

## Analog Multi-Axis Nanopositioning Controllers

With Analog & Digital Interfaces

COST EFFICIENT



COMPACT



FLEXIBLE

More Info:  
Click Images



# Multi-Axis Controllers with Analog Servo



E-545 Economical controller for Plnano™ microscope stages, 3-Channels



E-500 Modular High-Power Piezo Controller System



E-664 Low-Cost Controller for NanoCube® XYZ piezo stages



E-536.3C PicoCube® XYZ AFM Scanner Controller



E-616 Economical Controller for 2&3-Axis Steering Mirrors. Module & Bench Top

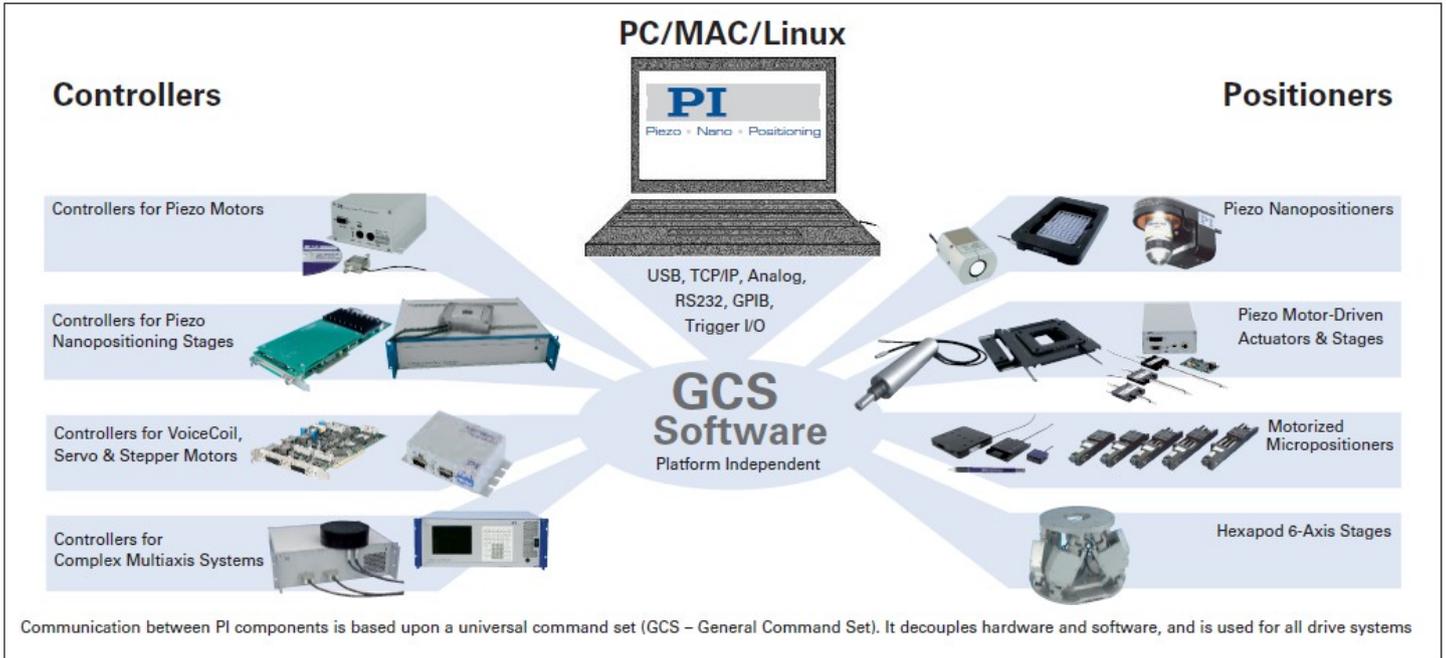


Multi-channel controller consisting of 3 E-500.621 chassis and 30 E-621 modules

## Software Tools

For LabView, C++, VB, Matlab, Image Acquisitong Packages, NI DAC Cards, .....

PI provides high-level, robust, easy-to-use software tools for fast, seamless integration of motion systems into application control software



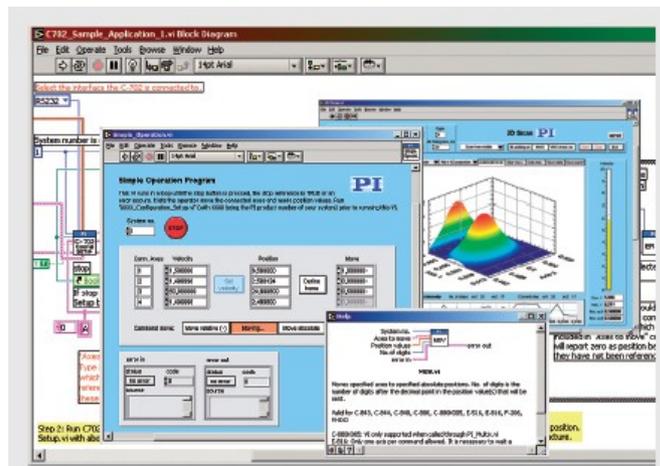
Communication between PI components is based upon a universal command set (GCS – General Command Set). It decouples hardware and software, and is used for all drive systems

The high quality of positioning systems is made apparent in daily operation by PI software. Starting with simple commissioning, through convenient operation with a graphical interface, to quick and simple integration in customized programs with high performance, PI software covers all aspects important to an application.

devices are identical in syntax and function. Through the use of the GCS command set with its convenient functions, the orientation phase and application development process is significantly accelerated. The GCS commands are available at the controller terminal, in macros and in the form of a universal driver set for LabVIEW (VIs), Windows dynamic link libraries (DLL) and Linux libraries. This facilitates the development of custom macros, as well as integration with programming languages like LabVIEW, C++ or MATLAB.

### Universal Command Set Simplifies Commissioning and Programming

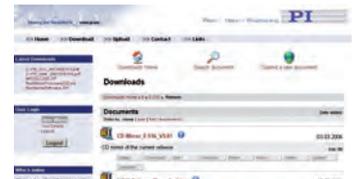
For uniform operation of nano and micropositioning systems, the universal PI General Command Set (GCS) is used. GCS operation is independent of the controller or drive principle used, so that several positioning systems can be controlled together, or new systems can be introduced with a minimum of programming effort. With GCS the development of custom application programs is simplified and less prone to errors, because the commands for all supported



Easy integration in LabView. Quick access to the full functionality Contact PI for our extensive library of software examples!

**PI piezo stages & controllers are compatible with all major image acquisition software packages such as, Metamorph™, μManager™, Slidebook™, Simple PCI™, NIS Elements™, ImagePro™.**

For more information on PI software support, go online or request the PI software brochure



Software and manuals can be downloaded, from the PI Support server

### Software Updates Online

PI supports users with free updates, detailed online help and well structured manuals which ease initiation of the inexperienced but still answer the detailed questions of the professional.

### Supported Operating Systems

- Microsoft Windows Vista
- Microsoft Windows XP
- Microsoft Windows 2000
- Linux

# E-545 Nanopositioning Controller for PInano™ XYZ Piezo Stages

## TCP/IP, USB, RS-232 & High Bandwidth Analog Interfaces. Analog Servo



E-545 PI nano™ series nanopositioning stage controller

- Low-noise 24-bit D/A Converter
- Sample Rate 25 kHz
- Linearization for Piezoresistive Sensors
- Notch Filter for Higher Bandwidth
- TCP/IP, USB und RS-232 Interfaces
- 3 x 14 W Peak Power
- Wave Generator with Programmable Trigger-I/O

The E-545 controller is ideally suited for the PI nano™ stage series P-545 for super-resolution microscopy. The controller meets all demands for this applications and provides useful additional functionality.

### USB Interface

The microprocessor controlled interface is equipped with low-noise, 24-bit D/A converters and can be controlled through three digital interfaces: TCP/IP, USB oder RS-232.

Alternatively, stand-alone operation is possible by uploading macro command sequences to the internal non-volatile memory.

### Wave Generator

The integrated wave generator can output periodic motion pro-

### Ordering Information

**E-545.3RD**  
PI nano™ Multi-Channel Piezo Controller with High-Speed Digital Interface, 3 Channels, Piezoresistive Sensors, Sub-D Connectors

files. In addition to sine and triangle waves, arbitrary, user-defined motion profiles can be created and stored.

### Extensive Software Support

The controllers are delivered with Windows operating software. Comprehensive DLLs, LINUX and LabVIEW drivers are available for automated control.

### Technical Data

Model	E-545.3RD
Function	Piezo Servo-Controller for PI nano™ stages
Axes	3
<b>Sensor</b>	
Servo characteristics	P-I (analog), notch filter
Sensor type	Piezoresistive sensors
<b>Amplifier</b>	
Min. output voltage min.	-20 to 120 V
Peak output power, < 5 ms	14 W
Average current	6 W
Peak current, < 5 ms	140 mA
Average current	60 mA
Current limitation	Short-circuit-proof
Voltage gain	10 ±0.1
<b>Interfaces and operation</b>	
Interface / communication	Ethernet (TCP/IP), USB, RS-232
Piezo system connector	Sub-D 25
Command set	PI General Command Set (GCS)
User software	PIMikroMove™
Supported functionality	Wave generator, data recorder, macro programming
<b>Miscellaneous</b>	
Operating temperature range	+5 to +50 °C
Overheat protection	Deactivation at 85°C
Operating Voltage	12 to 30 VDC, stabilized
Current consumption	2 A

# E-664 Low-Cost NanoCube® XYZ Nanopositioning Controller

## For XYZ-Piezo System P-611.3S



E-664 Controller for NanoCube® XYZ nanopositioning systems



NanoCube® XYZ-nanopositioning system, 100 x 100 x 100 µm closed-loop travel range, resolution 1 nm

- **Integrated Amplifier with 3 x 14 W Peak Power**
- **Position Servo-Control with Notch Filter for Higher Bandwidth and Stability**
- **3 Displays for Voltage / Position**
- **Cost-Effective Controller for P-611.3S NanoCube® Nanopositioning Systems**
- **Manual and External Control**

The E-664 is a bench-top amplifier & position servo-controller that is especially designed for the P-611.3S NanoCube® XYZ nanopositioning system (see p. 2-52). Three integrated low-noise amplifiers and control circuitry for strain gauge position sensors allow closed-loop position resolution down to 2 nm and dynamic operation.

The combination of the E-664 servo-controller and P-611.3S NanoCube® piezo stage makes for a very cost-effective precision 3D nanopositioning system.

### Closed-Loop and Open-Loop Piezo Positioning

The E-664 servo controller can be operated both in closed-loop (position-control) and in open-loop (voltage-control) mode. In closed-loop mode, piezo displacement is propor-

tional to the analog signal applied to the BNC control-input socket. The integrated notch filters (adjustable for each axis) improve the stability and allow high-bandwidth operation closer to the piezo-mechanics resonant frequency. In open-loop operation the output voltage is determined by the analog control signal at the BNC Control Input socket, optionally combined with the DC-offset potentiometer. Voltage controlled operation (in contrast to position-controlled operation) is used in applications where the fastest possible response and very high resolution with maximum bandwidth are essential, and/or when commanding and reading the target position in absolute values is either not important or accomplished with an external feedback loop (see p. 2-104). The precision

10-turn potentiometers can also be used alone to set the output voltages manually.

### Versatile I/O Supports Automation

On-target and overflow status information is displayed separately for every channel. This information is also present on a 14-pin I/O connector on the rear panel that also carries the analog control input and sensor monitor lines.

### Remote Control via Computer Interface

Optionally, digital control via an external D/A converter is

### Ordering Information

**E-664.S3**  
NanoCube® Piezo Controller,  
3 Channels, SGS-Sensors,  
-20 to 120 V

possible. For several D/A boards from National Instruments, PI offers a corresponding LabVIEW driver set which is compatible with the PI General Command Set (GCS), the command set used by all PI controllers. A further option includes the patented HyperBit™ technology providing enhanced system resolution.

### Technical Data

Model	E-664.S3
Function	Power amplifier & position servo controller for P-611.3S NanoCube® nanopositioning system
Axes	3
<b>Sensor</b>	
Servo characteristics	P-I (analog), notch filter
Sensor type	SGS
<b>Amplifier</b>	
Input voltage	-2 to +12 V
Output voltage	-20 to 120 V
Peak output power per channel <5 ms	14 W
Average output power per channel >5 ms	6 W
Peak current per channel <5 ms	140 mA
Average current per channel >5 ms	60 mA
Current limitation	Short-circuit-proof
Voltage gain	10 ±0.1
Ripple, noise, 0 to 100 kHz	<1 mVrms
<b>Interfaces and operation</b>	
Piezo connector	25-pin sub-D connector
Sensor connector	25-pin sub-D connector
Control Input sockets	3 x BNC (rear), I/O connector
I/O ports	14-pin connector for on-target and overflow status, Control In and sensor monitor outputs
Display	3 x 3½-digits, LED
<b>Miscellaneous</b>	
Operating temperature range	5 to 50°C
Overtmp protection	Deactivation at 75°C
Dimensions	236 x 88 x 273 mm + handles
Mass	3 kg
Operating voltage	90–120 / 220–240 VAC, 50–60 Hz (linear power supply)
Max. power consumption	60 W

## E-616 Low Cost Nanopositioning Controller for Piezo Tip/Tilt Mirrors Flexible Multi Channel OEM Electronics with Coordinate Transformation



The E-616 OEM controller and the S-334 fast steering mirror system providing a tip/tilt range of up to 60 mrad



E-616 Bench top controller

The E-616 is a special controller for piezo based tip/tilt mirrors and tip/tilt platforms. It contains two servo controllers, sensor channels and power amplifiers in a compact unit. The controller works with high-resolution SGS position sensors used in PI piezo mechanics and provides optimum position stability and fast response in the nanometer and  $\mu\text{rad}$ -range respectively. A high output power of 10 W per channel allows dynamic operation of the tip/tilt mirrors for applications such as (laser) beam steering and stabilization.

### Tripod or Differential Piezo Drive? One for All!

PI offers two basic piezo tip/tilt mirror designs. Both are parallel-kinematics designs where the individual piezo actuators affect the same moving platform. With the tripod design (e.g. S-325, see p. 2-92) the platform is driven by three piezo actuators placed with  $120^\circ$  spacing. The differential drive design (S-330, see p. 2-88 or S-334, see p. 2-90) with two orthogonal axes and a fixed pivot point is based on two pairs of actuators operating in

push / pull-mode. The differential evaluation of two sensors per axis provides an improved linearity and resolution.

### Internal Coordinate Transformation Simplifies Control

Parallel-kinematics require the transformation of the commanded tilt angles into the corresponding linear motion of the individual actuators. In the E-616.S0, this is taken care of by an integrated circuit, eliminating the need of additional external hardware or software. Additionally with the E-616.S0 all actuators can be commanded by an offset-voltage simultaneously. As a result a vertical movement, for example for optical path tuning, is obtained.

### Simple Setup and Operation

To facilitate integration, setup and operation the E-616 features both front and rear panel connections: The 25 pin sub-D piezo & sensor connector is located on the front, along with offset trim pots and LEDs for Power and Overflow. A 32 pin rear connector allows commanding and reading the sensor and amplifier monitor outputs.

- Three Integrated Amplifiers Provide up to 10 W Peak Power
- Closed-Loop and Open-Loop Versions
- Internal Coordinate Transformation Simplifies Control of Parallel Kinematics Designs (Tripod & Differential Drive)
- Compact and Cost-Effective Design for OEMs

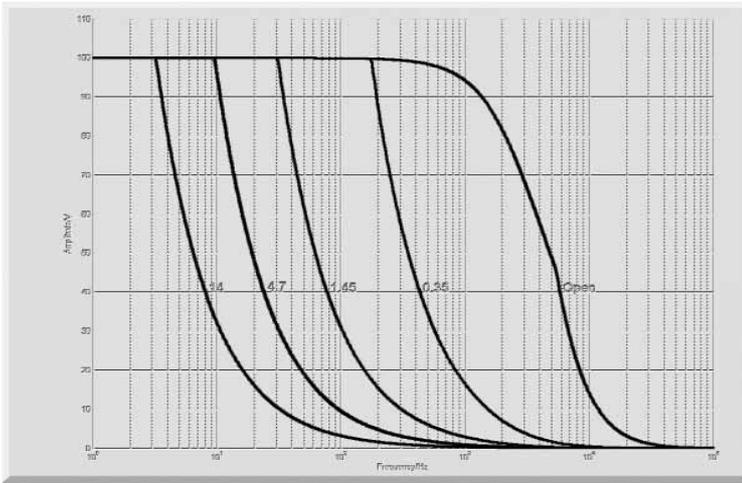
### Ordering Information

#### E-616.SS0

Multi Channel Servo-Controller / Driver for Piezo Tip/Tilt Mirror Platforms with SGS and Differential Drive

#### E-616.S0

Multi Channel Servo-Controller / Driver for Piezo Tip/Tilt Mirror Platforms with SGS and Tripod Drive



E-616: operating limits with various PZT loads (open-loop), capacitance is measured in  $\mu\text{F}$

## Technical Data

Model	E-616.S0	E-616.SS0
Function	Controller for parallel-kinematics piezo tip/tilt mirror systems with strain gauge sensors, tripod design	Controller for parallel-kinematics piezo tip/tilt mirror systems with strain gauge sensors, differential design
Tilt axes	2	2
<b>Sensor</b>		
Servo characteristics	P-I (analog), notch filter	P-I (analog), notch filter
Sensor type	SGS	SGS
Sensor channels	3	2
External synchronization	200 kHz TTL	200 kHz TTL
<b>Amplifier</b>		
Control input voltage range	-2 V to +12 V	-2 V to +12 V
Output voltage	-20 V to +120 V	-20 V to +120 V
Amplifier channels	3	3
Peak output power per channel	10 W	10 W
Average output power per channel	5 W	5 W
Peak current	100 mA	100 mA
Average current per channel	50 mA	50 mA
Current limitation	Short-circuit-proof	Short-circuit-proof
Voltage gain	10	10
Amplifier bandwidth, small signal	3 kHz	3 kHz
Amplifier bandwidth, large signal	See frequency diagram	See frequency diagram
Ripple, noise, 0 to 100 kHz	<20 mVpp	<20 mVpp
Amplifier resolution	<1 mV	<1 mV
<b>Interfaces and operation</b>		
Piezo / sensor connector	25-pin sub-D connector	25-pin sub-D connector
Analog input	32-pin connector	32-pin connector
Sensor monitor output	0 to +10 V for nominal displacement	0 to +10 V for nominal displacement
Sensor monitor socket	32-pin connector	32-pin connector
Display	Power-LED and sensor OFL display	Power-LED and sensor OFL display
<b>Miscellaneous</b>		
Operating temperature range	5 °C to 50 °C	5 °C to 50 °C
Overheat protection	Max. 75 °C, deactivation of the piezo voltage output	Max. 75 °C, deactivation of the piezo voltage output
Dimensions	160 mm x 100 mm x 10 TE	160 mm x 100 mm x 10 TE
Mass	700 g	700 g
Operating voltage	12 to 30 V DC	12 to 30 V DC
Power consumption	30 W	30 W

# E-500 and E-501 Racks

## Modular Piezo Nanopositioning Controller for High Power Amps

### Analog Servo, Digital & Analog Interfaces



Configuration example: E-500 Chassis with optional modules: E-505, 200 W High-Power piezo amplifier (3 x), E-509.S servo-controller, E-517.i3 24-bit interface / display module



Configuration example: E-501 chassis with optional modules: E-503 piezo amplifier, E-509.C2A servo-controller for capacitive position sensors, E-517.i3 24-bit interface / display module

- Up to 3 Axes, Custom Systems up to 12 Axes and More
- Choice of Amplifier Modules for Low-Voltage and High-Voltage, 14 to 400 W Peak Power
- Choice of Position Servo Control Modules for SGS & Capacitive Sensors, 1 to 3 Channels
- Choice of PC Interface / Display Modules
- 19- & 9½-Inch Chassis

The E-500 modular piezo controller system offers a broad choice of control modules for nanopositioning systems and actuators. This includes piezo

amplifier and position servo controller modules for up to three channels with different features as well as display and interface modules. Flexible



30-channel controller consisting of 3 E-500.621 chassis, each of which can accommodate up to 12 E-621 modules

configuration makes the system adaptable to a wide range of applications.

E-500 systems are assembled to order, tested, and, if a servo-controller is present, calibrated with the associated piezo mechanics.

#### Remote Control via Computer Interface

Installing the E-517, computer interface/display module (see p. 2-156) with 24-bit resolution makes possible control from a host PC.

Optionally, digital control via an external D/A converter is possible. For several D/A boards from National Instruments, PI offers a corresponding LabVIEW driver set which is compatible with the PI General Command Set (GCS), the command set used by all PI controllers. A further option includes the patented

#### Ordering Information

**E-500.00**  
19"-Chassis for Modular Piezo Controller System, 1 to 3 Channels

**E-501.00**  
9½"-Chassis for Modular Piezo Controller System, 1 to 3 Channels

**E-500.ACD**  
LabVIEW Driver Set for Analog Controllers

**E-500.HCD**  
HyperBit™ Functionality for Enhanced System Resolution (Supports Certain D/A Boards)

**Ask about custom designs!**

HyperBit™ technology providing enhanced system resolution.

**Two chassis are available:**  
The E-500.00 19" rackmount chassis provides operating voltages for all compatible modules including amplifiers, servo-controllers, display and interface modules (see system configuration see p. 2-144).

#### Technical Data

Model	E-500.00	E-501.00
Function	19"-Chassis for Piezo Controller System: Amplifier Modules, Sensor- / Servo-Control Modules, Interface / Display Modules	9.5"-Chassis for Piezo Controller System: Amplifier Modules, Sensor- / Servo-Control Modules, Interface / Display Modules
Channels	1, 2, 3 (up to 3 amplifier modules)	1, 3 (1 amplifier module)
Dimensions	450 x 132 x 296 mm + handles	236 x 132 x 296 mm + handles
Operating voltage	90–264 VAC, 50–60 Hz	90–120 / 220–264 VAC, 50–60 Hz
Max. power consumption	180 W	80 W

© Physik-Instrumente (PI) GmbH & Co. KG 2008. Subject to change without notice. All data are superseded by any new release. The newest release for data sheets is available for download at www.pi.ws. Cat120E Inspirations2009/08/10.18

# Available Modules for E-500 and E-501 Racks

E-509 3-channel servo-controller module for nanopositioning systems with strain gauge sensors



- E-509.C1A**  
Sensor / Piezo Servo-Control  
Capacitive Sensor, 1 Channel
- E-509.C2A**  
Sensor / Piezo Servo-Control  
Capacitive Sensors, 2 Channels
- E-509.C3A**  
Sensor / Piezo Servo-Control  
Capacitive Sensors, 3 Channels
- E-509.S1**  
Sensor / Piezo Servo-Control  
SGS Sensor, 1 Channel
- E-509.S3**  
Sensor / Piezo Servo-Control  
SGS-Sensors, 3 Channels

- High-Speed Analog Servo for Piezo with Capacitiv & SGS
- 1-, 2- and 3-Channel Versions
- Improves Linearity, Increases Piezo Stiffness
- Eliminates Drift and Hysteresis
- Notch Filter for Higher Bandwidth
- ILS Circuitry Maximizes Capacitive Sensor Linearity

The E-517 piezo display and D/A converter module, provides USB and TCP/IP connectivity



- E-517.i1**  
Interface / Display Module,  
24 Bit D/A, TCP/IP, USB, RS-232,  
Single Channel
- E-517.i3**  
Interface / Display Module,  
24 Bit D/A, TCP/IP, USB, RS-232,  
3 Channels

- Low-Noise 24-bit D/A Converter
- Sample Rate 25 kHz
- TCP/IP, USB, IEEE 488 and RS-232 Interfaces
- 6-Digit Display for Voltage and Position
- 1- & 3-Channel Versions
- Wave Generator with Programmable Trigger-I/O

The E-509.E3 module offers sensor signal read-out and servo control for three channels



- E-509.E3**  
PISeCa™ Sensor / Piezo Servo-  
Control Module for Single-  
Electrode Capacitive Sensor  
Probes, 3 Channels
- E-509.E03**  
PISeCa™ Modular Signal  
Conditioner Electronics for Single  
Electrode Capacitive Sensors,  
3 Channels

- E-509.E03: 3-Channel Signal Conditioner Module
- E-509.E3: 3-Channel Sensor Module with Additional Servo Controllers for Piezo Positioning Systems
- Integrated Linearization System (ILS) for Maximum Linearity

# Available Power Amp Modules for E-500 and E-501 Racks

E-505.00 is a high-performance amplifier module for the piezo servo-controller system E-500



**E-505.00**  
Piezo Amplifier Module, 2 A,  
-30 to 130 V, 1 Channel

**E-505.10**  
Piezo Amplifier Module for  
Switching Applications, 10 A,  
-30 to 130 V, 1 Channel

**E-505.00S**  
Offset Voltage Supply for Tip/Tilt  
Systems, One Fixed Voltage of  
+100 V

E-503.00 Piezo  
amplifier module



**E-503.00**  
Piezo Amplifier Module,  
-30 to 130 V, 3 Channels

**E-503.00S**  
Piezo Amplifier Module,  
-30 to 130 V, 2 Channels,  
Modified E-503.00 for S-330, S-334,  
S-340 Tip/Tilt Systems, with  
One Fixed Voltage of +100 V,  
Two Variable Voltages

- Up to 10 A Peak Current
- Output Voltage Range -30 to 130 V

- 3 x 140 mA Peak Current
- Output Voltage Range -30 to 130 V

E-504.00F High-power amplifier module  
with energy recovery



**E-504.00F**  
High-Power-Piezo Amplifier Modul  
1 Channel, 280 W Peak Power,  
100 W Average Power, -30 to 130 V

E-506.10 charge-controlled Piezo driver module



**E-506.10**  
High Linearity Piezo Amplifier  
Module, 30 W Average Output  
Power, -30 to 130 V, 1 Channel

- Peak Power 280 W
- High Average Output Power 100 W
- Very Energy Efficient Through Energy Recovery
- Output Voltage Range -30 to 130 V

- Highly Linear Amplifier Module
- 280 W Peak Power
- Output Voltage Range -30 to 130 V

# E-536 PicoCube® Nanopositioning Piezo Controller

## High Dynamics, High Resolution, for up to 3 Axes



E-536.3C 3-channel PicoCube® Controller

- For P-363 PicoCube® Systems
- Peak Power 3 x 100 W
- Ultra-Low Noise
- Output Voltage  $\pm 250$  V

The E-536 is a controller for the P-363 PicoCube® pico-positioning system providing three ultra-low-noise amplifier channels for piezo shear actuators. The controller design meets the special requirements of the high-speed, ultra-high-performance PicoCube® XY(Z) piezo stages (see p. 2-66) of  $\pm 250$  V for both static and dynamic applications.

The high-performance E-536.3x can output and sink peak currents up to 200 mA featuring a small-signal bandwidth of 10 kHz. The E-536.3xH ultra-high-resolution models provide a position resolution below 0.03 nm at a peak power of 50 W. Both models are available with or without a servo module for closed-loop or open-loop operation.

### Superior Resolution and High Dynamics

Open-loop operation is ideal for applications where fast response and very high resolution with maximum bandwidth are essential. Here, commanding and reading the target position in absolute values is either not important or carried out by external position sensors. Together with the P-363 PicoCube® a resolution of 0.05 nm or better is achieved.

### Excellent Position Accuracy with Capacitive Sensors

The E-536.3C versions have integrated sensor electronics and servo-controllers for closed-loop position control. Position feedback is provided by capacitive sensors, like

those in the PicoCube®, with resolutions down to 0.1 nm.

### Computer Control

Control via PC is possible by installing the E-517, 24-bit interface/display module.

Optionally digital control via a D/A converter is possible. For several D/A boards from National Instruments PI offers a corresponding LabVIEW™ driver set which is compatible with the PI General Command Set (GCS), the command set used by all PI controllers. A further option includes the patented Hyperbit™ technology providing enhanced system resolution.

### Ordering Information

**E-536.3C**  
PicoCube® Piezo Controller, 3 Channels, Capacitive Sensors

**E-536.30**  
PicoCube® Piezo Controller, 3 Channels, Open-Loop

**E-536.3CH**  
PicoCube® Piezo Controller, 3 Channels, High-Resolution, Capacitive Sensors

**E-536.30H**  
PicoCube® Piezo Controller, 3 Channels, High-Resolution, Open-Loop

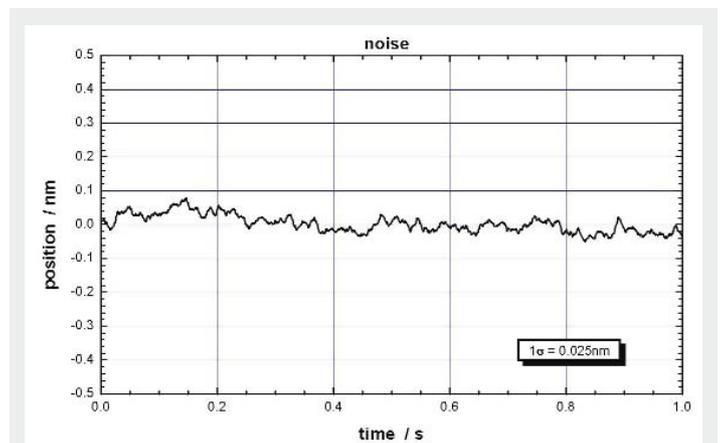
**E-517.i3**  
Interface- / Display Module, 24 Bit D/A, TCP/IP, USB, RS-232, 3 Channels

**E-500.HCD**  
Hyperbit™ Functionality for Enhanced System Resolution

(Supports certain D/A boards.)

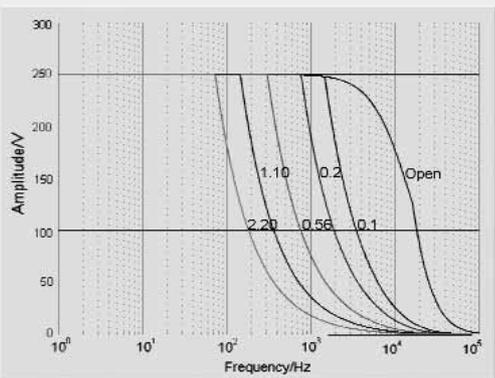


P-363.2CD and .3CD (background) PicoCube™, high-performance piezo positioning- and scanning systems or AFM/STM and nanomanipulation.

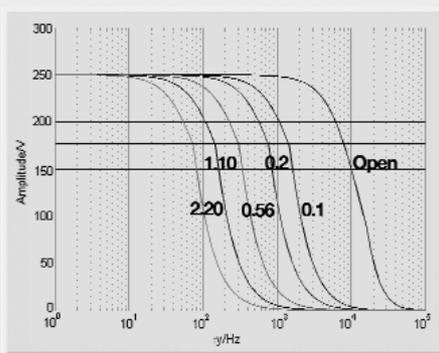


Positional noise measurement of E-536 amplifier driving a P-363 pico-positioning system in open loop shows 1-sigma resolution of 25 picometers (0.025 nm). Measured with ultra-high-resolution capacitive sensor

© Physik-Instrumente (PI) GmbH & Co. KG 2008. Subject to change without notice. All data are superseded by any new release. The newest release for data sheets is available for download at www.pi.ws. Cat120E Inspirations2009 08/10.18



E-536.3x: operating limits with various PZT loads, capacitance is measured in  $\mu\text{F}$



E-536.3xH: operating limits with various PZT loads, capacitance is measured in  $\mu\text{F}$

## Technical Data

Model	E-536.3C / E-536.30	E-536.3CH / E-536.30H
Function	Power amplifier & servo-controller for P-363 PicoCube®	Power amplifier & servo-controller for P-363 PicoCube®
<b>Amplifier</b>		
Output voltage	-250 to +250 V	-250 to +250 V
Amplifier channels	3	3
Average output power per channel	10 W, limited by temperature sensor	6 W, limited by temperature sensor
Peak output power per channel, <3 ms	100 W	50 W
Average current	30 mA	15 mA
Peak current per channel, <3 ms	200 mA	100 mA
Amplifier bandwidth, small signal	10 kHz	2 kHz
Amplifier bandwidth, large signal, @ 100 nF	0.2 kHz	0.125 kHz
Ripple, noise, 0 to 100 kHz	0.8 mV <sub>RMS</sub> , <5 mV <sub>P-P</sub> (100 nF)	0.5 mV <sub>RMS</sub> , <3 mV <sub>P-P</sub> (100 nF)
Current limitation	Short-circuit proof	Short-circuit proof
Voltage gain	+50	+50
Input impedance	100 k $\Omega$	100 k $\Omega$
<b>Sensor*</b>		
Servo characteristics	Analog proportional-integral (P-I) algorithm with notch filter	Analog proportional-integral (P-I) algorithm with notch filter
Sensor type	capacitive sensors	capacitive sensors
Sensor channels	3 / -	3 / -
Sensor bandwidth	1.5 kHz	1.5 kHz
Sensor Monitor output	0 to +10 V	0 to +10 V
<b>Interfaces and operation</b>		
PZT output sockets	LEMO EGG.0B.701.CJL.1173	LEMO EGG.0B.701.CJL.1173
Sensor target and probe sockets	LEMO EPL.00.250.NTD	LEMO EPL.00.250.NTD
Control Input sockets	SMB	SMB
Sensor Monitor socket	LEMO FGG.0B.306.CLAD56	LEMO FGG.0B.306.CLAD56
Control Input voltage	Servo off: -5 to +5 V, Servo on: 0 to +10 V	Servo off: -5 to +5 V, Servo on: 0 to +10 V
DC Offset	10-turn pot., adds 0 to +10 V to Control IN	10-turn pot., adds 0 to +10 V to Control IN
<b>Miscellaneous</b>		
Operating voltage	115 VAC / 50-60 Hz or 230 VAC / 50-60 Hz	115 VAC / 50-60 Hz or 230 VAC / 50-60 Hz
Mass	8.1 kg / 7.8 kg (with E-516 module)	8.1 kg / 7.8 kg (with E-516 module)
Dimensions	450 x 132 x 296 mm + handles	450 x 132 x 296 mm + handles

\*only E-536.3Cx with capacitive sensors

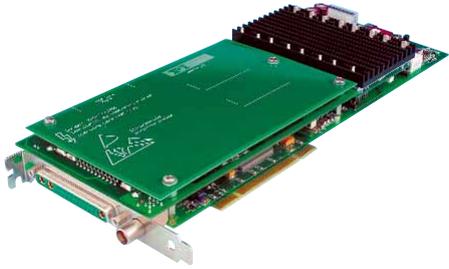
Interfaces / communication: RS-232, TCP/IP, USB (with optional E-517 computer interface and display module only)

Operating temperature range: +5 °C to +50 °C (over 40 °C, max. av. power derated 10 %), high-voltage output is automatically deactivated if temperature is too high by internal temperature sensor (75 °C max.)

More Info:  
Click Images



## Multi-Axis Nanopositioning Controllers with Digital Servo



E-761 Digital Piezo Controller PCI-Board, 3 Channel



E-725 Digital 3-channel controller



E-712 Ultra-High Performance Modular Controller



.6CD 6-axis Digital Piezo Controller top model of the E-710 family ,  
shown with custom Super-Invar 6-DOF piezo flexure nanopositioning stage

# E-725 High-Performance 3-Channel Digital Piezo Controller For 3-Axis High-Speed Precision Positioning Systems



E-725 Digital 3-channel controller with P-528 Z/tip/tilt nanopositioning system

- For Nanopositioning Systems with Capacitive Sensors
- 3-Channel Version
- Powerful Digital Controller: DSP 32-bit Floating Point, 225 MHz; 20 kHz Sampling Rate; 24-bit DAC
- Communication via Ethernet, USB, RS-232
- 4th Order Polynomial Linearization for Mechanics & Electronics
- Dynamic Digital Linearization (DDL) Option for Improved Path Accuracy
- Auto-Loading of Calibration Data from Stage ID-Chip for Interchangeability of Controller and Mechanics
- Additional High-Bandwidth Analog Control Input / Sensor Input
- Optional High-Speed Parallel I/O Interface
- Flexible Wave Generators
- Digital I/O Lines for Task Triggering
- Extensive Software Support

The E-725 digital piezo controller is a compact, high-performance drive electronics for nanopositioning systems with up to three axes. High-power amplifiers permit dynamic scans even for piezo systems with large range or direct drive. State-of-the-art processor technology optimizes the operating parameters for improved linearity and tracking accuracy. High-resolution D/A converters provide for nanopositioning that deserves this name.

With the E-725.3CM, PI for the first time offers a digital controller for the P-363 PicoCube™ (see p. 2-66), a fast precision scanner for atomic force microscopy.

Optional interfaces and analog in- and outputs make it possible to process external sensor or control values.

### Digital Linearization and Control Algorithms for Highest Accuracy

Linearization algorithms based on higher-order polynomials improve the positioning accuracy to better than 0.01 % for capacitive sensors, typically 10 times better than achievable with conventional controllers.

### More than just a Controller – Trajectory Control and Data Recording

During fast periodic motion, as typical for scanning applications, the tracking accuracy can

be further improved with Dynamic Digital Linearization (DDL, E-710.SCN). This optionally available control algorithm reduces the tracking error by a factor of up to 1000.

This control algorithm enables the spatial and temporal tracking during a dynamic scan. The integrated wave generator can output periodic motion profiles. In addition to sine and triangle waves, arbitrary, user-defined motion profiles can be created and stored. The flexibly configurable data recorder enables simultaneous recording and read-out of the corresponding data.

### Extensive Software Support

The controllers are delivered with Windows operating software. Comprehensive DLLs and LabVIEW drivers are available for automated control.

### Automatic Configuration

PI digital piezo controllers and nanopositioning stages with ID-Chip can be operated in any combination, supported by the AutoCalibration function of the controller. Individual stage data and optimized servo-control parameters are stored in the ID-Chip and are read out automatically by the digital controllers.

### Ordering Information

**E-725.3CD**  
Digital Multi-Channel Piezo Controller, 3-Channel, Sub-D Connector for Capacitive Sensors

**E-725.3CM**  
Digital Multi-Channel Piezo Controller, for PicoCube™ and Capacitive Sensors

Ask about custom designs

## Technical Data

Model	E-725.3CD	E-725.3CM	Tolerance
Function	Digital Controller for Multi-Axis Piezo Nanopositioning Systems with Capacitive Sensors	Digital Controller for Multi-Axis Piezo Nanopositioning Systems with Capacitive Sensors	
Axes	3	3	
Processor	DSP 32-bit floating point, 225 MHz	DSP 32-bit floating point, 225 MHz	
Sampling rate, servo-control	20 kHz	20 kHz	
Sampling rate, sensor	20 kHz	20 kHz	
<b>Sensor</b>			
Servo characteristics	P-I, two notch filters	P-I, two notch filters	
Sensor type	Capacitive	Capacitive	
Sensor channels	3	3	
Sensor bandwidth (-3 dB)	5.6 kHz	5.6 kHz	max.
Sensor resolution	18 bit	18 bit	
Ext. synchronization	Yes	Yes	
<b>Amplifier</b>			
Output voltage	-30 to 135 V	-250 to 250 V	±3 V
Amplifier channels	4	4	
Peak output power per channel	25 W	47 W	max.
Average output power per channel*	10 W	10 W	max.
Peak output current per channel	190 mA	190 mA	max.
Average output current per channel*	120 mA	60 mA	max.
Current limitation	Short-circuit proof	Short-circuit proof	
Resolution DAC	24 bit	24 bit	
<b>Interfaces and operation</b>			
Communication interfaces	Ethernet, USB, RS-232	Ethernet, USB, RS-232	
Piezo / sensor connector	Sub-D special connector	Sub-D special connector	
Analog input	1 x Lemo, ±10 V, 18 bit	1 x Lemo, ±10 V, 18 bit	
Digital input / output	MDR20; 2 x IN, 8 x OUT	MDR20; 2 x IN, 8 x OUT	
Command set	PI General Command Set (GCS)	PI General Command Set (GCS)	
User software	NanoCapture™, PIMikroMove™	NanoCapture™, PIMikroMove™	
Software drivers	LabVIEW driver, DLLs	LabVIEW driver, DLLs	
Supported functionality	Wave-Gen, Trigger I/O	Wave-Gen, Trigger I/O	
Display	LEDs for Power, On Target, Error, Cmd	LEDs for Power, On Target, Error, Cmd	
Linearization	4th order polynomial, DDL (Dynamic Digital Linearization)	4th order polynomial, DDL (Dynamic Digital Linearization)	
Separate protective ground connector	Yes	Yes	
<b>Miscellaneous</b>			
Operating temperature range	5 to 50 °C	5 to 50 °C	
Overheat protection	Max. 71 °C, deactivation of the piezo voltage output	Max. 71 °C, deactivation of the piezo voltage output	
Mass	3.5 kg	3.6 kg	
Dimensions	263 x 89 x 302 mm (with handles)	263 x 89 x 302 mm (with handles)	
Power consumption	70 W	70 W	max.
Operating voltage	24 VDC from external power supply (included)	24 VDC from external power supply (included)	

\* The total output power of all 4 amplifier channels should not exceed 34.5 W to avoid overcurrent (E-725 is equipped with a 3. 15 AM fuse).

# E-761 Digital Piezo Nanopositioning Controller Card, 3 Channels

## Cost-Efficient PCI Board for Piezo Stages with up to 3 Axes



E-761 Digital Piezo Controller in PCI-Board Format

- For Piezo Stages with Capacitive Sensors
- High-Speed PCI Interface
- 3 Logical Axes, 4 Piezo Amplifiers
- Additional High-Bandwidth Analog Interface
- 32-Bit Digital Filters
- Notch Filter for Higher Bandwidth
- 24-Bit Ultra-Low-Noise DAC Converters
- Auto-Loading of Calibration Data from Stage ID-Chip for Interchangeability of Controller and Mechanics
- Coordinate Transformation for Parallel-Kinematics / Parallel-Metrology Systems
- Extensive Software Support

E-761 digital piezo controllers offer advanced control technology in a cost-effective PCI-board format. They were designed to run piezo stages with up to three logical axes. The E-761 incorporates four instrumentation-class, 24-bit digital-analog converters (DAC) behind ultra-low-noise power amplifiers, and is based on a specialized 32-bit digital signal processor (DSP) with proprietary firmware.

Having PCI-board format, the E-761 digital controller can be easily installed in any commercial or industrial PC, allowing for easy integration with other devices such as frame grabbers. The PCI interface with its high bandwidth makes possible a very fast communication between software and

controller. This is a definite plus in time-critical applications or when controlling several axes.

Additionally, the E-761.3CT version offers three digital output lines for a variety of triggering tasks.

### Improved Trajectory Accuracy Through Parallel Metrology

Digital controllers have a number of advantages over conventional analog piezo controllers. Sensor and actuator axes need not be parallel to each other, or to the orthogonal logical axes used to command the system. The flexible coordinate transformation algorithm permits operation of complex, multi-axis, parallel metrology stages (e. g. 3-axis Z-tip-tilt-stages).

With parallel motion metrology, the controller compensates the undesired off-axis motion of each actuator automatically using the others (active trajectory control). High-end nanopositioning systems with active trajectory control can attain motion accuracies in the sub-nanometer range.

### Digital Linearization and Control Algorithms for Highest Accuracy

Linearization algorithms based on higher -order polynomials improve the positioning accuracy to 0.001 % of the travel range.

During fast periodic motion, as typical for scanning applications, the tracking accuracy can be further improved with Dynamic Digital Linearization (DDL, E-710.SCN). This optionally available control algorithm reduces the tracking error by a factor of up to 1000.

The integrated wave generator can save and output periodic motion profiles. In addition to sine and triangle waves, arbitrary, user-defined profiles can be created.

### Automatic Configuration

PI digital piezo controllers and nanopositioning stages with ID-chips can be operated in any combination, supported by the controller's AutoCalibration function. Individual stage data and optimized servo-control parameters are stored in the ID-Chips and are read out automatically by the digital controller.

### Simple System Integration

All parameters can be set and checked by software. System setup and configuration is done with the included

### Ordering Information

**E-761.3CD**  
Digital Piezo Nanopositioning Controller, 3 Axes, Sub-D-Special, PCI Board

**E-761.00T**  
Trigger Output Bracket for E-761.3CD

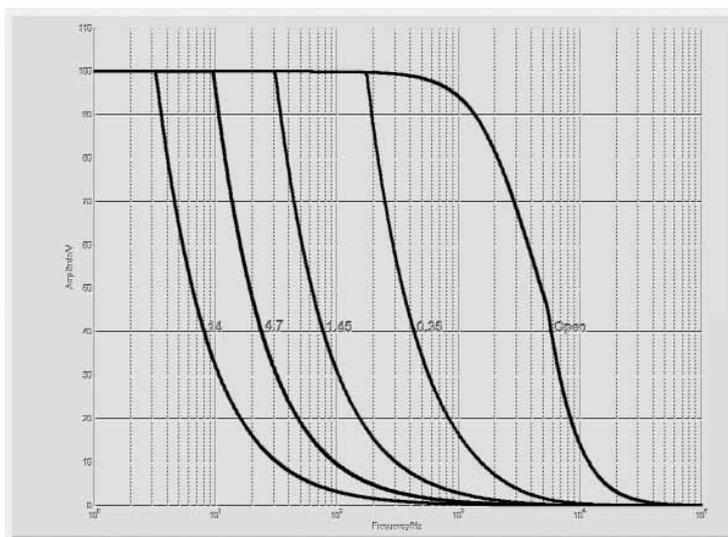
**E-761.3CT**  
Digital Piezo Nanopositioning Controller, 3 Axes, Sub-D-Special, PCI Board, Trigger Output

**Ask about custom designs!**

NanoCapture™ and PZTControl™ user-interface software. Interfacing to custom software is facilitated with included LabVIEW drivers and DLLs. All PI controllers use the same command set, a significant advantage during application software development, system upgrade or when operating a variety of different controllers from one application.

## Technical Data

Model	E-761.3CD	E-761.3CT
Function	Digital piezo controller and power amplifier, PCI board	Digital piezo controller and power amplifier, PCI board, trigger output
Axes	3	3
Processor	32-bit, floating-point DSP	32-bit, floating-point DSP
Sampling rate, servo-control	40 $\mu$ s / 25 kHz (sensor-oversampling factor 4)	40 $\mu$ s / 25 kHz (sensor-oversampling factor 4)
<b>Sensor</b>		
Servo characteristics	P-I, two notch filters	P-I, two notch filters
Sensor type	Capacitive	Capacitive
Sensor channels	3	3
Sensor resolution	16-bit	16-bit
Ext. synchronization	Yes	Yes
<b>Amplifier</b>		
Output voltage	-20 to 120 V	-20 to 120 V
Amplifier channels	4	4
Peak output power per channel,	5.3 W	5.3 W
Average output power per channel	1.7 W	1.7 W
Peak current per channel, <20 ms	50 mA	50 mA
Average current per channel, >20 ms	10 mA	10 mA
Current limitation	Short-circuit-proof	Short-circuit-proof
Resolution DAC	24-bit	24-bit
<b>Interfaces and operation</b>		
Interface / communication	PCI connector	PCI connector
Piezo / sensor connector	Sub-D special	Sub-D special
Control Input sockets	LEMO	LEMO
Digital output	-	3 x TTL
Command set	GCS	GCS
User software	NanoCapture™, PZTControl™	NanoCapture™, PZTControl™
Software drivers	LabVIEW drivers, Windows and Linux Libraries (DLL)	LabVIEW drivers, Windows and Linux Libraries (DLL)
Supported functionality	Wave generator	Wave generator, trigger output
Display	Status LED for piezo voltage	Status LED for piezo voltage
Linearization	4th order polynomial	4th order polynomial
<b>Miscellaneous</b>		
Operating temperature range	+5 to +50 °C (derated 10 % over 40 °C)	+5 to +50 °C (derated 10 % over 40 °C)
Overtemp protection	Deactivation at 60 °C	Deactivation at 60 °C
Dimensions	287 x 108 x 25 mm (2 slots)	287 x 108 x 25 mm + 122 x 45x 26 mm (3 slots)
Mass	0.56 kg	0.56 (PCI-board only)
Operating voltage	5 V	5 V
Power consumption	20 W, 4 A max.	20 W, 4 A max.



E-761: operating limits with various PZT loads (open-loop), capacitance is measured in  $\mu$ F

# E-710 Digital Piezo Nanopositioning Controller, Many Options

## 3 to 6 axes, extremely versatile



E-710.6CD 6-axis Digital Piezo Controller top model of the E-710 family, shown with custom Super-Invar 6-DOF piezo flexure nanopositioning stage

- For Nanopositioning Systems with Capacitive Feedback
- All Control Parameters Software-Settable
- 3-, 4- & 6-Channel Versions
- Firmware Linearization: Dynamic Digital Linearization (DDL) Option Improves Scanning Linearity
- Coordinate Transformation for Parallel-Kinematics / Parallel-Metrology Systems
- Auto-Loading of Calibration Data from Stage ID-Chip for Interchangeability of Controller and Mechanics
- Interface Options: High-Speed Parallel I/O Interface and Analog Inputs
- Notchfilter for Higher Bandwidth
- Extensive Software Support
- Option: Digital Sensor-Signal Transmission over 15 m and More

E-710 digital piezo controllers offer sophisticated functionality in a variety of configurations. Based on powerful 32-bit DSPs (digital signal processor) they include integrated, low-noise power amplifiers for piezo actuators and excitation/read-out electronics for extremely high-resolution capacitive position sensors. E-710s provide up to 8 piezo driver channels, 7 sensor channels and the processing power for coordinated control of up to 6 logical axes, e. g. for parallel kinematics systems.

### Digital Linearization and Control Algorithms for Highest Accuracy

Linearization algorithms based on higher-order polynomials improve the positioning accuracy to 0.001% of the travel range. The high-speed processor with a sensor sampling rate of 25 kHz, assures settling times in the millisecond range and below. The controller is perfectly suited for high-dynamics operation, thanks to its high-resolution DA-converters and high-performance voltage amplifiers.

### More than just a Controller—Trajectory Control and Data Recording

During fast periodic motion, as typical for scanning applications, the tracking accuracy can be further improved with Dynamic Digital Linearization (DDL, E-710.SCN). This optionally available control algorithm reduces the tracking error by a factor of up to 1000. This control algorithm enables the spatial and temporal tracking during a dynamic scan. The integrated wave generator can save and output periodic motion profiles. In addition to sine and triangle waves, arbitrary, user-defined profiles can be created. The flexibly configurable data recorder enables simultaneous recording and read-out of the corresponding data.

### Sensor-Signal Transmission up to 15 m

A remote sensor interface box is available for applications where the distance between the mechanics and electronics is greater than 10 m. This DST option (digital sensor-signal transmission), includes a compatible E-710 controller. It is designed to reduce the interference that begins to degrade performance when the analog sensor excitation and readout signal paths exceed 10 m. The connection between the sensor box and the controller can be up to 15 m (longer distances on request), as the digital signals it carries are far more robust.

### Simple System Integration

All parameters can be checked and reset via software. System setup and configuration is done with the included NanoCap - ture™ and PIMikroMove™ user-interface software. Interfacing to custom software is facilitated with included LabVIEW drivers and DLLs. System program-

### Ordering Information

See Ordering Numbers / Interface Options on next page

#### Options and Accessories

- E-710.SCN**  
DDL (Dynamic Digital Linearization) Firmware Upgrade
- E-710.3X3**  
Extension Cable for E-710.3CD, 3 Sub-D Connectors, 3 m
- E-710.3X5**  
Extension Cable for E-710.3CD, 3 Sub-D Connectors, 5 m
- E-710.1X3**  
Extension Cable for E-710, 1 Sub-D Connectors, 3 m
- E-710.DST4**  
DST Cable (Digital Signal Transmission) for E-710.6SD, 8 m

ming is the same with all PI controllers, so controlling a system with a variety of different controllers is possible without difficulty.

## Ordering Information / Interface Options

Channels	Connector (piezomechanics)	Base Model	Parallel I/O Interface	Analog Input*	Analog Input* + Parallel I/O Interface	DST** + Analog Input*
3	1 x Special Sub-D, 3 ch.	E-710.3CD	E-710.P3D	E-710.A3D	E-710.APD	incl. Parallel I/O Interface E-710.APS
4	4 x LEMO	E-710.4CL	E-710.P4L	–	–	–
	4 x Special Sub-D, 1 ch.	E-710.4CD	E-710.P4D	–	–	–
	1 x Special Sub-D, 3 ch. + 1 x Special Sub-D, 1 ch.	E-710.C4D	E-710.4PD	–	–	–
6	2 x Special Sub-D, 3 ch.	E-710.6CD	–	Standard	–	Analog input on DST box E-710.6SD

\*LEMO connector  
\*\*Digital Signal Transmission



The digital sensor-signal transmission (DST) allows a distance up to 15 m between positioning unit and controller

## Technical Data

Model	E-710.3CD / E-710.P3D / E-710.A3D E-710.APD / E-710.APS	E-710.4CD / E-710.4CL / E-710.C4D E-710.4PD / E-710.P4D / E-710.P4L	E-710.6CD / E-710.6SD
Function	Digital piezo controller for multi-axis nanopositioning systems with capacitive sensors	Digital piezo controller for multi-axis nanopositioning systems with capacitive sensors	Digital piezo controller for multi-axis nanopositioning systems with capacitive sensors
Axes	3	4	6
Processor	32-bit, floating-point DSP	32-bit, floating-point DSP	2 x 32-bit, floating-point DSP
Sampling rate, servo-control	200 µs / 5 kHz	200 µs / 5 kHz	200 µs / 5 kHz
Sampling rate, sensor	50 µs / 20 kHz	50 µs / 20 kHz	40 µs / 25 kHz
<b>Sensor</b>			
Servo characteristics	P-I, two notch filters	P-I, two notch filters	P-I, two notch filters
Sensor type	Capacitive	Capacitive	Capacitive
Sensor channels	3	4	6
Sensor resolution	16 bit	16 bit	16 bit
Ext. synchronization	Yes	Yes	Yes
<b>Amplifier</b>			
Output voltage	-20 to 110 V	-20 to 110 V	-20 to 110 V
Amplifier channels	4	4	8
Peak output power per channel,	25 W	25 W	25 W
Average output power per channel	6 W	6 W	6 W
Peak current per channel, <20 ms	200 mA	200 mA	200 mA
Average current per channel, >20 ms	60 mA	60 mA	60 mA
Current limitation	Short-circuit-proof	Short-circuit-proof	Short-circuit-proof
Resolution DAC	20 bit	20 bit	20 bit
<b>Interfaces and operation see separate table</b>			
Communication interfaces	RS-232; IEEE 488 Parallel I/O (E-710.Pxx / .xPx only)	RS-232; IEEE 488; Parallel I/O (E-710.Pxx / .xPx only)	RS-232; IEEE 488
Command set	GCS	GCS	GCS
User software	PIMikroMove™, PZTControl™, NanoCapture™	PIMikroMove™, PZTControl™, NanoCapture™	PIMikroMove™, PZTControl™, NanoCapture™
Software drivers	LabVIEW drivers, DLLs	LabVIEW drivers, DLLs	LabVIEW drivers, DLLs
Supported functionality	Wave generator, data recorder	Wave generator, data recorder	Wave generator, data recorder
Display	Power LED	Power LED	Power LED
Linearization	4th order polynomials, DDL (optional)	4th order polynomials, DDL (optional)	4th order polynomials, DDL
<b>Miscellaneous</b>			
Operating temperature range	5 to 50 °C	5 to 50 °C	5 to 50 °C
Dimensions	450 x 88 x 343 mm + handles	450 x 88 x 343 mm + handles	450 x 88 x 343 mm + handles
Mass	7 kg	7 kg	7 kg
Operating voltage	90–120 or 220–264 VAC, 50–60 Hz	90–120 or 220–264 VAC, 50–60 Hz	90–120 or 220–264 VAC, 50–60 Hz
Max. power consumption	60 W	60 W	120 W

# E-712 Ultra-High Performance Digital Nanopositioning Controller

## Modular Platform for Precision Piezo Systems and NEXLINE® Drives



Example for the modular use of an E-712 for the vertical and tilt system with three mixed, hybrid drives. They consist of NEXLINE® linear actuators with additional PICMA® actuators for an increased fine adjustment range.

The E-712 digital piezo controller is ideal when it comes to meeting the most demanding accuracy and dynamic-performance requirements of multi-axis nanopositioning systems. The high-performance, real-time operating system makes possible coordinated servo-control of multiple axes (also in parallel-kinematics systems) and thus ensures excellent trajectory control even during complex motion. The modular design allows flexible configuration of systems supporting the number of axes and channels required for the application. Flexibility in meeting customers' needs is also behind the interface design: The optional analog inputs and outputs support processing external sensor or control signals as well as driving external amplifiers.

### Digital Linearization and Control Algorithms for Highest Accuracy

Linearization algorithms based on higher-order polynomials improve the positioning accuracy to better than 0.01% for capacitive sensors, typically

10 times better than achievable with conventional controllers.

### More than just a Controller – Trajectory Control and Data Recording

During fast periodic motion, as typical for scanning applications, the tracking accuracy can be further improved with Dynamic Digital Linearization (DDL, E-710.SCN). This optionally available control algorithm reduces the tracking error by a factor of up to 1000 and enables the spatial and temporal tracking during a dynamic scan. The integrated wave generator can output periodic motion profiles. In addition to sine and triangle waves, arbitrary, user-defined motion profiles can be created and stored. The flexibly configurable data recorder enables simultaneous recording and read-out of the corresponding data.

### Flexible Analog Inputs and Real-time PIO

Each of the four optionally available analog inputs can be configured in two ways. When used as a control input, the applied voltage is linked to one of

the axes, for target value settings, for example. When configured as an external sensor input, additional sensor signals e.g. for auto-focusing, can be read in. Alternatively, the system can be equipped with a fast 32-bit PIO (Parallel I/O) for placing commands. The PIO supports a restricted command set required for the motion with 100,000 read and write commands per second.

### Simple System Integration

All parameters can be checked and reset via software. System setup and configuration is done with the included NanoCapture™ and PIMikroMove™ user-interface software. Interfacing to custom software is facilitated with included LabVIEW drivers and DLLs. System programming is the same with all PI controllers, so controlling a system with a variety of different controllers is possible without difficulty.

### Ordering Information

**E-712.3CD**  
Modular Digital Multi-Channel Piezo Controller, 3 Channels, Capacitive Sensors

**E-712.3CDA**  
Modular Digital Multi-Channel Piezo Controller, 3 Channels, Capacitive Sensors, Analog INs and OUTs

**E-712.6CD**  
Modular Digital Multi-Channel Piezo Controller, 6 Channels, Capacitive Sensors

**E-712.6CDA**  
Modular Digital Multi-Channel Piezo Controller, 6 Channels, Capacitive Sensors, Analog INs and OUTs

These models have RS-232, USB and TCP/IP Interfaces.

### Further Interfaces are available:

**E-711.IA4**  
Analog Interface Module, 4 I/O for E-712 modular, digital, Controller System

**E-711.IP**  
PIO Interface Module for E-712 modular, digital, Controller System

### Ask about custom designs!

### Options and Accessories:

**E-710.SCN**  
DDL (Dynamic Digital Linearization) Firmware Upgrade

**E-711.i1B**  
Analog Cable for Analog I/O, BNC Connector, 1.5 m

**E-711.i10**  
Analog Cable for Analog I/O, Solderable End, 1.5 m



Examples of the modular use of one E-712 for a mixed operation of low voltage and medium voltage actuators (120 V or ±250 V). The positioning system has two separate axis systems for the adjusting and actual measurement process in an inspection system.

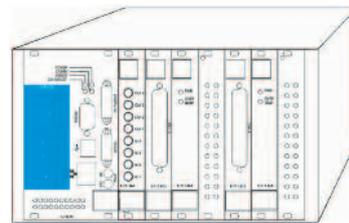
# E-712 Digital Nanopositioning Controller: Options

## Modular Platform for Precision Piezo Systems and NEXLINE® Drives



E-712 digital controller for nanopositioning systems with up to 6 axes

- Digital Controller of the Newest Generation: 600 MHz Tact Rate; up to 50 kHz Servo Update Rate; Highly Stable 20-bit D/A Converter
- Real-Time Operating System for Excellent Trajectory Control
- Modular Design for Greatest Flexibility in Meeting Custom Requirements
- Auto-Loading of Calibration Data from Stage ID-Chip for Interchangeability of Controller and Mechanics
- Versatile Interfaces: Ethernet, USB, RS-232
- Optional High-Bandwidth Analog Inputs and Outputs
- Extensive Software Support



	Preconfigured system	Digital controller unit	Case unit	Interface modul	Sensor modul	Amplifier modul	Sensor modul	Amplifier modul
Nanopositioning systems with voltage requirement of up to +120 V with 3 axes and capacitive sensors	E-712.3CD	E-712.M1*	E-712.R1*	-	E-711.SC3H*	E-711.AL4P*	-	-
Nanopositioning systems with voltage requirement of up to +120 V with up to 6 axes and capacitive sensors	E-712.6CD	E-712.M1*	E-712.R1*	-	E-711.SC3H*	E-711.AL4P*	E-711.SC3H*	E-711.AL4P*
Nanopositioning systems with voltage requirement of up to +120 V with three (six) axes and capacitive sensors; 4 analog inputs and outputs for direct issuing of commands and sensor/position evaluation	E-712.3CD (E-712.6CD)	E-712.M1*	E-712.R1*	E-711.IA4	E-711.SC3H*	E-711.AL4P*	(E-711.SC3H)*	(E-711.AL4P)*
Nanopositioning systems with voltage requirement of up to +120 V with 3 (six) axes and capacitive sensors; Parallel I/O interface for fast, digital commands PIO	E-712.3CD (E-712.6CD)	E-712.M1*	E-712.R1*	E-711.IP	E-711.SC3H*	E-711.AL4P*	(E-711.SC3H)*	(E-711.AL4P)*
Nanopositioning systems with voltage requirement of up to +120 V with 3 (six) axes and capacitive sensors and long distance between positioner and controller.		E-712.M1	E-712.R1	E-711.IA4 or E-711.IP optional	E-711.OCT	E-711.AL4P	(E-711.OCT)	(E-711.AL4P)
Nanopositioning systems with voltage requirement ±250 V (PICOCUBE®) with up to 3 axes and capacitive sensors	E-712.3CM	E-712.M1*	E-712.R4*	E-711.IA4 or E-711.IP optional	E-711.SC3H*	E-711.AM4*	-	-
Nanopositioning systems with voltage requirement of up to +120 V with three (six) axes and incremental sensors		E-712.M1	E-712.R1	E-711.IA4 or E-711.IP optional	E-711.SA3 (E-711.SA6)	E-711.AL4P	-	(E-711.AL4P)
NEXLINE® positioning system with single-axis, incremental sensors and analog interfaces or PIO (optional)		E-712.N1**	E-712.R4	E-711.IA4 or E-711.IP optional	E-711.SA3	E-711.AM4	-	-
NEXLINE® positioning system with 3 axes (combined stepping drive), incremental sensors and analog interfaces or PIO (optional)		E-712.N1**	E-712.R4	E-711.IA4 or E-711.IP optional	E-711.SA3	E-711.AM4	-	-
NEXLINE® positioning system with 3 axes (combined stepping drive), capacitive sensors and analog interfaces or PIO (optional)		E-712.N1**	E-712.R4	E-711.IA4 or E-711.IP optional	E-711.SC3	E-711.AM4	-	-

\* The modul is already included.

\*\* The single- or 3-channel NEXLINE® operation is adjustable via software commands.

# E-712 Ultra-High Performance Modular Digital Piezo Controller

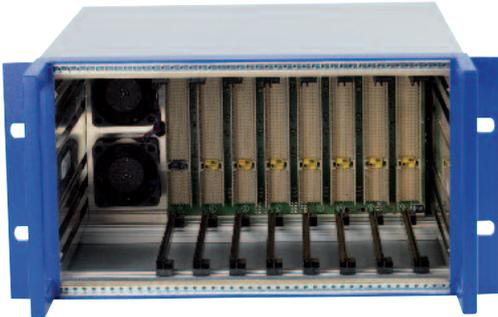
## Modular System for up to 6 Axes with Highest Precision

### Technical Data

Model	E 712.3CD	E 712.6CD	E-712.3CM
Function	Modular digital controller for multi-axis piezo nan positioning systems with capacitive sensors	Modular digital controller for multi-axis piezo nan positioning systems with capacitive sensors	Modular digital controller for PicoCube® nan positioning systems with capacitive sensors
Axes	3	6	3
Processor	PC-based, 600 MHz, real-time operating system	PC-based, 600 MHz, real-time operating system	PC-based, 600 MHz, real-time operating system
Sampling rate, servo-control	50 kHz	20 kHz	50 kHz
Sampling rate, sensor	50 kHz	20 kHz	50 kHz
<b>Sensor</b>			
Servo characteristics	P-I, two notch filters	P-I, two notch filters	P-I, two notch filters
Sensor type	Capacitive	Capacitive	Capacitive
Sensor channels	3	6	3
Sensor bandwidth (-3 dB)	10 kHz	10 kHz	10 kHz
Sensor resolution	18 Bit	18 Bit	18 Bit
Ext. synchronization	Yes	Yes	Yes
<b>Amplifier</b>			
Output voltage	-30 V to +135 V	-30 V to +135 V	-250 V to +250 V
Amplifier channels	4	8	4
Peak output power per channel	25 W	25 W	45 W
Average output power per channel	8 W	8 W	15 W
Peak current	250 mA	250 mA	180 mA
Average current per channel	100 mA	100 mA	60 mA
Current limitation	Short-circuit-proof	Short-circuit-proof	Short-circuit-proof
Resolution DAC	20-bit	20-bit	20-bit
<b>Interfaces and operation</b>			
Communication interfaces	Ethernet, USB, RS-232	Ethernet, USB, RS-232	Ethernet, USB, RS-232
Piezo / sensor connector	Sub-D special connector	Sub-D special connector	Sub-D special connector
Analog in/out	optional je 4 x LEMO, ±10 V (E-711.IA4)	optional je 4 x LEMO, ±10 V (E-711.IA4)	optional je 4 x LEMO, ±10 V (E-711.IA4)
Digital in/out	MDR20; 2 x IN, 8 x OUT; TTL	MDR20; 2 x IN, 8 x OUT; TTL	MDR20; 2 x IN, 8 x OUT; TTL
Command set	PI General Command Set (GCS)	PI General Command Set (GCS)	PI General Command Set (GCS)
User software	NanoCapture™, PIMikroMove®	NanoCapture™, PIMikroMove®	NanoCapture™, PIMikroMove®
Software drivers	LabVIEW Drivers, DLLs	LabVIEW Drivers, DLLs	LabVIEW Drivers, DLLs
Supported functionality	Wave gen, trigger I/O	Wave gen, trigger I/O	Wave gen, trigger I/O
Display	LEDs for OnTarget, Err, Power	LEDs for OnTarget, Err, Power	LEDs for OnTarget, Err, Power
Linearization	4th order polynomials, DDL-Option (Dynamic Digital Linearization)	4th order polynomials, DDL-Option (Dynamic Digital Linearization)	4th order polynomials, DDL-Option (Dynamic Digital Linearization)
<b>Miscellaneous</b>			
Operating temperature range	5 to 50 °C	5 to 50 °C	5 to 50 °C
Overtemp protection	Max. 75°C, of the piezo voltage output	Max. 75°C, deactivation of the piezo voltage output	Max. 75°C, deactivation of the piezo voltage output
Mass	5.35 kg	5.78 kg	5.43 kg
Dimensions	9,5" chassis, 236 x 132 x 296 mm + handles (47 mm length)	9,5" chassis, 236 x 132 x 296 mm + handles (47 mm length)	9,5" chassis, 236 x 132 x 296 mm + handles (47 mm length)
Power consumption	100 W max.	100 W max.	100 W max.
Operating voltage	90 to 240 VAC, 50–60 Hz	90 to 240 VAC, 50–60 Hz	90 to 240 VAC, 50–60 Hz

# E-712 Basic Modules

## Powerful Processor, Fast Digital Interfaces and Cases



The basic configuration of an E-712 system always includes a chassis (picture) and a rack- or rather an interface module



E-712 module with fast standard interfaces USB, Ethernet and RS-232

- **Digital Controller of the Newest Generation:**  
600 MHz Processor; up to 50 kHz Servo Update Rate
- **Versions for Conventional Nanopositioning and NEXLINE® Piezo Linear Drives**
- **Real-Time Operating System for Excellent Trajectory Control**
- **Flexible Interfaces: Ethernet, USB, RS-232**

The modular E-712 digital controller is the platform for the most demanding nanopositioning applications. The basic elements of the modular concept are the casing (E-712.R1 or E-712.R4) and the CPU (E-712.M1 or E-712.N1). Further components are available such as different amplifiers, signal conditioners and additional interfaces from the E-711 range.

### How many axes would you like?

For special applications, up to 13 channels can be operated in a 19" chassis (482 mm). Conventional applications with up to 6 axes can be fitted into compact 9.5" (241 mm) casings. The casings are equipped with power supplies to suit the type of drive: The E-712.R1 is designed for conventional nanopositioning with low-voltage actuators with up to 6 axes. The E-712.R4 is designed for up to 3 NEXLINE® drives or PicoCube® AFM scanners.

Adjusting the stepping motion of a drive allows operating

modes from fast stepping or a constant speed mode to the purely analog shear operation. As an alternative to operating one individual drive, the same E-712 controller can also operate nanopositioning systems with three NEXLINE® drives in coordination.

### The Hard Core

The E-712 is PC based. Its computing power is designed for processing times by having a servo update rate of up to 50 kHz, for example. In addition, algorithms for linearization, control, to transform coordinates or store trajectory information are carried out in real

time. Even for dynamic applications, the position can thus be achieved with an accuracy of a few nanometers, for example. The varying requirements placed on the motions mean there is a different computer module for nanopositioning applications with conventional ceramic actuators and NEXLINE® Walk Drives.

### Modern Interfaces

The computer module offers USB, RS-232 and a fast Ethernet interface as standard. The system can further be supplemented with an analog interface module or a very fast 32-bit PIO.



Custom design of an E-712 system in a 19" chassis for multi-combined piezo actuators and drives

### Ordering Information

For conventional nanopositioning systems with PICMA® low voltage piezo actuating or for PicoCube™

**E-712.M1**  
Digital Computer and Interface Module E-712 with Ethernet Interface, USB, RS-232

**E-712.R1**  
Digital Modular Piezo Controller System, 3 to 6 Channels, 9.5" Chassis with P/S

**E-710.SCN**  
DDL (Dynamic Digital Linearization) Firmware Upgrade

**E-712.U1**  
Advanced Piezo Control Option

**E-712.U2**  
Firmware Upgrade PicoPlane™: Option for Nanometer Precision (convenient hardware required)

**E-712.U3**  
Real-Time System Upgrade for Host PC

#### For NEXLINE® linear drives:

**E-712.N1**  
Digital NEXLINE® Processor and Interface Module E-712 with Ethernet Interface, USB, RS-232

**E-712.R4**  
Digital Modular Piezo Controller System, 3 to 6 Channels, 9.5" Chassis with Power Supply for ±250 V Piezo Voltage

**Ask about custom designs!**

## Technical Data

Model	E-712.M1	E-712.N1
Function	Digital NanoAutomation processor- and interface module with Ethernet Interface, USB Interface, RS-232	Digital NEXLINE® processor- and interface module with Ethernet Interface, USB Interface, RS-232
Processor	PC based, 600 MHz, real-time operating system	PC based, 600 MHz, real-time operating system
Sample rate control (max.)	50 kHz	50 kHz
Sample rate sensor (max.)	50 kHz	50 kHz
Sensor characteristics	P-I, two notch filters or advanced piezo control, optional	P-I, two notch filters
Temperature sensor	Yes	Yes
<b>Interfaces and operation</b>		
Communication interfaces	RS-232, USB, Ethernet (FTP, UDP, HTTP, TCP/IP)	RS-232, USB, Ethernet (FTP, UDP, HTTP, TCP/IP)
Digital Input	MDR 20, 2 x IN, TTL	MDR 20, 2 x IN, TTL
Digital Output	MDR 20, 8 x OUT, TTL	MDR 20,8 x OUT, TTL
Command set	PI General Command Set (GCS)	PI General Command Set (GCS)
User software	PI MikroMove™, NanoCapture™	PI MikroMove™, NanoCapture™
Software drivers	LabVIEW Driver, DLLs	LabVIEW Driver, DLLs
Supported functionality	Wave generator, data recorder, trigger I/O	data recorder, trigger I/O
Display	LEDs for OnTarget, Error, Power	LEDs for OnTarget, Error, Power
Linearization	4th order polynomials, DDL Option (Dynamic Digital Linearization)	4th order polynomials; linearization stepping drive
<b>Miscellaneous</b>		
Operating temperature range	5 to 50 °C	5 to 50 °C
Overtemp protection	max. 75 °C, deactivation of the piezo voltage output	max. 75 °C, deactivation of the piezo voltage output
Dimensions	12 TE 3 HE	12 TE 3HE
Mass	0.52 kg	0.52 kg
Operating voltage	90 to 240 VAC; 50–60 Hz	90 to 240 VAC; 50–60 Hz

# E-712 Sensor Modules

## High-Resolution and Solid for Capacitive and Incremental Sensors



E-711.SC3H sensor module for capacitive dual-plate sensors with nanometer resolution

- Flexible Choice of Sensor Analysis, depend on Positioning Mechanic
- For capacitive 2 or 1 Plate Sensors or incremental Sensors
- Resolution to the Sub-Nano Region
- Up to 6 Channels

### Ordering Information

#### E-711.SC3H

Module for Capacitive Sensors, 3 Channels, for E-712 modular, digital, Controller System

#### E-711.0CT

Digital Sensor Signal Transmission, 3 Channels, Capacitive Sensors, for E-712 Digital Controller

#### E-711.SE3

Module for PISeCa™ Capacitive Single-Electrode Sensors, 3 Channels, for E-712 modular, digital, Controller System

#### E-711.SA3

Module for incremental Sensors, 3 Channels, for E-712 modular, digital, Controller System

#### E-711.SA6

Module for incremental Sensors, 6 Channels, for E-712 modular, digital, Controller System

**Ask about custom designs!**

### Technical Data

Model	E-711.SC3H	E-711.0CT	E-711.SE3	E-711.SA3
Function	Modul for capacitive sensors	Module for capacitive sensors with sensor analysis (DST)	Module for capacitive PISeCa™ single-electrode sensors	Module for incremental sensors
Channels	3	3	3	3
Sensor type	capacitive	capacitive	Single-electrode, capacitive	incremental
Sensor bandwidth	10 kHz	10 kHz		
Sensor resolution	18-bit	18-bit	18-bit	16-bit
Sensor communication	Sub-D Special (multi-axis, capacitiv)	Sub-D Special (multi-axis, capacitiv), 10 m cable length between sensor analysis and controller	Sub-D Special (multi-axis, capacitiv)	Sub-D Special
Dimensions	4 TE 3 HE	4 TE 3 HE; Sensor analysis 198.5 x 102.9 x 38.3 mm	4 TE 3 HE	4 TE 3 HE
Mass	0.18 kg	Sensor analysis: 0.65 kg Interfacekarte: 0.15 kg	0.18 kg	0.15 kg

## E-712 Analog Interface Module



E-711.IA4 analog interface module

- 4 Analog Inputs
- 4 Analog Outputs
- 20-bit DA-Converter
- 18-bit AD-Converter
- Powerful FPGA
- Smallest Possible Latency
- Integrated Self-Testing

### Technical Data

Model	E-711.IA4
Function	Analog Interface Module
Channels	4 In-, 4 Outputs
Resolution Input	18-bit
Resolution Output	16-bit, 20-bit effective
Analog Input	4 LEMO, $\pm 10V$
Analog Output	4 LEMO, $\pm 10V$
Dimensions	4 TE 3 HE
Mass	0.16 kg

## E-712 Parallel-I/O Interface Modules

### Fast, Digital Command in Real-Time



E-711.IP 32-bit PIO interface

- 32-bit Resolution
- Configured for up to 6 Axis
- 500 ns Read and 1200 ns Write
- Optional Real-Time System

### Technical Data

Model	E-711.IP
Function	PIO Interface module
Resolution	32-bit
Communication interfaces	HD-Sub-D 62 connector
Speed of command	500 ns read / 1200 ns write
Supported functionality / software drivers	Optional Linux-based real-time system (E-712.U3)
Dimensions	4 TE 3 HE
Mass	0.15 kg

## E-712 Amplifier Modules

### High-Power and Low-Noise for Dynamic and Precision



E-711.AM4 amplifier module with  $\pm 250 V$  output voltage for PicoCube™ and NEXLINE®

- Flexible Options for Nanopositioning, PicoCube™ and NEXLINE® Drives
- 4 Channels
- High-Voltage, 8 W per Channel
- Highest Stability, Low Noise
- 20-bit Effective
- Powerful FPGA

### Technical Data

Model	E-711.AL4P
Function	High-Power amplifier module, 8 W, -30 bis +135 V
Channels	
Output Voltage min.	-30
Input Voltage max.	135
Peak output power per channel	25
Average output power per channel	8
Peak current per Channel	250
Average current per channel	100
Current limitation	Short-circuit-proof
Resolution DAC	20
Dimensions	8 TE 3 HE
Mass	0.48

## Program Overview

- Piezo Ceramic Actuators & Motors
- Piezo Nanopositioning Systems and Scanners
- Active Optics / Tip-Tilt Platforms
- Capacitive Nanometrology Sensors
- Piezo Electronics: Amplifiers and Controllers
- Hexapod 6-Axis Positioners / Robots
- Micropositioning Stages & Actuators
- Photonics Alignment Systems, Solutions for Telecommunications
- Motor Controllers
- Ultrasonic Linear Motors

## Request or download the complete PI Nanopositioning & Piezo Actuator Catalog



### USA (East) & CANADA

**PI (Physik Instrumente) L.P.**  
16 Albert St.  
Auburn, MA 01501  
Tel: +1 (508) 832 3456  
Fax: +1 (508) 832 0506  
info@pi-usa.us  
www.pi-usa.us

### JAPAN

**PI Japan Co., Ltd.**  
Akebono-cho 2-38-5  
Tachikawa-shi  
J-Tokyo 190  
Tel: +81 (42) 526 7300  
Fax: +81 (42) 526 7301  
info@pi-japan.jp  
www.pi-japan.jp

### CHINA

**Physik Instrumente  
(PI Shanghai) Co., Ltd.**  
Building No. 7-301  
Longdong Avenue 3000  
201203 Shanghai, China  
Tel: +86 (21) 687 900 08  
Fax: +86 (21) 687 900 98  
info@pi-china.cn  
www.pi-china.cn

### FRANCE

**PI France S.A.S**  
244 bis, avenue Max Dormoy  
92120 Montrouge  
Tel: +33 (1) 55 22 60 00  
Fax: +33 (1) 41 48 56 62  
info.france@pi.ws  
www.pi-france.fr

### GERMANY

**Physik Instrumente (PI)  
GmbH & Co. KG**  
Auf der Römerstr. 1  
D-76228 Karlsruhe/Palmbach  
Tel: +49 (721) 4846-0  
Fax: +49 (721) 4846-100  
info@pi.ws · www.pi.ws

### USA (West) & MEXICO

**PI (Physik Instrumente) L.P.**  
5420 Trabuco Rd., Suite 100  
Irvine, CA 92620  
Tel: +1 (949) 679 9191  
Fax: +1 (949) 679 9292  
info@pi-usa.us  
www.pi-usa.us

**PI Japan Co., Ltd.**  
Hanahara Dai-ni Building, #703  
4-11-27 Nishinakajima,  
Yodogawa-ku, Osaka-shi  
J-Osaka 532  
Tel: +81 (6) 6304 5605  
Fax: +81 (6) 6304 5606  
info@pi-japan.jp  
www.pi-japan.jp

### UK & IRELAND

**PI (Physik Instrumente) Ltd.**  
Trent House  
University Way,  
Cranfield Technology Park,  
Cranfield,  
Bedford MK43 0AN  
Tel: +44 (1234) 756 360  
Fax: +44 (1234) 756 369  
uk@pi.ws  
www.physikinstrumente.co.uk

### ITALY

**Physik Instrumente (PI) S.r.l.**  
Via G. Marconi, 28  
I-20091 Bresso (MI)  
Tel: +39 (02) 665 011 01  
Fax: +39 (02) 873 859 16  
info@pionline.it  
www.pionline.it