

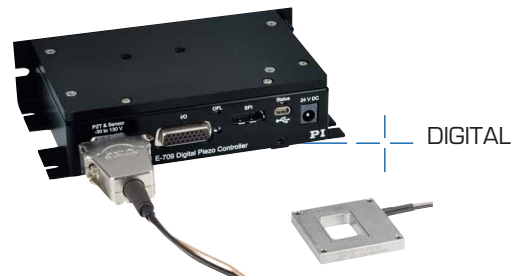
Controllers for Piezo (Flexure) Actuators

Digital, Analog, High Power, Affordable

HIGH POWER



FLEXIBLE



DIGITAL

E-709 Low-Cost Digital Piezo Nano-Positioning Controller

Increased Performance for Piezo Systems with Strain Sensors



Compact, low-cost E-709 digital controller (preliminary case design) with P-712 piezo-scanner

- **Fast Digital Controller, Software Configurable Servo Parameters**
- **Linearity of SGS and Piezoresistive Sensors Improved by up to 0.02 %**
- **USB and RS-232 Interfaces**
- **Fast 25 Mbit/s Serial Interface**
- **Comprehensive I/O Functions**
- **Additional High-Bandwidth Analog Control Input / Sensor Input**
- **Analog Output, e. g. for External Amplifiers**
- **Low-Cost OEM Versions Available**
- **Comprehensive Software Package**

The E-709 opens up the possibilities of digital control for piezo-driven nanopositioning systems for the same price as analog controllers. It was designed for piezo actuators and nanopositioning stages which are equipped with cost effective measuring systems such as strain gauges or piezoresistive sensors. The advantage: higher precision, more control options and very simple operation. In addition, PI provides the full functionality of its comprehensive software packages free of charge! The E-709 can also be used for applications providing analog control signals. In addition to a variety of digital interfaces an analog input and output are also included. A software command allows the analog input to be interpreted as position control signal or as a

sensor value. The analog output can be configured for the control of external amplifiers or for the output of position values.

Digital Linearization for Strain Sensors: 10 x More Precise!

For the first time, the E-709 nanopositioning controller opens up the advantages of digital control to compact systems with strain sensors. These sensors are based on the strain of metal foils or semiconductor films (piezoresistive sensors) and are used when space limitations prevent the use of the more advanced capacitive sensors, or where the requirements in terms of resolution or temperature stability are not as critical.

The limited linearity of these strain sensors can be improved by digital controllers, which use

additional linearization algorithms to minimize the deviation between target and actual position. This improves the accuracy by up to one order of magnitude and achieves linearity values of up to 0.02 %.

Flexibility: Software Configurable Servo Parameters

All servo controllers require tuning and adjustment of servo parameters for optimum performance (e.g. as a result of changes to the load or the motion profile). With a digital controller, all adjustments are carried out by simple software commands and the resulting motion or transient characteristics can be viewed, analyzed and further optimized immediately with the provided software. It is also possible to switch between previously found sets of parameters when the controller is in operation. Since jumpers and potentiometers no longer have to be set manually, system integration becomes much more straightforward.

OEM Versions at an Even Lower Price

E-709 controllers are also offered without case. A lower cost version sold as the E-609 is available for purely analog control signals, maintaining the advantages of digital signal processing and parameter setting.

Ordering Information

E-709.PRG
Digital Piezo Controller, 1 Channel, -30 to 130 V, Piezoresistive Sensors, Bench-Top

E-709.SRG
Digital Piezo Controller, 1 Channel, -30 to 130 V, SGS-Sensor, Bench-Top

E-709.PR
Digital Piezo Controller, 1 Channel, OEM Module, -30 to 130 V, Piezoresistive Sensors

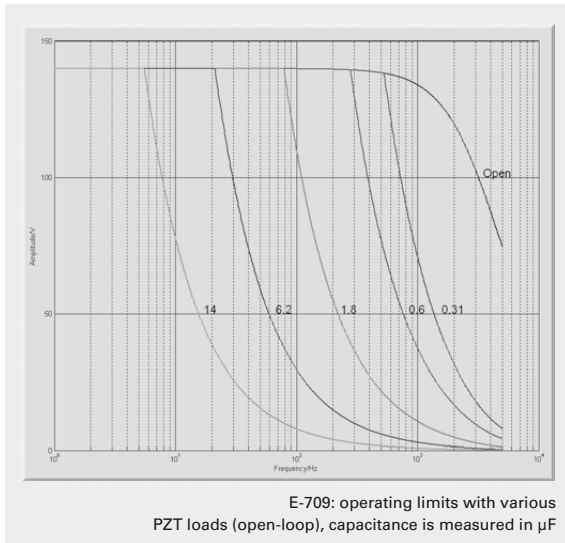
E-709.SR
Digital Piezo Controller, 1 Channel, OEM Module, -30 to 130 V, SGS-Sensor

The E-709 is also available for capacitive sensor-equipped positioning systems.

The target position is controlled via an analog signal, allowing system components with analog output (e.g. autofocus) to be integrated easily.

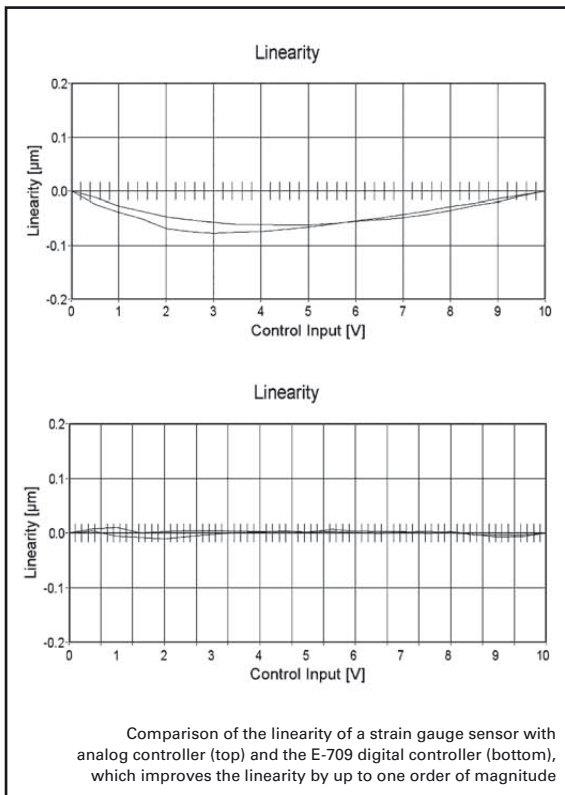


E-709 OEM Version board



Technical Data

Modell	E-709.SR E-709.SRG E-709.PR E-709.PRG
Function	Digital controller for single-axis piezo nanopositioning systems (.SR, .PR: OEM board)
Channels	1
Processor	DSP 32-bit floating point, 150 MHz
Servo characteristics	P-I, two notch filters, sensor linearization
Sampling rate, servo control	10 kHz
Sampling rate, sensor	10 kHz
Sensor	
Sensor type	Metal foil strain gauge sensors (.SR, .SRG), Piezoresistive sensors (.PR, .PRG)
Linearization	5th order polynomials
Sensor bandwidth	5 kHz
Sensor resolution	16 bit
Ext. synchronization	No
Amplifier	
Output voltage	-30 V to +130 V
Peak output power	10 W (<5 ms)
Average output power	5 W (>5 ms)
Peak current	100 mA (<5 ms)
Average current	50 mA (>5 ms)
Current limitation	Short-circuit-proof
Resolution DAC	17 bit
Interfaces and operation	
Communication interfaces	USB, RS-232, SPI
Piezo / sensor connector	Sub-D 9-pin
I/O connector	HD-Sub-D 26-pin, 1 analog control input 0 to 10 V, 1 sensor monitor 0 to 10 V, 1 digital input (LVTTTL, programmable), 1 analog output, 5 digital outputs (LVTTTL, 3 predefined, 2 programmable)
Command set	PI General Command Set (GCS)
User software	PIMikroMove, NanoCapture
Software drivers	LabVIEW drivers, DLLs
Supported functionality	Wave generator, data recorder, auto zero, trigger I/O
Display	Status LED, overflow LED
Miscellaneous	
Operating temperature range	8 to 50 °C (over 40 °C, max. power av. power derated)
Dimensions	160 x 96 x 33 mm
Mass	260 g (.SR/.PR), 470 g (.SRG/.PRG)
Operating voltage	24 VDC
Power consumption	24 W max.



E-625 Controller for Closed-Loop Piezo Linear Actuators

Compact Bench-Top Device with High-Speed Interface



E-625.CR compact piezo servo-controller

- **Integrated 24-Bit USB Interface**
- **Network Capability with up to 12 Channels**
- **120 mA Peak Current**
- **Position Control with Strain Gauge or Capacitive Sensor**
- **Notch Filter for Higher Bandwidth**
- **Table for User-Defined Curves**
- **Additional Analog Interface**

The single-channel E-625 piezo controller is equipped with a RS-232 and USB interface and precision 24-bit A/D converters for exceptional positional stability and resolution. It integrates a low-noise integrated piezo amplifier which can output and sink peak currents of 120 mA for low-voltage piezoelectric actuators. Servo-controller versions for position sensing with capacitive or SGS sensors are available.

PI employs proprietary position sensors for fast response and optimum positioning resolution and stability in the nanometer range and below. For high-end applications, capacitance sensors provide direct and non-contact position feedback (direct metrology). Strain gauge sensors (SGS) are available for cost-effective applications. The integrated notch filters (adjustable

for each axis) improve the stability and allow high-bandwidth operation closer to the resonant frequency of the mechanics.

Multi-Axis Network for up to 12 Channels

Up to twelve E-625 for capacitive or SGS sensors can be networked and controlled over a single PC interface. The different units are connected in parallel (not daisy-chained) over the link providing higher data rates than possible with serial links. Between the individual E-625s, parallel networking is realized via optional E-625.CN cables.

High-Resolution Digital Interface

The digital interface includes high-precision 24-bit A/D converters for optimum position stability and resolution and supports fast communication with the host-computer.

Waveform Memory

The built-in wave table can store user-defined data points internally. These values can then be output automatically (or under the control of an external signal) and programmed for point-by-point or full-scan triggering. Thus, trajectory profiles can be repeated reliably and commanded easily.

Extensive Software Support

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

The extensive command set is based on the hardware-independent General Command Set (GCS), which is common to all current PI controllers for both nano- and micropositioning systems. GCS reduces the pro-

Ordering Information

E-625.CR
Piezo Amplifier / Servo-Controller, 1 Channel, -30 to 130 V, Capacitive Sensor, USB, RS-232

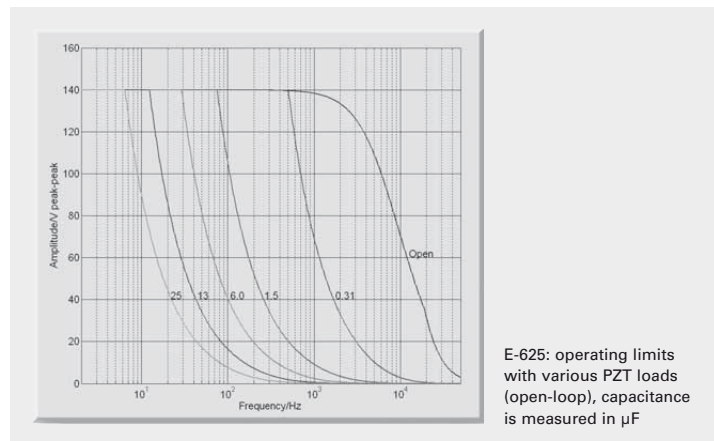
E-625.SR
Piezo Amplifier / Servo-Controller, 1 Channel, -30 to 130 V, SGS-Sensor, USB, RS-232

E-625.CN
Network Cable for Networking of Two E-625

E-625.C0
PIFOC® Piezo Amplifier / Servo-Controller, 1 Channel, -30 to 130 V, Capacitive Sensor

E-625.S0
PIFOC® Piezo Amplifier / Servo-Controller, 1 Channel, -30 to 130 V, SGS-Sensor

gramming effort in the face of complex multi-axis positioning tasks or when upgrading a system with a different PI controller.



E-625: operating limits with various PZT loads (open-loop), capacitance is measured in μF



Ideal system configuration: E-625.CR with P-725 PIFOC® microscope objective positioner



Two single-channel piezo controllers: E-625 and the more powerful E-665 (background)

Technical Data

Model	E-625.SR / E-625.CR
Function	Piezo Amplifier / Servo-Controller
Axes	1
Sensor	
Servo characteristics	P-I (analog), notch filter
Sensor type	SGS (.S) / capacitive (.C)
Amplifier	
Control input voltage range	-2 to 12 V
Min. output voltage	-30 to 130 V
Peak current, < 5 ms	120 mA
Average current	60 mA
Current limitation	Short-circuit-proof
Noise, 0 to 100 kHz	0.8 mVrms
Voltage gain	10 ±0.1
Input impedance	100 kΩ
Interfaces and operation	
Interface / communication*	USB, RS-232 (9-pin Sub-D connector, 9.6–115.2 kBaud), 24-bit A/D and 20-bit D/A
Piezo connector	LEMO ERA.00.250.CTL (.SR) / Sub-D Special (.CR)
Sensor connection	LEMO EPL.0S.304.HLN (.SR) / Sub-D Special (.CR)
Control input sockets	SMB
Sensor monitor socket	SMB
Controller network	up to 12 channels, parallel
Command set*	PI General Command Set (GCS)
User software*	PIMikroMove
Software drivers*	LabVIEW drivers, DLL's
Supported functionality*	Wave table, 256 data points, external trigger, 16 macros
Miscellaneous	
Operating temperature range	+5 to +50 °C
Overheat protection	Deactivation at 75°C
Dimensions	205 x 105 x 60 mm
Mass	1.05 kg
Operating voltage	12 to 30 V DC, stabilized (power supply included)
Current consumption	2 A

* E-625.S0 and E-625.C0 without interface

E-481 Controller for High-Force Piezo Linear Actuators

2000 W and Energy Recovery for High Efficiency



E-481.00 high-power amplifier, optionally available with E-509 servo-controller and E-517 interface and display module

- **Peak Power 2000 W**
- **Energy Recovery**
- **Output Voltage 0 to ± 1000 V or Bipolar**
- **Overheat Protection for Piezo Actuators with Temperature Sensor**
- **Optional Position Servo-Control Modules**
- **Computer Interface & Display Modules**

The E-481 high-power piezo amplifier/controller is specifically designed for dynamic operation of high-capacitance PICA™ PZT actuators.

The E-481 is based on a novel design combining pulse width modulation and energy recovery. Instead of dissipating the reactive power in heat sinks, this energy is temporarily stored in inductive elements. Only the active power used by the piezo actuator has to be delivered. The energy not used by the actuator is returned to the amplifier and reused as supply voltage via a step-up transforming process. A peak sink and source current of up to 2000 mA is possible.

Selectable Output Range

The output range can be set to positive, negative or bipolar, and provides a voltage swing of 1100 V in open-loop operation.

Open-Loop and Closed-Loop Operation

E-481 amplifiers can be used to drive open- and closed-loop piezo positioning systems.

For open-loop piezo operation the amplifier output voltage is determined by the analog signal at the Control Input combined with the DC-offset potentiometer setting. Open-loop operation is ideal for applications where the fastest response and the highest bandwidth are essential. Here, commanding and reading the target position in absolute values is either not important or carried out by an external feedback loop. The Control In signal can be adjusted by various settings.

Optional Servo Controller Upgrade

The E-481.00 allows easy installation of an optional E-509

(see p. 2-152) sensor- / servo-controller module for closed-loop piezo position control. In this mode the amplifier is slaved to the E-509 servo controller. Depending on the attached piezo mechanics and feedback sensor, positioning accuracy and repeatability in the nanometer range and below are feasible.

Computer Control

The E-517 computer interface/display module can also be installed in the E-481.

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.

Thermal Piezo Protection Circuit

The E-481 features a temperature sensor input and control circuit to shut down the amplifier if the connected piezo ceramic exceeds a maximum temperature threshold.



High-load piezo actuators P-235.1S, .4S and .9S, P-225.8S and .1S (from left) with CD for size comparison

Ordering Information

E-481.00
HVPZT Piezo Amplifier / Controller, Energy Recovery, 1100 V, 2000 W, 19"

Note
Requires Piezo Actuators with Option P-177.50, Temperature Sensor and Protective Air

Upgrades Sensor / Servo-Control Modules

E-509.C1A
Sensor / Servo-Controller Module, Capacitive Sensor

E-509.S1
Sensor / Servo-Controller Module, SGS-Sensor

Interface / Display Modules

E-517.i1
Interface-/Display Module, 24 Bit D/A Ethernet, USB, RS-232, 1 Channel

E-515.01
Display Module for PZT Voltage and Position

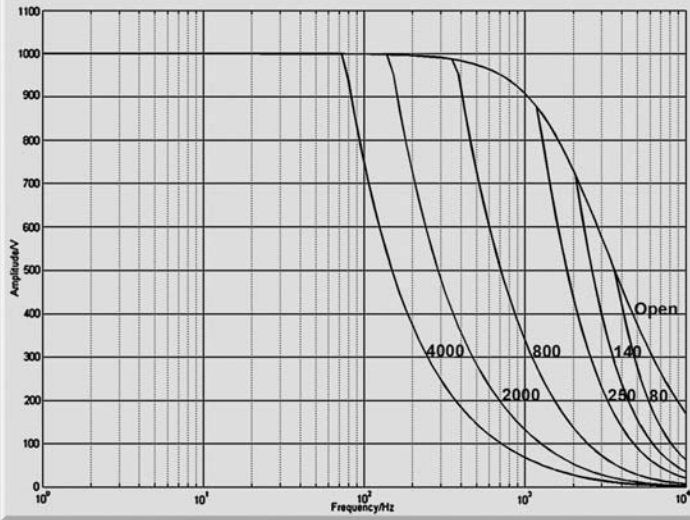
E-500.ACD
LabView with Driver Set for Analog Controllers

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

Supports Certain D/A Boards.

Extension cables, adapters & connectors: see in "Accessories" in the "Piezo Drivers / Servo Controllers" section, (p. 2-168 ff).

Ask about custom designs!



E-481: operating limits with various PZT loads, capacitance is measured in nF

Technical Data

Model	E-481.00
Function	Power amplifier for PICA™ high-voltage PZTs
Amplifier	
Output voltage	0 to 1100 V (default) (Selectable -260 to +780 V -550 to +550 V +260 to -780 V 0 to -1100 V)
Amplifier channels	1
Average output power	equivalent to 630 VA reactive power
Peak output power <5 ms	2000 VA
Average current	>600 mA
Peak current <5 ms	2000 mA
Amplifier bandwidth, small signal	5 kHz (660 nF), 1 Hz (3.4 μF)
Amplifier bandwidth, large signal	1.4 kHz (660 nF), 350 Hz (3.4 μF)
Ripple, noise	150 mV _{RMS} 0 to 100 kHz 2000 mV _{P-P} (100 nF)
Current limitation	Short-circuit-proof
Voltage gain	+100
Control input voltage	Servo off: ±1/100 of selected output range Servo on: 0 to 10 V
Input impedance	100 kΩ
Interface and operation	
PZT voltage output socket	LEMO EGG.0B.701.CJL1173
Control input socket	BNC
PZT temperature sensor	Max 85 °C, high voltage output is automatically deactivated if PZT temperature out of range
DC Offset	10-turn pot., adds 0 to +10 V to Control IN
Miscellaneous	
Operating voltage	100–120 or 220–240 VAC, 50–60 Hz (fuse change required)
Operating temperature range	+5 to +50 °C (over 40 °C, max. av. power derated 10 %)
Weight	8.6 kg
Dimensions	288 x 450 x 158 mm

E-500 · E-501 Modular Piezo Controller

Flexible System for Piezo Actuators and Nanopositioners



Configuration example: E-500 Chassis with optional modules: E-505 piezo amplifier (3 x), E-509.S servo-controller for SGS sensors, 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

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



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