MS249E

C-863.12 Mercury Controller

User Manual

Version: 2.1.0 Date: 2/13/22025

This document describes the following product:

- **C-863.12**
  Mercury servo controller; 1 axis/channel; data recorder, ID chip detection; closed-loop controlled variables: position; 4 analog inputs; 4 digital inputs; 4 digital outputs

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MOTION | POSITIONING

Original instructions
First printing: 2/13/2025
Document number: MS249E, ASt, Version 2.1.0

Subject to change. This manual is superseded by any new release. The latest respective release is available for download on our website (https://www.physikinstrumente.com/en/).

Contents

1 About this Document

1.1 Objective and Target Group of this User Manual

This user manual contains the information necessary for using the C-863.12 as intended.

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

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 result in damage to the equipment.

➢ Precautions to avoid the risk

INFORMATION

Information for easier handling, tricks, tips, etc.

Symbol/Label	**Meaning**
RS-232	Label on the product indicating an operating element (example: RS-232 interface socket)
⚠	Warning sign on the product referring 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 selected successively)
`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-863.12. For mechanics that allow motion in several directions (e.g., in X, Y, and Z), each direction of motion corresponds to a logical axis.
Daisy chain	Wiring diagram by which one controller is connected to the next in sequence (series connection principle). Here the first controller is connected directly to the PC. The additional controllers are always connected to the ones that precede them so that a chain is formed. The signal to and from a controller goes to the PC via the previous controllers.
Dynamics profile	Comprises the target position, velocity, and acceleration of the axis calculated by the profile generator of the C-863.12 for any point in time of the motion. The calculated values are called "commanded values".
Firmware	Software that is installed on the controller.
Volatile memory	RAM module where 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.
GCS	PI General Command Set: command set for PI controllers
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 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 into the volatile memory when the controller is started. In the PC software from PI, the parameter values in the nonvolatile memory are also referred to as "startup values".
Positioner	Mechanics connected to the C-863.12. In the case of positioners with just one motion axis, the designation "axis" is synonymous with "positioner". Positioners that allow motion in several axes are also designated as "multi-axis positioners". For these positioners, a distinction must be made between the individual axes.
Control value	The control value is the input for the PWM converter of the C-863.12. The PWM converter converts the control value into the PWM signal for the axis of the positioner.

1.4 Figures

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

1.5 Other Applicable Documents

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

Description	Document
Short instructions for the installation and startup of the C-863.12	MS242EK Short Instructions for Digital Motor Controllers
PI GCS driver library for use with NI LabVIEW software	SM158E Software Manual
PI MATLAB Driver GCS 2.0	SM155E Software Manual
PI GCS 2.0 DLL	SM151E Software Manual
GCS array data format description	SM146E Software Manual
PIMikroMove	SM148E Software Manual
PIStages3Editor: Software for managing the positioner database	SM156E Software Manual
PIUpdateFinder: Updating PI Software	A000T0028 User Manual
PI Software on ARM-Based Platforms	A000T0089 Technical Note
Downloading manuals from PI: PDF file with links to the manuals for digital electronics and software from PI. Supplied with the PI software.	A000T0081 Technical Note

1.6 Downloading manuals

INFORMATION

If a manual is missing or problems occur with downloading:

➢ Contact PI's customer service (p. 253).

Downloading manuals

1. Open the website **www.pi.ws**.
2. Search the website for the product number (e.g., C-863.12).
3. In the search results, select the product to open the product details page.
4. Select ***Downloads***.

   Manuals are shown under ***Documentation***. Software manuals are shown under ***General Software Documentation***.
5. For the desired manual, select ***ADD TO LIST*** and then ***REQUEST***.
6. Fill out the request form and select ***SEND REQUEST***.

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

2 Safety

2.1 Intended Use

The C-863.12 is a laboratory device as defined by DIN EN 61010. It is intended for indoor use and use in an environment that is free of dirt, oil, and lubricants.

In accordance with its design, the C-863.12 is intended for operating PI positioners equipped with DC motors or integrated PWM motor drivers.

The C-863.12 is intended for closed-loop operation with incremental position sensors. In addition, it can read and process the reference point and limit switch signals from the connected positioner.

The C-863.12 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-863.12 is built according to state-of-the-art technology and recognized safety standards. Improper use of the C-863.12 may result in personal injury and/or damage to the C-863.12.

- Use the C-863.12 for its intended purpose only, and only when it is in perfect condition.
- Read the user manual.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for installing and operating the C-863.12 correctly.

- Install the C-863.12 near the power supply so that the power plug can be quickly and easily disconnected from the mains.
- Use the components supplied (power supply and power cord) to connect the C-863.12 to the power supply.
- If one of the components supplied for connecting to the power supply has to be replaced, use a sufficiently rated component.

2.3 Organizational Measures

User manual

- Keep this user manual with the C-863.12 always.
  The latest versions of the user manuals are available for download on our website (p. 3).
- Add all manufacturer information such as supplements or technical notes to the user manual.
- If you give the C-863.12 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. The equipment can be damaged if your user manual is incomplete and is therefore missing important information.
- Install and operate the C-863.12 only after you have read and understood this user manual.

Personnel qualification

The C-863.12 may only be installed, started up, operated, maintained, and cleaned by authorized and appropriately qualified personnel.

3 Product Description

3.1 Product View

3.1.1 Front Panel

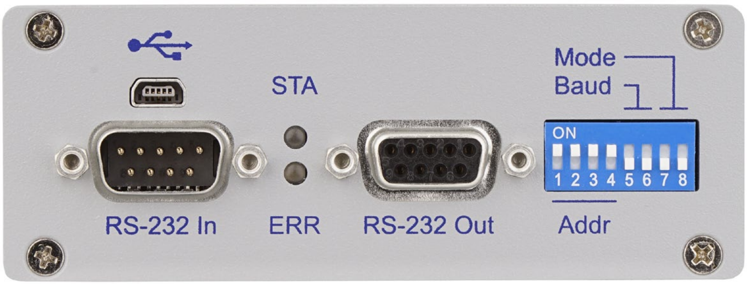


Figure 1: Front panel of the C-863.12

Labeling	Type	Function
⇶	Mini-USB type B	Universal serial bus for connection to the PC; do not connect if **RS-232 In** is already connected.
RS-232 In	D-sub 9 (m) (p. 263)	Serial connection to the PC or to the previous controller in a daisy chain network; do not connect to the PC if the USB interface is already connected.
RS-232 Out	D-sub 9 (f) (p. 263)	Serial connection to the subsequent controller in a daisy chain network
STA	LED green	Controller state: ▪ Lights up continuously: C-863.12 is ready for normal operation ▪ Flashing: C-863.12 is in firmware update mode ▪ Off: C-863.12 is not connected to the supply voltage
ERR	LED red	Error indicator: ▪ On: Error (error code ≠ 0) ▪ Off: No error (error code = 0) The error code can be queried with the `ERR?` command. The query resets the error code to zero and the LED is switched off.

Labeling	Type	Function
Mode **Baud** **Addr**	8-bit DIP switch (p. 53)	Setting of ▪ Device address (***Addr***) ▪ Baud rate for communication with the PC (***Baud***) The switches 7and 8 (***Mode***) have no function.

3.1.2 Rear Panel

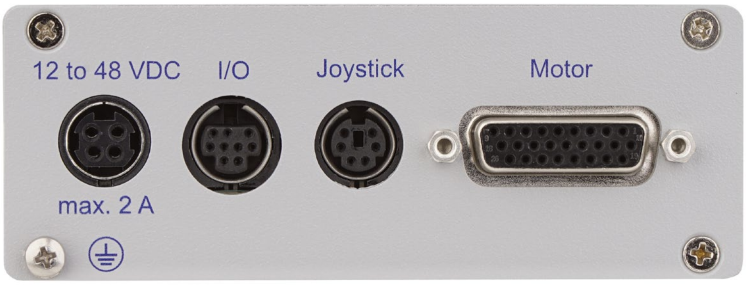


Figure 2: Rear panel of the C-863.12

Labeling	Type	Function
12 to 48 VDC **Max. 2 A**	DC power socket (Kycon), 4-pole (f), lockable (p. 265)	Connector for the supply voltage
I/O	Mini-DIN, 9-pole (f) (p. 260)	Digital inputs/outputs: ▪ Outputs: Trigger external devices ▪ Inputs: Use in macros or as switch signals Analog inputs: ▪ Use in macros or for scanning processes
Joystick	Mini-DIN, 6-pole (f) (p. 261)	Connector for analog joystick ▪ Inputs for signals from the joystick axes and buttons ▪ Output for the supply voltage of the joystick
Motor	HD D-sub 26 (f)	Positioner's connector ▪ ***Output for the motor's control signals*** ▪ Input of the signals of the incremental position sensor ▪ Signal input from the limit switches and reference switch

Labeling	Type	Function
⏚	Screw and toothed washer Grounding the C-863.12 (p. 45)	Ground connection If potential equalization is required, the screw can be connected to the grounding system.

3.2 Type Plate

Labeling	Function
▨	Data matrix code (example; contains the serial number)
C-863.12	Product name
PI	Manufacturer's logo
116056789	Serial number (example), individual for each C-863.12 Meaning of each position (from the left): 1 = internal information, 2 and 3 = year of manufacture, 4 to 9 = consecutive number
Country of origin: Germany	Country of origin
⚠	Warning sign "Pay attention to the manual!"
⊠	Old equipment disposal (p. 267)
CE	CE conformity mark
WWW.PI.WS	Manufacturer's address (website)

3.3 Scope of Delivery

Item	Component
C-863.12	Controller
C-501.24120DIN4	Wide input range power supply 24 V 120 W, mini-DIN, 4-pin
3763	Power cord
000036360	USB cable (type A to mini B) for connecting to the PC
C-815.34	RS-232 null modem cable, 3 m, 9/9-pin
C-862.CN	Network cable for daisy chain network, 30 cm
000084853	4 adhesive feet for C-863.12
C-990.CD1	Data storage device with PC software from PI
MS242EK	Short instructions for digital motor controllers

3.4 Optional Accessories

Item	Component
C-862.CN2	Network cable for daisy chain network, 3 m
C-819.20	Analog joystick for 2 axes, details see"Joysticks Available" (p. 97)
C-819.20Y	Y cable for connecting 2 controllers to C-819.20 joystick
C-819.30	Analog joystick for 3 axes, details see"Joysticks Available" (p. 98)
C-170.PB	Pushbutton box with 4 buttons and 4 LEDs Connection to the **I/O** socket of the C-863.12, sends 4 TTL input signals and displays the state of the 4 digital outputs via the LEDs.
C-170.IO	I/O cable, 2 m, open end (p. 261)

To order, contact our customer service department (p. 253).

3.5 Overview of PC Software

3.5.1 PI Software Suite

A data storage device with the PI Software Suite is included in the C-863.12's scope of delivery (p. 9). Some components of the PI Software Suite are described in the table below. For information on the compatibility of the software with PC operating systems see the C-990.CD1 Release News in the root directory of the data storage device.

Libraries, drivers

PC software	Short description	Recommended use
Dynamic program library for GCS	Allows software programming for the C-863.12 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 NI LabVIEW drivers.
Drivers for use with NI LabVIEW software	NI LabVIEW is a software for data acquisition and process control (must be ordered separately from National Instruments).The driver library is a collection of virtual instrument drivers for PI controllers. The drivers support the PI GCS.	For users who want to use NI LabVIEW to program their application.
MATLAB drivers	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 GCS. The PI MATLAB driver does not require any additional MATLAB toolboxes.	For users who want to use MATLAB to program their application.
USB driver	Driver for the USB interface	For users who want to connect the controller to the PC via the USB interface.

User software

PC software	Short description	Recommended use
PIMikroMove	Graphic user interface for Windows with which the C-863.12 and other controllers from PI can be used. ▪ The system can be started without programming effort ▪ Graph of motions in open-loop and closed-loop operation ▪ Macro functionality for storing command sequences on the PC (host macros) ▪ Support of HID devices ▪ Complete environment for command entry, for trying out different commands PIMikroMove uses the dynamic program library to supply commands to the controller.	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	Terminal program that can be used for nearly all PI controllers.	For users who want to send GCS commands directly to the controller.
PIStages3Editor	Program for opening and editing positioner databases in .db format.	For users who want to deal with the contents of positioner databases more intensively.
PIUpdateFinder	Checks the PI software installed on the PC. If more current versions of the PC software are available on the PI server, downloading is offered.	For users who want to update the PC software.
PIFirmwareManager	Program for user support when updating firmware of the C-863.12.	For users who want to update the firmware.

3.6 Positioner Databases

You can select a parameter set appropriate for your positioner from a positioner database in the PC software from PI. The PC software transfers the values of the selected parameter set to the volatile memory of the controller.

File name	Description
PISTAGES3.DB	Delivery includes parameter sets for all standard positioners from PI and PI miCos and is automatically saved to the PC when the PC software is installed New parameter sets can be created, edited, and saved (p. 232).
<Produkt>.db e.g.: M-xxxxxxx.db	Includes the parameter set for a custom positioner. In order for the parameter set to be selected in the PC software, it must be added to the PISTAGES3.DB first, see "Installing Custom Positioner Databases" (p. 43).

Parameters loaded from a positioner database are marked in color in the parameter overview (p. 236).

For more information on the positioner database, see the manuals for the PIStages3Editor and the PI GCS program library.

INFORMATION

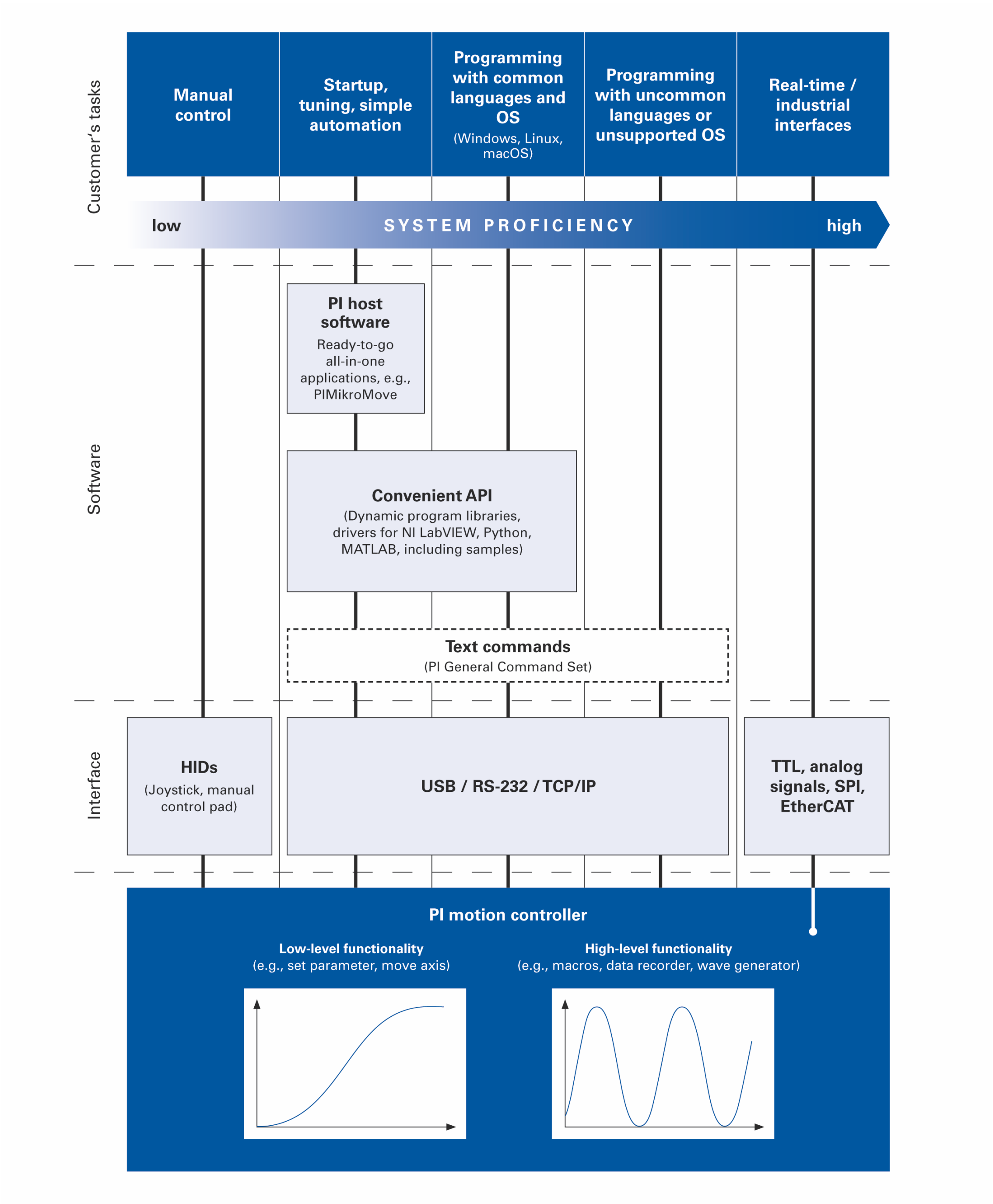
If the pistages2.dat and pimicosstages2.dat positioner databases are on your PC:

Positioner databases in .dat format are only installed for compatibility reasons and **not** used for the C-863.12 described in this manual.

3.7 Communication Interfaces

3.7.1 Control of PI Systems

Basically, systems from PI can be controlled as follows:


Customer's tasks
Manual control
Startup, tuning, simple automation
Programming with common languages and OS
(Windows, Linux, macOS)
Programming with uncommon languages or unsupported OS
Real-time / industrial interfaces
low
SYSTEM PROFICIENCY
high
Software
PI host software
Ready-to-go all-in-one applications, e.g., PIMikroMove
Convenient API
(Dynamic program libraries, drivers for NI LabVIEW, Python, MATLAB, including samples)
Text commands
(PI General Command Set)
Interface
HIDs
(Joystick, manual control pad)
USB / RS-232 / TCP/IP
TTL, analog signals, SPI, EtherCAT
PI motion controller
Low-level functionality
(e.g., set parameter, move axis)
High-level functionality
(e.g., macros, data recorder, wave generator)

3.7.2 C-863.12 Communication Interfaces

The C-863.12 can be controlled with ASCII commands from a PC: The connection to the PC can be made via a direct connection or via a daisy-chain network. The following interfaces of the C-863.12 can be used for direct connection to the PC:

- Serial RS-232 connection
- USB connection

Only one of the two interfaces may be connected to the PC at all times.

Default communication settings

Interface	Property	Default value
RS-232	Baud rate	115200 Settings for DIP switches 5 and 6; see "Baud Rate" (p. 55) Other: 8 data bits and 1 stop bit, without parity; internal buffers do not require a handshake

INFORMATION

A USB UART module (FTDI) is used for the USB interface in the C-863.12. Therefore, if the C-863.12 is connected via USB and switched on, the USB interface is also shown as COM port in the PC software. The C-863.12 uses a baud rate of 115200 for this interface.

Daisy chain network

Using a daisy chain network, up to 16 controllers can be connected to the PC via a single RS-232 or USB connection. Interlinking occurs in series. See also "Definition of Terms" (p. 2).

3.8 Functional Principles

3.8.1 Block Diagram

The C-863.12 controls the motion of the logical axis of a positioner. The following block diagram shows how the C-863.12 generates the output signal for the axis connected:

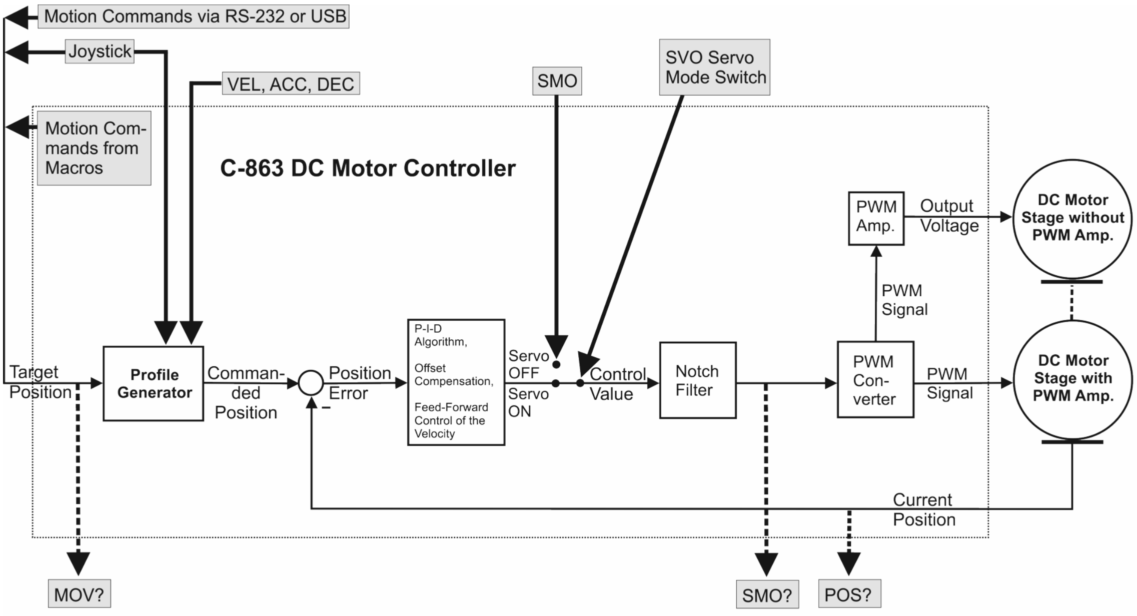


Figure 3: C-863.12: Control value generation

The C-863.12 supports both positioners with PWM amplifier and positioners without PWM amplifier (p. 45). The positioner must be equipped with an encoder with A/B quadrature signal transmission for feedback of the current position.

3.8.2 Motor Control

The maximum output voltage of the C-863.12 is only as high as its supply voltage. To avoid damaging the motor by excessive operating voltage, the C-863.12 scales its output voltage to the motor connected.

Details on scaling:

- The C-863.12 compares its current supply voltage (maximum 48 V) to the value of parameter 0x7C (***Maximum Motor Output (V)***), which specifies the maximum permissible operating voltage of the motor (maximum of 48 V depending on the motor type; see the documentation for the positioner).
- Depending on the result of the comparison, the C-863.12 scales the control value for the PWM converter (see block diagram (p. 16)) and therefore the output voltage as well.

Example:

The C-863.12 is operated with a 24 V power adapter. The motor of the positioner connected is designed for a maximum operating voltage of 12 V, which means that parameter 0x7C has a value of 12. The PWM signal then has a duty cycle of maximum 50 %, i.e., the output voltage is maximum 12 V.

INFORMATION

If the positioner is equipped with a PWM amplifier that is supplied via a separate power adapter:

➢ To achieve the optimum motor performance, use a power adapter for the C-863.12 that supplies the same output voltage as the power adapter for the PWM amplifier.

The C-863.12 is configured for the maximum operating voltage of the motor with the following parameters:

Parameter	Description and Possible Values
Maximum Motor Output (V) 0x7C	Maximum permissible operating voltage of the motor 0 to 48 V
Maximum Motor Output 0x9	Maximum permissible absolute measure of the control value (dimensionless) 0 to 32767 The value 32767 (standard) corresponds to the maximum permissible operating voltage of the motor, which is specified by parameter 0x7C. The standard value of parameter 0x9 should not be changed.

3.8.3 Commandable Elements

The following table contains the elements that can be commanded with GCS commands (p. 127).

Element	Number	Identifier	Description
Logical axis	1	1 (modifiable)	The logical axis represents the motion of the positioner in the firmware of the C-863.12. It corresponds to an axis of a linear coordinate system. All commands for the motion of a positioner refer to logical axes. Motion for logical axes is commanded in the firmware of the C-863.12 (i.e., for the directions of motion of a positioner). The motion commands `MOV` and `MVR` are for example, available in closed-loop operation. The motion command for open-loop operation is `SMO`. The axis identifier can be queried with the `SAI?` command

Element	Number	Identifier	Description
			and modified with the `SAI` command. It can consist of up to 8 characters; valid characters are 1234567890ABCDEFGHIJKLMNOPQRSTUVWXYZ-_ The new axis identifier is only transferred to the volatile memory of the C-863.12. A changed axis identifier can be stored permanently in the C-863.12 with the `WPA` command (p. 201).
Analog inputs	7	1 to 7	The analog input lines with the identifiers 1 to 4 are the inputs 1 to 4 of the **I/O** socket (p. 260). Their number is displayed with the `TAC?` command and their values can be queried with the `TAV?` command. Note that these lines can also be used as digital inputs (see below). Additional analog input lines are located at the **Joystick** socket (p. 261). These lines are not output via `TAC?` and `TAV?`. The values of all inputs can be recorded via record option 81 of the `DRC` command.
Digital outputs	4	1 to 4	1 to 4 identify digital output lines 1 to 4 of the **I/O** socket (p. 260). For further information, see "Digital Output Signals" (p. 78).
Digital inputs	4	1 to 4	1 to 4 identify digital input lines 1 to 4 of the **I/O** socket (p. 260), which can also be used as analog inputs (see above). For further information, see "Digital Input Signals" (p. 86).
Joystick Joystick axis Joystick button	1 1 1	1 1 1	A joystick can be connected to the C-863.12's **Joystick** socket (p. 261). Pin 4: Commanding as axis 1 of joystick 1 Pin 6: Commanding as button 1 of joystick 1 For further information, see "Joystick Control" (p. 91). For data recorder configuration with the `DRC` command, the following data source identifiers apply: 5 = axis 1 of joystick 1 6 = button 1 of joystick 1
Data recorder table	4	1 to 4	The C-863.12 has 4 data recorder tables (query with `TNR?`) with 1024 data points per table.
Controller address	1	1 to 16	The controller address can be set in the range from 1 to 16 with the DIP switches on the front panel of the C-863.12. In a daisy chain (p. 47), each controller must have a unique address (p. 119).
Overall system	1	1	C-863.12 as an overall system

3.8.4 Important Components of the Firmware

The firmware of the C-863.12 provides the following functional units:

Firmware Component	Description
ASCII commands	Communication with the C-863.12 can be managed using the commands of the PI General Command Set (GCS; version 2.0). The GCS is independent of the hardware (controller, positioners connected). Examples of the use of GCS: ▪ Configuring the C-863.12 ▪ Setting the operating mode ▪ Starting motion of the positioner ▪ Getting system and position values You can find a list of the available commands in the "Command Overview" section (p. 122).
Parameter	Parameters reflect the properties of the positioner connected (e.g., travel range) and specify the behavior of the C-863.12 (e.g., settings for the servo algorithm or for the use of the digital inputs). Parameter values can be changed to adapt the system to the particular application. For further information, see "Adapting Settings" (p. 227). Write access for the parameters of the C-863.12 is defined by command levels. After the controller is switched on or rebooted, the active command level is always 0. On command levels > 1, write access is only available to PI service personnel.
Profile generator and servo algorithm	In closed-loop operation, a profile generator generates the dynamics profile. The position error that results from the difference between the calculated dynamics profile and the actual position (sensor feedback) runs through a PID servo algorithm. Further information can be found in the sections "Generation of Dynamics Profile" (p. 22), "Servo Algorithm and Other Control Value Corrections" (p. 26) and "Motion Triggering" (p. 21).
Data Recorder	The C-863.12 contains a real-time data recorder (p. 76). The data recorder can record various signals (e. g., position, analog input) from different data sources (e. g., logical axes or input channels).
Macros	The C-863.12 can store macros (p. 99). Command sequences can be defined and stored permanently in the nonvolatile memory of the device via the macro function. A startup macro can be defined that runs each time the C-863.12 is switched on or rebooted. The startup macro simplifies stand-alone operation (operation without a connection to the PC). Further information can be found in the "Controller Macros" section (p. 99).

The firmware can be updated with a tool (p. 245).

3.8.5 Operating Modes

The C-863.12 supports the following operating modes:

Operating Mode	Description
Closed-loop operation (servo mode On)	A profile generator calculates the dynamics profile from the values specified for target position, velocity, acceleration, and deceleration. The position error that results from the difference between the calculated dynamics profile and the actual position (sensor feedback) runs through a PID servo algorithm (**p**roportional **i**ntegral **d**erivative). Additional corrections can be made as well. The result is the control value for the PWM converter integrated in the C-863.12. Further information can be found in the sections "Generation of Dynamics Profile" (p. 22) and "Servo Algorithm and Other Control Value Corrections" (p. 26).
Open-loop operation (servo mode Off)	In open-loop operation, the C-863.12 does not calculate a dynamics profile and does not evaluate the signals of the position sensor. As a result, the positioner can move unbraked to the end of the travel range and, despite the limit switch function, strike the hard stop.

INFORMATION

The C-863.12 is intended for closed-loop operation with incremental position sensors (servo mode On). After switch-on, open-loop operation is active by default (servo mode Off).

- Query the current operating mode with the `SVO?`, `#4` or `SRG?` commands.
- Activate closed-loop operation with the `SVO` command.
- If necessary, program a startup macro that starts the C-863.12 via the `SVO` command in closed-loop operation; see "Setting up a startup macro" (p. 107).
- Avoid motion in open-loop operation.

3.8.6 Physical Units

The C-863.12 supports various units of length for positions. Adapting is done by a factor that converts the incremental encoder counts into the physical unit of length required. The conversion factor is set with the following parameters:

Parameters	Description and Possible Values
Numerator Of The Counts-Per-Physical-Unit Factor 0xE	Numerator and denominator of the factor for counts per physical length unit 1 to 1.000.000.000 for each parameter. The factor for the counts per physical unit of length specifies the unit of length for position queries and motion commands in closed-loop operation. The values of every parameter, whose unit is either the physical unit of length itself or a unit of measurement based on it, are
Denominator Of The Counts-Per-Physical-Unit Factor 0xF	

Parameters	Description and Possible Values
	automatically adapted to the set factor. The factor for the counts per physical unit of length has no impact on the stability of the servo loop but is used for the input and output scaling of position values.

The unit symbol can be customized for display purposes with the following parameter:

Parameters	Description and Possible Values
Axis Unit 0x07000601	Unit symbol Maximum of 20 characters. For example, the unit symbol is "MM", if the factor for the counts per physical unit of length is set with parameters 0xE and 0xF so that the encoder counts are converted into millimeters. The unit for rotation stages is normally "deg". The value of the parameter 0x07000601 is not evaluated by the C-863.12 but is used by the PC software for display purposes. Examples: 1 encoder count = 100 nm Counts per physical length unit: 10000:1 → Unit symbol: mm 1 encoder count = 0.254 mm Counts per physical length unit: 100:1 → Unit symbol: inch

3.8.7 Motion Triggering

Motion in closed-loop operation

Trigger of the motion	Commands	Description
Motion commands, sent from the command line or via the PC software	MOV, MVR	Motion to absolute or relative target position
	GOH	Motion to zero position
	STE	Starts a step and records the response
	FNL, FPL, FRF	Starts referencing moves
	FED	Starts moves to signal edges
Controller macros with motion commands	MAC	Calls a macro function. Permits recording, deleting, and running macros on the controller. Any commands can be sent from the command line while a macro is running on the controller. The macro content and motion commands received

Trigger of the motion	Commands	Description
		from the command line can overwrite each other.
	Additional macro commands and information see "Controller Macros" (p. 99).	
Joystick control The joystick controls the velocity of the axis (commanded velocity output from the profile generator).	JON	Activates or deactivates a joystick connected to the controller. Motion commands are not allowed when joystick control is activated for the axis.
	JAX	Specifies the axis controlled by a joystick connected to the controller.
	Additional joystick commands see "Joystick Control" (p. 91).	

INFORMATION

Absolute target positions can only be commanded if the axis was referenced beforehand; see "Referencing" (p. 34).

Motion in open-loop operation

Motion is triggered by the `SMO` command, which specifies the control value for the PWM converter in the C-863.12.

Joystick control is not possible in open-loop operation.

3.8.8 Generation of the Dynamics Profile

In closed-loop operation the profile generator performs calculations to specify the target position, velocity and acceleration of the axis for any point in time (dynamics profile). The values calculated are called commanded values. The dynamics profile generated by the profile generator of the C-863.12 depends on the motion parameters which are given by commands (p. 127), parameters and/or by joystick.

Motion parameter	Comman ds	Parameters	Remarks
Acceleration (A)	`ACC` `ACC?`	Acceleration in closed-loop operation (parameter 0xB; physical unit of length/s^2); change with the `ACC` command or with `SPA` / `SEP`; can be saved with `WPA`.	Is limited by parameter 0x4A (maximum acceleration in closed-loop operation).
Deceleration (D)	`DEC` `DEC?`	Deceleration in closed-loop operation	Is limited by parameter 0x4B (maximum deceleration in closed-

Motion parameter	Commands	Parameters	Remarks
		(parameter 0xC; physical unit of length/s²); change with the DEC command or with SPA / SEP; can be saved with WPA.	loop operation).
Velocity (V)	VEL VEL?	Velocity in closed-loop operation (parameter 0x49; physical unit of length/s); change with the VEL command or with SPA / SEP; can be saved with WPA.	Is limited by parameter 0xA (maximum velocity in closed-loop operation). When a joystick is connected to the C-863.12 and the joystick is activated with the JON command, a factor is applied to the current velocity set with the VEL command. Further information see "Joystick Control" (p. 91).
Target position at the end of the motion	MOV MVR GOH STE	-	When a joystick is connected to the C-863.12 and the joystick is activated with the JON command, the soft limits are set for the particular target position. When disabling the joystick, the target position is set to the current position for the joystick-controlled axes. Further information see "Joystick Control" (p. 91). When switching on the servo mode with the SVO command or when stopping the axis motion with the #24, STP or HLT commands, the target position is set to the current position.

The profile generator of the C-863.12 only supports trapezoidal velocity profiles: The axis accelerates linearly (based on the acceleration value specified) until it reaches the specified velocity. It continues to move with this velocity until it decelerates linearly (based on the deceleration value specified) and stops at the specified target position.

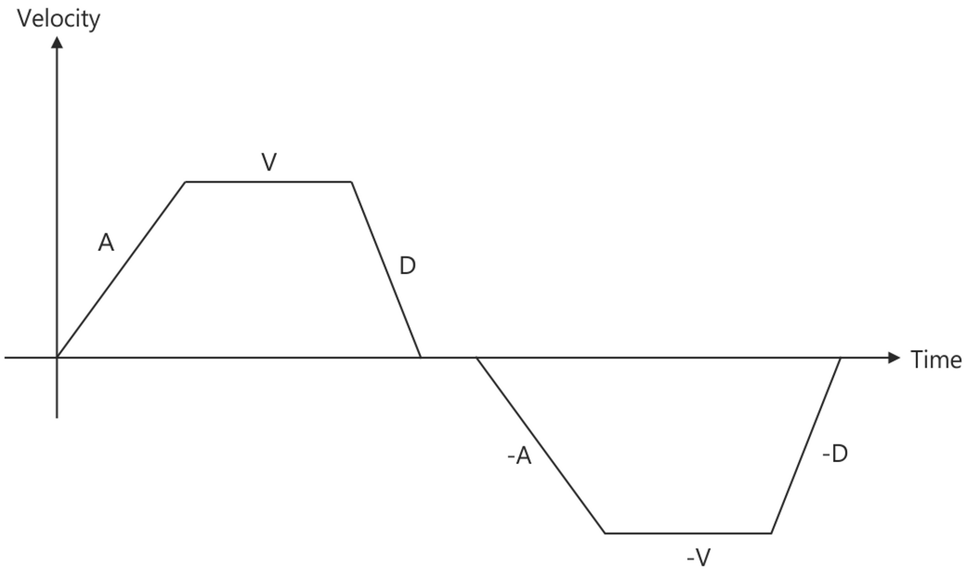


Figure 4: Basic trapezoidal velocity profile; A = acceleration, D = deceleration, V = velocity

If the deceleration has to begin before the axis reaches the specified velocity, the profile will not have a constant velocity portion and the trapezoid becomes a triangle.

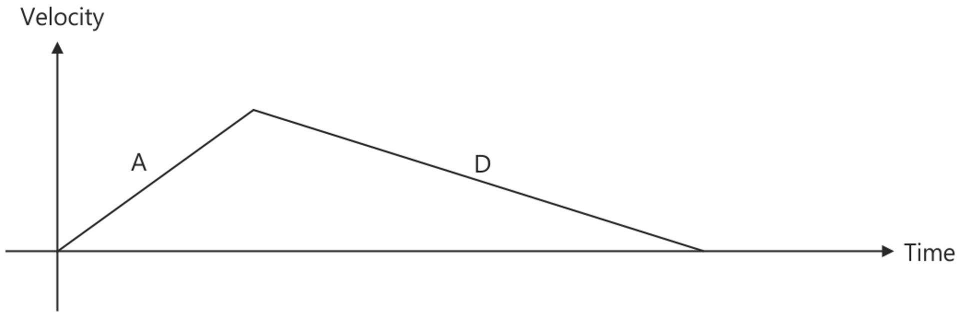


Figure 5: Basic trapezoidal velocity profile; A = acceleration, D = deceleration, no constant velocity

The edges for acceleration and deceleration can be symmetrical (acceleration = deceleration) or asymmetrical (acceleration ≠ deceleration). The acceleration value is always used at the start of the motion. After that the acceleration value is used during an increase in the absolute velocity and the deceleration value during a decrease in the absolute velocity. If no motion parameters are changed during the course of the motion, the acceleration value is used until the maximum velocity is reached and the deceleration value is used for the decrease in velocity down to zero.

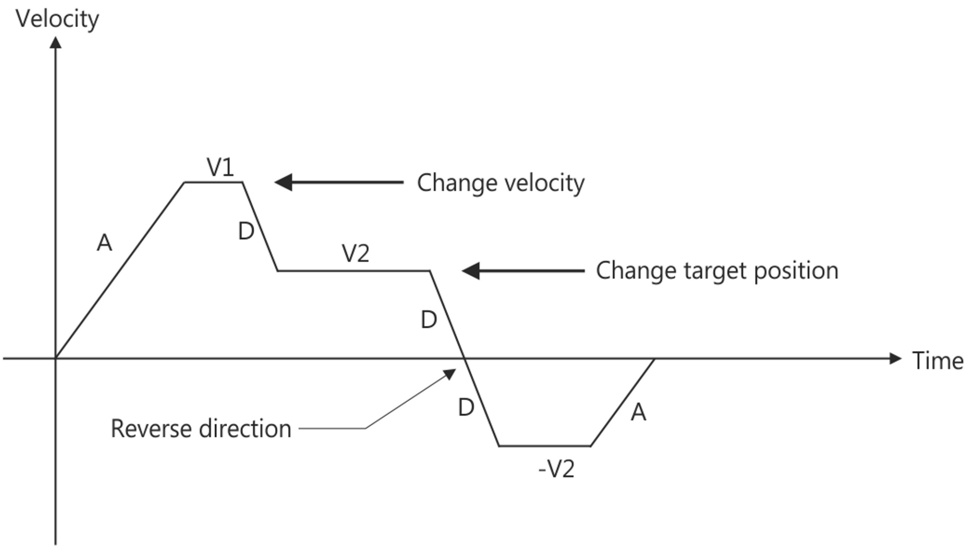


Figure 6: Complex trapezoidal profile with parameter changes; A = acceleration; D = deceleration; V1, V2, -V2 = velocities

All motion parameters can be changed while the axis is in motion. The profile generator will always attempt to stay within the permissible motion limits specified by the motion parameters. If the target position is changed during the motion so that overshooting is unavoidable, the profile generator will decelerate to the extent of stopping and reverse the direction of motion in order to reach the specified position.

3.8.9 Servo Algorithm and Other Control Value Corrections

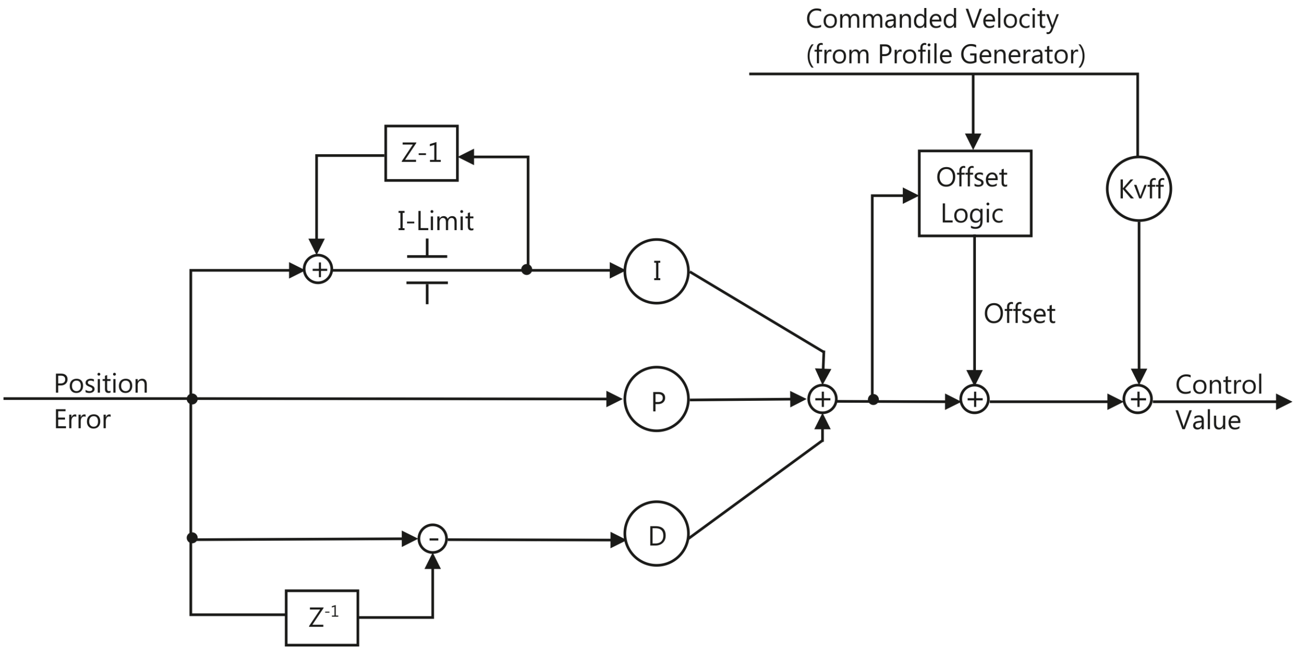


Figure 7: PID algorithm, offset correction and feed-forward control of the velocity (KVff); the notch filter is not shown here

In closed-loop operation, the control value for the PWM converter integrated in the C-863.12 and therefore the settling behavior of the system is optimized via the following corrections:

- Servo algorithm: The position error, which results from the difference between the calculated dynamics profile (see "Generation of Dynamics Profile" (p. 22)) and the actual position (sensor feedback), runs through a PID servo algorithm (**p**roportional **i**ntegral **d**erivative).
- Dynamics profile corrections: The dynamics profile generated can be subject to an offset correction and a feed-forward control of the velocity.

Regardless of the operating mode, the control value can be subjected to an additional correction via the notch filter.

Servo algorithm

The servo algorithm uses the following servo control parameters. The optimum servo control parameter setting depends on your application and your requirements; see "Optimizing Servo Control Parameters" (p. 68).

Parameters	Description and Possible Values
P Term 0x411	Proportional constant (dimensionless) 0 to 32767 Aim: Rapid correction of the position error
I Term	Integration constant (dimensionless)

Parameters	Description and Possible Values
0x412	0 to 32767 Objective: Reduction of static position error
D Term 0x413	Differential constant (dimensionless) 0 to 32767 Aim: Damping of rapid control oscillations
I-Limit 0x414	Limit of the integration constant (dimensionless) 0 to 32767
D Term Delay (No. Of Servo Cycles) 0x71	D term delay The D term can be calculated as a floating average over several servo cycles. The parameter specifies how many values (i.e., servo cycles) are to be used for averaging.

The input of the servo algorithm can be configured for the C-863.12 with the following parameters:

Parameters	Description and Possible Values
Numerator Of The Servo Loop Input Factor 0x5A	Numerator and denominator of the servo-loop input factor 1 to 1,000,000 for both parameters The servo-loop input factor decouples the servo control parameters from the encoder resolution. The servo-loop input factor is independent of the factor for counts per physical length unit (0xE and 0xF). Numerator and denominator of the servo-loop input factor should not be changed.
Denominator Of The Servo-Loop Input Factor 0x5B	

Corrections of the dynamics profile

The dynamics profile corrections for closed-loop operation can be configured via the parameters listed below:

Parameters	Description and Possible Values
Motor Offset Positive 0x33	Offset for the positive direction of motion (dimensionless). 0 to 32766
Motor Offset Negative 0x34	Offset for the negative direction of motion (dimensionless). 0 to 32766
Motor Drive Offset 0x48	Velocity-dependent offset (dimensionless). Is used if the commanded velocity does not equal zero (i.e., if the end of the dynamic profile has still not been reached). 0 to 32766

Parameters	Description and Possible Values
Kvff 0x415	Feed-forward control of the commanded velocity 0 to 32767 Aim: Minimization of the position error

Control value corrections regardless of the operating mode

The parameters listed below correct the control value both in closed- and open-loop operation.

Parameters	Description and Possible Values
Notch Filter Frequency 1 (Hz) 0x94	Frequency of the first notch filter 40 to 20000 Hz The appropriate frequency component is reduced in the control value to compensate for undesired resonances in the mechanics. An adjustment can be particularly useful in the case of very high loads.
Notch Filter Edge 1 0x95	Rise of the edge of the first notch filter (dimensionless) 0.1 to 10 This parameter value should not be changed.

Filtering of the encoder signals

For slow motion of the connected positioner, it is possible to use the following parameter to set a filter that reduces any interference in the encoder signal.

Parameter	Description and possible values
Quadrature Encoder Filter 0x03003900	Filter for the AB encoder signal: 0 = Filter disabled (default setting) 1 = fast: Filter for motion at high velocity 2 = medium: Filter for motion at medium velocity 3 = slow: Filter for motion at low velocity When the filter is disabled (0), the controller processes the encoder signals as quickly as possible. For slower motion, it may be purposeful to set the filter to one of the 3 steps: from 1 for rapid motion (least filtering) to 3 for slow motion (strongest filtering). Also in the event of problems with the encoder signal, the filter can be used to reduce interference. The filter does not have to be set for normal operation.

3.8.10 On-Target State

In closed-loop operation, the on-target state can be used to check whether the target position has been reached:

- On-target state = true (1): the target position is considered as reached
- On-target state = false (0): the target position is considered as not reached

The C-863.12 determines the on-target state on the basis of the following criteria:

- Settling window around the target position (parameter 0x36)
- Delay time for setting the on-target state (parameter 0x3F)

The on-target state has the value **true** in the following cases:

- The current position is inside the settling window and stays there at least for the duration of the delay time.
- If the value for the delay time is set to 0: The end of the dynamics profile is reached.

The on-target state can be read with the `ONT?`, `#4` and `SRG?` commands.

In the *On Target* trigger mode (p. 82), the on-target state of the selected axis is output at the selected trigger output.

Parameter	Description and Possible Values
Settling Time (s) 0x3F	Delay time for setting the on-target state 0 to 1.000 s
Settling Window (encoder counts) 0x36	Settling window around the target position 0 to 2^{31} counts of the encoder Specifies the window limits. If the current position exits the settling window, the target position is no longer considered as reached. The parameter value corresponds to half the width of the window. It can be changed only if the servo mode is switched off.

3.8.11 Reference Switch Detection

The C-863.12 receives the signal from the reference switch at the **Motor** socket (p. 259).

Reference switch detection by the C-863.12 can be configured with the following parameters:

Parameters	Description and Possible Values
Invert Reference? 0x31	Should the reference signal be inverted? 0 = Reference signal not inverted 1 = Reference signal inverted This parameter is used for inverting the reference signal whose source can be either the reference switch or a digital input which is used instead of the reference switch (p. 89).
Has Reference? 0x14	Does the positioner have a reference switch? 0 = Reference switch not installed 1 = Reference switch available (signal input on motor connector) This parameter activates or deactivates referencing moves to the installed reference switch.
Reference Signal Type 0x70	Reference signal type 0 = Direction-sensing reference switch (default setting). The signal level changes when passing the reference switch. 1 = Pulse signal with a pulse width of several nanoseconds (parameter 0x47 must be set correctly). 2 = Index pulse. The approach takes place via the negative limit switch.

The signal from the reference switch of the positioner can be used for referencing moves. After a referencing move to the reference switch, the controller knows the absolute axis position; see "Referencing" (p. 34).

3.8.12 Limit Switch Detection

The C-863.12 receives limit switch signals at the **Motor (p. 259)** socket:

- Pin 12: Positive limit switch
- Pin 11: Negative limit switch

The following parameters can be used to configure how the C-863.12 detects the limit switches:

Parameters	Description and Possible Values
Limit Mode 0x18	Signal logic of the limit switches 0 = Positive limit switch active high (pos-HI), negative limit switch active high (neg-HI) 1 = Positive limit switch active low (pos-LO), neg-HI 2 = pos-HI, neg-LO 3 = pos-LO, neg-LO

Parameters	Description and Possible Values
Has No Limit Switches? 0x32	Does the positioner have limit switches? 0 = Positioner has limit switches (signal inputs on motor connector) 1 = Positioner does not have limit switches This parameter activates or deactivates a stop of the motion at the limit switches installed.
Use Limit Switches Only For Reference Moves? 0x77	Should the limit switches only be used for referencing moves? 0 = Use limit switches for stopping at the end of the travel range and for referencing moves (default) 1 = Use limit switches only for referencing moves This parameter is intended for use with rotation stages. This parameter is only evaluated when the parameter 0x32 has the value 0.

The signals from the limit switches (also end-of-travel sensors) of a linear positioner are used to stop motion in front of the hard stop at both ends of the travel range. Because the set deceleration is not taken into account here, there is a risk at high velocities that the positioner will hit the hard stop anyway. To prevent this, soft limits (p. 31) can be set via parameters of the C-863.12.

The limit switch signals can also be used for referencing moves. After a referencing move to a limit switch, the controller knows the absolute axis position; see "Referencing" (p. 34).

3.8.13 Travel Range and Soft Limits

The following parameters of the C-863.12 reflect the physical travel range of the positioner and define soft limits:

Parameter	Description and Possible Values
Maximum Travel In Positive Direction (Phys. Unit) 0x15	Soft limit in positive direction (physical unit) Based on the zero position. If this value is smaller than the position value for the positive limit switch (which results from the sum of the parameters 0x16 and 0x2F), the positive limit switch cannot be used for referencing moves. The value can be negative.
Value At Reference Position (Phys. Unit) 0x16	Position value at the reference switch (physical unit) The current position is set to this value if the axis has performed a referencing move to the reference switch. The parameter value is also used for calculating the position values set after referencing moves to the limit switches; this also applies when the mechanics do not have a reference switch.
Distance From Negative Limit To Reference Position (Phys. Unit) 0x17	Gap between reference switch and negative limit switch (physical unit) If the axis has performed a referencing move to the negative limit switch, the current position is set to the difference between the values of parameters 0x16 and 0x17.

Parameter	Description and Possible Values
Distance From Reference Position To Positive Limit (Phys. Unit) 0x2F	Gap between reference switch and positive limit switch (physical unit) If the axis has performed a referencing move to the positive limit switch, the current position is set to the sum of the values of parameters 0x16 and 0x2F.
Maximum Travel In Negative Direction (Phys. Unit) 0x30	Soft limit in a negative direction (physical unit) Based on the zero position. If this value is larger than the position value for the negative limit switch (which results from the difference between the parameters 0x16 and 0x17), the negative limit switch cannot be used for referencing moves. The value can be negative.

INFORMATION

The C-863.12 determines the soft limits from parameters 0x15 (***Maximum Travel In Positive Direction (Phys. Unit)***) and 0x30 (***Maximum Travel In Negative Direction (Phys. Unit)***):

- The limits establish the permissible travel range in closed-loop operation.
- Motion commands are executed only if the commanded position is within these soft limits.
- The limits always refer to the current zero position.
- Appropriate values are loaded when the positioner type is selected from the positioner database.

Examples

The following examples refer to an axis of a positioner with incremental sensor, reference switch and limit switches.

The distance between the negative and positive limit switches of the axis is 20 mm. The reference switch has a distance of 8 mm to the negative limit switch and a distance of 12 mm to the positive limit switch.

This switch setup of the axis is reflected in the following parameters:

- Parameter 0x17: Distance between negative limit switch and reference switch = 8 mm
- Parameter 0x2F: Distance between reference switch and positive limit switch = 12 mm

INFORMATION

The switch setup of the axis can be determined with the `FED` and `POS?` commands.

Example 1: Maximum travel range available

After referencing moves (p. 34), the current position is to have the following values:

- Move to the negative limit switch (start with `FNL`): current position = 0
- Move to the reference switch (start with `FRF`): current position = 8

- Move to the positive limit switch (start with FPL): current position = 20

As a result, parameter 0x16, which specifies the position value for the reference switch and is included in the calculation of the position values for the limit switches during referencing moves, has the value 8.

The travel range is not to be limited by soft limits. As a result, the respective parameters are set as follows:

- Parameter 0x15 = 20
- Parameter 0x30 = 0

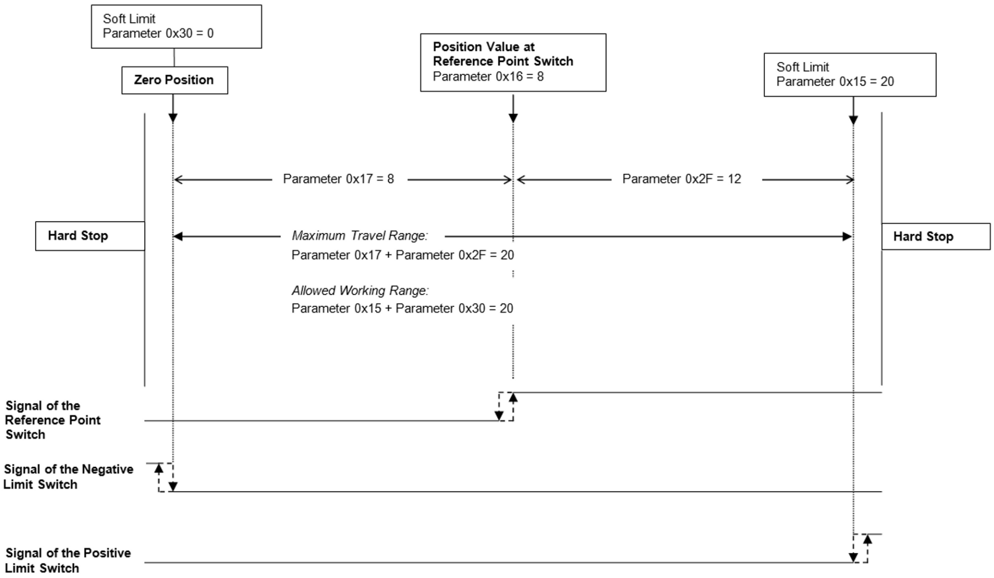


Figure 8: The travel range of the axis is not limited by soft limits.

After a referencing move of the axis to the reference switch (FRF command), query commands return the following responses:

- TMN? returns the value 0
- TMX? returns the value 20
- POS? returns the value 8

Example 2: Travel range limited by soft limits

The zero position should be located at approximately a third of the distance between the negative limit switch and the reference switch. As a result, parameter 0x16 now has the value 5.4.

A safety distance is to be put in place at both ends of the travel range by establishing soft limits. As a result, the soft limits are set as follows:

- Parameter 0x15 = 16.4
- Parameter 0x30 = -2.1

According to that, the axis can move 16.4 mm from the zero position in the positive direction and 2.1 mm in the negative direction respectively. The limit switches can no longer be used for referencing moves.

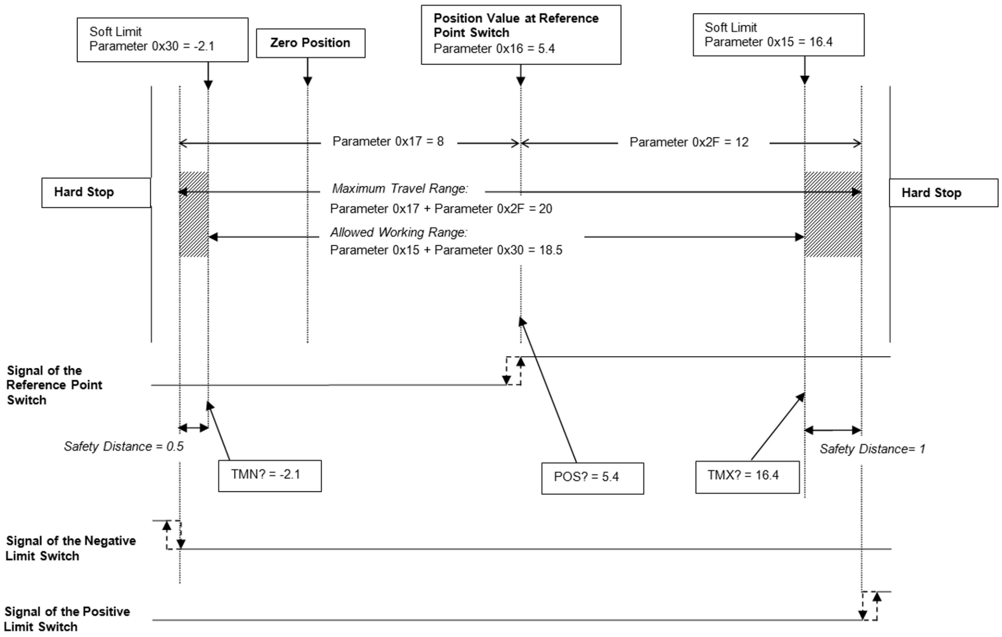


Figure 9: The travel range of the axis is limited by soft limits.

After a referencing move of the axis to the reference switch (FRF command), query commands return the following responses:

- TMN? returns the value -2.1
- TMX? returns the value 16.4
- POS? returns the value 5.4

3.8.14 Referencing

When switching on or restarting, the controller does not know the absolute position of the axis. Before absolute target positions can be commanded and reached, referencing must therefore be done for the axis.

Referencing can be done in different ways:

- **Referencing move** (default): A referencing move moves the axis to a defined point, e.g., to the reference switch or to a limit switch. At this point, the current position is set to a defined value. The controller now knows the absolute axis position.
- **Setting the absolute position manually**: If this referencing method was activated by the RON command (p. 180), you can set the current position of the axis to an arbitrary value at an arbitrary point using the POS command (p. 179). The axis is not moved here. The controller knows the absolute axis position afterwards.

INFORMATION

During startup using PIMikroMove, referencing is done via a referencing move by default. Knowledge of the commands and parameters described here is not needed for referencing using PIMikroMove.

INFORMATION

To achieve maximum repeatability when referencing, each referencing move comprises the following steps:

1. First move to the switch selected. The maximum velocity is specified via parameter 0x49 (***Closed-Loop Velocity (Phys. Unit/s)***, equivalent to setting with the VEL command).
2. Stop on reaching the switch edge. The higher the velocity on approach, the farther the axis overruns the edge of the switch (overshooting).
3. Move in the opposite direction to compensate for overshoot.
4. Second move to the switch selected. The maximum velocity is specified via parameter 0x50 (***Velocity For Reference Moves (Phys. Unit/s)***, specific velocity for referencing moves only).
5. Stop when reaching the switch edge.
6. Move in the opposite direction to compensate for overshoot.
7. Set the current position to a defined value, referencing is finished.

The lower the velocity is when approaching the switch, the less the overshoot will be and the higher the repeatability. Therefore, the maximum value of parameter 0x50 should be as large as the value of parameter 0x49, though ideally substantially less.

The actual velocities during the referencing move are calculated from the values of the following parameters and can be lower than the maximum values.

- Parameter 0x49 or 0x50
- Parameter 0x63 (***Distance Between Limit And Hard Stop (Phys. Unit)***)
- Parameter 0xC (***Closed-Loop Deceleration (Phys. Unit/s^2)***)

Commands

The following commands are available for referencing:

Command	Syntax	Function
RON	RON {<AxisID> <ReferenceOn>}	Selects the referencing method: ■ <ReferenceOn> = 0: An absolute position value can be assigned with POS, or a referencing move can be started with FRF, FNL or FPL. ■ <ReferenceOn> = 1 (default): A referencing move must be started with FRF, FNL or FPL. Using POS is not allowed.

Command	Syntax	Function
RON?	RON? [{<AxisID>}]	Gets the referencing method.
FRF	FRF [{<AxisID>}]	Starts a reference move to the reference switch. The approach depends on the value of the ***Reference Signal Type*** parameter (ID 0x70): ▪ 0 or 1: The approach always takes place from the same side irrespective of the axis position when the command is sent. ▪ 2: The approach takes place via the negative limit switch.
FRF?	FRF? [{<AxisID>}]	Queries whether referencing for an axis has already been done. 1 = Referencing has been done 0 = Referencing has not been done
FNL	FNL [{<AxisID>}]	Starts a referencing move to the negative limit switch.
FPL	FPL [{<AxisID>}]	Starts a referencing move to the positive limit switch.
POS	POS {<AxisID> <Position>}	Sets the current axis position (does not trigger motion) to reference the axis.

Parameters

Referencing moves can be configured with the following parameters:

Parameters	Description and Possible Values
Closed-Loop Deceleration (Phys. Unit/s^2) 0xC	Deceleration in closed-loop operation For details, see "Generation of Dynamics Profile" (p. 22).
Reference Travel Direction 0x47	Default direction for the referencing move 0 = automatic detection 1 = negative direction 2 = positive direction
Closed-Loop Velocity (Phys. Unit/s) 0x49	Velocity in closed-loop operation For details, see "Generation of Dynamics Profile" (p. 22).

Parameters	Description and Possible Values
Velocity For Reference Moves (Phys. Unit/s) 0x50	Velocity for referencing move Specifies the maximum velocity during a referencing move for the second approach of the switch selected. For high repeatability during referencing, the maximum of this value should be as large as the value of parameter 0x49. If the value of parameter 0x50 is set to 0, referencing moves are not possible.
Distance Between Limit And Hard Stop (Phys. Unit) 0x63	Distance between the built-in limit switch and the hard stop Determines the maximum stopping distance during referencing moves. The actual velocities during a referencing move are calculated on the basis of this value, the set deceleration (0xC) and the set velocities (0x49 and 0x50).
Distance From Limit To Start Of Ref. Search (Phys. Unit) 0x78	Distance between limit switch and the starting position for motion to the index pulse.
Distance For Reference Search (Phys. Unit) 0x79	Maximum distance for motion to the index pulse The parameters 0x78 and 0x79 are used for referencing moves when the two following conditions are met: ▪ The referencing move is started with FRF. ▪ The ***Reference Signal Type*** parameter (0x70) has the value 2. Sequence of the referencing move: 1. The axis moves to the negative limit switch. 2. The axis moves the distance specified by parameter 0x78 away from the limit switch. 3. The axis moves to the index pulse and covers the maximum distance specified by parameter 0x79.

INFORMATION

➢ For maximum repeatability, the referencing move must always be done in the same way.

INFORMATION

The limit switches can be used for referencing moves only if the travel range is not limited by soft limits (p. 31).

INFORMATION

For referencing moves, you can also use the digital inputs of the C-863.12 as the source of the reference signal, the negative limit switch signal or the positive limit switch signal. See "Using Digital Input Signals as Switch Signals" (p. 89) for more information.

INFORMATION

If the absolute position of the axis is defined manually with the `POS` command, conflicts with the settings for the soft limits can occur (parameter 0x15, query with `TMX?`, and 0x30, query with `TMN?`).

➢ Set the absolute position of the axis manually only if referencing is not otherwise possible.

INFORMATION

If the current parameter settings of the C-863.12 are written to the nonvolatile memory in PIMikroMove or by entering the WPA command, the axis will no longer be considered "referenced" (the response to FRF? is 0).

4 Unpacking

1. Unpack the C-863.12 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 immediately (p. 253).
4. Keep all packaging materials in case the product needs to be returned.

5 Installing

5.1 Installing the PC Software

Communication between the C-863.12 and a PC is required to configure the C-863.12 and to command motion using the GCS commands. Various PC software applications are available for this purpose.

5.1.1 Doing Initial Installation

Accessories

- PC with Windows or Linux operating system and at least 30 MB free storage space
- Data storage device with PI Software Suite (included in the scope of delivery)

  For information on the compatibility of the software with PC operating systems see the C-990.CD1 Release News in the root directory of the data storage device.

Installing the PC software on Windows

1. Start the installation wizard by opening ***PISoftwareSuite.exe*** in the installation directory (root directory of the data storage device).

   The ***InstallShield Wizard*** window opens for installing the PI Software Suite.
2. Follow the instructions on the screen.

   The PI Software Suite includes the following components:

   – Drivers for use with NI LabVIEW software

   – Dynamic program library for GCS

   – PIMikroMove

   – PC software for updating the firmware of the C-863.12

   – PIUpdateFinder for updating the PI Software Suite

   – USB driver

Installing the PC software on Linux

1. Unpack the tar archive from the /Linux directory of the data storage device 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 a superuser (root privileges).

4. To start the installation, enter ./INSTALL
   Pay attention to capitalization while entering the command.
5. Follow the instructions on the screen.

You can select individual components for installation.

5.1.2 Installing Updates

PI is constantly improving the PI Software Suite.

➢ Always install the latest version of PI Software Suite and the positioner database.

Requirements

✓ Active connection to the Internet

✓ If your PC uses a Windows operating system:

- You have downloaded the PIUpdateFinder manual (A000T0028) from the PI website. The link is in the "A000T0081-Downloading Manuals from PI.pdf" file in the \Manuals folder on the data storage device with the PI Software Suite.

Updating the PC software and PISTAGES3.DB in Windows

➢ Use the PIUpdateFinder:

- Follow the instructions in the manual for the PIUpdateFinder (A000T0028).

Updating the PC software on Linux

1. Open the website https://www.physikinstrumente.com/en/products/software-suite (https://www.physikinstrumente.com/en/products/software-suite).
2. Scroll down to ***Downloads***.
3. For ***PI Software Suite C-990.CD1***: Select ***ADD TO LIST+***
4. Select ***REQUEST***
5. Fill out the download request form and send the request.

   The download link will be sent to the email address entered in the form.
6. Unpack the archive file on your PC to a separate installation directory.
7. In the directory with the unpacked files, go to the ***linux*** subdirectory.
8. Unpack the archive file in the ***linux*** directory by entering the command tar -xvpf <name of the archive file> on the console.
9. Log into the PC as superuser (root privileges).
10. Install the update.

INFORMATION

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

➢ Contact PI's customer service (p. 253).

Updating PISTAGES3.DB in Linux

1. Contact the customer service department (p. 253) to get the latest version of the PISTAGES3.DB positioner database.
2. Log into the PC as superuser (root privileges).
3. Install the update that you received from our customer service department on your PC.

5.1.3 Installing Custom Positioner Databases

PI provides a data carrier with a custom positioner that has the following contents:

- Program Import PI CustomStage
- Custom positioner database with the parameter set for the positioner

In order for the parameter set to be selected in the PC software, it must first be inserted into the PIStages3 positioner database by the Import PI Custom Stage program.

➢ Install the custom positioner database by double-clicking the file ***Import_PI_CustomStage.exe*** in the root directory of the data carrier.

The parameter set from the custom positioner database is inserted into PIStages3.

If a message appears that installation of the custom positioner database failed:

a) Update the PIStages3 database on your PC, see "Installing Updates" (p. 42).

b) Repeat the installation of the custom positioner database.

5.2 Mounting the C-863.12

The C-863.12 can be used as benchtop device or mounted in any orientation on a surface.

The C-863.12 is stackable and can be installed in a control cabinet.

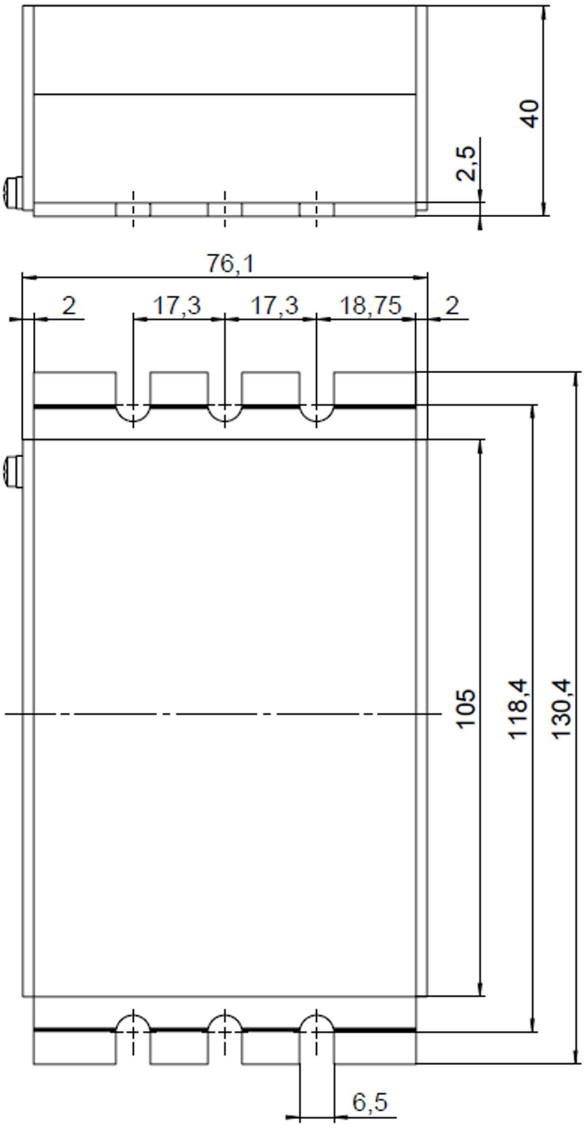


Figure 10: C-863.12, dimensions in mm

Tools and accessories

- Suitable screws
- Suitable screwdriver

Mounting the C-863.12 onto a surface

1. Make the necessary holes in the surface.

   The arrangement of the recesses in the mounting rails of the C-863.12 can be found in the figure above.

2. Use two screws on each side to affix the C-863.12 to the recesses in the mounting rails.

5.3 Grounding the C-863.12

The C-863.12 is not grounded via the power supply connection.

If a potential equalization is required:

- ➢ Connect the screw on the rear panel of the C-863.12's housing marked with the protective earth symbol (see figure) to the grounding system.

5.4 Connecting the Positioner

NOTICE

Damage if a wrong motor is connected!

Connecting a Positioner with stepper motor to a DC motor controller can cause irreparable damage.

- ➢ Only connect a Positioner with DC motor or PWM motor driver to the C-863.12.

INFORMATION

The C-863.12 supports both positioners with PWM amplifier and positioners without PWM amplifier. Separate lines on the **Motor** socket (p. 259) are available for both positioner variants. Makes sure that suitable lines are selected via the connector of the positioner.

INFORMATION

When the positioner, cable, and C-863.12 are marked as a system:

- ➢ Contact our customer service department (p. 253) before exchanging system components.

Requirements

- ✓ The C-863.12 is switched off, i.e., the power adapter is **not** connected to the power socket with the power cord.

✓ You have read and understood the user manual for the positioner.

Tools and accessories

- Positioner with DC motor and encoder with A/B quadrature signal transmission
- Suitable cable from the scope of delivery of the positioner

Connecting the positioner

1. Connect the positioner to the C-863.12's **Motor** socket.
2. Use the integrated screws to secure the connections against accidental disconnection.

5.5 Connecting the PC

Communication between the C-863.12 and a PC is required to configure the C-863.12 and to command motion using the GCS commands. The C-863.12 has the following interfaces for this purpose:

- RS-232 interface
- USB interface

In this section, you learn how to establish proper cable connections between the C-863.12 and a PC and in a daisy chain network. The steps for establishing communication between C-863.12 and PC are described in the section "Startup":

- "Establishing Communication via RS-232" (p. 57)
- "Establishing Communication via USB" (p. 58)
- "Establishing Communication for Networked Controllers" (p. 59)

INFORMATION

Using a daisy chain network, up to 16 controllers can be connected to the PC via a single RS-232 or USB connection.

5.5.1 Connecting to the RS-232 Interface

NOTICE

Incorrect wiring!

Connecting the USB and RS-232 interfaces of the controller to the PC at the same time can damage the PC or the controller.

➢ Connect either the USB or the RS-232 interface to the PC.

Requirements

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

Tools and accessories

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

Connecting the C-863.12 to the PC

➢ Connect the **RS-232 In** socket on the front panel of the C-863.12 and the RS-232 interface of the PC (a D-sub 9(m) panel plug) to the null-modem cable.

5.5.2 Connecting to the USB Interface

NOTICE

Incorrect wiring!
Connecting the USB and RS-232 interfaces of the controller to the PC at the same time can damage the PC or the controller.

➢ Connect either the USB or the RS-232 interface to the PC.

Requirements

✓ 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. 9)

Connecting the C-863.12 to the PC

➢ Connect the USB socket of the C-863.12 and the USB interface of the PC with the USB cable.

5.5.3 Building a Daisy Chain Network

INFORMATION

Networking in a daisy chain is done in series. See also "Definition of Terms" (p. 2). The first controller is connected directly to the PC.

INFORMATION

The DIP switches of the C-863.12 must be set accordingly:

➢ Set a unique address for each controller in a daisy chain network. One of the controllers must have the address 1. This controller does not have to be the one directly connected to the PC. See "Controller Address" (p. 54) for details.

- ➢ Set the same baud rate for every controller in a daisy chain network. See "Baud Rate" (p. 55) for details.

Tools and accessories

- A network cable for every controller to be connected to the network. Currently available:
  - C-862.CN, 30 cm, included in the scope of delivery
  - C-862.CN2, 180 cm, available as an optional accessory (p. 10)

Networking the controllers

- ➢ Set up the controller chain. For this purpose, always connect the **RS-232 Out** connection of the previous controller to the **RS-232 In** connection of the subsequent controller via the network cable.
- ➢ Connect the first controller of the chain to the PC.
  - Use the RS-232 interface (p. 46).

  or

  - Use the USB interface (p. 47).

INFORMATION

A C-863.12 can be operated in a common daisy chain network with the following controllers:

- C-863.11, C-663.11, C-663.12 Mercury controllers
- PILine® Motion Controller from the C-867 and C-877 series
- PiezoWalk® NEXACT® controller E-861

5.6 Connecting the Power Adapter to the C-863.12

INFORMATION

If the positioner is equipped with a PWM amplifier that is supplied via a separate power adapter:

- ➢ To achieve the optimum motor performance, use a power adapter for the C-863.12 that supplies the same output voltage as the power adapter for the PWM amplifier.

Requirements

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

Tools and accessories

- Wide input range power supply (p. 9) included, for line voltages between 100 and 240 volts alternating voltage at 50 or 60 Hz

- Alternative: Sufficiently rated power adapter
- Power cord supplied
- Alternative: Sufficiently sized power cord

Connecting the power adapter to the C-863.12

- ➢ Connect the 4-pin connector of the power adapter to the **48 V 2 A** socket of the C-863.12.
  - – Make sure that the connector is locked in the socket.
- ➢ Connect the power cord to the power adapter.

5.7 Connecting an Analog Joystick

INFORMATION

You can connect an axis and a button of an analog joystick to the **Joystick** socket:

- Pin 4: Axis 1 of joystick 1
- Pin 6: Button 1 of joystick 1

You can use joystick axis to control the velocity of the positioner connected to the C-863.12.

INFORMATION

The C-819.20 and C-819.30 joysticks, available as optional accessories, use pins 4 and 6 of the **Joystick** socket. Pin 3 of this socket is used as power supply of the joystick.

You can use a C-819.20Y Y cable to connect two C-863.12 to a C-819.20 joystick. In this case, power is supplied to the joystick by the C-863.12, which is connected to the X branch of the cable.

Tools and accessories

- Analog joystick from PI for operation with 0 to 3.3 V, available as an optional accessory (p. 10):
  - – C-819.20 analog joystick for 2 axes
  - – If a C-819.20 joystick is to be connected to two controllers: C-819.20Y Y cable

  or

  - – C-819.30 analog joystick for 3 axes

Connecting an analog joystick

- ➢ Connect the joystick to the **Joystick** socket of the C-863.12:
  - – If you want to operate a C-819.20 joystick with this controller only, connect it directly to the controller.

- If you want to operate a C-819.20 joystick with two controllers (i.e., two axes), connect the joystick to the C-819.20Y Y cable and connect both controllers to the X and Y branches of the cable. The power is supplied to the joystick via the X branch. For this reason, the X branch has to be connected to a controller even if joystick control is not to be activated for this controller.
- If you want to connect an axis of a C-819.30 joystick, connect the corresponding cable of the joystick to the controller.

5.8 Connecting Digital Inputs and Outputs

The digital inputs and outputs on the **I/O** socket of the C-863.12 can be used as follows:

- Outputs: Triggering of external devices; see "Digital Output Signals" (p. 78).
- Inputs: Use in macros (p. 88) and/or as source for the reference and limit switch signals of the axis (p. 89)

5.8.1 Connecting the Digital Outputs

INFORMATION

Digital output signals are available on pins 5, 6, 7 and 8 of the **I/O** socket.

INFORMATION

If the C-170.PB pushbutton box from PI is connected to the **I/O** socket, it displays via LEDs the state of the digital output lines.

Tools and accessories

- Suitable cable, e. g. C-170.IO IO cable with open end, available as an optional accessory (p. 10)
- Device to be triggered having digital input for TTL signals

Connecting a device to be triggered

➢ Connect an appropriate device to one of pins 5, 6, 7, and 8 of the **I/O** socket of the C-863.12.

5.8.2 Connecting the Digital Inputs

INFORMATION

Digital input signals can be fed via pins 1, 2, 3, and 4 of the **I/O** socket into the C-863.12.

INFORMATION

The digital inputs (pins 1 to 4) on the **I/O** socket can also be used as analog inputs.

- Digital: TTL
- Analog: 0 to +5 V

Tools and accessories

- Suitable signal source:
  - If the digital inputs are to be used in macros, the C-170.PB pushbutton box, for example, can be connected, available as an optional accessory (p. 10).
  - If the digital inputs are to be used as the source for the reference and limit switch signals of the axis, the signal level may only change once across the entire travel range.
- If necessary: Suitable cable, e. g. C-170.IO IO cable with open end, available as an optional accessory (p. 10).

Connecting a digital signal source

➢ Connect an appropriate signal source to one of pins 1, 2, 3, or 4 of the **I/O** socket of the C-863.12.

5.9 Connecting Analog Signal Sources

The analog inputs on the **I/O** socket of the C-863.12 can be used as follows:

- Use in macros (p. 91): Details and examples of macros are found in "Controller Macros" (p. 99).
- Scanning applications with PIMikroMove (see PIMikroMove manual)

INFORMATION

Analog input signals can be fed via pins 1, 2, 3, and 4 of the **I/O** socket into the C-863.12.

INFORMATION

The analog inputs (pins 1 to 4) on the **I/O** socket can also be used as digital inputs.

- Analog: 0 to +5 V
- Digital: TTL

Tools and accessories

- Suitable signal source

- If necessary: Suitable cable, e. g. C-170.IO IO cable with open end, available as an optional accessory (p. 10).

Connecting an analog signal source

- ➢ Connect an appropriate signal source to one of pins 1, 2, 3 or 4 of the **I/O** socket of the C-863.12.

6 Startup

6.1 General Notes on Startup

NOTICE

Damage due to disabled limit switch evaluation!

The collision of a moving part at the end of the travel range, or with an obstacle, as well as high acceleration, can cause damage to or considerable wear on the mechanics.

- ➢ Avoid motion in open-loop operation.
- ➢ If motion in open-loop operation is necessary:
  - – Set the control value with the SMO command so that the axis moves with low velocity.
  - – Stop the axis in time. For this purpose, use the #24, STP or HLT command, or set the control value to zero with the SMO command.
- ➢ Do not disable the evaluation of the limit switches by the C-863.12 via parameter setting.
- ➢ Check the function of the limit switches at about 10 % to 20 % of the maximum velocity.
- ➢ In the event of a malfunction of the limit switches, stop the motion immediately.

6.2 Adapting the DIP Switch Settings

6.2.1 General Procedure

INFORMATION

Changed DIP switch settings become effective after the C-863.12 is switched on.

- ➢ If you have changed the DIP switch settings while the C-863.12 was switched on, switch the C-863.12 off and back on again to activate the new settings.

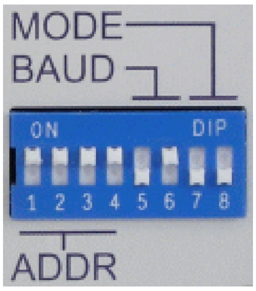


Figure 11: DIP switches: switch up = ON; switch down = OFF

Switch	Function
1 to 4	Controller address (p. 54)
5 and 6	Baud rate (p. 55)
7 and 8	Without function

Requirements

✓ The C-863.12 is switched off, i.e., the power supply is **not** connected to the power socket with the power cord.

Adapting the DIP switch settings

➢ Put the individual DIP switches in the correct position for your application. Details are specified in the following tables.

6.2.2 Controller Address

Address*	S1	S2	S3	S4
1	**ON**	**ON**	**ON**	**ON**
2	ON	ON	ON	OFF
3	ON	ON	OFF	ON
4	ON	ON	OFF	OFF
5	ON	OFF	ON	ON
6	ON	OFF	ON	OFF
7	ON	OFF	OFF	ON
8	ON	OFF	OFF	OFF
9	OFF	ON	ON	ON
10	OFF	ON	ON	OFF
11	OFF	ON	OFF	ON
12	OFF	ON	OFF	OFF
13	OFF	OFF	ON	ON
14	OFF	OFF	ON	OFF
15	OFF	OFF	OFF	ON
16	OFF	OFF	OFF	OFF

*Factory settings are shown in bold.

INFORMATION

A unique address must be set for each controller in a daisy chain network. One of the controllers must have the address 1. This controller does not have to be the one directly connected to the PC.

INFORMATION

A non-networked controller must have address 1, if it

- is to be used in PIMikroMove.
- is to be used in drivers for NI LabVIEW software.
- is to be addressed with PITerminal without specifying the target address; in this case, the target and sender address (p. 119) are also not specified in the responses from the C-863.12.

6.2.3 Baud Rate

Baud rate*	S5	S6
9600	ON	ON
19200	ON	OFF
38400	OFF	ON
115200	**OFF**	**OFF**

*Factory settings are shown in bold.

INFORMATION

The same baud rate must be set for all controllers in a daisy chain network.

6.3 Switching the C-863.12 On

INFORMATION

The C-863.12 is intended for closed-loop operation with incremental position sensors (servo mode On). After switch-on, open-loop operation is active by default (servo mode Off).

- ➢ Query the current operating mode with the `SVO?`, `#4` or `SRG?` commands.
- ➢ Activate closed-loop operation with the `SVO` command.
- ➢ If necessary, program a startup macro that starts the C-863.12 via the `SVO` command in closed-loop operation; see "Setting up a startup macro" (p. 107).
- ➢ Avoid motion in open-loop operation.

Requirements

- ✓ You have read and understood the General Notes on Startup (p. 53).
- ✓ The C-863.12 has been installed properly (p. 41).
- ✓ You have set the DIP switches on the C-863.12 in accordance with your application (p. 53).

Switching on the C-863.12

- ➢ Plug the power cord of the power adapter into the power socket.

  The C-863.12 loads the parameter values from the nonvolatile memory into the volatile memory.

  The **STA** LED on the front panel of the C-863.12 displays the state of the C-863.12:

  - Lights up continuously: C-863.12 is ready for normal operation
  - Flashing: C-863.12 is in firmware update mode
  - Off: C-863.12 is not connected to the power supply or could be defective
- ➢ If the C-863.12 is in firmware update mode, update the firmware (p. 245).
- ➢ If the C-863.12 is properly connected to the power adapter (p. 48) and the **STA** LED does not light up after switching on, contact our customer service department (p. 253).

6.4 Establishing Communication

INFORMATION

A USB UART module (FTDI) is used for the USB interface in the C-863.12. Therefore, if the C-863.12 is connected via USB and switched on, the USB interface is also shown as COM port in the PC software. The C-863.12 uses a baud rate of 115200 for this interface.

INFORMATION

Use the ***USB Daisy Chain*** and ***RS-232 Daisy Chain*** tabs in the PC software for establishing communication only if you have actually connected a daisy chain network to the PC.

INFORMATION

A non-networked controller must have the address 1, if it is to be used in PIMikroMove. See "Controller Address" (p. 54) for details.

The procedure for PIMikroMove is described in the following.

For information on establishing the communication on Linux systems see the Technical Note "PI Software on ARM-Based Platforms", A000T0089 (p. 3).

6.4.1 Establishing Communication via RS-232

Requirements

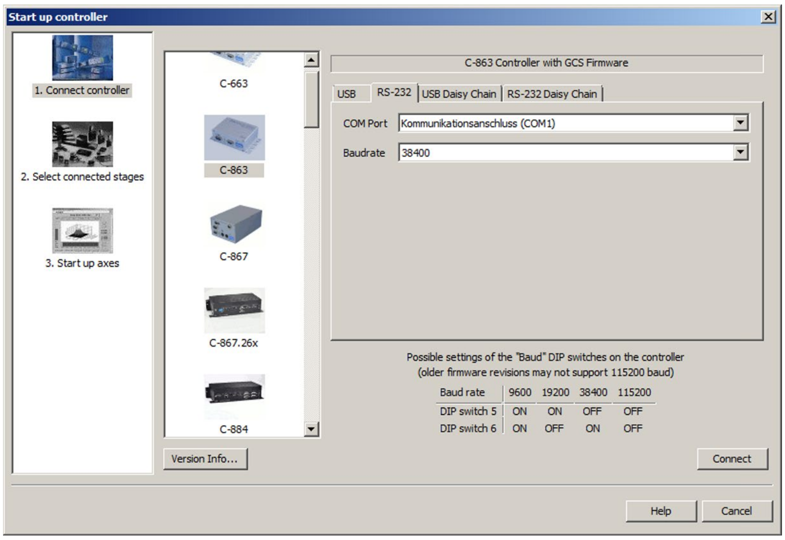
- ✓ You have read and understood the General Notes on Startup (p. 53).
- ✓ The C-863.12 is connected to the RS-232 interface of the PC (p. 46).
- ✓ You have made the following settings with the respective DIP switches prior to switching on the C-863.12 (p. 53):
  - – controller address = 1
  - – appropriate baud rate
- ✓ The C-863.12 is switched on (p. 55).
- ✓ The PC is switched on.
- ✓ The required software is installed on the PC (p. 41).
- ✓ You have read and understood the manual for the PC software. The links to the software manuals are in the A000T0081 file on the PI software data storage medium.

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.



COM Port: Kommunikationsanschluss (COM1)

Baudrate: 38400

Possible settings of the "Baud" DIP switches on the controller
(older firmware revisions may not support 115200 baud)

Baud rate	9600	19200	38400	115200
DIP switch 5	ON	ON	OFF	OFF
DIP switch 6	ON	OFF	ON	OFF

Figure 12: Start up controller – Connect controller

2. Select ***C-863*** in the controller selection field.
3. Select the ***RS-232*** tab on the right-hand side of the window.

4. In the ***COM Port*** field, select the COM port of the PC to which you have connected the C-863.12.
5. In the ***Baudrate*** field, set the value which is set with DIP switches 5 and 6 of the C-863.12.

   This adapts the baud rate of the PC to the baud rate of the C-863.12.
6. Click ***Connect*** to establish communication.

If communication was established successfully, PIMikroMove guides you through the configuration of the C-863.12 for the connected positioner; see "Starting Motion" (p. 64).

6.4.2 Establishing Communication via USB

INFORMATION

If the controller is connected via the USB connection and switched on, the USB interface in the PC software is also shown as a COM port.

Requirements

✓ You have read and understood the General Notes on Startup (p. 53).

✓ The C-863.12 is connected to the USB interface of the PC.

✓ Prior to switching on the C-863.12 you set the DIP switches for the controller address to address 1 (p. 53).

✓ The C-863.12 is switched on (p. 55).

✓ The PC is switched on.

✓ The required software and USB drivers are installed on the PC.

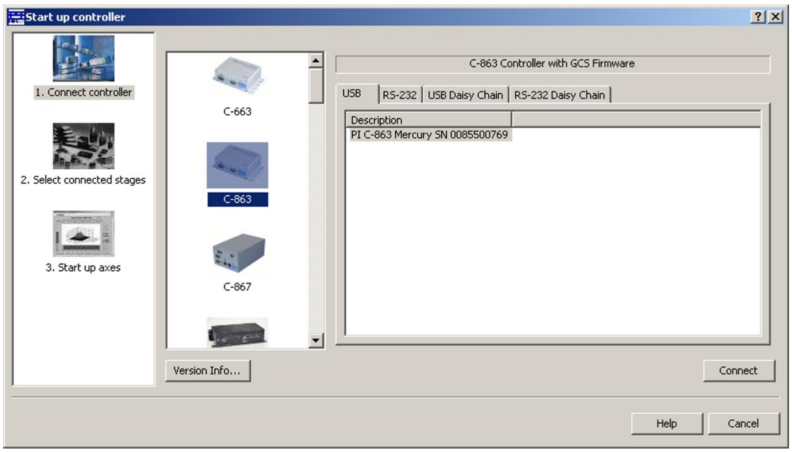
✓ You have read and understood the manual for the PC software. The links to the software manuals are in the A000T0081 file on the PI software data storage medium.

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.



Description
PI C-863 Mercury SN 0085500769

Figure 13: Start up controller – Connect controller

2. Select ***C-863*** in the controller selection field.
3. Select the ***USB*** tab on the right-hand side of the window.
4. Select the connected C-863.12 in the ***USB*** tab.
5. Click ***Connect*** to establish communication.

If communication was established successfully, PIMikroMove guides you through the configuration of the C-863.12 for the connected positioner; see "Starting Motion" (p. 64).

➢ If communication could not be established, look for a solution to the problem in "Troubleshooting" (p. 249).

6.4.3 Establishing Communication for Networked Controllers

The following describes the procedure for PIMikroMove and for PITerminal.

INFORMATION

If you are establishing communication with a networked controller via PITerminal, the address of the controller to be addressed is required in every command line. See "Target and Sender Address" (p. 119) for details.

➢ Use PITerminal to test communication with networked controllers.

INFORMATION

The RS-232 output lines of some PCs are not adapted for the maximum number of 16 controllers in a network. If you have connected a daisy chain network to such a PC via the RS-232 interface, communication malfunctions may occur (e.g., timeout). In case of communication malfunctions:

1. Disconnect the null-modem cable from the **RS-232 In** socket of the controller which is connected to the PC.
2. Connect the daisy chain network to the PC via the USB interface of this controller.

Requirements

- ✓ You have read and understood the General Notes on Startup (p. 53).
- ✓ You have set up a daisy chain network .
- ✓ You have assigned (p. 54)a unique address to each of the networked controllers.
- ✓ You have set (p. 55) the same baud rate for all controllers.
- ✓ All controllers in the daisy chain network are switched on (p. 55).
- ✓ The PC is switched on.
- ✓ The required software is installed on the PC (p. 41).
- ✓ If you have connected the first controller in the chain to the PC via the USB interface: The USB drivers are installed on the PC (p. 41).
- ✓ You have read and understood the manual for the PC software. The links to the software manuals are in the A000T0081 file on the PI software data storage medium.

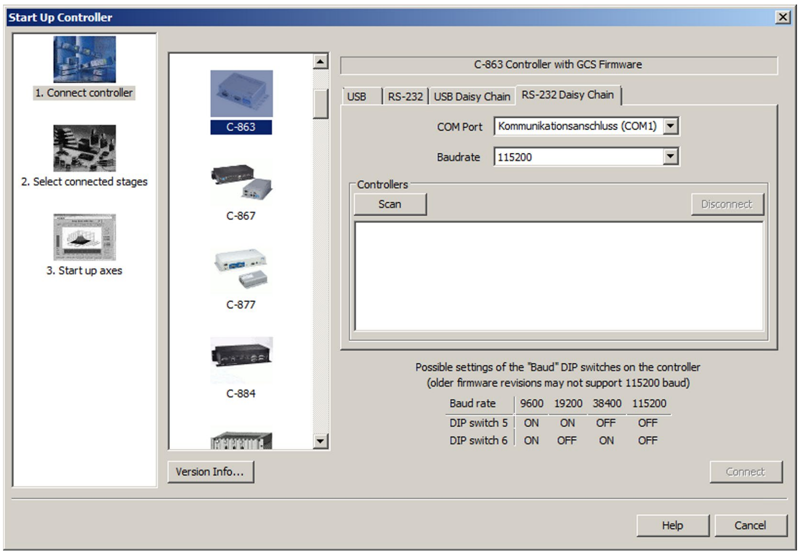
Establishing communication with PIMikroMove

1. Start PIMikroMove.

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

   – If the ***Start up controller*** window does not automatically open, select the ***Connections > New...*** menu item in the main window.
2. Select the appropriate controller type in the field for controller selection.

In the example in the following figures, there is a daisy chain network from a C-863.12 with the controller address 1 and a C-663.12 with the controller address 2. If you want to connect the C-863.12 first, select ***C-863***.



COM Port: Kommunikationsanschluss (COM1)

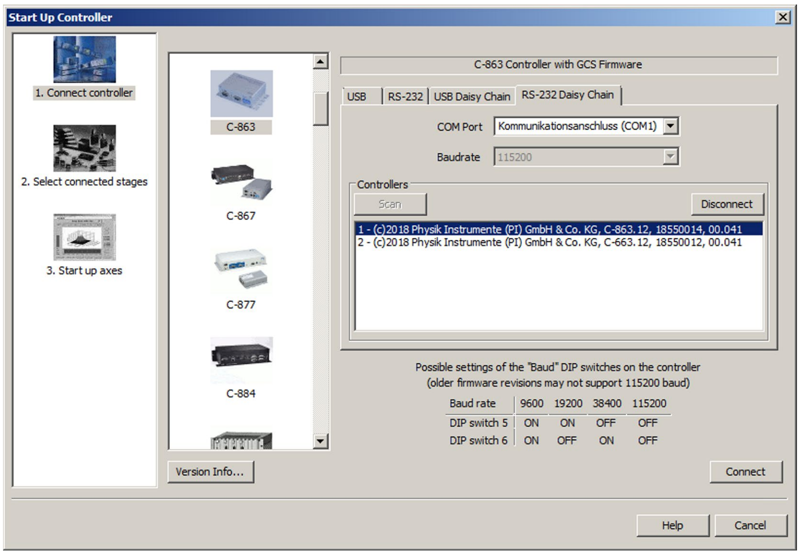
Baudrate: 115200

Possible settings of the "Baud" DIP switches on the controller
(older firmware revisions may not support 115200 baud)

Baud rate	9600	19200	38400	115200
DIP switch 5	ON	ON	OFF	OFF
DIP switch 6	ON	OFF	ON	OFF

3. Select the appropriate tab on the right-hand side of the window:
   - If you have connected the first controller in the chain to the PC via the RS-232 interface, select the ***RS-232 Daisy Chain*** tab.
   - If you have connected the first controller in the chain to the PC via the USB interfaces, select the ***USB Daisy Chain*** tab.
4. Make the settings for the interface in the tab selected:
   - ***RS-232 Daisy Chain*** tab:
     - Select the COM port of the PC in the ***COM Port*** field which you connected to the first controller in the chain.
     - Set the value in the ***Baudrate*** field that is set for all controllers in the chain.
   - ***USB Daisy Chain*** tab:
     - Select the controller in the upper part of the tab connected to the PC.

5. Click the ***Scan*** button in the bottom section of the tab to list every controller in the daisy chain network.



C-863 Controller with GCS Firmware

COM Port: Kommunikationsanschluss (COM1)

Baudrate: 115200

Controllers

1 - (c)2018 Physik Instrumente (PI) GmbH & Co. KG, C-863.12, 18550014, 00.041
2 - (c)2018 Physik Instrumente (PI) GmbH & Co. KG, C-663.12, 18550012, 00.041

Possible settings of the "Baud" DIP switches on the controller
(older firmware revisions may not support 115200 baud)

Baud rate	9600	19200	38400	115200
DIP switch 5	ON	ON	OFF	OFF
DIP switch 6	ON	OFF	ON	OFF

6. Select a controller from the list. The selection must match the controller type that you selected in step 2.

7. Click ***Connect*** to establish communication with the controller selected.

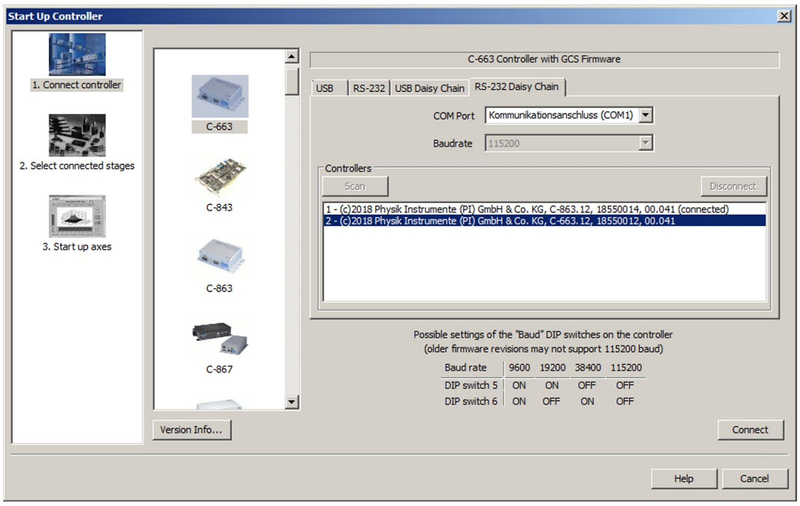
   When communication has been successfully established, PIMikroMove guides you through the configuration of the C-863.12 for the connected positioner.

   – Proceed further as described in "Starting Motion" (p. 64).

8. If you want to connect an additional controller of the daisy chain network, select the ***Connections > New...*** menu item in the main window.

9. Do steps 2, 6, and 7 once again in the specified order.

   In the following figure, the ***C-663*** is to be connected as well.



C-663 Controller with GCS Firmware

COM Port: Kommunikationsanschluss (COM1)

Baudrate: 115200

Controllers

1 - (c)2018 Physik Instrumente (PI) GmbH & Co. KG, C-863.12, 18550014, 00.041 (connected)
2 - (c)2018 Physik Instrumente (PI) GmbH & Co. KG, C-663.12, 18550012, 00.041

Possible settings of the "Baud" DIP switches on the controller
(older firmware revisions may not support 115200 baud)

Baud rate	9600	19200	38400	115200
DIP switch 5	ON	ON	OFF	OFF
DIP switch 6	ON	OFF	ON	OFF

10. Repeat steps 8, 2, 6 and 7 for every additional controller of the daisy chain network, which you want to connect.

If you want to terminate communication with one of the controllers of the daisy chain network:

- Select the ***Connections > Close*** menu item for the corresponding controller in the main window.

Establishing communication with PITerminal

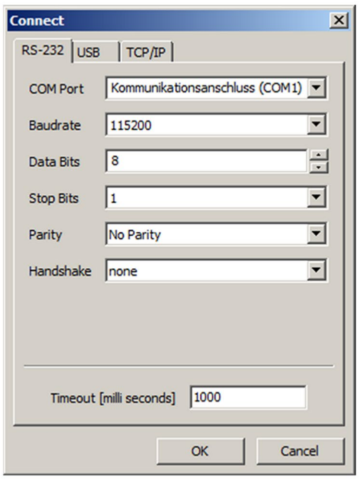
INFORMATION

Via the ***Mercury*** button PITerminal supports controllers with older firmware versions that are not compatible with GCS.

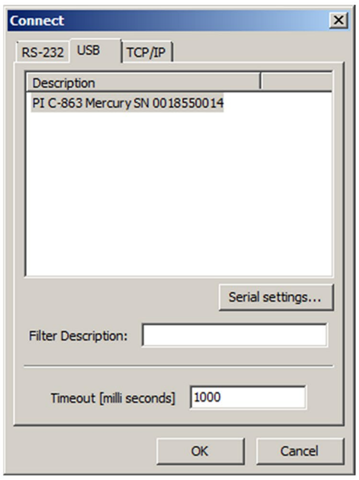
- Make sure that the ***Mercury*** button is **not** activated in PITerminal.

1. Start PITerminal.
2. Click on ***Connect…***.

   The ***Connect*** window opens.
3. Select the ***RS-232*** or ***USB*** tab in the ***Connect*** window according to the interface you used to connect the first controller in the chain to the PC.



COM Port: Kommunikationsanschluss (COM1)
Baudrate: 115200
Data Bits: 8
Stop Bits: 1
Parity: No Parity
Handshake: none
Timeout [milli seconds]: 1000



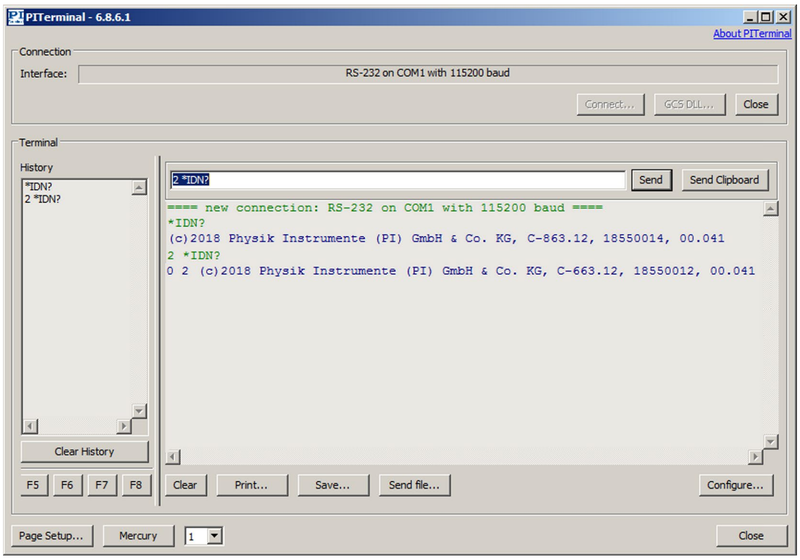
PI C-863 Mercury SN 0018550014
Filter Description:
Timeout [milli seconds]: 1000

4. Make the settings for the interface in the selected tab:
   - ***RS-232*** tab:
     - Select the COM port of the PC connected to the C-863.12 in the ***COM Port*** field.
     - Set the value of the C-863.12 in the ***Baudrate*** field with DIP switches 5 and 6.
   - ***USB*** tab:
     - Select the C-863.12 connected.
5. Click ***OK*** to establish communication.
6. Send the `*IDN?` command for every controller in the daisy chain network to check the communication.

In the example in the following figure, the daisy chain network comprises a C-863.12 with the controller address 1 and a C-663.12 with the controller address 2. Send:

- `*IDN?` to query the device identification string of the controller with the address 1; the controller address is not required (because = 1)
- `2 *IDN?` to query the device identification string of the controller with the address 2.

For further information, see "Target and Sender Address" (p. 119).



Interface: RS-232 on COM1 with 115200 baud

History:
*IDN?
2 *IDN?

Command input: 2 *IDN?

```
==== new connection: RS-232 on COM1 with 115200 baud ====
*IDN?
(c)2018 Physik Instrumente (PI) GmbH & Co. KG, C-863.12, 18550014, 00.041
2 *IDN?
0 2 (c)2018 Physik Instrumente (PI) GmbH & Co. KG, C-663.12, 18550012, 00.041
```

6.5 Starting Motion

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

- Adapting the parameter settings of the C-863.12 to the connected positioner by loading a parameter set from a positioner database
- Switching on the servo mode (closed-loop operation)
- Doing a referencing move; details see "Referencing" (p. 34).

NOTICE

Selecting an incorrect positioner type

Selecting an incorrect positioner type in the PC software can damage the positioner.

➢ Make sure that the type of positioner selected in the PC software matches the positioner that is connected.

NOTICE

Oscillation!

Unsuitable setting of the C-863.12's servo control parameters can cause the positioner to oscillate. Oscillation can damage the positioner and/or the load fixed to it.

- ➢ Secure the positioner and all loads adequately.
- ➢ If the connected positioner is oscillating (unusual operating noise), immediately switch off the servo mode or disconnect the C-863.12 from the power source.
- ➢ Only switch on the servo mode after you have modified the servo control parameter settings of the C-863.12; see "Optimizing Servo Control Parameters" (p. 68).
- ➢ If, due to a very high load, oscillation occurs during the referencing move, follow the instructions for the referencing move in "Troubleshooting" (p. 249).

INFORMATION

The C-863.12 has a nonvolatile memory for parameter values. Therefore, after switching on, the correct parameter settings for the connected positioner may already be loaded.

- ➢ However, if you have loaded a parameter set from the positioner database and overwritten the original settings of the C-863.12 in the volatile memory during the process, avoid saving the new settings in the nonvolatile memory of the C-863.12. The original settings are active again after the C-863.12 has been switched off and on again or been rebooted.
- ➢ If you are using the ***Start up controller*** window in PIMikroMove for selecting the positioner and you are asked how you want to save the new settings, click the ***Save all settings permanently on controller*** button only if you are sure that the C-863.12 is working correctly with the settings.

INFORMATION

If the ***Select connected stages*** step is not displayed in PIMikroMove, the controller has probably already loaded the correct parameter settings for the positioner type connected.

1. Check ***Start up axes*** step to ensure that the correct positioner type is in the ***Stage*** column in the middle of the window.
2. If the positioner type is not correct, click ***Select connected stages*** in the left area of the ***Start up controller*** window to change the positioner type.

Requirements

- ✓ You have read and understood the General Notes on Startup (p. 53).
- ✓ PIMikroMove is installed on the PC (p. 41).
- ✓ You have read and understood the PIMikroMove manual. The links to the software manuals are in the file A000T0081 on the data storage device with the PI software.
- ✓ You have installed the latest version of the PISTAGES3.DB database onto your PC (p. 41).

- ✓ If PI provided a custom positioner database for your positioner, the dataset was imported into PIStages3 (p. 43).
- ✓ You have installed the positioner in the same way as it will be used in your application (corresponding load, orientation, and mounting).
- ✓ You have connected the C-863.12 to the positioner (p. 46).
- ✓ You have established communication with PIMikroMove between the C-863.12 and the PC (p. 56).

Starting motion with PIMikroMove

1. If in PIMikroMove the ***Select connected stages*** step is displayed, select the positioner type of the positioner connected:

   If the correct positioner type is already listed in the ***Current stage type*** column in the ***Controller axes*** list on the right of the window:

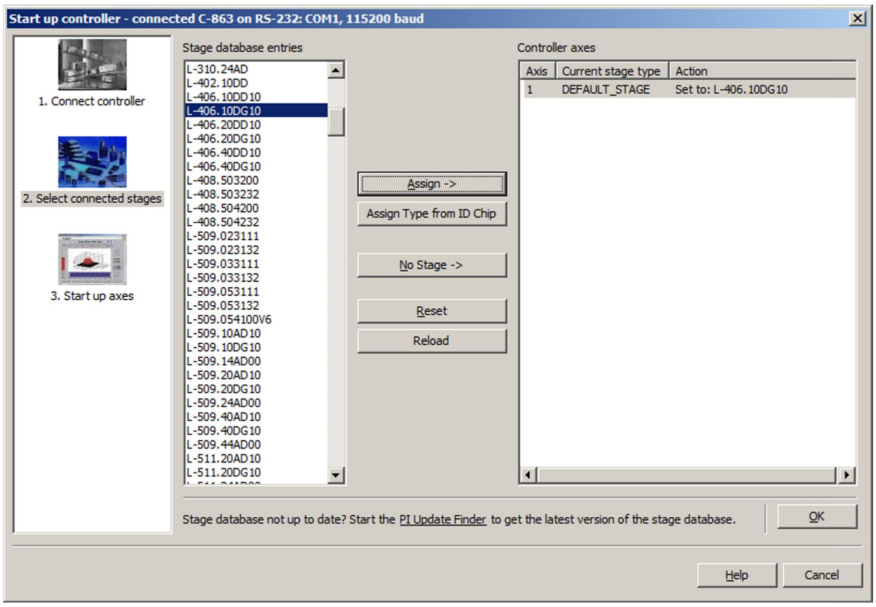
   – Click ***OK***.

   If the listed positioner type is not correct:

   a) Mark the positioner type in the ***Stage database entries*** list.

   b) Click ***Assign***.

   c) Confirm the selection with ***OK***.



Start up controller - connected C-863 on RS-232: COM1, 115200 baud

Stage database entries

L-310.24AD
L-402.10DD
L-406.10DD10
L-406.10DG10
L-406.20DD10
L-406.20DG10
L-406.40DD10
L-406.40DG10
L-408.503200
L-408.503232
L-408.504200
L-408.504232
L-509.023111
L-509.023132
L-509.033111
L-509.033132
L-509.053111
L-509.053132
L-509.054100V6
L-509.10AD10
L-509.10DG10
L-509.14AD00
L-509.20AD10
L-509.20DG10
L-509.24AD00
L-509.40AD10
L-509.40DG10
L-509.44AD00
L-511.20AD10
L-511.20DG10

Controller axes

Axis	Current stage type	Action
1	DEFAULT_STAGE	Set to: L-406.10DG10

Stage database not up to date? Start the PI Update Finder to get the latest version of the stage database.

Figure 14: Start up controller – Select connected stages

2. Specify how you want to load the parameter settings into the C-863.12 in the ***Save all changes permanently?*** dialog box:

   – Temporary load: Click ***Keep the changes temporarily*** to load the parameter settings into the volatile memory of the C-863.12. The settings are lost when the C-863.12 is switched off or rebooted.

- Load as default values: Click ***Save all settings permanently on controller*** to load the parameter settings into the nonvolatile memory of the C-863.12. The settings are available immediately after switching on or rebooting the C-863.12 and do not need to be reloaded.

The ***Start up controller*** window changes to the ***Start up axes*** step.

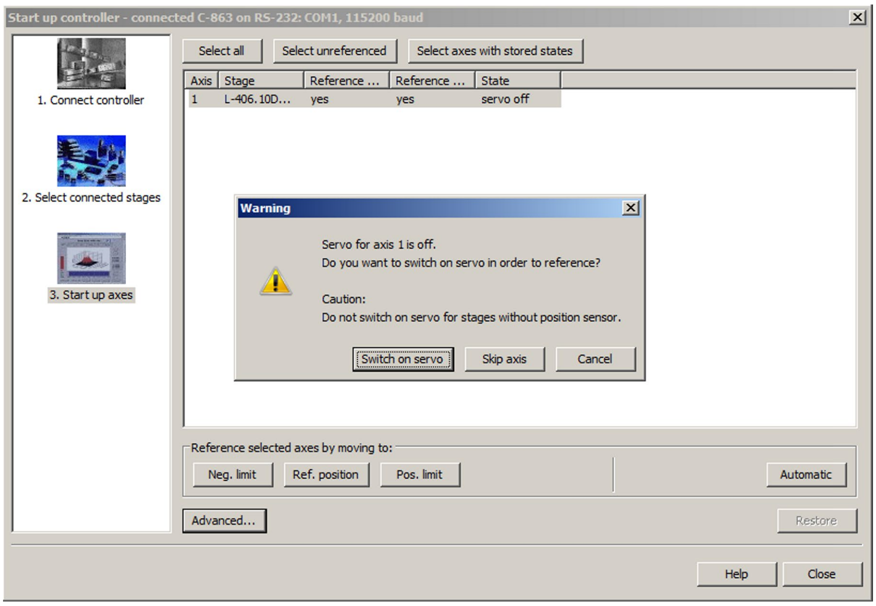
3. In the ***Start up axes*** step, perform the referencing move for the axis so that the controller knows the absolute axis position:

   - If you want to start the referencing move to the reference switch, click ***Ref. switch***.
   - If you want to start the referencing move to the negative limit switch, click ***Neg. limit***.
   - If you want to start the referencing move to the positive limit switch, click ***Pos. limit***.

   If a warning message appears indicating that servo mode is switched off:

   - Switch on the servo mode by clicking on the ***Switch on servo*** button (closed-loop operation).

   The axis performs the referencing move.



Start up controller - connected C-863 on RS-232: COM1, 115200 baud

Axis	Stage	Reference ...	Reference ...	State
1	L-406.10D...	yes	yes	servo off

Warning

Servo for axis 1 is off.
Do you want to switch on servo in order to reference?

Caution:
Do not switch on servo for stages without position sensor.

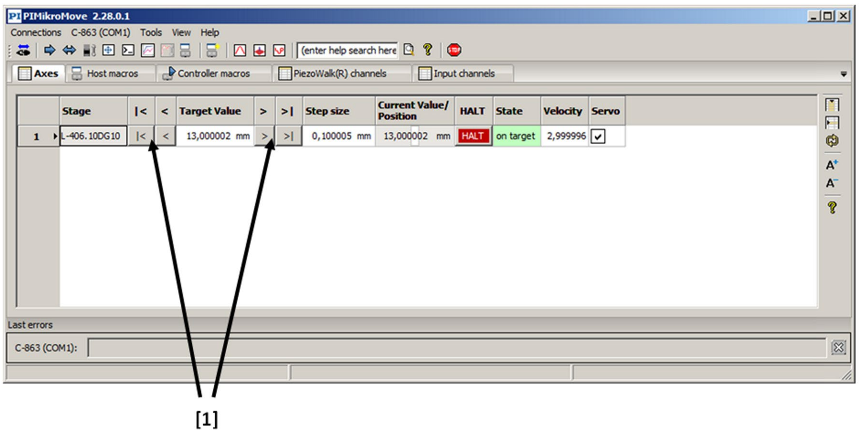
Figure 15: Start up controller – Start up axes

4. After a successful referencing move, close the ***Start up controller*** window by clicking ***OK > Close***.

   The main window of PIMikroMove opens.

5. Test the motion of the axis several times.

By clicking the corresponding arrow keys for the axis in the main window of PIMikroMove for example, it is possible to initiate motion over a particular distance (specification in ***Step size*** column) or to the limits of the travel range.



	Stage	|<	<	Target Value	>	>|	Step size	Current Value/ Position	HALT	State	Velocity	Servo
1	L-406.10DG10	|<	<	13,000002 mm	>	>|	0,100005 mm	13,000002 mm	HALT	on target	2,999996	☑

[1] Arrow keys for motion; main window of PIMikroMove

6.6 Optimizing the Servo Control Parameters

Adjusting the PID controller optimizes the dynamic properties of the system (overshoot and settling time). The optimum P-I-D controller settings depend on your application and your requirements.

As a rule, optimization occurs empirically and involves the following parameters. For details, see "Servo Algorithm and Other Control Value Corrections" (p. 26):

- ***P Term*** (0x411)
- ***I Term*** (0x412)
- ***D Term*** (0x413)
- ***I-Limit*** (0x414)

Various values are used in closed-loop operation and the behavior of the positioner is monitored.

PIMikroMove is used in the following for optimizing the servo control parameters.

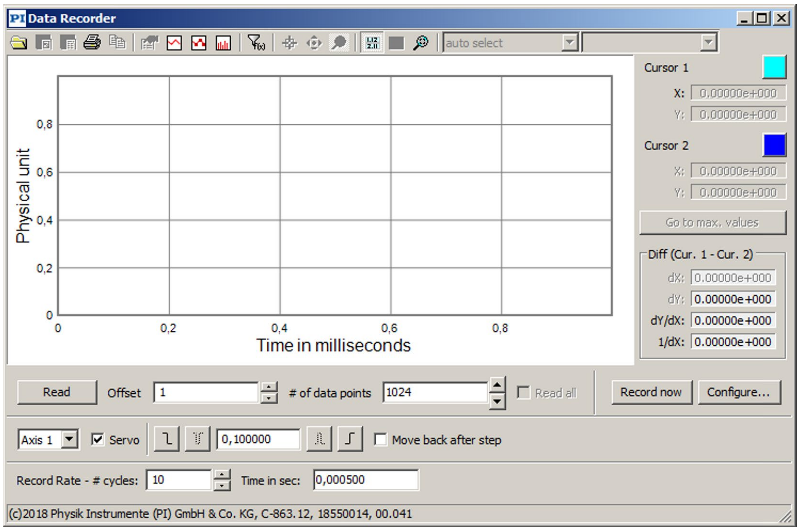
Requirement

- ✓ You have installed the positioner in the same way as it will be used in your application (corresponding load, orientation, and mounting).
- ✓ You have started initial motion (p. 64) with PIMikroMove.
- ✓ All devices are still ready for operation.

Checking the servo control parameters: Record the step response

With the recording of the step response, you determine the settling behavior of the positioner in closed-loop operation.

1. Open the ***Data Recorder*** window in the main window of PIMikroMove via the ***C-863.12 > Show data recorder*** menu item.
2. With the ***Servo*** checkbox, make sure that the servo mode is switched on.
   – If the ***Servo*** checkbox is not checked, the servo mode is switched off. Click the checkbox to switch on the servo mode.
3. Configure the data recorder.
   a) Set the size of the step to be made to a value that is typical for your application, e.g., 0.100000 (specified in physical units).
   b) Set the value 10 for the record table rate in the ***Record Rate - # cycles*** field.
   c) Set the value 1024 (or less) for the number of data points to be read for the graphic display in the field ***# of data points***.



Cursor 1 X: 0,00000e+000 Y: 0,00000e+000

Cursor 2 X: 0,00000e+000 Y: 0,00000e+000

dX: 0.00000e+000
dY: 0.00000e+000
dY/dX: 0.00000e+000
1/dX: 0.00000e+000

Offset 1 # of data points 1024 □ Read all

Axis 1 ☑ Servo 0,100000 □ Move back after step

Record Rate - # cycles: 10 Time in sec: 0,000500

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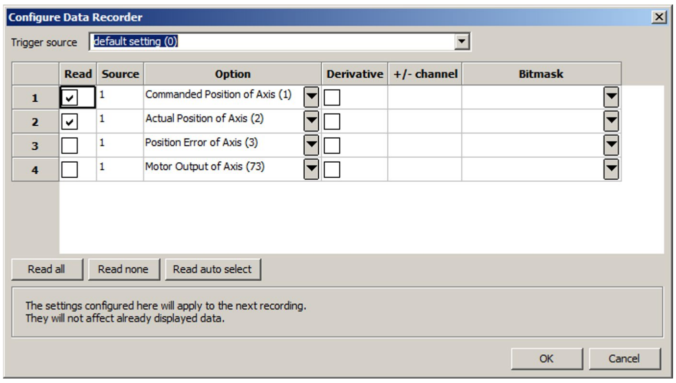
   d) Click the ***Configure…*** button and make sure that "Commanded Position of Axis" and "Actual Position of Axis" are selected in the ***Configure Data Recorder*** window as the variables to be recorded. Close the window with ***OK***.



Trigger source default setting (0)

	Read	Source	Option	Derivative	+/- channel	Bitmask
1	☑	1	Commanded Position of Axis (1)	□		
2	☑	1	Actual Position of Axis (2)	□		
3	□	1	Position Error of Axis (3)	□		
4	□	1	Motor Output of Axis (73)	□		

The settings configured here will apply to the next recording.
They will not affect already displayed data.

4. Start the jump in the positive direction as well as the recording by clicking the ⎍ button in the ***Data Recorder*** window.

   The axis performs the step and the step response is recorded and displayed graphically.

5. Check the displayed step response (see examples below).

   – If necessary, enlarge the view by clicking the 🔍 button and, while pressing the left mouse button, dragging the mouse pointer, which has turned into a magnifying glass, over a section of the graphic display (clicking the right mouse button in the graphics field reduces the view back to the original size).

Examples for step responses:

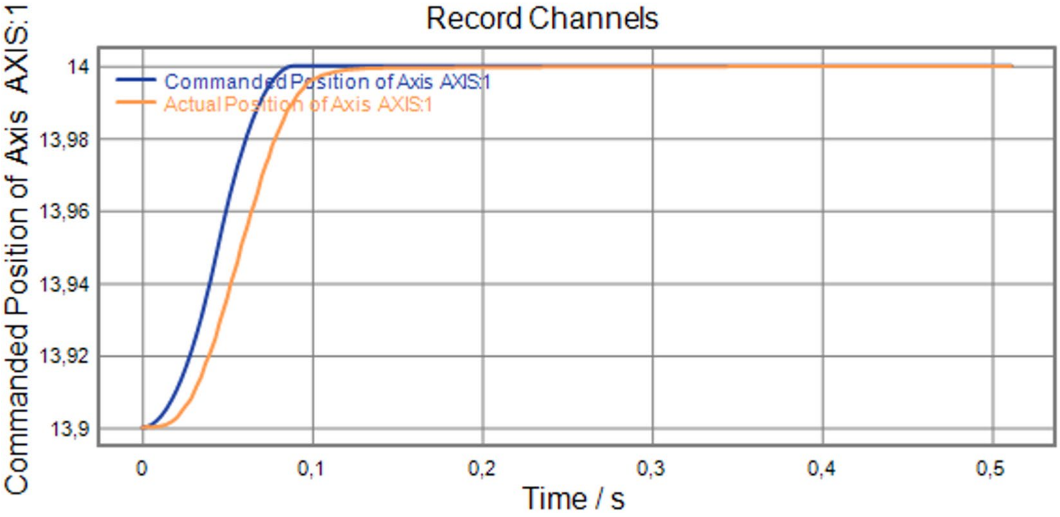


Figure 16: Step-and-settle too slow

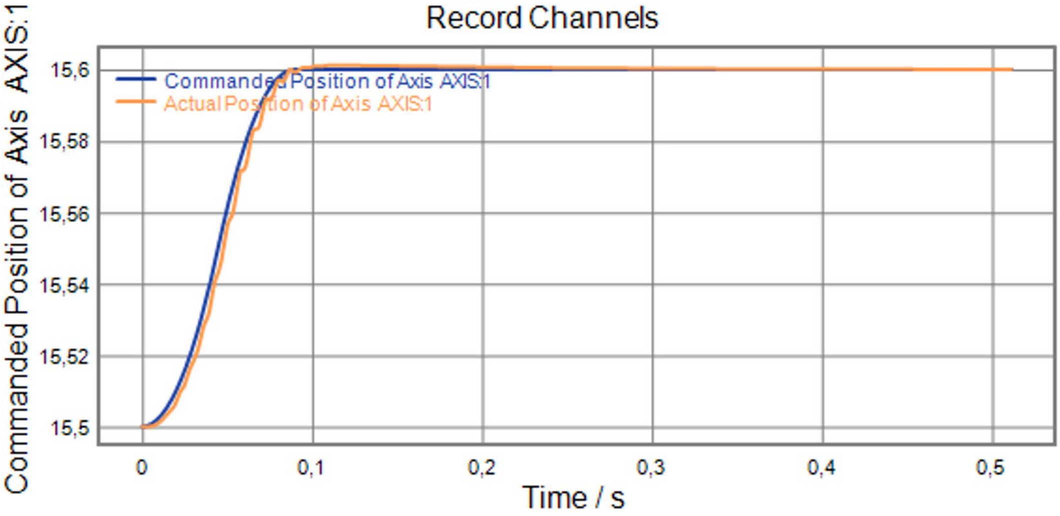


Figure 17: Oscillation

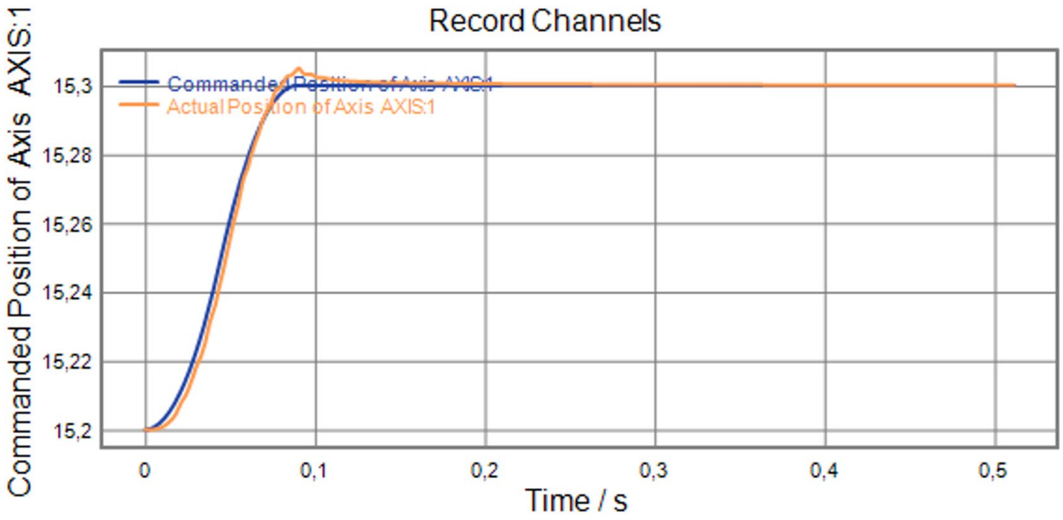


Figure 18: Strong overshooting

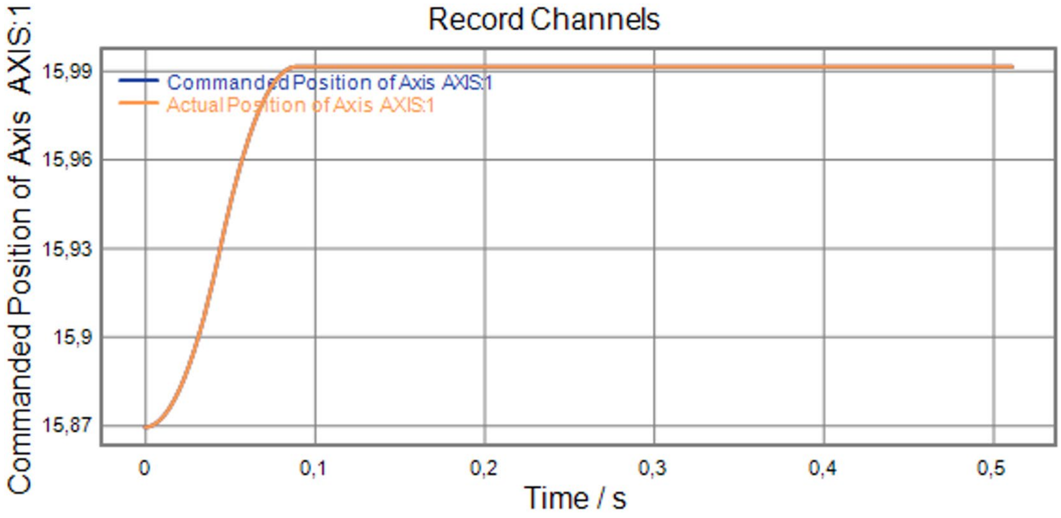


Figure 19: Optimal settling behavior (commanded and actual position congruent)

If the result is satisfactory (i.e., minimum overshoot, settling time not too long):

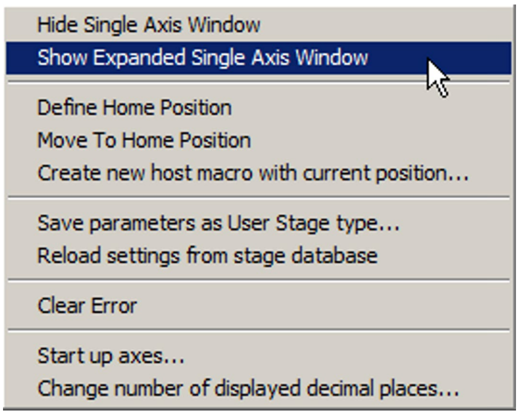
– You already have optimum parameter settings and do not have to do anything further.

If the result is not satisfactory:

– Optimize the servo control parameters, see below.

Optimizing the servo control parameters

1. Open the expanded single axis window for the connected positioner in the main window of PIMikroMove by clicking the right mouse button on the corresponding line of the ***Axes*** tab and selecting ***Show Expanded Single Axis Window*** in the context menu.

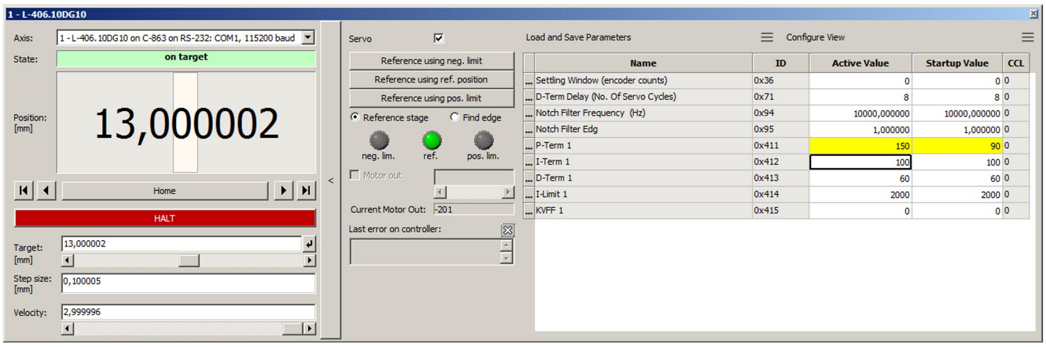

Hide Single Axis Window
Show Expanded Single Axis Window
Define Home Position
Move To Home Position
Create new host macro with current position...
Save parameters as User Stage type...
Reload settings from stage database
Clear Error
Start up axes...
Change number of displayed decimal places...

2. Enter new values for the parameters to be adapted:

   a) If the parameters to be changed are not included in the list on the right-hand side of the window, click ***Configure View -> C-863 - CONTROL ALGORITHM***.

   b) Type the new parameter value into the corresponding input field in the ***Active Value*** column of the list.

   c) Press the Enter key on the PC keyboard or click outside the input field with the mouse to transfer the parameter value to the volatile memory of the controller. Note: If a parameter value in the volatile memory (***Active Value*** column) is different to the parameter value in the nonvolatile memory (***Startup Value*** column), the line in the list is highlighted in color.



Axis: 1 - L-406.10DG10 on C-863 on RS-232: COM1, 115200 baud

State: on target

Position: [mm] 13,000002

Target: [mm] 13,000002

Step size: [mm] 0,100005

Velocity: 2,999996

Servo ☑

● Reference stage ○ Find edge

□ Motor out

Current Motor Out: -201

Last error on controller:

Name	ID	Active Value	Startup Value	CCL
Settling Window (encoder counts)	0x36	0	0	0
D-Term Delay (No. Of Servo Cycles)	0x71	8	8	0
Notch Filter Frequency (Hz)	0x94	10000,000000	10000,000000	0
Notch Filter Edg	0x95	1,000000	1,000000	0
P-Term 1	0x411	150	90	0
I-Term 1	0x412	100	100	0
D-Term 1	0x413	60	60	0
I-Limit 1	0x414	2000	2000	0
KVFF 1	0x415	0	0	0

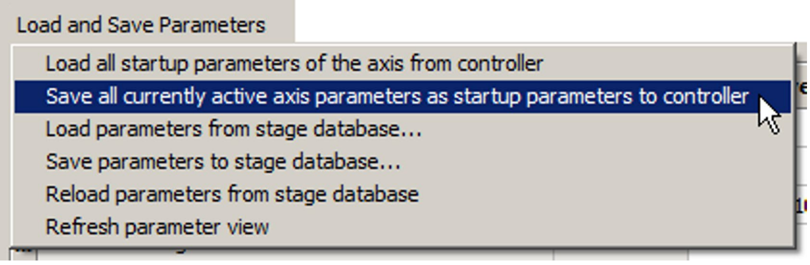
3. In the ***Data Recorder*** window, record the step response of the positioner again.

   If the result is not satisfactory:

   – Enter different values for the servo control parameters into the expanded single axis window and record the step response again.

   If you are satisfied with the result and want to keep the new servo control parameter settings, save the new settings. You have the following options:

- Save a parameter set in the positioner database on the PC by clicking on ***Load and Save Parameters -> Save parameters to stage database...*** in the expanded single axis window, see "Creating or Changing a Positioner Type" (p. 232).
- Transfer the current values of the listed parameters from the volatile memory to the nonvolatile memory of the C-863.12 by clicking ***Load and Save Parameters -> Save all currently active axis parameters as startup parameters to controller*** in the expanded single axis window.


Load and Save Parameters
Load all startup parameters of the axis from controller
Save all currently active axis parameters as startup parameters to controller
Load parameters from stage database...
Save parameters to stage database...
Reload parameters from stage database
Refresh parameter view

7 Operation

7.1 Motion Errors

7.1.1 Behavior with Motion Errors

Motion errors can be caused for example, by malfunctions of the drive or the position sensor of the positioner.

A motion error occurs, when the position error (i.e., the absolute value of the difference between the current position and the commanded position) exceeds the specified maximum value in closed-loop operation. The range in which the deviation may lie is specified by the ***Maximum Position Error (Phys. Unit)*** parameter (ID 0x8).

If motion error occurs, the C-863.12 reacts as follows to protect the system against damage:

- The servo mode is switched off for the axis in question.
- If applicable, the brake is activated for the axis in question.
- All motion is stopped.
- Error code -1024 is set.

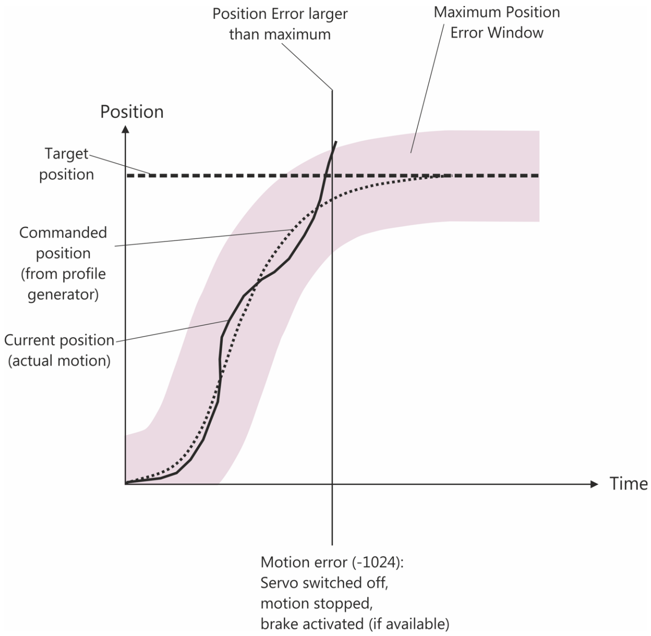

Position Error larger than maximum
Maximum Position Error Window
Position
Target position
Commanded position (from profile generator)
Current position (actual motion)
Time
Motion error (-1024):
Servo switched off,
motion stopped,
brake activated (if available)

Figure 20: Behavior in case of motion errors

7.1.2 Re-establishing Readiness for Operation

NOTICE

Unintentional motion after brake deactivated!

If servo mode is switched off, e.g., after a motion error occurs, the brake of the positioner can be deactivated by command. Deactivating the brake can cause the positioner to move unintentionally.

➢ Secure the positioner against moving unintentionally before you deactivate the brake by command!

Re-establishing readiness for operation

1. Send the `ERR?` command to read out the error code.

   If there is a motion error, error code -1024 is output. `ERR?` resets the error code to zero during the query.

2. Check your system and make sure that all axes can be moved safely.
3. Switch on the servo mode for the axis in question with the `SVO` command (p. 191).

   When switching on the servo mode, the target position is set to the current axis position and the brake is deactivated, if necessary. Now the axis can move again and you can command a new target position.

INFORMATION

With the `CTO` (p. 137) and `TRO` (p. 195) commands, you can program the digital output lines of the C-863.12 so that they are activated in the case of motion errors. The programmed output lines remain activated until the error code is reset to 0. Refer to "Configuring the "Motion Error" Trigger Mode" (p. 82) for details.

7.2 Data Recorder

7.2.1 Configuring the Data Recorder

The C-863.12 contains a real-time data recorder. The data recorder can record for example, the current position of the axis.

The recorded data is stored temporarily in 4 data recorder tables with 1024 points each. Each data recorder table contains the data of one data source.

You can configure the data recorder for example, by defining the data type to be recorded and the data sources, and by specifying how the recording is to be started.

INFORMATION

The settings for configuring the data recorder can only be changed in the volatile memory of the C-863.12. After switching on or rebooting the C-863.12, the factory settings are active, unless a configuration has already been made using a startup macro.

Reading general information from the data recorder

➢ Send the `HDR?` command (p. 157).

The options available for recording and triggering are displayed together with the information on additional parameters and commands for data recording.

Configuring data to be recorded

You can assign the data sources and record options to the data recorder tables.

➢ Send the `DRC?` command (p. 147) to read out the current configuration. Data recorder tables with the record option 0 are deactivated, i.e., nothing is recorded. By default, the data recorder tables of the C-863.12 record the following:

   – Data recorder table 1: Record option 1: Commanded position of the axis

   – Data recorder table 2: Record option 2: Current position of the axis

   – Data recorder table 3: Record option 3: Position error of the axis

   – Data recorder table 4: Record option 73: Control value of the axis

➢ Configure the data recorder with the `DRC` command (p. 146).

Configuring the recording trigger

You can specify how the recording is to be triggered.

➢ Get the current trigger option with `DRT?` (p. 150)

➢ Change the trigger option with the `DRT` command (p. 149). The trigger option applies to all data recorder tables whose record option is not set to 0.

Setting the record table rate

- Send the `RTR?` command (p. 182) to read out the record table rate of the data recorder.

  The parameter indicates the number of servo cycles required for recording each data point. The default value is 10 servo cycles. The servo cycle time of the C-863.12 is 50 µs.

- Change the record table rate with the `RTR` command (p. 182).

  As the record table rate increases, the maximum duration of the data recording is increased.

7.2.2 Starting the Recording

- Start the recording with the trigger option set with `DRT`.

Regardless of the trigger option set, the data recording is always triggered when a step response measurement is started with `STE` (p. 190).

The data recording always takes place for all data recorder tables whose record option is not set to 0. It ends when the data recorder tables are full.

7.2.3 Reading Recorded Data

INFORMATION

Reading the recorded data can take some time, depending on the number of data points.

The data can also be read while data is being recorded.

- Read out the last recorded data with the `DRR?` command (p. 148).

  The data is output in the GCS array format (refer to the SM146E user manual).

- Query the number of points in the last recording with the `DRL?` command (p. 147).

7.3 Digital Output Signals

The digital outputs of the C-863.12 are available at the **I/O** socket (p. 260).

- Get the number of the output lines available on the C-863.12 with the `TIO?` command (p. 194).

External devices can be triggered via the digital outputs of the C-863.12. Potential applications:

- Linking the trigger output to the motion of the axis. Details and examples can be found in this section.
- Direct switching of output lines, e. g., in macros. Details and examples of macros can be found in "Controller Macros" (p. 99).

7.3.1 Commands for Digital Outputs

The following commands are available for the use of digital outputs:

Command	Syntax	Function
`CTO`	CTO {<TrigOutID> <CTOPam> <Value>}	Configures the conditions for the trigger output. Couples the trigger output to the axis motion.
`DIO`	DIO {<DIOID> <OutputOn>}	Switches digital output lines directly to the low or high state, either separately or all lines at once. Should not be used for output lines where the trigger output is activated by `TRO`.
`TRO`	TRO {<TrigOutID> <TrigMode>}	Activates or deactivates the trigger output conditions set with `CTO`. Default: Trigger output deactivated.

One configuration setting can be made per `CTO` command:

```
CTO <TrigOutID> <CTOPam> <Value>
```

- `<TrigOutID>` is one digital output line of the controller.
- `<CTOPam>` is the CTO parameter ID in decimal format.
- `<Value>` is the value to which the CTO parameter is set.

The following trigger modes (<Value>) can be set for <CTOPam> = 3:

<Value>	Trigger mode	Short description
0 (default)	Position Distance	Once the axis has moved a specified distance, a trigger pulse is output (p. 80). Optionally, start and stop values can be defined to limit triggering to one position range and one particular direction of motion (negative or positive).
2	On Target	The on-target state of the axis selected is output at the selected trigger output (p. 82).

<Value>	Trigger mode	Short description
5	Motion Error	The selected digital output line becomes active when a motion error occurs (p. 82). The line stays active until the error code is reset to 0 (by an `ERR?` query).
6	In Motion	The selected digital output line is active as long as the selected axis is in motion (p. 83).
7	Position+Offset	The first trigger pulse is output when the axis has reached a specified position. The next trigger pulses are each output when the axis position equals the sum of the last valid trigger position and a specified distance. The trigger output is stopped when a stop value is reached. The polarity sign of the distance value determines the direction of motion in which trigger pulses are to be output. Refer to "Configuring the "Position + Offset" Trigger Mode" (p. 83).
8	Single Position	The selected digital output line is active when the axis position has reached or exceeded a specified position (p. 85).

In addition, the polarity (active high / active low) of the signal at the digital output can be set (p. 85).

INFORMATION

The settings for the configuration of the digital output lines can only be modified in the volatile memory of the C-863.12. After switching on or restarting the C-863.12 the factory default settings are active, unless a configuration has already been made using the startup macro.

7.3.2 Configuring the "Position Distance" Trigger Mode

The *Position Distance* trigger mode is suitable for scanning applications. Once the axis has moved along the distance that was set with CTO parameter ID = 1 (TriggerStep), a trigger pulse is output. The pulse width is one servo cycle.

The unit of the distance (TriggerStep) is subject to the settings of parameters 0xE and 0xF. Default is mm.

1. Configure the digital output line (<TrigOutID>) that is to be used as the trigger output:
   - Send `CTO <TrigOutID> 2 A`, where *A* indicates the axis to be moved.
   - Send `CTO <TrigOutID> 3 0`, where 0 specifies the *Position Distance* trigger mode.
   - Send `CTO <TrigOutID> 1 S`, where *S* indicates the distance.
2. If you want to activate the conditions for trigger output, send `TRO <TrigOutID> 1`.

Example:

A pulse on digital output line 1 is output every time the axis 1 of the positioner has covered a distance of 0.1 µm.

➢ Send:

```
CTO 1 2 1
CTO 1 3 0
CTO 1 1 0.0001
TRO 1 1
```

"Position Distance" trigger mode with start and stop values for positive motion direction of the axis

Optionally, you can define start and stop values for limiting the range and for specifying the motion direction of the axis (positive or negative).

INFORMATION

If start and stop values have the same value, they are ignored.

If the direction of motion is reversed before the axis position has reached the stop value, trigger pulses continue to be output.

1. Configure the digital output line (<TrigOutID>) that is to be used as the trigger output:
   - Send `CTO <TrigOutID> 2 A`, where *A* indicates the axis to be moved.
   - Send `CTO <TrigOutID> 3 0`, where 0 specifies the *Position Distance* trigger mode.
   - Send `CTO <TrigOutID> 1 S`, where *S* indicates the distance.
   - Send `CTO <TrigOutID> 8 Start`, where *Start* indicates the start value.
   - Send `CTO <TrigOutID> 9 Stop`, where *Stop* indicates the stop value.
2. If you want to activate the conditions for trigger output, send `TRO <TrigOutID> 1`.

Example

A pulse on digital output line 1 is output every time the axis 1 of the positioner has covered a distance of 0.1 µm, as long as axis 1 is moving in positive direction of motion within the range of 0.2 µm to 0.55 µm (start value < stop value).

➢ Send:

```
CTO 1 2 1
CTO 1 3 0
CTO 1 1 0.0001
CTO 1 8 0.0002
CTO 1 9 0.00055
TRO 1 1
```

"Position Distance" trigger mode with start and stop values for negative motion direction of the axis

The above example is presented with interchanged start and stop values in the following. Triggering occurs in negative motion direction of the axis (stop value < start value) in the range between 0.55 µm and 0.2 µm.

Example:

- Send:

```
CTO 1 2 1
CTO 1 3 0
CTO 1 1 0.0001
CTO 1 8 0.00055
CTO 1 9 0.0002
TRO 1 1
```

7.3.3 Configuring the "On Target" Trigger Mode

The on-target state of the axis selected (p. 29) is output at the selected trigger output in *On Target* trigger mode.

1. Configure the digital output line (<TrigOutID>) to be used as the trigger output:
   - Send `CTO <TrigOutID> 2 A`, where *A* indicates the axis to be moved.
   - Send `CTO <TrigOutID> 3 2`, where *2* specifies the *On Target* trigger mode.
2. If you want to activate the conditions for trigger output, send `TRO <TrigOutID> 1`.

Example:

The on-target state of axis 1 is to be output on the digital output line 1.

- Send:

```
CTO 1 2 1
CTO 1 3 2
TRO 1 1
```

7.3.4 Configuring the "Motion Error" Trigger Mode

The *Motion Error* trigger mode is suitable for monitoring motion. The selected digital output line becomes active when a motion error occurs on one of the connected axes. The line stays active until the error code is reset to 0 (by an `ERR?` query).

INFORMATION

A motion error occurs when the current position differs too much from the commanded position during motion.
For further information, see "Motion Error" (p. 75).

1. Configure the digital output line (<TrigOutID>) that is to be used as the trigger output:
   - Send `CTO <TrigOutID> 3 5`, where 5 specifies the *Motion Error* trigger mode.
2. If you want to activate the conditions for trigger output, send `TRO <TrigOutID> 1`.

7.3.5 Configuring the "In Motion" Trigger Mode

The motion state of the selected axis is output at the selected trigger output in *In Motion* trigger mode. The line is active, as long as the selected axis is in motion.

The motion state can also be read with the `#5` (p. 128), `#4` (p. 128), and `SRG?` (p. 189) commands.

INFORMATION

If the axis is in motion, then bit 14 of the state register 1 of the axis is set.

1. Configure the digital output line (<TrigOutID>) that is to be used as the trigger output:
   - Send `CTO <TrigOutID> 2 A`, where *A* indicates the axis to be moved.
   - Send `CTO <TrigOutID> 3 6`, where 6 specifies the *In Motion* trigger mode.
2. If you want to activate the conditions for trigger output, send `TRO <TrigOutID> 1`.

Example:

Digital output line 1 is to be active if axis 1 of the positioner is in motion.

➢ Send:

```
CTO 1 2 1
CTO 1 3 6
TRO 1 1
```

7.3.6 Configuring the "Position + Offset" Trigger Mode

The *Position+Offset* trigger mode is suitable for scanning applications. The first trigger pulse is output when the axis has reached a specified position (TriggerPosition). The next trigger pulses are output respectively when the axis position equals the sum of the last valid trigger position and a specified distance (TriggerStep). The trigger output is stopped when a stop value is reached. The polarity sign of the distance value determines the direction of motion in which trigger pulses are to be output.

The pulse width is one servo cycle.

The unit for TriggerPosition, TriggerStep and stop value is subject to the settings of parameters 0xE and 0xF. Default is mm.

1. Configure the digital output line (<TrigOutID>) that is to be used as the trigger output:
   - Send `CTO <TrigOutID> 2 A`, where *A* indicates the axis to be moved.
   - Send `CTO <TrigOutID> 3 7`, where 7 specifies the *Position+Offset* trigger mode.
   - Send `CTO <TrigOutID> 1 S`, where *S* indicates the distance.
   - Send `CTO <TrigOutID> 10 TriPos`, where *TriPos* indicates the position for the output of the first trigger pulse.
   - Send `CTO <TrigOutID> 9 Stop`, where *Stop* indicates the stop value.
2. If you want to activate the conditions for trigger output, send `TRO <TrigOutID> 1`.

Example 1:

The first trigger pulse is to be output on digital output line 1 if the absolute position of axis 1 is 1.5 mm. A pulse should then be output on this line every time axis 1 has covered a distance of 0.1 µm in the positive direction. The last trigger pulse is to be output if the absolute axis position is 2.5 mm.

➢ Send:

```
CTO 1 2 1
CTO 1 3 7
CTO 1 1 0.0001
CTO 1 10 1.5
CTO 1 9 2.5
TRO 1 1
```

Example 2:

The first trigger pulse is to be output on digital output line 2 if the absolute position of axis B is 0.4 mm. A pulse should then be output on this line every time axis B has covered a distance of 1 µm in the negative direction. The last trigger pulse is to be output if the absolute axis position is 0.1 mm.

➢ Send:

```
CTO 2 2 B
CTO 2 3 7
CTO 2 1 -0.001
CTO 2 10 0.4
CTO 2 9 0.1
```

INFORMATION

The velocity setting of the axis must be appropriate for the distance setting (TriggerStep) commanded by the `CTO` command. Recommended value:

Maximum velocity = distance * 20 kHz / 2

where 20 kHz is the servo cycle frequency of the C-863.12.

7.3.7 Configuring the "Single Position" Trigger Mode

The selected digital output line is active in *Single Position* trigger mode, when the axis position has reached or exceeded a specified position (TriggerPosition).

The unit for TriggerPosition depends on the settings of the parameters 0xE and 0xF. Default is mm.

1. Configure the digital output line (<TrigOutID>) to be used as the trigger output:
   - Send `CTO <TrigOutID> 2 A`, where *A* indicates the axis to be moved.
   - Send `CTO <TrigOutID> 3 8`, where 8 specifies the *Single Position* trigger mode.
   - Send `CTO <TrigOutID> 10 TriPos`, where *TriPos* indicates the position at which the output line is to become active.
2. If you want to activates the conditions for trigger output, send `TRO <TrigOutID> 1`.

Example:

Digital output line 1 is to become active when the absolute position of axis 1 is at least 1.5 mm.

➢ Send:

```
CTO 1 2 1
CTO 1 3 8
CTO 1 10 1.5
```

7.3.8 Setting Signal Polarity

The polarity of the signal at the digital output which is used for triggering can be selected with the *Polarity* CTO parameter. The polarity can have the following values:

- active high = 1 (default setting)
- active low = 0

➢ Configure the digital output line (<TrigOutID>) to be used as the trigger output:

- Send `CTO <TrigOutID> 7 P`, where *P* indicates the polarity.

Example:

The signal polarity for digital output line 1 is to be set to active low.

- Send:

```
CTO 1 7 0
```

7.4 Digital Input Signals

The digital inputs of the C-863.12 are available on the **I/O** socket (p. 260).

- Get the number of the input lines available on the C-863.12 with the `TIO?` command (p. 194).
- Get the state of the input lines with the `DIO?` command (p. 145).

Potential applications:

- Use in macros (p. 88). Details and examples of macros can be found in "Controller Macros" (p. 99).
- Use as switch signals (p. 89)

INFORMATION

The digital inputs (pins 1 to 4) on the **I/O** socket can also be used as analog inputs.

- Digital: TTL
- Analog: 0 to +5 V

7.4.1 Commands and Parameters for Digital Inputs

Commands

The following commands are available for the use of digital inputs:

Command	Syntax	Function
`CPY`	CPY <Variable> <CMD?>	Copies the state of a digital input line to a variable when used in conjunction with the DIO? query command. Use in macros to set local variables (p. 120).
`DIO?`	DIO? [{<DIOID>}]	Gets the state of the digital input lines.
`FED`	FED {<AxisID> <EdgeID> <Param>}	Starts a move to a signal edge. The signal source can be a digital input line.
`FNL`	FNL [{<AxisID>}]	Starts a referencing move to the negative physical limit of the travel range A digital input line can be used as the source of the negative limit switch signal instead of the negative limit switch.

Command	Syntax	Function
FPL	FPL [{<AxisID>}]	Starts a referencing move to the positive physical limit of the travel range Limit switch. A digital input line can be used as the source of the positive limit switch signal instead of the positive limit switch.
FRF	FRF [{<AxisID>}]	Starts a referencing move to the reference switch. A digital input line can be used as the source of the reference switch signal instead of the reference switch.
JRC	JRC <Jump> <CMD?> <OP> <Value>	Can only be used in macros. Triggers a relative jump of the macro run pointer depending on the state of a digital input line when used in conjunction with the DIO? query command.
MEX	MEX <CMD?> <OP> <Value>	Can only be used in macros. Stops running of the macro depending on the state of a digital input line when used in conjunction with the DIO? query command.
WAC	WAC <CMD?> <OP> <Value>	Can only be used in macros. Waits until a digital input line reaches a certain state when used in conjunction with the DIO? query command.

Parameters

The following parameters are available for the configuration of digital inputs:

Parameters	Description and Possible Values
Source Of Reference Signal 0x5C	Specifies the source of the reference signal for the FRF and FED commands: 0 = reference switch 1 = Digital input 1 2 = Digital input 2 3 = Digital input 3 4 = Digital input 4
Source Of Negative Limit Signal 0x5D	Specifies the source(s) of the negative limit switch signal for the FNL and FED commands via a bitmask: 0 = Negative limit switch (default setting) 1 = Digital input 1 (bit 0) 2 = Digital input 2 (bit 1) 4 = Digital input 3 (bit 2) 8 = Digital input 4 (bit 3)

Parameters	Description and Possible Values
Source Of Positive Limit Signal 0x5E	Specifies the source(s) of the positive limit switch signal for the `FPL` and `FED` commands via a bitmask: 0 = Positive limit switch (default setting) 1 = Digital input 1 (bit 0) 2 = Digital input 2 (bit 1) 4 = Digital input 3 (bit 2) 8 = Digital input 4 (bit 3)
Invert Digital Input Used For Negative Limit 0x5F	Inverts the polarity of the digital inputs, which are used for the source of the negative limit switch signal, via a bitmask: 0 = No digital input inverted (default setting). 1 = Digital input 1 inverted (bit 0) 2 = Digital input 2 inverted (bit 1) 4 = Digital input 3 inverted (bit 2) 8 = Digital input 4 inverted (bit 3)
Invert Digital Input Used For Positive Limit 0x60	Inverts the polarity of the digital inputs, which are used for the source of the positive limit switch signal, via a bitmask: 0 = No digital input inverted (default setting). 1 = Digital input 1 inverted (bit 0) 2 = Digital input 2 inverted (bit 1) 4 = Digital input 3 inverted (bit 2) 8 = Digital input 4 inverted (bit 3)

7.4.2 Using Digital Input Signals in Macros

The digital inputs on the **I/O** socket can be used in macros as follows:

- Conditional running of the macro
- Conditional stopping of the macro
- Conditional jump of the macro pointer
- Copying the input state to a variable

Further information and examples can be found in "Controller Macros" (p. 99).

INFORMATION

You can connect the C-170.PB pushbutton box from PI to the **I/O** socket (p. 260) to generate the digital input signals for use in macros. It also displays the state of the digital output lines via LEDs.

7.4.3 Using Digital Input Signals as Switch Signals

The digital inputs on the **I/O** socket can be used as the source of reference point and limit switch signals (e.g., for referencing moves (p. 34)) for an axis.

Using digital input as reference signal

INFORMATION

The level of the digital input signal which you use instead of the reference switch may only change once across the entire travel range.

- Use a suitable signal source.
- If necessary, invert the signal logic of the digital input line by setting the ***Invert Reference?*** parameter (ID 0x31) accordingly.

INFORMATION

The ***Has Reference?*** parameter (ID 0x14) has no influence on the use of a digital input line as the source of the reference signal.

- Select the source of the reference signal for the axis by changing the ***Source Of Reference Signal*** parameter (ID 0x5C).

Detailed information on changing parameters can be found in "Adapting Settings" (p. 227).

Using digital inputs as source of the limit switch signals

INFORMATION

Several digital inputs can be selected as the source for a limit switch signal.

If a limit switch signal is used for referencing moves, only one digital input line may be selected as the source of the limit switch signal.

INFORMATION

The level of the digital input signal which you use instead of an internal limit switch may only change once across the entire travel range.

- Use suitable signal sources.
- If necessary, invert the signal logic of the digital input lines by setting parameters ***Invert Digital Input Used For Negative Limit*** (ID 0x5F) and ***Invert Digital Input Used For Positive Limit*** (ID 0x60) accordingly.

INFORMATION

The ***Has No Limit Switches?*** parameter (ID 0x32) determines whether the C-863.12 evaluates the signals from the internal limit switches of the positioner. This parameter has no influence on the use of digital input lines as the source of the limit switch signal.

- Select the source(s) of the negative limit switch signal for the axis by changing the ***Source Of Negative Limit Signal*** parameter (ID 0x5D).
- Select the source(s) of the positive limit switch signal for the axis by changing the ***Source Of Positive Limit Signal*** parameter (ID 0x5E).

Detailed information on changing parameters can be found in "Adapting Settings" (p. 227).

Example:

Digital input lines 1, 3, and 4 are to be used for axis 1 as the sources of the positive limit switch signal. In addition, the signal polarity of lines 1 and 3 is to be inverted for axis 1. All adaptations are made in the volatile memory of the C-863.12 only.

- Send:

  `SPA 1 0x5E 13`, to select lines 1, 3, and 4.

  `SPA 1 0x60 5`, to invert the signal polarity of lines 1 and 3.

7.5 Analog Input Signals

The analog inputs of the C-863.12 are available on the **I/O** socket (p. 260).

- Get the number of the analog input lines available on the C-863.12 with the `TAC?` command (p. 193).
- Query the voltage on the analog inputs with the `TAV?` command (p. 193).
- Use the data recorder (p. 76) to record the analog input signals.

Potential applications:

- Use in macros (p. 91): Details and examples of macros are found in "Controller Macros" (p. 99).
- Scanning applications with PIMikroMove (see PIMikroMove manual)

INFORMATION

The analog inputs (pins 1 to 4) on the **I/O** socket can also be used as digital inputs.

- Analog: 0 to +5 V
- Digital: TTL

7.5.1 Commands for Analog Inputs

The following commands are available for the use of analog inputs:

Command	Syntax	Function
`CPY`	CPY <Variable> <CMD?>	Copies the voltage value of an analog input line to a variable when used in combination with the TAV? query command. Use in macros to set local variables (p. 120).

Command	Syntax	Function
DRC	DRC {<RecTableID> <Source> <RecOption>}	Configures the data recorder. Analog input values can be recorded using record option 81.
JRC	JRC <Jump> <CMD?> <OP> <Value>	Can only be used in macros. Triggers a relative jump of the pointer when running the macro depending on the voltage at an analog input line when used in conjunction with the TAV? query command.
MEX	MEX <CMD?> <OP> <Value>	Can only be used in macros. Stops running of the macro depending on the voltage at an analog input line when used in conjunction with the TAV? query command.
TAC?	TAC?	Get the number of installed analog lines.
TAV?	TAV? [{<AnalogInputID>}]	Get voltage at analog input.
WAC	WAC <CMD?> <OP> <Value>	Can only be used in macros. Waits until an analog input line reaches a certain voltage when used in conjunction with the TAV? query command.

7.5.2 Using Analog Input Signals in Macros

The analog inputs on the **I/O** socket can be used in macros as follows:

- Conditional running of the macro
- Conditional stopping of the macro
- Conditional jump of the macro pointer
- Copying the input state to a variable

Further information and examples can be found in "Controller Macros" (p. 99).

7.6 Joystick Control

7.6.1 How Joystick Control Works

The joystick axis controls the velocity of the positioner axis connected to the C-863.12 (commanded velocity output from the profile generator).

The relationship between the displacement of the joystick axis and the velocity of the positioner axis is established by the C-863.12 using a lookup table. The 256 values in the lookup table are factors that are applied to the velocity set with the VEL command (p. 199) during joystick control. The value range is from -1.0000 to 1.0000.

The firmware of the controller provides two predefined lookup table types to choose from (linear and parabolic) and allows the lookup table to be filled with custom values. The content of the lookup table is automatically saved in the nonvolatile memory of the C-863.12.

During joystick control, the soft limit specified by the parameter 0x15 or 0x30 is used as the target position. For details, see "Travel Range and Soft Limits" (p. 31). When disabling the joystick, the current position of the joystick-controlled axis is set as the new target position.

INFORMATION

Motion commands are not allowed when a joystick is activated for the axis.
Joystick control is not possible in open-loop operation (servo mode OFF).

7.6.2 Commands and Parameters for Joystick Control

Commands

The following commands are available for the use of the joystick:

Command	Syntax	Function
JON	JON {<JoystickID> <uint>}	Activates or deactivates a joystick connected to the controller.
JON?	JON? [{<JoystickID>}]	Gets the activation state of the joystick.
JAX	JAX <JoystickID> <JoystickAxis> <AxisID>	Specifies the axis that is controlled by a joystick connected to the controller.
JAX?	JAX? [{<JoystickID> <JoystickAxis>}]	Gets the axis that is controlled by a joystick connected to the controller.
JAS?	JAS? [{<JoystickID> <JoystickAxis>}]	Gets the current state of a joystick axis (displacement).
JBS?	JBS? [{<JoystickID> <JoystickButton>}]	Gets the current state of a joystick button (pressed or not pressed).

Command	Syntax	Function
`JDT`	JDT {<JoystickID> <JoystickAxis> <uint>}	Specifies a default lookup table type for a joystick axis.
`JLT`	JLT <JoystickID> <JoystickAxis> <Addr> <floatn>	Fills the lookup table for a joystick axis with custom values.
`JLT?`	JLT? [<StartPoint> <NumberOfPoints> [{<JoystickID> <JoystickAxis>}]]	Gets the current valid lookup table values.

Parameters

The following parameters are available for the use of the joystick:

Parameters	Description and possible values
Invert Direction Of Motion For Joystick-Controlled Axis? 0x61	Specifies the direction of motion for joystick-controlled axes. 0 = direction of motion not inverted (default setting) 1 = direction of motion inverted

7.6.3 Controlling Axis Motion

PIMikroMove is used in the following to activate joystick control for the positioner. It is not necessary to know the corresponding GCS commands.

NOTICE

Unintentional motion while activating the joystick!

If no joystick is connected to the C-863.12, activating the joystick in the software can cause unintentional motion of the axis connected.

➢ Activate the joystick in the software only if a joystick is actually connected to the C-863.12.

INFORMATION

The use of macros provides a wide range of application possibilities for joystick control. In particular, the joystick button can be used in macros for a wide variety of applications. Details and examples of macros are found in "Controller Macros" (p. 99).

INFORMATION

The C-863.12 supports one logical axis and is therefore normally used with positioners that only have one motion axis. In this case, the designation "axis" is synonymous with "positioner". Therefore, no distinction is made between "positioner" and "axis" in the following operational instructions.

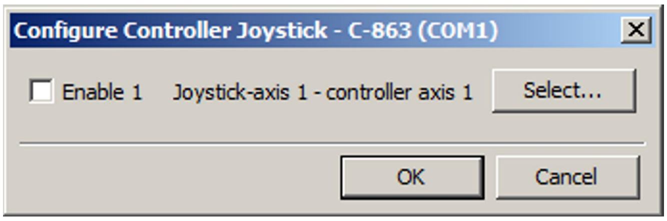
Requirements

- ✓ You have started operation of the positioner (p. 64) and initial motion with PIMikroMove.
- ✓ You have connected a joystick to the C-863.12 (p. 49).

Controlling axis motion via a joystick

1. Open the ***Configure Controller Joystick*** window in the main window of PIMikroMove via the ***C-863.12 > Configure controller joystick(s)...***menu item.

   The C-863.12 joystick and its axis are listed in the ***Configure Controller Joystick*** window.

   Configure Controller Joystick - C-863 (COM1)

   □ Enable 1 Joystick-axis 1 - controller axis 1

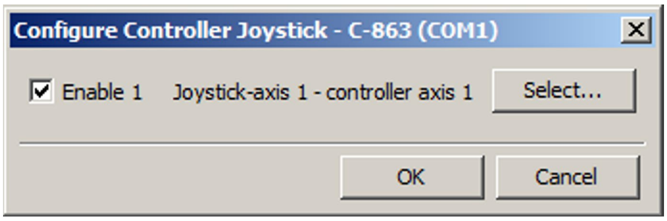
2. Assign the axis to be moved to the joystick axis:

   a) Click ***Select*** in the ***Configure Controller Joystick*** window.

   b) Mark the correct positioner name in the ***Select controller axis*** window.

   c) Click ***OK*** in the ***Select controller axis*** window to confirm selection and close the window.

3. Activate the joystick in the ***Configure Controller Joystick*** window by checking the respective ***Enable*** checkbox.

   Configure Controller Joystick - C-863 (COM1)

   ☑ Enable 1 Joystick-axis 1 - controller axis 1

   If joystick control does not operate satisfactorily or the positioner moves even though you are not moving the joystick:

   – Check whether the joystick is locked mechanically.

   – Calibrate the joystick (p. 95).

4. Control the velocity of the positioner via the joystick.

5. If you want to deactivate joystick control, remove the tick from the respective ***Enable*** checkbox in the ***Configure Controller Joystick*** window.

7.6.4 Calibrating the Joystick

Calibration of the individual joystick axes is recommended after connecting a joystick to the C-863.12 for the first time.

Calibration involves the following steps:

- If corresponding operating elements are on the joystick: Adjusting the joystick axes mechanically.
- Calibrating the joystick axes in PIMikroMove

INFORMATION

The lookup table type to be used is selected or the lookup table is filled with custom values when calibrating the joystick in PIMikroMove. To do this, a positioner does not need to be connected to the C-863.12.

Calibration is necessary for proper joystick control in the following cases:

- After activating joystick control, the positioner moves even though you are not moving the joystick.
- The response behavior of the joystick does not correspond to your requirements.
- You are using the Z axis of a C-819.30 joystick.

INFORMATION

The number of write cycles in the nonvolatile memory is restricted by the limited lifetime of the memory chip (EEPROM).

- Calibrate the joystick axes in PIMikroMove only if it is necessary.
- Contact our customer service department (p. 253) if the C-863.12 shows unexpected behavior.

INFORMATION

It is not possible to adjust the Z axis of C-819.30's joystick mechanically and it cannot be operated using the C-863.12's standard lookup table types (linear or parabolic) .

- Calibrate the Z axis of the joystick after connecting to the C-863.12 with PIMikroMove.
- Use the ***Measure Joystick Parameters and Use Custom Lookup Table*** method for calibrating the Z axis.
- Repeat calibration of the Z axis if you are connecting the Z axis to another controller.

INFORMATION

The parabolic lookup table type allows greater sensitivity at low velocity.

Adjusting a joystick axis mechanically

➢ Check whether the positioner moves when joystick control is activated even though you are not moving the joystick.

If so:

- Check whether the joystick is locked mechanically and unlock if necessary.
- Keep the affected joystick axis (that means for example, the control lever) at the center position and adjust it with the appropriate operating elements until the positioner no longer moves. With the C-819.20 and C-819.30 joysticks, turn the corresponding rotary knob for adjustment (p. 97).

If not:

- Check whether the response behavior of the joystick corresponds to your requirements.

  If so:

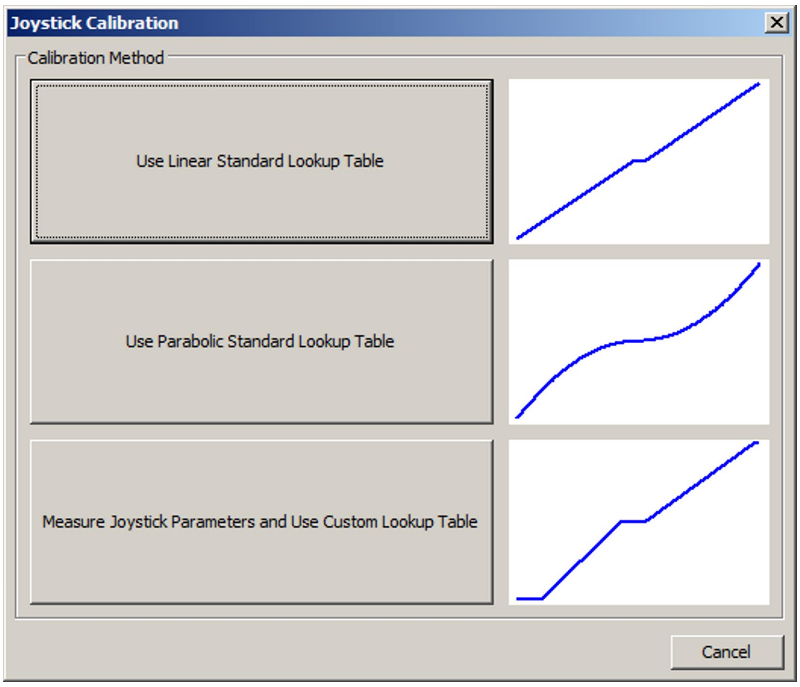
  – The calibration is finished.

  If not:

  – Calibrate the joystick axis in PIMikroMove.

Calibrating the joystick axis in PIMikroMove

1. Open the ***Joystick Calibration*** window in the main window of PIMikroMove via the ***C-863.12 > Calibrate controller joystick…*** menu item.


Joystick Calibration
Calibration Method
Use Linear Standard Lookup Table
Use Parabolic Standard Lookup Table
Measure Joystick Parameters and Use Custom Lookup Table
Cancel

2. Select the calibration method by clicking on the appropriate button:

   – If you want to use the linear lookup table type for the joystick axis, click ***Use Linear Standard Lookup Table***. With this, the appropriate lookup table type is loaded and the calibration is finished.

   – If you want to use the parabolic lookup table type for the joystick axis, click ***Use Parabolic Standard Lookup Table***. With this, the appropriate lookup table type is loaded and the calibration is finished.

- If you have connected the Z axis of a C-819.30 joystick or generally want to map the behavior of the joystick in an individual lookup table, click ***Measure Joystick Parameters and Use Custom Lookup Table***. Here the ***Controller Joystick Calibration*** window opens.

3. When the ***Controller Joystick Calibration*** window has opened, follow the instructions in this window.

   The custom lookup table values are determined in this way.

   By clicking on ***OK***, you load the lookup table values into the nonvolatile memory of the C-863.12. Calibration is now finished.

7.6.5 Joysticks Available

PI provides the joysticks described in the following as optional accessories (p. 10).

Analog C-819.20 joystick, 2 axes

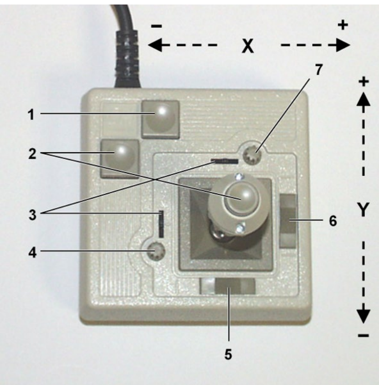


Figure 21: C-819.20 joystick

1	Pushbutton for the X axis
2	Pushbutton for the Y axis
3	Adjustment indicator
4	Rotary knob for adjustment of the Y axis (calibration)
5	X axis lock
6	Y axis lock
7	Rotary knob for adjustment of the X axis (calibration)

C-819.30 analog joystick, 3 axes

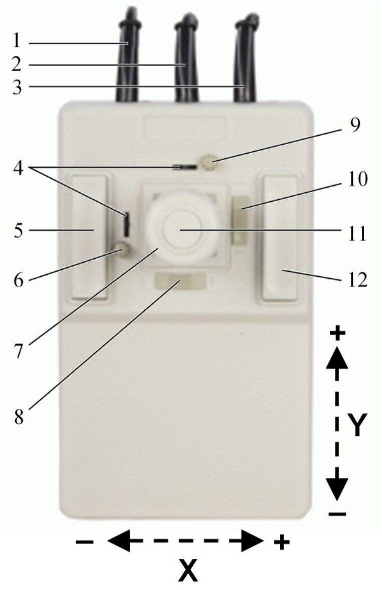


Figure 22: C-819.30 joystick

1	Cable for the Z axis
2	Cable for the Y axis
3	Cable for the X axis
4	Adjustment indicator
5	Pushbutton for the Y axis
6	Rotary knob for adjustment of the Y axis (calibration)
7	XY control lever with rotary knob for Z axis
8	X axis lock
9	Rotary knob for adjustment of the X axis (calibration)
10	Y axis lock
11	Pushbutton for the Z axis
12	Pushbutton for the X axis

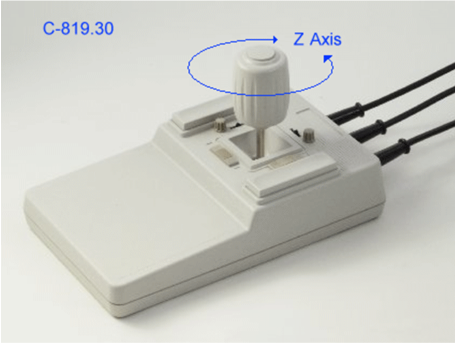


Figure 23: C-819.30 joystick, rotary knob for the Z axis

7.7 Controller Macros

7.7.1 Overview: Macro Functionality and Example Macros

The C-863.12 can save and process command sequences as macros.

The following functionalities make macros an important tool in many application areas:

- Several macros can be saved at the same time.
- Any macro can be defined as the startup macro. The startup macro runs each time the C-863.12 is switched on or rebooted.
- Processing and stopping a macro can be linked to conditions. This makes loops possible.
- Macros can call up themselves or other macros.
- Variables (p. 120) can be set for the macro and in the macro itself and used in different operations.
- Input signals can be evaluated for conditions and variables.

You will find example macros in this manual for the following tasks:

- Moving an axis back and forth (p. 103)
- Recording a macro for a controller whose address is different to 1 (p. 104)
- Moving an axis with a variable travel range back and forth (p. 106)
- Implementing multiple calls of a macro via a loop (p. 107)
- Preparing an axis for operation via a startup macro (p. 108)
- Synchronizing two controllers (p. 110)
- Stopping motion by pushbutton (p. 111)
- Joystick control with storage of positions (p. 112)
- Joystick control with change in velocity (p. 115)

7.7.2 Commands and Parameters for Macros

Commands

The following commands are available specifically for handling macros or for use in macros:

Command	Syntax	Function
ADD (p. 131)	ADD <Variable> <FLOAT1> <FLOAT2>	Adds two values and saves the result to a variable (p. 120). Can only be used for local variables in macros.
CPY (p. 136)	CPY <Variable> <CMD?>	Copies a command response to a variable (p. 120). Can only be used for local variables in macros.
DEL (p. 142)	DEL <uint>	Can only be used in macros. Delays <uint> milliseconds.
JRC (p. 167)	JRC <Jump> <CMD?> <OP> <Value>	Can only be used in macros. Triggers a relative jump of the macro execution pointer depending on a condition.
MAC (p. 169)	MAC BEG <macro name>	Starts the recording of a macro with the name *macro name* on the controller. *macro name* can consist of up to 8 characters.
	MAC DEF <macro name>	Defines the specified macro as the startup macro.
	MAC DEF?	Gets the startup macro.
	MAC DEL <macro name>	Deletes the specified macro.
	MAC END	Ends the macro recording.
	MAC ERR?	Reports the last error that occurred while the macro was running.
	MAC NSTART <macro name> <uint> [<String1> [<String2>]]	Starts the specified macro n times in succession (n = number of times). The values of local variables can be set for the macro with <String1> and <String2>.
	MAC START <macro name> [<String1> [<String2>]]	Runs the specified macro. The values of local variables can be set for the macro with <String1> and <String2>.
MAC? (p. 172)	MAC? [<macro name>]	Lists all macros or the content of a specified macro.
MEX (p. 174)	MEX <CMD?> <OP> <Value>	Can only be used in macros. Stops the macro execution depending on a condition.
RMC? (p. 180)	RMC?	Lists macros which are currently running.
VAR (p. 197)	VAR <Variable> <String>	Sets a variable (p. 120) to a certain value or deletes it. Can only be used for local variables in macros.

Command	Syntax	Function
VAR? (p. 199)	VAR? [{<Variable>}]	Gets variable values.
WAC (p. 200)	WAC <CMD?> <OP> <Value>	Can only be used in macros. Waits until a condition is met.
#8 (p. 129)	-	Tests if a macro is running on the controller.

Parameters

The following parameter is available for working with macros:

Parameters	Description and Possible Values
Ignore Macro Error? 0x72	Determines whether the controller macro is stopped if an error occurs when it is running. ▪ 0 = Stop macro when error occurs (default) ▪ 1 = Ignore error

7.7.3 Working with Macros

Work with macros comprises the following:

- Recording macros (p. 101)
- Starting macros (p. 105)
- Stopping macros (p. 107)
- Configuring a startup macro (p. 107)
- Deleting macros (p. 108)

INFORMATION

It is recommended to use the ***Controller macros*** tab in PIMikroMove when working with controller macros. There you can record, start, and manage controller macros easily. Refer to the PIMikroMove manual for details.

Recording a macro

INFORMATION

The C-863.12 can save up to 32 macros simultaneously. A maximum of 5 nesting levels are possible in macros.

INFORMATION

Basically all GCS commands (p. 117) can be included in a macro. Exceptions:

- `RBT` for rebooting the C-863.12
- `MAC BEG` and `MAC END` for macro recording
- `MAC DEL` for deleting a macro

Query commands can be used in macros in conjunction with the `CPY`, `JRC`, `MEX`, and `WAC` commands. Otherwise they have no effect, since macros do not send any responses to interfaces.

INFORMATION

If you record a macro on a C-863.12 whose controller address is different to 1, note the following when entering the commands that are to be an element of the macro:

- If you are working with PITerminal and have established communication with the ***Connect…*** button, the target address has to be typed in in every command line.
- If you are working with PIMikroMove or have established communication with PITerminal using the ***GCS DLL…*** button, the target address is automatically sent and may not be typed in.

INFORMATION

To make the use of macros more flexible, you can use local and global variables in macros. For further information, see "Variables" (p. 120).

INFORMATION

The number of write cycles in the nonvolatile memory is restricted by the limited lifetime of the memory chip.

➢ Only record macros if it is necessary.

➢ Use variables (p. 120) in macros to make macros more flexible, and give the corresponding variable values when starting macro execution.

➢ Contact our customer service department (p. 253) if the C-863.12 shows unexpected behavior.

INFORMATION

A macro is overwritten if a macro with the same name is re-recorded.

1. Start the macro recording.

   – If you are working with PITerminal or in the ***Command entry*** window of PIMikroMove: Send the `MAC BEG macroname` command, where *macro name* indicates the name of the macro.

   - If you are working in PIMikroMove on the ***Controller macros*** tab: Click the ***Create new empty macro*** icon to create a tab for entering a new macro. Do **not** enter the `MAC BEG macroname` command.

2. Enter the commands to be included in the *macro name* macro line by line, using the normal command syntax.

   Macros can call up themselves or other macros in several nesting levels.

3. End the macro recording.

   - If you are working with PITerminal or in the ***Command entry*** window of PIMikroMove: Send the `MAC END` command.
   - If you are working in PIMikroMove on the ***Controller macros*** tab: Do **not** enter the `MAC END` command. Click the ***Send macro to controller*** icon and enter the name of the macro in a separate dialog window.

   The macro has been stored in the nonvolatile memory of the C-863.12.

4. If you want to check whether the macro has been correctly recorded:

   If you are working with PITerminal or in the ***Command entry*** window of PIMikroMove:

   - Get which macros are saved in the C-863.12 by sending the `MAC?` command.
   - Get the contents of the *macro name* macro by sending the `MAC? macroname` command.

   If you are working in PIMikroMove on the ***Controller macros*** tab:

   - Click the ***Read list of macros from controller*** icon.
   - Mark the macro to be checked in the list on the left-hand side and click the ***Load selected macro from controller*** icon.

Example: Moving an axis back and forth

INFORMATION

When macros are recorded on the ***Controller macros*** tab in PIMikroMove, the commands `MAC BEG` and `MAC END` must be left out.

The axis 1 is to move back and forth. For this purpose, 3 macros are recorded. Macro 1 starts motion in a positive direction and waits until the axis has reached the target position. Macro 2 does this task for the negative direction of motion. Macro 3 calls up macro 1 and 2.

➢ Record the macros by sending:

```
MAC BEG macro1
MVR 1 12.5
WAC ONT? 1 = 1
MAC END
MAC BEG macro2
MVR 1 -12.5
```

```
WAC ONT? 1 = 1
MAC END
MAC BEG macro3
MAC START macro1
MAC START macro2
MAC END
```

Example: Recording macro for controller whose address is different from 1

INFORMATION

When macros are recorded on the ***Controller macros*** tab in PIMikroMove, the commands `MAC BEG` and `MAC END` must be left out.

The controller address is set to 2 via the DIP switches. In this example, macro recording is done using PITerminal, whereby communication was established with the ***Connect…*** button (as a result, the target address has to be typed in in every command line).

The servo mode is to be switched on for axis 1 via the ref macro and a referencing move to the reference switch is to be started.

1. Record the macro by sending:

   ```
   2 MAC BEG ref
   2 SVO 1 1
   2 DEL 1000
   2 FRF 1
   2 MAC END
   ```

2. Check the content of the ref macro by sending:

   ```
   2 MAC? ref
   ```

   The response reads:

   ```
   0 2 SVO 1 1
   DEL 1000
   FRF 1
   ```

   The first line of the response contains the target and sender address corresponding to the GCS syntax for multiline responses. However, the target address is not included in the macro.

Starting a macro

INFORMATION

Any commands can be sent from the command line when a macro is running on the controller. The macro content and motion commands received from the command line can overwrite each other.

INFORMATION

It is not possible to run several macros simultaneously. Only one macro can be run at a time.

INFORMATION

You can link the macro execution to conditions with the `JRC` and `WAC` commands. The commands must be included in the macro.

In the following, PITerminal or the ***Command entry*** window of PIMikroMove is used to enter commands. Details on working with the ***Controller macros*** tab in PIMikroMove are in the PIMikroMove manual.

1. If the macro is to continue running despite an error:
   - Set the ***Ignore Macro Error?*** parameter (ID 0x72) correspondingly: Send the `SPA 1 0x72 Status` command, whereby *Status* can have the value 0 or 1 (0 = Stop macro when error occurs (default); 1 = Ignore macro error).

   Further information on changing parameters can be found in "Adapting Settings" (p. 227).
2. Start the macro:
   - If the macro is to be run once, send the `MAC START macroname string` command, whereby *macroname* indicates the name of the macro.
   - If the macro is to be run n times, send the `MAC NSTART macroname n string` command, whereby *macroname* indicates the name of the macro and *n* indicates the number of runs.

   string stands for the values of local variables. The values only have to be specified when the macro contains corresponding local variables. The sequence of the values in the input must correspond to the numbering of the appropriate local variables, starting with the value of local variable 1. The individual values must be separated from each other by spaces.
3. If you want to check whether the macro is running:
   - Query whether a macro is running on the controller by sending the `#8` command.
   - Query the name of the macro that is currently running on the controller by sending the `RMC?` command.

Example: Moving an axis with a variable travel distance back and forth

INFORMATION

When macros are recorded on the ***Controller macros*** tab in PIMikroMove, the commands `MAC BEG` and `MAC END` must be left out.

The axis 1 is to move back and forth. The travel to the left and to the right is to be variably adjustable without having to change the used macros. Local and global variables are therefore used.

1. Create the global variables LEFT and RIGHT by sending:

   ```
   VAR LEFT 5
   VAR RIGHT 15
   ```

   LEFT therefore has the value 5, and RIGHT has the value 15. These values can be changed at any time, e.g., by sending the `VAR` command again.

   – Create the global variables again each time the C-863.12 is switched on or rebooted, since they are only written to the volatile memory of the C-863.12.

2. Record the MOVLR macro by sending:

   ```
   MAC BEG movlr
   MAC START movwai ${LEFT}
   MAC START movwai ${RIGHT}
   MAC END
   ```

   MOVLR successively starts the MOVWAI macro (which is still to be recorded) for both directions of motion. The values of the global variables LEFT and RIGHT are used when MOVWAI is started, to set the value of the local variable 1 contained in MOVWAI (dollar signs and braces are necessary for the local variable 1 in the macro to actually be replaced by the *value* of the global variable and not by its *name*).

3. Record the MOVWAI macro by sending:

   ```
   MAC BEG movwai
   MOV 1 $1
   WAC ONT? 1 = 1
   MAC END
   ```

   MOVWAI moves axis 1 to the target position which is specified by the value of the local variable 1 and waits until the axis has reached the target position.

4. Run the MOVLR macro by sending:

   ```
   MAC NSTART movlr 5
   ```

   The MOVLR macro is executed five times in succession, i.e., axis 1 alternately moves to the positions 5 and 15 five times. You can also select any other value for the number of executions.

Example: Implementing multiple calls of a macro via a loop

INFORMATION

When macros are recorded on the ***Controller macros*** tab in PIMikroMove, the commands `MAC BEG` and `MAC END` must be left out.

The TESTDION macro checks the status of the digital input lines on the **I/O** socket. It uses a local variable to identify the digital input line (1 to 4). So that the TESTDION macro does not have to be called separately for each input line, another macro with a loop is recorded.

- ➢ Record the LOOPDION macro by sending:

```
MAC BEG loopdion
VAR COUNTER 1
MAC START TESTDION ${COUNTER}
ADD COUNTER ${COUNTER} 1
JRC -2 VAR? COUNTER < 5
MAC END
```

The COUNTER variable is created with the value 1. After this, the TESTDION macro is started for the input line whose identifier is specified via the COUNTER variable. Then the value of the COUNTER is increased by 1. As long as the value of the COUNTER is less than 5, the macro execution pointer subsequently jumps two lines back, so that the TESTDION is now started for the next digital input line.

Stopping a macro

INFORMATION

You can link the stopping of the macro execution to a condition with the `MEX` command. The command must be included in the macro.

In the following, PITerminal or the ***Command entry*** window of PIMikroMove is used to enter commands. Details on working with the ***Controller macros*** tab in PIMikroMove are in the PIMikroMove manual.

- ➢ Stop the macro execution with the `#24` or `STP` commands.
- ➢ If you want to check whether an error has occurred during macro execution, send the `MAC ERR?` command. The response shows the last error that occurred.

Configuring a startup macro

Any macro can be defined as the startup macro. The startup macro is executed each time the C-863.12 is switched on or rebooted.

INFORMATION

Deleting a macro does not delete its selection as a startup macro.

In the following, PITerminal or the ***Command entry*** window of PIMikroMove is used to enter commands. Details on working with the ***Controller macros*** tab in PIMikroMove are in the PIMikroMove manual.

- Define a macro as the startup macro with the `MAC DEF macroname` command, whereby *macroname* indicates the name of the macro.
- If you want to cancel the selection of the startup macro and do not want to define another macro as the startup macro, only send `MAC DEF`.
- Get the name of the currently defined startup macro by sending the `MAC DEF?` command.

Example: Preparing an axis for operation via a startup macro

INFORMATION

When macros are recorded on the ***Controller macros*** tab in PIMikroMove, the commands `MAC BEG` and `MAC END` must be left out.

The STARTCL macro switches joystick control off and the servo mode on for axis 1 and starts a referencing move to the negative limit switch. As STARTCL is defined as the startup macro, axis 1 is ready for closed-loop operation immediately after switch-on.

- Send:

```
MAC BEG startcl
JON 1 0
SVO 1 1
DEL 1000
FNL 1
MAC END
MAC DEF startcl
```

INFORMATION

When this macro is used, the parameter settings of the C-863.12's parameter settings should be adapted to the connected positioner in the nonvolatile memory. Alternatively, the parameter settings can also be configured in the volatile memory via the startup macro. For further information, see "Adapting Settings" (p. 227).

Deleting a macro

INFORMATION

A macro cannot be deleted while it is running.

In the following, PITerminal or the ***Command entry*** window of PIMikroMove is used to enter commands. Details on working with the ***Controller macros*** tab in PIMikroMove are in the PIMikroMove manual.

- Delete a macro with the `MAC DEL macroname` command, whereby *macro name* indicates the name of the macro.

7.7.4 Making Backups and Loading Controller Macros

For example, making backups of controller macros on the PC can be useful before updating the firmware (p. 245).

INFORMATION

The use of the ***Controller macros*** tab in PIMikroMove is recommended for backing up and loading controller macros. A detailed description of the tab can be found in the PIMikroMove manual.

Backing up controller macros onto the PC with PIMikroMove

1. Select the ***Controller macros*** tab in the PIMikroMove main window.
2. Select the macros in the ***Macros on controller*** list that you want to back up to the PC:
   – Click the desired entry in the list to select an macro.
   – To select several macros, hold down the Shift button and click the desired entries in the list.
   – To deselect, click an empty area in the list.

   By selecting one or more macros, the (*Save selected macros to PC*) button becomes active.
3. Save the selected macros on the PC:
   a) Click the button to open a directory selection window.
   b) Select the directory on the PC where you want to save the macros.
   c) Click ***Save***.

   The macros are saved as text files (<macro name>.txt) to the directory selected on the PC.

Loading controller macros from the PC to the C-863.12 with PIMikroMove

1. Select the ***Controller macros*** tab in the PIMikroMove main window.
2. Load macros from the PC to the C-863.12:
   a) Click the button to open a file selection window.
   b) Select the text files (<macro name>.txt) in the file selection window whose contents you want to load as a macro from the PC to the C-863.12.
   c) Click ***Open***.

For each selected text file (<macro name>.txt), the content is loaded as a macro <macro name> into the C-863.12.

7.7.5 Macro Example: Synchronization of Two Controllers

INFORMATION

When macros are recorded on the ***Controller macros*** tab in PIMikroMove, the commands `MAC BEG` and `MAC END` must be left out.

Action	Command	Result
Connect the digital output line 1 on the **I/O** socket of the master controller to digital input line 1 on the **I/O** socket of the slave controller.	- Use a suitable cable. Pin assignment see "I/O" (p. 260).	The digital output signal of the master controller can be used as the trigger for the motion of the axis connected to the slave controller.

Set up the motion on the master controller and on the slave controller.	`SVO 1 1`
	`FRF 1 1`
	`VEL 1 0`
	`MOV 1 5.5`
		For both controllers: The servo mode is switched on and the axis has executed a referencing move – here to the reference switch. The velocity is set to zero. The axis does not move for now as a result, even though the motion command for the move to absolute position 5.5 has already been sent.

Record the MASTER macro on the master controller.	`MAC BEG master`
	`DIO 1 1`
	`VEL 1 100`
	`MAC END`
		The macro has the following tasks:
		▪ Switch the digital output line 1 of the master controller to high state to trigger the slave controller
		▪ Set velocity to 100 to start the motion

Record the SLAVE macro on the slave controller.	`MAC BEG slave`
	`WAC DIO? 1 = 1`
	`VEL 1 100`
	`MAC END`
		The macro has the following tasks:
		▪ Set condition: The macro continues only if digital input line 1 has the high state (i.e., if the master controller outputs the trigger signal).
		▪ Set velocity to 100 to start the motion

Start the SLAVE macro on the slave controller.	`MAC START slave`	The axis on the slave controller is still not moving because the condition for further macro execution has not yet been met.
Start the MASTER macro on the master controller.	`MAC START master`	Both axes are moving because their velocity is now each different from zero. The motion occurs synchronously.

7.7.6 Macro Example: Stopping Motion by Pushbutton

INFORMATION

You can connect the C-170.PB pushbutton box from PI to the **I/O** socket to generate the digital input signals for use in macros. It also displays the state of the digital output lines via LEDs.

INFORMATION

When macros are recorded on the ***Controller macros*** tab in PIMikroMove, the commands `MAC BEG` and `MAC END` must be left out.

Action	Command	Result
Connect digital input line 1 on the **I/O** socket to an appropriate signal source.	- Pin assignment see "I/O" (p. 260).	For example,the digital input signal can be used for a conditional jump of the macro pointer.

Record the HALT macro on the controller.	`MAC BEG halt`
	`MVR 1 5`
	`JRC 2 DIO? 1 = 1`
	`JRC -1 ONT? 1 = 0`
	`HLT 1`
	`MAC END`
		The macro has the following tasks:
		▪ Start relative motion of axis 1
		▪ Set a condition: If digital input line 1 has the high state (when using the pushbutton box: button 1 is pressed), the macro execution pointer jumps two lines forward. This stops the axis. Otherwise macro execution is continued with the next line.
		▪ Set condition: The macro execution pointer jumps back one line as long as axis 1 has not yet reached the target position. A loop is established as a result.

Run the HALT macro on the controller.	`MAC START halt`	Axis 1 starts to move. It is stopped by switching digital input line 1 to the high state (e.g., by pushbutton). Irrespective of whether the axis has reached the target position or was halted previously, the error code is set to 10 via the `HLT` command.

If error code 10 interferes: Record alternative HALTVAR macro which uses a variable. Details see "Variables" (p. 120).	`MAC BEG haltvar`
	`MVR 1 5`
	`JRC 2 DIO? 1 = 1`
	`JRC -1 ONT? 1 = 0`
	`CPY TARGET POS? 1`
	`MOV 1 ${TARGET}`
	`VAR TARGET`
	`MAC END`
		The macro has the same tasks as the HALT macro. However, axis 1 is not stopped by pushbutton via the `HLT` command; instead the result of the `POS? 1` query is copied to the TARGET variable. Then this variable is used as the target position for the `MOV` command. As a result, the axis stays right where it was. To clean up, TARGET is defined as empty with the `VAR` command which deletes the variable.

Start the HALTVAR macro on the	`MAC START haltvar`	Axis 1 starts to move. It is stopped by switching digital input line 1 to the high state (e.g., by pushbutton). Error code 10 is not set because no halt or stop

Action	Command	Result
controller.		command is used.

7.7.7 Macro Example: Joystick Control with Storage of Positions

Task:

Axis 1 is to be controlled with a joystick. Joystick control is to be activated only when the joystick button is pressed at the same time. By using the buttons of a connected pushbutton box, in addition up to four positions are to be stored in the controller or approached by the axis. The LEDs of the pushbutton box should indicate whether the controller is ready to save the current position and whether it has been saved.

Approach:

The STARTUP, MAINLOOP, TESTJOYB, TESTDION, and MVAX2ST macros are recorded on the controller. They use the global variables STORE1, STORE2, STORE3, STORE4, COUNTER, and the local variables 1 and 2.

INFORMATION

When macros are recorded on the ***Controller macros*** tab in PIMikroMove, the commands `MAC BEG` and `MAC END` must be left out.

Action	Command	Result
Connect C-170.PB pushbutton box from PI to the **I/O** socket.	-	Digital input lines 1 to 4 are switched to high state as long as the respective button is pressed. The states of digital output lines 1 to 4 are indicated by the LEDs which are integrated in the buttons.
Connect C-819.20 or C-819.30 joystick to the **Joystick** socket.	-	For commands, the joystick axis connected is accessible as axis 1 of joystick 1 and the joystick button is accessible as button 1 of joystick 1.
Switch on servo mode for axis 1.	`SVO 1 1`	The servo mode must be switched on, so that axis 1 can be controlled via a joystick.
Start referencing move for axis 1.	`FRF 1`	The axis starts a referencing move – here to the reference switch. After this, absolute axis positions can be commanded.
Specify which axis is to be controlled via the joystick axis.	`JAX 1 1 1`	Axis 1 is assigned to joystick axis 1 of joystick 1. Joystick control is not yet active.

Record the STARTUP macro on the controller.	`MAC BEG startup`
	`CPY STORE1 POS? 1`
	`CPY STORE2 POS? 1`
	`CPY STORE3 POS? 1`
	`CPY STORE4 POS? 1`
		The macro has the following tasks:
		▪ Initialize variables for storing the position
		▪ Start MAINLOOP macro for the main loop

Action	Command	Result

	`MAC START MAINLOOP`
	`MAC END`	

Record the MAINLOOP macro on the controller.	`MAC BEG mainloop`
	`MAC START TESTJOYB`
	`VAR COUNTER 1`
	`MAC START TESTDION ${COUNTER}`
	`ADD COUNTER ${COUNTER} 1`
	`JRC -2 VAR? COUNTER < 5`
	`MAC START MAINLOOP`
	`MAC END`
		The macro has the following tasks:
		▪ Start TESTJOYB macro for joystick control
		▪ Start TESTDION macro successively for all digital inputs (i.e., every button on the pushbutton box), using a loop
		▪ Call itself to set up the main loop

Record the TESTJOYB macro on the controller.	`MAC BEG testjoyb`	The macro has the following tasks:
	`MEX JBS? 1 1 = 0`	▪ Stop macro execution if joystick button 1 is not pressed
	`JON 1 1`	▪ Activate joystick 1
	`DIO 0 15`	▪ Switch on all LEDs on the pushbutton box
	`JRC 6 JBS? 1 1 = 0`	▪ Jump forward 6 lines (to JON 1 0), if joystick button 1 is no longer pressed
	`DEL 50`	▪ Wait 50 ms
	`DIO 0 0`	▪ Switch off all LEDs on the pushbutton box
	`JRC 3 JBS? 1 1 = 0`	▪ Jump forward 3 lines (to JON 1 0), if joystick button 1 is no longer pressed
	`DEL 50`	▪ Wait additional 50 ms
	`JRC -6 JBS? 1 1 = 1`	▪ Jump back 6 lines (to DIO 0 15), if joystick button 1 is still pressed
	`JON 1 0`	▪ Deactivate joystick 1
	`DIO 0 0`	▪ Switch all LEDs on the pushbutton box off
	`MAC END`	
Record the TESTDION macro on the controller.	`MAC BEG testdion`	The macro has the following tasks:
	`MEX VAR? 0 != 1`	▪ Stop macro execution if the number of local variables given when starting TESTDION is not 1
	`MEX DIO? $1 = 0`	▪ Stop macro execution if the button specified via local variable 1 on the pushbutton box is no longer pressed (corresponding input line has the low state)

Action	Command	Result
	`DEL 300`	▪ Wait 300 ms
	`JRC 3 DIO? $1 = 1`	▪ If the button is still pressed, jump 3 lines forward (to `DEL 400`)
	`MAC START MVAX2ST $1`	▪ Start the MVAX2ST macro because the button was only briefly pressed. The value of the local variable 1 is also used for local variable 1 in MVAX2ST. MVAX2ST moves axis 1 to the position assigned for the button.
	`MEX DIO? $1 = 0`	▪ Stop macro execution if button is no longer pressed
	`DEL 400`	▪ Wait 400 ms
	`MEX DIO? $1 = 0`	▪ Stop macro execution if button is no longer pressed
	`DIO $1 1`	▪ Switch the pushbutton box LED on that is associated with the button pressed to indicate storing of the current position
	`WAC DIO? $1 = 0`	▪ The macro is executed further only if the button is no longer pressed
	`DIO $1 0`	▪ Switch LED off
	`CPY STORE$1 POS? 1`	▪ Save the current position of axis 1 in the global variable designated via local variable 1
	`MAC END`	
Record the MVAX2ST macro on the controller.	`MAC BEG MVAX2ST`	The macro has the following tasks:
	`CPY 2 VAR? STORE$1`	▪ Get the storage variable designated via local variable 1 and copies its value to local variable 2
	`MOV 1 $2`	▪ Start motion of axis 1 to the target position specified via local variable 2
	`MAC END`	
Start the STARTUP macro on the controller. Alternative: If the variables for storing positions are not to be initialized, start the MAINLOOP macro on the controller instead.	`MAC START startup`	Joystick control is activated by pressing the joystick button. When joystick control is activated, the pushbutton box LEDs flash rapidly and therefore indicate that the box buttons should not be pressed. After releasing the joystick button, joystick control is deactivated and the LEDs switch themselves off. The pushbutton box can now be used for moving to the saved positions or for saving the current position. The respective button on the pushbutton box is pressed briefly to move the positioner to a stored position. To store the current position of the positioner, a

Action	Command	Result
		button is pressed on the pushbutton box until the button LED lights up.

7.7.8 Macro Example: Joystick Control with Change in Velocity

INFORMATION

When macros are recorded on the ***Controller macros*** tab in PIMikroMove, the commands `MAC BEG` and `MAC END` must be left out.

Action	Command	Result
Connect C-819.20 or C-819.30 joystick to the **Joystick** socket.	-	For commands, the joystick axis connected is accessible as axis 1 of joystick 1 and the joystick button is accessible as button 1 of joystick 1.
Switch on servo mode for axis 1.	`SVO 1 1`	The servo mode must be switched on, so that axis 1 can be controlled via a joystick.
Start referencing move for axis 1.	`FRF 1`	The axis starts a referencing move – here to the reference switch. After this, absolute axis positions can be commanded.
Specify which axis is to be controlled via the joystick axis.	`JAX 1 1 1`	Axis 1 is assigned to joystick axis 1 of joystick 1. Joystick control is not yet active.
Record the JOYVEL macro on the controller.	`MAC BEG joyvel`	The macro has the following tasks:
	`JON 1 1`	▪ Activate joystick 1
	`JRC 3 JBS? 1 1 = 1`	▪ If joystick button 1 is pressed, jump 3 lines forward (to `VEL 1 1`).
	`VEL 1 0.5`	▪ Maximum velocity during joystick control is 0.5.
	`JRC -2 JBS? 1 1 = 0`	▪ If joystick button 1 is not pressed, jump 2 lines back to set up a loop.
	`VEL 1 1`	▪ Maximum velocity during joystick control is 1.
	`JRC -4 JON? 1 = 1`	▪ If joystick 1 is still active, jump 4 lines back to set up a loop.
	`MAC END`	
Start the JOYVEL macro on the controller.	`MAC START joyvel`	Motion with low velocity: Move the joystick control lever. Motion with high velocity: Keep pushbutton 1 of the joystick pressed and move the control lever.

8 GCS Commands

8.1 Notation

The following notation is used to define the GCS syntax and to describe the commands:

<...> Angle brackets indicate an argument of a command, can be an element identifier or a command-specific parameter.

[...] Square brackets indicate an optional entry.

{...} Curly brackets indicate a repetition of entries, i.e., it is possible to access more than one element (e.g., several axes) in one command line.

LF LineFeed (line feed, ASCII character 10), is the default termination character (character at the end of a command line).

SP Space (ASCII character 32) indicates a space.

"..." Quotation marks indicate that the characters enclosed are returned or to be entered.

8.2 GCS Syntax for Syntax Version 2.0

A GCS command consists of 3 characters, e.g., CMD. The corresponding query command has a question mark at the end, e.g., CMD?

Command mnemonic:

CMD ::= character1 character2 character3 [?]

Exceptions:

- Single-character commands, e.g., fast query commands, consist only of one ASCII character. The ASCII character is written as combination of # and the character code in decimal format, e.g., as `#24`.
- `*IDN?` (for GPIB compatibility).

The command mnemonic is not case-sensitive. The command mnemonic and all arguments (e.g., axis identifiers, channel identifiers, parameters, etc.) must be separated from each other by a space (SP). The command line has to be terminated with a line feed (LF).

CMD[{{SP}<Argument>}]LF

CMD?[{{SP}<Argument>}]LF

Exception:

- Single-character commands are not followed by a termination character. However, the response to a single-character command is followed by a termination character.

The argument <AxisID> is used for the logical axes of the controller. Depending on the controller, an axis identifier can consist of up to 16 characters. All alphanumeric characters and the underscore are allowed. Refer to "Commandable Elements" (p. 17) for the identifiers supported by the C-863.12.

Example 1:

Axis 1 is to be moved to position 10.0. The unit depends on the controller (e.g., µm or mm).

Send: `MOV`SP`1`SP`10.0`LF

More than one command mnemonic per line is not allowed. Several groups of arguments following a command mnemonic are allowed.

Example 2:

Two axes connected to the same controller are to be moved:

Send: `MOV`SP`1`SP`17.3`SP`2`SP`2.05`LF

When a part of a command line cannot be executed, the line is not executed at all.

When all arguments are optional and are not specified, the command is executed for all possible argument values.

Example 3:

All parameters in the volatile memory are to be reset.

Send: `RPA`LF

Example 4:

The position of all axes is to be queried.

Send: `POS?`LF

The response syntax is as follows:

[<Argument>[{SP<Argument>}]"="]<Value>LF

With multi-line replies, the space preceding the termination character is left out of the last line:

{[<Argument>[{SP<Argument>}]"="]<Value>SPLF}

[<Argument>[{SP<Argument>}]"="]<Value>LF for the last line!

The arguments are listed in the response in the same order as in the query command.

Query command:

CMD?SP<Arg3>SP<Arg1>SP<Arg2>LF

Response to this command:

<Arg3>"="<Val3>SPLF

<Arg1>"="<Val1>SPLF

<Arg2>"="<Val2>LF

Example 5:

Send: `TSP?`SP`2`SP`1`LF

Receive: `2=-1158.4405`SPLF

`1=+0000.0000`LF

INFORMATION

With the C-863.12 only a single element per command line can be addressed (e. g. axis or parameter).
Example:
By sending command line

```
SEP 100 1 0x32 0
```

a new value of parameter 0x32 is saved in nonvolatile memory for axis 1,
sending command line

```
SEP 100 1 0x32 0 1 0x14 1
```

is not possible, however, because two parameters are to be changed.

If the command supports this, all elements can be addressed by omitting the element identifier.
Example:
By sending command line

```
SEP?
```

all parameters from the nonvolatile memory are queried.

8.3 Target and Sender Address

In principle, the addresses of the target controller and the sender are required in every command line. This applies even to single-character commands like #4 or to macro recording. Because only the PC may send command lines to the controllers, its address (0) does not need to be specified. However, both target and sender address are part of any controller response. Multiline responses contain the target and sender address in the first line

Example:

In a terminal, e.g., PITerminal, the identification string of a controller with address 2 (here: a C-863.11) is queried using the *IDN? command.

Send: `2 0 *IDN?`

or

Send: `2 *IDN?`

The response in either case is:

```
0 2 (c)2011 Physik Instrumente(PI) Karlsruhe, C-863.11,0,1.2.0.0
```

Exception:

The target address can be omitted if the target controller has the address 1, even if this controller is part of a daisy chain. If the target address is not specified when addressing a controller, the target and sender addresses will also not be specified in the response from the controller.

Example:

Send: `*IDN?`

The controller with address 1 (here: a C-863.11) responds with:

```
(c)2011 Physik Instrumente(PI) Karlsruhe, C-863.11,0,1.2.0.0
```

Send: `1 *IDN?`

The same controller responds with:

```
0 1 (c)2011 Physik Instrumente(PI) Karlsruhe, C-863.11,0,1.2.0.0
```

See "Adapting DIP Switch Settings" (p. 53) on how to set the controller address. The controller address can be in the range of 1 to 16, address 1 is default. The PC always has the address 0. With the broadcast address 255, all controllers in a daisy chain can be addressed at the same time, but no responses are sent to the PC.

8.4 Variables

For more flexible programming, the C-863.12 supports variables. While global variables are always available, local variables are only valid for a specified macro. Typically, variables are used when working with macros.

Variables are present in volatile memory (RAM) only. The variable values are of the STRING data type.

The following conventions apply to variable names:

- Variable names may not contain special characters (especially not “$”).
- The maximum number of characters is 8.

- Names of global variables can consist of characters A to Z and 0 to 9. They must start with an alphabetic character.
- Names of local variables may not contain alphabetic characters. Possible characters are 0 to 9.
- The variable name can also be specified via the value of another variable.

If the value of a variable is to be used, the notation must be as follows:

- The variable name must be preceded by the dollar sign ($).
- Variable names consisting of multiple characters must be put in braces.

If the variable name consists of a single character, the braces can be left out.

Note that if the braces are left out of variable names consisting of multiple characters, the first character after the “$” is interpreted as the variable name.

Local variables:

- Local variables can only be used in macros.
- At present, the controller firmware supports three local variables: 0, 1 and 2.
- The values of the local variables 1 and 2 are specified as arguments of the `MAC START` or `MAC NSTART` command when starting the macro.

  The command formats are:

  ```
  MAC START <macroname> [<String1> [<String2>]]
  ```

  ```
  MAC NSTART <macroname> <uint> [<String1> [<String2>]]
  ```

  <STRING1> and <STRING2> indicate the values for the local variables 1 and 2 used in the macro. <STRING1> and <STRING2> can be specified directly or via the values of variables. <uint> defines the number of times the macro is to be run. See the `MAC` command (p. 169) description for more information.
- The local variable 0 is read-only. Its value gives the number of arguments (i.e., values of local variables) set when starting the macro.
- Inside a macro, the values of local variables can be modified using `ADD` (p. 131), `CPY` (p. 136) or `VAR` (p. 197), and can be deleted with `VAR` (except for the local variable 0).
- As long as the macro is running, the values of the local variables can be queried with

  ```
  VAR? 0
  ```

  ```
  VAR? 1
  ```

  ```
  VAR? 2
  ```

  The queries can be sent inside or outside of the macro.

Global variables:

- Global variables can be used inside and outside of macros.
- The maximum number of global variables is 10.

- Global variables are created and modified using ADD, CPY or VAR. They can be deleted with VAR.
- The variable values can be queried with VAR?.

8.5 Command Overview

Command	Format	Description
#4 (p. 128)	#4	Request Status Register
#5 (p. 128)	#5	Request Motion Status
#7 (p. 129)	#7	Request Controller Ready Status
#8 (p. 129)	#8	Query If Macro Is Running
#24 (p. 129)	#24	Stop All Axes
*IDN? (p. 130)	*IDN?	Get Device Identification
ACC (p. 130)	ACC {<AxisID> <Acceleration>}	Set Closed-Loop Acceleration
ACC? (p. 131)	ACC? [{<AxisID>}]	Get Closed-Loop Acceleration
ADD (p. 131)	ADD <Variable> <FLOAT1> <FLOAT2>	Add and Save To Variable
BRA (p. 133)	BRA {<AxisID> <BrakeState>}	Set Brake Activation State
BRA? (p. 134)	BRA? [{<AxisID>}]	Get Brake Activation State
CCL (p. 134)	CCL? <Level> [<PSWD>]	Set Command Level
CCL? (p. 135)	CCL?	Get Command Level
CPY (p. 136)	CPY <Variable> <CMD?>	Copy Into Variable
CST? (p. 136)	CST? [{<AxisID>}]	Get Assignment Of Stages To Axes
CSV? (p. 137)	CSV?	Get Current Syntax Version
CTO (p. 137)	CTO {<TrigOutID> <CTOPam> <Value>}	Set Configuration Of Trigger Output

Command	Format	Description
CTO? (p. 141)	CTO? [{<TrigOutID> <CTOPam>}]	Get Configuration Of Trigger Output
DEC (p. 141)	DEC {<AxisID> <Deceleration>}	Set Closed-Loop Deceleration
DEC? (p. 142)	DEC? [{<AxisID>}]	Get Closed-Loop Deceleration
DEL (p. 142)	DEL <uint>	Delay The Command Interpreter
DFH (p. 142)	DFH [{<AxisID>}]	Define Home Position
DFH? (p. 144)	DFH? [{<AxisID>}]	Get Home Position Definition
DIO (p. 144)	DIO {<DIOID> <OutputOn>}	Set Digital Output Lines
DIO? (p. 145)	DIO? [{<DIOID>}]	Get Digital Input Lines
DRC (p. 146)	DRC {<RecTableID> <Source> <RecOption>}	Set Data Recorder Configuration
DRC? (p. 147)	DRC? [{<RecTableID>}]	Get Data Recorder Configuration
DRL? (p. 147)	DRL? [{<RecTableID>}]	Get Number Of Recorded Points
DRR? (p. 148)	DRR? [<StartPoint> <NumberOfPoints> [{<RecTableID>}]]	Get Recorded Data Values
DRT (p. 149)	DRT {<RecTableID> <TriggerSource> <Value>}	Set Data Recorder Trigger Source
DRT? (p. 150)	DRT? [{<RecTableID>}]	Get Data Recorder Trigger Source
ERR? (p. 151)	ERR?	Get Error Number
FED (p. 152)	FED {<AxisID> <EdgeID> <Param>}	Find Edge
FNL (p. 153)	FNL [{<AxisID>}]	Fast Reference Move To Negative Limit
FPL (p. 154)	FPL [{<AxisID>}]	Fast Reference Move To Positive Limit
FRF (p. 155)	FRF [{<AxisID>}]	Fast Reference Move To Reference Switch

Command	Format	Description
FRF? (p. 156)	FRF? [{<AxisID>}]	Get Referencing Result
GOH (p. 156)	GOH [{<AxisID>}]	Go To Home Position
HDR? (p. 157)	HDR?	Get All Data Recorder Options
HLP? (p. 157)	HLP?	Get List of Available Commands
HLT (p. 158)	HLT [{<AxisID>}]	Halt Motion Smoothly
HPA? (p. 158)	HPA?	Get List Of Available Parameters
HPV? (p. 159)	HPV?	Get List Of Possible Parameter Values
JAS? (p. 161)	JAS? [{<JoystickID> <JoystickAxis>}]	Query Joystick Axis Status
JAX (p. 161)	JAX <JoystickID> <JoystickAxis> <AxisID>	Set Axis Controlled By Joystick
JAX? (p. 162)	JAX? [{<JoystickID> <JoystickAxis>}]	Get Axis Controlled By Joystick
JBS? (p. 162)	JBS? [{<JoystickID> <JoystickButton>}]	Query Joystick Button Status
JDT (p. 163)	JDT {<JoystickID> <JoystickAxis> <uint>}	Set Joystick Default Lookup Table
JLT (p. 164)	JLT <JoystickID> <JoystickAxis> <Addr> <floatn>	Fill Joystick Lookup Table
JLT? (p. 165)	JLT? [<StartPoint> <NumberOfPoints> [{<JoystickID> <JoystickAxis>}]]	Get Joystick Lookup Table Values
JON (p. 166)	JON {<JoystickID> <uint>}	Set Joystick Activation Status
JON? (p. 167)	JON? [{<JoystickID>}]	Get Joystick Activation Status
JRC (p. 167)	JRC <Jump> <CMD?> <OP> <Value>	Jump Relatively Depending On Condition
LIM? (p. 168)	LIM? [{<AxisID>}]	Indicate Limit Switches

Command	Format	Description
MAC (p. 169)	MAC <keyword> {<parameter>} in particular: MAC BEG <macro name> MAC DEF <macro name> MAC DEF? MAC DEL <macro name> MAC END MAC ERR? MAC NSTART <macro name> <uint> [<String1> [<String2>]] MAC START <macro name> [<String1> [<String2>]]	Call Macro Function
MAC? (p. 172)	MAC? [<macro name>]	List Macros
MAN? (p. 172)	MAN? <CMD>	Get Help String For Command
MAT (p. 173)	MAT <Variable> <=> <FLOAT1> <OP> <FLOAT2>	Calculate And Save To Variable
MEX (p. 174)	MEX <CMD?> <OP> <Value>	Stop Macro Execution Due To Condition
MOV (p. 176)	MOV {<AxisID> <Position>}	Set Target Position
MOV? (p. 176)	MOV? [{<AxisID>}]	Get Target Position
MVR (p. 177)	MVR {<AxisID> <Distance>}	Set Target Relative To Current Position
ONT? (p. 178)	ONT? [{<AxisID>}]	Get On-Target State
POS (p. 179)	POS {<AxisID> <Position>}	Set Real Position
POS? (p. 179)	POS? [{<AxisID>}]	Get Real Position
RBT (p. 180)	RBT	Reboot System
RMC? (p. 180)	RMC?	List Running Macros
RON (p. 180)	RON {<AxisID> <ReferenceOn>}	Set Reference Mode
RON? (p. 181)	RON? [{<AxisID>}]	Get Reference Mode

Command	Format	Description
RPA (p. 181)	RPA [{<ItemID> <PamID>}]	Reset Volatile Memory Parameters
RTR (p. 182)	RTR <RecordTableRate>	Set Record Table Rate
RTR? (p. 182)	RTR?	Get Record Table Rate
SAI (p. 183)	SAI {<AxisID> <NewIdentifier>}	Set Current Axis Identifiers
SAI? (p. 183)	SAI? [ALL]	Get List Of Current Axis Identifiers
SEP (p. 183)	SEP <Pswd> {<ItemID> <PamID> <PamValue>}	Set Nonvolatile Memory Parameters
SEP? (p. 185)	SEP? [{<ItemID> <PamID>}]	Get Nonvolatile Memory Parameters
SMO (p. 185)	SMO {<AxisID> <ControlValue>}	Set Open-Loop Control Value
SMO? (p. 186)	SMO? [{<AxisID>}]	Get Control Value
SPA (p. 187)	SPA {<ItemID> <PamID> <PamValue>}	Set Volatile Memory Parameters
SPA? (p. 189)	SPA? [{<ItemID> <PamID>}]	Get Volatile Memory Parameters
SRG? (p. 189)	SRG? {<AxisID> <RegisterID>}	Query Status Register Value
STE (p. 190)	STE <AxisID> <Amplitude>	Start Step And Response Measurement
STP (p. 191)	STP	Stop All Axes
SVO (p. 191)	SVO {<AxisID> <ServoState>}	Set Servo Mode
SVO? (p. 192)	SVO? [{<AxisID>}]	Get Servo Mode
TAC? (p. 193)	TAC?	Tell Analog Channels
TAV? (p. 193)	TAV? [{<AnalogInputID>}]	Get Analog Input Voltage
TCV? (p. 194)	TCV? [{AxisID}]	Get Commanded Closed-Loop Velocity

Command	Format	Description
TIO? (p. 194)	TIO?	Tell Digital I/O Lines
TMN? (p. 194)	TMN? [{<AxisID>}]	Get Minimum Commandable Position
TMX? (p. 195)	TMX? [{<AxisID>}]	Get Maximum Commandable Position
TNR? (p. 195)	TNR?	Get Number Of Record Tables
TRO (p. 195)	TRO {<TrigOutID> <TrigMode>}	Set Trigger Output State
TRO? (p. 196)	TRO? [{<TrigOutID>}]	Get Trigger Output State
TRS? (p. 196)	TRS? [{<AxisID>}]	Indicate Reference Switch
TVI? (p. 197)	TVI?	Tell Valid Character Set For Axis Identifiers
VAR (p. 197)	VAR <Variable> <String>	Set Variable Value
VAR? (p. 199)	VAR? [{<Variable>}]	Get Variable Value
VEL (p. 199)	VEL {<AxisID> <Velocity>}	Set Closed-Loop Velocity
VEL? (p. 200)	VEL? [{<AxisID>}]	Get Closed-Loop Velocity
VER? (p. 200)	VER?	Get Versions Of Firmware And Drivers
WAC (p. 200)	WAC <CMD?> <OP> <Value>	Wait For Condition
WPA (p. 201)	WPA <Pswd> [{<ItemID> <PamID>}]	Save Parameters To Nonvolatile Memory

8.6 Command Descriptions for GCS 2.0

#4 (Request Status Register)

Description: Queries system status information.

Format: #4

Arguments: none

Response: The response is bit-mapped. See below for the individual codes.

Notes: This command is identical in function to SRG? (p. 189), but only one character is sent via the interface. Therefore #4 can also be used while the controller is performing time-consuming tasks.

For the C-863.12, the response is the sum of the following codes, in hexadecimal format:

Bit	15	14	13	12	11	10	9	8
Descript-ion	On-target state	Is referencing	In motion	Servo mode on	-	-	-	Error flag

Bit	7	6	5	4	3	2	1	0
Descript-ion	Digital in-put line 4	Digital in-put line 3	Digital in-put line 2	Digital in-put line 1	-	Positiv e limit switch	Ref-erence switch	Nega-tive limit switch

Example: Send: `#4`

Receive: `0x9005`

Note: The response is in hexadecimal format. It means that the axis is on target (on-target state =true), the servo mode is on, no error has occurred, the states of the digital input lines 1 to 4 are low, and the positioner is on the positive side of the reference switch (limit switches are not active; note that the logic of the signals is inverted in this example).

#5 (Request Motion Status)

Description: Queries the motion status of the axes.

Format: #5

Arguments: None

Response: The response <uint> is bit-mapped and returned as the hexadecimal sum of the following codes:

1=First axis in motion
2=Second axis in motion
4=Third axis in motion
...
0 indicates that all axes have finished moving.

#7 (Request Controller Ready Status)

Description: Queries the controller for ready state (tests if controller is ready to do a new command).

Note: Use #5 (p. 128) instead of #7 to verify if motion has finished.

Format: #7

Arguments: None

Response: B1h (ASCII character 177 = "±" in Windows) if controller is ready

B0h (ASCII character 176 = "°" in Windows) if controller is not ready
(e.g., executing a referencing move)

Troubleshooting: The response characters may be displayed differently in non-Western character sets or other operating systems.

#8 (Query if Macro Is Running)

Description: Tests if a macro is running on the controller.

Format: #8

Arguments: None

Response: <uint>=0 no macro is running
<uint>=1 a macro is currently running

#24 (Stop All Axes)

Description: Stops all axes abruptly. See the notes below for further details.

Sets error code to 10.

This command is identical in function to STP (p. 191), but only one character is sent via the interface.

Format: #24

Arguments: None

Response: None

Notes: #24 stops all motion caused by motion commands (e.g., MOV (p. 176), MVR (p. 177), GOH (p. 156), STE (p. 190), SMO (p. 185)), commands for referencing (FNL (p. 153), FPL (p. 154), FRF (p. 155)) and macros (MAC (p. 169)). Also stops macro running.

After the axes are stopped, their target positions are set to their current positions.

HLT (p. 158) in contrast to #24 stops motion with specified deceleration with respect to system inertia.

*IDN? (Get Device Identification)

Description: Reports the device identity number.

Format: *IDN?

Arguments: None

Response: Single-line text terminated with a termination character (line feed) with controller name, serial number, and firmware version

ACC (Set Closed-Loop Acceleration)

Description: Sets acceleration of specified axes.

ACC can be changed while the axis is moving.

Format: ACC {<AxisID> <Acceleration>}

Arguments: <AxisID> is one axis of the controller

<Acceleration> is the acceleration value in physical units/s^2.

Response: None

Troubleshooting: Illegal axis identifiers

Notes: The ACC setting only takes effect when the specified axis is in closed-loop operation (servo mode ON).

The lowest possible value for <Acceleration> is 0.

ACC changes the value of the ***Closed-Loop Acceleration (Phys. Unit/s^2)*** parameter (ID 0xB) in the volatile memory of the C-863.12. The parameter value can be stored as default with WPA (p. 201), for details see "Adapting Settings" (p. 227).

The maximum value that can be set with the ACC command is specified by the ***Maximum Closed-Loop Acceleration (Phys. Unit/s^2)*** parameter (ID 0x4A).

ACC? (Get Closed-Loop Acceleration)

Description: Queries the acceleration value set with ACC (p. 130).

If all arguments are left out, gets the value of all axes set with ACC.

Format: ACC? [{<AxisID>}]

Arguments: <AxisID> is one axis of the controller

Response: {<AxisID>"="<float> LF}

where

<float> is the acceleration value set with ACC, in physical units/s^2.

ADD (Add and Save to Variable)

Description: Adds two values and saves the result to a variable (p. 120).

The variable is present in volatile memory (RAM) only.

Format: ADD <Variable> <FLOAT1> <FLOAT2>

Arguments: <Variable> is the name of the variable to which the result is to be saved.

<FLOAT1> is the first summand.

<FLOAT2> is the second summand.

Floating point numbers are expected for the summands. They can be specified directly or via the value of a variable.

Response: None

Notes: Local variables can be set using ADD in macros only.

Example 1: Value $B is added to value $A, and the result is saved to variable C:

```
ADD C $A $B
```

Example 2: The name of the variable where the result is to be copied is specified via the value of another variable:

Send: `VAR?`

Receive:

```
A=468
B=123
3Z=WORKS
```

Send: `ADD A${3Z} $A $B`

Send: `VAR?`

Receive:

```
A=468
B=123
AWORKS=591
3Z=WORKS
```

Send: `ADD ${3Z} $A $B`

Send: `VAR?`

Receive:

```
A=468
B=123
AWORKS=591
WORKS=591
3Z=WORKS
```

Example 3: The macros below can be used to create a "flashing light" with LEDs that are connected to the digital output lines of the controller. $1 and $2 are values of local variables and must be specified as arguments of MAC START or MAC NSTART command when starting the macros (see below).

DIO 0 <bitmask>: Sets the output channels according to <bitmask>. For example, "DIO 0 5" activates channels 1 and 3 and deactivates all other channels (5 is 0000 0101 in binary notation).

To implement the "flashing light", do the following steps:

1. Write the "STEPS" macro:

```
MAC BEG STEPS
DIO 0 $1
ADD 1 $1 1
DEL $2
JRC -3 VAR? 1 <= 15
ADD 1 $1 -1
DIO 0 $1
DEL $2
JRC -3 VAR? 1 > 0
MAC END
```

2. Write the "TEST" macro:

```
MAC BEG TEST
MAC START STEPS 0 $1
ADD 1 $1 10
JRC -2 VAR? 1 < 110
VAR 1 10
ADD 2 $2 -1
JRC -5 VAR? 2 > 0
MAC END
```

3. Start the TEST macro with arguments that define the variable values $1 and $2:

```
MAC START Test 10 50
```

Meaning of the variables here:

$1: Delay in ms between each step in the STEPS macro. The value is incremented by 10 by the TEST macro until it reaches 110.

$2: Number of repetitions of the whole "flashing light" procedure.

BRA (Set Brake Activation State)

Description: Activates/deactivates brake for specified axes.

Format: BRA {<AxisID> <BrakeState>}

Arguments: <AxisID> is one axis of the controller

<BrakeState> can have the following values:
0 = Brake deactivated
1 = Brake activated

Response: None

Troubleshooting: Illegal axis identifier

Notes: The brake can only be used if parameter 0x1A (***Has Brake?***)

has the value 1 ("yes").

If parameter 0x1A (***Has Brake?***) has the value 1 ("yes"), the following applies:

- The brake can be activated or deactivated with BRA only if the servo mode is switched off. Secure the positioner against moving unintentionally before you deactivate the brake before you deactivate the brake with BRA!
- Setting the servo mode with SVO (p. 191) influences the activation state of the brake:
  - Switching servo mode on deactivates the brake.
  - Switching servo mode off activates the brake.
- If a motion error occurs (p. 75), the servo mode is switched off and the brake is activated.

If the integrated brake driver of the C-863.12 is to be used, parameter 0x3094 (***Internal Brake***) must also have the value 1. Refer the descriptions in "Parameter Overview" (p. 236) for further information.

BRA? (Get Brake Activation State)

Description: Gets brake activation state of specified axes.

If all arguments are left out, gets state of all axes.

Format: BRA? [{<AxisID>}]

Arguments: <AxisID> is one axis of the controller

Response: {<AxisID>"="<BrakeState> LF}

where

<BrakeState> is the current brake activation state of the axis:
0 = Brake deactivated
1 = Brake activated

Troubleshooting: Illegal axis identifier

CCL (Set Command Level)

Description: Changes the active "command level" and therefore determines the availability of commands and write access to system parameters.

Format: CCL <Level> [<PSWD>]

Arguments: <Level> is a command level of the controller

	<PSWD> is the password required for changing to the appropriate command level The following command levels and passwords apply: Level = 0 is the default setting, all commands provided for "normal" users are available, read access to all parameters, no password required. Level = 1 adds additional commands and write access to level-1 parameters (commands and parameters from level 0 are included). The password required is "advanced". Level > 1 is only intended for PI service personnel. Users cannot change to a level > 1. Contact the customer service department (p. 253) if you have problems with the parameters for command level 2 or higher.
Response:	none
Troubleshooting:	Invalid password
Notes:	With the C-863.12, the command levels only determine the write permission for the parameters. The availability of the commands of the C-863.12 is independent of the active command level. HPA? (p. 158) lists the parameters including the information on which command level allows write access to them. For further information on using parameters, see "Adapting Settings" (p. 227). After controller switch-on or reboot, the active command level is always level 0.

CCL? (Get Command Level)

Description:	Get the active "command level".
Format:	CCL?
Arguments:	none
Response:	<Level> is the currently active command level; uint.
Notes:	<Level> should be 0 or 1. <Level> = 0 is the default setting, write access is specified for level 0 parameters, read access is specified for all parameters <Level> = 1 allows write access for level 1 parameters

(parameters from level 0 are included).

CPY (Copy Into Variable)

Description: Copies a command response to a variable (p. 120).

The variable is present in volatile memory (RAM) only.

Format: CPY <Variable> <CMD?>

Arguments: <Variable> is the name of the variable to which the command response is to be copied.

<CMD?> is one query command in its usual notation. The response has to be a single value and not more.

Response: None

Notes: Local variables can be set using CPY in macros only.

Example 1: Using the following macro, it is possible to connect through the digital input and output lines of the controller. 1 is a local variable whose value must be specified as argument of the MAC START or MAC NSTART command when starting the macro.

Write the "connect" macro:

```
MAC BEG connect
CPY 1 DIO? 0
DIO 0 $1
MAC START CONNECT
MAC END
```

Example 2: It is possible to copy the value of one variable (e.g., SOURCE) to another variable (e.g., TARGET):

```
CPY TARGET VAR? SOURCE
```

CST? (Get Assignment Of Stages To Axes)

Description: Returns the name of the connected positioner type for the queried axis.

Format: CST? [{<AxisID>}]

Arguments: <AxisID> is one axis of the controller

Response: {<AxisID>"="<string> LF}

where

<string> is the name of the positioner type assigned to the

	axis.
Notes:	The positioner name is read from the ***Stage Name*** parameter (ID 0x3C) whose factory default value is "DEFAULT_STAGE". You can set the parameter value to the name of your positioner with SPA (p. 187) or SEP (p. 183). You can find details in the parameter overview (p. 236).

CSV? (Get Current Syntax Version)

Description:	Queries the GCS syntax version used in the firmware.
Format:	CSV?
Arguments:	None
Response:	The current GCS syntax version
Notes:	1.0 (for GCS 1.0) or 2.0 (for GCS 2.0) are possible responses.

CTO (Set Configuration Of Trigger Output)

Description:	Configures the trigger output conditions for the specified digital output line.
Format:	CTO {<TrigOutID> <CTOPam> <Value>}
Arguments:	<TrigOutID> is one digital output line of the controller, see below for details. <CTOPam> is the CTO parameter ID in decimal format, see below for the available IDs. <Value> is the value that the CTO parameter is set to, see below.
Response:	None
Notes:	The trigger output conditions will become active when enabled with TRO (p. 195). Do not use DIO (p. 144) on digital output lines where the trigger output is activated by TRO. The CTO settings are lost when you power down or reboot the C-863.12. They can be easily maintained by saving them in a macro.
Output lines and trigger conditions available:	<TrigOutID> corresponds to digital output lines 1 to 4, IDs = 1 to 4; see "I/O" (p. 260). <CTOPam> parameter IDs available for C-863.12: 1 = TriggerStep

2 = Axis
3 = TriggerMode
7 = Polarity
8 = StartThreshold
9 = StopThreshold
10 = TriggerPosition

<Value> available for the appropriate <CTOPam> ID:

for TriggerStep: Distance

for Axis: The identifier of the axis to be connected to the digital output line. Irrelevant for the MotionError trigger mode.

for TriggerMode (default value is 0):

- 0 = PositionDistance;
  a trigger pulse is written whenever the axis has covered the TriggerStep distance (<CTOPam> ID 1). Optionally, values for StartThreshold and StopThreshold (<CTOPam> IDs 8 and 9) can be defined to activate the trigger output for a limited position range and a certain direction of motion only (negative or positive; Note: If the motion direction is reversed before the axis position has reached the stop threshold, trigger pulses will continue to be generated). When StartThreshold and StopThreshold are set to the same value, they will not be used.
- 2 = OnTarget;
  the on-target state of the selected axis is transferred to the selected digital output line (this state can also be read with the ONT? command).
- 5 = MotionError;
  the selected digital output line becomes active when a motion error occurs. The line will stay active until the error code is reset to 0 (by a query).
- 6 = InMotion;
  the selected digital output line is active as long as the selected axis is in motion (the motion state can also be read with commands, e.g. SRG? or #5).
- 7 = Position+Offset;
  the first trigger pulse is written when the axis has reached the position specified by TriggerPosition (<CTOPam> ID 10). The next trigger pulses are written each time the axis position equals the sum of the last valid trigger position and the distance specified by TriggerStep (<CTOPam> ID 1). Trigger output ends

when the axis position exceeds the value specified by StopThreshold (<CTOPam> ID 9). The sign of the TriggerStep value determines the direction of motion in which trigger pulses are to be output. Trigger processing is done by the DSP of the C-863.12.

- 8 = SinglePosition;
  the selected digital output line is active when the axis position has reached or exceeded the position specified by TriggerPosition (<CTOPam> ID 10).

for Polarity (default value is 1): sets the signal polarity for the digital output line
0 = Active Low
1 = Active High

for StartThreshold/StopThreshold: position value;
if used for the PositionDistance trigger mode, both thresholds must be set in order to determine the position range and the direction of motion for trigger output;
StopThreshold is used as the stop condition for Position+Offset trigger mode

for TriggerPosition: position value;
if used in the Position+Offset trigger mode, the first trigger pulse is output at this position;
if used in the SinglePosition trigger mode, the output line is active when this position is reached or exceeded

For application examples and further details see "Digital Output Signals" (p. 78) and the lines below.

Example 1: A pulse is to be generated on digital output line 1 (ID 1) whenever axis 1 has covered a distance of 0.05 µm. The following parameters must be set:

TrigOutID = 1
Axis = 1
TriggerMode = 0
TriggerStep = 0.05
Send: `CTO 1 2 1`
Send: `CTO 1 3 0`
Send: `CTO 1 1 0.00005`

Example 2: In this example, digital output line 1 is to be set from low to high when axis A starts to move. The following parameters must be set:
TrigOutID = 1
Axis = A (axis identifier was changed with `SAI`)
TriggerMode = 6

Polarity = Active High

So you have to send:

```
CTO 1 2 A
CTO 1 3 6
CTO 1 7 1
```

Example 3:

L-509.1xxxxx (travel range: 26 mm) is connected to axis 1. The reference position of the L-509.1xxxxx is 13 mm. Starting from its reference position, the axis is to be moved alternating forwards and backwards; trigger pulses are to be output with the Position+Offset trigger mode for both directions of motion in a range of 1 mm. For that purpose, two macros are written to the controller. Macro TRIGREF initializes the controller and could also be defined as startup macro, while macro TRIGGER starts motion and therefore trigger output. Write the macros as shown below. Further details about macros see "Working with Macros" (p. 101).

Make sure that the velocity for the axis matches the CTO setting for the distance. Recommended value:
maximum velocity = distance * 20 kHz / 2
where 20 kHz is the frequency of the C-863.12 servo cycle.

A trigger signal frequency of 1 kHz results at a velocity of 20 mm/s.

➢ Record a macro named TRIGREF with the following contents:

```
CTO 1 3 7
SVO 1 1
FRF
TRO 1 1
MAC START TRIGGER
```

➢ Record a macro named TRIGGER with the following contents:

```
CTO 1 1 0.02
CTO 1 9 15
CTO 1 10 14
DEL 1000
DRT 0 2 0
MOV 1 15.01
WAC POS? 1 > 14.8
MEX CTO? 1 10 < 13.9
CTO 1 1 -0.02
CTO 1 9 14
CTO 1 10 15
```

```
DEL 1000
MOV 1 13.99
WAC POS? 1 < 14
MEX CTO? 1 10 > 14.1
MAC START TRIGGER
```

CTO? (Get Configuration Of Trigger Output)

Description: Queries the values set for specified trigger output lines and parameters.

Format: CTO? [{<TrigOutID> <CTOPam>}]

Arguments: <TrigOutID>: is a digital output line of the controller; see CTO.

<CTOPam>: parameter ID; see CTO.

If all arguments are left out, the response contains the values for all parameters and all output lines.

Response: {<TrigOutID> <CTOPam>"="<Value> LF}

For <Value> see CTO.

DEC (Set Closed-Loop Deceleration)

Description: Sets deceleration of specified axes.

DEC can be changed while the axis is in motion.

Format: DEC {<AxisID> <Deceleration>}

Arguments: <AxisID> is one axis of the controller.

<Deceleration> is the deceleration value in physical units/s^2.

Response: None

Troubleshooting: Illegal axis identifiers

Notes: The DEC setting only takes effect when the specified axis is in closed-loop operation (servo mode ON).

The lowest possible value for <Deceleration> is 0.

DEC changes the value of the ***Closed Loop Deceleration (Phys. Unit/s^2)*** parameter (ID 0xC) in the volatile memory of the C-863.12. The parameter value can be stored as default with WPA (p. 201), for details see "Adapting

Settings" (p. 227).

The maximum value that can be set with the DEC command is specified by the ***Maximum Closed-Loop Deceleration (Phys. Unit/s^2)*** parameter (ID 0x4B).

DEC? (Get Closed-Loop Deceleration)

Description: Queries the deceleration value set with DEC (p. 141).

If no arguments are specified, queries the value of all axes set with DEC.

Format: DEC? [{<AxisID>}]

Arguments: <AxisID> is one axis of the controller.

Response: {<AxisID>"="<float> LF}

where

<float> is the deceleration value set with DEC, in physical units/s^2.

DEL (Delay the Command Interpreter)

Description: Delays <uint> milliseconds.

Format: DEL <uint>

Arguments: <uint> is the delay value in milliseconds.

Response: None

Notes: DEL can only be used in macros. Do not mistake MAC DEL (deletes macros) for DEL (delays).

Further information can be found in the description of the MAC command (p. 169) and in the "Controller Macros" (p. 99) section.

DFH (Define Home Position)

Description: Redefines the zero position of the specified axis by setting the position value to zero at the current position.

If no arguments are specified, DFH defines the zero position of all axes.

Format: DFH [{<AxisID>}]

Arguments: <AxisID> is one axis of the controller.

Response: none

Troubleshooting: Illegal axis identifier

Notes: DFH sets the current position of the axis to zero and saves the position value which was valid when the command was called as offset in the volatile memory. By adding this offset to the response, the output values of the following commands are adapted to the new zero position:

- POS? (p. 179) (Get the current position)
- TMN? (p. 194) (Get the minimum commandable position)
- TMX? (p. 195) (Get the maximum commandable position)

DFH does **not** change the values of the parameters for the definition of travel range and soft limits (p. 31).

The offset is reset to zero in the following cases:

- When switching on and rebooting the C-863.12: For all axes
- During referencing: For the affected axis

Example: Send: `MOV 1 9.87`

Send: `POS? 1`

Receive: `1=9.8700005`

Send: `DFH? 1`

Receive: `1=0.0000000`

Send: `TMN? 1`

Receive: `1=0.0000000`

Send: `TMX? 1`

Receive: `1=14.9999982`

Note: Axis 1 is moved to absolute position 9.87 mm. Finally, the current axis position (with POS?), the current offset value (with DFH?), and the minimum and maximum commandable position (with TMN? and TMX?) are queried.

Send: `DFH 1`

Send: `POS? 1`

Receive: `1=0.0000000`

Send: `DFH? 1`

Receive: `1=9.8700005`

Send: `TMN? 1`

Receive: `1=-9.8700005`

Send: `TMX? 1`

Receive: `1=5.1299978`

Note: The axis has not moved. The current axis position was defined as new zero position using DFH. Therefore, the offset value of axis 1 is 9.87 mm. The values for the minimum and maximum commandable position were adapted to the new zero position by adding the offset.

DFH? (Get Home Position Definition)

Description: Queries the position value that is currently used as the offset for the specified axis to move the zero position.

If no arguments are specified, queries the position value of all axes.

Format: DFH? [{<AxisID>}]

Arguments: <AxisID> is one axis of the controller

Response: {<AxisID>"="<PositionOffset> LF}

where

<PositionOffset> is the axis position that was valid at the time the last DFH command was processed. This position value is used internally as offset for the calculation of the current axis position.

Troubleshooting: Illegal axis identifier

Notes: The axis position that was valid when the last DFH command was processed, is available in the volatile memory as an offset. The offset is reset to zero in the following cases:

- When switching on and rebooting the C-863.12: For all axes
- During referencing: For the affected axis

See DFH for an example.

DIO (Set Digital Output Line)

Description: Switches the specified digital output line(s) to specified state(s).

Use TIO? (p. 194) to get the number of installed digital I/O lines.

Format: DIO {<DIOID> <OutputOn>}

Arguments: <DIOID> is one digital output line of the controller, see below for details.

<OutputOn> is the state of the digital output line, see below for details.

Response: none

Notes: You can use the DIO command to activate/deactivate the Output 1 to Output 4 lines on the I/O socket (p. 260). The C-863.12 allows you to either set a single line per DIO command, or all lines at once.

The <DIOID> identifiers to use for the lines are 1 to 4. With the identifier 0, all lines are set according to a bit pattern specified by <OutputOn>.

If <OutputOn>=1 the line is set to HIGH/ON, if <OutputOn>=0 it is set to LOW/OFF.

Do not use DIO on output lines for which the trigger output is activated with TRO (p. 195).

DIO? (Get Digital Input Lines)

Description: Queries the states of the specified digital input lines.

Use TIO? (p. 194) to query the number of available digital I/O lines.

Format: DIO? [{<DIOID>}]

Arguments: <DIOID> is the identifier of the digital input line, see below for details.

Response: {<DIOID>"="<InputOn> LF}

where

<InputOn> specifies the state of the digital input line, see below for details.

Notes: You can use the DIO? command to read digital input lines 1 to 4 on the **I/O** socket directly (p. 260).

The <DIOID> identifiers to use for the lines are 1 to 4. If the identifier is left out or 0, all lines are queried.

If <InputOn>=0, the digital input is LOW/OFF; if <InputOn>=1, the digital input is HIGH/ON. If <DIOID> is 0, <InputOn> is a bit pattern which gives the states of all lines in hexadecimal format.

DRC (Set Data Recorder Configuration)

Description: Determines the data source to be used and the type of data to be recorded (record option) for the data recorder table specified.

Format: DRC {<RecTableID> <Source> <RecOption>}

Arguments: <RecTableID> is one data recorder table of the controller, see below.

<Source> is the ID of the data source, for example, an axis or channel of the controller. The required source depends on the selected record option.

<RecOption> is the type of data to be recorded (record option).

Refer to the following list of available record options and the corresponding data sources for details

Response: None

Notes: The C-863.12 has 4 data recorder tables with 1024 points per table.

With HDR? (p. 157), you will obtain a list of all available record and trigger options and additional information on the data recording. The number of available data recorder tables can be read with TNR? (p. 195).

Refer to "Data Recorder" (p. 76) for further information.

Recording options available with the corresponding data sources:

- 0=Nothing is recorded

Data source is the axis:

- 1=Commanded position of axis
- 2=Actual position of axis
- 3=Position error of axis
- 70=Commanded velocity of axis
- 71=Commanded acceleration of axis
- 73=Motor output of axis (dimensionless control value)
- 74=Kp of axis
- 75=Ki of axis
- 76=Kd of axis
- 77=Kv of axis

- 80=Signal status register of axis
- 90=active parameterset (only relevant if the controller supports several groups of servo control parameters)

Data source is the analog input:

- 81=Analog input (channel = 1 - 4)

Data source is a motor output (see pin assignment (p. 259)):

- 100=Current Phase A [mA]
- 101=Current Phase B [mA]

Note: The analog inputs for the record option 81 can be the Input 1 to Input 4 lines of the **I/O** socket (p. 260). Use the identifiers 1 to 4 for these data sources.

Data source identifiers 5 and 6 refer to the inputs for the joystick's axis and button:

5 = Axis 1 of the joystick

6 = Button 1 of the joystick

DRC? (Get Data Recorder Configuration)

Description: Queries the settings for the data to be recorded.

Format: DRC? [{<RecTableID>}]

Arguments: <RecTableID>: is a data recorder table of the controller; if this entry is not specified, the response will contain the settings for all tables.

Response: The current DRC settings:

{<RecTableID>"="<Source> <RecOption> LF}

where

<Source>: is the data source, for example, an axis or a channel of the controller. The source type depends on the record option.

<RecOption>: is the type of data to be recorded (record option).

The available record options can be queried with HDR? (p. 157).

DRL? (Get Number of Recorded Points)

Description: Reads the number of points comprised by the last recording.

Format: DRL? [{<RecTableID>}]

Arguments: <RecTableID> is one data recorder table of the controller

Response: {<RecTableID>"="<uint> LF}

where

<uint> specifies the number of points recorded with the last recording

Notes: The number of points is reset to zero for a data recorder table when changing its configuration with DRC (p. 146).

DRR? (Get Recorded Data Values)

Description: Queries the last recorded data.

Querying can take some time depending on the number of points to be read!

It is possible to read the data while recording is still in progress.

Format: DRR? [<StartPoint> <NumberOfPoints> [{<RecTableID>}]]

Arguments: <StartPoint> is the first point to be read from the data recorder table, starts with index 1.

<NumberOfPoints> is the number of points to be read per table.

<RecTableID> is one data recorder table of the controller.

Response: For the recorded data in GCS array format, refer to the separate manual for the GCS array, SM146E, and the example below.

Notes: If <RecTableID> is not specified, the data is read from all tables with a record option not equal to zero.

With HDR? (p. 157), you will obtain a list of all available recording and triggering options as well as additional information on data recording.

Refer to the description of the DRC command (p. 146) as well as "Data Recorder" (p. 76) for further information.

Example:

```
rtr?
10
drr? 1 20
```

```
# REM C-863.12
#
# VERSION = 1
# TYPE = 1
# SEPARATOR = 32
# DIM = 2
# SAMPLE_TIME = 0.000500
# NDATA = 20
#
# NAME0 = Actual Position of Axis
AXIS:1
# NAME1 = Position Error of Axis  AXIS:1
#
# END_HEADER
5.00000 0.00000
4.99998 0.00002
5.00000 0.00000
5.00000 0.00000
5.00000 0.00000
5.00000 0.00000
5.00000 0.00000
4.99998 0.00002
5.00000 0.00000
4.99998 0.00002
5.00000 0.00000
5.00000 0.00000
5.00000 0.00000
5.00000 0.00000
4.99998 0.00002
5.00000 0.00000
4.99998 0.00002
4.99998 0.00002
5.00000 0.00002
4.99998 0.00004
```

DRT (Set Data Recorder Trigger Source)

Description: Defines a trigger source for the specified data recorder table.

Format: DRT <RecTableID> <TriggerSource> <Value>

Arguments: <RecTableID> is one data recorder table of the controller. See below for details.

	<TriggerSource> ID of the trigger source, see below for a list of available options. <Value> depends on the trigger source, can be a dummy, see below.
Response:	none
Notes:	At present, only 0 is valid for <RecTableID>; this means that the specified trigger source is set for all data recorder tables that have a record option that is not zero. Irrespective of the trigger option set, data recording is always triggered when step response measuring is done with STE (p. 190). With HDR? (p. 157), you will obtain a list of all available record and trigger options and additional information on the data recording. For further information, see the description of the DRC command (p. 146) as well as "Data Recorder" (p. 76).
Available trigger options:	0 = default setting Data recording is triggered by STE; <Value> must be a dummy. 1 = any command changing target position e.g., MVR (p. 177), MOV (p. 176); <Value> must be a dummy. 2 = next command resets trigger after execution; <Value> must be a dummy. 6 = any command changing target position, reset trigger after execution e.g., MVR, MOV; resets trigger after execution; <Value> must be a dummy.

DRT? (Get Data Recorder Trigger Source)

Description:	Queries the trigger source for the data recorder tables.
Format:	DRT? [{<RecTableID>}]
Arguments:	<RecTableID> is one data recorder table of the controller.
Response:	{<RecTableID>"="<TriggerSource> <Value> LF}

where

<TriggerSource> is the identifier of the trigger source.

<Value> depends on the trigger source.

Further information can be found in the description of the DRT command (p. 149).

Notes: Because all data record tables of the C-863.12 have the same trigger source, the DRT? response is specified as a single line of the form

0=<TriggerSource> <Value>

ERR? (Get Error Number)

Description: Get error code <int> of the last occurred error and reset the error to 0.

Only the last error is buffered. You should therefore call ERR? after each command.

The error codes and their descriptions are listed in "Error Codes" (p. 203).

Format: ERR?

Arguments: None

Response: The error code of the last error that occurred (integer).

Troubleshooting: Communication breakdown

Notes: In the case of simultaneous access to the controller by several instances, the error code is only returned to the first instance that sent the ERR? command. Because the error is reset to 0 by the query, the error is not visible for any further querying instance.

- ➢ If possible, access the controller with one instance only.
- ➢ If incorrect system behavior does not cause the controller to send an error code, check whether the error code is queried regularly in the background by a macro, script or the PC software (e.g., PIMikroMove).

If the cause of an error continues, the corresponding error code is immediately set again after a query with ERR?.

FED (Find Edge)

Description: Moves the specified axis to a specified signal edge.

FED does not set a certain position value at the selected edge (in contrast to the FNL (p. 153), FPL (p. 154), and FRF (p. 155) commands for referencing), i.e., the axis is not "referenced" after using FED.

If multiple axes are specified in the command, they are moved synchronously.

Format: FED {<AxisID> <EdgeID> <Param>}

Arguments: <AxisID> is one axis of the controller.

<EdgeID> is the type of edge the axis has to move to. See below for available edge types.

<Param> depends on the selected edge and qualifies it. See below for details.

Response: None

Troubleshooting: Illegal axis identifier; limit switches and/or reference switch are disabled (see below); SVO? (p. 192) responds with the value 0.

Notes: Servo mode must be switched on with SVO (p. 191) for the commanded axis prior to using this command (closed-loop operation).

The C-863.12 firmware detects the presence or absence of reference switch and limit switches using parameters (ID 0x14 for reference switch; ID 0x32 for limit switches). The C-863.12 activates or deactivates FED motion to the appropriate signal edges according to the values of those parameters. Adapt the parameter values to your hardware using SPA (p. 187) or SEP (p. 183). See "Parameter Overview" (p. 236) for more information.

You can use the digital input lines instead of the switches as source of the switch signals for FED. For further information see "Digital Input Signals" (p. 86).

FED can be used to measure the physical travel range of a new mechanics and therefore to identify the values for the corresponding parameters: the distance from negative to positive limit switch, the distance between the negative limit switch and the reference switch (parameter ID 0x17), and the distance between reference switch and positive limit switch (parameter ID 0x2F). For further information see "Travel Range and Soft Limits" (p. 31).

The motion can be stopped by #24 (p. 129), STP (p. 191) and HLT (p. 158).

Motion commands like FED are not allowed when the joystick is active for the axis. For further information see "Joystick Control" (p. 91).

Available edge types and parameters: The following edge types with their parameter settings are available:

1 = negative limit switch, <Param> must be 0
2 = positive limit switch, <Param> must be 0
3 = reference switch, <Param> must be 0

FNL (Fast Reference Move To Negative Limit)

Description: Performs a referencing move

Moves the specified axis to the negative physical limit of its travel range and sets the current position to a defined value. See below for details.

If multiple axes are specified in the command, they are moved synchronously.

Format: FNL [{<AxisID>}]

Arguments: <AxisID> is a controller's axis, all axes are affected if not specified.

Response: None

Troubleshooting: Illegal axis identifier

Notes: Servo mode must be switched on with SVO (p. 191) for the commanded axis prior to using this command (closed-loop operation).

If the referencing move was successful, absolute motion will then be possible in closed-loop operation.

The negative physical limit of the travel range is represented by the negative limit switch of the positioner. The difference in the values of the parameters 0x16 and 0x17 is set as the current position when the axis is at the negative limit switch.

You can use a digital input instead of the negative limit switch as source of the negative limit switch signal for FNL. Refer to "Digital Input Signals" (p. 86) for further information.

The motion can be stopped by #24 (p. 129), STP (p. 191) and HLT (p. 158).

Use FRF? (p. 156) to check whether the referencing move was successful.

For best repeatability, referencing must always be done in the same way.

If soft limits (parameters 0x15 and 0x30) are used to reduce the travel range, the limit switches cannot be used for referencing moves.

Refer to "Referencing" (p. 34) and "Travel Range and Soft Limits" (p. 31) for further information.

FPL (Fast Reference Move To Positive Limit)

Description: Starts a referencing move

Moves the specified axis to the positive physical limit of its travel range and sets the current position to a defined value. See below for details.

If multiple axes are specified in the command, they are moved synchronously.

Format: FPL [{<AxisID>}]

Arguments: <AxisID> is one axis of the controller, if not specified, all axes are involved.

Response: none

Troubleshooting: Illegal axis identifier

Notes: Servo mode must be switched on with SVO (p. 191) for the commanded axis prior to using this command (closed-loop operation).

If the referencing move was successful, absolute motion will then be possible in closed-loop operation.

The positive physical limit of the travel range is represented by the positive limit switch of the positioner. The sum of the values of the parameters 0x16 and 0x2F is set as the current position when the axis is at the positive limit switch.

You can use a digital input instead of the positive limit switch as source of the positive limit switch signal for FPL. For further information, see "Digital Input Signals" (p. 86).

Motion can be stopped by #24 (p. 129), STP (p. 191) and HLT (p. 158).

Use FRF? (p. 156) to check whether the referencing move was successful.

For best repeatability, referencing must always be done in the same way.

If soft limits (parameters 0x15 and 0x30) are used to reduce the travel range, the limit switches cannot be used for referencing moves.

For further information, see "Referencing" (p. 34) and "Travel Range and Soft Limits" (p. 31).

FRF (Fast Reference Move To Reference Switch)

Description: Starts a referencing move.

Moves the specified axis to the reference switch and sets the current position to a defined value. See below for details.

If multiple axes are specified in the command, they are started simultaneously.

Format: FRF [{<AxisID>}]

Arguments: <AxisID> is a controller's axis, all axes are affected if not specified.

Response: None

Troubleshooting: Illegal axis identifier

Notes: Servo mode must be switched on with SVO (p. 191) for the commanded axis prior to using this command (closed-loop operation).

If the referencing move was successful, absolute motion will then be possible in closed-loop operation.

The value of the parameter 0x16 is set as the current position when the axis is at the reference switch.

You can use a digital input instead of the reference switch as source of the reference signal for the FRF command. For further information, see "Digital Input Signals" (p. 86).

The motion can be stopped by #24 (p. 129), STP (p. 191) and HLT (p. 158).

Use FRF? (p. 156) to check whether the referencing move was successful.

Use FNL (p. 153) or FPL (p. 154) instead of FRF (p. 155) to do a referencing move for an axis that has no reference switch but limit switches.

For best repeatability, referencing must always be done in the same way. The FRF command always approaches the reference switch from the same side, no matter where the axis is when the command is called.

For further information, see "Travel Range and Soft Limits" (p. 31).

FRF? (Get Referencing Result)

Description:	Queries whether the specified axis is referenced or not.
Format:	FRF? [{<AxisID>}]
Arguments:	<AxisID> is one axis of the controller.
Response:	{<AxisID>"="<uint> LF} where <uint> indicates whether the axis has been successfully referenced (=1) or not (=0).
Troubleshooting:	Illegal axis identifier
Notes:	An axis is considered as "referenced" when the current position value is set to a known position. This is the case when a referencing move was successfully done with FNL (p. 153), FPL (p. 154) or FRF (p. 155) or when the position was set directly with POS (p. 179) (depending on the referencing method selected with RON (p. 180)).

GOH (Go To Home Position)

Description:	Moves the specified axis to the zero position. GOH [{<AxisID>}] is the same as MOV {<AxisID> 0} The motion can be stopped by #24 (p. 129), STP (p. 191), and HLT (p. 158).
Format:	GOH [{<AxisID>}]

Arguments: <AxisID>: Is one axis of the controller; if not specified, all axes are affected.

Response: None

Troubleshooting: Illegal axis identifier

Notes: Servo mode must be switched on for the commanded axis prior to using this command (closed-loop operation).

HDR? (Get All Data Recorder Options)

Description: Lists a help string which contains all information available on data recording (record options and trigger options, information on additional parameters and commands concerning data recording).

Format: HDR?

Arguments: None

Response

#RecordOptions
{<RecOption>"="<DescriptionString>[of <Channel>]}

#TriggerOptions
[{<TriggerOption>"="<DescriptionString>}]

#Parameters to be set with SPA
[{<ParameterID>"="<DescriptionString>}]

#Additional information
[{<Command description>"("<Command>")"}]

#Sources for Record Options
[{<RecOption>"="<Source>}]

end of help

Note: TriggerOptions = 0 (default) means that recording is triggered by the STE command (p. 190).

HLP? (Get List Of Available Commands)

Description: Lists a help string which contains all commands available.

Format: HLP?

Arguments: none

Response: List of commands available

Troubleshooting: Communication breakdown

HLT (Halt Motion Smoothly)

Description:	Stops the motion of specified axes smoothly. See the notes below for further details. Error code 10 is set. #24 (p. 129) and STP (p. 191) in contrast abort current motion as fast as possible for the controller without taking care of maximum velocity and acceleration.
Format:	HLT [{<AxisID>}]
Arguments:	<AxisID>: is one axis of the controller, if left out, all axes are stopped
Response:	none
Troubleshooting:	Illegal axis identifier
Notes:	HLT stops motion with specified system deceleration regarding system inertia. HLT stops all motion caused by motion commands (e.g., MOV (p. 176), MVR (p. 177), GOH (p. 156), STE (p. 190)), commands for referencing (FNL (p. 153), FPL (p. 154), FRF (p. 155)), and macros (MAC (p. 169)). After the axes are stopped, their target positions are set to their current positions.

HPA? (Get List Of Available Parameters)

Description:	Responds with a help string that contains all available parameters with short descriptions. Refer to "Parameter Overview" (p. 236) for further information.
Format:	HPA?
Arguments:	None
Response	{<PamID>"="<string> LF} where <PamID> is the ID of one parameter, hexadecimal format <string> is a string which describes the corresponding parameter. The string has the following format: <CmdLevel>TAB<MaxItem>TAB<DataType>TAB<FunctionGroupDescription>TAB<ParameterDescription>[{TAB<Possib

leValue>"="<ValueDescription>}]

where

<CmdLevel> is the command level that allows write access to the parameter value.

<MaxItem> is the maximum number of items of the same type which are affected by the parameter. With the C-863.12, an "item" is an axis or the entire system.

<DataType> is the data type of the parameter value; it can be INT, FLOAT, or CHAR.

<FunctionGroupDescription> is the name of the function group which the parameter belongs to.

<ParameterDescription> is the parameter name.

<PossibleValue> is one value from the permissible data range.

<ValueDescription> is the meaning of the corresponding value.

The parameters listed with HPA? can be changed and/or saved using the following commands:

SPA (p. 187) influences the parameter settings in volatile memory (RAM).

WPA (p. 201) copies parameter settings from volatile to nonvolatile memory.

SEP (p. 183) writes parameter settings directly into nonvolatile memory (without changing settings in volatile memory).

RPA (p. 181) resets volatile memory to the values from nonvolatile memory.

HPV? (Get Parameter Value Description)

Description: Responds with a help string that contains possible parameter values. Use HPA? instead to get a help string that contains all available parameters with short descriptions.

Format: HPV?

Arguments: None

Response: <string> has the following format:

“#Possible parameter values are:
{<PamID> <ItemID> “=” <ListType>
[{TAB <PossibleValue> “=” <ValueDescription>}] }
#CCL levels are:
{<PamID> <ItemID> “=”<CmdLevel> }
#HPA_Category enabled
end of help”

where

<PamID> is the ID of one parameter, hexadecimal format

<ItemID> is one item (axis, channel, whole system) of the controller, if item=0 the description applies to all items

<ListType> determines how the possible parameter values listed in the string have to be interpreted:
0 = parameter not applicable for this item
1 = enumeration
2 = min/max

<PossibleValue> is a value from the permissible data range

<ValueDescription> is the meaning of the corresponding value

Some parameters are write protected (by a command level > 1) for certain items. These parameters are listed below the “#CCL levels are” line.

<CmdLevel> is the command level that allows write access to the parameter value.

The "#HPA_Category enabled" line is evaluated by the PC software for display purposes.

Notes: For C-863.12, the specifications

```
#Possible parameter values are:
```

and

```
#CCL levels are:
```

are left out of the response to HPV?, because all required information is already in the response to HPA?

JAS? (Query Joystick Axis Status)

Description: Queries the current status of the specified axis of the specified joystick connected to the controller.

Format: JAS? [{<JoystickID> <JoystickAxis>}]

Arguments: <JoystickID> is one joystick connected to the controller; see below for details.

<JoystickAxis> is one of the axes of the joystick; see below for details.

Response: {<JoystickID> <JoystickAxis>"="<Amplitude>}

where

<Amplitude> is the factor which is currently applied to the current valid velocity setting of the controlled motion axis, corresponds to the current displacement of the joystick axis. See below for details.

Notes: A joystick can be connected to the **Joystick** (p. 261) socket of the C-863.12, the identifier is 1. The C-863.12 supports one axis of the joystick, the identifier of the joystick axis is 1. Refer also to "Commandable Elements" (p. 17) for more information.

The <Amplitude> factor is applied to the velocity set with VEL (p. 199), the range is from -1.0 to 1.0. Examples: With a factor of 0, the joystick axis is at the center position; with a factor of -0.7, the displacement of the joystick axis is about 2/3 in negative direction, provided that a linear lookup table is currently valid (see JLT (p. 164) for an example).

JAX (Set Axis Controlled By Joystick)

Description: Sets axis controlled by a joystick which is connected to the controller.

Each axis of the controller can only be controlled by one joystick axis.

Format: JAX <JoystickID> <JoystickAxis> <AxisID>

Arguments: <JoystickID> is one joystick connected to the controller;

see below for details.

<JoystickAxis> is one of the axes of the joystick; see below for details.

<AxisID> is one axis of the controller.

Response: none

Notes: A joystick can be connected to the **Joystick** (p. 261) socket of the C-863.12, the identifier is 1. The C-863.12 supports one axis of the joystick, the identifier of the joystick axis is 1. Refer also to "Commandable Elements" (p. 17) for more information.

JAX? (Get Axis Controlled By Joystick)

Description: Queries axis controlled by a joystick which is connected to the controller.

Format: JAX? [{<JoystickID> <JoystickAxis>}]

Arguments: <JoystickID> is one joystick connected to the controller; see below for details.

<JoystickAxis> is one of the axes of the joystick; see below for details.

Response: {<JoystickID> <JoystickAxis>"="{<AxisID> }LF}

where

<AxisID> is one axis of the controller.

Notes: A joystick can be connected to the **Joystick** (p. 261) socket of the C-863.12, the identifier is 1. The C-863.12 supports one axis of the joystick, the identifier of the joystick axis is 1. Refer also to "Commandable Elements" (p. 17) for more information.

JBS? (Query Joystick Button Status)

Description: Queries the current status of the specified button of the specified joystick connected to the controller.

Format: JBS? [{<JoystickID> <JoystickButton>}]

Arguments: <JoystickID> is one joystick connected to the controller; see below for details.

<JoystickButton> is one of the buttons of the joystick; see below for details.

Response: {<JoystickID> <JoystickButton> "="<State>}

where

<State> indicates if the joystick button is pressed; 0 = not pressed, 1 = pressed.

Notes: A joystick can be connected to the **Joystick** (p. 261) socket of the C-863.12, the identifier is 1. The C-863.12 supports one button of the joystick, the identifier of the joystick button is 1. Refer also to "Commandable Elements" (p. 17).

JDT (Set Joystick Default Lookup Table)

Description: Sets lookup table type for the specified axis of the specified joystick connected to the controller.

The current valid lookup-table content for the specified joystick axis is overwritten by the selection made with JDT.

Format: JDT {<JoystickID> <JoystickAxis> <uint>}

Arguments: <JoystickID> is one joystick connected to the controller; see below for details.

<JoystickAxis> is one of the axes of the joystick; see below for details.

<uint> defines the type of lookup-table profile to use; see below for details.

Response: none

Notes: A joystick can be connected to the **Joystick** (p. 261) socket of the C-863.12, the identifier is 1. The C-863.12 supports one axis of the joystick, the identifier of the joystick axis is 1. Refer also to "Commandable Elements" (p. 17) for more information.

Note: The number of write cycles in the nonvolatile memory is limited. Change the lookup table type only if necessary.

Available lookup tables: The C-863.12 provides the following types for the lookup-table profile:

1 = linear (default)
2 = parabolic

JLT (Fill Joystick Lookup Table)

Description: Fills the lookup table for the specified axis of the joystick specified that is connected to the controller.

The amplitudes of the joystick axes (i.e., their displacements) are mapped to the current valid velocity settings of the controller axes. For each joystick axis there is a lookup table that defines this mapping. With JLT this table can be written, or a default table profile provided by the controller can be loaded with the JDT command (p. 163).

Each lookup table consists of 256 points. By default, the first point corresponds to the maximum joystick axis displacement in negative direction, the 256th point to the maximum displacement in positive direction.

Format: JLT <JoystickID> <JoystickAxis> <Addr> <floatn>

Arguments: <JoystickID> is one joystick connected to the controller; see below for details.

<JoystickAxis> is one of the axes of the joystick; see below for details.

<Addr> is the index of a point in the lookup table, starts with 1.

<floatn> is the value of point n.

Response: none

Notes: A joystick can be connected to the **Joystick** (p. 261) socket of the C-863.12, the identifier is 1. The C-863.12 supports one axis of the joystick, the identifier of the joystick axis is 1. Refer also to "Commandable Elements" (p. 17) for more information.

The values <floatn> are factors applied during joystick control to the velocity set with VEL (p. 199), the range is from -1.0000 to 1.0000.

The values <floatn> are automatically stored in the non-volatile memory of the C-863.12.

Example: Point 1 has the value -1 in the current lookup table and therefore the controlled axis will move with full velocity in a negative direction at the maximum negative displacement of the joystick. Points 124 to 133 have a value of 0, i.e., at the center position of the joystick and in a small area around the center, the velocity is 0 and the controlled axis will not move. Point 236 has the value 0.8369, i.e., when the displacement of the joystick axis is about 2/3 in positive direction, the controlled axis will move in a positive direction with about 4/5 of the full velocity. Point 256 has the value 1, i.e., the controlled axis will move with full velocity in positive direction at the maximum positive displacement of the joystick.

Note: The number of write cycles in the nonvolatile memory is limited. Write values to the lookup table only if necessary.

JLT? (Get Joystick Lookup Table Values)

Description: Queries the current valid lookup table values.

Format: JLT? [<StartPoint> <NumberOfPoints> [{<JoystickID> <JoystickAxis>}]]

Arguments: <StartPoint>: is the start point in the lookup table, starts with 1

<NumberOfPoints>: is the number of points to be read per joystick axis; maximum number is 256.

<JoystickID> is one joystick connected to the controller; see below for details.

<JoystickAxis> is one of the axes of the joystick; see below for details.

Response: The lookup table content in GCS array format, see the separate manual for GCS array, SM 146E, and the example below.

Notes: With the C-863.12, <JoystickID> and <JoystickAxis> must be left out in the JLT? command, but <StartPoint> and <NumberOfPoints> are always required.

The values <floatn> in the lookup table are factors that are applied to the velocity set with VEL (p. 199), the range is -1.0000 to 1.0000.

Example:

```
jlt? 1 20
# TYPE = 1
#
# SEPARATOR = 32
# DIM = 1
# NDATA = 20
# NAME0 = Joysticktable 1
# END HEADER
-1.0000
-0.9922
-0.9834
-0.9756
-0.9678
-0.9590
-0.9512
-0.9434
-0.9346
-0.9268
-0.9189
-0.9102
-0.9023
-0.8945
-0.8857
-0.8779
-0.8701
-0.8613
-0.8535
-0.8457
```

JON (Set Joystick Activation Status)

Description: Activates or deactivates a joystick connected to the controller.

Format: JON {<JoystickID> <uint>}

Arguments: <JoystickID> is one joystick connected to the controller; see below for details.

<uint> 1 activates the joystick, 0 deactivates the joystick.

Response: none

Notes: A joystick can be connected to the **Joystick** (p. 261) socket of the C-863.12, the identifier is 1. For more information, see "Connecting an Analog Joystick" (p. 49).

Before a joystick can be activated with JON, its axes must have been assigned to the controller axes using JAX (p. 161).

When a joystick connected to the C-863.12 is activated with the JON command, this joystick controls the axis velocity ("commanded velocity" output by the profile

generator).
During joystick control, the soft limit specified by the parameter 0x15 or 0x30 is set as the target position. Details on the parameters can be found in "Travel Range and Soft Limits" (p. 31). When disabling a joystick, the target position is set to the current position of the joystick-controlled axis.

Motion commands such as MOV (p. 176) are not allowed when a joystick is active for the axis. For further information, see "Joystick Control" (p. 91).

JON? (Get Joystick Activation Status)

Description: Queries the activation state of the specified joystick connected to the controller.

Format: JON? [{<JoystickID>}]

Arguments: <JoystickID> is one joystick connected to the controller; see below for details.

Response: {<JoystickID>"="<uint>}

where

<uint> is the joystick activation state: 1 = joystick activated, 0 = joystick deactivated.

Notes: A joystick can be connected to the **Joystick** (p. 261) socket of the C-863.12, the identifier is 1. For more information, see "Connecting an Analog Joystick" (p. 49).

JRC (Jump Relatively Depending On Condition)

Description: Jumps relatively depending on a specified condition of the following type: one specified value is compared with a queried value according to a specified rule.

Can only be used in macros.

Format: JRC <Jump> <CMD?> <OP> <Value>

Arguments: <Jump> is the size of the relative jump. -1 means that the macro execution pointer jumps back to the previous line; 0 means that the command is executed again, which is the same behavior as with WAC (p. 200). 1 jumps to the next line, making the command unnecessary, and 2 jumps over the next command. Jumps are only permitted in the current macro.
<CMD?> is one query command in its usual notation. The

response must be a single value and not more. For an example see below.

<OP> is the operator to be used. The following operators are possible:
= <= < > >= !=
Important: There must be a space before and after the operator!

<Value> is the value to be compared with the response to <CMD?>.

Response: none

Troubleshooting: Check proper jump target

Example: Using the following macro, you can stop motion of axis "1" using a stop button connected to a digital input. The stop button is checked until the axis has reached the target position (query ONT?). When the stop button is pressed before the target position has been reached: The response to the POS? query is copied into the TARGET variable. This variable is then used as second argument for the MOV command. Therefore, the positioner just stays where it was. To clean up, TARGET is defined as empty with the VAR command which deletes the variable.

Write the "stop" macro:

```
MAC BEG stop
MOV 1 20
JRC 2 DIO? 1 = 1
JRC -1 ONT? 1 = 0
CPY TARGET POS? 1
MOV 1 ${TARGET}
VAR TARGET
MAC END
```

LIM? (Indicate Limit Switches)

Description: Queries whether axes have limit switches.

Format: LIM? [{<AxisID>}]

Arguments: <AxisID>: is one axis of the controller

Response: {<AxisID>"="<uint> LF}

where

<uint> indicates whether the axis has limit switches (=1) or not (=0).

Troubleshooting: Illegal axis identifier

Notes:

The C-863.12 firmware detects the presence or absence of limit switches using a parameter (ID 0x32). The C-863.12 activates or deactivates the stop motion function at the limit switches according to the value of this parameter as well as referencing moves using FNL (p. 153) or FPL (p. 154).

Adapt the parameter value to your hardware using SPA (p. 187) or SEP (p. 183). For further information, see "Limit Switch Detection" (p. 30).

You can use the digital input lines instead of the limit switches as source of the negative or positive limit switch signal. For further information, see "Digital Input Signals" (p. 86).

MAC (Call Macro Function)

Description:

Calls a macro function. Permits recording, deleting, and running macros on the controller.

Format:

MAC <keyword> {<parameter>}

in particular:

MAC BEG <macro name>
MAC DEF <macro name>
MAC DEF?
MAC DEL <macro name>
MAC END
MAC ERR?
MAC NSTART <macro name> <uint> [<String1> [<String2>]]
MAC START <macro name> [<String1> [<String2>]]

Arguments:

<keyword> determines which macro function is called. The following keywords and parameters are used:

MAC BEG <macroname>
Starts recording a macro to be named *macroname* on the controller; may not be used in a macro; the commands that follow become the macro. End the recording with MAC END. Note that erroneous macro content cannot be detected by sending the ERR? command.

MAC END
Stops macro recording (cannot become part of a macro)

MAC ERR?
RepoReports the last error that occurred while the macro was running.

Response: <macroname> <uint1>”=”<uint2> <”<”CMD”>”>

where <macroname> is the name of the macro, <uint1> is the line in the macro, <uint2> is the error code and <”<”CMD”>”> is the erroneous command which was sent to the parser.

MAC DEF <macroname>

Sets specified macro as startup macro. This macro will be run automatically after the next switch-on or reboot of the controller. If <macroname> is not specified, the current startup macro selection is canceled.

MAC DEF?

Asks for the startup macro
Response: <macroname>
If a startup macro is not defined, the response is an empty string with the terminating character.

MAC DEL <macroname>

Deletes specified macro.

MAC NSTART <macro name> <uint> [<String1> [<String2>]]

Repeats the specified macro <uint> times. The macro is re-run each time.

<String1> and <String2> are optional arguments which specify the values for local variables 1 and 2 used in the specified macro. <String1> and <String2> can be specified directly or via the values of variables. Macro will not run if the macro contains local variables but <String1> and <String2> are not specified in the MAC NSTART command. Refer to “Variables” (p. 120) for further details.

MAC START <macroname> [<String1> [<String2>]]

Runs the specified macro once. <String1> and <String2> have the same function as with MAC NSTART.

Response: None

Troubleshooting: Macro recording is active (keywords BEG, DEL) or inactive (END)

Macro contains a disallowed MAC command

Notes: Running a macro is not allowed when a macro is being recorded.

When a macro is recorded for a controller whose address is different from 1, the target address must be part of each command line, but will not become part of the macro content. PIMikroMove automatically sends the target address during the macro recording so that it does not have to be entered there. You will find further information in "Working with Macros" (p. 101) and "Target and Sender Address" (p. 119).

The `MAC BEG` and `MAC END` commands may not be specified when macros are recorded in the ***Controller macros*** tab in PIMikroMove.

A macro can be overwritten by a macro with the same name.

Macros can contain local and global variables. Refer to "Variables" (p. 120) for further information.

A running macro sends no responses to any interface.

Depending on the value of parameter 0x72 (***Ignore Macro Error?***), the following options exist when an error is caused by a running macro:

0 = Macro running is aborted (default).
1 = The error is ignored and the macro continues to run.

MAC ERR? always reports the last error that occurred while the a macro was running irrespective of the parameter setting.

The following commands provided by the C-863.12 can only be used in macros:
DEL (p. 142), JRC (p. 167), MEX (p. 174) and WAC (p. 200).

A macro can start another macro. The maximum number of nesting levels is 5. A macro can call itself to form an infinite loop.

All commands can be sent from the command line while a macro is running. The macro content and motion commands received from the command line can overwrite each other.

Macro execution can be stopped with #24 (p. 129) and STP (p. 191).

It is not possible to run several macros simultaneously. Only one macro can be run at a time.

A macro cannot be deleted while it is running.

You can query with #8 (p. 129) if a macro is currently running on the controller.

Note: The number of write cycles in the nonvolatile

memory is limited. Only record macros if this is necessary.

MAC? (List Macros)

Description: Lists macros or content of a specified macro.

Format: MAC? [<macroname>]

Arguments <macroname>: name of the macro where the content is to be listed; if not specified, the names of all stored macros are listed.

Response: <string>

If <macroname> was specified, <string> is the content of this macro;

If <macroname> was not specified, <string> is a list with the names of all stored macros

Troubleshooting: Macro <macroname> not found

MAN? (Get Help String For Command)

Description: Shows a detailed help text for individual commands.

Format: MAN? <CMD>

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

Response: A string that describes the command.

Notes: A detailed help text can be displayed for the following GCS commands:
CTO, CTO?, WPA

Example: Send: `MAN? CTO`

Receive:

```
CTO {<TrigOutID> <CTOPam> <Value>} Set
Configuration Of Trigger Output
#AvailableCTOparameters
<CTOPam> <Description>
<CTOPam> (configuration parameter):
1 TriggerStep
2 Axis
3 TriggerMode
7 Polarity
8 StartThreshold
9 StopThreshold
10 TriggerPosition
```

```
#AvailableTriggerModes
<Value> <Description>
0 PositionDistance
2 OnTarget
5 MotionError
6 InMotion
7 Position+Offset
8 SinglePosition
#AvailablePolarities
<Value> <Description>
0 ActiveLow
1 ActiveHigh
end of help
```

MAT (Calculate And Save To Variable)

Description: Carries out a mathematical operation or bit operation and saves the result as a variable (p. 120).

The variable is in volatile memory (RAM) only.

Format: MAT <Variable> "=" <FLOAT1> <OP> <FLOAT2>

Arguments: <Variable> is the name of the variable where the result is to be saved.

<FLOAT1> and <FLOAT2> are the values for calculating the result. They can be specified directly or via the value of a variable.

<OP> is the operator to be used: The following operators are possible:

<OP>	Operation	Type
+	Addition	Mathematical operation
-	Subtraction	Mathematical operation
*	Multiplication	Mathematical operation
AND	UND	Bit operation
OR	ODER	Bit operation
XOR	XOR	Bit operation

Important: There must be a blank space before and after each "=" and the operator!

Response: None

Notes: Using MAT to set local variables is only possible in macros.

Example 1: Send: `MAT TARGET = ${POS} * 2.0`
The `TARGET` variable contains 2.0 times the value of the `POS` variable.

Example 2: Send: `MAT TARGET = 2 * 0x10`
Send: `VAR? TARGET`
Receive: `TARGET=32`
NOTICE: The values from which the result is to be calculated can be written in hexadecimal or decimal format. The result is always output in decimal format.

Example 3: Send: `MAT INVERT = 0x45 XOR 0xFF`
Send: `VAR? INVERT`
Receive: `INVERT=186`
NOTICE: The bit operation XOR with the value 0xFF corresponds to an inversion of the value 0x45. The result is output in decimal format.

MEX (Stop Macro Execution Due To Condition)

Description: Stops running the macro due to a specified condition of the following type: a specified value is compared with a queried value according to a specified rule.

Can only be used in macros.

When the macro interpreter accesses this command, the condition is checked. If it is true, the current macro is stopped; otherwise the macro continues to run with the next line. Should the condition be fulfilled later, the interpreter will ignore it.

See also the WAC command (p. 200).

Format: MEX <CMD?> <OP> <Value>

Arguments <CMD?> is one query command in its usual syntax. The response has to be a single value and not more. For an example see below.

<OP> is the operator to be used. The following operators are possible:
= <= < > >= !=
Important: There must be a blank space before and after the operator!

<Value> is the value that is compared with the response to <CMD?>.

Response: None

Example: Send: `MAC START LOOP`

Note:
LOOP macro contains the following:

```
MAC START KEY1
MAC START KEY2
MEX DIO? 4 = 1
MAC START LOOP
```

KEY1 macro contains the following:

```
MEX DIO? 4 = 1
 MEX DIO? 1 = 0
 MVR 1 1.0
DEL 100
```

KEY2 macro contains the following:

```
MEX DIO? 4 = 1
MEX DIO? 2 = 0
 MVR 1 -1.0
DEL 100
```

LOOP macro forms an infinite loop by permanently calling KEY1, KEY2 and itself.

KEY1 checks the state of the digital input channel 1 (is on the I/O socket (p. 260)). If it is not set (0), the macro is aborted, otherwise the macro will move axis 1 by 1.0 in positive direction (relative move).

KEY2 checks the state of the digital input channel 2 and moves axis 1 in negative direction accordingly.

By connecting the digital input channels 1, 2 and 4 with pushbuttons, e.g., with the C-170.PB pushbutton box, it is possible to realize interactive control of an axis without any software assistance. The delay (DEL 100) is required to avoid generating multiple MVR commands while pressing the pushbutton for a short time.

Channel 4 is used as a global exit. Since MEX only stops execution of the current macro, it must also be included in the calling macro, which would otherwise continue.

MOV (Set Target Position)

Description: Sets an absolute target position for the specified axis.

Format: MOV {<AxisID> <Position>}

Arguments: <AxisID> is one axis of the controller.

<Position> is the absolute target position in physical units.

Response: none

Notes: The servo mode must be switched on when this command is used (closed-loop operation).

The target position must be inside the soft limits. Use TMN? (p. 194) and TMX? (p. 195) to query the current valid soft limits.

The motion can be stopped by #24 (p. 129), STP (p. 191), and HLT (p. 158).

During motion, a new motion command resets the target to a new value and the old value may never be reached. This is also valid with macros: Motion commands can be sent from the command line when a macro is running. The macro content and motion commands received from the command line can overwrite each other.

Motion commands such as MOV are not permitted when a joystick is active for the axis. For further information, see "Joystick Control" (p. 91).

Example 1: Send: `MOV 1 10`

Note: Axis 1 moves to 10 (target position in mm)

Example 2: Send: `MOV 1 243`

Send: `ERR?`

Receive: `7`

Note: The axis does not move. The error code "7" in the reply to the ERR? command (p. 151) indicates that the target position specified in the motion command is out of limits.

MOV? (Get Target Position)

Description: Returns last valid commanded target position.

Format: MOV? [{<AxisID>}]

Arguments: <AxisID> is one axis of the controller

Response: {<AxisID>"="<float> LF}

where

<float> is the last commanded target position in physical units

Troubleshooting: Illegal axis identifier

Notes: The target position can be changed by commands that cause motion (e.g. MOV (p. 176), MVR (p. 177), GOH (p. 156), STE (p. 190)) or by the joystick (when disabling a joystick, the target position is set to the current position for joystick-controlled axes in closed-loop operation).

MOV? gets the commanded positions. Use POS? (p. 179) to get the current positions.

MVR (Set Target Relative To Current Position)

Description: Moves the specified axis relative to the last commanded target position.

Format: MVR {<AxisID> <Distance>}

Arguments: <AxisID> is one axis of the controller.

<Distance> specifies the distance that the axis is to move; the sum of the distance and the last commanded target position is set as the new target position (in physical units).

Response: none

Notes: The servo mode must be switched on when this command is used (closed-loop operation).

The target position must be inside the soft limits. Use TMN? (p. 194) and TMX? (p. 195) to get the currently valid soft limits, and MOV? (p. 176) to get the current target.

The motion can be stopped by #24 (p. 129), STP (p. 191) and HLT (p. 158).

During motion, a new motion command resets the target to a new value and the old value may never be reached. This is also valid with macros: Motion commands can be sent from the command line when a macro is running. The macro content and motion commands received from the command line can overwrite each other.

Motion commands such as MVR are not permitted when a joystick is active for the axis. For further information, see

"Joystick Control" (p. 91).

Example:

Send: `MOV 1 0.5`

Note: This is an absolute motion.

Send: `POS? 1`

Receive: `1=0.500000`

Send: `MOV? 1`

Receive: `1=0.500000`

Send: `MVR 1 2`

Note: This is a relative motion.

Send: `POS? 1`

Receive: `1=2.500000`

Send: `MVR 1 2000`

Note: New target position of axis 1 would exceed motion range. Command is ignored, i.e., the target position remains unchanged, and the axis does not move.

Send: `MOV? 1`

Receive: `1=2.500000`

Send: `POS? 1`

Receive: `1=2.500000`

ONT? (Get On-Target State)

Description: Queries the on-target state of the specified axis.

If all arguments are left out, queries state of all axes.

Format: ONT? [{<AxisID>}]

Arguments: <AxisID> is one axis of the controller.

Response: {<AxisID>"="<uint> LF}

where

<uint> = "1" when the specified axis has reached the target value, otherwise "0".

Troubleshooting: Illegal axis identifier

Notes: The detection of the on-target state is only possible in closed-loop operation (servo mode ON).

The on-target state is influenced by the settings for the settling window (parameter 0x36) and the delay time (parameter 0x3F). Details see "On-Target State" (p. 29).

POS (Set Real Position)

Description:	Sets the current position of the axis (does not cause motion).
Format:	POS {<AxisID> <Position>}
Arguments:	<AxisID> is one axis of the controller. <Position> is the new current position in physical units.
Response:	None
Troubleshooting:	Illegal axis identifier
Notes:	It is only possible to set the current position with POS when the referencing method "0" is selected, see RON (p. 180). An axis is considered to be "referenced" when the position has been set with POS (for more information, see "Referencing" (p. 34)). The minimum and maximum commandable positions (TMN? (p. 194), TMX? (p. 195)) are not adapted when a position is set with POS. This can result in target positions which are allowed by the C-863.12 but cannot be reached by the hardware. Target positions are also possible that can be reached by the hardware but are refused by the C-863.12. Furthermore, the zero position can be outside of the physical travel range after using POS.

POS? (Get Real Position)

Description:	Queries the current axis position. If no arguments are specified, the current position of all axes is queried.
Format:	POS? [{<AxisID>}]
Arguments:	<AxisID> is one axis of the controller.
Response:	{<AxisID>"="<float> LF} where <float> is the current axis position in physical units.
Troubleshooting:	Illegal axis identifier

RBT (Reboot System)

Description: Reboots system. The controller behaves the same as after switching on.

Format: RBT

Arguments: none

Response: none

Notes: RBT cannot be used in macros. This is to avoid problems with startup macro execution.

RMC? (List Running Macros)

Description: Lists macros which are currently running.

Format: RMC?

Arguments: None

Response: {<macroname> LF}

where

<macroname> is the name of one macro which is saved on the controller and currently running. The response is an empty line when no macro is running.

RON (Set Reference Mode)

Description: Selects the referencing method for the specified axes

Format: RON {<AxisID> <ReferenceOn>}

Arguments: <AxisID> is one axis of the controller.

<ReferenceOn> is the referencing method. Can be 0 or 1. 1 is default. See below for details.

Response: None

Troubleshooting: Illegal axis identifier

Notes: <ReferenceOn> = 0: An absolute position value can be assigned with POS (p. 179) or a referencing move can be started with FRF (p. 155), FNL (p. 153) or FPL (p. 154). Relative motion with MVR is possible, even when referencing has not been done for the axis.

<ReferenceOn> = 1: A referencing move for the axis must be started with FRF, FNL or FPL. Using POS is not allowed. Motion in closed-loop operation is only possible when the axis has been referenced.

For further information, see "Referencing" (p. 34) and "Travel Range and Soft Limits" (p. 31).

RON? (Get Reference Mode)

Description: Queries referencing method of specified axes.

Format: RON? [{ <AxisID>}]

Arguments: <AxisID> is one axis of the controller.

Response: {<AxisID>"="<ReferenceOn> LF}

where

<ReferenceOn> is the currently selected referencing method for the axis

Troubleshooting: Illegal axis identifier

Note: Further information can be found in the description of the RON command (p. 180).

RPA (Reset Volatile Memory Parameters)

Description: Resets the specified parameter of the specified element. The value from nonvolatile memory is written into volatile memory.

Related commands:

With HPA? (p. 158) you can obtain a list of the available parameters. SPA (p. 187) influences the parameter settings in volatile memory, WPA (p. 201) writes parameter settings from volatile to nonvolatile memory, and SEP (p. 183) writes parameter settings directly into nonvolatile memory (without changing the settings in volatile memory).

See SPA for an example.

Format: RPA [{<ItemID> <PamID>}]

Arguments: <ItemID> is the element for resetting a parameter. See below for details.

<PamID> is the parameter ID, can be written in hexadecimal or decimal format. See below for details.

Response: none

Troubleshooting: Illegal element identifier, wrong parameter ID

Notes: With the C-863.12, you can reset either all parameters or one single parameter with RPA.

Available element IDs and parameter IDs: An element is an axis (the identifier can be changed with SAI (p. 183)) or the entire system. Refer to "Commandable Elements" (p. 17) for further information.

Valid parameter IDs are specified in "Parameter Overview" (p. 236).

RTR (Set Record Table Rate)

Description: Sets the record table rate, i.e., the number of cycles to be used in data recording operations. Settings larger than 1 make it possible to cover longer time periods.

Format: RTR <RecordTableRate>

Arguments: <RecordTableRate> is the record table rate to be used for recording operations (unit: number of cycles), must be an integer value larger than zero.

Response: None

Notes: The duration of the recording can be calculated as follows:

Rec. duration = cycle time of the servo loop * RTR value * number of points

where

the cycle time of the servo loop for the C-863.12 is 50 µs

the number of points for the C-863.12 is 1024 (length of data recorder table)

For further information, see "Data Recorder" (p. 76).

The record table rate set with RTR is saved in volatile memory (RAM) only.

RTR? (Get Record Table Rate)

Description: Queries the current record table rate, i.e., the number of cycles used in data recording operations.

Format: RTR?

Arguments: None

Response: <RecordTableRate> is the table rate used for recording operations (unit: number of cycles).

SAI (Set Current Axis Identifiers)

Description:	Sets the axis identifiers for the specified axes. After it was set with SAI, the new axis identifier must be used as <AxisID> in all axis-related commands.
Format:	SAI {<AxisID> <NewIdentifier>}
Arguments:	<AxisID> is one axis of the controller <NewIdentifier> is the new identifier to use for the axis, see below for details
Response:	none
Notes:	An axis identifier can consist of up to 8 characters. Use TVI? (p. 197) to get valid characters. The new axis identifier is only stored in the volatile memory of the C-863.12. A changed axis identifier can be stored permanently in the C-863.12 with the WPA (p. 201) command.

SAI? (Get List Of Current Axis Identifiers)

Description:	Queries the axis identifiers. Refer also to "Commandable Elements" (p. 17).
Format:	SAI? [ALL]
Arguments:	[ALL] is optional. For controllers that allow deactivating the axis, [ALL] ensures that the response also includes the axes that are "deactivated".
Response:	{<AxisID> LF} <AxisID> is one axis of the controller.

SEP (Set Non-Volatile Memory Parameters)

Description:	Sets a parameter of a specified element to a different value in nonvolatile memory, where it becomes the new default. After parameters were set with SEP, you can use RPA (p. 181) to activate them (write them to volatile memory) without controller reboot.

Note that this command is for setting hardware-specific parameters. Wrong values may lead to improper operation or damage of your hardware!

Related commands:

HPA? (p. 158) returns a list of the available parameters.

SPA (p. 187) writes parameter settings into volatile memory (without changing the settings in nonvolatile memory).

WPA (p. 201) writes parameter settings from volatile to nonvolatile memory.

Format: SEP <Pswd> {<ItemID> <PamID> <PamValue>}

Arguments <Pswd> is the password for writing to the nonvolatile memory; the default value is "100".

<ItemID> is the element for changing a parameter in the nonvolatile memory. See below for details.

<PamID> is the parameter identifier, can be written in hexadecimal or decimal format. See below for details.

<PamValue> is the value for setting the specified parameter of the specified element.

Response: None

Troubleshooting: Illegal element identifier, wrong parameter ID, invalid password

Notes: **Note that the number of write cycles in the nonvolatile memory is limited. Write default settings only if necessary.**

With the C-863.12 you can only write one parameter per SEP command.

Available item IDs and parameter IDs: An element is an axis (the identifier can be changed with SAI (p. 183)) or the entire system. Refer to "Commandable Elements" (p. 17) for further information.

Valid parameter IDs are specified in "Parameter Overview" (p. 236).

SEP? (Get Nonvolatile Memory Parameters)

Description:	Queries the value of a parameter of a specified element from nonvolatile memory. With HPA? (p. 158) you can obtain a list of the available parameters and their IDs.
Format:	SEP? [{<ItemID> <PamID>}]
Arguments:	<ItemID> is the element for querying a parameter value from nonvolatile memory. See below for details. <PamID> is the parameter ID, can be written in hexadecimal or decimal format. See below for details.
Response:	{<ItemID> <PamID>"="<PamValue> LF} where <PamValue> is the value of the specified parameter for the specified element
Troubleshooting:	Illegal element identifier, wrong parameter ID
Notes:	With the C-863.12, you can query either all parameters or one single parameter per SEP? command.
Available element IDs and parameter IDs:	An element is an axis (the identifier can be changed with SAI (p. 183)) or the entire system. Refer to "Commandable Elements" (p. 17) for further information. Valid parameter IDs are specified in "Parameter Overview" (p. 236).

SMO (Set Open-Loop Control Value)

Description:	Sets control value directly to move the axis. Profile generator (if present), sensor feedback and servo algorithm are not taken into account. Servo mode must be switched off when using this command (open-loop operation).
Format:	SMO {<AxisID> <ControlValue>}
Arguments	<AxisID> is one axis of the controller. <ControlValue> is the new control value (dimensionless). See below for details.
Response:	None
Troubleshooting:	Illegal axis identifier

Servo mode is switched on for one of the specified axes.

Notes: **NOTICE: In the case of large control values, the positioner can collide with the hard stop despite the limit switch function. This can cause damage to equipment.**

The unsigned control value may not be greater than the value of the ***Maximum Motor Output*** parameter (0x9). When this parameter is set to its maximum (32767), <ControlValue> ranges from -32766 to 32766 (dimensionless). The sign of the value determines the direction of motion.

<ControlValue> controls the PWM converter for the axis (see block diagram (p. 16)).

For further information, see "Motor Control" (p. 16).

Example: Send: `SMO 1 -16000`

Note: The control value is about half the maximum control value. The axis moves in negative direction.

SMO? (Get Control Value)

Description: Gets last valid control value of given axis.

Format: SMO? [{<AxisID>}]

Arguments <AxisID> is one axis of the controller

Response: {<AxisID>"="<float> LF}

where

<float> is the last valid control value (dimensionless). For details see below.

Troubleshooting: Illegal axis identifier

Notes: The control value which is returned by SMO? can be the result of the servo algorithm and other corrections, or it can be the value set by an SMO command (p. 185) in open-loop operation. See the block diagram (p. 16) for further information.

The control value ranges from -32766 to 32766 (dimensionless) and controls the PWM converter for the axis. The sign of the value determines the direction of motion.

SPA (Set Volatile Memory Parameters)

Description: Sets a parameter of the specified element in the volatile memory (RAM) to a specific value. Parameter changes are lost when the controller is switched off or rebooted.

Format: SPA {<ItemID> <PamID> <PamValue>}

Arguments: <ItemID> is the element for which a parameter is changed in volatile memory. See below for details.

<PamID> is the parameter ID, can be written in hexadecimal or decimal format. See below for details.

<PamValue> is the value to which the specified parameter of the specified element is set.

Response: None

Parameter changes are also lost when the parameters are reset to their default values with RPA (p. 181).

Note that this command is for setting hardware-specific parameters. Wrong values may lead to improper operation or damage of your hardware!

Related commands:

HPA? (p. 158) returns a list of the available parameters.

SEP (p. 183) writes parameter settings directly into nonvolatile memory (without changing the settings in volatile memory).

WPA (p. 201) writes parameter settings from volatile to nonvolatile memory.

RPA resets volatile memory to the value in nonvolatile memory.

Troubleshooting: Illegal element identifier, wrong parameter ID, value out of range

Notes: With the C-863.12, you can write only one parameter per SPA command.

Available item IDs and parameter IDs: An item is an axis (the identifier can be changed with SAI (p. 183)) or the entire system. For further information, see "Commandable Items" (p. 17).

Valid parameter IDs are specified in the parameter overview (p. 236).

Example 1: Send: `SPA 1 0x411 100`

Note: Sets the P term of the servo algorithm for axis 1 to 100; the parameter ID is written in hexadecimal format

Send: `SPA 1 1041 150`

Note: Sets the P term of the servo algorithm for axis 1 to 150; the parameter ID is written in decimal format

Example 2: The P, I and D parameters of the servo algorithm must be adapted to a new load applied to the mechanics connected.

Send: `SPA 1 0x411 150`

Note: The P term is set to 150 for axis 1. The setting is made in volatile memory only.

Use SPA to set the I and D terms in volatile memory and then test the function of the system. If the closed-loop system performance proves satisfactory and you want to use this system configuration as default, save the parameter settings from volatile to nonvolatile memory.

Send: `WPA 100`

Note: See the command description for WPA (p. 201) for details on the extent of the saved settings.

Example 3: Send: `SEP 100 LEFT 0xA 20`

Note: The maximum velocity must be set to 20 mm/s for axis LEFT (axis was renamed with SAI). The setting is made in nonvolatile memory and is therefore the new default, but is not yet active. To use the new settings immediately, you now have to load them to volatile memory (otherwise they would become active after the next power-on or reboot of the controller).

Send: `RPA`

Note: The new configuration is active now.

Send: `SPA? LEFT 0xA`

Receive: `LEFT 0xA=20.00000`

Note: Check the parameter settings in volatile memory.

SPA? (Get Volatile Memory Parameters)

Description:	Queries the value of a parameter of a specified element from volatile memory (RAM). You can obtain a list of the available parameters with HPA? (p. 158).
Format:	SPA? [{<ItemID> <PamID>}]
Arguments:	<ItemID> is the element for querying a parameter in volatile memory. See below for details. <PamID> is the parameter identifier, can be written in hexadecimal or decimal format. See below for details.
Response:	{<ItemID> <PamID>"="<PamValue> LF} where <PamValue> is the value of the specified parameter for the specified element
Troubleshooting:	Illegal element identifier, wrong parameter ID
Notes:	With the C-863.12, you can query either all parameters or one single parameter per SPA? command.
Available item IDs and parameter IDs:	An item is an axis (the identifier can be changed with SAI (p. 183)) or the entire system. For further information, see "Commandable Items" (p. 17). Valid parameter IDs are specified in the parameter overview (p. 236).

SRG? (Query Status Register Value)

Description:	Returns register values for queried elements and registers.
Format:	SRG? [{<ItemID> <RegisterID>}]
Arguments:	<ItemID> is the element for querying a register. See below for details. <RegisterID> is the ID of the specified register; see below for available registers.
Response:	{<ItemID><RegisterID>"="<Value> LF} where <Value> is the value of the register; see below for more details.
Note:	This command is identical in function to #4 (p. 128) which

should be preferred when the controller is performing time-consuming tasks.

Possible register IDs and response values:

<ItemID> is one axis of the controller.

<RegisterID> can be 1.

<Value> is the bit-encoded response and is returned as the sum of the following individual codes in hexadecimal format:

Bit	15	14	13	12	11	10	9	8
Descript-ion	On-target state	Is referencing	In motion	Servo mode on	-	-	-	Error flag

Bit	7	6	5	4	3	2	1	0
Descript-ion	Digital in-put line 4	Digital in-put line 3	Digital in-put line 2	Digital in-put line 1	-	Positiv e limit switch	Ref-erence switch	Nega-tive limit switch

Example:

Send: `SRG? 1 1`

Receive: `1 1=0x9002`

Note: The response is in hexadecimal format. It means that axis 1 is on target (on-target state = true), the servo mode is ON for that axis, no error has occurred, the states of digital input lines 1 to 4 are low, and axis 1 is on the positive side of the reference switch.

STE (Start Step And Response Measurement)

Description:

Starts a step and records the step response for the specified axis.

The data recorder configuration, i.e., the assignment of data sources and record options to the recorder tables, can be set with DRC (p. 146).

The recorded data can be read with the DRR? command (p. 148).

Format: STE <AxisID> <Amplitude>

Arguments: <AxisID> is one axis of the controller

<Amplitude> is the size of the step. See below for details.

Response: None

Troubleshooting: Servo mode must be switched on for the commanded axis prior to using this command (closed-loop operation).

The target position must be inside the soft limits. Use TMN? (p. 194) and TMX? (p. 195) to ask for the current valid soft limits, and MOV? (p. 176) for the current target.

Motion commands like STE are not allowed when the joystick is active for the axis. For further information see "Joystick Control" (p. 91).

Notes: A "step" consists of a relative move of the specified amplitude which is performed relative to the current position.

STP (Stop All Axes)

Description: Stops all axes abruptly. See the notes below for further details.

Sets error code to 10.

This command is identical in function to #24 (p. 129).

Format: STP

Arguments: None

Response: None

Troubleshooting: Communication breakdown

Notes: STP stops all motion caused by motion commands (e.g., MOV (p. 176), MVR (p. 177), GOH (p. 156), STE (p. 190)), commands for referencing (FNL (p. 153), FPL (p. 154), FRF (p. 155)), and macros (MAC (p. 169)). Also stops macro running.

After the axes are stopped, their target positions are set to their current positions.

HLT (p. 158) in contrast to STP stops motion with specified system deceleration regarding system inertia.

SVO (Set Servo Mode)

Description: Sets the servo mode for specified axes (open-loop or closed-loop operation).

Format:	SVO {<AxisID> <ServoState>}
Arguments:	<AxisID> is one axis of the controller <ServoState> can have the following values: 0 = servo mode off (open-loop operation) 1 = servo mode on (closed-loop operation)
Response:	None
Troubleshooting:	Illegal axis identifier

Notes:

When switching from open-loop to closed-loop operation, the target is set to the current position to avoid jumps of the mechanics.

The current state of the servo mode determines the applicable motion commands:
Servo mode on: Use the MOV (p. 176), MVR (p. 177), GOH (p. 156) commands or joystick control (p. 91).
Servo mode off: Use SMO (p. 185).

The servo mode must be switched on before referencing moves can be started with FRF (p. 155), FNL (p. 153) or FPL (p. 154).

When the servo mode is switched off while the axis is moving, the axis stops.

You can use a startup macro to configure the controller so that the servo mode is switched on automatically after switching on or rebooting. For further information, see "Setting up a startup macro" (p. 107).

If the axis has a brake, setting the servo mode with SVO influences the activation state of the brake:

- Switching on the servo mode deactivates the brake.
- Switching off the servo mode activates the brake. When the servo mode is switched off, the brake can be activated or deactivated with BRA (p. 133). Secure the positioner against unintentional motion before you deactivate the brake with BRA!

If a motion error occurs, the servo mode is switched off and the brake is activated. For more information see "Motion Errors" (p. 75).

SVO? (Get Servo Mode)

Description: Queries the servo mode for the axes specified.

If arguments are not specified, queries the servo mode of all axes.

Format: SVO? [{<AxisID>}]

Arguments: <AxisID> is one axis of the controller.

Response: {<AxisID>"="<ServoState> LF}

where

<ServoState> is the current servo mode for the axis:
0 = servo mode off (open-loop operation)
1 = servo mode on (closed-loop operation)

Troubleshooting: Illegal axis identifier

TAC? (Tell Analog Channels)

Description: Gets the number of installed analog lines.

Format: TAC?

Arguments: None

Response: <uint> indicates the total number of analog lines (inputs and outputs).

Notes: Gets the number of analog input lines on the **I/O** socket (p. 260) of the C-863.12 (Input 1 to Input 4). Note that these lines can also be used for digital input. For further information, refer to "Commandable Elements" (p. 17).

TAV? (Get Analog Input Voltage)

Description: Get voltage at analog input.

Format: TAV? [{<AnalogInputID>}]

Arguments: <AnalogInputID> is the identifier of the analog input channel; see below for details.

Response: {<AnalogInputID>"="<float> LF}

where

<float> is the current voltage at the analog input in volts

Notes: Using the TAV? command, you can directly read the Input 1 to Input 4 lines on the **I/O** socket (p. 260) of the C-863.12. The identifiers of the lines are 1 to 4. Refer to "Commandable Elements" (p. 17) for further information.

You can record the values of the analog input lines using the DRC record option 81 (p. 146).

TCV? (Get Commanded Closed-Loop Velocity)

Description: Queries the current value of the velocity (value calculated by the profile generator).

Format: TCV? [{<AxisID>}]

Arguments: <AxisID> is one axis of the controller.

Response: {<AxisID>"="<float> LF}

where

<float> is the velocity value in physical units per second.

TIO? (Tell Digital I/O Lines)

Description: Tells number of installed digital I/O lines

Format: TIO?

Arguments: none

Response: I=<uint1>
O=<uint2>

where

<uint1> is the number of digital input lines.
<uint2> is the number of digital output lines.

Notes: The digital output lines reported by TIO? are Output 1 to Output 4. The states of the Output 1 to Output 4 lines can be set using the DIO command (p. 144). Furthermore, you can program the Output 1 to Output 4 lines using the CTO command (p. 137) (trigger configuration) and the TRO command (p. 195) (trigger activation/deactivation).

The digital input lines reported by TIO? are Input 1 to Input 4. They can be read with DIO? (p. 145), #4 (p. 128) and SRG? (p. 189).

All the lines are located on the **I/O** socket (p. 260) of the C-863.12.

TMN? (Get Minimum Commandable Position)

Description: Get the minimum commandable position in physical units.

Format: TMN? [{ <AxisID>}]

Arguments: <AxisID> is one axis of the controller

Response {<AxisID>"="<float> LF}

where

<float> is the minimum commandable position in physical units

Note: The minimum commandable position is defined by the parameter 0x30. When redefining the zero position with the DFH (p. 142) command, the minimum commandable position is automatically adapted to the new zero position.

TMX? (Get Maximum Commandable Position)

Description: Get the maximum commandable position in physical units.

Format: TMX? [{ <AxisID>}]

Arguments: <AxisID> is one axis of the controller

Response {<AxisID>"="<float> LF}

where

<float> is the maximum commandable position in physical units

Note: The maximum commandable position is defined by the parameter 0x15. When redefining the zero position with the DFH (p. 142) command, the maximum commandable position is automatically adapted to the new zero position.

TNR? (Get Number of Record Tables)

Description: Queries the number of data recorder tables currently available on the controller.

Format: TNR?

Arguments: none

Response <uint> is the number of data recorder tables which are currently available

Notes: The C-863.12 has four data recorder tables with 1024 data points per table.

For further information, see "Data Recorder" (p. 76).

TRO (Set Trigger Output State)

Description: Activates or deactivates the trigger output conditions set with CTO (p. 137) for the specified digital output line.

Format: TRO {<TrigOutID> <TrigMode>}

Arguments: <TrigOutID> is a digital output line of the controller; see below for further details.

<TrigMode> can have the following values:
0 = Trigger output deactivated
1 = Trigger output activated

Response: None

Troubleshooting: Illegal identifier of the digital output line

Notes: <TrigOutID> corresponds to the digital output lines Output 1 to Output 4, IDs = 1 to 4; for further information, see "I/O" (p. 260).

Do not use DIO (p. 144) on digital output lines where the trigger output is activated by TRO.

TRO? (Get Trigger Output State)

Description: Queries the activation status of the trigger output configuration made with CTO (p. 137) for the specified digital output line.

If no arguments are specified, queries state of all digital output lines.

Format: TRO? [{<TrigOutID>}]

Arguments: <TrigOutID> is one digital output line of the controller, see TRO (p. 195) for more details.

Response: {<TrigOutID>"="<TrigMode> LF}

where

<TrigMode> is the current state of the digital output line:
0 = Trigger output deactivated
1 = Trigger output activated

Troubleshooting: Illegal identifier of the digital output line

TRS? (Indicate Reference Switch)

Description: Indicates whether axes have a reference switch with direction sensing.

Format: TRS? [{<AxisID>}]

Arguments: <AxisID> is one axis of the controller

Response: {<AxisID>"="<uint> LF}

where

<uint> indicates whether the axis has a direction-sensing reference switch (=1) or not (=0).

Troubleshooting: Illegal axis identifier

Notes: The C-863.12 firmware detects the presence or absence of a reference switch via a parameter (ID 0x14). The C-863.12 activates or deactivates referencing moves to the reference switch (FRF command (p. 155)) according to the value of this parameter. Adapt the parameter value to your hardware using SPA (p. 187) or SEP (p. 183). For further information, see "Reference Switch Detection" (p. 29).

You can use a digital input line instead of the reference switch as source of the reference point signal for the FRF command. For further information, see "Digital Input Signals" (p. 86).

TVI? (Tell Valid Character Set For Axis Identifiers)

Description: Returns a string with characters which can be used for axis identifiers.

Use SAI (p. 183) to change the axis identifiers and SAI? (p. 183) to ask for the current valid axis identifiers.

Format: TVI?

Arguments: None

Response: <string> is a list of characters

Notes: With the C-863.12, the string consists of 1234567890ABCDEFGHIJKLMNOPQRSTUVWXYZ-_

VAR (Set Variable Value)

Description: Sets a variable to a certain value.

Local variables can be set using VAR in macros only. See “Variables” (p. 120) for more details on local and global variables.

The variable is present in RAM only.

Format: VAR <Variable> <String>

Arguments: <Variable> is the name of the variable whose value is to be set.

<String> is the value to which the variable is to be set. If not specified, the variable is deleted.

The value can be specified directly or via the value of a variable.

Refer to “Variables” (p. 120) for more details on conventions regarding variable names and values.

Response: None

Example: It is possible to set the value of one variable (e.g., TARGET) to that of another variable (e.g., SOURCE):

```
VAR TARGET ${SOURCE}
```

Use braces if the name of the variable is longer than one character:

```
VAR A ONE
VAR VARB TWO
VAR $A 1
VAR ${VARB} 2
VAR $VARB 2 // this will result in an unwanted behavior
VAR?
A=ONE
VARB=TWO
ONE=1
TWO=2 // ${VARB}: is replaced by its value “TWO”.
ARB=2 // $VARB: $V is replaced by its (empty) value.
```

See ADD (p. 131) for another example.

VAR? (Get Variable Values)

Description:	Gets values of variables. If VAR? is combined with CPY (p. 136), JRC (p. 167), MEX (p. 174) or WAC (p. 200), the response to VAR? has to be a single value and not more. Refer to "Variables" (p. 120) for more details on local and global variables.
Format:	VAR? [{<Variable>}]
Arguments:	<Variable> is the name of the variable to be queried. Refer to "Variables" (p. 120) for more details on name conventions. All global variables present in RAM are listed if <Variable> is not specified.
Response:	{<Variable>"="<String>LF} where <String> gives the value to which the variable is set.
Notes:	Local variables can be queried using VAR? only when a macro with local variables is running. See "Variables" (p. 120) for details regarding local and global variables.
Example:	See ADD (p. 131) for an example.

VEL (Set Closed-Loop Velocity)

Description:	Set velocity of specified axes.
Format:	VEL {<AxisID> <Velocity>}
Arguments:	<AxisID> is one axis of the controller. <Velocity> is the velocity value in physical units/s.
Response:	None
Troubleshooting:	Illegal axis identifiers
Notes:	The VEL setting only takes effect when the specified axis is in closed-loop operation (servo mode ON). The lowest possible value for <Velocity> is 0. The velocity can be changed with VEL while the axis is moving. VEL changes the value of the ***Closed-Loop Velocity (Phys.***

Unit/s) parameter (ID 0x49) in the volatile memory of C-863.12. The parameter value can be stored as default with WPA (p. 201), for details see "Adapting Settings" (p. 227).

The maximum value that can be set with the VEL command is specified by the ***Maximum Closed-Loop Velocity (Phys. Unit/s)*** parameter, ID 0xA.

VEL? (Get Closed-Loop Velocity)

Description: Queries the commanded velocity.

If no arguments are specified, queries the value of all axes.

Format: VEL? [{<AxisID>}]

Arguments: <AxisID> is one axis of the controller.

Response: {<AxisID>"="<float> LF}

where

<float> is the currently valid velocity value commanded in physical units per second.

Notes: VEL? queries the velocity value for closed-loop operation.

VER? (Get Versions Of Firmware And Drivers)

Description: Gets the versions of the firmware of the C-863.12 as well as of further components like, for example, drivers and libraries.

Format: VER?

Arguments: None

Response {<string1>":" <string2> [<string3>]LF}

where

<string1> is the name of the component;
<string2> is the version information of the component <string1>;
<string3> is an optional note.

WAC (Wait For Condition)

Description: Waits until a specified condition of the following type occurs: a specified value is compared with a queried value according a specified rule.

Can only be used in macros.

See also the MEX command (p. 174).

Format: WAC <CMD?> <OP> <value>

Arguments <CMD?> is one query command in its usual notation. The response has to be a single value and not more. For an example see below.

<OP> is the operator to be used. The following operators are possible:
= <= < > >= !=
Important: There must be a blank space before and after the operator!

<value> is the value to be compared with the response to <CMD?>.

Response: None

Example: Send:

```
MAC BEG LPMOTION
MVR 1 1
 WAC ONT? 1 = 1
MVR 1 -1
 WAC ONT? 1 = 1
MAC START LPMOTION
MAC END
MAC START LPMOTION
```

Note: Macro LPMOTION is first recorded and then started. WAC ONT? 1 = 1 waits until the response to ONT? 1 is 1=1. To form an infinite loop, the macro calls itself.

WPA (Save Parameters To Non-Volatile Memory)

Description: Writes the currently valid value of a parameter of a specified element from volatile memory (RAM) to nonvolatile memory. The values saved this way become the default values.

Note: If the current parameter values are incorrect, this can cause a fault in the system. Make sure that the parameter settings are correct before you execute the WPA command.

RAM settings not saved with WPA will be lost when the controller is switched off or rebooted or when RPA (p. 181) is used to restore the parameters.

You can obtain a list of all available parameters with HPA? (p. 158).

Use SPA? (p. 187) to check the current parameter settings in volatile memory.

See SPA (p. 187) for an example.

Format: WPA <Pswd> [{<ItemID> <PamID>}]

Arguments: <Pswd> is the password for writing to the nonvolatile memory. See below for details.

<ItemID> is the element for which a parameter is to be saved from the volatile to the nonvolatile memory. See below for details.

<PamID> is the parameter identifier, can be written in hexadecimal or decimal format. See below for details.

Response: None

Troubleshooting: Illegal element identifier, wrong parameter ID, invalid password

Notes: Parameters can be changed in volatile memory with SPA (p. 187), ACC (p. 130), DEC (p. 141), and VEL (p. 199).

When WPA is used without specifying any arguments except the password, the currently valid values of all parameters affected by the specified password are saved. Otherwise only one single parameter can be saved per WPA command.

Note that the number of write cycles in the nonvolatile memory is limited. Write default settings only if necessary.

Valid passwords: The password for writing to the nonvolatile memory is "100".

Available element IDs and parameter IDs: An element is an axis (the identifier can be changed with SAI (p. 183)) or the entire system. Refer to "Commandable Elements" (p. 17) for further information.

Valid parameter IDs are specified in "Parameter Overview" (p. 236).

8.7 Error Codes

The error codes listed here are those of the PI General Command Set. As such, some may be not relevant to your controller and will simply never occur.

Controller Errors

0	PI_CNTR_NO_ERROR	No error
1	PI_CNTR_PARAM_SYNTAX	Parameter syntax error
2	PI_CNTR_UNKNOWN_COMMAND	Unknown command
3	PI_CNTR_COMMAND_TOO_LONG	Command length out of limits or command buffer overrun
4	PI_CNTR_SCAN_ERROR	Error while scanning
5	PI_CNTR_MOVE_WITHOUT_REF_OR_NO_SERVO	Unallowable move attempted on unreferenced axis, or move attempted with servo off
6	PI_CNTR_INVALID_SGA_PARAM	Parameter for SGA not valid
7	PI_CNTR_POS_OUT_OF_LIMITS	Position out of limits
8	PI_CNTR_VEL_OUT_OF_LIMITS	Velocity out of limits
9	PI_CNTR_SET_PIVOT_NOT_POSSIBLE	Attempt to set pivot point while U,V and W not all 0
10	PI_CNTR_STOP	Controller was stopped by command
11	PI_CNTR_SST_OR_SCAN_RANGE	Parameter for SST or for one of the embedded scan algorithms out of range
12	PI_CNTR_INVALID_SCAN_AXES	Invalid axis combination for fast scan
13	PI_CNTR_INVALID_NAV_PARAM	Parameter for NAV out of range
14	PI_CNTR_INVALID_ANALOG_INPUT	Invalid analog channel
15	PI_CNTR_INVALID_AXIS_IDENTIFIER	Invalid axis identifier
16	PI_CNTR_INVALID_STAGE_NAME	Unknown stage name
17	PI_CNTR_PARAM_OUT_OF_RANGE	Parameter out of range
18	PI_CNTR_INVALID_MACRO_NAME	Invalid macro name
19	PI_CNTR_MACRO_RECORD	Error while recording macro
20	PI_CNTR_MACRO_NOT_FOUND	Macro not found
21	PI_CNTR_AXIS_HAS_NO_BRAKE	Axis has no brake
22	PI_CNTR_DOUBLE_AXIS	Axis identifier specified more than once

23	PI_CNTR_ILLEGAL_AXIS	Illegal axis
24	PI_CNTR_PARAM_NR	Incorrect number of parameters
25	PI_CNTR_INVALID_REAL_NR	Invalid floating point number
26	PI_CNTR_MISSING_PARAM	Parameter missing
27	PI_CNTR_SOFT_LIMIT_OUT_OF_RANGE	Soft limit out of range
28	PI_CNTR_NO_MANUAL_PAD	No manual pad found
29	PI_CNTR_NO_JUMP	No more step-response values
30	PI_CNTR_INVALID_JUMP	No step-response values recorded
31	PI_CNTR_AXIS_HAS_NO_REFERENCE	Axis has no reference sensor
32	PI_CNTR_STAGE_HAS_NO_LIM_SWITCH	Axis has no limit switch
33	PI_CNTR_NO_RELAY_CARD	No relay card installed
34	PI_CNTR_CMD_NOT_ALLOWED_FOR_STAGE	Command not allowed for selected stage(s)
35	PI_CNTR_NO_DIGITAL_INPUT	No digital input installed
36	PI_CNTR_NO_DIGITAL_OUTPUT	No digital output configured
37	PI_CNTR_NO_MCM	No more MCM responses
38	PI_CNTR_INVALID_MCM	No MCM values recorded
39	PI_CNTR_INVALID_CNTR_NUMBER	Controller number invalid
40	PI_CNTR_NO_JOYSTICK_CONNECTED	No joystick configured
41	PI_CNTR_INVALID_EGE_AXIS	Invalid axis for electronic gearing, axis can not be slave
42	PI_CNTR_SLAVE_POSITION_OUT_OF_RANGE	Position of slave axis is out of range
43	PI_CNTR_COMMAND_EGE_SLAVE	Slave axis cannot be commanded directly when electronic gearing is enabled
44	PI_CNTR_JOYSTICK_CALIBRATION_FAILED	Calibration of joystick failed
45	PI_CNTR_REFERENCING_FAILED	Referencing failed
46	PI_CNTR_OPM_MISSING	OPM (Optical Power Meter) missing
47	PI_CNTR_OPM_NOT_INITIALIZED	OPM (Optical Power Meter) not initialized or cannot be initialized
48	PI_CNTR_OPM_COM_ERROR	OPM (Optical Power Meter) Communication Error
49	PI_CNTR_MOVE_TO_LIMIT_SWITCH_FAILED	Move to limit switch failed
50	PI_CNTR_REF_WITH_REF_DISABLED	Attempt to reference axis

		with referencing disabled
51	PI_CNTR_AXIS_UNDER_JOYSTICK_CONTROL	Selected axis is controlled by joystick
52	PI_CNTR_COMMUNICATION_ERROR	Controller detected communication error
53	PI_CNTR_DYNAMIC_MOVE_IN_PROCESS	MOV! motion still in progress
54	PI_CNTR_UNKNOWN_PARAMETER	Unknown parameter
55	PI_CNTR_NO_REP_RECORDED	No commands were recorded with REP
56	PI_CNTR_INVALID_PASSWORD	Password invalid
57	PI_CNTR_INVALID_RECORDER_CHAN	Data Record Table does not exist
58	PI_CNTR_INVALID_RECORDER_SRC_OPT	Source does not exist; number too low or too high
59	PI_CNTR_INVALID_RECORDER_SRC_CHAN	Source Record Table number too low or too high
60	PI_CNTR_PARAM_PROTECTION	Protected Param: current Command Level (CCL) too low
61	PI_CNTR_AUTOZERO_RUNNING	Command execution not possible while Autozero is running
62	PI_CNTR_NO_LINEAR_AXIS	Autozero requires at least one linear axis
63	PI_CNTR_INIT_RUNNING	Initialization still in progress
64	PI_CNTR_READ_ONLY_PARAMETER	Parameter is read-only
65	PI_CNTR_PAM_NOT_FOUND	Parameter not found in non-volatile memory
66	PI_CNTR_VOL_OUT_OF_LIMITS	Voltage out of limits
67	PI_CNTR_WAVE_TOO_LARGE	Not enough memory available for requested wave curve
68	PI_CNTR_NOT_ENOUGH_DDL_MEMORY	Not enough memory available for DDL table; DDL can not be started
69	PI_CNTR_DDL_TIME_DELAY_TOO_LARGE	Time delay larger than DDL table; DDL can not be started
70	PI_CNTR_DIFFERENT_ARRAY_LENGTH	The requested arrays have different lengths; query them separately
71	PI_CNTR_GEN_SINGLE_MODE_RESTART	Attempt to restart the generator while it is running in single step mode
72	PI_CNTR_ANALOG_TARGET_ACTIVE	Motion commands and wave generator activation are not

		allowed when analog target is active
73	PI_CNTR_WAVE_GENERATOR_ACTIVE	Motion commands are not allowed when wave generator is active
74	PI_CNTR_AUTOZERO_DISABLED	No sensor channel or no piezo channel connected to selected axis (sensor and piezo matrix)
75	PI_CNTR_NO_WAVE_SELECTED	Generator started (WGO) without having selected a wave table (WSL).
76	PI_CNTR_IF_BUFFER_OVERRUN	Interface buffer did overrun and command couldn't be received correctly
77	PI_CNTR_NOT_ENOUGH_RECORDED_DATA	Data Record Table does not hold enough recorded data
78	PI_CNTR_TABLE_DEACTIVATED	Data Record Table is not configured for recording
79	PI_CNTR_OPENLOOP_VALUE_SET_WHEN_SERVO_ON	Open-loop commands (SVA, SVR) are not allowed when servo is on
80	PI_CNTR_RAM_ERROR	Hardware error affecting RAM
81	PI_CNTR_MACRO_UNKNOWN_COMMAND	Not macro command
82	PI_CNTR_MACRO_PC_ERROR	Macro counter out of range
83	PI_CNTR_JOYSTICK_ACTIVE	Joystick is active
84	PI_CNTR_MOTOR_IS_OFF	Motor is off
85	PI_CNTR_ONLY_IN_MACRO	Macro-only command
86	PI_CNTR_JOYSTICK_UNKNOWN_AXIS	Invalid joystick axis
87	PI_CNTR_JOYSTICK_UNKNOWN_ID	Joystick unknown
88	PI_CNTR_REF_MODE_IS_ON	Move without referenced stage
89	PI_CNTR_NOT_ALLOWED_IN_CURRENT_MOTION_MODE	Command not allowed in current motion mode
90	PI_CNTR_DIO_AND_TRACING_NOT_POSSIBLE	No tracing possible while digital IOs are used on this HW revision. Reconnect to switch operation mode.
91	PI_CNTR_COLLISION	Move not possible, would cause collision
92	PI_CNTR_SLAVE_NOT_FAST_ENOUGH	Stage is not capable of following the master. Check the gear ratio.

93	PI_CNTR_CMD_NOT_ALLOWED_WHILE_AXIS_IN_MOTION	This command is not allowed while the affected axis or its master is in motion.
94	PI_CNTR_OPEN_LOOP_JOYSTICK_ENABLED	Servo cannot be switched on when open-loop joystick control is activated.
95	PI_CNTR_INVALID_SERVO_STATE_FOR_PARAMETER	This parameter cannot be changed in current servo mode.
96	PI_CNTR_UNKNOWN_STAGE_NAME	Unknown stage name
97	PI_CNTR_INVALID_VALUE_LENGTH	Invalid length of value (too much characters)
98	PI_CNTR_AUTOZERO_FAILED	AutoZero procedure was not successful
99	PI_CNTR_SENSOR_VOLTAGE_OFF	Sensor voltage is off
100	PI_LABVIEW_ERROR	PI driver for use with NI LabVIEW reports error. See source control for details.
200	PI_CNTR_NO_AXIS	No stage connected to axis
201	PI_CNTR_NO_AXIS_PARAM_FILE	File with axis parameters not found
202	PI_CNTR_INVALID_AXIS_PARAM_FILE	Invalid axis parameter file
203	PI_CNTR_NO_AXIS_PARAM_BACKUP	Backup file with axis parameters not found
204	PI_CNTR_RESERVED_204	PI internal error code 204
205	PI_CNTR_SMO_WITH_SERVO_ON	SMO with servo on
206	PI_CNTR_UUDECODE_INCOMPLETE_HEADER	uudecode: incomplete header
207	PI_CNTR_UUDECODE_NOTHING_TO_DECODE	uudecode: nothing to decode
208	PI_CNTR_UUDECODE_ILLEGAL_FORMAT	uudecode: illegal UUE format
209	PI_CNTR_CRC32_ERROR	CRC32 error
210	PI_CNTR_ILLEGAL_FILENAME	Illegal file name (must be 8-0 format)
211	PI_CNTR_FILE_NOT_FOUND	File not found on controller
212	PI_CNTR_FILE_WRITE_ERROR	Error writing file on controller
213	PI_CNTR_DTR_HINDERS_VELOCITY_CHANGE	VEL command not allowed in DTR Command Mode
214	PI_CNTR_POSITION_UNKNOWN	Position calculations failed
215	PI_CNTR_CONN_POSSIBLY_BROKEN	The connection between controller and stage may be broken

216	PI_CNTR_ON_LIMIT_SWITCH	The connected stage has driven into a limit switch, some controllers need CLR to resume operation
217	PI_CNTR_UNEXPECTED_STRUT_STOP	Strut test command failed because of an unexpected strut stop
218	PI_CNTR_POSITION_BASED_ON_ESTIMATION	While MOV! is running position can only be estimated!
219	PI_CNTR_POSITION_BASED_ON_INTERPOLATION	Position was calculated during MOV motion
220	PI_CNTR_INTERPOLATION_FIFO_UNDERRUN	FIFO buffer underrun during interpolation
221	PI_CNTR_INTERPOLATION_FIFO_OVERFLOW	FIFO buffer overflow during interpolation
230	PI_CNTR_INVALID_HANDLE	Invalid handle
231	PI_CNTR_NO_BIOS_FOUND	No bios found
232	PI_CNTR_SAVE_SYS_CFG_FAILED	Save system configuration failed
233	PI_CNTR_LOAD_SYS_CFG_FAILED	Load system configuration failed
301	PI_CNTR_SEND_BUFFER_OVERFLOW	Send buffer overflow
302	PI_CNTR_VOLTAGE_OUT_OF_LIMITS	Voltage out of limits
303	PI_CNTR_OPEN_LOOP_MOTION_SET_WHEN_SERVO_ON	Open-loop motion attempted when servo ON
304	PI_CNTR_RECEIVING_BUFFER_OVERFLOW	Received command is too long
305	PI_CNTR_EEPROM_ERROR	Error while reading/writing EEPROM
306	PI_CNTR_I2C_ERROR	Error on I2C bus
307	PI_CNTR_RECEIVING_TIMEOUT	Timeout while receiving command
308	PI_CNTR_TIMEOUT	A lengthy operation has not finished in the expected time
309	PI_CNTR_MACRO_OUT_OF_SPACE	Insufficient space to store macro
310	PI_CNTR_EUI_OLDVERSION_CFGDATA	Configuration data has old version number
311	PI_CNTR_EUI_INVALID_CFGDATA	Invalid configuration data
333	PI_CNTR_HARDWARE_ERROR	Internal hardware error
400	PI_CNTR_WAV_INDEX_ERROR	Wave generator index error

401	PI_CNTR_WAV_NOT_DEFINED	Wave table not defined
402	PI_CNTR_WAV_TYPE_NOT_SUPPORTED	Wave type not supported
403	PI_CNTR_WAV_LENGTH_EXCEEDS_LIMIT	Wave length exceeds limit
404	PI_CNTR_WAV_PARAMETER_NR	Wave parameter number error
405	PI_CNTR_WAV_PARAMETER_OUT_OF_LIMIT	Wave parameter out of range
406	PI_CNTR_WGO_BIT_NOT_SUPPORTED	WGO command bit not supported
500	PI_CNTR_EMERGENCY_STOP_BUTTON_ACTIVATED	The \"red knob\" is still set and disables system
501	PI_CNTR_EMERGENCY_STOP_BUTTON_WAS_ACTIVATED	The \"red knob\" was activated and still disables system - reanimation required
502	PI_CNTR_REDUNDANCY_LIMIT_EXCEEDED	Position consistency check failed
503	PI_CNTR_COLLISION_SWITCH_ACTIVATED	Hardware collision sensor(s) are activated
504	PI_CNTR_FOLLOWING_ERROR	Strut following error occurred, e.g. caused by overload or encoder failure
505	PI_CNTR_SENSOR_SIGNAL_INVALID	One sensor signal is not valid
506	PI_CNTR_SERVO_LOOP_UNSTABLE	Servo loop was unstable due to wrong parameter setting and switched off to avoid damage.
507	PI_CNTR_LOST_SPI_SLAVE_CONNECTION	Digital connection to external SPI slave device is lost
508	PI_CNTR_MOVE_ATTEMPT_NOT_PERMITTED	Move attempt not permitted due to customer or limit settings
509	PI_CNTR_TRIGGER_EMERGENCY_STOP	Emergency stop caused by trigger input
530	PI_CNTR_NODE_DOES_NOT_EXIST	A command refers to a node that does not exist
531	PI_CNTR_PARENT_NODE_DOES_NOT_EXIST	A command refers to a node that has no parent node
532	PI_CNTR_NODE_IN_USE	Attempt to delete a node that is in use
533	PI_CNTR_NODE_DEFINITION_IS_CYCLIC	Definition of a node is cyclic

536	PI_CNTR_HEXAPOD_IN_MOTION	Transformation cannot be defined as long as Hexapod is in motion
537	PI_CNTR_TRANSFORMATION_TYPE_NOT_SUPPORTED	Transformation node cannot be activated
539	PI_CNTR_NODE_PARENT_IDENTICAL_TO_CHILD	A node cannot be linked to itself
540	PI_CNTR_NODE_DEFINITION_INCONSISTENT	Node definition is erroneous or not complete (replace or delete it)
542	PI_CNTR_NODES_NOT_IN_SAME_CHAIN	The nodes are not part of the same chain
543	PI_CNTR_NODE_MEMORY_FULL	Unused nodes must be deleted before new nodes can be stored
544	PI_CNTR_PIVOT_POINT_FEATURE_NOT_SUPPORTED	With some transformations pivot point usage is not supported
545	PI_CNTR_SOFTLIMITS_INVALID	Soft limits invalid due to changes in coordinate system
546	PI_CNTR_CS_WRITE_PROTECTED	Coordinate system is write protected
547	PI_CNTR_CS_CONTENT_FROM_CONFIG_FILE	Coordinate system cannot be changed because its content is loaded from a configuration file
548	PI_CNTR_CS_CANNOT_BE_LINKED	Coordinate system may not be linked
549	PI_CNTR_KSB_CS_ROTATION_ONLY	A KSB-type coordinate system can only be rotated by multiples of 90 degrees
551	PI_CNTR_CS_DATA_CANNOT_BE_QUERIED	This query is not supported for this coordinate system type
552	PI_CNTR_CS_COMBINATION_DOES_NOT_EXIST	This combination of work-and-tool coordinate systems does not exist
553	PI_CNTR_CS_COMBINATION_INVALID	The combination must consist of one work and one tool coordinate system
554	PI_CNTR_CS_TYPE_DOES_NOT_EXIST	This coordinate system type does not exist
555	PI_CNTR_UNKNOWN_ERROR	BasMac: unknown controller error

556	PI_CNTR_CS_TYPE_NOT_ACTIVATED	No coordinate system of this type is activated
557	PI_CNTR_CS_NAME_INVALID	Name of coordinate system is invalid
558	PI_CNTR_CS_GENERAL_FILE_MISSING	File with stored CS systems is missing or erroneous
559	PI_CNTR_CS_LEVELING_FILE_MISSING	File with leveling CS is missing or erroneous
601	PI_CNTR_NOT_ENOUGH_MEMORY	not enough memory
602	PI_CNTR_HW_VOLTAGE_ERROR	hardware voltage error
603	PI_CNTR_HW_TEMPERATURE_ERROR	hardware temperature out of range
604	PI_CNTR_POSITION_ERROR_TOO_HIGH	Position error of any axis in the system is too high
606	PI_CNTR_INPUT_OUT_OF_RANGE	Maximum value of input signal has been exceeded
607	PI_CNTR_NO_INTEGER	Value is not integer
608	PI_CNTR_FAST_ALIGNMENT_PROCESS_IS_NOT_RUNNING	Fast alignment process cannot be paused because it is not running
609	PI_CNTR_FAST_ALIGNMENT_PROCESS_IS_NOT_PAUSED	Fast alignment process cannot be restarted/resumed because it is not paused
650	PI_CNTR_UNABLE_TO_SET_PARAM_WITH_SPA	Parameter could not be set with SPA - SEP needed?
651	PI_CNTR_PHASE_FINDING_ERROR	Phase finding error
652	PI_CNTR_SENSOR_SETUP_ERROR	Sensor setup error
653	PI_CNTR_SENSOR_COMM_ERROR	Sensor communication error
654	PI_CNTR_MOTOR_AMPLIFIER_ERROR	Motor amplifier error
655	PI_CNTR_OVER_CURR_PROTEC_TRIGGERED_BY_I2T	Overcurrent protection triggered by I2T-module
656	PI_CNTR_OVER_CURR_PROTEC_TRIGGERED_BY_AMP_MODULE	Overcurrent protection triggered by amplifier module
657	PI_CNTR_SAFETY_STOP_TRIGGERED	Safety stop triggered
658	PI_SENSOR_OFF	Sensor off?

659	PI_CNTR_PARAM_CONFLICT	Parameter could not be set. Conflict with another parameter.
700	PI_CNTR_COMMAND_NOT_ALLOWED_IN_EXTERNAL_MODE	Command not allowed in external mode
710	PI_CNTR_EXTERNAL_MODE_ERROR	External mode communication error
715	PI_CNTR_INVALID_MODE_OF_OPERATION	Invalid mode of operation
716	PI_CNTR_FIRMWARE_STOPPED_BY_CMD	Firmware stopped by command (#27)
717	PI_CNTR_EXTERNAL_MODE_DRIVER_MISSING	External mode driver missing
718	PI_CNTR_CONFIGURATION_FAILURE_EXTERNAL_MODE	Missing or incorrect configuration of external mode
719	PI_CNTR_EXTERNAL_MODE_CYCLETIME_INVALID	External mode cycletime invalid
720	PI_CNTR_BRAKE_ACTIVATED	Brake is activated
725	PI_CNTR_DRIVE_STATE_TRANSITION_ERROR	Drive state transition error
731	PI_CNTR_SURFACEDETECTION_RUNNING	Command not allowed while surface detection is running
732	PI_CNTR_SURFACEDETECTION_FAILED	Last surface detection failed
733	PI_CNTR_FIELDBUS_IS_ACTIVE	Fieldbus is active and is blocking GCS control commands
1000	PI_CNTR_TOO_MANY_NESTED_MACROS	Too many nested macros
1001	PI_CNTR_MACRO_ALREADY_DEFINED	Macro already defined
1002	PI_CNTR_NO_MACRO_RECORDING	Macro recording not activated
1003	PI_CNTR_INVALID_MAC_PARAM	Invalid parameter for MAC
1004	PI_CNTR_RESERVED_1004	PI internal error code 1004
1005	PI_CNTR_CONTROLLER_BUSY	Controller is busy with some lengthy operation (e.g. reference move, fast scan algorithm)

1006	PI_CNTR_INVALID_IDENTIFIER	Invalid identifier (invalid special characters, ...)
1007	PI_CNTR_UNKNOWN_VARIABLE_OR_ARGUMENT	Variable or argument not defined
1008	PI_CNTR_RUNNING_MACRO	Controller is (already) running a macro
1009	PI_CNTR_MACRO_INVALID_OPERATOR	Invalid or missing operator for condition. Check necessary spaces around operator.
1010	PI_CNTR_MACRO_NO_ANSWER	No response was received while executing WAC/MEX/JRC/...
1011	PI_CMD_NOT_VALID_IN_MACRO_MODE	Command not valid during macro execution
1012	PI_CNTR_ERROR_IN_MACRO	Error occured during macro execution
1013	PI_CNTR_NO_MACRO_OR_EMPTY	No macro with given name on controller, or macro is empty
1015	PI_CNTR_INVALID_ARGUMENT	One or more arguments given to function is invalid (empty string, index out of range, ...)
1024	PI_CNTR_MOTION_ERROR	Motion error: position error too large, servo is switched off automatically
1025	PI_CNTR_MAX_MOTOR_OUTPUT_REACHED	Maximum motor output reached
1028	PI_CNTR_UNKNOWN_CHANNEL_IDENTIFIER	Unknown channel identifier
1063	PI_CNTR_EXT_PROFILE_UNALLOWED_CMD	User Profile Mode: Command is not allowed, check for required preparatory commands
1064	PI_CNTR_EXT_PROFILE_EXPECTING_MOTION_ERROR	User Profile Mode: First target position in User Profile is too far from current position
1065	PI_CNTR_PROFILE_ACTIVE	Controller is (already) in User Profile Mode
1066	PI_CNTR_PROFILE_INDEX_OUT_OF_RANGE	User Profile Mode: Block or Data Set index out of allowed range
1071	PI_CNTR_PROFILE_OUT_OF_MEMORY	User Profile Mode: Out of memory

1072	PI_CNTR_PROFILE_WRONG_CLUSTER	User Profile Mode: Cluster is not assigned to this axis
1073	PI_CNTR_PROFILE_UNKNOWN_CLUSTER_IDENTIFIER	Unknown cluster identifier
1090	PI_CNTR_TOO_MANY_TCP_CONNECTIONS_OPEN	There are too many open tcpip connections
2000	PI_CNTR_ALREADY_HAS_SERIAL_NUMBER	Controller already has a serial number
2100	PI_CNTR_FEATURE_LICENSE_INVALID	Entered license is invalid
4000	PI_CNTR_SECTOR_ERASE_FAILED	Sector erase failed
4001	PI_CNTR_FLASH_PROGRAM_FAILED	Flash program failed
4002	PI_CNTR_FLASH_READ_FAILED	Flash read failed
4003	PI_CNTR_HW_MATCHCODE_ERROR	HW match code missing/invalid
4004	PI_CNTR_FW_MATCHCODE_ERROR	FW match code missing/invalid
4005	PI_CNTR_HW_VERSION_ERROR	HW version missing/invalid
4006	PI_CNTR_FW_VERSION_ERROR	FW version missing/invalid
4007	PI_CNTR_FW_UPDATE_ERROR	FW update failed
4008	PI_CNTR_FW_CRC_PAR_ERROR	FW Parameter CRC wrong
4009	PI_CNTR_FW_CRC_FW_ERROR	FW CRC wrong
5000	PI_CNTR_INVALID_PCC_SCAN_DATA	PicoCompensation scan data is not valid
5001	PI_CNTR_PCC_SCAN_RUNNING	PicoCompensation is running, some actions can not be executed during scanning/recording
5002	PI_CNTR_INVALID_PCC_AXIS	Given axis cannot be defined as PPC axis
5003	PI_CNTR_PCC_SCAN_OUT_OF_RANGE	Defined scan area is larger than the travel range
5004	PI_CNTR_PCC_TYPE_NOT_EXISTING	Given PicoCompensation type is not defined
5005	PI_CNTR_PCC_PAM_ERROR	PicoCompensation parameter error
5006	PI_CNTR_PCC_TABLE_ARRAY_TOO_LARGE	PicoCompensation table is larger than maximum table

		length
5100	PI_CNTR_NEXLINE_ERROR	Common error in NEXLINE® firmware module
5101	PI_CNTR_CHANNEL_ALREADY_USED	Output channel for NEXLINE® can not be redefined for other usage
5102	PI_CNTR_NEXLINE_TABLE_TOO_SMALL	Memory for NEXLINE® signals is too small
5103	PI_CNTR_RNP_WITH_SERVO_ON	RNP can not be executed if axis is in closed loop
5104	PI_CNTR_RNP_NEEDED	Relax procedure (RNP) needed
5200	PI_CNTR_AXIS_NOT_CONFIGURED	Axis must be configured for this action
5300	PI_CNTR_FREQU_ANALYSIS_FAILED	Frequency analysis failed
5301	PI_CNTR_FREQU_ANALYSIS_RUNNING	Another frequency analysis is running
6000	PI_CNTR_SENSOR_ABS_INVALID_VALUE	Invalid preset value of absolute sensor
6001	PI_CNTR_SENSOR_ABS_WRITE_ERROR	Error while writing to sensor
6002	PI_CNTR_SENSOR_ABS_READ_ERROR	Error while reading from sensor
6003	PI_CNTR_SENSOR_ABS_CRC_ERROR	Checksum error of absolute sensor
6004	PI_CNTR_SENSOR_ABS_ERROR	General error of absolute sensor
6005	PI_CNTR_SENSOR_ABS_OVERFLOW	Overflow of absolute sensor position

Interface Errors

0	COM_NO_ERROR	No error occurred during function call
-1	COM_ERROR	Error during com operation (could not be specified)
-2	SEND_ERROR	Error while sending data
-3	REC_ERROR	Error while receiving data
-4	NOT_CONNECTED_ERROR	Not connected (no port with given ID open)
-5	COM_BUFFER_OVERFLOW	Buffer overflow

-6	CONNECTION_FAILED	Error while opening port
-7	COM_TIMEOUT	Timeout error
-8	COM_MULTILINE_RESPONSE	There are more lines waiting in buffer
-9	COM_INVALID_ID	There is no interface or DLL handle with the given ID
-10	COM_NOTIFY_EVENT_ERROR	Event/message for notification could not be opened
-11	COM_NOT_IMPLEMENTED	Function not supported by this interface type
-12	COM_ECHO_ERROR	Error while sending "echoed" data
-13	COM_GPIB_EDVR	IEEE488: System error
-14	COM_GPIB_ECIC	IEEE488: Function requires GPIB board to be CIC
-15	COM_GPIB_ENOL	IEEE488: Write function detected no listeners
-16	COM_GPIB_EADR	IEEE488: Interface board not addressed correctly
-17	COM_GPIB_EARG	IEEE488: Invalid argument to function call
-18	COM_GPIB_ESAC	IEEE488: Function requires GPIB board to be SAC
-19	COM_GPIB_EABO	IEEE488: I/O operation aborted
-20	COM_GPIB_ENEB	IEEE488: Interface board not found
-21	COM_GPIB_EDMA	IEEE488: Error performing DMA
-22	COM_GPIB_EOIP	IEEE488: I/O operation started before previous operation completed
-23	COM_GPIB_ECAP	IEEE488: No capability for intended operation
-24	COM_GPIB_EFSO	IEEE488: File system operation error
-25	COM_GPIB_EBUS	IEEE488: Command error during device call
-26	COM_GPIB_ESTB	IEEE488: Serial poll-status byte lost
-27	COM_GPIB_ESRQ	IEEE488: SRQ remains asserted

-28	COM_GPIB_ETAB	IEEE488: Return buffer full
-29	COM_GPIB_ELCK	IEEE488: Address or board locked
-30	COM_RS_INVALID_DATA_BITS	RS-232: 5 data bits with 2 stop bits is an invalid combination, as is 6, 7, or 8 data bits with 1.5 stop bits
-31	COM_ERROR_RS_SETTINGS	RS-232: Error configuring the COM port
-32	COM_INTERNAL_RESOURCES_ERROR	Error dealing with internal system resources (events, threads, ...)
-33	COM_DLL_FUNC_ERROR	A DLL or one of the required functions could not be loaded
-34	COM_FTDIUSB_INVALID_HANDLE	FTDIUSB: invalid handle
-35	COM_FTDIUSB_DEVICE_NOT_FOUND	FTDIUSB: device not found
-36	COM_FTDIUSB_DEVICE_NOT_OPENED	FTDIUSB: device not opened
-37	COM_FTDIUSB_IO_ERROR	FTDIUSB: IO error
-38	COM_FTDIUSB_INSUFFICIENT_RESOURCES	FTDIUSB: insufficient resources
-39	COM_FTDIUSB_INVALID_PARAMETER	FTDIUSB: invalid parameter
-40	COM_FTDIUSB_INVALID_BAUD_RATE	FTDIUSB: invalid baud rate
-41	COM_FTDIUSB_DEVICE_NOT_OPENED_FOR_ERASE	FTDIUSB: device not opened for erase
-42	COM_FTDIUSB_DEVICE_NOT_OPENED_FOR_WRITE	FTDIUSB: device not opened for write
-43	COM_FTDIUSB_FAILED_TO_WRITE_DEVICE	FTDIUSB: failed to write device
-44	COM_FTDIUSB_EEPROM_READ_FAILED	FTDIUSB: EEPROM read failed
-45	COM_FTDIUSB_EEPROM_WRITE_FAILED	FTDIUSB: EEPROM write failed
-46	COM_FTDIUSB_EEPROM_ERASE_FAILED	FTDIUSB: EEPROM erase failed
-47	COM_FTDIUSB_EEPROM_NOT_PRESENT	FTDIUSB: EEPROM not present
-48	COM_FTDIUSB_EEPROM_NOT_PROGRAMMED	FTDIUSB: EEPROM not programmed
-49	COM_FTDIUSB_INVALID_ARGS	FTDIUSB: invalid arguments
-50	COM_FTDIUSB_NOT_SUPPORTED	FTDIUSB: not supported
-51	COM_FTDIUSB_OTHER_ERROR	FTDIUSB: other error
-52	COM_PORT_ALREADY_OPEN	Error while opening the COM port: was already open

-53	COM_PORT_CHECKSUM_ERROR	Checksum error in received data from COM port
-54	COM_SOCKET_NOT_READY	Socket not ready, you should call the function again
-55	COM_SOCKET_PORT_IN_USE	Port is used by another socket
-56	COM_SOCKET_NOT_CONNECTED	Socket not connected (or not valid)
-57	COM_SOCKET_TERMINATED	Connection terminated (by peer)
-58	COM_SOCKET_NO_RESPONSE	Can't connect to peer
-59	COM_SOCKET_INTERRUPTED	Operation was interrupted by a nonblocked signal
-60	COM_PCI_INVALID_ID	No device with this ID is present
-61	COM_PCI_ACCESS_DENIED	Driver could not be opened (on Vista: run as administrator!)
-62	COM_SOCKET_HOST_NOT_FOUND	Host not found
-63	COM_DEVICE_CONNECTED	Device already connected
-64	COM_INVALID_COM_PORT	Invalid COM port
-65	COM_USB_DEVICE_NOT_FOUND	USB device not found
-66	COM_NO_USB_DRIVER	No USB driver installed
-67	COM_USB_NOT_SUPPORTED	USB is not supported

DLL Errors

-1001	PI_UNKNOWN_AXIS_IDENTIFIER	Unknown axis identifier
-1002	PI_NR_NAV_OUT_OF_RANGE	Number for NAV out of range--must be in [1,10000]
-1003	PI_INVALID_SGA	Invalid value for SGA--must be one of 1, 10, 100, 1000
-1004	PI_UNEXPECTED_RESPONSE	Controller sent unexpected response
-1005	PI_NO_MANUAL_PAD	No manual control pad installed, calls to SMA and related commands are not allowed
-1006	PI_INVALID_MANUAL_PAD_KNOB	Invalid number for manual control pad knob
-1007	PI_INVALID_MANUAL_PAD_AXIS	Axis not currently controlled by a manual control pad
-1008	PI_CONTROLLER_BUSY	Controller is busy with some

		lengthy operation (e.g., reference move, fast scan algorithm)
-1009	PI_THREAD_ERROR	Internal error--could not start thread
-1010	PI_IN_MACRO_MODE	Controller is (already) in macro mode--command not valid in macro mode
-1011	PI_NOT_IN_MACRO_MODE	Controller not in macro mode--command not valid unless macro mode active
-1012	PI_MACRO_FILE_ERROR	Could not open file to write or read macro
-1013	PI_NO_MACRO_OR_EMPTY	No macro with given name on controller, or macro is empty
-1014	PI_MACRO_EDITOR_ERROR	Internal error in macro editor
-1015	PI_INVALID_ARGUMENT	One or more arguments given to function is invalid (empty string, index out of range, ...)
-1016	PI_AXIS_ALREADY_EXISTS	Axis identifier is already in use by a connected stage
-1017	PI_INVALID_AXIS_IDENTIFIER	Invalid axis identifier
-1018	PI_COM_ARRAY_ERROR	Could not access array data in COM server
-1019	PI_COM_ARRAY_RANGE_ERROR	Range of array does not fit the number of parameters
-1020	PI_INVALID_SPA_CMD_ID	Invalid parameter ID given to SPA or SPA?
-1021	PI_NR_AVG_OUT_OF_RANGE	Number for AVG out of range--must be >0
-1022	PI_WAV_SAMPLES_OUT_OF_RANGE	Incorrect number of samples given to WAV
-1023	PI_WAV_FAILED	Generation of wave failed
-1024	PI_MOTION_ERROR	Motion error: position error too large, servo is switched off automatically
-1025	PI_RUNNING_MACRO	Controller is (already) running a macro
-1026	PI_PZT_CONFIG_FAILED	Configuration of PZT stage or amplifier failed
-1027	PI_PZT_CONFIG_INVALID_PARAMS	Current settings are not valid for desired configuration
-1028	PI_UNKNOWN_CHANNEL_IDENTIFIER	Unknown channel identifier

-1029	PI_WAVE_PARAM_FILE_ERROR	Error while reading/writing wave generator parameter file
-1030	PI_UNKNOWN_WAVE_SET	Could not find description of wave form. Maybe WG.INI is missing?
-1031	PI_WAVE_EDITOR_FUNC_NOT_LOADED	The WGWaveEditor DLL function was not found at startup
-1032	PI_USER_CANCELLED	The user cancelled a dialog
-1033	PI_C844_ERROR	Error from C-844 Controller
-1034	PI_DLL_NOT_LOADED	DLL necessary to call function not loaded, or function not found in DLL
-1035	PI_PARAMETER_FILE_PROTECTED	The open parameter file is protected and cannot be edited
-1036	PI_NO_PARAMETER_FILE_OPENED	There is no parameter file open
-1037	PI_STAGE_DOES_NOT_EXIST	Selected stage does not exist
-1038	PI_PARAMETER_FILE_ALREADY_OPENED	There is already a parameter file open. Close it before opening a new file
-1039	PI_PARAMETER_FILE_OPEN_ERROR	Could not open parameter file
-1040	PI_INVALID_CONTROLLER_VERSION	The version of the connected controller is invalid
-1041	PI_PARAM_SET_ERROR	Parameter could not be set with SPA--parameter not defined for this controller!
-1042	PI_NUMBER_OF_POSSIBLE_WAVES_EXCEEDED	The maximum number of wave definitions has been exceeded
-1043	PI_NUMBER_OF_POSSIBLE_GENERATORS_EXCEEDED	The maximum number of wave generators has been exceeded
-1044	PI_NO_WAVE_FOR_AXIS_DEFINED	No wave defined for specified axis
-1045	PI_CANT_STOP_OR_START_WAV	Wave output to axis already stopped/started
-1046	PI_REFERENCE_ERROR	Not all axes could be referenced
-1047	PI_REQUIRED_WAVE_NOT_FOUND	Could not find parameter set required by frequency relation

-1048	PI_INVALID_SPP_CMD_ID	Command ID given to SPP or SPP? is not valid
-1049	PI_STAGE_NAME_ISNT_UNIQUE	A stage name given to CST is not unique
-1050	PI_FILE_TRANSFER_BEGIN_MISSING	A uuencoded file transferred did not start with "begin" followed by the proper filename
-1051	PI_FILE_TRANSFER_ERROR_TEMP_FILE	Could not create/read file on host PC
-1052	PI_FILE_TRANSFER_CRC_ERROR	Checksum error when transferring a file to/from the controller
-1053	PI_COULDNT_FIND_PISTAGES_DAT	The PiStages.dat database could not be found. This file is required to connect a stage with the CST command
-1054	PI_NO_WAVE_RUNNING	No wave being output to specified axis
-1055	PI_INVALID_PASSWORD	Invalid password
-1056	PI_OPM_COM_ERROR	Error during communication with OPM (Optical Power Meter), maybe no OPM connected
-1057	PI_WAVE_EDITOR_WRONG_PARAMNUM	WaveEditor: Error during wave creation, incorrect number of parameters
-1058	PI_WAVE_EDITOR_FREQUENCY_OUT_OF_RANGE	WaveEditor: Frequency out of range
-1059	PI_WAVE_EDITOR_WRONG_IP_VALUE	WaveEditor: Error during wave creation, incorrect index for integer parameter
-1060	PI_WAVE_EDITOR_WRONG_DP_VALUE	WaveEditor: Error during wave creation, incorrect index for floating point parameter
-1061	PI_WAVE_EDITOR_WRONG_ITEM_VALUE	WaveEditor: Error during wave creation, could not calculate value
-1062	PI_WAVE_EDITOR_MISSING_GRAPH_COMPONENT	WaveEditor: Graph display component not installed
-1063	PI_EXT_PROFILE_UNALLOWED_CMD	User Profile Mode: Command is not allowed, check for required preparatory commands
-1064	PI_EXT_PROFILE_EXPECTING_MOTION_ER	User Profile Mode: First

	ROR	target position in User Profile is too far from current position
-1065	PI_EXT_PROFILE_ACTIVE	Controller is (already) in User Profile Mode
-1066	PI_EXT_PROFILE_INDEX_OUT_OF_RANGE	User Profile Mode: Block or Data Set index out of allowed range
-1067	PI_PROFILE_GENERATOR_NO_PROFILE	ProfileGenerator: No profile has been created yet
-1068	PI_PROFILE_GENERATOR_OUT_OF_LIMITS	ProfileGenerator: Generated profile exceeds limits of one or both axes
-1069	PI_PROFILE_GENERATOR_UNKNOWN_PARAMETER	ProfileGenerator: Unknown parameter ID in Set/Get Parameter command
-1070	PI_PROFILE_GENERATOR_PAR_OUT_OF_RANGE	ProfileGenerator: Parameter out of allowed range
-1071	PI_EXT_PROFILE_OUT_OF_MEMORY	User Profile Mode: Out of memory
-1072	PI_EXT_PROFILE_WRONG_CLUSTER	User Profile Mode: Cluster is not assigned to this axis
-1073	PI_UNKNOWN_CLUSTER_IDENTIFIER	Unknown cluster identifier
-1074	PI_INVALID_DEVICE_DRIVER_VERSION	The installed device driver doesn't match the required version. Please see the documentation to determine the required device driver version.
-1075	PI_INVALID_LIBRARY_VERSION	The library used doesn't match the required version. Please see the documentation to determine the required library version.
-1076	PI_INTERFACE_LOCKED	The interface is currently locked by another function. Please try again later.
-1077	PI_PARAM_DAT_FILE_INVALID_VERSION	Version of parameter DAT file does not match the required version. Current files are available at www.pi.ws.
-1078	PI_CANNOT_WRITE_TO_PARAM_DAT_FILE	Cannot write to parameter DAT file to store user defined stage type.
-1079	PI_CANNOT_CREATE_PARAM_DAT_FILE	Cannot create parameter DAT

		file to store user defined stage type.
-1080	PI_PARAM_DAT_FILE_INVALID_REVISION	Parameter DAT file does not have correct revision.
-1081	PI_USERSTAGES_DAT_FILE_INVALID_REVISION	User stages DAT file does not have correct revision.
-1082	PI_SOFTWARE_TIMEOUT	Timeout Error. Some lengthy operation did not finish within expected time.
-1083	PI_WRONG_DATA_TYPE	A function argument has an unexpected data type.
-1084	PI_DIFFERENT_ARRAY_SIZES	Length of data arrays is different.
-1085	PI_PARAM_NOT_FOUND_IN_PARAM_DAT_FILE	Parameter value not found in parameter DAT file.
-1086	PI_MACRO_RECORDING_NOT_ALLOWED_IN_THIS_MODE	Macro recording is not allowed in this mode of operation.
-1087	PI_USER_CANCELLED_COMMAND	Command cancelled by user input.
-1088	PI_TOO_FEW_GCS_DATA	Controller sent too few GCS data sets
-1089	PI_TOO_MANY_GCS_DATA	Controller sent too many GCS data sets
-1090	PI_GCS_DATA_READ_ERROR	Communication error while reading GCS data
-1091	PI_WRONG_NUMBER_OF_INPUT_ARGUMENTS	Wrong number of input arguments.
-1092	PI_FAILED_TO_CHANGE_CCL_LEVEL	Change of command level has failed.
-1093	PI_FAILED_TO_SWITCH_OFF_SERVO	Switching off the servo mode has failed.
-1094	PI_FAILED_TO_SET_SINGLE_PARAMETER_WHILE_PERFORMING_CST	A parameter could not be set while performing CST: CST was not performed (parameters remain unchanged).
-1095	PI_ERROR_CONTROLLER_REBOOT	Connection could not be reestablished after reboot.
-1096	PI_ERROR_AT_QHPA	Sending HPA? or receiving the response has failed.
-1097	PI_QHPA_NONCOMPLIANT_WITH_GCS	HPA? response does not comply with GCS2 syntax.

-1098	PI_FAILED_TO_READ_QSPA	Response to SPA? could not be received.
-1099	PI_PAM_FILE_WRONG_VERSION	Version of PAM file cannot be handled (too old or too new)
-1100	PI_PAM_FILE_INVALID_FORMAT	PAM file does not contain required data in PAM-file format
-1101	PI_INCOMPLETE_INFORMATION	Information does not contain all required data
-1102	PI_NO_VALUE_AVAILABLE	No value for parameter available
-1103	PI_NO_PAM_FILE_OPEN	No PAM file is open
-1104	PI_INVALID_VALUE	Invalid value
-1105	PI_UNKNOWN_PARAMETER	Unknown parameter
-1106	PI_RESPONSE_TO_QSEP_FAILED	Response to SEP? could not be received.
-1107	PI_RESPONSE_TO_QSPA_FAILED	Response to SPA? could not be received.
-1108	PI_ERROR_IN_CST_VALIDATION	Error while performing CST: One or more parameters were not set correctly.
-1109	PI_ERROR_PAM_FILE_HAS_DUPLICATE_ENTRY_WITH_DIFFERENT_VALUES	PAM file has duplicate entry with different values.
-1110	PI_ERROR_FILE_NO_SIGNATURE	File has no signature
-1111	PI_ERROR_FILE_INVALID_SIGNATURE	File has invalid signature
-1112	PI_ERROR_CANNOT_DETERMINE_ACTUAL_END_OF_TRAVEL_WHILE_PLATFORM_IS_MOVING	Cannot determine actual end of travel range while platform is moving.
-1113	PI_ERROR_AT_QIDN	Sending IDN? or receiving the response has failed.
-1114	PI_ERROR_AT_MAC_DEF	Sending MAC_DEF or receiving the response has failed.
-1115	PI_CONTROLLER_OR_CONTROLLER_VERSION_DOES_NOT_EXIST_IN_PISTAGES_DATABASE	Sending Controller or controller version does not exist in PIStages database.
-1116	PI_NOT_ENOUGH_MEMORY	Not enough memory
-1117	PI_ERROR_AXIS_RUNTIME_ERROR	Runtime error indicated for axis, check error log with \"LOG?\" to find more details.
-1118	PI_ERROR_SYSTEM_RUNTIME_CRITICAL_ERROR	Critical error indicated for system, check error log with \"LOG?\" to find more details.

-1119	PI_ERROR_CANNOT_START_EMULATOR	Cannot start emulation software.
-1120	COM_DEVICE_NOT_SUPPORTED	Device is not supported
-10000	PI_PARAMETER_DB_INVALID_STAGE_TYPE_FORMAT	PI stage database: String containing stage type and description has invalid format.
-10001	PI_PARAMETER_DB_SYSTEM_NOT_AVAILABLE	PI stage database: Database does not contain the selected stage type for the connected controller.
-10002	PI_PARAMETER_DB_FAILED_TO_ESTABLISH_CONNECTION	PI stage database: Establishing the connection has failed.
-10003	PI_PARAMETER_DB_COMMUNICATION_ERROR	PI stage database: Communication was interrupted (e.g. because database was deleted).
-10004	PI_PARAMETER_DB_ERROR_WHILE_QUERYING_PARAMETERS	PI stage database: Querying data failed.
-10005	PI_PARAMETER_DB_SYSTEM_ALREADY_EXISTS	PI stage database: System already exists. Rename stage and try again.
-10006	PI_PARAMETER_DB_QHPA_CONTANS_UNKNOWN_PAM_IDS	PI stage database: Response to HPA? contains unknown parameter IDs.
-10007	PI_PARAMETER_DB_AND_QHPA_ARE_INCONSISTENT	PI stage database: Inconsistency between database and response to HPA?.
-10008	PI_PARAMETER_DB_SYSTEM_COULD_NOT_BE_ADDED	PI stage database: Stage has not been added.
-10009	PI_PARAMETER_DB_SYSTEM_COULD_NOT_BE_REMOVED	PI stage database: Stage has not been removed.
-10010	PI_PARAMETER_DB_CONTROLLER_DB_PARAMETERS_MISMATCH	Controller does not support all stage parameters stored in PI stage database. No parameters were set.
-10011	PI_PARAMETER_DB_DATABASE_IS_OUTDATED	The version of PISTAGES3.DB stage database is out of date. Please update via PIUpdateFinder. No parameters were set.

-10012	PI_PARAMETER_DB_AND_HPA_MISMATCH_STRICT	Mismatch between number of parameters present in stage database and available in controller interface. No parameters were set.
-10013	PI_PARAMETER_DB_AND_HPA_MISMATCH_LOOSE	Mismatch between number of parameters present in stage database and available in controller interface. Some parameters were ignored.
-10014	PI_PARAMETER_DB_FAILED_TO_SET_PARAMETERS_CORRECTLY	One or more parameters could not be set correctly on the controller.
-10015	PI_PARAMETER_DB_MISSING_PARAMETER_DEFINITIONS_IN_DATABASE	One or more parameter definitions are not present in stage database. Please update PISTAGES3.DB via PIUpdateFinder. Missing parameters were ignored.
-10016	PI_PARAMETER_DB_MISSING_FIRMWARE_FEATURE_ON_CONTROLLER	Parameters could not be set on controller because the corresponding firmware feature is missing

9 Adapting Settings

9.1 Settings of the C-863.12

The properties of the C-863.12 and the connected positioner are stored in the C-863.12 as parameter values (e.g., settings for the servo algorithm (p. 26)).

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 levels.

Every parameter is in the volatile as well as in the nonvolatile memory of the C-863.12. The values in the nonvolatile memory are loaded to the volatile memory as default values when switching on or rebooting the C-863.12. The values in the volatile memory determine the current behavior of the system.

The designation "Active Values" is used for the parameter values in the volatile memory and "Startup Values" is used for the parameter values in the nonvolatile memory in the PC software from PI.

9.2 Changing Parameter Values in the C-863.12

NOTICE

Unsuitable parameter settings!
The values in the nonvolatile memory are loaded to the volatile memory as default values when switching on or rebooting the C-863.12 and take effect immediately. Unsuitable parameter settings can cause damage to the connected mechanics.

- ➢ Change parameter values only after careful consideration.
- ➢ Save the current parameter values to the PC (p. 229) before you make changes in the nonvolatile memory.

INFORMATION

The number of write cycles in the nonvolatile memory is restricted by the limited lifetime of the memory chip (EEPROM).

- ➢ Overwrite the default values only when it is necessary.
- ➢ Save the current parameter values to the PC (p. 229) before you make changes in the nonvolatile memory.
- ➢ Contact our customer service department (p. 253), if the C-863.12 exhibits unexpected

behavior.

INFORMATION

When you use the PC software from PI, information is loaded as parameter values from a positioner database (p. 12) into the volatile memory of the C-863.12.

Parameters loaded from a positioner database are marked in color in the parameter overview (p. 236).

9.2.1 General Commands for Parameters

The following general commands are available for parameters:

Command	Function
`CCL`	Change to a higher command level, e.g., to obtain write permission for particular parameters.
`CCL?`	Get active command level.
`HPA?`	Responds with a help string that contains all available parameters with short descriptions.
`RPA`	Copy a parameter value from the nonvolatile to the volatile memory.
`SEP`	Change parameters in the nonvolatile memory.
`SEP?`	Get parameter values from the nonvolatile memory.
`SPA`	Change parameters in the volatile memory.
`SPA?`	Get parameter values from the volatile memory.
`WPA`	Copy a current parameter value from the volatile to the nonvolatile memory. Here it is used as a default value.

You can find details in the command descriptions (p. 127).

9.2.2 Commands for Fast Access to Individual Parameters

The following special commands only change the corresponding parameters in the volatile memory. When necessary, the changed values must be written to the nonvolatile memory with the `WPA` command (p. 201).

INFORMATION

The parameters listed below can also be changed with the general commands.

Command	Adaptable parameters
ACC	Acceleration in closed-loop operation (0xB)
DEC	Deceleration in closed-loop operation (0xC)
VEL	Velocity in closed-loop operation (0x49)

You can find details in the command descriptions (p. 127).

9.2.3 Saving Parameter Values in a Text File

INFORMATION

The C-863.12 is configured via parameters, e.g., to adapt the mechanics connected. Changing parameter values can cause undesirable results.

- ➢ Create a backup copy on the PC before changing the parameter settings of the C-863.12. You can then restore the original settings at any time.
- ➢ Create an additional backup copy with a new file name each time after optimizing the parameter values or adapting the C-863.12 to specific mechanics.

INFORMATION

Parameter values saved in a text file on the PC can be loaded back to the C-863.12 in PIMikroMove or PITerminal. The ***Send file...*** button is available for this purpose in the send command window. Before loading into the C-863.12, the individual lines of the text files must be converted into command lines that contain the corresponding SPA or SEP commands.

Requirements

- ✓ You have established communication with PIMikroMove or PITerminal between the C-863.12 and the PC (p. 56).

Saving parameter values in a text file

1. If you use PIMikroMove, open the window for sending commands:
   - – Select the ***Tools > Command entry*** menu item in the main window or press the F4 key on the keyboard.

   In PITerminal the main window from which commands can be sent is opened automatically after establishing communication.
2. Get the parameter values from which you want to create a backup copy.
   - – If you want to save the parameter values from the volatile memory of the C-863.12: Send the `SPA?` command.
   - – If you want to save the parameter values from the nonvolatile memory of the C-863.12: Send the `SEP?` command.

3. Click on the ***Save...*** button.

   The ***Save content of terminal as textfile*** window opens.

4. Save the queried parameter values in a text file to your PC in the ***Save content of terminal as textfile*** window.

9.2.4 Changing Parameter Values: General Procedure

For working with parameters, you can use the general commands (p. 228) and the commands for quick access (p. 228).

For simpler access to parameters, PIMikroMove is used in the following, so you do not have to deal with the corresponding commands.

NOTICE

Unsuitable parameter settings!
The values in the nonvolatile memory are loaded to the volatile memory as default values when switching on or rebooting the C-863.12 and take effect immediately. Unsuitable parameter settings can cause damage to the connected mechanics.

- ➢ Change parameter values only after careful consideration.
- ➢ Save the current parameter values to the PC (p. 229) before you make changes in the nonvolatile memory.

INFORMATION

The following procedure is generally recommended for changing parameter values:

1. Change the parameter values in the volatile memory.
2. Check whether the C-863.12 works correctly with the changed parameter values.

If so:

- ➢ Write the changed parameter values into the nonvolatile memory.

If not:

- ➢ Change and check the parameter values in the volatile memory again.

INFORMATION

The write access for the parameters of the C-863.12 is defined by command levels. After the controller is switched on or rebooted, the active command level is always 0. On command levels > 1, write access is only available to PI service personnel.

- ➢ Contact the customer service department if there seem to be problems with parameters of command level 2 or higher (p. 253).

Requirements

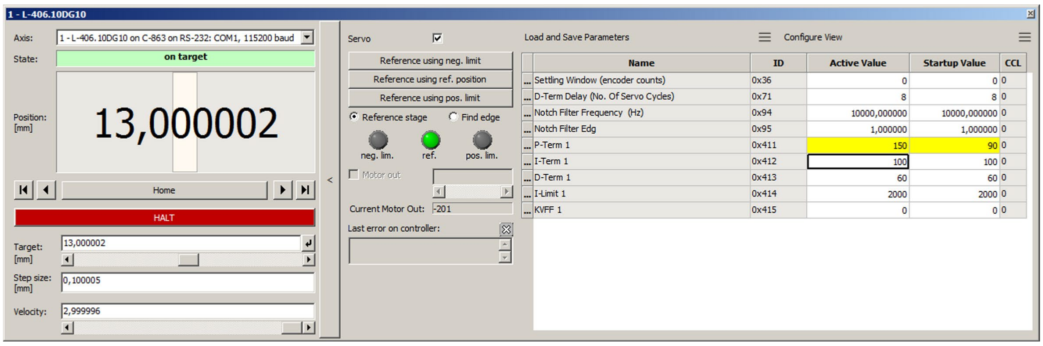
- ✓ If you want to change parameter values in the nonvolatile memory of the C-863.12: You have saved the parameter values of the C-863.12 in a text file on the PC (p. 229).
- ✓ You have established communication between the C-863.12 and the PC with PIMikroMove (p. 56).

Changing parameter values: General procedure

1. Display the parameter list in PIMikroMove.

   If you want to change the axis-related parameters of the C-863.12:

   a) Open the expanded single axis window for the connected positioner in the main window of PIMikroMove by clicking the right mouse button on the corresponding line of the ***Axes*** tab and selecting ***Show Expanded Single Axis Window*** in the context menu.



1 - L-406.10DG10

Axis: 1 - L-406. 10DG10 on C-863 on RS-232: COM1, 115200 baud

State: on target

Position: [mm] 13,000002

Target: [mm] 13,000002

Step size: [mm] 0,100005

Velocity: 2,999996

Servo ☑

○ Reference stage ○ Find edge

□ Motor out

Current Motor Out: -201

Last error on controller:

Load and Save Parameters ☰ Configure View ☰

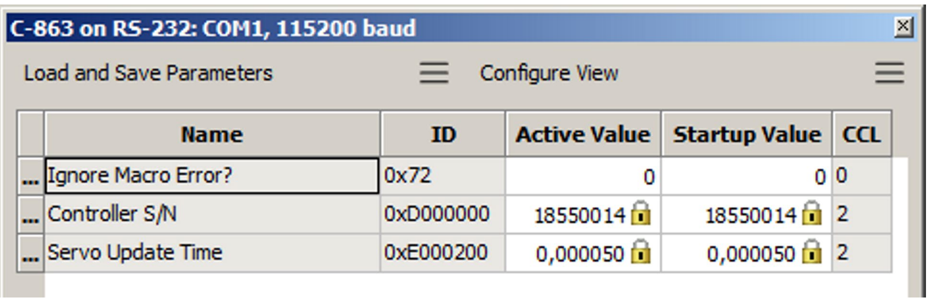
	Name	ID	Active Value	Startup Value	CCL
...	Settling Window (encoder counts)	0x36	0	0	0
...	D-Term Delay (No. Of Servo Cycles)	0x71	8	8	0
...	Notch Filter Frequency (Hz)	0x94	10000,000000	10000,000000	0
...	Notch Filter Edg	0x95	1,000000	1,000000	0
...	P-Term 1	0x411	150	90	0
...	I-Term 1	0x412	100	100	0
...	D-Term 1	0x413	60	60	0
...	I-Limit 1	0x414	2000	2000	0
...	KVFF 1	0x415	0	0	0

Home
HALT
Reference using neg. limit
Reference using ref. position
Reference using pos. limit
neg. lim.
ref.
pos. lim.

   b) If the parameter to be modified is not included in the list on the right-hand side of the window, click ***Configure View > Select parameters...*** and add it to the list. You can also display certain groups of parameters or all axis-related parameters.

   If you want to change the system-related parameters of the C-863.12:

   – Open the window for the system-related parameters of the C-863.12 in the main window of PIMikroMove by selecting ***C-863.12 > Show system parameters*** in the menu.



C-863 on RS-232: COM1, 115200 baud

Load and Save Parameters ☰ Configure View ☰

	Name	ID	Active Value	Startup Value	CCL
...	Ignore Macro Error?	0x72	0	0	0
...	Controller S/N	0xD000000	18550014 🔒	18550014 🔒	2
...	Servo Update Time	0xE000200	0,000050 🔒	0,000050 🔒	2

2. Change the desired parameter values in the volatile or nonvolatile memory of the C-863.12 in the corresponding parameter list.

   If you want to change parameter values in the volatile memory, you have the following options:

- Type the new parameter value into the corresponding input field in the ***Active Value*** column of the list. Press the Enter key on the PC keyboard or click with the mouse outside the input field to transfer the parameter value to the volatile memory of the C-863.12.
- Click ***Load and Save Parameters -> Load all startup parameters of the axis / system from controller*** in order to load the values of all axis-related / system-related parameters from the nonvolatile memory of the C-863.12.
- Click ***Load and Save Parameters > Load parameters from stage database…*** in the extended single-axis window to load a selected parameter set for the axis from the positioner database. You can use ***Load and Save Parameters > Reload parameters from stage database…*** to reload the currently loaded parameter set.

If you want to change parameter values in the nonvolatile memory, you have the following options:

- Type the new parameter value into the appropriate input field in the ***Startup Value*** column in the list. Press the Enter key on the PC keyboard or click with the mouse outside the input field to transfer the parameter value to the nonvolatile memory of the C-863.12.
- Click ***Load and Save Parameters -> Save all currently active axis / system parameters as startup parameters to controller*** to write the values of all axis-related / system-related parameters from the volatile to the nonvolatile memory of the C-863.12. You can skip parameters that do not have write access on the current command level.

If a parameter value in the volatile memory (***Active Value*** column) is different from the parameter value in the nonvolatile memory (***Startup Value*** column), the line in the list is highlighted in color.

9.3 Creating or Changing a Positioner Type

You can select a parameter set appropriate for your positioner from a positioner database in the PC software from PI. The software transfers the values of the selected parameter set to the volatile or nonvolatile memory of the controller. For further information, see "Positioner Databases" (p. 12).

You can create and edit new parameter records in the PIStages3 database. This can be required in the following cases, for example:

- You want to operate a positioner with different servo control parameter settings than the one from the default parameter set.
- You want to adapt the soft limits of the positioner to your application.
- You have a custom positioner.

INFORMATION

Possibilities for creating and editing parameter sets in the PISTAGES3.DB database:

- You can create a new positioner type easily by modifying an existing positioner type in PIMikroMove and saving it under a new name.
- You can open and edit the positioner database directly with the PIStages3Editor, which is included in the PI Software Suite.

PIMikroMove is used in the following for creating a new positioner type and for changing an existing positioner type.

Requirements

✓ You have installed the latest version of the PISTAGES3.DB database onto your PC (p. 41).

✓ If PI provided a custom positioner database for your positioner, the dataset was imported into PIStages3 (p. 43).

✓ You have established communication with PIMikroMove between the C-863.12 and the PC (p. 56).

Creating a positioner type in the positioner database

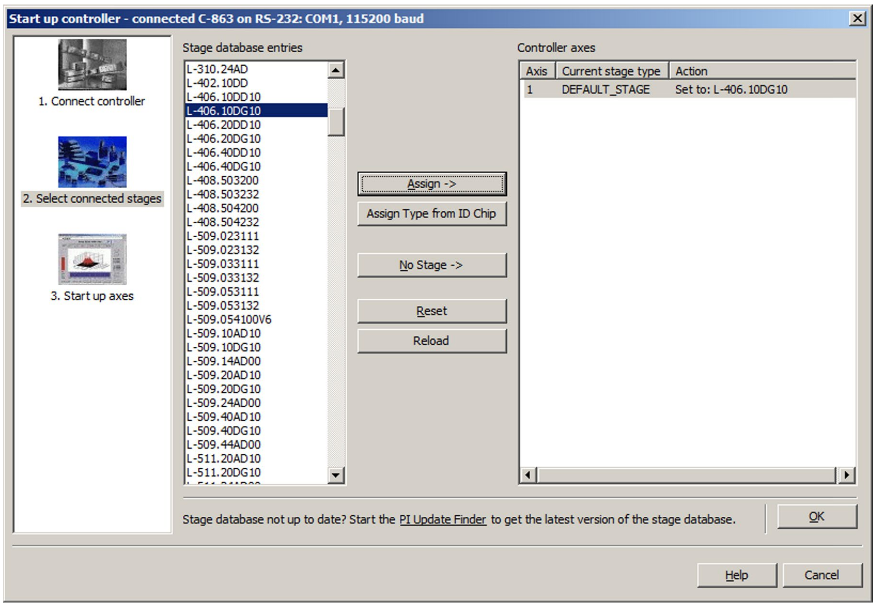
1. Select the ***C-863 > Select connected stages...*** menu item in the main window of PIMikroMove.

   The ***Start up stages/axes for C-863*** window opens and the ***Select connected stages*** step is active.

2. Select an appropriate type of positioner during the ***Select connected stages*** step:

   a) Mark the positioner type in the ***Stage database entries*** list.

b) Click ***Assign***.



Start up controller - connected C-863 on RS-232: COM1, 115200 baud

Stage database entries

L-310.24AD
L-402.10DD
L-406.10DD10
L-406.10DG10
L-406.20DD10
L-406.20DG10
L-406.40DD10
L-406.40DG10
L-408.503200
L-408.503232
L-408.504200
L-408.504232
L-509.023111
L-509.023132
L-509.033111
L-509.033132
L-509.053111
L-509.053132
L-509.054100V6
L-509.10AD10
L-509.10DG10
L-509.14AD00
L-509.20AD10
L-509.20DG10
L-509.24AD00
L-509.40AD10
L-509.40DG10
L-509.44AD00
L-511.20AD10
L-511.20DG10

Controller axes

Axis	Current stage type	Action
1	DEFAULT_STAGE	Set to: L-406.10DG10

Stage database not up to date? Start the PI Update Finder to get the latest version of the stage database.

Figure 24: Start up controller – Select connected stages

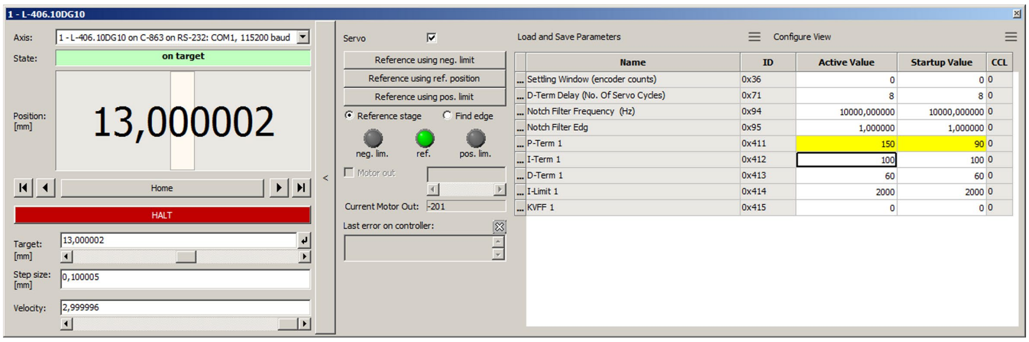
c) Confirm the selection with ***OK***.

3. Click ***Keep the changes temporarily*** in the ***Save all changes permanently*** dialog to load the parameter settings into the volatile memory of the C-863.12.

   The ***Start up stages/axes*** window changes to the ***Start up axes*** step.

4. Click ***Close*** in the ***Start up axes*** step to close the ***Start up stages/axes*** window.

5. Open the expanded single axis window for the selected positioner in the main window of PIMikroMove by clicking the right mouse button on the corresponding line of the ***Axes*** tab and selecting ***Show Expanded Single Axis Window*** in the context menu.



1 - L-406.10DG10

Axis: 1 - L-406.10DG10 on C-863 on RS-232: COM1, 115200 baud

State: on target

Position: [mm] 13,000002

Target: [mm] 13,000002

Step size: [mm] 0,100005

Velocity: 2,999996

Servo ☑

Current Motor Out: -201

Last error on controller:

Name	ID	Active Value	Startup Value	CCL
Settling Window (encoder counts)	0x36	0	0	0
D-Term Delay (No. Of Servo Cycles)	0x71	8	8	0
Notch Filter Frequency (Hz)	0x94	10000,000000	10000,000000	0
Notch Filter Edg	0x95	1,000000	1,000000	0
P-Term 1	0x411	150	90	0
I-Term 1	0x412	100	100	0
D-Term 1	0x413	60	60	0
I-Limit 1	0x414	2000	2000	0
KVFF 1	0x415	0	0	0

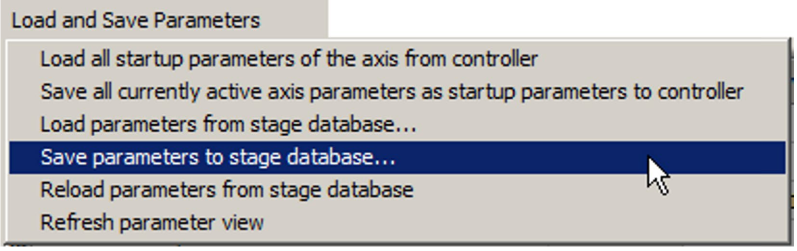
6. Enter new values for the parameters to be changed:

   a) If the parameter to be modified is not included in the list on the right-hand side of the window, click ***Configure view > Select parameters...*** and add it to the list. You can also display certain groups of parameters or all axes-related parameters.

   b) Type the new parameter value into the corresponding input field in the ***Active Value*** column of the list.

c) Press the Enter key on the PC keyboard or click outside the input field with the mouse to transfer the parameter value to the volatile memory of the controller. Note: If a parameter value in the volatile memory (***Active Value*** column) is different to the parameter value in the nonvolatile memory (***Startup Value*** column), the line in the list is highlighted in color.

7. Click ***Load and Save Parameters -> Save parameters to stage database...***.


Load and Save Parameters
Load all startup parameters of the axis from controller
Save all currently active axis parameters as startup parameters to controller
Load parameters from stage database...
Save parameters to stage database...
Reload parameters from stage database
Refresh parameter view

The ***Save Parameters as User Stage Type*** dialog opens.

8. Save the changed parameter values as new positioner type in the ***Save Parameters as User Stage Type*** dialog:

a) Leave the entry in the ***Parameters of axis*** field unchanged.

b) Enter the name for the new positioner type into the ***Save as*** field.

c) Click ***OK***.

The new positioner type was saved to the PISTAGES3.DB positioner database. The display of the connected positioner type was updated in the single axis window and in the main window of PIMikroMove. The new positioner type is also available immediately for selection in the ***Select connected stages*** step too.

Changing a positioner type in the positioner database

1. Select the ***C-863.12 > Select connected stages...*** menu item in the main window of PIMikroMove.

   The ***Start up stages/axes for C-863.12*** window opens, the ***Select connected stages*** step is active.

2. Select one of the positioners you created as described above (p. 233): Proceed with the selection as described in step 2 of the **Creating a positioner type in the positioner database** instruction.

3. Proceed with steps 3 to 7 in **Creating a positioner type in the positioner database**.

4. Save the modified parameter values of the positioner type in the ***Save Parameters as User Stage Type*** dialog:

a) Leave the entry in the ***Parameters of axis*** field unchanged.

b) Leave the entry in the ***Save as*** field unchanged.

c) Click ***OK***.

d) Click ***Change settings i***n the ***Stage type already defined*** dialog. The ***Save Parameters as User Stage Type*** dialog closes automatically after a short time.

The parameter values of the positioner type have been updated in the PISTAGES3.DB positioner database and in the main window of PIMikroMove.

9.4 Parameter Overview

INFORMATION

The write access for the parameters of the C-863.12 is defined by command levels. After the controller is switched on or rebooted, the active command level is always 0. On command levels > 1, write access is only available to PI service personnel.

➢ Contact the customer service department if there seem to be problems with parameters of command level 2 or higher (p. 253).

INFORMATION

The password for saving the parameter values in the nonvolatile memory is 100.

Meaning of the color highlight in the parameter table:

Colorless	The parameter value can be loaded from a positioner database (p. 12).
Light gray:	The value of the parameter is from one of the following sources: ▪ Factory setting ▪ Set by the controller during runtime and read only ▪ Read from the ID chip of the positioner (for future use)

Designations in the header of the following table:

- ID = Parameter ID, hexadecimal format
- Type = Data type:
  - INT = integer value, including Boolean values
  - FLOAT = floating-point number
  - CHAR = String format
- CL = Command Level for write access
- Item = Item type that the parameter refers to, refer to "Commandable items" (p. 17) for further information
- Parameter name = Name of the parameter
- Description = Explanation of the parameter

ID	Type	CL	Item	Parameter name	Description
0x8	FLOAT	0	Axis	Maximum Position Error (Phys. Unit)	Maximum position error Is used for detecting motion errors. For details, see "Motion errors" (p. 75).
0x9	INT	0	Axis	Maximum Motor Output	Maximum permissible absolute measure of the control value (dimensionless) For details, see "Motor control" (p. 16).
0xA	FLOAT	0	Axis	Maximum Closed-Loop Velocity (Phys. Unit/s)	Maximum velocity in closed-loop operation Specifies the maximum value for parameter 0x49.
0xB	FLOAT	0	Axis	Closed-Loop Acceleration (Phys. Unit/s^2)	Acceleration in closed-loop operation Limited by parameter 0x4A. Refer to "Generation of the dynamics profile" (p. 22) for details.
0xC	FLOAT	0	Axis	Closed-Loop Deceleration (Phys. Unit/s^2)	Deceleration in closed-loop operation Limited by parameter 0x4B. Refer to "Generation of the dynamics profile" (p. 22) for details.
0xE	INT	0	Axis	Numerator Of The Counts-Per-Physical-Unit Factor	Numerator of the factor for counts per physical unit of length For details, see "Physical units" (p. 20).
0xF	INT	0	Axis	Denominator Of The Counts-Per-Physical-Unit Factor	Denominator of the factor for counts per physical unit of length For details, see "Physical units" (p. 20).
0x13	INT	0	Axis	Is Rotary Stage?	Is this a rotation stage? 0 = Not a rotation stage 1 = Rotation stage No evaluation by the C-863.12 but only by the PC software: PIMikroMove determines which motion is permissible on the basis of this value.
0x14	INT	0	Axis	Has Reference?	Does the positioner have a reference switch? For details, see "Reference switch detection" (p. 29).

ID	Type	CL	Item	Parameter name	Description
0x15	FLOAT	0	Axis	Maximum Travel In Positive Direction (Phys. Unit)	Soft limit in positive direction See examples in "Travel range and soft limits" (p. 32).
0x16	FLOAT	0	Axis	Value At Reference Position (Phys. Unit)	Position value at the reference switch See examples in "Travel range and soft limits" (p. 32).
0x17	FLOAT	0	Axis	Distance From Negative Limit To Reference Position (Phys. Unit)	Distance between the reference switch and the negative limit switch See examples in "Travel range and soft limits" (p. 32).
0x18	INT	0	Axis	Limit Mode	Signal logic of the limit switches Refer to "Detecting limit switches" (p. 30) for details.
0x1A	INT	0	Axis	Has Brake?	Does the positioner have a brake? 0 = No brake present 1 = Brake present. In this case, switching the servo mode on/off and activating/deactivating the brake are coupled to each other, see `BRA` (p. 133) and `SVO` (p. 191). The brake is controlled via the **Motor (p. 259)** socket: ▪ Pin 15, when the brake driver is integrated in the positioner ▪ Pins 9 and 16, when the C-863.12's integrated brake driver is used. Configuration is performed with parameters 0x3094, 0x3095, 0x3096.
0x2F	FLOAT	0	Axis	Distance From Reference Position To Positive Limit (Phys. Unit)	Distance between reference switch and positive limit switch See examples in "Travel range and soft limits" (p. 32).
0x30	FLOAT	0	Axis	Maximum Travel In Negative Direction (Phys. Unit)	Soft limit in negative direction See examples in "Travel range and soft limits" (p. 32).
0x31	INT	0	Axis	Invert Reference?	Should the reference signal be inverted? For details, see "Reference switch detection" (p. 29).
0x32	INT	0	Axis	Has No Limit Switches?	Does the positioner have limit switches? Refer to "Detecting limit switches" (p.

ID	Type	CL	Item	Parameter name	Description
					30) for details.
0x33	INT	0	Axis	Motor Offset Positive	Offset for the positive direction of motion Refer to "Control algorithm and other control value corrections" (p. 26) for details.
0x34	INT	0	Axis	Motor Offset Negative	Offset for the negative direction of motion Refer to "Control algorithm and other control value corrections" (p. 26) for details.
0x36	INT	0	Axis	Settling Window (encoder counts)	Settling window around the target position Refer to "On-target state" (p. 29) for details.
0x3C	CHAR	0	Axis	Stage Name	Positioner name Maximum of 20 characters; default value: DEFAULT_STAGE
0x3F	FLOAT	0	Axis	Settling Time (s)	Delay time for setting the on-target state. Refer to "On-target state" (p. 29) for details.
0x47	INT	0	Axis	Reference Travel Direction	Default direction for the referencing move Refer to "Referencing" (p. 34) for details.
0x48	INT	0	Axis	Motor Drive Offset	Velocity-dependent offset Refer to "Control algorithm and other control value corrections" (p. 26) for details.
0x49	FLOAT	0	Axis	Closed-Loop Velocity (Phys. Unit/s)	Velocity in closed-loop operation Limited by parameter 0xA Refer to "Generation of the dynamics profile" (p. 22) for details.
0x4A	FLOAT	0	Axis	Maximum Closed-Loop Acceleration (Phys. Unit/s^2)	Maximum acceleration in closed-loop operation Specifies the maximum value for parameter 0xB.
0x4B	FLOAT	0	Axis	Maximum Closed-Loop Deceleration (Phys. Unit/s^2)	Maximum deceleration in closed-loop operation Specifies the maximum value for parameter 0xC.

ID	Type	CL	Item	Parameter name	Description
0x50	FLOAT	0	Axis	Velocity For Reference Moves (Phys. Unit/s)	Velocity for referencing move Refer to "Referencing" (p. 34) for details.
0x5A	INT	0	Axis	Numerator Of The Servo-Loop Input Factor	Numerator of the control loop input factor Refer to "Control algorithm and other control value corrections" (p. 26) for details.
0x5B	INT	0	Axis	Denominator Of The Servo-Loop Input Factor	Denominator of the control-loop input factor Refer to "Control algorithm and other control value corrections" (p. 26) for details.
0x5C	INT	0	Axis	Source Of Reference Signal	Reference signal source for the `FRF` or `FED` commands Refer to "Commands and parameters for digital inputs" (p. 86) and "Using digital input signals as switch signals" (p. 89) for details.
0x5D	INT	0	Axis	Source Of Negative Limit Signal	Reference signal source for the `FNL` or `FED` commands Refer to "Commands and parameters for digital inputs" (p. 86) and "Using digital input signals as switch signals" (p. 89) for details.
0x5E	INT	0	Axis	Source Of Positive Limit Signal	Reference signal source for the `FPL` or `FED` commands Refer to "Commands and parameters for digital inputs" (p. 86) and "Using digital input signals as switch signals" (p. 89) for details.
0x5F	INT	0	Axis	Invert Digital Input Used For Negative Limit	Inverts the polarity of the digital inputs that are used as the sources of the negative limit switch signal. Refer to "Commands and parameters for digital inputs" (p. 86) and "Using digital input signals as switch signals" (p. 89) for details.
0x60	INT	0	Axis	Invert Digital Input Used For Positive Limit	Inverts the polarity of the digital inputs that are used as the sources of the positive limit switch signal. Refer to "Commands and parameters for digital inputs" (p. 86) and "Using digital input signals as switch signals"

ID	Type	CL	Item	Parameter name	Description
					(p. 89) for details.
0x61	INT	0	Axis	Invert Direction Of Motion For Joystick-Controlled Axis?	Should the direction of motion for joystick-controlled axes be inverted? For details see "Commands and parameters for joystick control" (p. 92).
0x63	FLOAT	0	Axis	Distance Between Limit And Hard Stop (Phys. Unit)	Distance between the built-in limit switch and the hard stop Refer to "Referencing" (p. 34) for details.
0x70	INT	0	Axis	Reference Signal Type	Reference signal type For details, see "Reference switch detection" (p. 29).
0x71	INT	0	Axis	D-Term Delay (No. Of Servo Cycles)	D term delay Refer to "Control algorithm and other control value corrections" (p. 26) for details.
0x72	INT	0	System	Ignore Macro Error?	Ignore macro error? For details, see "Commands and parameters for macros" (p. 99).
0x77	INT	0	Axis	Use Limit Switches Only For Reference Moves?	Should the limit switches only be used for referencing moves? Refer to "Detecting limit switches" (p. 30) for details.
0x78	FLOAT	0	Axis	Distance From Limit To Start Of Ref. Search (Phys. Unit)	Distance between the limit switch or hard stop and the starting position for the referencing move to the index pulse Refer to "Referencing" (p. 34) for details.
0x79	FLOAT	0	Axis	Distance For Reference Search (Phys. Unit)	Maximum distance for the referencing move to the index pulse Refer to "Referencing" (p. 34) for details.
0x7C	FLOAT	0	Axis	Maximum Motor Output (V)	Maximum permissible operating voltage of the motor. For details, see "Motor control" (p. 16).
0x94	FLOAT	0	Axis	Notch Filter Frequency 1 (Hz)	Frequency of the first notch filter For details, see "Control algorithm and other control value corrections" (p. 26).

ID	Type	CL	Item	Parameter name	Description
0x95	FLOAT	0	Axis	Notch Filter Edge 1	Rise of the edge of the first notch filter Refer to "Control algorithm and other control value corrections" (p. 26) for details.
0x3094	INT	0	Axis	Internal Brake	Use the integrated brake driver of the C-863.12? 0 = do not use brake driver 1 = use brake driver. The brake is activated (closed) when the supply voltage drops below the value of parameter 0x3096. In addition, switching the servo mode on/off and activating/deactivating the brake are coupled to each other, see BRA (p. 133) and SVO (p. 191). The setting only takes effect when parameter 0x1A has the value 1 ("brake available"). The signals from the brake driver are output at pins 9 and 16 of the **Motor** (p. 259) socket.
0x3095	FLOAT	0	Axis	Brake Activation Voltage (V)	Supply voltage for releasing the brake 0 to 48 V Is only used when parameters 0x1A and 0x3094 each have the value 1.
0x3096	FLOAT	0	Axis	Brake Continuous Voltage (V)	Supply voltage for keeping the brake released continuously 0 to 48 V Should be smaller than the value of parameter 0x3095. To keep heat build-up as low as possible, continuous supply of voltage to the brake should be kept as low as possible. Is only used when parameters 0x1A and 0x3094 each have the value 1.
0x411	INT	0	Axis	P-Term 1	0 to 32767; for details see "Control algorithm and other control value corrections" (p. 26).
0x412	INT	0	Axis	I-Term 1	0 to 32767; for details see "Control algorithm and other control value corrections" (p. 26).
0x413	INT	0	Axis	D-Term 1	0 to 32767; for details see "Control

ID	Type	CL	Item	Parameter name	Description
					algorithm and other control value corrections" (p. 26).
0x414	INT	0	Axis	I-Limit 1	0 to 32767; for details see "Control algorithm and other control value corrections" (p. 26).
0x415	INT	0	Axis	Kvff 1	0 to 32767; for details see "Control algorithm and other control value corrections" (p. 26).
0x03003900	INT	0	Axis	Quadrature Encoder Filter	Filtering of the encoder signal for reducing interference? 0 - off (default setting) 1 - for rapid motion 2 - for medium-speed motion 3 - for slow motion Refer to "Control algorithm and other control value corrections" (p. 26) for details.
0x07000601	CHAR	0	Axis	Axis Unit	Unit symbol For details, see "Physical units" (p. 20).
0x0D000000	CHAR	2	System	Controller S/N	Serial number of the C-863.12 Refer to "Type plate" (p. 9) for details.
0x0E000200	FLOAT	2	System	Servo Update Time	Servo cycle time in seconds
0x0F000100	CHAR	2	Axis	Stage Type	Positioner type Format for standard positioners: x-xxx Format for customized positioners: x-xxxKxxx
0x0F000200	CHAR	2	Axis	Stage Serial Number	Serial number of the positioner 9-digit number
0x0F000300	CHAR	2	Axis	Stage Assembly Date	Manufacturing date of the positioner Date format: DDMMYY
0x0F000400	INT	2	Axis	Stage HW Version	Version number of the positioner hardware

10 Maintenance

10.1 Cleaning the C-863.12

NOTICE

Short circuits or flashovers!

The C-863.12 contains electrostatic-sensitive devices that can be damaged by short-circuiting or flashovers when cleaning fluids penetrate the housing.

➢ Before cleaning, disconnect the C-863.12 from the power source by removing the mains plug.

➢ Prevent cleaning fluid from penetrating the housing.

➢ When necessary, clean the surfaces of the C-863.12's housing using a cloth dampened with a mild cleanser or disinfectant.

10.2 Updating Firmware

NOTE

Malfunction due to faulty firmware update!

An incorrect or incomplete firmware update of the C-863.12can lead to a situation where the C-863.12 can only be restored to operational readiness by the PI customer service.

➢ Only update the firmware of the C-863.12 with approval from the PI customer service. If possible, have the PI customer service perform the firmware update.

➢ Before starting the firmware update, ensure that you have received suitable firmware from the PI customer service and stored it in a location that is accessible by the update program.

➢ Do **not** switch the C-863.12 off during the firmware update.

INFORMATION

The **STA** LED flashes when the C-863.12 is in firmware update mode. The C-863.12 does not leave the firmware update mode until it is **restarted** after a **successful** firmware update. If the firmware update was unsuccessful or aborted, the C-863.12 remains in the firmware update mode after a reboot.

If the **STA** LED still flashes, even though the C-863.12 has been restarted after the firmware update:

➢ Repeat the firmware update.

- ➢ If the update of the firmware fails, contact our customer service department (p. 253).

INFORMATION

If new parameters are introduced with the firmware update or the C-863.12 memory management is changed, an initialization of the C-863.12 is required after updating the firmware.

Requirements

- ✓ You have connected the C-863.12 to the PC via the USB or RS-232 interface (p. 46).
- ✓ You have made sure that the C-863.12 is **not** a part of a daisy chain network.
- ✓ You have made sure that **no** cable is connected to the **RS-232 Out** socket.
- ✓ The ***PIFirmwareManager*** program is installed on the PC (p. 41).
- ✓ You have copied the new firmware file, which you have received from our customer service department, to a directory on the PC.
- ✓ You have read and understood the documentation which you received from our customer service department together with the new firmware. You have learned from the documentation whether new parameters are introduced with the firmware update or the memory management of the C-863.12 changes.
- ✓ You have saved the parameter values of the C-863.12 to a text file on the PC (p. 229)
- ✓ You have saved the C-863.12 controller macros to files on the PC (p. 109).
- ✓ You have established communication with PIMikroMove or PITerminal between the C-863.12 and the PC (p. 56).

Updating the firmware of the C-863.12

- ➢ Start the ***PIFirmwareManager*** program on the PC and update the controller firmware.

  Proceed as described in the user manual SM164E (p. 3).

Restarting the C-863.12

1. Switch off the C-863.12.
2. Switch the C-863.12 on again.

   If the firmware update was successful, the C-863.12 exits the firmware update mode and the **STA** LED lights up continuously.

Have new parameters been added by the firmware update, or has the memory management of the C-863.12 been changed?

- If no: Firmware update is finished.
- If yes: An initialization of the C-863.12 is required, see below.

Initializing the C-863.12 after a firmware update

The initialization of the C-863.12 resets **all** parameters to their factory settings and deletes all controller macros. Consequently, parameter values and controller macros that are not saved are lost during the initialization process.

1. Make sure that the current parameter values and controller macros of the C-863.12 have been saved on the PC.
2. On the PC, start PITerminal or PIMikroMove, connect to the C-863.12, and, if necessary, open the window to send commands.
3. Initialize theC-863.12, by sending the following commands one by one:

   ```
   ZZZ 100 parameter
   ```

   ```
   ZZZ 100 macros
   ```

   After successful initialization, the controller issues a corresponding message.
4. Adapt the parameter values of the C-863.12.

   For instructions on the general procedure, see "Changing Parameter Values: General Procedure" (p. 230).

   - Reset the parameters that were already present prior to the firmware update to the saved values from the text file.
   - Set the parameters that were introduced with the firmware update to the appropriate values.
5. If you have saved controller macros on the PC: Load the controller macros back to the C-863.12, see "Making Backups and Loading Controller Macros" (p. 109).

11 Troubleshooting

Fault: Positioner does not move	
Possible causes	**Remedial measures**
Cable not connected correctly	➢ Check the cable connections.
Positioner or cable is defective	➢ If available, replace the defective positioner with another positioner and test the new combination.
Unsuitable positioner cable used	If unsuitable cables are used, interference can occur in the signal transmission between the positioner and the C-863.12. ➢ If the positioner, cable, and C-863.12 are marked as a related system, replace the system components with other components only after consulting PI.
Positioner not connected to power adapter	Positioners with integrated PWM amplifier are supplied via a separate power adapter. ➢ If the positioner has an integrated PWM amplifier, connect it to a suitable power adapter. ➢ To achieve the optimum motor performance, use a power adapter for the C-863.12 that supplies the same output voltage as the power adapter for the PWM amplifier. ➢ Make sure that the power adapter is functioning properly.
Limit switch signal logic set incorrectly	In order for the positioner to be able to move, the settings of the C-863.12 must correspond to the limit switch logic level of the positioner; see "Limit Switch Detection" (p. 30). ➢ Adjust the ***Limit Mode*** parameter (0x18) accordingly.
Limit switch signals not compatible with the C-863.12	It is possible that positioners from third-party suppliers use unsuitable limit switch signals. ➢ Contact the customer service department (p. 253) and the manufacturer of the positioner.
Incorrect configuration	➢ Check the parameter settings of the C-863.12 with the commands `SPA?` (volatile memory) and `SEP?` (nonvolatile memory); for details, see "Adapting Settings" (p. 227).
Incorrect command or incorrect syntax	➢ Send the `ERR?` command and check the error code that is returned.
Wrong axis commanded	➢ Make sure that the correct axis identifier is used and that the commanded axis belongs to the correct positioner.
Joystick control is active	Motion commands are not allowed when a joystick is activated for the axis. ➢ Deactivate the joystick with the `JON` command (p. 166).

Fault: Positioner performs unintentional motion	
Possible causes	**Remedial measures**
Joystick is not connected, but activated in the C-863.12	➢ Activate the joystick in the software only if the C-863.12 is actually connected to a joystick (p. 93).
Joystick not calibrated	➢ Calibrate the joystick (p. 95).
Startup macro is run	➢ Check whether a macro is specified as the startup macro and cancel the selection of the startup macro if necessary (p. 101).
Positioner's brake deactivated with the `BRA` command (p. 133) when servo mode is switched off	➢ Secure the positioner against moving unintentionally before you deactivate the brake by command!

Fault: Positioner is oscillating or positions inaccurately	
Possible causes	**Troubleshooting**
The load was changed.	➢ Readjust the system according to the changed load (p. 68).
Interference of encoder signal	When filtering of the encoder signal (p. 28) is disabled: If major interference is impacting the signal, the encoder may count too many cycles or no longer accurately identify the edges. ➢ Set the ***Quadrature Encoder Filter*** (0x03003900) parameter to a value > 0 to enable the filter for the encoder signal. ➢ Conduct referencing (p. 34) anew. When filtering of the encoder signal is enabled: If velocities are too high, the encoder might not identify all edges. ➢ If necessary, set the ***Quadrature Encoder Filter*** (0x03003900) parameter to a lower value. ➢ Conduct referencing (p. 34) anew.

Fault: Positioner is already oscillating during the referencing move	
Possible causes	**Remedial measures**
Very high load on the positioner	In case of a very high load, proceed with PIMikroMove during the referencing move as follows: 1. Do **not** start the referencing move in the ***Start up axes*** step, but click on ***Close*** to close the ***Start up controller*** window instead. 2. In the main window, open the single axis window for the positioner connected by selecting the positioner in the

Fault: Positioner is already oscillating during the referencing move	
Possible causes	**Remedial measures**
	View > Single Axis Window menu. 3. Expand the view of the single axis window by clicking on the **>** button at the right edge of the window. 4. With the ***Servo*** check box, make sure that the servo mode is switched on. 5. Start the referencing move by clicking on one of the ***Reference...*** buttons. 6. If the positioner is oscillating: Stop the referencing move immediately in the ***Reference Axes*** dialog, close the dialog and switch off the servo mode by removing the tick from the respective check box in the single axis window. 7. Enter new values for the servo control parameters, see "Optimizing the Servo Control Parameters" (p. 68). 8. Restart the referencing move. 9. If the positioner is still oscillating, repeat steps 6 to 8 until the referencing move has completed successfully without oscillation.

Fault: There is no communication between the controller and the PC	
Possible causes	**Remedial measures**
The wrong communication cable is used or it is defective	➢ Use a null modem cable for the RS-232 connection. ➢ If necessary, check whether the cable works on a fault-free system.
Baud rate not configured correctly	➢ Check the settings of DIP switches 5 and 6 for the baud rate (p. 55). ➢ In a daisy chain network make sure that the same baud rate is set for every controller.
Controller address not configured correctly	➢ Check the settings of DIP switches 1 to 4 for the controller address (p. 54).
Another program is accessing the interface.	➢ Close the other program.

Fault: There is no communication between the controller and the PC	
Possible causes	**Remedial measures**
Problems with special software	➢ Check whether the system works with other software, such as a terminal program or a development environment. You can test the communication by starting a terminal program (e.g., PITerminal) and entering `*IDN?` or `HLP?`. ➢ Make sure that you end the commands with an LF (line feed). A command is only executed when LF has been received.

Fault: The customer software does not function with the PI drivers	
Possible causes	**Remedial measures**
Incorrect combination of driver routines/VIs	➢ Check whether the system functions with a terminal program (e.g., PITerminal). If so: ➢ Read the information in the corresponding software manual and compare your program code with the sample code on the data storage device with the PI Software Suite.

If the problem that occurred with your system is not in the list above or cannot be solved as described, contact our customer service department (p. 253).

12 Customer Service

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

- ➢ If you have questions concerning your system, provide the following information:
  - – Product and serial numbers of all products in the system
  - – Firmware version of the controller (if applicable)
  - – Version of the driver or the software (if applicable)
  - – PC operating system (if applicable)

If possible: Take photographs or make videos of your system that can be sent to our customer service if requested.

13 Technical Data

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

13.1 Specifications

13.1.1 Data Table

	C-863.12
Function	DC motor control
Drive types	DC motor, servo controlled Motors with PWM control, e.g., ActiveDrive amplifiers or brushless motors with integrated block commutation
Axes	1
Supported functions	Point-to-point motion. Startup macro. Data recorder for recording operating data such as motor voltage, velocity, position or position error. ID chip detection. Internal safety circuitry: Watchdog timer.

Motion and control	C-863.12
Controller type	PID controller, parameter changing during operation
Servo cycle time	50 µs
Profile generator	Trapezoidal velocity profile
Encoder input	A/B quadrature single-ended or differential TTL signal acc. to RS-422; 60 MHz
Stall detection	Automatic motor stop when a programmable position error is exceeded
Limit switches	2 × TTL (programmable polarity)
Reference switch	1 × TTL
Motor brake	1 × TTL, can be switched by software

Electrical properties	C-863.12
Max. output voltage*	0 V to operating voltage, for direct control of DC motors
Max. output power	60 W
Average output power	48 W
Power consumption, full load	48 W

Electrical properties	C-863.12
Power consumption without load	3 W
Current limitation	2.5 A

Interfaces and operation	C-863.12
Communication interfaces	USB; RS-232, D-sub 9 (m)
Motor connector	HD D-sub 26 (f)
Controller network	Up to 16 units** on a single interface
I/O lines	4 analog / digital inputs (0 to 5 V / TTL), 4 digital outputs (TTL)
Command set	PI General Command Set (GCS)
User software	PIMikroMove
Application programming interfaces	C, C++, C#, MATLAB, NI LabVIEW, Python
Manual control	Joystick, Y cable for 2-D motion, pushbutton box

Miscellaneous	C-863.12
Operating voltage	12 to 48 V DC *** from external power adapter (24 V DC power adapter included in the scope of delivery)
Max. current consumption	40 mA without load (when supplied with 48 V) 80 mA without load (when supplied with 24 V)
Operating temperature range	5 to 50 °C (temperature protection switches off at excessively high temperatures)
Mass	0.48 kg
Dimensions	130 mm × 76 mm × 40 mm (incl. mounting rails)

* The output voltage depends on the power adapter connected.

** 16 units with USB; 6 units with RS-232.

*** Recommended operating voltage: 24 to 48 V DC

13.1.2 Maximum Ratings

The C-863.12 is designed for the following operating data:

Input on:	**Maximum operating voltage** ⚠	**Operating frequency** ⚠	**Maximum current consumption** ⚠
Mini-DIN 4-pin. (f)	48 V	⎓	3 A

Output on:	**Maximum output voltage** ⚠	**Maximum output current** ⚠	**Maximum output frequency** ⚠
HD D-sub 26 (f)	48 V	2.5 A	20kHz (PWM)

13.1.3 Ambient Conditions and Classifications

The following ambient conditions and classifications for the C-863.12 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

13.2 Dimensions

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

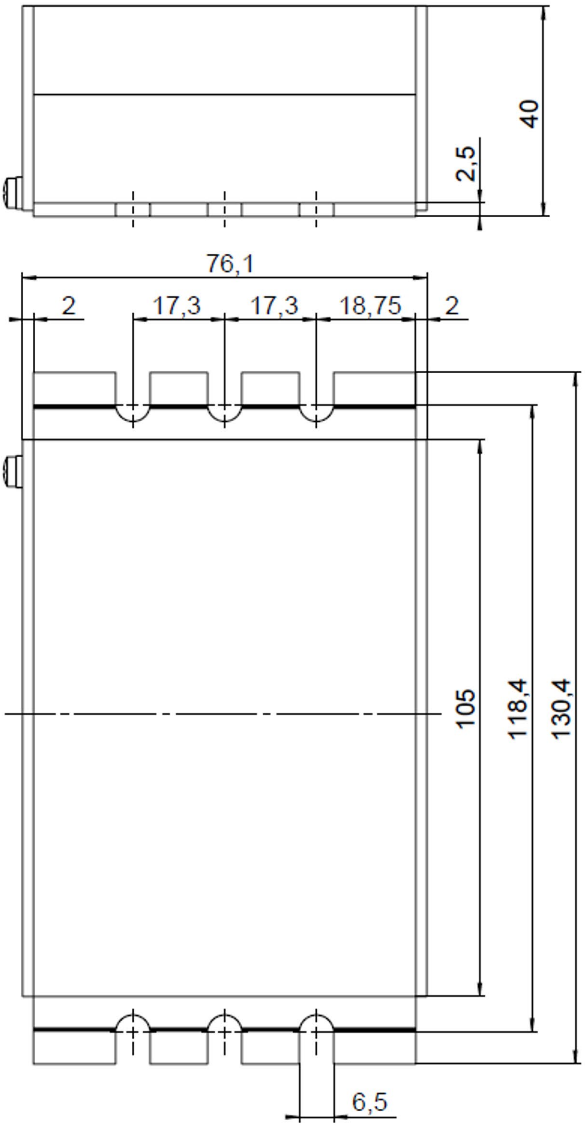
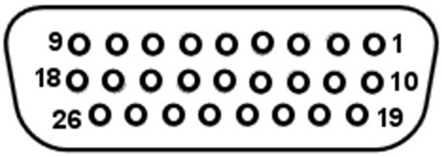


Figure 25: C-863.12, dimensions in mm

13.3 Pin Assignment

13.3.1 Motor

HD D-sub 26 (f)



Pin	Signal	Direction	Function
1	OUT0	Output	Motor + (differential; power PWM); for positioners without PWM amplifier
2	OUT0	Output	Motor + (differential; power PWM); for positioners without PWM amplifier
3	OUT1	Output	Motor - (differential; power PWM); for positioners without PWM amplifier
4	OUT1	Output	Motor - (differential; power PWM); for positioners without PWM amplifier
5	-	-	Reserved
6	-	-	Reserved
7	-	-	Reserved
8	-	-	Reserved
9	BRAKE_OUT	Output	Motor brake driver
10	REF	Input	Reference switch (5 V TTL input, single-ended)
11	NLIM	Input	Negative limit switch (5 V TTL input)
12	PLIM	Input	Positive limit switch (5 V TTL input)
13	PWM-SIGNE	Output	PWM sign (TTL); for positioners with PWM amplifier
14	PWM-MAGE	Output	PWM magnitude (TTL); for positioners with PWM amplifier
15	BRAKEE	Output	Motor brake 5 V TTL, for positioners with integrated brake driver
16	VB_HC	Output	Motor brake driver (0 to 48 V supply)
17	ID Chip	Bidirectional	ID chip (intended for future use)
18	VCC_ENC	Output	Position sensor power supply (5 V, 200 mA)
19	ENCA+	Input	Encoder input A+ (RS-422)
20	ENCA-	Input	Encoder input A- (RS-422)

Pin	Signal	Direction	Function
21	ENCB+	Input	Encoder input B+ (RS-422)
22	ENCB-	Input	Encoder input B- (RS-422)
23	INDEX+	Input	Reference switch, differential
24	INDEX-	Input	Reference switch, differential
25	GND		GND
26	VCC_ENC	Output	Position sensor power supply (5 V, 200 mA)

Do not connect anything to reserved pins.

13.3.2 I/O

Mini-DIN socket, 9-pin, female

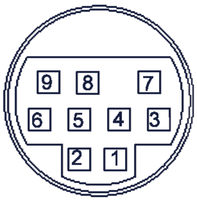


Figure 26: Front view of the mini-DIN socket

Pin	Function
1	Input 1 (analog: 0 to +5V / digital: TTL)
2	Input 2 (analog: 0 to +5V/ digital: TTL)
3	Input 3 (analog: 0 to +5V/ digital: TTL)
4	Input 4 (analog: 0 to +5V/ digital: TTL)
5	Output 1 (digital: TTL)
6	Output 2 (digital: TTL)
7	Output 3 (digital: TTL)
8	Output 4 (digital: TTL)
9	Vcc (+5 V)
Shield	GND

13.3.3 C-170.IO Cable for Connecting to the I/O Socket

Mini-DIN connector, 9-pin, male, open end

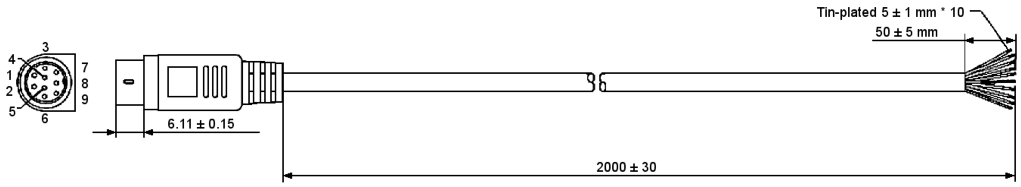


Figure 27: C-170.IO cable

Pin	Wire Color	Function on the I/O socket of the C-863.12
1	Black	Input 1 (analog: 0 to +5V / digital: TTL)
2	white	Input 2 (analog: 0 to +5V / digital: TTL)
3	Red	Input 3 (analog: 0 to +5V / digital: TTL)
4	Yellow	Input 4 (analog: 0 to +5V / digital: TTL)
5	Purple	Output 1 (digital, TTL)
6	Blue	Output 2 (digital, TTL)
7	Green	Output 3 (digital, TTL)
8	Brown	Output 4 (digital, TTL)
9	Gray	Vcc (+5V)
Sheath	Shield, coated black (thicker than the wire connected to pin 1)	GND

13.3.4 Joystick

Mini-DIN socket, 6-pin, female (PS/2)

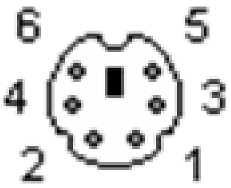


Figure 28: Front view of Mini-DIN socket

Pin	Function
1	GND
2	Not connected
3	Output: Vcc (3.3 V)
4	Input: axis 1 of joystick 1 (0 to 3.3 V)
5	Not connected
6	Input: Button 1 of joystick 1 (0 or 3.3 V)

13.3.5 C-819.20Y Cable for C-819.20 Joystick

The C-819.20Y cable makes it possible to connect 2 controllers to the C-819.20 joystick.

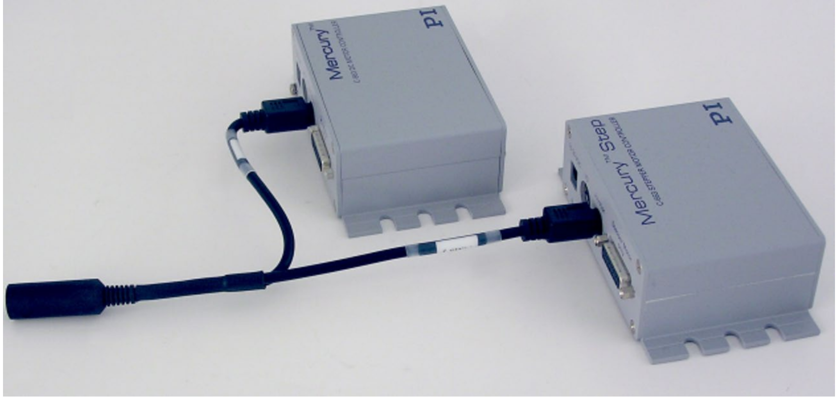


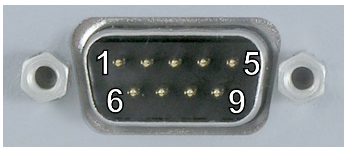
Figure 29: Y cable C-819.20Y for joystick with 2 controllers

Mini-DIN connector, 6-pin, female on 2 Mini-DIN connectors, 6-pin, male

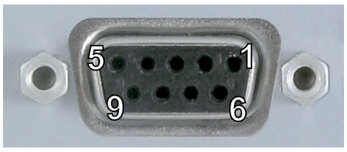
Mini-DIN 6-pin, female (to joystick)	Signal	Mini-DIN, 6-pin, male, X branch (to controller 1)	Mini-DIN, 6-pin, male, Y branch (to controller 2)
Pin 1	GND	Pin 1	Pin 1
Pin 2	Button for joystick Y axis	Not connected	Pin 6
Pin 3	Joystick power source	Pin 3	Not connected
Pin 4	Joystick X axis	Pin 4	Not connected
Pin 5	Joystick Y axis	Not connected	Pin 4
Pin 6	Button for joystick X axis	Pin 6	Not connected

13.3.6 RS-232 In and RS-232 Out

RS-232 In: D-sub 9 panel plug



RS-232 Out: D-sub 9 socket



Pin	Function
1	Not connected
2	RxD (PC to controller)
3	TxD (controller to PC)
4	Not connected
5	GND
6	Not connected
7	Not connected
8	Not connected
9	Not connected

INFORMATION

The pins of the **RS-232 In** and **RS-232 Out** sockets are connected to each other in the C-863.12 1:1.

INFORMATION

In a daisy chain network connected to the PC via the RS-232 interface of the first controller, only the PC feeds the RxD line. Depending on how performant the RS-232 driver of the PC is, the range of the network may be limited to 6 devices.

INFORMATION

The C-863.12 copies every signal that it receives from the PC via USB to the RxD line of the **RS-232 In** and **RS-232 Out** sockets. The C-863.12 copies the signal of the TxD line via USB to the PC.

13.3.7 Power Adapter Connector

DC power socket (Kycon), 4-pole (f), lockable

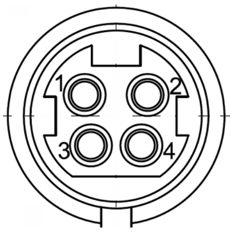


Figure 30: DC power socket (Kycon), 4-pole (f)

Pin	Signal	Direction
1	GND	GND
2	48 V DC supply voltage	Input
3	GND	GND
4	48 V DC supply voltage	Input
Shield	GND connected via the housing	GND

14 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 device according to international, national, and local rules and regulations.

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

If you have an old device from PI, you can send it to the following address free of charge:

Physik Instrumente (PI) SE & Co. KG
Auf der Römerstraße 1
76228 Karlsruhe, Germany

15 European Declarations of Conformity

For the C-863.12, declarations of conformity were issued according to the following European statutory requirements:

EMC Directive

RoHS Directive

The standards applied for certifying conformity are listed below.

EMC: EN 61326-1

Safety: EN 61010-1

RoHS: EN IEC 63000