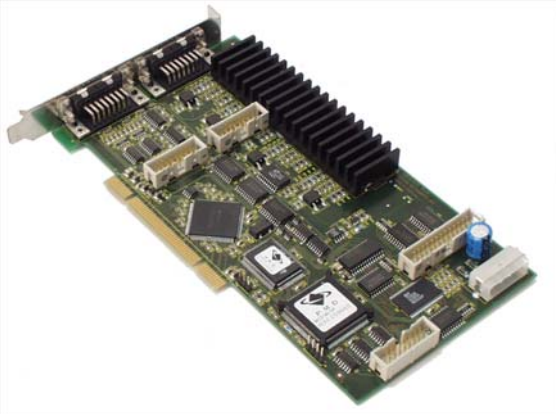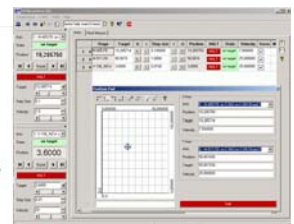**PI**

MS121E User Manual

C-843 PM Motor Controller Card

Release: 2.5.0   Date: 2006-03-27

This document describes the following product(s):

■ **C-843 PM.21**
  Motor Controller Card (PCI), 2 motor axes

■ **C-843 PM.41**
  Motor Controller Card (PCI), 4 motor axes

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Declaration of Conformity

according to ISO / IEC Guide 22 and EN 45014

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

The manufacturer hereby declares that the product

Product Name: **Motor Controller Card**
Model Numbers: **C-843**
Product Options: **all**

conforms to the following EMC Standards and normative documents:

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

Electromagnetic Immunity: EN 61000-6-1

Safety (Low Voltage Directive) :   EN 61010-1

Electrical equipment which is intended to be integrated in other electrical equipment only conforms to the cited EMC Standards and normative documents, if the user ensures a compliant connection when implementing the total system. Possible necessary measures are installation of the component in a suitable shielded enclosure and usage of suitable connectors.

March 14, 2005
Karlsruhe, Germany

Dr. Karl Spanner
President

About this Document

Users of this Manual

This manual is designed to help the reader to install and operate the C-843 Motor Controller Card. It assumes that the reader has a fundamental understanding of basic servo systems, as well as motion control concepts and applicable safety procedures.
The manual describes the physical specifications and dimensions of the C-843 Motor Controller Card as well as the software and hardware installation procedures which are required to put the associated motion system into operation.
This document is available as PDF file on the product CD. Updated releases are available via FTP or email: contact your Physik Instrumente sales engineer or write info@pi.ws.

Conventions

The notes and symbols used in this manual have the following meanings:

WARNING

> Calls attention to a procedure, practice or condition which, if not correctly performed or adhered to, could result in injury or death.

DANGER

> Indicates the presence of high voltage (> 50 V). Calls attention to a procedure, practice or condition which, if not correctly performed or adhered to, could result in injury or death.

CAUTION

> Calls attention to a procedure, practice, or condition which, if not correctly performed or adhered to, could result in damage to equipment.

NOTE

> Provides additional information or application hints.

Related Documents

The stage / motor, the driver electronics and the software tools which might be delivered with C-843 Motor Controller Card, are described in their own manuals. All documents are available as PDF files on the Motion CD or special product CD. Note that here is no special manual available for the GCS_COM library. Refer to the GCS_DLL Manual (MS 115E) for function descriptions.
Updated releases are available via FTP or email: contact your Physik Instrumente sales engineer or write info@pi.ws.

Contents

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1 Introduction

The C-843 is a 2- or 4-channel Motor Controller, designed as a PCI plug-in board that can be used in any PC with a free PCI slot. With the software on the C-843 PM CD, it can control DC Motors, PI Voice Coil Stages and PILine® Piezomotors in any combination.

The board is available in a 2-axis and a 4-axis version:

- **C-843.21** Motor Controller for 2 axes

- **C-843.41** Motor Controller for 4 axes

C-843 features at a glance:

- PCI-bus-compatible PC board

- Analog amplifiers for 5 W motors

- Selectable PWM output (10-bit resolution, 24.5 kHz)

- Full P-I-D motion control, with near and far parameter sets

- Multiple trajectory profile generation

- Profile modes: trapezoidal, S-curve, user specified

- Incremental encoder input (differential)

- Limit switch control

- Motor brake support for each axis

- High-level command language

- 8 TTL input and 8 TTL output channels

- Software DLL for C, C++, Visual Basic

- 64 kword on-board RAM for high-precision, user-specified trajectory profile control

1.1 Purpose of the C-843

The C-843 with the included hardware and software drivers is designed to drive PILine® piezo linear motors, DC motors and PI Voice Coil Drives in any combination up to a total power

consumption of about 20 watts. Five-watt motors can be driven directly from the integrated amplifiers. More powerful motors need external amplifiers. PILine® piezomotors require additional, separate driver electronics, which is controlled by PWM signals from the C-843.

The C-843 is based on a fast DSP processor providing high-performance PID motion control with many options for trajectory generation and filter setting. The motors can be controlled as to position, velocity, acceleration and many other motion-relevant parameters. Incremental rotary encoders or linear scales are used for position feedback.

To operate the C-843, it must be part of a motion system consisting of a host PC and at least one motorized axis (stage). The card itself and the appropriate software must be installed in a PC with Windows operating system (Win 98, ME, NT, 2000, XP) and a free PCI slot.

1.2   Safety Precautions

NOTE

The C-843 Motor Controller Card does not contain any user-serviceable parts of adjustment elements.

DANGER

Failure to heed warnings in this manual can result in bodily injury or material damage.

DANGER

Before opening the host PC, remove the line-voltage connection.

Heed any warnings provided by the manufacturer of the PC or of other add-on cards it may contain.

WARNING

The C-843 Motor Controller Card is an ESD-sensitive (electrostatic discharge sensitive) device. Observe all

precautions against static charge buildup before touching this device.

Avoid touching circuit components, pins and PCB traces. Discharge any static charge you may have on your body by briefly touching a conductive, grounded object before you touch any electronic assembly. Pose PCBs only on conductive surfaces, such as ESD-safe transport containers (envelopes, foam). Electronic subassemblies must always be kept and transported/shipped in conductive packaging.

Make sure that no conductive particles of any kind (metallic dust or shavings, broken pencil leads, loose screws) get on the card or into the PC

Make sure that no electrical contact between the various add-on cards in the PC is possible.

All motion of the connected motors and mechanical stages is software controlled, and software may fail. Be aware that some motorized stages can generate large forces which can cause personal injury or other damage if not properly handled.

! CAUTION

DO NOT EXCEED MAXIMUM CURRENTS!

Keep in mind that the total current for the C-843 is supplied from the PC power supply only.

Extreme power peaks will occur when:

- Motors accelerate or decelerate very fast
- Motors are reversed at high speed
- Motors stall
- Stages are driven into the hard stop

The total current may exceed the current capability of the PC power supply. Voltage drops may occur with the risk of PC malfunction or damage to other devices such as hard disks drives.

CAUTION

!

To prevent damage to piezomotor drives when using commands from command sets below the GCS level, dithering around the target must be prevented. GCS automatically surpresses dither and the MC PM DLL version has special functions for dither-free motion.

CAUTION

!

The C-843 has factory-set output current limitation. Nevertheless the user has to ensure that the total current does not exceed the capability of the PC power supply.

1.3 Unpacking

WARNING

The C-843 Motor Controller Card is an ESD-sensitive (electrostatic discharge sensitive) device. Observe all precautions against static charge buildup before touching this device.

Avoid touching circuit components, pins and PCB traces. Discharge any static charge you may have on your body by briefly touching a conductive, grounded object before you touch any electronic assembly. Pose PCBs only on conductive surfaces, such as ESD-safe transport containers (envelopes, foam). Electronic subassemblies must always be kept and transported/shipped in conductive packaging.

Unpack the C-843 Motor Controller Card with care. Compare the contents against the sales contract and packing slip.

The following components should be included:

- C-843.x1 Motor Controller Card

- Separate mounting bracket with sub-D 25 connector for the digital I/O lines

- 5.25-inch-style, 4-wire power Y-connector

- With C-843.41 cards only: separate mounting bracket with two 15-conductor sub-D connectors for motors #3 and #4

- C-843 PM distribution CD containing host software, hardware driver and all manuals as PDF files (for an overview over the host software see p.22)

- Piezomotor version of the C-843 User Manual (this document) in printed form

- User Manual for *PIMikroMove®* software in printed form

Inspect the contents for signs of damage. If parts are missing or you notice signs of damage contact PI immediately.

Save all packing materials in the event the product needs to be reshipped.

1.4   Additional Components

Depending on your application, you might need the following unincluded items for use with the C-843 Controller Card:

- C-843.JS option (for use with LabView VIs and *PIMikroMove®* operating software): joystick and sound card with game port

- C-842.AP1 PWM to analog adapter box, for driving analog stages with high power consumption using an external PWM amplifier

Contact your PI sales engineer or write info@pi.ws, if you need additional components.

1.5   System Requirements

To start working with the C-843 Motor Controller card, your motion system needs to meet the following conditions:

- A PC with a free PCI slot to install the C-843

- Windows operating system (Win 98, ME, NT, 2000, XP)

- One or more motorized positioners with incremental encoders (e.g. PILine® piezo motor with driver

electronics, a linear, rotary, or voice coil stage or a DC-Mike)

■ Cables to connect stage and controller (PI cable order numbers: C-815.35 or C-815.36)

We recommend that you make your first trials with the C-843 using the *PIMikroMove*® software package. This is the quickest way to verify that your system is connected and operating properly. You can even run simple automation tasks with the *PIMikroMove*® macro facility. All information about *PIMikroMove*® is found in a separate manual, which is included both in printed form and on the C-843 PM CD.

2 Quick Start

With a motion system that meets the requirements listed above, carry out the following steps to put it into operation:

1　Install the drivers and software on host PC (see p.9)

2　Install the card, with the PC powered completely down (see p. 9)

3　Begin operation (see p. 12)

If C-843 or C-843 PM host software is already installed, it must be uninstalled before the new version can be installed. To uninstall, follow the instructions on p. 14.

2.1　Install the Software on Host PC

For a short description of the available host software see Section 4.2 on p.26.

1　Be sure to log in with administrator privileges and insert the C-843 PM CD in the host PC.

2　If the Setup Wizard does not start automatically, start it from the root directory of the CD with the 🖼️ icon.

3　Follow the on-screen instructions. You can choose between "typical" and "custom" installation. Typical components are hardware driver, LabView drivers, DLLs and *PIMikroMove*®. "Typical" is recommended.

4　Shut down the PC.

2.2　Install the Card in Host PC

⚠️

WARNING

The C-843 Motor Controller Card is an ESD-sensitive (electrostatic discharge sensitive) device. Observe all precautions against static charge buildup before touching this device.

Avoid touching circuit components, pins and PCB traces. Discharge any static charge you may have on your body by briefly touching a conductive, grounded object before you

touch any electronic assembly. Pose PCBs only on conductive surfaces, such as ESD-safe transport containers (envelopes, foam). Electronic subassemblies must always be kept and transported/shipped in conductive packaging.

Make sure that no conductive particles of any kind (metallic dust or shavings, broken pencil leads, loose screws) get on the card or into the PC

Make sure that no electrical contact between the various add-on cards in the PC is possible.

DANGER

Before opening the host PC, remove the line-voltage connection.

Heed any warnings provided by the manufacturer of the PC or of other add-on cards it may contain.

1   Turn off the host PC and unplug the line cord. Then open the PC housing.

2   With C-843.41 only: to use motor axes #3 and #4 of the C-843.41, you must connect the two ribbon cables of the included 2-connector bracket adapter to the corresponding 16-pin header connectors on the C-843.41 board (for component locations see Fig. 1).

3   Optional: to make the digital I/O lines of the C-843 available (see section 3.4.3 on p. 18), you must connect the ribbon cable of the included sub-D-25 bracket adapter to the 26-pin Digital I/O header on the C-843 board (for component locations see Fig. 1).

4   Remove the slot covers from the positions in the PC which you plan to use.

5   For multiple-card installations: make sure the card numbers are properly configured in EEPROM (see p. 18 before continuing).

6   Install the C-843 card in a free PCI slot; install any adapter brackets you connected in steps 2 and 3 in suitable (neighboring) positions.

Piezo · Nano · Positioning

PI

7   Screw down the card and any adapter brackets.
Otherwise the card may creep out of its connector or
the adapters will slip and may cause a short circuit.

8   Connect the C-843 to the PC internal power supply
(see Fig. 2).
If there is no free cable of sufficient length from the
power supply, use the Y-cable which comes with the
card as a splitter or extension.

9   Close the PC case.

Axis 3 & 4 header connectors

Axis 3 & 4 connectors and ribbon cables

Digital IO connector and ribbon cable

Digital IO header

Motor power input

Cable from PC power supply or Y-connector
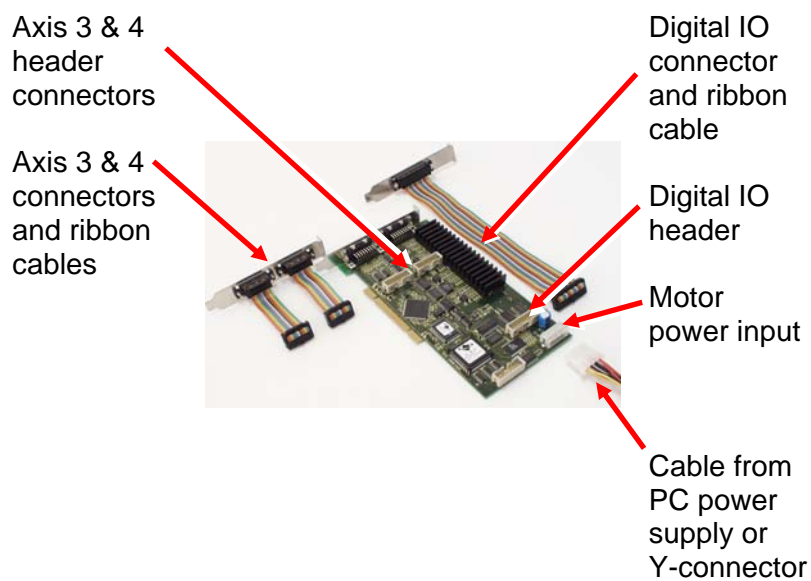
Fig. 1: C-843 and connectors
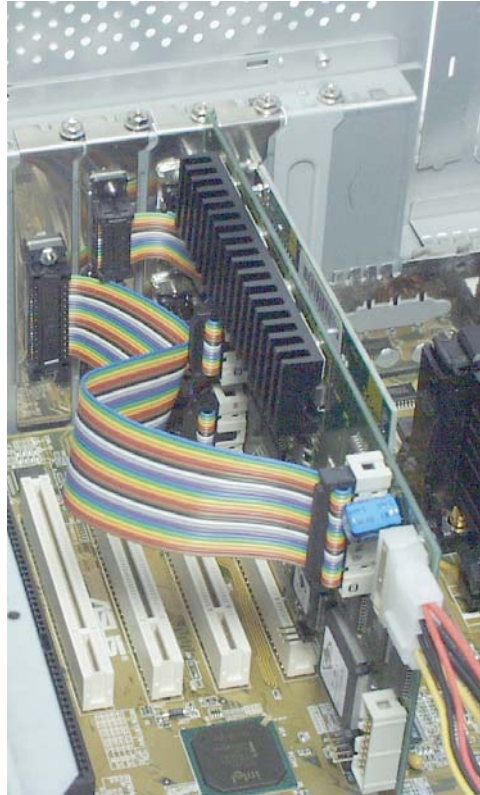
Fig. 2: C-843.41 installed, with power connector at lower right

2.3 Begin Operation

> ## CAUTION
>
> **DO NOT EXCEED MAXIMUM CURRENTS!**
>
> Keep in mind that the total current for the C-843 is supplied from the PC power supply only.
>
> Extreme power peaks will occur when:
>
> ■ Motors accelerate or decelerate very fast
>
> ■ Motors are reversed at high speed
>
> ■ Motors stall
>
> ■ Stages are driven into the hard stop
>
> The total current may exceed the current capability of the PC power supply. Voltage drops may occur with the risk of

!

PC malfunction or damage to other devices such as hard disks drives.

The C-843 has factory-set output current limitation. Nevertheless the user has to ensure that the total current does not exceed the capability of the PC power supply.

1   Restart the host PC.

2   When the New Hardware Wizard appears, do the following:

- 1st window: click *Next*

- 2nd window (Win XP only): Do not connect to Windows Update to search for software

- Next window: Do not search, but choose the option that will display a list of drivers and click *Next*

- Next window: in the *Model* list pane, "C843 Device Driver" should be highlighted. Otherwise click *Have Disk* and select the CD-ROM drive with the C-843PM CD and the path \Driver\Win*(your operating system)*\c843[...].inf, then click *Next*

- Next window: click *Next*

- Next window: click *Finish*

Note that this procedure is required, even though the hardware driver was already installed with the setup procedure in Section 2.1.

3   Connect the stages to the sub-D15 connectors in the mounting bracket(s). Be sure to note the channel designations; the labels on the brackets correspond to the axis or motor numbers used in *PIMikroMove*®. Other software may count starting from 0 instead of 1.

4   If you have chosen the corresponding option, *PIMikroMove*® will now start as soon as the C843 Device Driver is running. If not, you can start it manually and use its buttons and menus to command the connected axes. See the *PIMikroMove*® software manual for details.

2.4 Uninstalling and Updating

NOTE

Software that is no longer supported (e.g. *PISmartPM*) may be removed by the uninstall procedure but cannot be reinstalled from the new CD.

2.4.1 Uninstalling

To uninstall the C-843 PM host software use the *Start→Settings→Control Panel→Add/Remove Programs (Software)* menu sequence and follow the on-screen instructions.

2.4.2 Updating

To update the C-843 PM host software, proceed as follows:

If you have a C-843 host software installation which does not provide the control features for PILine® piezo linear motor stages, it is not necessary to uninstall it before you update your host PC with the C-843 PM host software. In this case you can install the C-843 PM host software as described in section 2.1 on p. 9.

If you have already installed C-843 PM host software, proceed as follows:

1. If you want to keep any existing configuration files, save them under new names or in a new directory

2. Uninstall the old C-843 PM host software version using the *Start→Settings→Control Panel→Add/Remove Programs (Software)* menu sequence (This also removes unneeded directories)

3. Install the new C-843 PM host software version by running the Setup Wizard from your update CD

4. If desired, move back any configuration files you saved in step 1

3   System Description

The C-843 Motor Controller is designed for high-performance motion control based on the *MC2140 (MC2120) Advanced Multi-Axis Motion Control* chipset (for detailed descriptions see the Motion Processor manuals on the C-843PM CD). The board is designed as a 32-bit, plug-and-play, PCI-bus card, compatible with main boards with 3.3 V and 5 V PCI bus slots (universal card). Read/Write operations are controlled via the PCI bus and memory-mapped PCI bridge, providing fast data transfer for complex motion control.

The C-843 provides closed-loop digital servo-control for a large variety of servo-motors. It uses incremental encoder position feedback signals. Sophisticated trajectory profile and digital servo capabilities are provided for each axis, resulting in very low position and velocity tracking errors. Axes can be programmed either independently or synchronously to allow advanced multi-axis motion, such as tracing circular and other complex path profiles.

For motor amplifier output the C-843 has one on-board linear amplifier per motor axis; each amplifier is capable of driving a 5 W motor. PWM outputs for external amplifiers and for the PILine® piezo motor stages are also available.

The chipset's integrated 64 k-word trace memory allows online tracing of up to four independent system variables (positions, velocities, internal register contents, etc.) at whole-number multiples of the servo-loop time.

To offer maximum flexibility, software interfaces at a number of different levels are provided and documented. In most cases, higher-level interfaces also provide pass-through functions for lower-level commands. See "Software Overview," p. 22 for more details.

3.1   Output Current Limitation

!

CAUTION

DO NOT EXCEED MAXIMUM CURRENTS!

Keep in mind that the total current for the C-843 is supplied from the PC power supply only.

Extreme power peaks will occur when:

> ■ Motors accelerate or decelerate very fast
>
> ■ Motors are reversed at high speed
>
> ■ Motors stall
>
> ■ Stages are driven into the hard stop
>
> The total current may exceed the current capability of the PC power supply. Voltage drops may occur with the risk of PC malfunction or damage to other devices such as hard disks drives.
>
> The C-843 has factory-set output current limitation. Nevertheless the user has to ensure that the total current does not exceed the capability of the PC power supply.

All output channels have separate current limiting. The factory default output current limit for each channel is 1 A, sufficient to drive a 5 W motor.

It is possible to drive stages with higher power consumption in PWM mode. See section 3.2 on p. 16.

Each analog power amplifier can be enabled or disabled independently from the others. See "Analog Amplifier and Brake Control," p. 28 for the hardware details.

3.2 Motor Output Modes

The motor output mode and thus the amplifier mode can be set by command for each axis separately. Possible modes are "16-bit DAC" (analog mode)[*] and "Sign/Magnitude PWM" (see the Motion Processor Users Guide p. 53 *ff.* for more information). The "50/50 PWM" mode of the motion processor chip is not presently supported by PI stages and thus not recommended. Nor is driving stepper motor stages currently supported.

Use the SPA command (GCS command set) to set the output mode (see the GCS Command Manual). Note: When working with the operating software provided on the product CD, the correct motor output mode for the selected stage is automatically set based on information in the internal stage database.

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[*] In analog mode, commanding the motor to run in positive direction puts a higher voltage on the "MOT+" output than on the "MOT - " output. Commanding the motor to run in negative direction puts a lower voltage on the "MOT+" output than on the "MOT - " output. The maximum differential is 12 V and no particular relationship to ground is guaranteed.

Axes connected to a given C-843 card may be in different modes, so that PWM and analog stages can be run off the same card. When PWM mode is used, the stages are driven by external amplifiers instead of the C-843 on-board amplifiers, thus allowing higher-power stages. PWM mode is required with PI ActiveDrive™ stages (.PD and .DD models).

If you want to drive an analog stage whose power consumption might exceed the output current limitation (see Section 3.1 on p. 15) a PWM converter box (C-842.AP1) can be used. The output mode of the appropriate axis must then be set to Sign/Magnitude PWM (or the stage with the "PWM" name suffix must be selected from the appropriate stage database).

3.3   On-Board Memory

The motion processor chipset has what its documentation calls "external" memory on the card which is accessible in real time by the motion processor. This fact is exploited in User Profile Mode, making it possible to define and trace highly precise, multi-axis motion profiles without transmission delay uncertainties. In addition it is possible to access this memory independent of the trace function, thereby allowing it to be used for storage of information like product configuration. The C-843 is equipped with 64 kB of memory for this purpose.

3.4   Connectors and Pinouts

3.4.1 Connector Locations
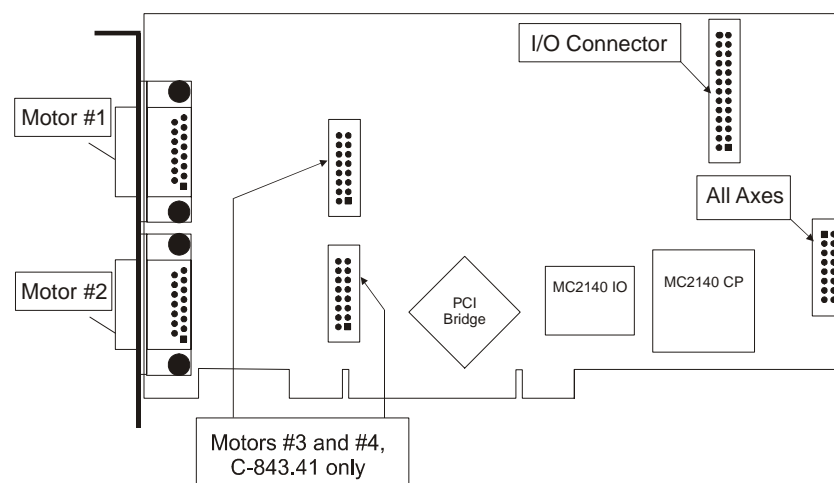
Fig. 3: C-843 Board layout

3.4.2 Motor Connector Pinouts

Connectors for Motors #3 & #4 (only on C-843.41) IDC16 header		Connectors for Motors #1 & #2 (on bracket) Sub-D15f	Function
Pin	1	1	Motor Brake
	2	9	Motor (+)
	3	2	Motor (-)
	4	10	GND
	5	3	MAGN
	6	11	SIGN
	7	4	Output + 5 V
	8	12	Negative limit
	9	5	Positive limit
	10	13	REFS
	11	6	GND
	12	14	Encoder A (+)
	13	7	Encoder A (-)
	14	15	Encoder B (+)
	15	8	Encoder B (-)
	16		n.c.

For the C-843.41 an adapter mounting bracket is provided with two sub-D 15 connectors to allow standard-connector access for motors #3 and #4.

3.4.3 Digital I/O Connector

Eight input and eight output lines are available on the C-843 for user-specific purposes, for example for reading external signals. These lines have no direct connection to the motion processor. For accessing to them via the registers on the C-843 see the "Low-Level Information" section on p. 27.

The I/O lines can be brought out using the included adapter bracket with a sub-D 25 connector. The adapter ribbon cable connects to the 26-pin IDC connector (J5) on the C-843 (see Fig. 3 on p. 17).

Connector on Board IDC26 header	Connector on Bracket Sub-D 25		Function
Pin 1	1		GND
2		14	Input #0
3	2		Input #1
4		15	Input #2
5	3		GND
6		16	Input #3
7	4		Input #4
8		17	Input #5
9	5		GND
10		18	Input #6
11	6		Input #7
12		19	n.c.
13	7		GND
14		20	Output #0
15	8		Output #1
16		21	Output #2
17	9		GND
18		22	Output #3
19	10		Output #4
20		23	Output #5
21	11		GND
22		24	Output #6
23	12		Output #7
24		25	n.c.
25	13		GND
26			no connection

3.4.4 All-axis Connector

This connector (16-pin IDC on the card, see Fig. 3 on p. 17) makes other digital I/O lines for all axes available (Axis-In = AIN pins and Axis-Out = AOUT pins). They offer direct access to the motion processor and can be programmed for solving multiple-axis-triggering tasks. See the Motion Processor User's Guide p. 46 *ff.* for details.

By default, these lines are not brought out on a bracket. If you need an appropriate connector and/or bracket, contact your PI sales engineer or write info@pi.ws.

All-Axis Connector on Board IDC16 header pins		Function Axis-In & Axis-Out
Pin	1	AOUT1
	2	GND
	3	AOUT2
	4	GND
	5	AOUT3
	6	GND
	7	AOUT4
	8	GND
	9	AIN1
	10	GND
	11	AIN2
	12	GND
	13	AIN3
	14	GND
	15	AIN4
	16	GND

3.5 Configuration Settings for Multiple Cards

If you want to use more than one C-843 card (up to 8 cards are possible) in one PC, the cards must be given different board ID settings. The mechanism used is comparable to setting jumpers on an ISA card, but instead of a jumper, a serial EEPROM on the card is used. By default all cards ordered from PI are configured with ID of 1, so Card 1 need not be reprogrammed. If you wish to have PI set your card before shipment, please let us know. Otherwise, to reset the EEPROM, the following steps must be performed:

WARNING

The C-843 Motor Controller Card is an ESD-sensitive (electrostatic discharge sensitive) device. Observe all precautions against static charge buildup before touching this device.

Avoid touching circuit components, pins and PCB traces. Discharge any static charge you may have on your body by briefly touching a conductive, grounded object before you

touch any electronic assembly. Pose PCBs only on conductive surfaces, such as ESD-safe transport containers (envelopes, foam). Electronic subassemblies must always be kept and transported/shipped in conductive packaging.

Make sure that no conductive particles of any kind (metallic dust or shavings, broken pencil leads, loose screws) get on the card or into the PC

Make sure that no electrical contact between the various add-on cards in the PC is possible.

DANGER

Before opening the host PC, remove the line-voltage connection.

Heed any warnings provided by the manufacturer of the PC or of other add-on cards it may contain.

1   Place the file EPROM.exe from the C843_EPROM_Tool directory of the C-843PM distribution CD on a bootable MS-DOS diskette.

2   Power down the PC and disconnect it from the AC power.

3   Remove any other C-843 cards currently in the PC and install the card to be reprogrammed. (For programming, only one C-843 at a time may be in the PC).

4   Boot the PC from the diskette. It may be necessary to change settings in the BIOS Setup in order to do this.

5   Start EPROM.exe and press a key from 1 to 8 to program the corresponding number as the card number in the EEPROM on the card. The card now has the specified identification number.

6   If you want to program another card, disconnect the PC from the AC power and repeat steps 3 to 6.

After programming all the cards whose settings need to be changed, disconnect the PC from the AC power and install all the cards.

4 Software Overview

With the C-843 Motor Controller card all motion of the connected stage is software controlled. To offer maximum flexibility, software interfaces at a number of different levels are provided and documented. In many cases, higher-level interfaces also provide pass-through functions for lower-level commands.

For a complete list of all software packages on the C-843 PM CD see Section 4.2 on p. 26. Most of the individual programs, command sets and driver libraries are described in separate manuals.

4.1 General

4.1.1 Architecture

The control signals for the attached axes are generated by the MC2140 or MC2120 motion control processor on the C-843 board. The following sections describe the communication paths to and around that processor, the command sets used at the different interfaces, and the database that holds information on available positioners so that motion parameters can be loaded automatically. Information you would need to actually access the device directly is contained in the "Low-Level Information" section on page 27 and in the motion chip manufacturer's manuals on the product CD.

4.1.2 Communication

The DSP motor controller chip on the card provides the output signals for the motors. Its I/O address space is mapped to the card's PCI-bus function registers, making it addressable from the PC. In addition, the lines on the All-Axes connector on the board connect directly to the DSP.

The digital I/O lines on the connector on the card are also available to the PC over the PCI function registers, but not to the DSP directly.

At the next level, the C-843 is controlled as a PCI card by a driver installed by the C-843 Setup.exe. That driver can read and write the PCI function registers in response to software that wishes to communicate with the device.

At intermediate levels, communications with a C-843 are

handled by DLL functions which refer to the card as a standard Windows PCI device. These functions are described in the corresponding DLL manuals. The DLLs depend upon proper installation of the hardware driver and/or other DLLs.

At the application level (LabView, *PIMikroMove*®, etc.), commands are usually input via the mouse and keyboard. In the *Command Entry* window of *PIMikroMove*®, for example, GCS commands can be entered as ASCII strings. The applications, including the pseudo-terminal program *PITerminal*, do not communicate with the card or its motion processor directly, but use the DLLs.

4.1.3 Command Sets

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> ## CAUTION
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> To prevent damage to piezomotor drives when using commands from command sets below the GCS level, dithering around the target must be prevented. GCS automatically suppresses dither and the MC PM DLL version has special functions for dither-free motion.

At the lowest level is the QMC command set of the DSP chipset, the MC2140 or MC2120 motion control processor. The chipset programmers' reference and user manuals are included on the C-843 CD. Note that the terminology and axis numbering often differs from that used elsewhere. Because of their complexity, successful use of these commands requires extensive experience.

At the next level is the MC DLL based on the QFL command set. (QFL commands are very close to the QMC commands of the motion control chip). A version of the MC DLL is included on the CD with special functions that support piezomotor drives. The MC DLL also has functions for sending QMC chipset commands directly through to the motion chip.

The software interfaces recommended for users who program their own applications are the C-843 PM GCS DLL (Windows Dynamic Link Library) and the C-843 PM COM Server (for interfacing with VB and Delphi[*]). Both have the same structure containing functions/methods based on the PI General Command Set (GCS). The GCS DLL or COM Server handles

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[*]See the VB samples on the CD: UP_X_COM_Test\UP_XTest.vbp and C843_GCS_COM_FirstSteps\DemoAppC843.vbp

communications and relieves the user-programmer of the details of tasks like referencing the connected stages, calculating encoder-to-physical-unit ratios or limit checking.

The GCS command set itself is independent of the specific hardware (the motor controller card or attached stages). The GCS commands are described in their own manual (SM149E), as are the functions of the GCS DLL (MS 115E). The COM Server does not currently have a dedicated manual*; it uses the DLL to implement its methods.

Because the chipset commands for the DSP can be sent via the GCS DLL as well, its complete functionality is available to the programmer.

4.1.4 PIStages Database

Like most motion controllers, the C-843 needs information about the connected stages in order to control them correctly. To keep you from having to enter all these values whenever a new stage is connected, most PI host software reads them from data files. Two types of DAT files are recognized, protected (read-only) DAT files, with data provided by PI, and User DAT files, containing special parameter sets created or customized by the user. See the *PIMikroMove®* and *PIStageEditor* software manuals for more information.

The most important protected DAT file is *PIStages.dat*. It contains all PI standard stages and installs automatically with the host software. If the PI standard stage you want to use is not available in your *PIStages.dat* version, download the latest *PIStages.dat* from the PI website (for detailed instructions, see the *PIMikroMove®* manual).

In case you want to operate a stage with other parameters than stated in the *PIStages.dat* or if you have a customized stage, use the *controller*USERSTAGES.DAT file. Add your stage to this DAT file, which is also installed with the host software but is initially empty. See the *PIMikroMove®* manual for details.

4.1.5 GUI Applications

Use of a number of Graphic User Interface applications is supported for the communication between the user or operator and the system. They are *PIMikroMove®*, *LabView*[*], *QuickRun* as well as the specialized tools such as the *StateViewer* and

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[*] PI provides customized LabView Virtual Instruments (drivers), but the LabView GUI itself must be obtained from National Instruments. Because the PI VIs use the DLLs, only PC LabView can be used.

the *PIStageEditor*. All these GUIs communicate with the hardware using the GCS DLL. The *PISmart* operating program has been replaced by *PIMikroMove*® and is no longer supported. More information on all included programs is provided in the table on p. 26.

PIMikroMove® is now the general operating program. It covers the range from basic motion to macros, joystick operation and simple user profiles.

4.2   Tools to Use

Software Tool	Purpose	Recommended for
PIMikroMove® operating software	*PIMikroMove®* permits you to start your motion system—controller and stage(s)—immediately without the need to write customized software. Its command input facility represents an easy way to experiment with various commands. Simple automation is also possible with its macro facility.	Users who want to test the equipment without programming an application
LabVIEW drivers	LabVIEW is a software environment available from National Instruments for data acquisition and process control. The LabVIEW software consists of a collection of virtual instrument (VI) drivers. PI provides a set of LabView VIs interfacing to the C-843 using the PI General *Command Set*[1].	Users who want to use LabVIEW for programming their application
GCS.DLL (Windows Dynamic Link Library)	For programming customized applications we recommend use of the C-843 PM GCS.DLL since all PI controllers understand this command set and your applications are thus portable between them.	For user programmers who want to use a DLL for programming their applications. Needed by the LabVIEW driver set.
GCS COM	For programming customized applications when using COM Server, same functionality as C-843 PM DLL. Note that here is no special manual available for the GCS_COM library. Refer to the GCS_DLL Manual (MS 115E) for function descriptions or to the *QuickRunPM* manual.	User programmers who want to use a COM server (e.g. want to work with Visual Basic or Delphi) for their application.
MC.DLL (Windows Dynamic Link Library)	The MC.DLL, based on the QFL command set which is close to that of the motion controller, is provided only for compatibility and historical reasons.	User programmers who want to use a DLL for lower level access to the motor controller card
QuickRunPM	*QuickRunPM* is a graphic user interface to the GCS DLL (Visual Basic sample program). It can be used to gain familiarity with the controller using the PI General Command Set. In addition it can be used to configure the servo-loop parameters of a stage.	Users who want to test the equipment before programming an application and who want to optimize the servo-loop parameters
StateViewer	This "online-reading" tool is recommended for testing the correct card installation and for debugging purposes. It reads out motion processor status registers, velocity, acceleration, position and position error, motor mode and motion errors for all axes on all C-843 cards which are installed in the PC.	Users who want to observe the operation of the card while it is being controlled with other software
PIStageEditor	Using this GUI tool you can easily add, remove and edit stages (parameter sets) in the customized stage parameter files[1] (DAT-files) used by the GCS DLL.	Users who want to configure their own stages

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[1] *Controller* UserStages.dat

5 Technical Data

5.1 Specifications

Model	C-843.21 / C-843.41
Function	PC plug-in Servo-Motor Controller Board, 32-bit plug-and-play PCI-bus, supported by main boards with 3.3 V and 5 V PCI bus connectors (universal card).
Axes	2 / 4
Servo characteristics	Programmable PID V-ff filter, supports on-the-fly parameter changes
Profile Modes	Trapezoidal, S-curve, user-defined
Output power	5 watts/channel (analog mode)
Resolution	12-bit D/A converters, PWM 10 bit, 24.5 kHz
Current limitation	1 A per channel (short-circuit proof)
Encoder input	AB (quadrature) differential TTL signal, max. 5×10^6 counts/s
Stall detection	Servo off, triggered by programmable position error
Limit switches	4/8 TTL (programmable as active high or low)
Reference switches	2/4 TTL (active high/low, programmable)
Digital I/O	8 TTL inputs, 8 TTL outputs
Motor connectors	15-pin (f) sub-D, one per channel (for C-843.41, 2 on card, 2 on adapter bracket, see Fig. 1)
Interface / Communication	PC PCI bus
Command set	Choice of PI General Command Set (GCS) or C-842-compatible QFL commands
Dimensions	Standard PCI card, length 20 cm
Weight	230 g ± 10%

5.2 Low-Level Information

With the comprehensive software support supplied, you will probably not need the information in this section.

Programmers who have sufficient knowledge and wish to bypass some or all of the higher-level software provided will

need and understand the information in this section. The motion chip command set is described in the Motion Processor Programmers Reference and User Manual included on the C-843PM CD.

5.2.1 Digital I/O Lines

The digital output and input lines of the digital I/O connector are available on the 8-bit registers at I/O address 0. This address space can be accessed via the *WriteIO* (output lines) and *ReadIO* (input lines) motor controller chip command.

5.2.2 Analog Amplifier and Brake Control

The hardware connection to the analog amplifier enable/disable function and brake actuation signals is via the *Write/O* command with address 1. The four lower bits control the analog amplifiers, the four upper bits the brake signals, motor axes 1-4.

5.2.3 Sense of Limit Switch and Reference Signals

The limit switch and reference signals are inverted by the hardware on the C-843 board before they are connected to the motion chipset. This is important to know if the actual signal status is read with the GET_SIGNAL_STATUS command. The value read is also combined with the signal sense register (SET_SIGNAL_SENSE command) and then returned to the user. For each bit in the signal sense register that is set to 1, the corresponding bit in the GET_SIGNAL_STATUS command will be inverted, so that a low signal is read as 1 and a high signal will be read as 0.

5.2.4 Encoder Signals

Standard quadrature encoder signals can be used with the C-843. The phase of ENCA signals is ENCB +90°. Both inputs have 10 k pull-up resistors.

5.2.5 Index and Home Reference Signals

The motion-control processor can capture separate *home* and *index* signals, although both inputs are connected to the same line, REFS.

Capturing home can be activated by the "SetCaptureSource A 1" command (Set Capture Source for axis a to 1). Home position recognition requires any transition from high to low or vice versa at the REFS input. The level of the

PI

REFS input can be read on bit 3 of the signal status register.

The command for index pulse capture is "SetCaptureSource A 0" (Set Capture Source to 0). Index pulses are clock-synchronized signals like those that are emitted by special rotary encoders (one signal per revolution). PI software does not use this configuration.

5.2.6 All-axis Connector

This connector (16-pin IDC on the card, see Fig. 3 on p. 17) makes other digital I/O lines for all axes available (Axis-In = AIN pins and Axis-Out = AOUT pins). They offer direct access to the motion processor and can be programmed for solving multiple-axis-triggering tasks. See the Motion Processor User's Guide p. 46 *ff.* for details.