MS224Equ

C-413 PIMag® Controller

User Manual Short Version

Version: 1.2.0 Date: 11.11.2019

This document describes the following products:

- **C-413.20**
  PIMag® motion controller, 2 channels, OEM board, USB and SPI interface, force control option
- **C-413.20A**
  PIMag® motion controller, 2 channels, OEM board, USB and SPI interface, analog inputs, force control option
- **C-413.2G**
  PIMag® motion controller, 2 channels, benchtop device, USB and SPI interface, force control option
- **C-413.2GA**
  PIMag® motion controller, 2 channels, benchtop device, USB and SPI interface, analog inputs, force control option

The detailed version of this user manual is included as a PDF file on the product CD and can be downloaded from our website.

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Contents

1 About this Document

In this Chapter

1.1 Objective and Target Audience of this User Manual

The short version of the MS224E user manual includes the following information on the intended use of the C-413:

- Product description and technical data of the C-413
- Installation instructions for the C-413
- Startup instructions for the C-413
- Command overview
- Instructions for adapting settings
- Cleaning instructions for the C-413
- Overview for troubleshooting

In the detailed MS224E user manual, which is included as a PDF file on the product CD, you can find all other information and instructions regarding 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.

The latest versions of the user manuals are available for download (p. 4) on our website.

If you have questions, contact our customer service department (p. 69).

1.2 Symbols and Typographic Conventions

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

NOTICE

Dangerous situation
Failure to comply could cause damage to equipment.

➢ Precautionary measures for avoiding the risk.

INFORMATION

Information for easier handling, tricks, tips, etc.

Symbol/Label	Meaning
1. 2.	Action consisting of several steps whose sequential order must be observed
➢	Action consisting of one or several steps whose sequential order is irrelevant
▪	List item
p. 5	Cross-reference to page 5
RS-232	Labeling of an operating element on the product (example: socket of the RS-232 interface)
	Warning sign on the product which refers to detailed information in this manual.
Start > Settings	Menu path in the PC software (example: to open the menu, the ***Start*** and ***Settings*** menu items must be clicked in succession)
POS?	Command line or a command from PI's General Command Set (GCS) (example: Command to get the axis position).
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 of Terms

Term	Explanation
Axis	Also referred to as "logical axis". The logical axis represents the motion of the mechanics in the firmware of the C-413. For mechanics that allow motion in several directions (e.g., in X, Y, and Z), each direction of motion corresponds to a logical axis.
GCS	PI General Command Set; command set for PI controllers. Piezo drivers and servo controllers can be operated together with minimal programming effort thanks to GCS.
Firmware	Software that is installed on the controller.
Volatile memory	RAM module in which the parameters are saved when the controller is switched on (working memory). The parameter values in the volatile memory determine the current behavior of the system. The parameter values in the volatile memory are also referred to as "Active Values" in the PC software from PI.
Incremental position sensor	Sensor (encoder) for detecting changes of position or changes of angle. Signals from the incremental position sensor are used for axis position feedback. After the controller is switched on, referencing must be done before absolute target positions can be commanded and reached.
PC software	Software that is installed on the PC.
Nonvolatile memory	Memory module (read-only memory, e. g., EEPROM or flash memory), from which the default values of the parameters are loaded to the volatile memory when the controller is started. The parameter values in the nonvolatile memory are also referred to as "startup values" in the PC software from PI.
Mechanics	Mechanics connected to the C-413 with one or more motion axes.
Voice coil drive	A voice coil drive generates the feed via the Lorentz force on an energized coil (PIMag® principle) that is coupled to a moving rod. The drive therefore combines a relatively long travel range with a high velocity and a high resolution.

1.4 Other Applicable Documents

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

Description	Document
Detailed user manual for the C-413	MS224E User Manual
SPI Interface of the C-413	C413T0014 Technical Note
C-413 GCS driver library for use with NI LabVIEW software	MS225E Software Manual
Driver Merge Tool for use with NI LabVIEW software	SM154E Software Manual
PI GCS 2.0 DLL	SM151E Software Manual
PI MATLAB Driver GCS 2.0	SM155E Software Manual
GCS array data format description	SM146E Software Manual
PIMikroMove	SM148E Software Manual
PI Update Finder: Search and download updates	A000T0028 Technical Note
PI Update Finder: Updating PC without Internet connection	A000T0032 Technical Note

1.5 Downloading Manuals

INFORMATION

If a manual is missing or problems occur with downloading:

➢ Contact our customer service department (p. 69).

Downloading manuals

1. Open the website **www.pi.ws**.
2. Search the website for the product number (e.g., P-882) or the product family (e.g., PICMA® bender).
3. Click the corresponding product to open the product detail page.
4. Click ***Downloads***.

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

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

2 Safety

In this Chapter

2.1 Intended Use

The C-413 is a laboratory device as defined by DIN EN 61010-1. It is intended for indoor use and use in an environment that is free of dirt, oil, and lubricants.

The C-413.20A and .20 OEM boards must be installed in a suitable housing before startup.

In accordance with its design, the C-413 is intended to be used for operating mechanics with voice coil drives (p. 3).

The C-413 is intended for closed-loop operation. For closed-loop operation, sensor signals must be provided via an SPI interface or optionally as analog input signals. Furthermore, the C-413 can read out the reference switch signals of the mechanics and process them further.

The C-413 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-413 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-413.

- Use the C-413 for its intended purpose only, and only when it is in perfect technical condition.
- Read the user manual.
- Eliminate any malfunctions that may affect safety immediately.

The operator is responsible for the correct installation and operation of the C-413.

- Install the C-413 near the power source so that the power plug can be quickly and easily disconnected from the mains.
- Use the supplied components (power supply, adapter and power cord (p. 12)) to connect the C-413 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.

2.3 Organizational Measures

User manual

- Keep this user manual with the C-413 always.
  The latest versions of the user manuals are available for download (p. 4) on our website.
- Add all information given by the manufacturer to the user manual, for example supplements or technical notes.
- If you give the C-413 to other users, also include this user manual as well as other relevant information provided by the manufacturer.
- Always work according to the complete user manual. If your user manual is incomplete and is therefore missing important information, damage to equipment can result.
- Install and operate the C-413 only after you have read and understood this user manual.

Personnel qualification

The C-413 may only be installed, started up, operated, maintained, and cleaned by authorized and appropriately qualified personnel.

3 Product Description

In this Chapter

3.1 Features and Applications

Digital motion controller for PIMag® **voice coil drives**

2 motor channels, 4 sensors channels. PID controller for force, position, velocity. Servo update rate can be selected between 5 and 10 kHz.

Force Control

PIMag® systems are ideally suited for push-pull applications. Force control allows PIMag® drives and stages to be operated with a defined holding or feed force. PI offers PIMag® actuators with a force sensor. The C-413.20A / .2GA models allow external force sensors to be read via analog inputs.

Extensive functionality

Data recorder: Recording operating data such as motor current, velocity, position or position error. Wave generator: Saves and outputs periodic motion profiles. The autozero function defines the holding current, at which the drive generates a force of 0 N in open-loop operation, e.g., to compensate for the weight force. ID chip support: Detects the mechanics connected and simplifies configuration and interchangeability. Supports direction-sensing reference switches. Extensive software support, e.g., for NI LabVIEW, dynamic libraries for Windows and Linux

Interfaces

USB 2.0, SPI for sending commands. Digital inputs and outputs for automation. Optional analog inputs and outputs e. g. for sensors, commanding or feedback of the position, force or velocity.

3.2 Model Overview

The C-413 is available in the following versions:

Model	Name
C-413.2G	PIMag® motion controller, 2 channels, benchtop device, USB and SPI interface, force control option
C-413.2GA	PIMag® motion controller, 2 channels, benchtop device, USB and SPI interface, analog inputs, force control option
C-413.20	PIMag® motion controller, 2 channels, OEM board, USB and SPI interface, force control option
C-413.20A	PIMag® motion controller, 2 channels, OEM board, USB and SPI interface, analog inputs, force control option

3.3 Product View

3.3.1 Front View

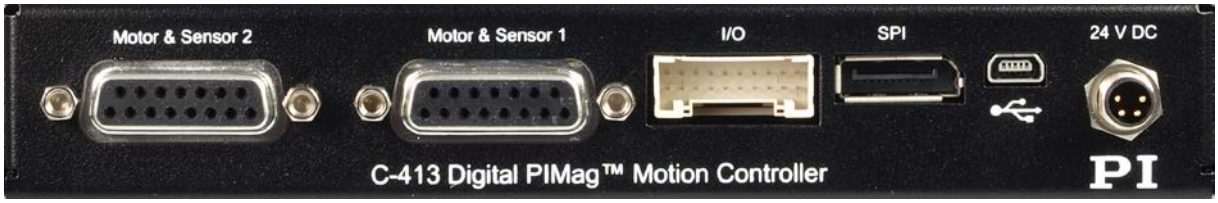


Figure 1: C-413.2GA and .2G; front view

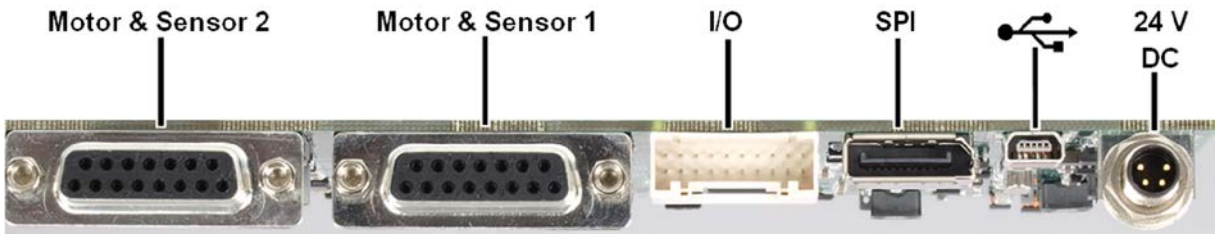


Figure 2: C-413.20A and .20; front view

Labeling	Type	Function
Motor & Sensor 1	D-sub 15 (f) (p. 76)	Connector for PI mechanics with voice coil drive and sensor: ▪ Output current for output signal channel 1 ▪ Sensor and ID chip data for input signal channels 1 and 2 (via SPI) ▪ Reference switch signals for input signal channels 1 and 2
Motor & Sensor 2	D-sub 15 (f) (p. 76)	Connector for PI mechanics with voice coil drive and sensor: ▪ Output current for output signal channel 2 ▪ Sensor and ID chip data for input signal channels 3 and 4 (via SPI) ▪ Reference switch signals for input signal channels 3 and 4
I/O	PUD panel plug (m), 20-pin (JST) (p. 77)	Digital lines: ▪ Outputs: Triggering of external devices, output of the servo cycles ▪ Inputs: Triggering of data recorder or wave generator Only C-413.2GA and .20A - analog lines: ▪ Inputs: Used for external sensors or as analog control inputs ▪ Outputs: Used to monitor the position, force or velocity of an axis or for controlling external motor drivers
SPI	Display port	Connector for SPI master (**S**erial **P**eripheral **I**nterface). For transmission of current values and target/control values between the C-413 and the SPI master with minimum latency and high update rate. ASCII data can also be transmitted so that the SPI master has full access to the PI General Command Set (GCS). Refer to the C413T0014 technical note for details.
	Mini-USB type B 	Universal serial bus for connecting to the PC
24 V DC	M8 panel plug, 4-pin (p. 79)	Connector for the supply voltage

3.3.2 Type Plate

Figure 3: C-413.2GA: Type plate on the top side

Labeling	Function
	Data matrix code (example; contains the serial number)
C-413	Product name (example), the characters following the period refer to the model
	Manufacturer's logo
113064443	Serial number (example), individual for each C-413 Meaning of each position (from the left): 1 = internal information, 2 and 3 = year of manufacture, 4 to 9 = consecutive number
24 V / 2 A DC	Operating voltage / current consumption
Country of origin: Germany	Country of origin
	Warning sign "Pay attention to the manual!"
	Old equipment disposal (p. 81)
WWW.PI.WS	Manufacturer's address (website)
	CE conformity mark

3.3.3 Protective Earth Connection

C-413.2GA and .2G models

Figure 4: Protective earth connection of the C-413.2GA and .2G models

Labeling	Type	Function
⏚	M4 threaded pin	Protective earth connection

C-413.20A and .20 models

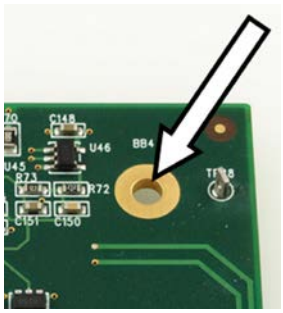


Figure 5: One of four mounting holes of the C-413.20A and .20 models

Labeling	Type	Function
-	Hole with Ø 2.8 mm, 4 x present	Mounting holes with GND potential Protective earth connection via the electrical connection of the mounting holes with a housing connected to the protective earth conductor (p. 32).

3.4 Scope of Delivery

Order number	Components
C-413	Model according to your order
K050B0003	Adapter for the power supply connection; barrel connector to M8 4-pin connector (f)
C-413.CD	Product CD with software and user manuals for the C-413
MS224Equ	Short version of the user manual for the C-413
Only with the C-413.2G and .2GA benchtop devices:	
C-501.24050H	Wide-range-input power supply 24 V DC / 50 W
3763	Power cord
000036360	USB cable (type A to mini-B) for connection to the PC, 3 m

3.5 Accessories

Order number	Description
C-413.1IO	I/O cable for C-413 PIMag® Motion controller, 1 m, open end Refer to the "C-413.1IO Cable for the I/O Connection" (p. 78) for details.

To order, contact our customer service department (p. 69).

3.6 Functional Principles

You will find descriptions on the following topics in the detailed MS224E manual that is available as a PDF file on the product CD and as download from our website (p. 4):

- **Block diagram** of the C-413
- **Commandable items of the C-413** and their identifiers:
  - Logical axes
  - Input and output single channels
  - Digital inputs and outputs
  - Wave generators
  - Wave tables for wave generators
  - Data recorder tables
  - C-413 as an overall system
- Overview of **important firmware components**
- **Allocating axes to channels**

- **Processing input single channels**
- **Servo mode**: Closed-loop and open-loop operation
- Options for **triggering motion** in closed-loop and open-loop operation: Motion commands, wave generator, analog control input
- **Control modes, control variables** (position, velocity, force), and **physical units**
- **Generation dynamics profiles** (profile generator)
- **Servo algorithm and other control value corrections**: PID servo algorithms, optional feedforward, notch filter
- **Contact detection in force control**
- **On-target state**
- **Referencing**: Reference move (default) or manual setting of absolute position
- **AutoZero procedure** for weight force compensation
- **Deactivation of axes**
- **ID chip detection**

3.7 I^2t Monitoring for Protecting the Mechanics

The C-413's I^2t monitoring can prevent the voice coil drive from overheating as a result of overcurrent. On delivery, I^2t monitoring is deactivated by default. You can activate I^2t monitoring via parameters and adapt it to the drive of your mechanics.

When I^2t monitoring is activated, the C-413 calculates the overcurrent limit I^2t_{max} from drive-specific parameters. The C-413 reduces the output current to the drive's nominal current when the current I^2t value reaches the overcurrent limit I^2t_{max}. You will find a formula-based description of the functionality underneath the parameter table.

You can record the current I^2t value with the C-413's data recorder, record option 33 (I2T Value).

Limiting the current by I^2t monitoring can be noticeable in the behavior of the mechanics, e.g., by reduced the velocity or force.

Parameters

I^2t monitoring by the C-413 can be configured with the following parameters:

Parameters	Description and Possible Values
I2T Peak Current [A] 0x0C001000	Peak current I_p of the drive (unit: A) Refer to the datasheet for the mechanics. Used by the C-413 for calculating the overcurrent limit I^2t_{max}.
I2T Peak Current Time [s] 0x0C001001	Maximum duration t_p of peak current (unit: s) Refer to the datasheet for the mechanics. Used by the C-413 for calculating the overcurrent limit I^2t_{max}.

Parameters	Description and Possible Values
I2T Nominal Current [A] 0x0C001002	Nominal current I_n of the drive (unit: A) Refer to the datasheet for the mechanics. Used by the C-413 for calculating the current I^2t value and overcurrent limit I^2t_{max}. The C-413 limits the output current to the value of this parameter when the current I^2t value reaches the overcurrent limit I^2t_{max}.
I2T Active 0x0C001003	Determines the activation state of I^2t monitoring: 0 = I^2t monitoring is deactivated (default) 1 = I^2t monitoring is activated

Formula-based description of I^2t monitoring:

$$I^2t = \int (I^2 - {I_n}^2)\, dt$$

$$I^2t_{max} = ({I_p}^2 - {I_n}^2) * t_p$$

$$I^2t \geq I^2t_{max} \rightarrow I = I_n$$

where

I = current output current of the C-413

I_n = nominal current of the drive

I_p = peak current of the drive

t_p = maximum duration of peak current

INFORMATION

If the settings that were changed in the volatile memory are to be maintained when the C-413 is switched off or rebooted, they have to be saved with WPA, see also "Adapting Settings" (p. 59).

3.8 Communication Interfaces

The C-413 can be controlled from a PC with the ASCII commands of the PI General Command Set (p. 53). The connection to the PC is made via a USB connection.

In addition, the C-413 can also be controlled from an SPI master; refer to the C413T0014 Technical Note for details.

INFORMATION

In the C-413, a USB UART module is used for the USB interface. This results in the following:

- A baud rate setting is necessary for the USB interface.
- If the controller is connected via the USB connection and switched on, the USB interface is also shown as a virtual COM port in the PC software.

To successfully establish communication via USB, the baud rates of the PC and C-413 must be identical. The PIMikroMove PC software, which PI recommends for initial startup of the C-413, therefore automatically adapts the baud rate of the PC to the current baud rate of the C-413.

Only when the PC software offers the selection of the baud rate of the PC when communication is established via USB:

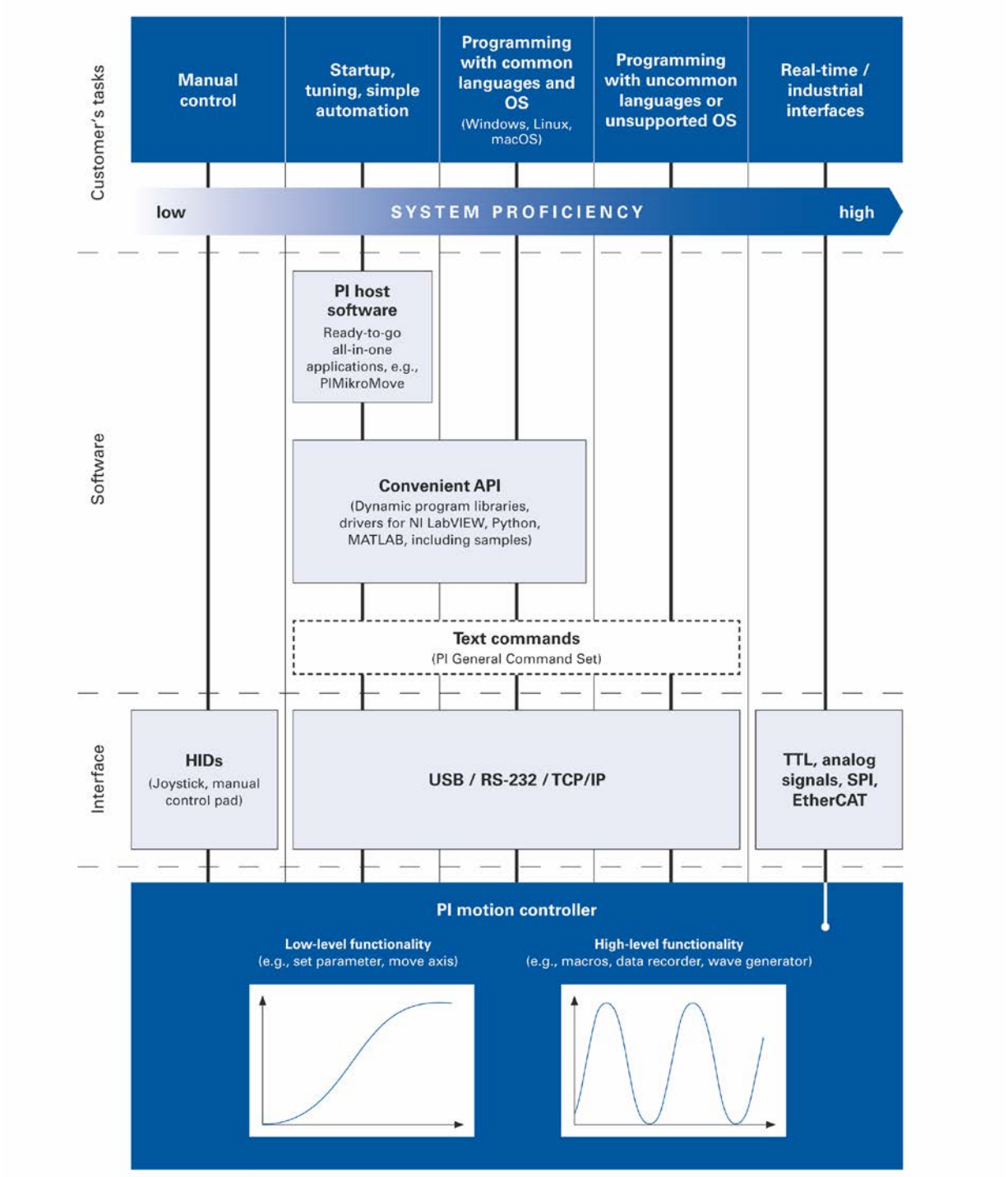
➢ Adapt the baud rate of the PC to the current baud rate of the C-413.

The baud rate of the C-413 can be set with the following parameter:

Parameters	Description and Possible Values
UART Baudrate 0x11000400	Baud rate for the UART of the USB interface Possible values: 9600, 14400, 19200, 38400, 57600, 115200 baud

3.9 Overview of PC Software

Basically, PI systems can be controlled as follows:



The following table shows the PC software on the product CD. The specified operating systems stand for the following versions:

- Windows: Versions 7, 8, 10 (32-bit, 64-bit)
- Linux: Kernel 2.6, GTK 2.0, from glibc 2.15

PC software	Operating system	Short description	Recommended use
Dynamic program library for GCS	Windows, Linux (communication under Linux only via virtual COM port)	Allows software programming for the C-413 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. Is required for PIMikroMove. Is required for the NI LabVIEW drivers.
Driver for use with NI LabVIEW software	Windows, Linux	NI LabVIEW is a software for data acquisition and process control (must be ordered separately from National Instruments). The C-413 software is a collection of virtual instrument drivers (VI drivers) for the C-413 controller. In addition to the product-specific drivers, the product CD also includes the Analog NI LabVIEW drivers, a collection of drivers for generating an analog control signal; refer to "Doing Initial Installation" (p. 27). The drivers support the PI General Command Set.	For users who want to use NI LabVIEW to program their application.
Driver Merge Tool for use with NI LabVIEW software	Windows	The Merge Tool allows product-specific drivers from PI to be combined with each other.	For users who want to operate several products from PI at the same time while using NI LabVIEW.
MATLAB drivers	Windows	MATLAB is a development environment and programming language for numerical calculations (must be ordered separately from MathWorks). The PI MATLAB driver consists of a MATLAB class that can be included in any MATLAB script. This class supports the PI General Command Set. The PI MATLAB driver does not require any additional MATLAB toolboxes.	For users who want to use MATLAB to program their application.

PC software	Operating system	Short description	Recommended use
PIMikroMove	Windows	Graphical user interface for Windows with which the C-413 and other controllers from PI can be used: ▪ The system can be started without programming effort ▪ Graph of motion in open-loop and closed-loop operation ▪ Macro functionality for storing command sequences on the PC (host macros) ▪ Support of human interface devices ▪ Complete environment for command entry, for trying out different commands No command knowledge is necessary to operate PIMikroMove. PIMikroMove uses the dynamic program library to supply commands to the controller. To provide the ***Device Parameter Configuration*** window, PIMikroMove requires the NI LabVIEW Run-Time Engine; see "Doing Initial Installation" (p. 27).	For users who want to do 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	Terminal program that can be used for nearly all PI controllers (see the description of the ***Command Entry*** window in the 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 newer versions of the PC software are available on the PI server, they are offered for download.	For users who want to update the PC software.
PI Firmware Wizard	Windows	Program for user support when updating the firmware of the C-413.	For users who want to update the firmware.
USB driver	Windows	Driver for the USB interface	For all users.

4 Unpacking

For the C-413.20A and .20 OEM boards, the following applies:

NOTICE

Electrostatic hazard

The C-413 contains electrostatic-sensitive components (ESD) and can be damaged if handled improperly.

- Avoid touching assemblies, pins and PCB traces.
- Before you touch the C-413, discharge your body appropriately, e.g., by using an antistatic wrist strap.
- Only handle and store the C-413 in environments that dissipate existing static charges to earth in a controlled way and prevent electrostatic charges (ESD workplace or electrostatic discharge protected area, abbreviated to EPA).

1. Unpack the C-413 with care.
2. Compare the contents with the scope of delivery according to the contract and the delivery note.
3. Inspect the contents for signs of damage. If any parts are damaged or missing, contact our customer service department (p. 69) immediately.
4. Keep all packaging materials in case the product needs to be returned.

5 Quick Start

NOTICE

Electromagnetic disturbances!

If a C-413 OEM board is operated without a housing, live parts are accessible. Electrical, magnetic and electromagnetic fields emitted by live parts can disturb the C-413 and/or the environment.

- ➢ Install a C-413 OEM board in a suitable housing before startup (p. 32).
- ➢ Make sure that the C-413 OEM board fulfills all requirements for electromagnetic compatibility after being installed in a housing.

NOTICE

Unexpected motion from lack of self-locking!

Due to the lack of self-locking of the voice coil drive, mechanics connected to the C-413 can move unexpectedly in the following cases:

- Switching the C-413 off
- Rebooting the C-413 with the RBT command or with the corresponding functions of the PC software
- Switching servo mode off for the axis.
- ➢ Note: The C-413 switches servo mode off automatically when the axis is in overflow condition for more than 60 s.

Unexpected motion can result in damage to the mechanics and/or the load attached to it, e.g., from the moving part falling onto the hard stop.

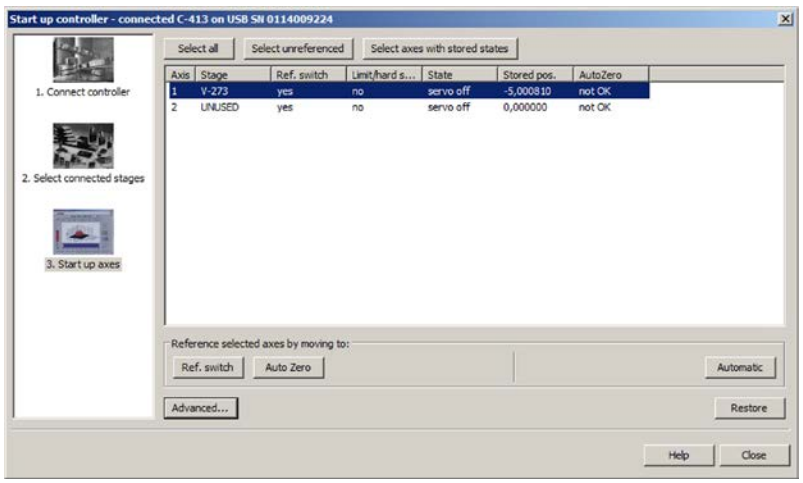
- ➢ When the motion axis is aligned vertically: Do an autozero procedure for the axis so that the weight force of the moving mass is also compensated when servo mode is switched off.
- ➢ Before switching off or rebooting the C-413, take suitable precautionary measures to ensure that no unexpected motion is possible due to lack of self-locking of the voice coil drive. Examples of measures:
  - – Moving to a "safe" position, e.g., the lower end of the travel range when the motion axis is aligned vertically
  - – Installing a mechanical device to catch the moving part

The objective of quick start is to start initial test motion of the mechanics connected to a C-413 in the PIMikroMove PC software. The default setting is used for the control mode: PID_Pos_Vel. The control variable is therefore the position.

1. Install the following on the PC:
   - The PC software and the USB drivers from the product CD
   - Updates for the PC software

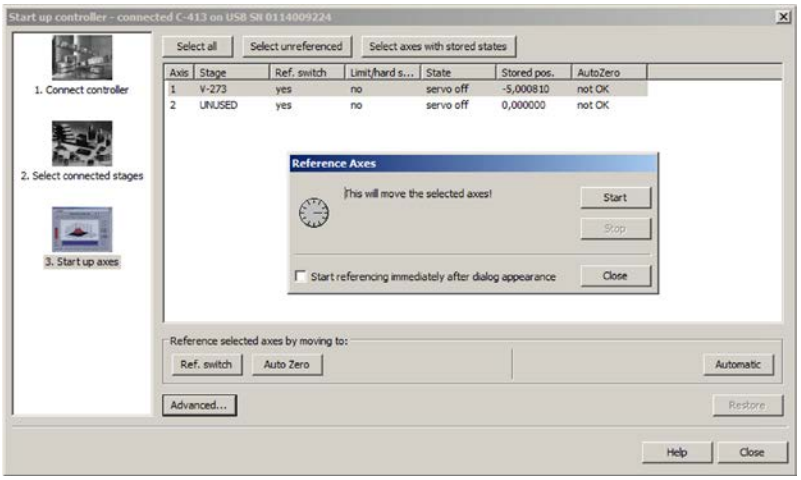
   Refer to "Installing the PC Software" (p. 27) for details.
2. Install the C-413:
   - Pay attention to the general information on installation (p. 27).
   - Ensure the ventilation (p. 32).
   - C-413.20A and .20 models: Install the C-413 into a suitable housing (p. 32).
   - Connect the C-413 to the protective earth conductor (p. 32, p. 33).
3. Connect the following to the C-413:
   - a 24 V wide input range power supply (**not** connected to the power socket via the power cord) to the **24 V DC** connector. Refer to "Connecting the Power Adapter to the C-413" for details (p. 34).
   - the mechanics to one or both **Motor & Sensor** socket(s). Refer to "Connecting the Mechanics" (p. 34) for details.
   - the PC to the USB interface. Refer to "Connecting the PC" (p. 36) for details.
4. Switch on the C-413 (p. 40) by connecting the power cord of the wide input range power supply to the power socket.
5. Start PIMikroMove on the PC.
6. Establish communication between the C-413 and the PC in PIMikroMove via the USB interface. Refer to "Establishing Communication" (p. 41) for details.
7. Do the reference move during the ***Start up axes*** step so that the controller knows the absolute axis position (refer to "Referencing" in the detailed MS224E manual for details). Proceed as follows for each connected axis:

   a) Mark the axis in the list.

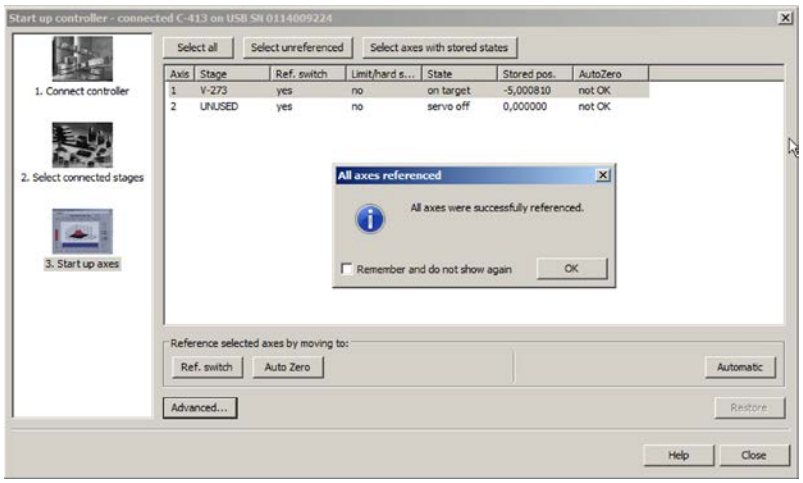


   b) Click the ***Ref. switch*** or ***Automatic*** button. The ***Reference Axes*** dialog opens.

c) Start the reference move by clicking the ***Start*** button in the ***Reference Axes*** dialog.



d) After a successful reference move, click ***OK***.

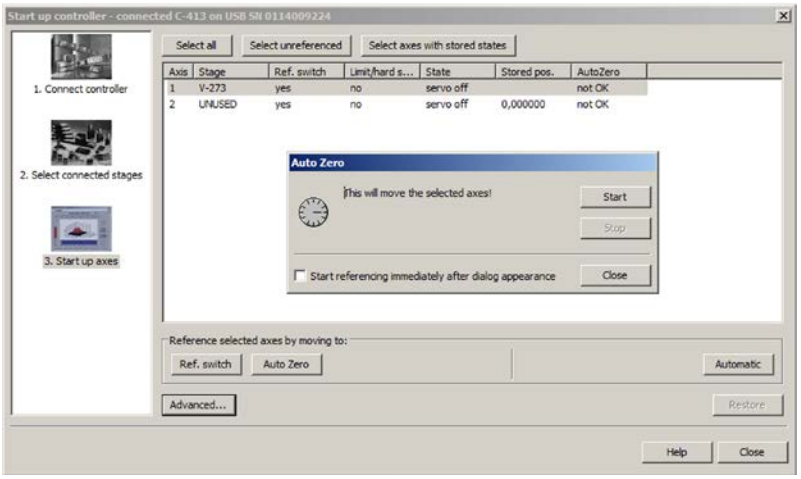


8. Run the autozero procedure during tje ***Start up axes*** step (refer to "Autozero Procedure for Compensating the Weight Force" in the detailed MS224E manual) for details. Proceed as follows for each connected axis:

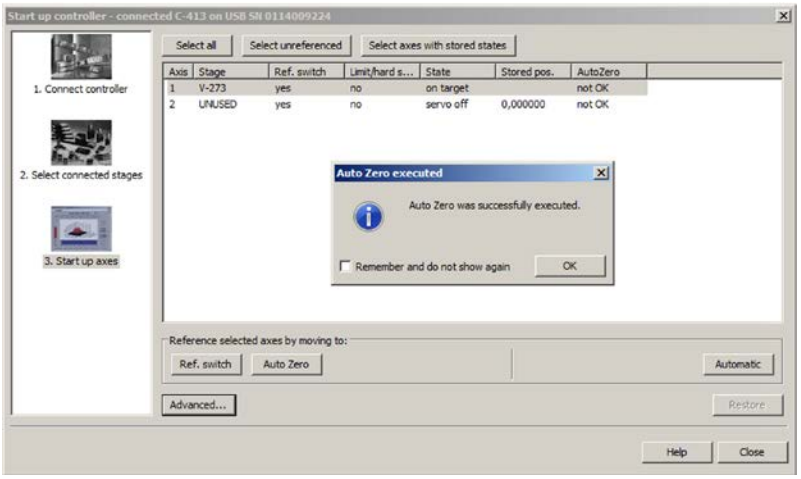
   a) Mark the axis in the list.

   b) Click the ***Auto Zero*** button. The ***Auto Zero*** dialog opens.

c) Start the autozero procedure by clicking the ***Start*** button in the ***Auto Zero*** dialog.



d) After a successful autozero procedure, click ***OK***.

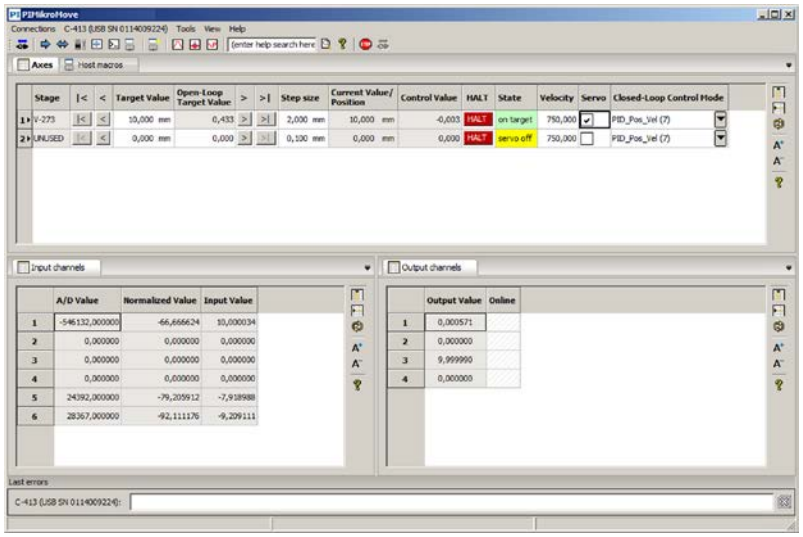


9. Click the ***Close*** button in the ***Start up controller*** window.

   The main window of PIMikroMove opens.

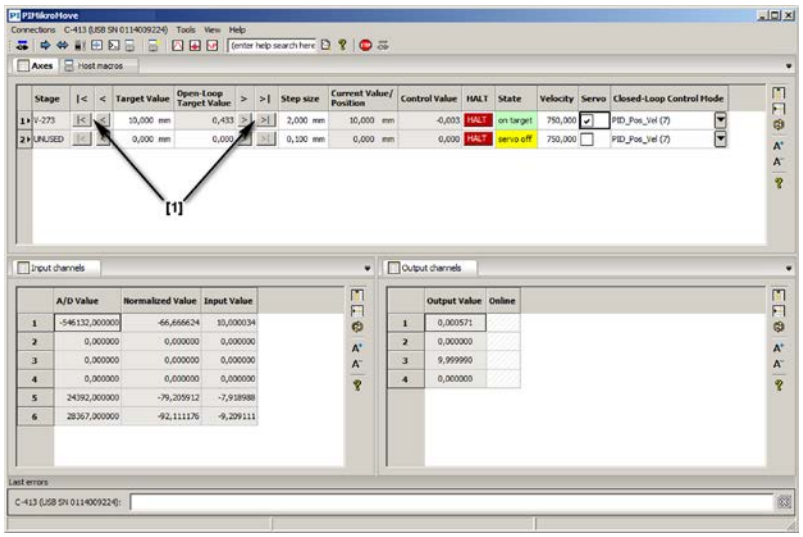
10. Switch servo mode on for each axis to be moved on the ***Axes*** tab in the PIMikroMove main window:

    – Click the checkbox in the ***Servo*** column to switch servo mode on.



11. Start testing the motion to position the axis.

    You can for example, start motion over a certain distance (specified in the ***Step size*** column) or the travel range limits, by clicking the corresponding arrow buttons [1] for the axis on the ***Axes*** tab in the PIMikroMove main window.



6 Installation

In this Chapter

6.1 General Notes on Installation

- Install the C-413 near the power source so that the power plug can be quickly and easily disconnected from the mains.
- Only use cables and connectors that meet local safety regulations.

6.2 Installing the PC Software

The communication between the C-413 and a PC is necessary to configure the C-413 and send motion commands using the commands of the GCS. Various PC software applications are available for this purpose.

6.2.1 Doing Initial Installation

Accessories

- PC with a Windows operating system (XP, Vista, 7, 8) or Linux operating system
- Product CD (included in the scope of delivery)

Important information on the procedure for installation on Windows

➢ Before you start installing the PC software on a PC with a Windows operating system (p. 29), read the following information.

INFORMATION

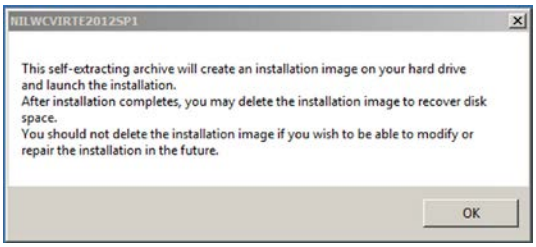
When PIMikroMove **is installed (default installation):**

NI LabVIEW requires the PIMikroMove runtime engine to provide the ***Device Parameter Configuration*** window. Installing PIMikroMove therefore includes installation of the NI LabVIEW runtime engine. A separate window opens for installing the NI LabVIEW runtime engine in addition to the ***InstallShield Wizard*** window.

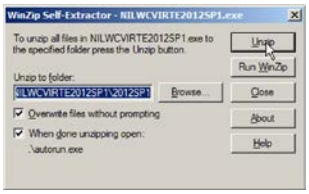
The InstallShield Wizard interrupts installation of the PC software for the C-413 until the installation of the NI LabVIEW runtime engine is started in the separate window.

➢ Note that the separate window on the screen can be covered by the ***InstallShield Wizard*** window. If necessary, display the separate window (e.g. by moving the ***InstallShield Wizard*** window).

➢ Follow the instructions for installing the NI LabVIEW runtime engine that appear in the separate window (see figures below):
Note that the files needed for installing have to be unpacked first. This does **not** complete the installation though, but must be continued in a separate window according to the instructions.



Agree to unpacking with ***OK***



Start unpacking with ***Unzip***

Finish unpacking with ***OK***

Install the NI LabVIEW runtime engine with ***Install NI LabWindows/CVI Run-Time Engine 2012 SP1***

- Note that installing the NI LabVIEW run time engine can take some time.
- If you accidently close the separate window before the NI LabVIEW runtime engine was installed successfully: Go to the \SingleSetups directory on the product CD and start the installation by double-clicking the NI_LabWindows-CVI-RTE_2012_SP1_Setup.exe file.

Installing the PC software in Windows

1. Read "Important information on the procedure for installation in Windows" (p. 27).
2. Start the installation wizard by double-clicking the ***PI_C-413.CD_Setup.exe*** file in the installation directory (root directory of the CD).

   The ***InstallShield Wizard*** window for the installation of programs and manuals for the C-413 opens.
3. Follow the instructions on the screen.

   You can choose between default installation (*Complete*) and user-defined installation (*Custom*).

   With default installation (recommended), all components are installed. These include among others:

   - Driver for use with NI LabVIEW software
     Exception: The *Analog LabVIEW drivers* component is provided for some PI controllers. This component is only available through user-defined installation.
   - Dynamic program library for GCS
   - PIMikroMove
   - PC software for updating the firmware of the C-413
   - PI Update Finder for updating the PC software
   - For controllers that have a USB interface for communication with the PC: USB drivers

   With user-defined installation, you have the option of excluding individual components from the installation.

Installing the PC software in 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 in as superuser (root privileges).
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.

6.2.2 Installing Updates

PI is constantly improving the PC software.

➢ Always install the latest version of the PC software.

Requirements

✓ Active connection to the Internet.

✓ If your PC uses a Windows operating system:

– You have installed (p. 27) the PI Update Finder from the product CD.

– You have the A000T0028 Technical Note for the PI Update Finder ready. You will find the document on the product CD.

– If the PC to be updated is **not** directly connected to the Internet:
You have the A000T0032 Technical Note for the PI Update Finder ready. You will find the document on the product CD.

✓ If your PC uses a Linux operating system:

– You have the access data (user name and password) for the C-413. Information regarding the access data can be found in the file "xxx_Releasenews.pdf" (x_x_x: Version number of the CD) in the \Manuals folder on the product CD.

Updating the PC software on Windows

➢ Use the PI Update Finder:

– When the PC to be updated is directly connected to the Internet: Follow the instructions in the A000T0028 Technical Note (TECHNICAL_NOTE_PI_UPDATE_FINDER_xx.pdf).

– When the PC to be updated is **not** directly connected to the Internet: Follow the instructions in the A000T0032 Technical Note .

Updating the PC software in Linux

1. Open the website www.pi.ws.
2. Click ***Login***.
3. Log in with the user name and password for the C-413.
4. Click ***Search***.
5. Enter the product number up to the period (e. g., C-413) into the search field.
6. Click ***Start search*** or press the Enter key.
7. Open the corresponding product detail page in the list of search results:
   a) If necessary: Scroll down the list.
   b) If necessary: Click ***Load more results*** at the bottom of the list.
   c) Click the corresponding product in the list.
8. Click the ***Downloads*** tab.

   The software files are shown under ***Software Downloads***.
9. Click the archive file "CD Mirror" or the associated download link.
10. Select the option in the following request to save the file to your PC.

    If you do not specify anything else, the "CD Mirror" archive file is stored in the default download directory of your PC.
11. Unpack the archive file into a separate installation directory.
12. Go to the ***linux*** subdirectory in the directory with the unpacked files.
13. Unpack the archive file in the ***linux*** directory by entering the command tar -xvpf <name of the archive file> on the console.
14. Read the accompanying information on the software update (readme file and/or "xxx_Releasenews.pdf" file) and decide whether the update makes sense for your application.
    – If no: Stop the update procedure.
    – If yes: Go through the following steps.
15. Log into the PC as superuser (root privileges).
16. Install the update.

INFORMATION

If software is missing in the ***Downloads*** area or problems occur with downloading:

➢ Contact our customer service department (p. 69).

6.3 Ensuring Ventilation

High temperatures can overheat the C-413.

- ➢ Set up the C-413 with a distance of at least 10 cm to the top and rear sides 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 (<50° C).

6.4 Mounting the C-413

The C-413.2G and .2GA models can be used as a bench-top device or mounted in any orientation on a surface.

Tools and accessories

- Suitable screws
- Suitable screwdriver

Mounting the C-413

1. Make the necessary holes in the surface.

   The arrangement of the recesses in the mounting rails of the C-413.2G and .2GA models can be found in the dimensional drawing in "Dimensions" (p. 74).
2. Mount the C-413 in the recesses in the mounting rails with two suitable screws on each side.

6.5 Installing the C-413 in a Case

The C-413.20A and .20 models must be installed in a suitable case before startup.

NOTICE

Electrostatic hazard

The C-413 contains electrostatic-sensitive components (ESD) and can be damaged if handled improperly.

- ➢ Avoid touching assemblies, pins and PCB traces.
- ➢ Before you touch the C-413, discharge your body appropriately, e.g., by using an antistatic wrist strap.
- ➢ Only handle and store the C-413 in environments that dissipate existing static charges to earth in a controlled way and prevent electrostatic charges (ESD workplace or electrostatic discharge protected area, abbreviated to EPA).

INFORMATION

The C-413 is intended to be screwed into a case. For this purpose, the board has four mounting holes with Ø 2.8 mm. The mounting holes have GND potential.

Tools and accessories

- Suitable case:
  - The case is shielded and designed in such a way that the C-413 fulfills all requirements for electromagnetic compatibility after installation.
  - The case has suitable retainers for screwing in the C-413. The arrangement of the mounting holes of the C-413.20 and .20A models can be found in the dimensional drawing in "Dimensions" (p. 74).
  - The case is connected to a suitable protective earth conductor. The retainers for screwing in the C-413 have a conductive connection to the protective earth conductor.
- Four sufficiently conductive M2.5 screws with a suitable length

Installing the C-413 in the case

1. Mount the C-413.20 or .20A with four screws in the case.
2. Close the case.

6.6 Connecting the C-413 to the Protective Earth Conductor

C-413.2GA and .2G models

Figure 6: Protective earth connection of the C-413.2GA and .2G models

➢ Connect the threaded pin with the protective earth conductor symbol (see figure) on the case of the C-413 to the protective earth conductor.

C-413.20A and .20 models

➢ Follow the instructions in "Installing the C-413 in a Case" (p. 32).

6.7 Connecting the Power Supply to the C-413

Requirements

✓ The power cord is **not** connected to the power socket.

Tools and accessories

- 24 V wide range input power supply included (for line voltages between 100 and 240 VAC at 50 or 60 Hz)
- Alternative: Sufficiently rated power supply
- Adapter for the power supply connector included; barrel connector to M8 4-pin connector (f)
- Alternative: Sufficiently sized adapter
- Power cord included
- Alternative: Sufficiently sized power cord

Connecting the power supply to the C-413

➢ Connect the adapter's M8 connector (f) to the C-413's 24 V connection (M8 panel plug).
➢ Connect the adapter's barrel connector to the power supply's barrel connector socket.
➢ Connect the power cord to the power supply.

6.8 Connecting the Mechanics

INFORMATION

If unsuitable cables are used, interference can occur in the signal transmission between the mechanics and the C-413.

➢ Only use original PI parts to connect the C-413 to the mechanics. The maximum cable length is **1 m**.
➢ If you need longer cables, contact our customer service department (p. 69).

INFORMATION

It is possible to assign the input signal channels and output signal channels in the C-413's firmware to the logical axes. The allocation determines the identifiers that are to be used for commanding the axes connected to the mechanics. Allocation with the default settings of the C-413:

- Input signal channel 1 and output signal channel 1 are allocated to axis 1. Both channels are on the **Motor & Sensor 1** socket. The axis of the mechanics connected to the **Motor & Sensor 1** socket is therefore commanded as axis 1.
- Input signal channel 3 and output signal channel 2 are allocated to axis 2. Both channels are on the **Motor & Sensor 2** socket. The axis of the mechanics connected to the **Motor & Sensor 2** socket is therefore commanded as axis 2.

INFORMATION

Force sensors can be connected to the C-413 via the following connectors:

- **Motor & Sensor** sockets: Incremental force sensors with data transmission via sensor SPI. Mechanics that have a separate D-sub 15 (m) connector for the force sensor in addition to the motor connector (e.g., V-273.431 model from PI) occupies both **Motor & Sensor** sockets.
- **I/O** panel plug: Force sensors with analog output signal, refer to "Connecting Analog Signal Sources" in the detailed MS224E manual for details

When a force sensor is connected and to be used, the corresponding input signal channel must be allocated to the axis via the ***Input Channel for Force Feedback*** parameter (ID 0x07000400).

INFORMATION

C-413 and mechanics are delivered as a preconfigured system.

➢ If assigning the connection is specified on a label on the C-413 and/or mechanics, pay attention to this assignment when connecting the mechanics.

INFORMATION

The C-413 does the following when switching on or rebooting:

- Initializing the sensor electronics in the mechanics
- For details on how to read the ID chips of the sensors; refer to "Detecting the ID Chip" in the detailed MS224E manual

➢ When you have connected mechanics to the switched on C-413: Switch the C-413 off and on again, or reboot the C-413 with the RBT command or with the corresponding function of the PC software.

Requirement

✓ The C-413 is switched off, i.e., the power adapter is **not** connected to the power socket with the power cord.

Tools and accessories

- Mechanics that the C-413 is configured with at PI
- Alternative: Mechanics of the same type

Connecting the mechanics

➢ Connect the motor connector of the mechanics to a **Motor & Sensor** socket on the C-413.

➢ If the mechanics has a force sensor with a separate D-Sub 15 (m) connector: Connect the force sensor to an unused **Motor & Sensor** socket on the C-413.

6.9 Connecting the PC

Prerequisites

✓ The PC has a free USB interface.

Tools and accessories

- USB cable (type A to mini-B) for connection to the PC, in the scope of delivery (p. 12)

Connecting the C-413 to the PC

➢ Connect the USB socket of the C-413 and the USB interface of the PC with the USB cable.

6.10 Connecting Digital Inputs - see detailed manual

You can find information on this topic in the detailed MS224E user manual which is included as a PDF file on the product CD and can be downloaded from our website (p. 4).

6.11 Connecting Digital Outputs - see detailed manual

You can find information on this topic in the detailed MS224E user manual which is included as a PDF file on the product CD and can be downloaded from our website (p. 4).

6.12 Connecting Signal Sources to the C-413 - see detailed manual

You can find information on this topic in the detailed MS224E user manual which is included as a PDF file on the product CD and can be downloaded from our website (p. 4).

6.13 Connecting a Device to an Analog Output of the C-413 - see detailed manual

You can find information on this topic in the detailed MS224E user manual which is included as a PDF file on the product CD and can be downloaded from our website (p. 4).

7 Startup

In this Chapter

7.1 General Notes on Startup

NOTICE

Electromagnetic disturbances!

If a C-413 OEM board is operated without a housing, live parts are accessible. Electrical, magnetic and electromagnetic fields emitted by live parts can disturb the C-413 and/or the environment.

- ➢ Install a C-413 OEM board in a suitable housing before startup (p. 32).
- ➢ Make sure that the C-413 OEM board fulfills all requirements for electromagnetic compatibility after being installed in a housing.

NOTICE

Unexpected motion because of the C-413 configuration!

The C-413 can be configured with parameter settings so that the reference move and/or the autozero procedure is run automatically after switching on or rebooting. If setup has not been prepared for the corresponding motion yet, the mechanics and/or the load attached to it could be damaged by collisions.

- ➢ Make sure that the connected mechanics can move over the entire travel range safely when the C-413 is switched on or rebooted.
- ➢ If you have configured the C-413 to do a reference move and/or the autozero procedure automatically: Make sure that all system users have been informed about the configuration before the C-413 is switched on or rebooted.

NOTICE

Unexpected motion from lack of self-locking!

Due to the lack of self-locking of the voice coil drive, mechanics connected to the C-413 can move unexpectedly in the following cases:

- Switching the C-413 off
- Rebooting the C-413 with the RBT command or with the corresponding functions of the PC software
- Switching servo mode off for the axis.

➢ Note: The C-413 switches servo mode off automatically when the axis is in overflow condition for more than 60 s.

Unexpected motion can result in damage to the mechanics and/or the load attached to it, e.g., from the moving part falling onto the hard stop.

➢ When the motion axis is aligned vertically: Do an autozero procedure for the axis so that the weight force of the moving mass is also compensated when servo mode is switched off.

➢ Before switching off or rebooting the C-413, take suitable precautionary measures to ensure that no unexpected motion is possible due to lack of self-locking of the voice coil drive. Examples of measures:

- Moving to a "safe" position, e.g., the lower end of the travel range when the motion axis is aligned vertically
- Installing a mechanical device to catch the moving part

NOTICE

Moving to the hard stop!

The axis can move to the hard stop at a high velocity in the following cases:

- Motions are triggered in open-loop operation.
- Motions are triggered in closed-loop operation, and the control variable is the velocity or the force.

Moving to the hard stop at a high velocity can result in damage to the mechanics.

➢ Ensure that the hard stop is approached at low velocity.

NOTICE

Mechanics overheating!

When a high control value remains set over a long period of time, the connected mechanics can heat up. Overheating can result in damage to the mechanics.

I^2t monitoring:

- Activate I2t monitoring (p. 13) to prevent the mechanics from overheating.

Closed-loop operation, the control variable is the position or the force:

To protect the mechanics, the C-413 switches servo mode off automatically for the axis, when the axis is in overflow state for more than 60 s (query with OVF?). Switching servo mode off reduces the maximum absolute measure of the control value to the value of the ***AutoZero Result*** (ID 0x07000A03, refer to "AutoZero Procedure for Compensating the Weight Force" in the detailed MS224E manual).

Closed-loop operation, the control variable is the velocity:

If the axis is moved to the hard stop or blocked by an obstacle **and** the target velocity is zero (e.g., after the axis has stopped), the overflow state does **not** occur, and servo mode is **not** switched off automatically. Reduce the absolute measure of the control value as follows:

- Switch off servo mode for the axis manually.

or

1. Command slow motion of the axis away from the hard stop or obstacle.
2. Stop the axis while it is moving freely.

NOTICE

Mechanics oscillating!

The optimum values of the servo control parameters of the C-413 depend on the selected control mode and the application. In particular the parameter values for direct control of a control variable strongly differ from the values that are required for control with a cascade structure. Unsuitable setting of the C-413's servo control parameters can cause the mechanics to oscillate. Oscillation can damage the mechanics and/or the load fixed to it.

- If the mechanics oscillating (unusual operating noise), switch off servo mode or the C-413 immediately.
- Switch the servo mode back on only after you have modified the servo control parameter settings.
- Check the values of the servo control parameters each time the control mode is changed.
- If you have configured the C-413 to switch on servo mode automatically when the C-413 is switched on or rebooted: Make sure that all system users have been informed about the configuration.

The ***Available Closed-Loop Control Modes*** (ID 0x07030101) is intended to prevent inadvertent selection of a control mode where the servo control parameters of the C-413 are not adapted; see "Control Modes and Control Variables" in the detailed MS224E manual.

- Change the value of the ***Available Closed-Loop Control Modes*** parameter only when necessary.

INFORMATION

When the axis is in overflow state for more than 60 s (get with OVF?), the C-413 switches off the servo mode for the axis. Possible causes for the occurrence of the overflow state:

- The axis has not yet been referenced (query with FRF?).
- Axis oscillates
- When the control variable is the position or the velocity: The axis is blocked by an obstacle.
- When the control variable is the velocity or the force: The axis has reached the hard stop.

INFORMATION

The C-413 is switched off by disconnecting the power source. Options:

- ➢ Pull the power cord out of the power socket.
- ➢ Pull the power cord out of the power supply.
- ➢ Pull the barrel connector socket of the power supply out of the adapter on the C-413.

7.2 Switching on the C-413

INFORMATION

The C-413 does the following when switching on or rebooting:

- Initializing the sensor electronics in the mechanics
- For details on how to read the ID chips of the sensors; refer to "Detecting the ID Chip" in the detailed MS224E manual
- ➢ When you have connected mechanics to the switched on C-413: Switch the C-413 off and on again, or reboot the C-413 with the RBT command or with the corresponding function of the PC software.

Prerequisites

- ✓ You have read and understood the general notes on startup (p. 37).
- ✓ The C-413 has been installed properly (p. 27).

Switching on the C-413

- ➢ Connect the power cord of the power supply with the power socket.

7.3 Establishing Communication

The procedure for PIMikroMove is described in the following.

INFORMATION

In the C-413, a USB UART module is used for the USB interface. This results in the following:

- A baud rate setting is necessary for the USB interface.
- If the controller is connected via the USB connection and switched on, the USB interface is also shown as a virtual COM port in the PC software.

To successfully establish communication via USB, the baud rates of the PC and C-413 must be identical. The PIMikroMove PC software, which PI recommends for initial startup of the C-413, therefore automatically adapts the baud rate of the PC to the current baud rate of the C-413.

Only when the PC software offers the selection of the baud rate of the PC when communication is established via USB:

➢ Adapt the baud rate of the PC to the current baud rate of the C-413.

Requirements

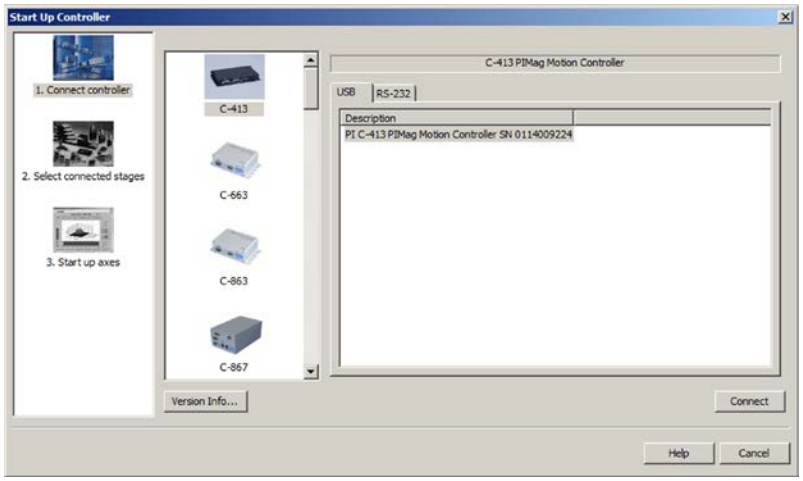
- ✓ You have read and understood the general notes on startup (p. 37).
- ✓ The C-413 is connected to the USB interface of the PC (p. 36).
- ✓ The C-413 is switched on (p. 40).
- ✓ The PC is switched on.
- ✓ The required software and USB drivers are installed on the PC (p. 27).
- ✓ You have read and understood the manual for the PC software used. The software manuals are on the product CD.

Establishing communication

1. Start PIMikroMove.

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

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



2. Select ***C-413*** in the controller selection field.
3. Select the ***USB*** tab on the right-hand side of the window.
4. Select the connected C-413 in the ***USB*** tab.
5. Click ***Connect*** to establish communication.

If communication was established successfully, PIMikroMove guides you through configuring the C-413 for the connected mechanics; see "Starting Motion" (p. 42).

➢ If communication could not be established, look for a solution to the problem in "Troubleshooting" (p. 63).

7.4 Starting Motion

PIMikroMove is used to move the mechanics in the following. The program guides you through the following steps so that you do not have to deal with the respective GCS commands:

- Refer to "Referencing" in the detailed MS224E manual for details on doing a reference move.
- Refer to "AutoZero Procedure for Compensating the Weight Force" in the detailed MS224E manual for details on running an autozero procedure.

NOTICE

Unexpected motion from lack of self-locking!
Due to the lack of self-locking of the voice coil drive, mechanics connected to the C-413 can move unexpectedly in the following cases:

- Switching the C-413 off
- Rebooting the C-413 with the RBT command or with the corresponding functions of the PC software
- Switching servo mode off for the axis.

➢ Note: The C-413 switches servo mode off automatically when the axis is in overflow condition for more than 60 s.

Unexpected motion can result in damage to the mechanics and/or the load attached to it, e.g., from the moving part falling onto the hard stop.

➢ When the motion axis is aligned vertically: Do an autozero procedure for the axis so that the weight force of the moving mass is also compensated when servo mode is switched off.

➢ Before switching off or rebooting the C-413, take suitable precautionary measures to ensure that no unexpected motion is possible due to lack of self-locking of the voice coil drive. Examples of measures:

– Moving to a "safe" position, e.g., the lower end of the travel range when the motion axis is aligned vertically
– Installing a mechanical device to catch the moving part

INFORMATION

When the axis is in overflow state for more than 60 s (get with OVF?), the C-413 switches off the servo mode for the axis. Possible causes for the occurrence of the overflow state:

- The axis has not yet been referenced (query with FRF?).
- Axis oscillates
- When the control variable is the position or the velocity: The axis is blocked by an obstacle.
- When the control variable is the velocity or the force: The axis has reached the hard stop.

INFORMATION

In the following, work is done with the default settings of the C-413:

- Control variable: Position (PID_Pos_Vel = PID position control with velocity control, ID 7)
- Further selectable control variables:
  - Velocity (PID_Vel = Direct PID velocity control, ID 6)
  - Force (PID_Force_Pos_Vel = PID force control with position control and velocity control, ID 10)

To show a change in the control variable, PID_Pos_Vel is used at the beginning and then switched to PID_Force_Pos_Vel in the following.

➢ Note that changing the control variable from position to force changes the behavior of the axis:
  - Position as control variable: The target position is approached and maintained. The motion is then finished.
  - Force as control variable: The target force is achieved (on-target state = true) when a counterforce acts on the axis with the same amount. When the counterforce is lower than the target force, the axis moves to the hard stop. At the hard stop, the overflow state occurs.

Requirements

✓ You have read and understood the general notes on startup (p. 37).

✓ PIMikroMove is installed on the PC (p. 27).

✓ You have read and understood the PIMikroMove manual. The manual is found on the product CD.

✓ You have installed the mechanics in the same way as they will be used in your application (corresponding load, orientation, and fixing).

✓ You have connected the C-413 to the mechanics (p. 34).

✓ PIMikroMove has established communication between the C-413 and the PC (p. 41).

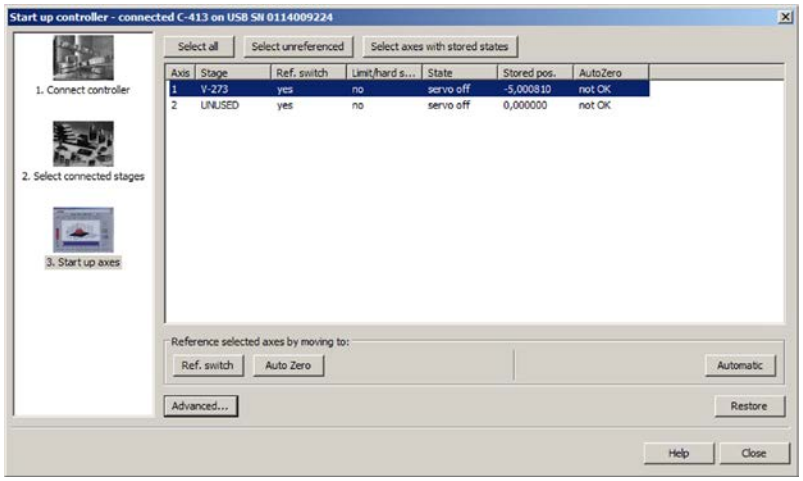
Starting motions with PIMikroMove

The figures in the following instructions show an example in which axis 2 is **not** used.

When communication has been successfully established between the C-413 and the PC (p. 41), the ***Start up controller*** window automatically goes to the ***Start up axes*** step.

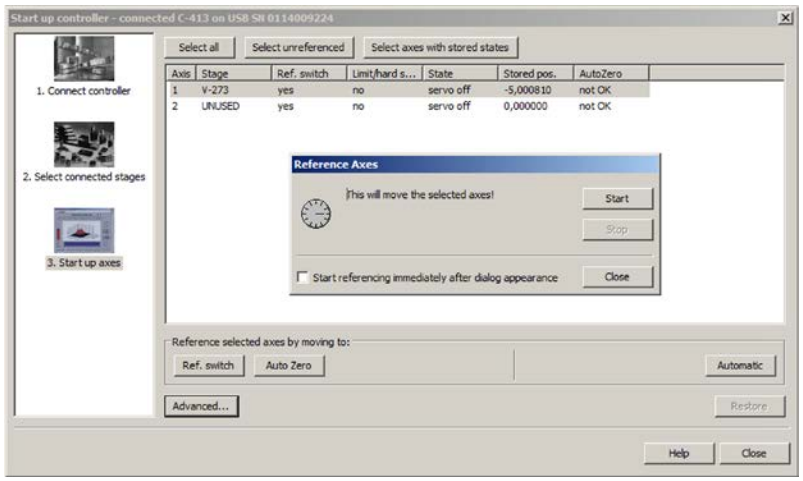
1. In the ***Start up axes*** step, execute the reference move so that the controller knows the absolute axis position. Proceed as follows for each axis that is connected:

   a) Mark the axis in the list.

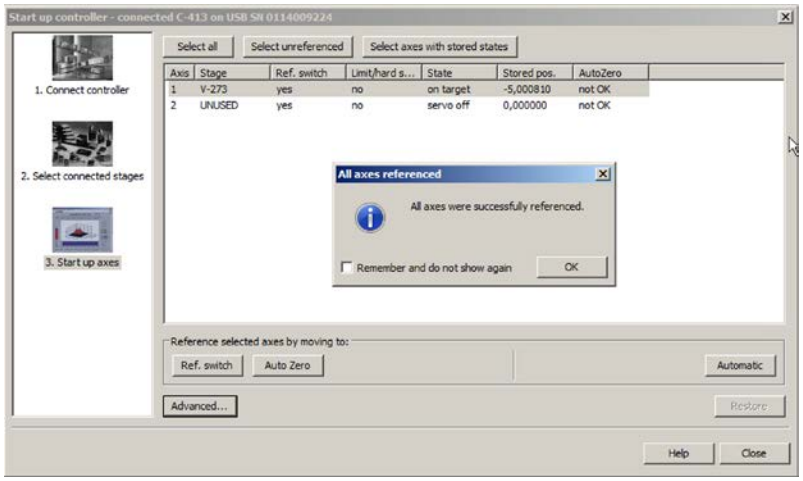


   b) Click ***Ref. switch*** or ***Automatic***. The ***Reference Axes*** dialog opens.

   c) In the ***Reference Axes*** dialog, start the reference move by clicking ***Start***.



d) After a successful reference move, click ***OK***.

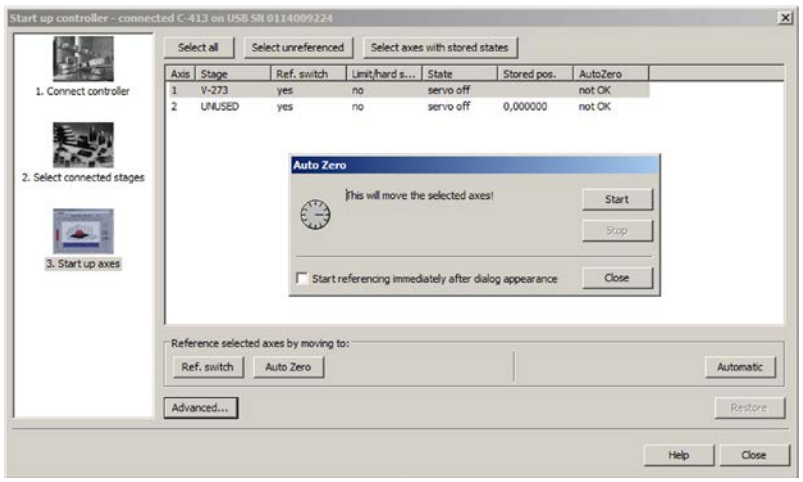


2. In the ***Start up axes*** step, execute the AutoZero procedure. Proceed as follows for each axis that is connected:

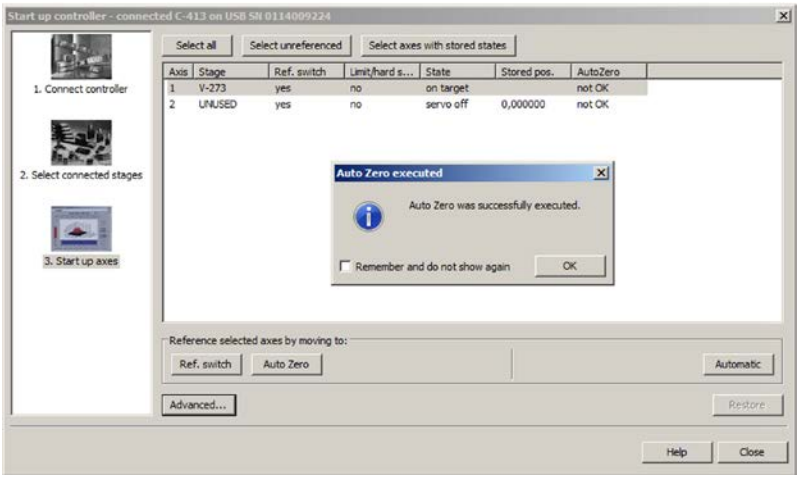
   a) Mark the axis in the list.

   b) Click ***Auto Zero***. The ***Auto Zero*** dialog opens.

   c) In the ***Auto Zero*** dialog, start the AutoZero procedure by clicking ***Start***.



d) After a successful AutoZero procedure, click ***OK***.

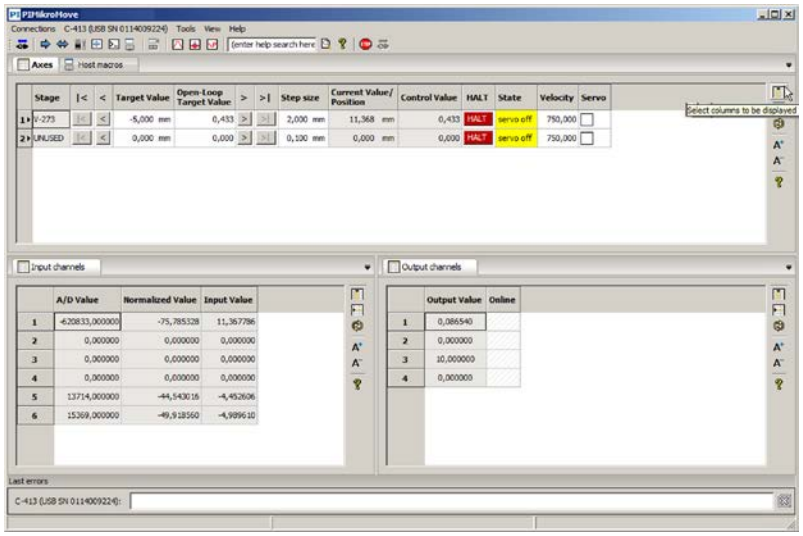


3. In the ***Start up controller*** window, click ***Close***.

   The main window of PIMikroMove opens.

4. In the main window of PIMikroMove, go to the ***Axes*** card and display the ***Closed-Loop Control Mode*** column, which shows the selected control mode:

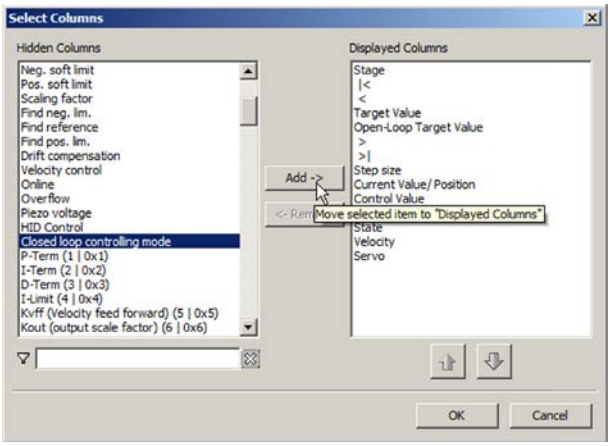
   a) On the right margin of the ***Axes*** card, click  (***Select columns to be displayed***).



   The ***Select Columns*** dialog opens.

   b) In the ***Select Columns*** dialog, go to the ***Hidden Columns*** area and select the ***Closed-Loop Control Mode*** line.

c) In the ***Select Columns*** dialog, click ***Add ->***.

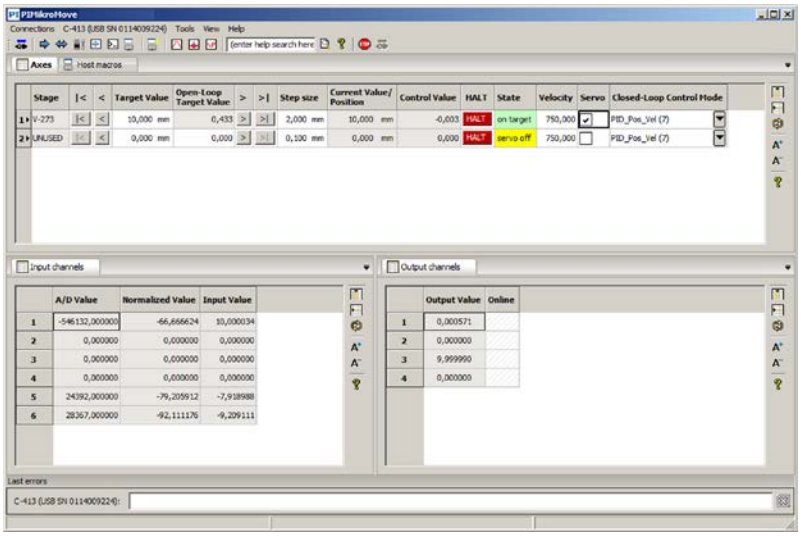


d) Close the ***Select Columns*** dialog by clicking ***OK***.

5. On the ***Axes*** card in the main window of PIMikroMove, switch on the servo mode. Proceed as follows for each axis that is to be moved:

   a) Read the selected control mode in the ***Closed-Loop Control Mode*** column.

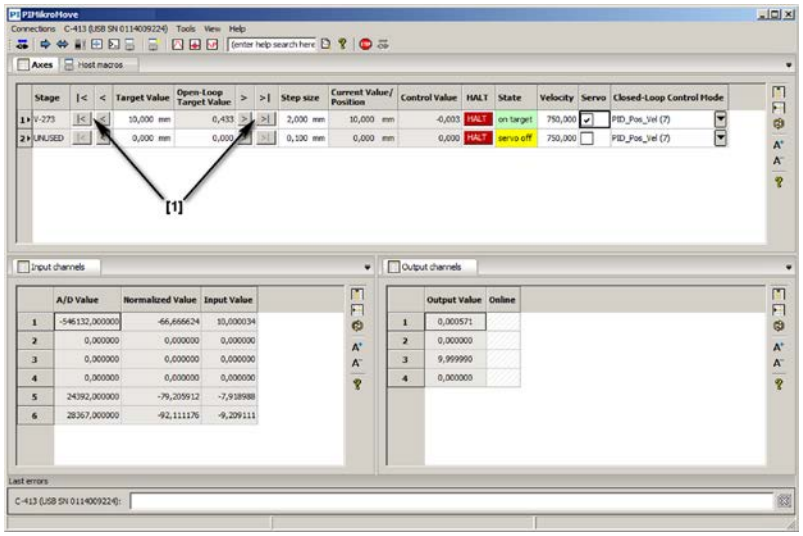
   b) Switch on the servo mode by marking the check box in the ***Servo*** column.



In the example given in the figure above, axis 1 is in closed-loop operation, and the control variable is the position (the PID_Pos_Vel (7) control mode is selected by default).

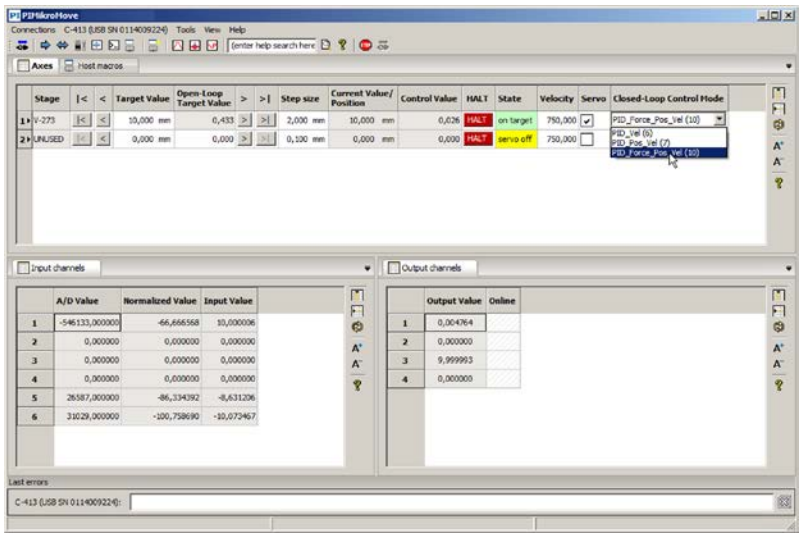
6. Start a few test motions to position the axis.

   On the ***Axes*** card in the main window of PIMikroMove, you can execute, for example, motions of a particular distance (specification in ***Step size*** column) or to the limits of the travel range by clicking the corresponding arrow keys [1] for the axis.



7. If you want to change the control variable for the axis:

   – In the main window of PIMikroMove, select the new control mode in the ***Closed-Loop Control Mode*** column of the ***Axes*** card.

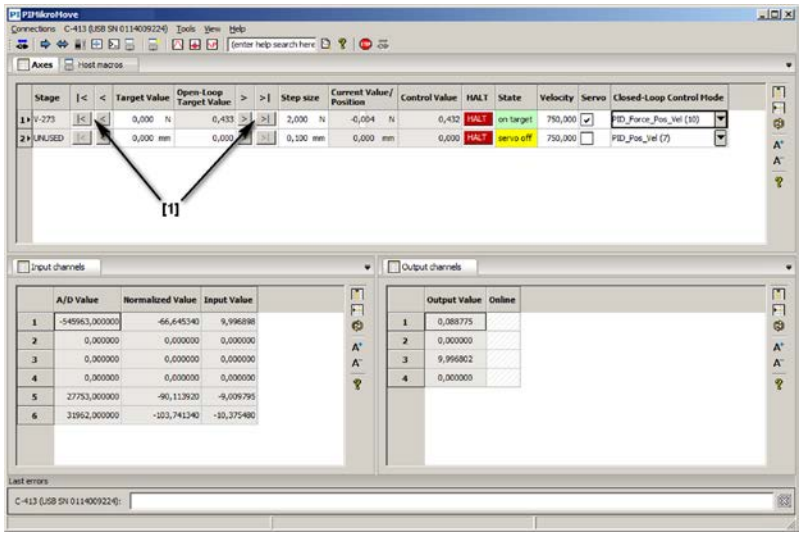


   Default setting: The PID_Vel (6), PID_Pos_Vel (7) and PID_Force_Pos_Vel (10) control modes can be selected. When switching between these control modes, it is not necessary to adapt the servo control parameters of the C-413.

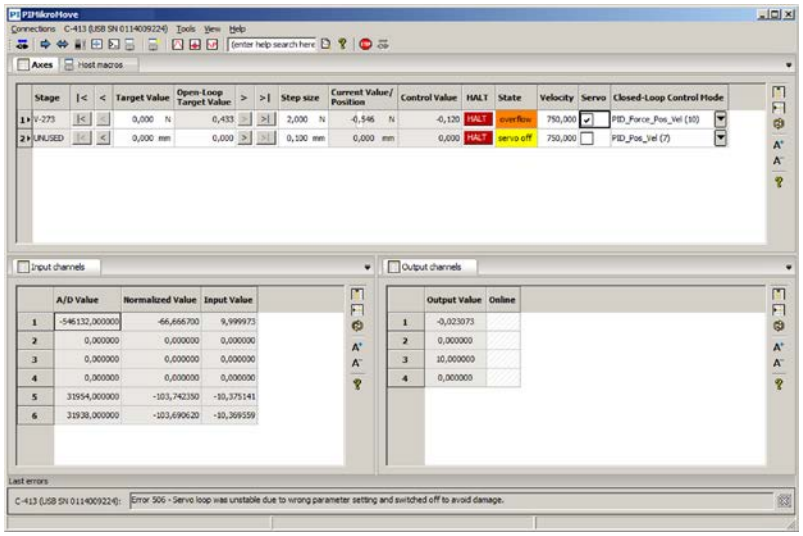
   In the example given in the figure above, PID_Force_Pos_Vel (10) is selected. The new control variable is therefore the force. The unit sign on the ***Axes*** card is automatically adjusted.

8. Start a few test motions in which the axis is to apply different forces.

   On the ***Axes*** card in the main window of PIMikroMove, you can change, for example, the applied force by a particular amount (specification in the ***Step size*** column) or have the maximum force applied by clicking corresponding arrow keys [1] for the axis.



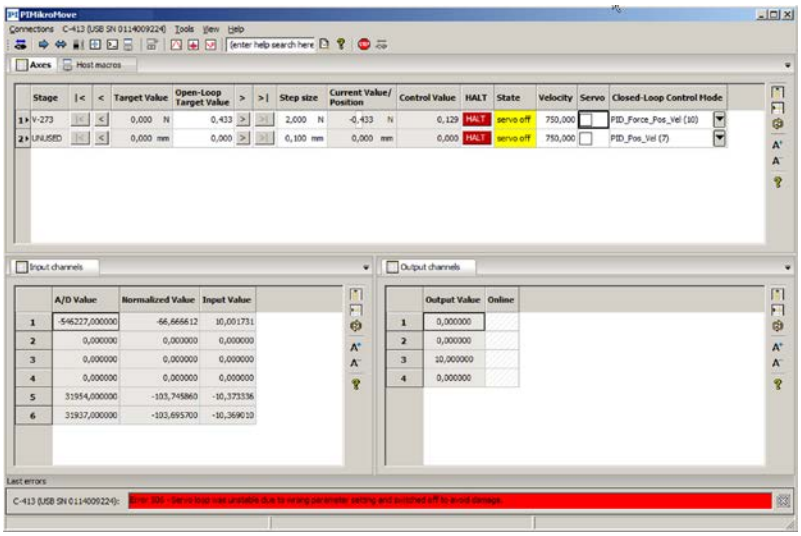
   When the overflow state occurs for the axis (display in the ***State*** column):



   a) When the axis is at the hard stop: Change the value for the target force so that the axis moves away from the hard stop.

   b) Have a counterforce applied to the axis in the amount of the target force.

When the C-413 has switched off the servo mode for the axis because the axis was in the overflow state for more than 60 s, an error code is set:



c) Switch the servo mode for the axis back on by marking the check box in the line of the axis in the ***Servo*** column.

d) Prevent the overflow state from occurring again, see steps a) and b).

8 Operation

In this Chapter

8.1 Data Recorder - see detailed manual

You can find information on this topic in the detailed MS224E user manual which is included as a PDF file on the product CD and can be downloaded from our website (p. 4).

8.2 Digital Output Signals - see detailed manual

You can find information on this topic in the detailed MS224E user manual which is included as a PDF file on the product CD and can be downloaded from our website (p. 4).

8.3 Digital Input Signals - see detailed manual

You can find information on this topic in the detailed MS224E user manual which is included as a PDF file on the product CD and can be downloaded from our website (p. 4).

8.4 Analog Input Signals - see detailed manual

You can find information on this topic in the detailed MS224E user manual which is included as a PDF file on the product CD and can be downloaded from our website (p. 4).

8.5 Analog Output Signals - see detailed manual

You can find information on this topic in the detailed MS224E user manual which is included as a PDF file on the product CD and can be downloaded from our website (p. 4).

8.6 Wave Generator - see detailed manual

You can find information on this topic in the detailed MS224E user manual which is included as a PDF file on the product CD and can be downloaded from our website (p. 4).

8.7 Optimizing the Servo Cycle Time - see detailed manual

You can find information on this topic in the detailed MS224E user manual which is included as a PDF file on the product CD and can be downloaded from our website (p. 4).

9 GCS Commands

In this Chapter

9.1 GCS Syntax for Syntax Version 2.0 - see detailed manual

You can find information on this topic in the detailed MS224E user manual which is included as a PDF file on the product CD and can be downloaded from our website (p. 4).

9.2 Command Overview

The commands listed in the following are described in the detailed MS224E user manual, which is included as a PDF file on the product CD and can be downloaded from our website (p. 4).

Command	Format	Description
#5	#5	Request Motion Status
#7	#7	Request Controller Ready Status
#9	#9	Get Wave Generator Status
#24	#24	Stop All Axes
*IDN?	*IDN?	Get Device Identification
AOS	AOS {<AxisID> <Offset>}	Set Analog Input Offset
AOS?	AOS? [{<AxisID>}]	Get Analog Input Offset
ATZ	ATZ [{<AxisID> <LowValue>}]	Set Automatic Zero Point Calibration
ATZ?	ATZ? [{<AxisID>}]	Get State Of Automatic Zero Point Calibration
CAV?	CAV? [{<AxisID>}]	Get Current Value Of Controlled Variable
CCL	CCL <Level> [<PSWD>]	Set Command Level
CCL?	CCL?	Get Command Level
CCV?	CCV? [{<AxisID>}]	Get Control Value

Command	Format	Description
CMN?	CMN? [{<AxisID>}]	Get Minimum Commandable Closed-Loop Target
CMO	CMO {<AxisID> <CtrlMode>}	Set Closed-Loop Control Mode
CMO?	CMO? [{<AxisID>}]	Get Closed-Loop Control Mode
CMX?	CMX? [{<AxisID>}]	Get Maximum Commandable Closed-Loop Target
CST?	CST? [{<AxisID>}]	Get Assignment Of Stages To Axes
CSV?	CSV?	Get Current Syntax Version
CTI	CTI {<TrigInID> <CTIPam> <Value>}	Set Configuration Of Trigger Input
CTI?	CTI? [{<TrigInID> <CTIPam>}]	Get Configuration Of Trigger Input
CTO	CTO {<TrigOutID> <CTOPam> <Value>}	Set Configuration Of Trigger Output
CTO?	CTO? [{<TrigOutID> <CTOPam>}]	Get Configuration Of Trigger Output
CTR	CTR {<AxisID> <TargetRelative>}	Set Target Relative To Current Closed-Loop Target
CTV	CTV {<AxisID> <TargetAbsolute>}	Set Absolute Closed-Loop Target
CTV?	CTV? [{<AxisID>}]	Get Closed-Loop Target
DIO	DIO {<DIOID> <OutputOn>}	Set Digital Output Lines
DIO?	DIO? [{<DIOID>}]	Get Digital Input Lines
DRC	DRC {<RecTableID> <Source> <RecOption>}	Set Data Recorder Configuration
DRC?	DRC? [{<RecTableID>}]	Get Data Recorder Configuration
DRL?	DRL? [{<RecTableID>}]	Get Number Of Recorded Points
DRR?	DRR? [<StartPoint> <NumberOfPoints> [{<RecTableID>}]]	Get Recorded Data Values
DRT	DRT {<RecTableID> <TriggerSource> <Value>}	Set Data Recorder Trigger Source
DRT?	DRT? [{<RecTableID>}]	Get Data Recorder Trigger Source
ERR?	ERR?	Get Error Number
FRF	FRF [{<AxisID>}]	Fast Reference Move To Reference Switch

Command	Format	Description
FRF?	FRF? [{<AxisID>}]	Get Referencing Result
GWD?	GWD? [<StartPoint> <NumberOfPoints> [{<WaveTableID>}]]	Get Wave Table Data
HDR?	HDR?	Get All Data Recorder Options
HLP?	HLP?	Get List of Available Commands
HLT	HLT [{<AxisID>}]	Halt Motion Smoothly
HPA?	HPA?	Get List Of Available Parameters
HPV?	HPV?	Get Parameter Value Description
IDN?	IDN?	Get Device Identification
IMP	IMP <AxisID> <Amplitude>	Start Impulse and Response Measurement
LIM?	LIM? [{<AxisID>}]	Indicate Limit Switches
MOV	MOV {<AxisID> <Position>}	Set Target Position
MOV?	MOV? [{<AxisID>}]	Get Target Position
MVR	MVR {<AxisID> <Distance>}	Set Target Relative To Current Position
ONT?	ONT? [{<AxisID>}]	Get On-Target State
OVF?	OVF? [{<AxisID>}]	Get Overflow State
POS	POS {<AxisID> <Position>}	Set Real Position
POS?	POS? [{<AxisID>}]	Get Real Position
PUN?	PUN? [{<AxisID>}]	Get Axis Unit
RBT	RBT	Reboot System
RON	RON {<AxisID> <ReferenceOn>}	Set Reference Mode
RON?	RON? [{<AxisID>}]	Get Reference Mode
RPA	RPA [{<ItemID> <PamID>}]	Reset Volatile Memory Parameters
RTR	RTR <RecordTableRate>	Set Record Table Rate
RTR?	RTR?	Get Record Table Rate
SAI?	SAI? [ALL]	Get List Of Current Axis Identifiers
SEP	SEP <Pswd> {<ItemID> <PamID> <PamValue>}	Set Non-Volatile Memory Parameters
SEP?	SEP? [{<ItemID> <PamID>}]	Get Non-Volatile Memory Parameters
SPA	SPA {<ItemID> <PamID> <PamValue>}	Set Volatile Memory Parameters

Command	Format	Description
SPA?	SPA? [{<ItemID> <PamID>}]	Get Volatile Memory Parameters
SRG?	SRG? {<AxisID> <RegisterID>}	Query Status Register Value
STE	STE <AxisID> <Amplitude>	Start Step And Response Measurement
STP	STP	Stop All Axes
SVA	SVA {<AxisID> <ControlValueAbs>}	Set Absolute Open-Loop Control Value
SVA?	SVA? [{<AxisID>}]	Get Open-Loop Control Value
SVO	SVO {<AxisID> <ServoState>}	Set Servo Mode
SVO?	SVO? [{<AxisID>}]	Get Servo Mode
SVR	SVR {<AxisID> <ControlValueRel>}	Set Relative Open-Loop Control Value
TAD?	TAD? [{<InputSignalID>}]	Get ADC Value Of Input Signal
TIO?	TIO?	Tell Digital I/O Lines
TMN?	TMN? [{<AxisID>}]	Get Minimum Commandable Position
TMX?	TMX? [{<AxisID>}]	Get Maximum Commandable Position
TNR?	TNR?	Get Number Of Record Tables
TNS?	TNS? [{<InputSignalID>}]	Get Normalized Input Signal Value
TPC?	TPC?	Get Number of Output Signal Channels
TRI	TRI {<TrigInID> <TrigInMode>}	Set Trigger Input State
TRI?	TRI? [{<TrigInID>}]	Get Trigger Input State
TRO	TRO {<TrigOutID> <TrigMode>}	Set Trigger Output State
TRO?	TRO? [{<TrigOutID>}]	Get Trigger Output State
TRS?	TRS? [{<AxisID>}]	Indicate Reference Switch
TSC?	TSC?	Get Number of Input Signal Channels
TSP?	TSP? [{<InputSignalID>}]	Get Input Signal Value
TWG?	TWG?	Get Number of Wave Generators
VEL	VEL {<AxisID> <Velocity>}	Set Closed-Loop Velocity
VEL?	VEL? [{<AxisID>}]	Get Closed-Loop Velocity
VOL?	VOL? [{<OutputSignalID>}]	Get Value Of Output Signal

Command	Format	Description
WAV	WAV <WaveTableID> <AppendWave> <WaveType> <WaveTypeParameters>	Set Waveform Definition
WAV?	WAV? [{<WaveTableID> <WaveParameterID>}]	Get Waveform Definition
WCL	WCL {<WaveTableID>}	Clear Wave Table Data
WGC	WGC {<WaveGenID> <Cycles>}	Set Number Of Wave Generator Cycles
WGC?	WGC? [{<WaveGenID>}]	Get Number Of Wave Generator Cycles
WGO	WGO {<WaveGenID> <StartMode>}	Set Wave Generator Start/Stop Mode
WGO?	WGO? [{<WaveGenID>}]	Get Wave Generator Start/Stop Mode
WGR	WGR	Starts Recording In Sync With Wave Generator
WOS	WOS {<WaveGenID> <Offset>}	Set Wave Generator Output Offset
WOS?	WOS? [{<WaveGenID>}]	Get Wave Generator Output Offset
WPA	WPA <Pswd> [{<ItemID> <PamID>}]	Save Parameters To Non-Volatile Memory
WSL	WSL {<WaveGenID> <WaveTableID>}	Set Connection Of Wave Table To Wave Generator
WSL?	WSL? [{<WaveGenID>}]	Get Connection Of Wave Table To Wave Generator
WTR	WTR {<WaveGenID> <WaveTableRate> <InterpolationType>}	Set Wave Generator Table Rate
WTR?	WTR? [{<WaveGenID>}]	Get Wave Generator Table Rate

9.3 Error Codes - see detailed manual

The error codes of the PI General Command Set are listed in the detailed MS224E user manual which is included as a PDF file on the product CD.

10 Adapting Settings

In this Chapter

10.1 Changing Parameter Values in the C-413

The properties of the C-413 and the connected mechanics are stored in the C-413 as parameter values (e.g., settings for matrices, selection of the control mode, settings for the servo algorithm).

The parameters can be divided into the following categories:

- Protected parameters whose default settings cannot be changed
- Parameters that can be set by the user to adapt to the application

The write permission for the parameters is determined by command level.

Every parameter is present in the volatile as well as in the nonvolatile memory of the C-413. The values in the nonvolatile memory are loaded to the volatile memory as default values when the C-413 is switched on or rebooted. The values in the volatile memory determine the current behavior of the system.

You can find descriptions and instructions on the following topics in the detailed MS224E user manual which is included as a PDF file on the product CD and can be downloaded from our website (p. 4):

- **Commands for parameters - overview**
- **Creating and loading a backup copy of parameter values**
- **Changing parameter values: General procedure**

10.2 Parameter Overview - see detailed manual

You can find information on this topic in the detailed MS224E user manual which is included as a PDF file on the product CD and can be downloaded from our website (p. 4).

11 Maintenance

In this Chapter

11.1 Cleaning the C-413

NOTICE

Short circuits or flashovers!
The C-413 contains electrostatic-sensitive devices that can be damaged by short-circuiting or flashovers when cleaning fluids penetrate the housing.

- ➢ Before cleaning, disconnect the C-413 from the power source by removing the mains plug.
- ➢ Prevent cleaning fluid from penetrating the housing.

- ➢ When necessary, clean the surfaces of the C-413's housing using a cloth dampened with a mild cleanser or disinfectant.

11.2 Updating Firmware - see detailed manual

You can find information on this topic in the detailed MS224E user manual which is included as a PDF file on the product CD and can be downloaded from our website (p. 4).

12 Troubleshooting

Fault: Mechanics does not move	
Possible causes	**Solution**
Cable not connected correctly	➢ Check the cable connections. ➢ If a connection assignment is given on the labels of the C-413 and/or mechanics, observe this assignment when connecting the mechanics.
The mechanics has been connected to the switched-on C-413	The sensor electronics in the mechanics has not been initialized, and the ID chip of the sensor has not been read out. ➢ Switch the C-413 off and on again, or reboot the C-413 with the RBT command or with the corresponding functions of the PC software.
Unsuitable cable used	If unsuitable cables are used, interferences can occur in the signal transmission between the mechanics and the C-413. ➢ Only use original PI parts to connect the mechanics to the C-413. The maximum cable length is 1 m. ➢ If you need longer cables, contact our customer service department (p. 69).
C-413 is defective	➢ Send the ERR? command and check the error code this returns. When error code 333 (internal hardware error) is reported back: 1. Switch the C-413 off and on again. 2. Get the error code again. 3. If error code 333 is still reported back, switch off the C-413 and contact our customer service department (p. 69).
Mechanics or cable is defective	➢ If available, replace the defective mechanics with a different mechanics of the same type and test the new combination. Prevent damage to the mechanics as follows: ➢ Prevent the mechanics from overheating by activating I^2t monitoring (p. 13). ➢ Prevent the mechanics from exceeding the maximally permissible operating frequency, e.g. by using suitable waveforms with the wave generator output. ➢ Prevent the mechanics from oscillating by suitably setting the control parameters. ➢ Prevent the axis from moving to the hard stop at a high velocity (possible in open-loop operation or when the control variable is the velocity or the force).

Fault: Mechanics does not move	
Possible causes	**Solution**
Motor driver of the C-413 is deactivated due to overheating	Overheating of the motor driver in the C-413 ➢ Reduce the frequency of the wave generator output
Incorrect configuration	➢ Check the parameter settings of the C-413 with the SPA? (volatile memory) and SEP? (nonvolatile memory) commands or in the ***Device Parameter Configuration*** window of PIMikroMove. Details on parameter settings see "Adapting Settings" (p. 59).
Incorrect command or incorrect syntax	➢ Send the ERR? command and check the error code this returns. ➢ Make sure that the used motion commands match the control mode and the servo mode.
Motion commands or wave generator output are ignored.	➢ Send the ERR? command and check the error code this returns. ➢ Observe the different priorities of the control sources; see "Control Value Generation".
Incorrect axis commanded	An axis identifier is even required in commands on systems with only one axis. ➢ Make sure that the correct axis identifier is used and that the commanded axis belongs to the correct mechanics.
In the case of analog control, there is no connection between the axis and the analog input.	➢ To control an axis via an analog input, allocate the corresponding input signal channel to the axis. Further information see "Analog Input Signals". ➢ When you have stopped the motion with STP or #24: Repeat the allocation.

Fault: Mechanics move unintentionally	
Possible causes	**Solution**
Configuration of the C-413	The C-413 can be configured with parameter settings so that the reference move and/or the AutoZero procedure is run automatically after switching on or rebooting. ➢ Check the settings of the ***Power Up Reference Move Enable*** parameter (ID 0x07000806) and the ***Power Up AutoZero Enable*** parameter (ID 0x07000802) and adjust them if necessary.

Fault: Mechanics move unintentionally	
Possible causes	**Solution**
C-413 was switched off	➢ Compensate for the lack of self-locking of the voice coil drive of the mechanics: – Avoid the overflow state of the axis (servo mode is switched off automatically when the axis has been in the overflow state for more than 60 s). – When the motion axis is aligned vertically: Do an AutoZero procedure for the axis so that the weight force of the moving mass is also compensated when servo mode is switched off. – Before switching off or rebooting the C-413, take suitable precautionary measures to ensure that no unexpected motion is possible due to lack of self-locking of the voice coil drive. Optimum sequence of the steps for starting and operating the C-413: 1. Do a reference move 2. Switch on servo mode 3. When the ***AutoZero Result*** parameter has not yet been set suitably: Run an AutoZero procedure
C-413 was rebooted (with RBT or corresponding functions of the PC software)	
Servo mode for the axis was switched off	

Fault: Mechanics are oscillating or positions inaccurately	
Possible causes	**Solution**
The load was changed.	➢ If the mechanics is oscillating (unusual operating noise), switch off servo mode or the C-413 immediately. ➢ Switch the servo mode back on only after you have modified the servo control parameter settings. ➢ Check the values of the servo control parameters each time the control mode is changed.
The control mode was changed.	
The profile generator worsens the dynamic behavior of the axis.	➢ In the following cases, check whether deactivating the profile generator improves the dynamic behavior of the axis: – The wave generator is running for the axis. – An analog input is used as the control source for the axis.

Fault: Force measurement by force sensor does not work	
Possible causes	**Solution**
Force sensor is not allocated to the axis	Force sensors are directly allocated to the logical axes of the C-413 via the ***Input Channel For Force Feedback*** parameter (ID 0x07000400). ➢ Ensure the correct allocation via the corresponding parameter setting.

Fault: Servo mode was switched off automatically	
Possible causes	**Solution**
Axis was in the overflow state for more than 60 s	➢ Check why the overflow state occurred. Possible causes: – The axis has not yet been referenced (query with FRF?). – Axis oscillates – When the control variable is the position or the velocity: The axis is blocked by an obstacle. – When the control variable is the velocity or the force: The axis has reached the hard stop. ➢ Remedy the cause of the overflow state.

Fault: Communication with the controller does not work	
Possible causes	**Solution**
The wrong communication cable is used or it is defective	➢ If necessary, check whether the cable works on a fault-free system.
Baud rate not configured correctly	A USB UART module is used in the C-413 for the USB interface. To successfully establish communication via USB, the baud rates of the PC and C-413 must therefore be identical. When the PC software offers PC baud rate selection when communication is established via USB: ➢ Adapt the baud rate of the PC to the current baud rate of the C-413.
Loss of the communication due to excessive utilization of the C-413 processor	When the communication is faulty or has been terminated: 1. Reboot the C-413. 2. Make sure that the C-413 is not doing any time-intensive tasks. 3. Extend the servo cycle time; see "Optimizing the Servo Cycle Time of the C-413".
Another program is accessing the interface.	➢ Close the other program.
Problems with special software	➢ Check whether the system works with other software, such as a terminal program or a development environment. ➢ Test the communication by sending the *IDN? or HLP? command. ➢ Make sure that you end the commands with an LF (line feed). Exception: Single-character commands are not followed by a terminating character; see "GCS Syntax for Syntax Version 2.0".

Fault: The customer software does not run with the PI drivers	
Possible causes	**Solution**
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 product CD with your program code.

Fault: The Device Parameter Configuration window is not available in PIMikroMove.	
Possible causes	**Solution**
NI LabVIEW Run-Time Engine was not installed	➢ Install the NI LabVIEW Run-Time Engine, refer to "Doing Initial Installation" (p. 27).

If the problem with your system is not listed in the table above or cannot be solved as described, contact our customer service department (p. 69).

13 Customer Service

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

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

The latest versions of the user manuals are available for download (p. 4) on our website.

14 Technical Data

In this Chapter

14.1 Specifications

14.1.1 Data Table

	C-413.20/.20A, C-413.2G/.2GA
Function	PIMag® motion controller for voice coil drives, 2 channels C-413.20/.20A: OEM board C-413.2G/.2GA: Housed device
Motor channels	2
Sensor channels	4
Motion and control	**C-413.20/.20A, C-413.2G/.2GA**
Controller type	PID controller for force, position and velocity; parameter changing during operation
Servo cycle time	100 µs to 200 µs, selectable in 4 steps
Profile generator	Trapezoidal velocity profile, specification of the maximum velocity and acceleration
Encoder input	SPI sensor interface
Reference switch	4 × TTL, direction-sensing
Electrical properties	**C-413.20/.20A, C-413.2G/.2GA**
Max. output voltage	24 V
Max. output current	±1.5 A (regulated)
Interfaces and operation	**C-413.20/.20A, C-413.2G/.2GA**
Communication interfaces	USB 2.0, real time SPI
Motor / sensor connection	D-sub 15 (f) combined for motor and sensor
I/O port	2 × analog input, -10 to 10 V, 16 bit, 1 kHz (only .20A and .2GA) 2 × analog output, -10 to 10 V, 17 bit, 1 kHz (only .20A and .2GA) 6 × digital outputs (open collector, voltage range 5 V to 24 V, 33 kΩ internal pull-up to 5 V) 4 × digital input (5 V TTL level, to 24 V max. input voltage, 10 kΩ input resistance)

	C-413.20/.20A, C-413.2G/.2GA
Command set	PI General Command Set (GCS)
User software	PIMikroMove
Application programming interfaces	API for C / C++ / C# / VB.NET / MATLAB / Python, drivers for NI LabVIEW
Supported functions	Point-to-point motion. Data recorder. Wave generator. Autozero. ID chip detection.
Miscellaneous	**C-413.20/.20A, C-413.2G/.2GA**
Operating voltage	24 V DC from external power adapter (included in the scope of delivery for C-413.2G and .2GA)
Max. current consumption	2 A
Operating temperature range	5 to 50 °C
Mass	0.3 kg
Dimensions	189 mm × 28 mm × 105 mm (.2G/.2GA) 160 mm × 18 mm × 100 mm (.20/.20A)

Ask about custom designs!

14.1.2 Maximum Ratings

The C-413 is designed for the following maximum ratings:

Input on:	**Maximum Operating Voltage** ⚠	**Operating Frequency** ⚠	**Maximum Current Consumption** ⚠
M8 panel plug, 4-pin (m)	24 V	⎓	2 A

14.1.3 Ambient Conditions and Classifications

The following ambient conditions and classifications for the C-413 must be observed:

Area of application	For indoor use only
Maximum altitude	2000 m
Air pressure	1100 hPa to 0.1 hPa
Relative humidity	Highest relative humidity 80 % for temperatures up to 31 °C Decreasing linearly to 50 % relative air 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
Degree of protection according to IEC 60529	IP20

14.2 System Requirements

The following system requirements must be met to operate the C-413:

- PC with at least 30 MB of free memory and one of the following operating systems:
  - Windows: Vista Service Pack 1, Windows 7, 8, and 10 (32 bit, 64 bit)
  - Linux
- Communication interface to the PC: USB
- C-413 with power adapter
- Mechanics with voice coil drive and incremental position sensor
- USB cable for connecting the C-413 to the PC
- Product CD with PC software

14.3 Dimensions

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

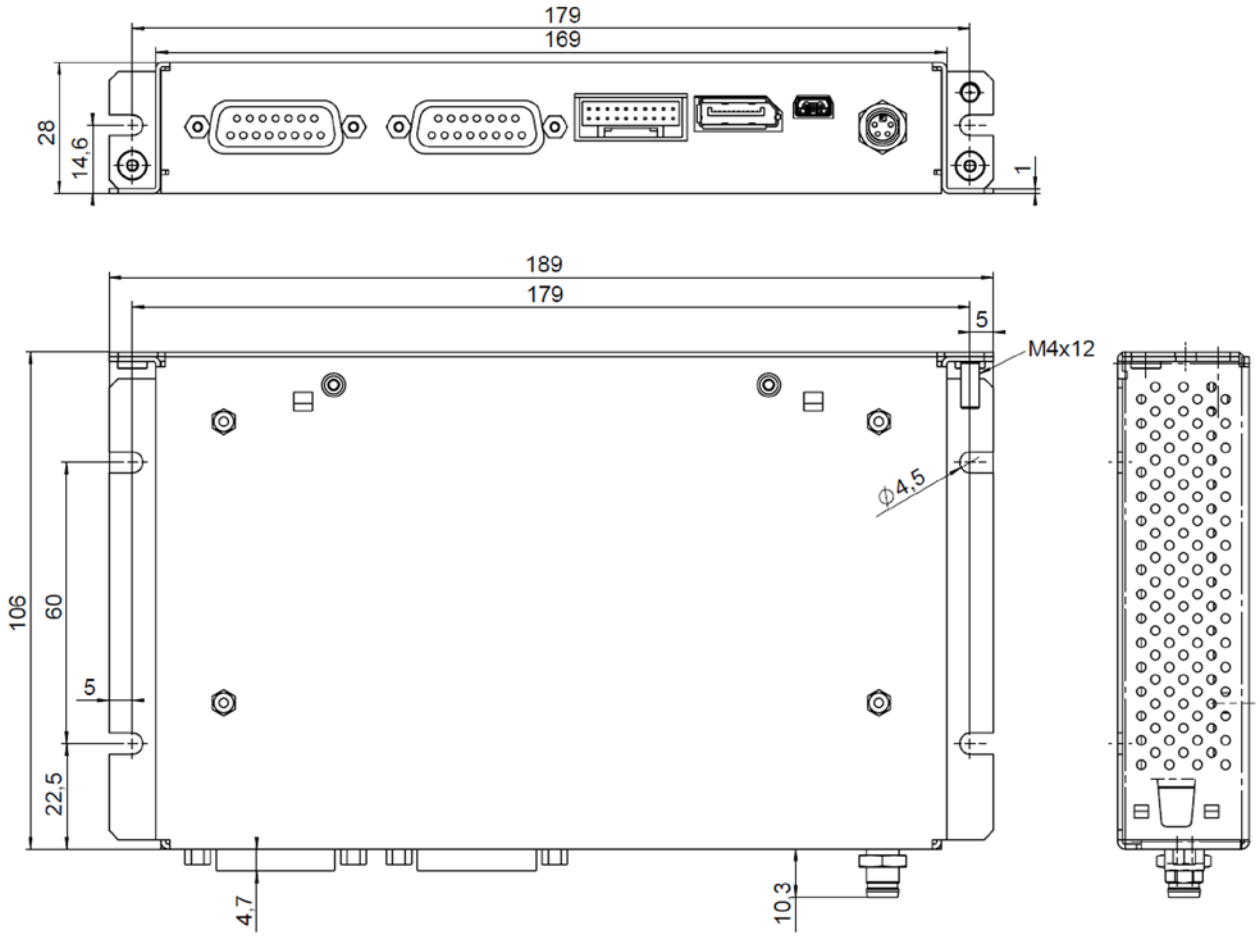


Figure 7: Dimensions of the C-413.2GA and C-413.2G models

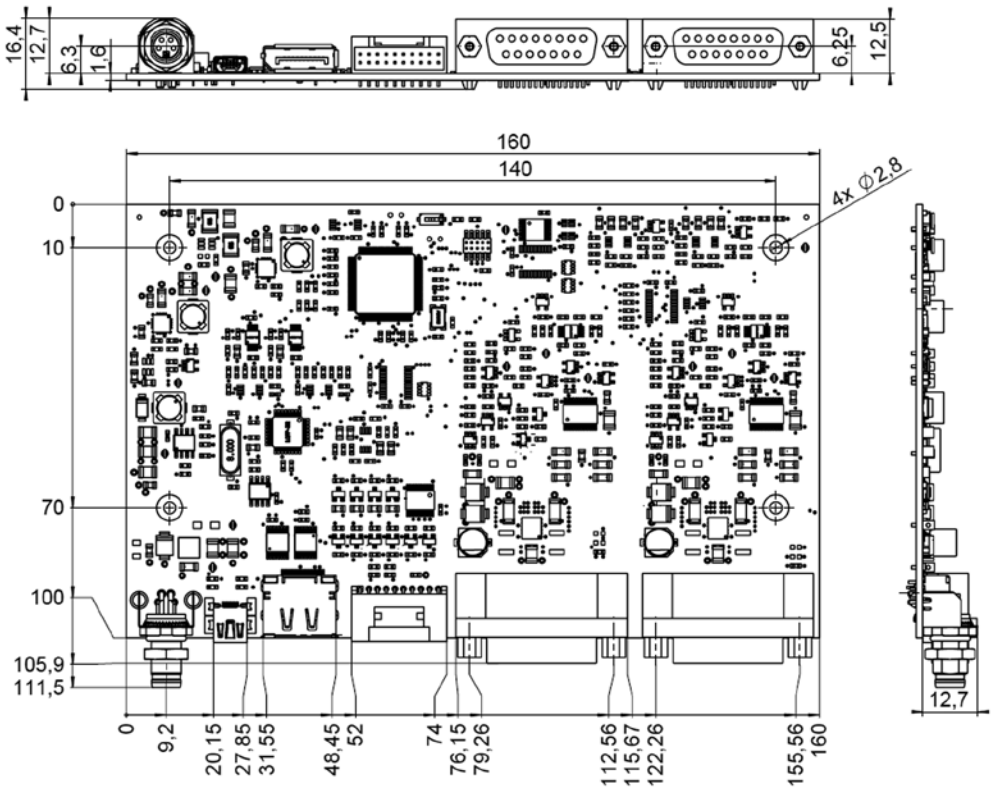


Figure 8: Dimensions of the C-413.20A and C-413.20 models

14.4 Pin Assignment

14.4.1 Motor & Sensor

D-sub socket, 15-pin, female

Pin	Signal	Direction	Function***
1	REF2*/4**	Input	Reference switch (direction sensing) for input signal channel 2* / 4**, TTL
2	Motor N1*/2**	Output	Output current for output signal channel 1* / 2** (±1.5 A, regulated; 24 V max.)
3	GND	-	GND
4	5 V	Output	Output voltage, maximum output power 500 mW
5	CS_MEM2*/4**	Output	SPI Chip Select: Selection of the ID chip for input signal channel 2* / 4** for data transmission
6	CS_MEM1*/3**	Output	SPI Chip Select: Selection of the ID chip for input signal channel 1* / 3** for data transmission
7	SEN_MOSI1*/2**	Output	SPI data line for ID chip and sensor signals of the input signal channels 1 and 2* / 3 and 4**
8	SEN_MISO1*/2**	Input	SPI data line for ID chip and sensor signals of the input signal channels 1 and 2* / 3 and 4**
9	Motor P1*/2**	Output	Output current for output signal channel 1* / 2** (±1.5 A, regulated; 24 V max.)
10	GND	-	GND
11	GND	-	GND
12	CS_SEN2*/4**	Output	SPI Chip Select: Selection of input signal channel 2* / 4** for data transmission
13	REF1*/3**	Input	Reference switch (direction sensing) for input signal channel 1* / 3**, TTL
14	SEN_CLK1*/2**	Output	SPI Serial Clock for ID chip and sensor signals of input signal channels 1 and 2* / 3 and 4**
15	CS_SEN1*/3**	Output	SPI Chip Select: Selection of input signal channel 1* / 3** for data transmission

* Assignment for **Motor & Sensor 1** socket

** Assignment for **Motor & Sensor 2** socket

*** "Input signal channel" corresponds to "sensor" here; "output signal channel" corresponds to "drive" here

14.4.2 I/O

PUD panel plug, 20-pin, male

Figure 9: Front view of the PUD panel plug

Pin	Signal	Function	Pin	Signal	Function
1	AIN1	Analog input, input signal channel 5* -10 to 10 V, 16 bit, 1 kHz	2	GND	GND
3	AIN2	Analog input, input signal channel 6* -10 to 10 V, 16 bit, 1 kHz	4	GND	GND
5	AOUT1	Analog output, output signal channel 3* -10 to 10 V, 17 bit, 1 kHz	6	GND	GND
7	AOUT2	Analog output, output signal channel 4* -10 to 10 V, 17 bit, 1 kHz	8	GND	GND
9	DIN1	Digital input 1***	10	DIN2	Digital input 2***
11	DIN3	Digital input 3***	12	DIN4	Digital input 4***
13	5 V	Output voltage, maximum output power 500 mW	14	GND	GND
15	DOUT1	Digital output 1**	16	DOUT2	Digital output 2**
17	DOUT3	Digital output 3**	18	DOUT4	Digital output 4**
19	DOUT5	Digital output 5**	20	DOUT6	Digital output 6** Not accessible for commands; output of the servo cycles

* Analog inputs and outputs only with C-413.2GA and .20A

** Digital outputs: Open collector (range 5 V to 24 V, 33 kOhm internal pull-up to 5 V)

*** Digital inputs: 5 V TTL level, up to 24 V max. input voltage, 10 kOhm input resistance

14.4.3 C-413.1IO Cable for the I/O Connection

JST connector, 20-pin, female, open end

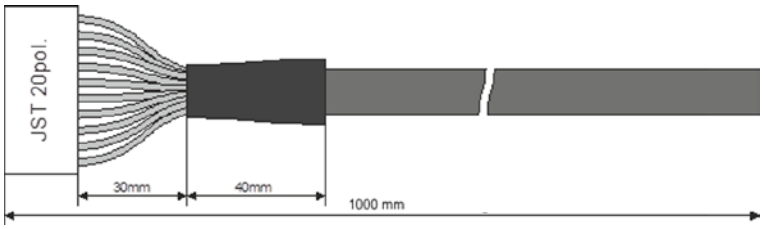


Figure 10: C-413.1IO cable

Specifications

Temperature range: -25 °C to +85 °C
Nominal current: 1 A AC/DC
Insulation resistance: 50 MΩ min.
Nominal voltage: 50 V AC/DC
Voltage impulse: 500 V AC for 1 minute

Pin	Wire Color	Function at the I/O Panel Plug of the C-413
1	Black	Analog input, input signal channel 5* -10 to 10 V, 16 bit, 1 kHz
2	Brown	GND
3	Red	Analog input, input signal channel 6* -10 to 10 V, 16 bit, 1 kHz
4	Orange	GND
5	Yellow	Analog output, output signal channel 3* -10 to 10 V, 17 bit, 1 kHz
6	n.c.	GND
7	Green	Analog output, output signal channel 4* -10 to 10 V, 17 bit, 1 kHz
8	n.c.	GND
9	Blue	Digital input 1***
10	Violet	Digital input 2***
11	Gray	Digital input 3***
12	White	Digital input 4***
13	White/black	5 V output voltage, maximum output power 500 mW
14	White/brown	GND
15	White/red	Digital output 1**

Pin	Wire Color	Function at the I/O Panel Plug of the C-413
16	White/orange	Digital output 2**
17	White/yellow	Digital output 3**
18	White/green	Digital output 4**
19	White/blue	Digital output 5**
20	White/violet	Digital output 6** Not accessible for commands; output of the servo cycles

* Analog inputs and outputs only with C-413.2GA and .20A

** Digital outputs: Open collector (range 5 V to 24 V, 33 kOhm internal pull-up to 5 V)

*** Digital inputs: 5 V TTL level, up to 24 V max. input voltage, 10 kOhm input resistance

14.4.4 Power Supply Connector 24 V DC

Phoenix M8 panel plug, 4-pin, male

Pin	Function
1	GND (power)
2	GND (power)
3	Input: 24 V DC
4	Input: 24 V DC

15 Old Equipment Disposal

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

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

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

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

Physik Instrumente (PI) GmbH & Co. KG

Auf der Roemerstr. 1

D-76228 Karlsruhe, Germany

16 EU Declaration of Conformity

For the C-413, an EU Declaration of Conformity has been issued in accordance with the following European directives:

2004/108/EC, EMC Directive

2011/65/EU, RoHS Directive

The applied standards certifying the conformity are listed below.

EMC: EN 61326-1:2013

Safety: EN 61010-1:2010

RoHS: EN 50581:2012

If an electrical operating device is designed to be integrated into another electrical operating device: The operator is responsible for standards compliant integration of the electrical device into the overall system.