.
	**PWR**	LED green/off	Power: ▪ Continuously lit: The booting of the firmware has been completed, and the controller is ready for normal operation. ▪ Off: C-887.52 is switched off or the firmware is booting.

Element	Labeling	Type	Function
	**STA**	LED green/off	State: ▪ Continuously lit: The booting of the firmware has been completed, and the controller is ready for normal operation. ▪ Off: C-887.52 is switched off or the firmware is booting.
	**MAC**	LED green/red/off	Macro: ▪ Lit green: Macro is running ▪ Lit red: Macro error The error code can be queried with the `MAC ERR?` command. The query resets the error code to zero and the LED is deactivated. ▪ Off: No macro is running and no macro error is present.
	**Hexapod**	HD Sub-D 78 (f) (p. 19)	Connection for data transmission between Hexapod and controller
	**24 V Out 7 A**	4-pin M12 socket (f) (p. 22)	Power source connection for Hexapod
	**24 V In 8 A**	4-pin M12 panel plug (m) (p. 21)	Connection for the supply voltage of the C-887.52 When the Hexapod is connected to the **24 V Out** socket of the controller, the supply voltage of the C-887.52 is also used to supply the Hexapod.
	**Motor A** **Motor B**	Sub-D 15 (f) (p. 21)	Two connections for stages. Only for stages with DC motors and PWM amplifiers! ▪ Output of PWM signals for the stage ▪ Input of the signals of the incremental position sensor ▪ Input of the signals from the limit switches and reference point switch
	**E-Stop**	Closed with blanking plug	Provided for future applications.
	-	Toggle switch	Power on/off switch: ▪ O position: C-887.52 is switched off* ▪ | position: C-887.52 is switched on* * When the Hexapod is connected to the **24 V Out** socket of the controller, the Hexapod is also switched on/off.

Protective Earth Connection

Figure 3: C-887.52 Hexapod controller, protective earth connection

Labeling	Type	Function
⏚	M4 threaded pin	Protective earth connection If potential equalization is required, the C-887.52 can be connected to the grounding system.

GCS Commands

The C-887.52 supports the commands of the PI General Command Set (PI GCS), syntax version 2.0. See the following documents for descriptions:

Document	Content
MS204E user manual of the C-887.11/.21 Hexapod controller	▪ Command reference of the PI GCS ▪ Information on the syntax used in the command descriptions ▪ Information on the PI GCS syntax
C887T0007 Technical Note	Descriptions of the commands that were introduced for working with user-defined coordinate systems
C887T0008 Technical Note (this document)	Descriptions of the commands DIO, DIO?, HIB?, IFC?, MAN?, WPA

Command Overview

Command	Format	Description
DIO (p. 10)	DIO {<DIOID> <OutputOn>}	Set Digital Output Lines
DIO? (p. 10)	DIO? [{<DIOID>}]	Get Digital Input Lines
HIB? (p. 11)	HIB? [{<HIDeviceID> <HIDeviceButton>}]	Get State Of HID Button
IFC? (p. 12)	IFC? [{<InterfacePam>}]	Get Current Interface Parameters
MAN? (p. 13)	MAN? {<CMD>}	Get Help String For Command
WPA (p. 14)	WPA <Pswd> [{<ItemID> <PamID>}]	Save Settings To Non-Volatile Memory

Command Descriptions

DIO (Set Digital Output Line)

Description:	Switches the specified digital output line(s) to specified state(s).
Format:	DIO {<DIOID> <OutputOn>}
Arguments:	<DIOID> is one digital output line of the controller, see below for details. <OutputOn> is the state of the digital output line, see below for details.
Response:	none
Notes:	Using the DIO command, you can activate/deactivate digital output lines 1 to 4, which are located on the **I/O** socket (p. 20). The <DIOID> identifiers to use for the lines are 1 to 4. If <OutputOn>=1 the line is set to HIGH/ON, if <OutputOn>=0 it is set to LOW/OFF.

DIO? (Get Digital Input Lines)

Description:	Gets the states of the specified digital input lines.
Format:	DIO? [{<DIOID>}]
Arguments:	<DIOID> is the identifier of the digital input line, see below for details.
Response:	{<DIOID>"="<InputOn> LF} where <InputOn> indicates the state of the digital input line, see below for details.
Notes:	You can use the DIO? command to directly read the digital input lines 1 to 4 that are located on the **I/O** socket (p. 20). The <DIOID> identifiers to use for the lines are 1 to 4. If the identifier is omitted, all lines are queried. If <InputOn>=0, the digital input is LOW/OFF, if <InputOn>=1, the digital input is HIGH/ON.

HIB? (Get State Of HID Button)

Description:	Gets the current state of the given button of the given HID device.
Format:	HIB? [{<HIDeviceID> <HIDeviceButton>}]
Arguments:	<HIDeviceID> is one HID device connected to the controller; see below for details. <HIDeviceButton> is one button of the HID device; for more details, see below.
Response:	{<HIDeviceID> <HIDeviceButton> "="<HIDButtonState>} where <HIDButtonState> indicates the state of the button as an integer value: 0 = Button not pressed, 1 = Button pressed
Notes:	An HID device can be connected to one of the USB sockets of the C-887.52. The identifier of the HID device is 1. When the C-887.MC control unit is connected to a USB socket of the C-887.52, you can use HIB? to query the state of the two push buttons of the control unit (button IDs are 1 and 2). When using the HIB? response e.g. in a macro, keep in mind that the value of the ***HID Device Button Mode*** parameter (ID 0x0e001600) determines the behaviour of the push buttons: ▪ Parameter value is 0 (default): The buttons trigger actions (stop, reference move) as described in the C887T0003 Technical Note for the C-887.MC control unit. In addition, the button state can be read with the HIB? command. ▪ Parameter value is 1: The buttons do not trigger any action. The button state can be read with the HIB? command. The value of the parameter can be changed with the SPA command (see MS204E user manual).

IFC? (Get Current Interface Parameters)

Description: Gets the values of the interface parameters for communication from volatile memory.

Format: IFC? [{<InterfacePam>}]

Arguments: <InterfacePam> is the interface parameter to be queried, see below for possible values.

Response: {<InterfacePam>"="<PamValue> LF}

where

<PamValue> gives the value of the interface parameter from volatile memory.

<InterfacePam> can be RSPORT, RSBAUD, RSHSHK, IPADR, IPSTART, IPMASK, IPMAXCONN, MACADR and TERMSTR

For <InterfacePam> = RSPORT, <PamValue> indicates the port used for RS-232 communication.

For <InterfacePam> = RSBAUD, <PamValue> indicates the current baud rate of the RS-232 communication.

For <InterfacePam> = RSHSHK, <PamValue> returns the handshake setting for RS-232 communication:
1 = RTS/CTS

For <InterfacePam> = IPSTART, <PamValue> indicates the current setting of the startup behavior for configuration of the IP address for TCP/IP communication,
0 = The IP address defined with IPADR is used.
1 = DHCP is used to obtain the IP address (default).

For <InterfacePam> = IPADR, the first four parts of <PamValue> indicate the IP address that is currently used for TCP/IP communication, the last part indicates the port;

For <InterfacePam> = IPMASK, <PamValue> gives the IP mask setting that is currently used for TCP/IP communication, in the form uint.uint.uint.uint.

For <InterfacePam> = IPMAXCONN, <PamValue> indicates the maximum number of allowed IP connections

for TCP/IP communication.

For <InterfacePam> = MACADR, <PamValue> gives the unchangeable, unique address of the network hardware in the C-887.52.

For <InterfacePam> = TERMSTR, <PamValue> returns the termination character for the commands of the GCS:
0 = LineFeed (ASCII character 10)

MAN? (Get Help String For Command)

Description: Shows a detailed help text for individual commands.

Format: MAN? <CMD>

Arguments: <CMD> is the command mnemonic of the command for which the help text is to be displayed (see below).

Response: A string that describes the command.

Notes: A detailed help text can be displayed for the following commands:

WPA

Example: Send: `MAN? WPA`

Receive:

```
<Password> [{<ItemD> <PamID>}] Save Parameters To Non-Volatile Memory
#AvailablePasswords
<Pswd> <Param_Setting>
100 All Parameters, Settings of Coordinate System Configuration and Assignment of Axes A, B
101 All Parameters
SKS Settings of Coordinate System Configuration
A12 Assignment of Axes A, B
end of help
```

WPA (Save Settings To Non-Volatile Memory)

Description:	Writes the current settings from the volatile to the nonvolatile memory. The settings saved using WPA are automatically loaded from the nonvolatile memory to the volatile memory when the C-887 is switched on or rebooted. **Note: Incorrect settings can cause the system to malfunction. Make sure that the current settings are correct before you execute the WPA command.** Settings in the volatile memory not saved using WPA will be lost when the controller is switched off or rebooted, or when settings are restored.
Format:	WPA <Pswd> [{<ItemID> <PamID>}]
Arguments:	<Pswd> is the password for writing to the nonvolatile memory. See below for details. <ItemID> is the item for which a parameter is to be saved from the volatile to the nonvolatile memory. See below for details. <PamID> is the parameter ID, it can be written in hexadecimal or decimal format. See below for details.
Response:	None
Troubleshooting:	Illegal item identifier, wrong parameter ID, invalid password
Notes:	Parameters can be changed in the volatile memory with SPA. In addition to the parameter settings, the following can be written to the nonvolatile memory using WPA: ▪ Settings for coordinate systems (for details, see the table below and C887T0007 Technical Note) ▪ Assignment of stage types to the A and B axes (for details, see description of the CST command in the MS204 user manual) Saving using WPA does **not** overwrite the default settings for coordinate systems which can be restored using DPA (see C887T0007 Technical Note).

The used password determines what is saved with WPA:

Valid passwords for writing in the nonvolatile memory:

100	Saves the currently valid values of all parameters, the currently valid settings for coordinate systems (for details, see password SKS) and the current assignment of stage types to the A and B axes
101	Saves the currently valid values of all parameters
SKS	Saves the currently valid settings for coordinate systems (details see C887T0007 Technical Note): • Properties of the coordinate systems and combinations of coordinate systems which are present in the volatile memory, see KLS? and KLC? • Activation state of coordinate systems, see KEN • Linking of coordinate systems, see KLN When ZERO is enabled: The current values for NLM, PLM, SSL, SPI and SST are not saved. This ensures that KEN ZERO fully re-enables the default settings for the operating coordinate system.
A12	Assignment of stage types to the A and B axes

Valid passwords can be queried using MAN? WPA.

Available item IDs and parameter IDs:

The item can be an axis, a sensor channel or the overall system; the item type depends on the parameter.

For the identifiers of the items, see "Commandable Items" in the MS204 user manual.

With HPA? you can obtain a list of all available parameters.

Technical Data

Data Table

	C-887.52 Hexapod Controller
Function	6-D controller for Hexapods, incl. control of two additional single axes
Drive type	DC servo motors (Hexapod and additional axes)
Motion and control	
Servo characteristics	32-bit PID filter
Trajectory profile modes	Jerk-limited trajectory generation with linear interpolation
Processor	CPU: ATOM Dual Core (1.8 GHz), motion control chip with 10 kHz servo update rate
Encoder input	AB differential TTL signal, 50 MHz
Stall detection	Servo off, triggered by position error
Reference point switch	TTL signal
Electrical properties	
Max. output power per channel	12-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
Hexapod connection	HD Sub-D 78 (f) for data transmission M12 (f) for supply voltage
Connection for additional single axes	15-pin sub-D
I/O ports	HD Sub-D 26 (f) 4 x analog input (-10 to 10 V; 12 bit) 4 x digital input (TTL) 4 x digital output (TTL)
Command set	PI General Command Set (GCS), syntax version 2.0
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	24 V, max. 8 A
Operating temperature range	5 to 40°C
Mass	2.8 kg

Maximum Ratings

The C-887.52 is designed for the following operating data:

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

Output on:	Maximum Output Voltage	Maximum Output Frequency	Maximum Output Current
4-pin M12 socket (f)	24 V	⎓	7 A

Ambient Conditions and Classifications

Area of application	For indoor use only
Maximum altitude	2000 m
Air pressure	1100 hPa to 0.1 hPa (corresponds to roughly 825 torr to 0.075 torr)
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

Dimensions

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

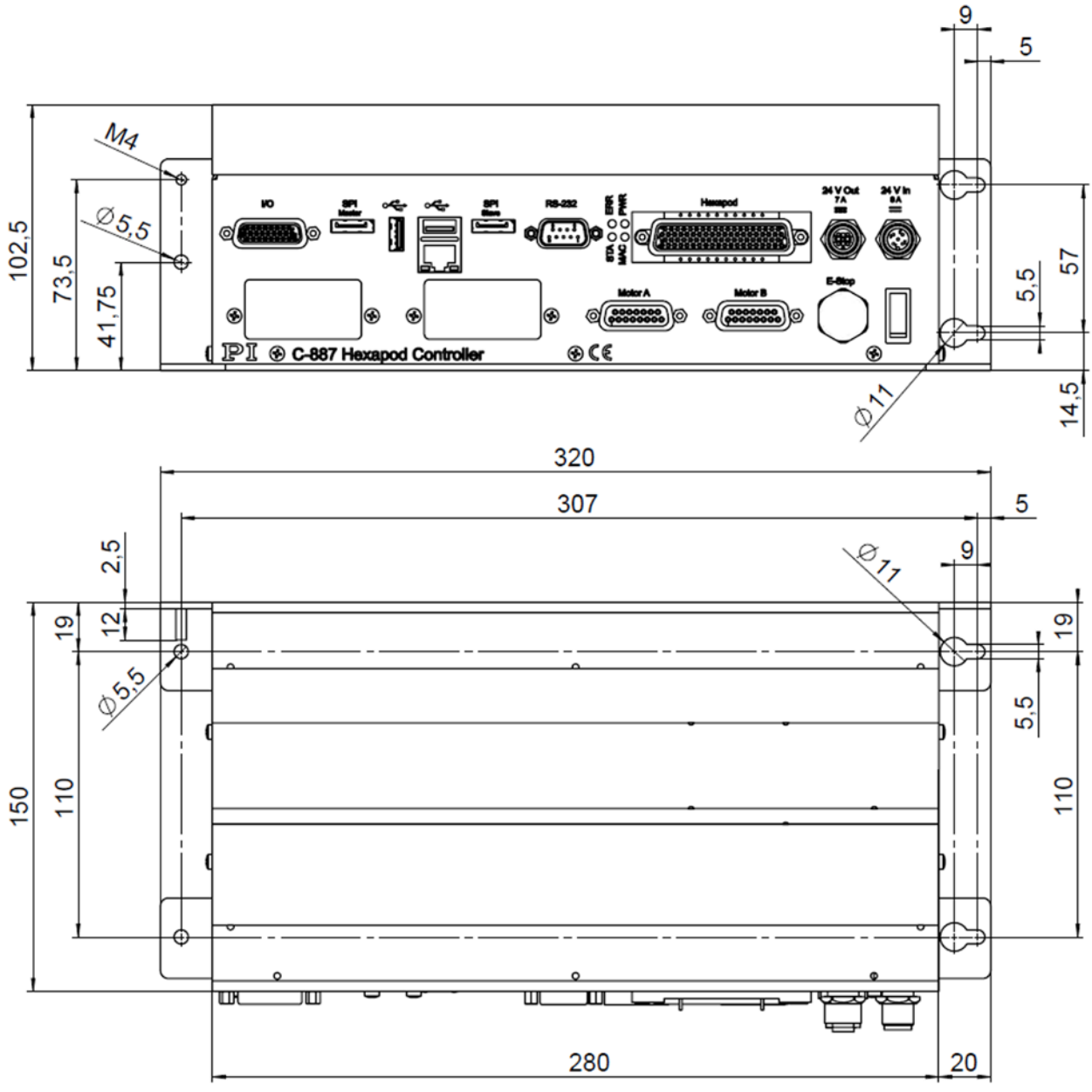


Figure 4: C-887.52 Hexapod controller

Pin Assignment

Hexapod (Data Transmission)

HD Sub-D 78 (f)

Pin	Pin	Signal
1		CH1 Sign
	21	CH1 Ref
2		CH1 VDD
	22	CH1 A+
3		CH1 A-
	23	GND
4		CH2 Sign
	24	CH2 Ref
5		CH2 VDD
	25	CH2 A+
6		CH2 A-
	26	GND
7		CH3 Sign
	27	CH3 Ref
8		CH3 VDD
	28	CH3 A+
9		CH3 A-
	29	GND
10		CH4 Sign
	30	CH4 Ref
11		CH4 VDD
	31	CH4 A+
12		CH4 A-
	32	GND
13		CH5 Sign
	33	CH5 Ref
14		CH5 VDD
	34	CH5 A+
15		CH5 A-
	35	GND
16		CH6 Sign

Pin	Pin	Signal
40		CH1 MAGN
	60	CH1 LimP
41		CH1 LimN
	61	CH1 B+
42		CH1 B-
	62	GND
43		CH2 MAGN
	63	CH2 LimP
44		CH2 LimN
	64	CH2 B+
45		CH2 B-
	65	GND
46		CH3 MAGN
	66	CH3 LimP
47		CH3 LimN
	67	CH3 B+
48		CH3 B-
	68	GND
49		CH4 MAGN
	69	CH4 LimP
50		CH4 LimN
	70	CH4 B+
51		CH4 B-
	71	GND
52		CH5 MAGN
	72	CH5 LimP
53		CH5 LimN
	73	CH5 B+
54		CH5 B-
	74	GND
55		CH6 MAGN

Pin	Pin	Signal
	36	CH6 Ref
17		CH6 VDD
	37	CH6 A+
18		CH6 A-
	38	GND
19		Reserved
	39	GND
20		24 V output

Pin	Pin	Signal
	75	CH6 LimP
56		CH6 LimN
	76	CH6 B+
57		CH6 B-
	77	GND
58		Brake/Enable drive
	78	GND
59		Power good 24 V input

I/O Connection

HD Sub-D 26 (f))

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

Pin	Pin	Pin	Signal
8			Digital output 4 (TTL)
		26	Digital output 3 (TTL)
	18		Digital output 2 (TTL)
9			Digital output 1 (TTL)

* -10 V to 10 V, 12 bit; 15 kΩ input impedance

Motor A, Motor B

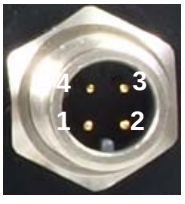
Sub-D 15 (f))

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

Supply Power for Controller

M12 4-pin panel plug (m)

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



Power Output for Hexapod

M12 4-pin socket (f)

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