

## Servo & Stepper Motor Controllers

Motion Control Solutions for DC Motors, Stepping Motors & Piezo Motors



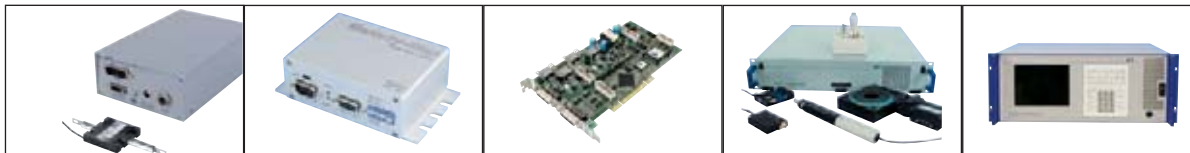
# Selection Guide: Motor Controllers

## For Servo Motors and Stepper Motors, Piezo Motors and Hybrid Systems

PI offers a large variety of innovative motion control solutions for precision micropositioning devices from classical stepper motors, ceramic linear motors to fast voice-coil-driven scanners and complex Hexapod 6-degree-of-freedom robots. Standard automation controllers handle up to 18 axes. Custom systems have been built capable of coordinating up to 273 axes.

Models	Description	Axes	Output for Motor Types	PC Interfaces	Page
C-184 C-185	Drivers for PLine® ultrasonic piezo linear motors	1	PLine® ultrasonic piezomotor	–	1-36
C-663	Mercury™ stepper motor controller compact, networkable, economical	1, to 16**	2-phase-stepper	RS-232, USB	4-112
C-863	Mercury™ DC-Servo motor controller compact, networkable, economical	1, to 16**	DC-servo	USB, RS-232	4-114
C-843	PCI bus controller card, integrated linear amplifier and PWM outputs, also drives the V-106 voice coil scanners	2, 4	DC-servo, voice coil	PCI Bus	4-120
C-848	Servo-motor controller, 19"-package, integrated linear amplifier and PWM outputs	2, 4	DC-servo	RS-232, TCP/IP	4-122
C-880	Automation platform, very flexible, optional photometer and photonics alignment routines	4 - 18	DC-servo, piezo, voice coil	RS-232, TCP/IP	4-124
C-702	Motion Controller & Driver for Simultaneous Operation of Closed-Loop DC Servo Motors and Piezo Actuators	2	DC-servo (PWM) / piezo	TCP/IP, RS-232, VGA, Keyboard	4-118
C-867	High-speed, closed-loop controller/driver for closed-loop PLine® piezomotors, networkable	1 to 16**	PLine® ultrasonic piezomotor	USB, RS-232	4-116
E-861	Networkable Controller for NEXACT® Linear Motors and Positioners	1 to 16**	NEXACT® piezo stepping motors	USB, RS-232	1-20

\*\* networkable, on single interface



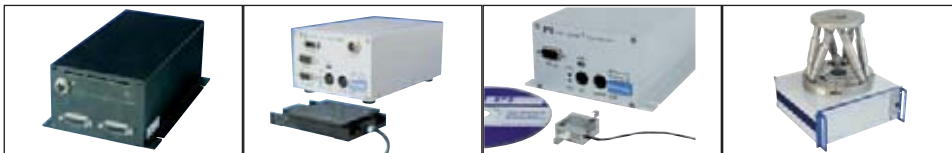
C-184, C-185 PLine® driver electronics

C-663 Stepper motor controller, C-863 Servo motor controller

C-843 PCI bus DC motor controller card

C-848 Servo motor controller

C-880 Automation platform for plug-in cards



C-702 Hybrid motion controller & driver

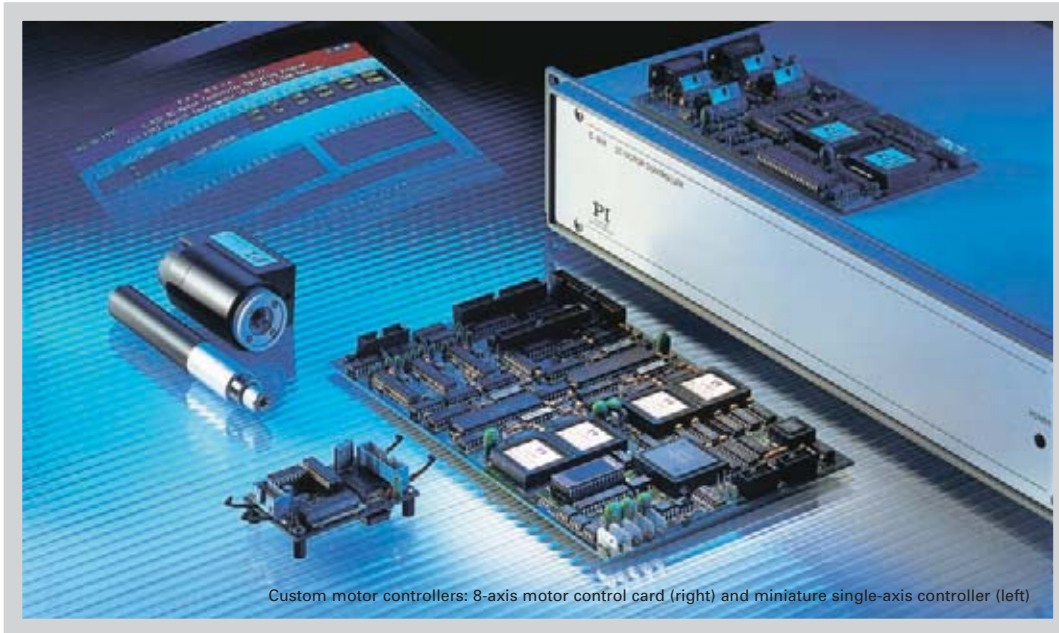
C-867 High-speed, ultrasonic piezo motor controller

E-861 NEXACT® piezo stepping motor controller

Hexapod controller for 6-axis parallel kinematics systems; RS-232, TCP/IP; optional display & keyboard; description see Hexapods, p. 4-3 ff

Piezo Drivers / Servo Controllers: See Page 2-99 ff  
Accessories, p. 4-126

# Motion Controllers for Micropositioning Systems: Features, Applications, Systems Experience



Custom motor controllers: 8-axis motor control card (right) and miniature single-axis controller (left)

PI offers a large variety of innovative motion control solutions for precision positioners. Included products range from compact, single-axis controllers for DC servomotors, stepper motors and piezomotors, to complex multi-axis control systems for parallel-kinematics, 6-DOF Hexapods. PI's novel dual-loop hybrid controller combines the advantages of electromagnetic motors and piezo technology. Custom motion control systems have been built capable of coordinating up to 273 axes.

## Positioning and Sequencing: Automation System Solutions from PI

The motion controllers shown here are specially designed for PI micropositioning systems. With PI mechanics, the comprehensive palette of software, and all necessary cables included, plug-and-play operation is the rule. With some controllers, it is possible to network up to 16 axes or more for simple system scalability. In addition to standard systems, custom systems have been

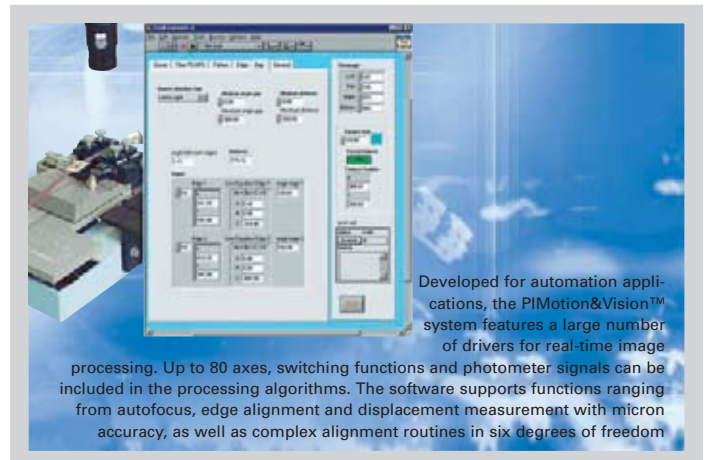
assembled with control for several hundred axes.

## Integrated Drivers

All PI motor controllers are equipped with integrated servo-amplifiers and/or drivers in order to simplify system design and reduce costs. In addition, the DC-motor controllers offer PWM outputs for use with external amplifiers or with the integrated amplifiers in PI's direct-drive, ActiveDrive™ stages, such as the M-511.PD.

## Range of Motion Controllers

- Choice of Different Control Strategies
- Stepper Motor Controllers
- DC-Motor Controllers
- Dual Servo-Loop Hybrid Controllers
- Drivers / Controllers for Ceramic Ultrasonic Servo-Drives
- Controllers for PiezoWalk® Stepping Motors (see p. 1-3 ff)
- Six Degree-of-Freedom Hexapod Controllers
- Automation Platform
- Custom Controllers with up to 273 Channels



Developed for automation applications, the PIMotion&Vision™ system features a large number of drivers for real-time image processing. Up to 80 axes, switching functions and photometer signals can be included in the processing algorithms. The software supports functions ranging from autofocus, edge alignment and displacement measurement with micron accuracy, as well as complex alignment routines in six degrees of freedom

Linear Actuators & Motors

Nanopositioning / Piezoelectrics

Nanometrology

**Micropositioning**

Hexapod 6-Axis Systems / Parallel Kinematics

Linear Stages

Translation (X)

Vertical (Y)

Multi-Axis

Rotary & Tilt Stages

Accessories

**Servo & Stepper Motor Controllers**

Single-Channel

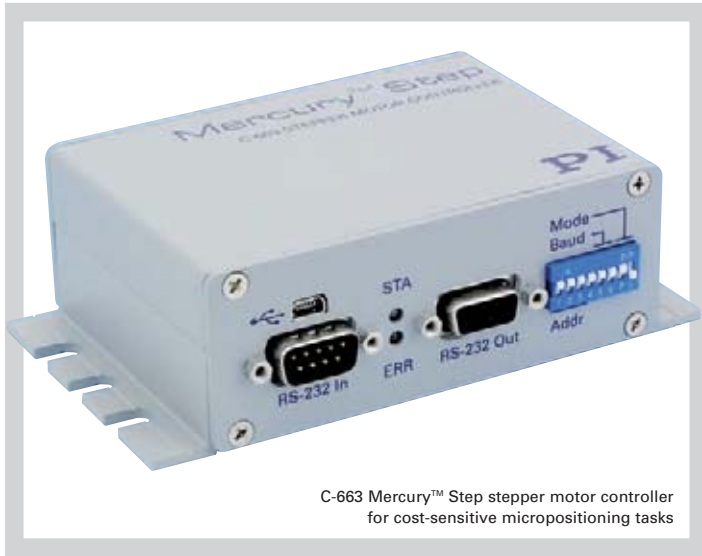
Hybrid

Multi-Channel

Micropositioning Fundamentals

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## C-663 Mercury™ Step Controller 1-Axis Networkable Stepper-Motor Controller



C-663 Mercury™ Step stepper motor controller for cost-sensitive micropositioning tasks

- High Performance at Low Cost
- Stand-Alone Functionality
- Network Capability for Multi-Axis Applications
- Compatible and Networkable with C-863 Mercury™ DC-Motor Controllers
- Joystick Port for Manual Control
- Non-Volatile Macro Memory
- Parameters Changeable On-the-Fly

The Mercury™ Step stepper motor controller is the perfect solution for cost-effective and flexible motion control applications where a precision positioner is to be controlled by a PC or PLC (programmable

logic controller). The C-663 supplements the successful C-863 Mercury™ servo motor controller.

Microstepping of 1/16 full step (up to 6400 steps/rev. with PI

stepper motors) provides for ultra-smooth, high-resolution motion.

### Multi-Axis Control, Combination of DC & Stepper Motors

The networking feature allows the user to start out with one Mercury™ controller and add more units later for multi-axis setups.

The Mercury™ Step stepper motor controller shares its programming language with the well-established Mercury™ DC-motor controller. Up to 16 Mercury™ controllers (DC and stepper) can be daisy chained and operated from one computer.

### Flexible Automation

The C-663 offers a number of features to achieve automation and handling tasks in a very cost-effective way. Programming is facilitated by the high-level mnemonic command language with macro and compound-command functionality. Macros can be stored in the non-volatile memory for later recall.

For easy synchronization of motion with internal or external trigger signals four input and four output lines are provided. A joystick can also be connected for manual control.

Stand-alone capability is provided by a user-programmable autostart macro to run automation tasks at power up (no runtime computer communication required!).

### User-Friendly: Comprehensive Software Package and Two Interface Options

Easy data interchange with laptop or PC is possible via the USB interface. To facilitate industrial applications, an RS-232 interface is also standard.

The included software supports networking of multiple controller devices. LabVIEW™ drivers and Windows DLLs allow for easy programming and integration into your system. Mercury™ Step controllers can also be operated using the PI General Command Set (GCS) via a DLL. PI-GCS allows networking of different PI-con-

### Ordering Information

**C-663.10**  
Mercury™ Step Stepper Motor Controller with Wide-Range Power Supply, 24 V

**C-819.20**  
2-Axis Analog Joystick for Mercury™ Controller

**C-819.20Y**  
Y-Cable for Connecting 2 Controllers to C-819.20

**C-170.IO**  
I/O cable, 2 m, open end

**C-170.PB**  
Push Button Box, 4 Buttons and 4 LEDs

trollers such as piezo drivers and multi-axis servo controllers with minimal programming effort.

### Contents of Delivery

Each Mercury™ Step comes with a wide-range power supply, RS-232 communications cables, a USB cable and a comprehensive software package.

### Application Examples

- Flexible automation
- Handling
- Quality control
- Testing equipment
- Photonics applications
- Fiber positioning



Mercury™ Step controller with M-403.62S precision translation stage

## Technical Data

<b>Model</b>	<b>C-663.10</b>
Function	Stepper motor controller, stand-alone capability
Drive type	2-phase stepper motor
Channels	1
<b>Motion and control</b>	
Trajectory profile modes	Trapezoidal, point-to-point
Microstep resolution	1/16 full step
Limit switches	2 x TTL, programmable
Reference switches	1 x TTL, programmable
Motor brake	1 x TTL, programmable
<b>Electrical properties</b>	
Operating voltage	15 to 30 V
Current limitation per motor phase	1000 mA
<b>Interface and operation</b>	
Interface/Communication	USB, RS-232 (bus architecture)
Motor connector	Sub-D 15 (f)
Controller network	Up to 16 units* on single interface
I/O ports	4 analog/digital in, 4 digital out
Command set	Mercury™ native command set, GCS
User software	MMCRun, PIMikroMove®
Software drivers	GCS (PI General Command Set)-DLL, LabVIEW drivers, native Mercury™ DLL
Supported functionality	Start-up macro
Manual control	Joystick, Y-cable for 2D motion, pushbutton box
<b>Miscellaneous</b>	
Operating temperature range	0 to 50 °C
Mass	0.3 kg
Dimensions	130 x 76 x 40 mm <sup>3</sup>

\*16 with USB; 6 with RS-232 (depending on RS-232 output driver of PC)

Linear Actuators &amp; Motors

Nanopositioning / Piezoelectrics

Nanometrology

**Micropositioning**
Hexapod 6-Axis Systems /  
Parallel Kinematics

Linear Stages

Translation (X)

Vertical (Y)

Multi-Axis

Rotary &amp; Tilt Stages

Accessories

**Servo & Stepper  
Motor Controllers**
**Single-Channel**

Hybrid

Multi-Channel

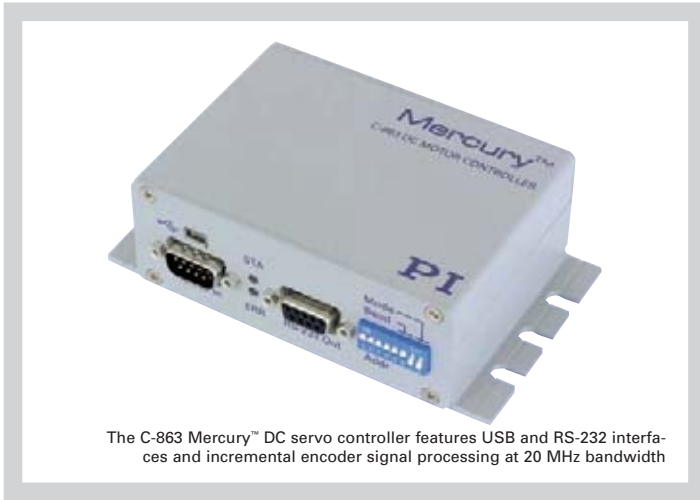
Micropositioning  
Fundamentals

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## C-863 Mercury™ Servo Controller

### 1-Axis DC-Servo-Motor Controller with Network Feature



The C-863 Mercury™ DC servo controller features USB and RS-232 interfaces and incremental encoder signal processing at 20 MHz bandwidth

- High Performance at Low Cost
- DC Servo-Motor Controller Supplies up to 30 W
- 20 MHz Encoder Input for High Speed & Resolution
- Macro Programmable Stand-Alone Functionality
- Network Capability for Multi-Axis Applications
- Non-Volatile EEPROM for Macros and Parameters
- Digital I/O Lines (TTL)
- Motor-Brake Control
- USB and RS-232 Interface
- Optional Joystick for Manual Control
- Works with All PI Micropositioners

The latest generation Mercury™ C-863 servo motor controller is even more powerful and versatile than its predecessors. Easy data interchange with laptop or PC is possible via the USB interface. The RS-232 interface provides for easy integration in industrial applications. The compact design with its integrated amplifier makes it ideal for building high-performance,

cost-effective micropositioning systems.

#### Flexible Automation

The Mercury™ offers a number of features to achieve automation and handling tasks in research and industry in a very cost-effective way. Programming is facilitated by the high-level mnemonic command language with macro and compound-command functionality. Macros can be stored in the non-volatile memory for later recall.

Stand-alone capability is provided by a user-programmable autostart macro to run automation tasks at power up (no runtime computer communication required!).

For easy synchronization of motion with internal or external trigger signals four input and four output lines are provided.

#### Multi-Axis Control, Combination of DC & Stepper Motors

Up to 16 C-863 Mercury™ DC servo controllers and C-663 stepper motor controllers can be daisy-chained and addressed via the same interface.

The networking feature allows the user to start out with one controller and add more units later for multiaxis setups.

#### Easy Programming

All servo and stepper motor controllers of the Mercury™ family can be operated using the PI general command set (GCS). PI-GCS allows networking of different controller units, both for piezo-based and motorized positioning units, with minimal programming effort. In addition, the C-863 can be programmed using the native command set of previous Mercury™ controllers.

#### Cost-Saving Due to Integrated Amplifier and PWM Outputs

The unique Mercury™ concept combines a high-performance motion controller and an integrated power amplifier in a small package. Additional PWM control outputs allow the direct operation of any DC-motor-driven PI micro-positioning system—even high-speed stages such as the M-500 ActiveDrive™ Translation Stages—reducing costs, increasing reliability and simplifying the setup.

#### Contents of Delivery

Each controller is delivered with a wide-range power sup-

#### Ordering Information

**C-863.10**  
Mercury™ DC-Motor Controller, 1 Channel, with Wide-Range Power Supply

**C-819.20**  
2-Axis Analog Joystick for Mercury™ Controller

**C-819.20Y**  
Y-Cable for Connecting 2 Controllers to C-819.20

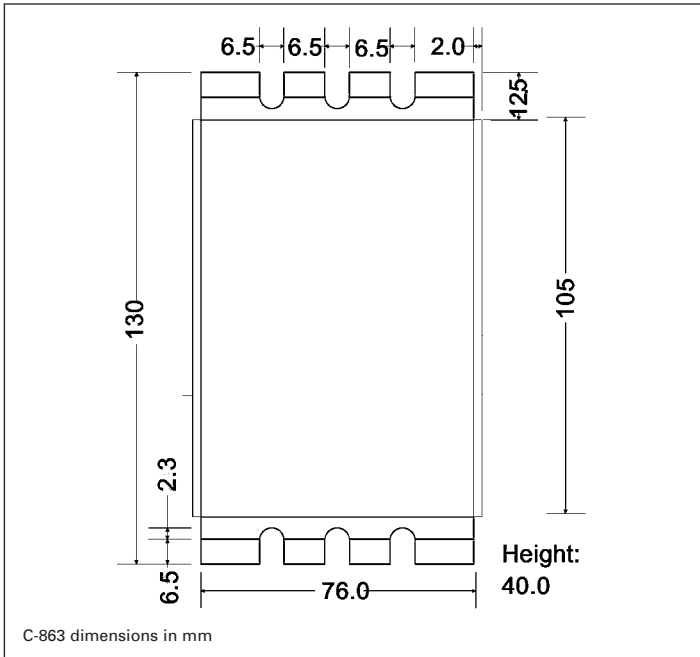
**C-170.IO**  
I/O Cable, 2 m, Open End

**C-170.PB**  
Push Button Box, 4 Buttons and 4 LEDs

ply, RS-232 communication cable, a daisy-chain network cable and a comprehensive software package.

#### Application Examples

- Fiber positioning
- Automation
- Photonics / integrated optics
- Quality assurance testing
- Testing equipment



### Technical Data

<b>Model</b>	<b>C-863.10</b>
Function	DC-servo-motor controller, 1 channel
<b>Motion and control</b>	
Servo characteristics	P-I-D servo control, parameter change on-the-fly
Trajectory profile modes	Trapezoidal, point-to-point
Encoder input	AB (quadrature) single-ended or differential TTL signal, 20 MHz
Stall detection	Servo off, triggered by programmable position error
Input limit switch	2 x TTL (pull-up/pull-down, programmable)
Input reference switch	1 x TTL
Motor brake	1 x TTL, software controlled
<b>Electrical properties</b>	
Output power	max. 30 W (PWM)
Output voltage	0 to 15 V
Current	80 mA + motor current (3 A max.)
<b>Interfaces and operation</b>	
Communication interfaces	USB, RS-232 (9-pin [m] sub-D)
Motor connector	15-pin (f) sub-D
Controller network	Up to 16 units on single interface
I/O ports	4 analog/digital in, 4 digital out (TTL)
Command set	Mercury Command Set, GCS (via DLL)
User software	PIMikroMove®, MMCRun
Software drivers	GCS (PI General Command Set)-DLL, LabVIEW drivers, native Mercury™ DLL
Supported functionality	Start-up macro; internal safety circuitry: watchdog timer
Manual control (optional)	2-axis joystick, Y-cable for 2D motion, pushbutton box
<b>Miscellaneous</b>	
Operating voltage	15 to 30 V included: external power supply, 15 V / 2 A
Operating temperature range	+5 to +50 °C
Mass	0.3 kg
Dimensions	130 x 76 x 40 mm

Linear Actuators & Motors

Nanopositioning / Piezoelectrics

Nanometrology

**Micropositioning**

Hexapod 6-Axis Systems /  
Parallel Kinematics

Linear Stages

Translation (X)

Vertical (Y)

Multi-Axis

Rotary & Tilt Stages

Accessories

**Servo & Stepper  
Motor Controllers**

**Single-Channel**

Hybrid

Multi-Channel

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## C-867 Controller for PLine® Piezo Linear Drives Servo-Controller with Integrated Driver for High-Speed Ultrasonic Piezo Motors



The C-867 piezo motor controller and the M-664 low-profile positioner with integrated PLine® ceramic linear drive

- **Optimized for PLine® Ultrasonic Piezo Linear Motors**
- **High-Bandwidth Encoder Inputs Allow High Speed and Resolution**
- **PID Servo-Control with Dynamic Parameter Switching**
- **Integrated Piezo Motor Power Driver**
- **USB, RS-232 and Analog Interfaces (e. g. for Joystick)**
- **4 + 4 Programmable TTL-I/Os for Flexible Automation**
- **Data Recorder**
- **Daisy-Chain Networking for up to 16 Axes**
- **Powerful Macro Programming Language, e. g. for Stand-Alone Operation**
- **Extensive Software Support, LabVIEW, DLL, ...**

The C-867 controller was especially designed for closed-loop positioning systems equipped with PLine® piezo linear motor drives. In addition to the digital servo-controller, the compact case also contains the driver electronics for the piezo ceramic motors.

### Application Examples

- Biotechnology
- Fiber positioning
- Automation
- Photonics / integrated optics
- Quality assurance testing
- Testing equipment

The controller can be operated by a host PC either via a USB port or an RS-232 interface. Alternatively, stand-alone operation is possible by uploading macro command sequences to the internal non-volatile memory, or through a joystick or a push-button box.

### Highly Specialized PID Servo-Controller

The C-867 is based on a highly specialized DSP (Digital Signal Processor) to handle the PID servo-control algorithm as well as other system functions. Because of the motion properties typical for ultrasonic piezomotors, the controller has a number of advanced features, including dynamic control param-

eter adaption. By automatically switching between gainsets for dynamic and static operation optimized settling behavior of a couple of 10 milliseconds is achieved. The broadband encoder input (50 MHz) allows the use of high resolution encoders with the outstanding high accelerations and velocities PLine® drives deliver.

### Integrated Piezomotor Drivers

To reduce the number of components in PLine® positioning systems, the piezomotor drive electronics has been integrated in the controller. Various controller versions are available, each optimized for the piezomotor type used. The C-867.161 version, for example, contains the drive electronics for the M-663 see p. 4-28 linear stages.

The integrated drivers are finetuned to the connected drives before delivery in order to provide optimal system performance.

### Software / Programming

In addition to the user software for setup, system optimization and operation, comprehensive LabVIEW and DLL libraries are provided.

The PIMikroMove™ user software provides the PITuningTool for system performance optimization. Graphic displays show the system's behaviour and facilitate parameter setting.

### Advantages of PLine® Micro Positioning Systems

PLine® ultrasonic ceramic drives provide several advantages over classical motors and drivers:

- Smaller dimensions
- Self-locking when powered down; no holding current

### Ordering Information

**C-867.161**  
Piezomotor Controller with Drive Electronics, Networkable, for PLine® Systems with P-661 Motors

**C-867.164**  
Piezomotor Controller with Drive Electronics, Networkable, for PLine® Systems with P-664 Motors

**C-867.D64**  
Piezomotor Controller with Drive Electronics, Networkable, for PLine® Systems with M-674 RodDrive

### Accessories:

**C-819.20**  
2-Axis Analog Joystick

**C-819.20Y**  
Y-Cable for Connecting 2 Controllers to C-819.20

**C-170.PB**  
Push Button Box, 4 Buttons and 4 LEDs

**Ask about custom designs!**

- High acceleration up to 5 g
- High velocity up to 500 mm/s
- No leadscrews, gears or other mechanical components, no wear or maintenance
- No lubricants
- Non-magnetic and vacuum compatible operating principle



## Technical Data

Model	C-867.161	C-867.164	C-867.D64
Function	Controller and drive electronics for PLine® piezomotors / systems	Controller and drive electronics for PLine® piezomotors / systems	Controller and drive electronics for PLine® piezomotors / systems
Drive type	PLine® P-661 motors	PLine® P-664 motors	PLine® RodDrive M-674, 2 x P-664
Channels	1	1	1
<b>Motion and control</b>			
Servo characteristics	Programmable PID V-ff filter, parameter changes on the fly	Programmable PID V-ff filter, parameter changes on the fly	Programmable PID V-ff filter, parameter changes on the fly
Trajectory profile modes	Trapezoidal	Trapezoidal	Trapezoidal
Encoder input	A/B differential signals, 50 x 10 <sup>6</sup> impulse/s	A/B differential signals, 50 x 10 <sup>6</sup> impulse/s	A/B differential signals, 50 x 10 <sup>6</sup> impulse/s
Stall detection	Servo off, triggered by programmable position error	Servo off, triggered by programmable position error	Servo off, triggered by programmable position error
Limit switch	2 TTL (programmable)	2 TTL (programmable)	2 TTL (programmable)
Reference switch	1 TTL (active high/low, programmable)	1 TTL (active high/low, programmable)	1 TTL (active high/low, programmable)
<b>Electrical properties</b>			
Output power	5 W	10 W	15 W
Output voltage	120 V <sub>pp</sub> , 42 V <sub>rms</sub>	168 V <sub>pp</sub> , 60 V <sub>rms</sub>	190 V <sub>pp</sub> , 67 V <sub>rms</sub>
<b>Interfaces and operation</b>			
Communication interfaces	USB, RS-232	USB, RS-232	USB, RS-232
Motor connector	MDR14	MDR14	MDR14
Controller network	Up to 16 units on single interface	Up to 16 units on single interface	Up to 16 units on single interface
I/O ports	4 analog/digital in, 4 digital out on mini DIN 9-pin digital: TTL analog: 0 to 5 V	4 analog/digital in, 4 digital out on mini DIN 9-pin digital: TTL analog: 0 to 5 V	4 analog/digital in, 4 digital out on mini DIN 9-pin digital: TTL analog: 0 to 5 V
Command set	PI General Command Set (GCS)	PI General Command Set (GCS)	PI General Command Set (GCS)
User software	PIMikroMove™	PIMikroMove™	PIMikroMove™
Software drivers	GCS-DLL, LabVIEW drivers	GCS-DLL, LabVIEW drivers	GCS-DLL, LabVIEW drivers
Supported functionality	Start-up macro; macro; data recorder for recording parameters as motor input voltage, velocity, position or position error	Start-up macro; macro; data recorder for recording parameters as motor input voltage, velocity, position or position error	Start-up macro; macro; data recorder for recording parameters as motor input voltage, velocity, position or position error
Manual control	Pushbutton box, joystick (for 2 axes), Y-cable for 2D motion	Pushbutton box, joystick (for 2 axes), Y-cable for 2D motion	Pushbutton box, joystick (for 2 axes), Y-cable for 2D motion
<b>Miscellaneous</b>			
Operating Voltage	12 VDC from external power supply (included)	12 VDC from external power supply (included)	12 VDC from external power supply (included)
Current consumption	300 mA without motor	300 mA without motor	300 mA without motor
Operating temperature range	+5 to +40 °C	+5 to +40 °C	+5 to +40 °C
Mass	950 g	950 g	950 g
Dimensions	174 x 104 x 63 mm (without ground connection, rubber feet) 182 x 104 x 74 mm	174 x 104 x 63 mm (without ground connection, rubber feet) 182 x 104 x 74 mm	174 x 104 x 63 mm (without ground connection, rubber feet) 182 x 104 x 74 mm

## Linear Actuators & Motors

### Nanopositioning / Piezoelectrics

### Nanometrology

### Micropositioning

#### Hexapod 6-Axis Systems / Parallel Kinematics

#### Linear Stages

Translation (X)

Vertical (Y)

Multi-Axis

#### Rotary & Tilt Stages

#### Accessories

### Servo & Stepper Motor Controllers

#### Single-Channel

Hybrid

Multi-Channel

#### Micropositioning Fundamentals

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# C-702 Hybrid System Controller

## High Velocity-Constancy for Nanometer-Precision Hybrid DC/Piezo Nanopositioning Systems



C-702 Hybrid Controller

- **Motion Controller & Driver for Simultaneous Operation of Closed-Loop DC Servo Motors and Piezo Actuators**
- **2 Channels**
- **Sample Rate 10 kHz**
- **Piezo Resolution 24-bit**
- **Fast Serial Bus for Incremental High-Resolution Sensor**
- **Realtime Operating System**
- **Interfaces: TCP/IP Ethernet, RS-232, VGA, Keyboard**

The C-702 digital hybrid motion controller has been designed for precision control of the M-511.HD (see p. 4-46) and M-714 (see p. 4-62) nanopositioning stages. Both are based upon the PI hybrid drive technology integrating piezoelectric and motorized drive components to form one motion and servo-control system. The result is a nanopositioning system for high loads that can follow a motion profile with nanometer position accuracy and high constancy of velocity over several millimeters of travel.

### Application Examples

- Surface Inspection
- Microscopy
- Laser technology
- Interferometry
- Metrology

### Highly Effective Servo-Control for a Complex Drive Technology

The optimized interaction between the piezoelectric and motorized drive components to make them a single motion unit requires a high-speed sensor as well as powerful control algorithms. The digital, 2-channel, C-702 controller, based on modern CPU technology with a real time operating system, has been designed for this task. It is able to read the position signals with virtually no delay and process the data immediately. The integrated piezo amplifiers use a high-resolution 24-bit DAC to fully support the high position resolution of the piezo actuators. The new ultra-fast broadband SSI interface for the optical linear encoder supports stage velocities of 300 mm/s at a resolution of 2 nm. With special cabling, external sensor signals, like

those from an interferometer, can be used for servo-control via an SSI interface.

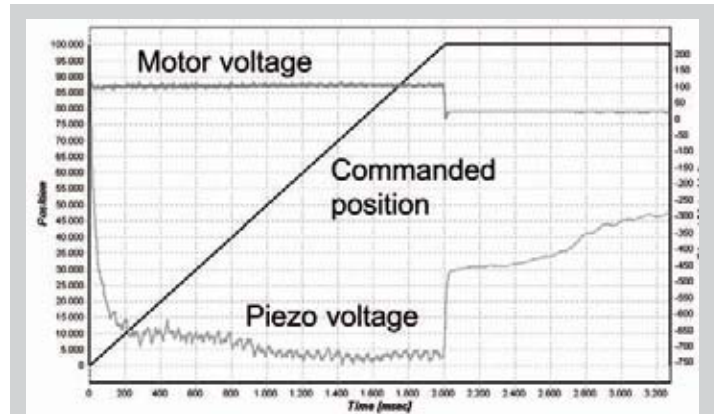
### One Controller for One Motion System

In PI hybrid systems, the motor-lead-screw and piezo actuator are fully integrated to form one motion system. The motor and piezo act together at all times. The result is far more than a coarse-adjust/fine-adjust system: effects like startup stick/slip and backlash can be completely compensated and a motion profile with high constancy of velocity can be followed. Because of the high-piezo stiffness, setting to a few nanometers only takes a few

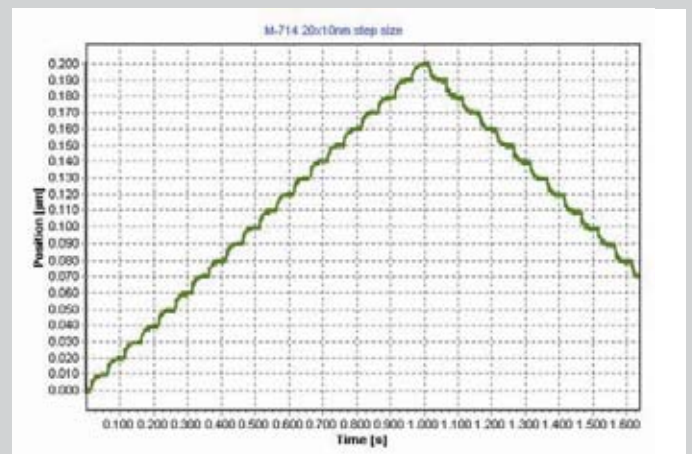
### Ordering Information

**C-702.00**  
Ultra-High-Precision  
Hybrid Controller, 2 Channels

milliseconds, significantly faster than with conventional, higher-inertia, linear-motor-driven stages. Furthermore minimal increments in the range of the sensor resolution can be reliably executed. To allow high velocities beyond 100 mm/sec and nanometer-range incremental resolution, position information must be transmitted and processed very rapidly and a complex control algorithm is required.



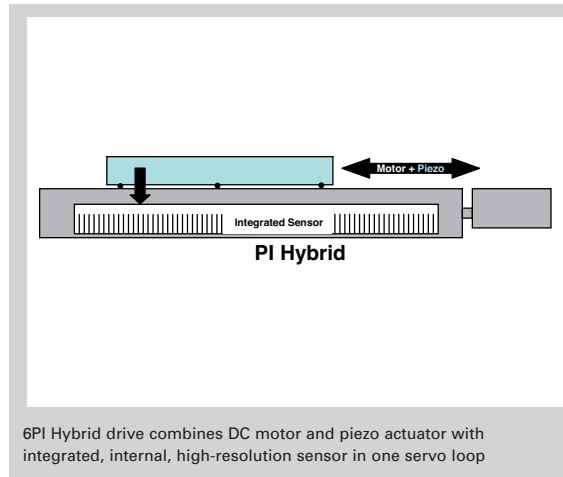
PI hybrid servo-controller output during a positioning command. The controller reads the system position off a high-resolution encoder and actuates both the motor and piezoelectric actuator at the same time giving a system with the advantages of both drives



10 nm steps of an M-714 stage, as measured by an interferometer



M-511.HD hybrid stage (left),  
M-714.00 (right front) and the C-702 controller (rear)



## Technical Data

<b>Model</b>	<b>C-702.00</b>
Function	Motion Controller for Hybrid Nanopositioning Systems
Drive type	DC motor (PWM)/piezo
Channels	2
<b>Motion and control</b>	
Servo characteristics	PID V-ff filter, notch filter, hysteresis setting (motor); proportional-integral (P-I) algorithm with notch filter (piezo)
Sampling rate	10 kHz
Trajectory profile modes	Trapezoidal, S-curve
Processor	32-bit Intel Celeron
Position range	32 bit
Limit switches	2 lines per axis
Reference switch	1 line per axis
Motor brake	Software programmable
<b>Electrical properties</b>	
Operating voltage	24 VDC (via M-500.PS wide range power supply*)
Output power/channel	PWM: 19.5 kHz, 10-bit resolution
Piezo voltage	±36 V (24-bit resolution)
Power consumption	< 25 W
<b>Interfaces and operation</b>	
Communication interfaces	TCP/IP, RS-232, VGA, Keyboard
Motor connector	Sub-D connector, 26-pin**
Encoder input	Serial SSI interface for incremental encoder
Controller network	via TCP/IP
I/O ports	8 TTL inputs, 8 TTL outputs
Command set	ASCII, PI General Command Set (GCS)
User software	PI MikroMove®
Software drivers	GCS (PI General Command Set)-DLL, LabVIEW™ drivers
Supported functionality	Autostart macro, user-programmable macro
<b>Miscellaneous</b>	
Operating temperature range	+10 to +50 °C
Mass	1.35 kg
Dimensions	130 x 205 x 76 mm

\*M-500.PS: wide range power supply, 100 to 250 VAC, 50 to 60 Hz

\*\*Sub-D 26 contains connection for motor, piezo, reference and limit switches and sensor,  
Internal heat sink with very silent fan

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## C-843 DC-Servo-Motor Controller

### Servo Motion Controller/Driver PCI Board for 2 or 4 Axes



C-843.41 DC-motor controller board with M-110.DG linear stage, M-235.5DG heavy duty linear actuator, M-511.DD direct drive translation stage and M-501.1DG vertical stage. No external amplifier is required to drive any of these or other PI stages. Small motors are driven through the C-843's onboard linear amplifiers, direct-drive PI stages (e.g. M-511.DD) employ ActiveDrive™ controlled off the C-843's PWM outputs.

- Two and Four Axis Version
- Very Cost-Effective: Servo Amplifiers On-Board
- Additional PWM Outputs for High-Power Motors
- Trapezoidal Curve, S-Curve and Velocity Profile
- 32 kSamples RAM for High-Speed Buffer Operations
- 16 I/O Lines for Flexible Automation
- Fast PCI Communication, 120 μs for Position Read
- Motor-Brake Control Output
- Extensive Software Support
- General Command Set (GCS) Compatible

The C-843 PCI motion controller card drives up to 4 axes of micropositioning equipment. Because there is no need for external servo-amplifiers, this new card is a very cost-effective, easy-to-set-up solution.

#### On-Board Servo-Amplifiers

Unlike other PCI controller cards, the new C-843 comes with on-board, low-noise linear amplifiers for the small DC motors used in most compact micropositioning stages and actuators.

In addition, PWM outputs are available to drive more powerful equipment (all direct-drive

translation and rotation stages from PI feature the integrated ActiveDrive™ PWM amplifiers, and also connect to the C-843 with no external power amplifiers).

The PWM mode and linear amplifier mode can be programmed individually for each of the 4 (or 2) channels.

#### High-Performance PID Control

The C-843 employs a fast DSP (digital signal processor) providing high-performance PID motion control with many options for trajectory generation and filter settings for superior positioning and tra-

cking accuracy. Position, velocity, acceleration and several other motion parameters can be programmed individually for each axis on-the-fly. High-bandwidth counters (5 MHz) support differential encoder feedback (incremental rotary encoders or linear scales) for fast and accurate positioning.

#### I/O for Flexible Automation

In addition to 3 TTL inputs per channel for limit and reference signals, 16 more I/O lines are available for flexible automation tasks (trigger functions, etc.). The C-843 also features motor-brake output lines (e.g. for M-531.DDB stages).

#### High-Speed Buffering

The integrated 32 k-sample trace memory allows online buffering (read and write) at integer multiples of the servo-loop time of up to four independent system variables (positions, velocities, internal register contents, etc.) This allows the observation of the motion system and also performing customized trajectory profiles.

#### PI General Command Set (GCS)

The comprehensive command structure is based on the PI General Command Set (GCS). With GCS the development of custom application programs is simplified, because the commands for all supported devices are identical in syntax and function. PI controllers for nanopositioning systems, for piezomotors and servo or stepper motors can be commanded with GCS.

#### Software / Programming

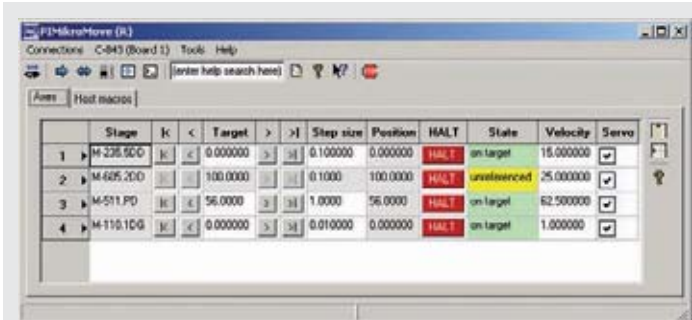
In addition to the user software for setup, system optimization and operation, comprehensive LabVIEW and DLL libraries are

#### Ordering Information

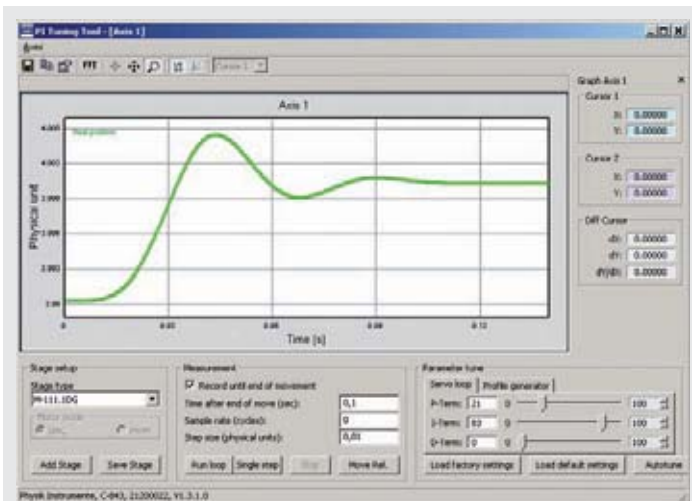
- C-843.21**  
DC-Motor Controller PCI PC Board, 2-Axis
- C-843.41**  
DC-Motor Controller PCI PC Board, 4-Axis
- C-843.JS**  
Joystick and PCI Interface Board for C-843 Motor Controller

provided. The user friendly PI MikroMove™ provides a convenient interface for stage operation including tuning tool, joystick operation, terminal and macro editor.

Communications to/from the board consist of packet-based messages passed via memory access. An interrupt line is provided so that the chipset can signal the PC when special conditions arise, such as reception of an encoder index pulse. For system programmers the C-843 offers direct access to the DSP.



PIMicroMove® tabular presentation of four connected axes with display of absolute and relative positioning input, current position, halt axis button, state and velocity setting.



The Tuning Tool which is integrated in PIMicroMove® demonstrates acquiring and displaying step and settle data of micropositioning systems. Controls allow adjustment of the PID parameters for best performance.

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## Technical Data

<b>Model</b>	<b>C-843</b>
Function	PC plug-in DC-servo-motor controller board, 32-bit plug-and-play PCI-bus interface, supported by main boards with 3.3 V and 5 V PCI bus connectors (universal card)
Axes	2 (C-843.21); 4 (C-843.41)
Servo characteristics	Programmable PID V-ff filter, parameter changes on-the-fly
Profile modes	Trapezoidal, S-curve, velocity profile
Output power / resolution	Analog 6 watts/channel (drawn directly from PC power supply), 12-bit D/A converters, PWM 10-bit, 24.5 kHz
Current limitation	500 mA per channel (short-circuit-proof)
Encoder input	AB (quadrature) differential TTL signals, $5 \times 10^6$ counts/s
Stall detection	Servo off, triggered by programmable position error
Limit switches	2 TTL / axis (active high/low, programmable)
Reference switches	1 TTL / axis (active high/low, programmable)
I/O ports	8 TTL inputs, 8 TTL outputs
Motor connectors	15-pin (f) sub-D per channel (2 on board + 2 on bracket for C-843.41)
Interface/communication	PC PCI bus
Command set	PI General Command Set (see p. A-8)



## C-848 DC-Servo-Motor Controller

### DC Motor Controller for 2 or 4 Axes



C-848.43 Precision Motion Controller with various PI-stages: M-112.2DG micro-translation stage, M-232.17 DC-Mike, M-062.DG rotary stage and M-235.5DG heavy-duty DC-Mike

- **Simultaneous Operation of up to 4 DC Servo-Motors/ -Positioning Stages or Voice-Coil Scanners**
- **Powerful Macro Command Language**
- **16 I/O Lines for Flexible Automation**
- **Electronic Gearing**
- **Extensive Software Support**
- **RS-232 and Optional IEEE 488 Interface**

The C-848 is a flexible, multi-purpose, rackmount positioning and motion controller for DC servo-motors. It is designed for general positioning and automation tasks in research and industry.

#### Flexible Multi-Processor Architecture

Based on a dual-processor structure, the C-848 offers the flexibility expected in today's demanding prototyping and high-precision production environment.

In parallel with the general processor handling communication and macro execution, a fast DSP motion-control chip-set is dedicated to trajectory generation and servo-control.

In addition to three inputs per channel for limit switches and home position, eight TTL inputs and eight TTL outputs are available for flexible automation.

The C-848 also offers advanced motion control features such as:

- Linear interpolation
- Trajectory generation for trapezoidal and s-curve profiles
- Electronic gearing
- Real-time reference and limit position capture

#### Integrated Servo-Amplifiers/-PWM Output

Integrated, low-noise, linear power amplifiers allow opera-

tion of any PI micropositioning system without additional external amplifiers, reducing costs and simplifying the setup. In addition to the linear amplifiers, PWM (pulse width modulation) output signals are available to drive PI micropositioning stages equipped with ActiveDrive™ motors.

#### PI General Command Set (GCS)

The comprehensive command structure is based on the PI General Command Set (GCS). With GCS the development of custom application programs is simplified, because the commands for all supported devices are identical in syntax and function. PI controllers for nanopositioning systems, for piezomotors and servo or stepper motors can be commanded with GCS.

#### Software / Programming

In addition to the user software for setup, system optimization and operation, comprehensive LabView™ and DLL libraries are provided.

Control of the C-848 is provided either through the RS-232 or an optional TCP/IP interface. For manual control, the unit can be operated with a C-819.10 joystick.

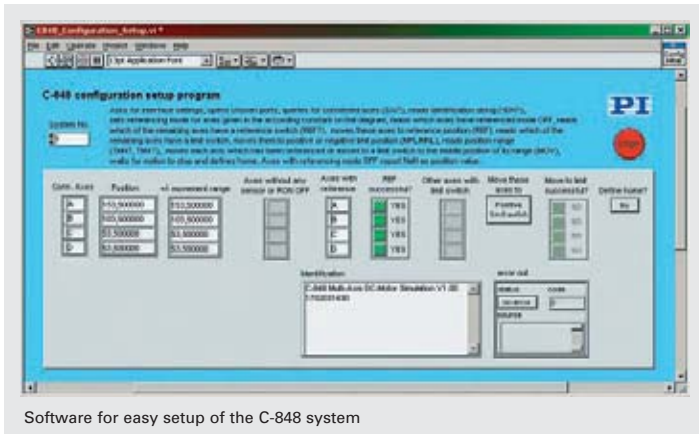
The C-848 can also run in stand-alone mode, and a standard computer keyboard and monitor can be connected for direct programming.

#### Ordering Information

**C-848.23**  
DC Servo Motion Controller,  
2 Channels, 19" Rack Mount,  
RS-232

**C-848.43**  
DC Servo Motion Controller,  
4 Channels, 19" Rack Mount,  
RS-232

**Accessories**  
**C-819.10**  
Analog Joystick



Software for easy setup of the C-848 system



C-848 Control software, terminal window

### Technical Data

Model	C-848.43	C-848.23
Function	DC-servo-motor controller	DC-servo-motor controller
Drive type	DC servo-motors Voice-Coil Linear Drives	DC servo-motors Voice-Coil Linear Drives
Channels	4	2
<b>Motion and control</b>		
Servo characteristics	Programmable PID V-ff filter, 100 $\mu$ s per active axis, parameter changes on the fly	
Trajectory profile	Linear interpolation, trapezoidal, s-curve, electronic gearing	
Processor	Dual Processor: CPU 133 MHz and Motion chip, 2.5 kHz servo update rate	
Encoder input	AB (quadrature) differential TTL signal, 5 MHz	
Stall detection	Servo off, triggered by programmable position error	
Limit switches	2 TTL lines per axis, programmable	
Reference switch	1 TTL line real-time position capture per axis	
Motor brake	TTL, software programmable	
<b>Electrical properties</b>		
Operating voltage	Wide-range power supply, 100 to 240 VAC, 50 to 60 Hz	
Output power/channel	Analog H-bridge $\pm$ 12 V, 5 W/channel, 12-bit D/A converters, 10-bit output for PWM drivers, 24.5 kHz	
Output voltage/channel	Analog: $\pm$ 10.5 V PWM: TTL for SIGN and MAGN	
Current limitation	1 A per channel (short-circuit proof)	
<b>Interfaces and operation</b>		
Communication interfaces	RS-232 standard (cable included), RS-232 standard (cable included),	
Motor connector	Sub-D connector, 15-pin	
Controller network	Via TCP/IP option	
I/O ports	8 TTL inputs, 8 TTL outputs	
Command set	PI General Command Set (GCS)	
User software	C-848 Control user software, PIMikromove®	
Software drivers	LabView™ driver, DLL & COM for C, BASIC for Windows	
Supported functionality	Autostart macro, user-programmable macro Monitor and keyboard connectors Motor-Brake Control	
Manual control	Joystick via controller or host PC	
<b>Miscellaneous</b>		
Temperature range	+10 to +50 °C	+10 to +50 °C
Mass	8.2 kg	8.4 kg
Dimensions	447 x 450 x 90 mm (19-inch rackmount)	447 x 450 x 90 mm (19-inch rackmount)

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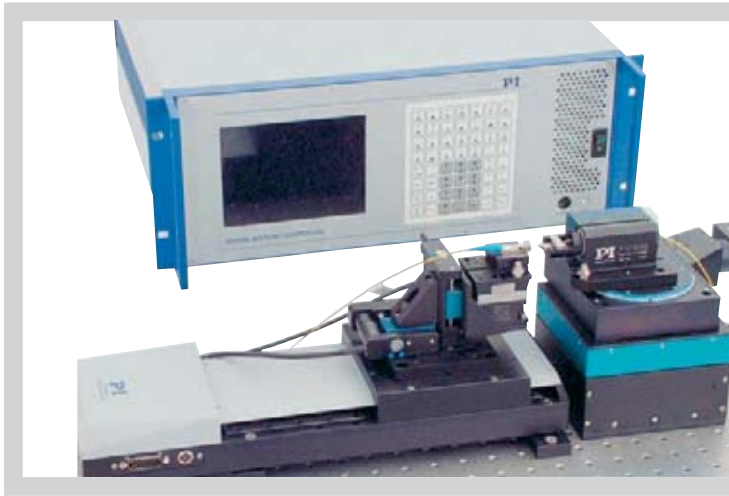
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## C-880 Automation Platform

### Flexible, Modular Controller for up to 18 Axes



Fiber alignment configuration example. Top: C-880.00D equipped with F-206.IRU IR-photometer card, 2 x C-842.43 servo-motor control cards and an E-760.3Si piezo controller card. Bottom left: M-511.DD precision translation stage with 0.1  $\mu\text{m}$  linear encoder for rapid loading/unloading; F-131.3SD fiber alignment system with 15 mm travel range in XYZ and 1 nm resolution. Bottom right: M-501.1PD precision vertical stage with 0.008  $\mu\text{m}$  encoder resolution; M-061.PD rotation stage and the F-210 fiber rotator

- Up to 18 Axes with (Servo-Motors, Voice Coil Drives and Piezo Actuators)
- Plug-and-Play Setup
- Large Variety of Accessories: I/O Cards, Photometers, Manual Control Pad
- RS-232 and Optional IEEE 488 Interface
- Extensive Software Support

The C-880 Automation Platform is a modular and highly versatile system for complex multi-axis positioning and automation tasks. It was conceived for applications ranging from photonics alignment and packaging to biotechnology.

Based on a rugged industrial PC, it offers the flexibility expected in today's demanding prototyping and high-precision production environment.

#### Application Examples

- Biotechnology
- Fiber positioning
- Flexible automation
- Semiconductor testing
- Micro-assembly
- Photonics / integrated optics
- Quality assurance testing

A variety of models and options are available, making it possible to control nanopositioning systems with up to 18 axes. Servo-motors, voice coil-drives and piezo actuators/stages can be combined in almost any combination. Available options include photometer cards for fully automated fiber alignment, a relay board for flexible automation, an integrated screen and keyboard for stand-alone operation, and a manual control pad.

#### PI General Command Set (GCS)

The comprehensive command structure is based on the PI General Command Set (GCS). With GCS the development of custom application programs is simplified, because the commands for all supported devices are identical in syntax and function. PI controllers for nanopositioning systems, for

piezomotors and servo or stepper motors can be commanded with GCS.

#### Software / Programming

In addition to the user software for setup, system optimization and operation, comprehensive LabView and DLL libraries are provided.

#### Accessories for Flexible Automation

To live up to its name of "Automation Controller", a variety of options and high-level drivers are available for the C-880:

- **C-880.TCP**  
TCP/IP interface card, allowing operation of more than one C-880 from a single PC interface.
- **C-880.R8**  
Relay Board which can switch power on up to 8 channels. The high-power capacity (24 V, 1 A) can be used to directly drive loads like pneumatic valves, magnets, relays, etc.
- **F-206.MC6**  
Interactive manual control pad. This option allows easy manual control of any 6 motorized axes in the system using control knobs with programmable step-sizes.

#### Ordering Information

- C-880.00**  
Automation Platform, Chassis with Power Supply, RS-232 Interface
- C-880.00D**  
Automation Platform, Chassis with Power Supply, RS-232 Interface with Front-Panel Keypad and LCD Monitor
- Options:**
- C-842.23**  
DC-Servo Motion Controller, 2 Channels, ISA-Bus
- C-842.43**  
DC-Servo Motion Controller, 4 Channels, ISA-Bus
- E-760.3Si**  
NanoCube® Piezo Controller, ISA-Bus PC Plug-In Board, Photometer IR Range
- E-760.3SV**  
NanoCube® Piezo Controller, ISA-Bus PC Plug-In Board, Photometer Visible Range
- Accessories:**
- C-880.TCP**  
TCP/IP Interface Card
- F-206.iiU**  
Photometer Card, IR Range, 2 Channels
- F-206.VVU**  
Photometer Card, Visible Range, 2 Channels
- F-206.MC6**  
Manual Control Pad for 6 Channels
- C-880.R8**  
Relay Board for 8 Relays

- **F-206.iiU / F-206.VVU**  
Photometer and A/D Cards. These cards are equipped with fiber-optic connectors, infrared- or visible-light photodiodes and amplifiers. Both have integrated 12-bit A/D converters with inputs accessible via a BNC socket on the card bracket.



C-880 Configuration Software makes for quick and easy on-site upgrades

## Technical Data

Model	C-880.00	C-880.00D
Function	Multi-Axis Automation Platform	Multi-Axis Automation Platform with Front-Panel Keyboard and LCD Monitor
Drive type	with C-842.23/C-842.43: Servo-Motors, Voice Coil Drives with E-760.3S0: Piezo Drives	
Channels	Up to 18 Axes with (servo-motors, voice coil drives), and Piezo Actuators (max. 6 piezo axes)	
<b>Motion and control</b>		
Servo characteristics	C-842.23 & C-842.43: Programmable 32-bit PID V-ff filter, 100 $\mu$ s per active axis, parameter changes on the fly E-760: Analog proportional-integral (P-I) algorithm with notch filter	
Trajectory profile modes	Linear interpolation, trapezoidal, s-curve, electronic gearing	
Processor	CPU 133 MHz C-842.23 & C-842.43: motion chip, 2.5 kHz servo update rate E-760: DSP	
<b>Electrical properties</b>		
Operating voltage	100 to 250 VAC, 50/60 Hz	
Output power per channel	C-842.23 & C-842.43: analog H-bridge with $\pm 12$ V output, 5 W/channel, 12-bit D/A converters, 10-bit output for PWM drivers, 24.5 kHz E-760: 9 W peak, 3 W continuous	
Output voltage / channel	C-842.23 & C-842.43: analog: $\pm 10.5$ V PWM mode: TTL level for SIGN and MAGN E-760: -20 to 120 V	
Current limitation	C-842.23 & C-842.43: 1 A/channel (short-circuit proof) E-760: 90 mA peak, 30 mA continuous	
<b>Interfaces and operation</b>		
Communication interfaces	RS-232 standard, including cable	
Motor connector	Sub-D 15-pin; Piezo: Sub-D, 25-pin	
Controller network	Via TCP/IP option	
I/O ports	C-842.23 & C-842.43: 8 TTL inputs, 8 TTL outputs C-880.R8: 8 channels, 60 W max., 24 V/channel, 1 A/channel	
Command set	PI General Command Set (GCS), ASCII Communications	
User software	PIMikroMove®	
Software drivers	GCS-DLL, LabVIEW™ drivers	
Supported functionality	Autostart macro, user-programmable macros, Monitor and keyboard connectors, Motor-brake control, Switching of high-power relays, Read-out of analog interface boards (photometer cards)	
Manual control	Manual control pad (F-206.MC6 option)	
<b>Miscellaneous</b>		
Operating temperature range	+10 to +50 °C	
Dimensions	19-inch case, 450 mm x 460 mm x 180 mm	

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### Micropositioning

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## Accessories

### C-819.10 Joystick

Analog Joystick for C-848 Motor Controller

The C-819.10 joystick can be used to operate the C-848 DC-motor-controllers via the PC game port.



### C-819.20

2-Axis Analog Joystick for Mercury™ Controller

### C-819.20Y

Y-Cable for Connecting 2 Controllers to C-819.20

### C-819.30

3-Axis Analog Joystick for Mercury™ Controller

### C-170.PB

Push Button Box, 4 Buttons and 4 LEDs

### C-815.34

RS-232 Cable, 3 m, Null Modem, 9/9-pin with 25/9-pin Adapter

### Motor Cables

All PI micropositioners come with the appropriate motor cables. The cables shown here are available as replacements or can be used as extension cables.

### C-815.38

Motor Cable, 3 m, sub-D 15-pin (f) / 15-pin (male)



### C-815.83

Motor Cable, 10 m, sub-D 15-pin (f) / 15-pin (male)



### C-815.62

Motor Cable, 3 m, 10-pin (Flat Ribbon)/15-pin (male)