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



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

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 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).

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!

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

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E-500 · E-501 Modular Piezo Controller

Module Survey & Ordering Information

A more compact 9½-inch version of the system is available as the E-501.00. It can hold one amplifier module (1- or 3-channel units available), one servo-control module (1- or 3-channel) and one display / interface module (1- or 3-channel).

A modified E-500 chassis for more channels is available on request. For systems with up to 12 channels, the E-500.621 chassis with E-621 amplifier / controller modules can be used (see p. 2-160).

The following modules can be installed in an E-500 / E-501 chassis:

Amplifier modules

E-503.00

Piezo Amplifier Module, -20 to 120 V, 3 Channels

E-504.00F

High-Power-Piezo Amplifier Module, 1 Channel, 280 W Peak Power, 100 W Average Power, -30 to 135 V

E-505.00

Piezo Amplifier Module, 200 W, -20 to 120 V, 1 Channel

E-508.00

HVPZT-Piezo Amplifier Module, +3 to +1100 V, 1 Channel

Sensor and Servo-Control Modules

E-509.C1A

Sensor / Piezo Servo-Control Module, Capacitive Sensor, 1 Channel

E-509.C2A

Sensor / Piezo Servo-Control Module, Capacitive Sensors, 2 Channels

E-509.C3A

Sensor / Piezo Servo-Control Module, Capacitive Sensors, 3 Channels

E-509.S1

Sensor / Piezo Servo-Control Module, SGS Sensor, 1 Channel

E-509.S3

Sensor / Piezo Servo-Control Module, SGS-Sensors, 3 Channels

E-509.E3 (see p. 3-12)

PISeca™ Sensor / Piezo Servo-Control Module for Single-Electrode Capacitive Sensor Probes, 3 Channels

E-509.E03 (see p. 3-12)

PISeca™ Modular Signal Conditioner Electronics for Single Electrode Capacitive Sensors, 3 Channels

Module for Servo-Control for External Piezo Amplifier

E-515.E3

In- / Output Module for Servo Control with External Piezo Amplifier, 3 Channels
Note: this module can only be used together with an E-509 servo controller module and is installed in the amplifier slot

Interface / Display Modules

E-517.i1

Interface / Display Module, 24-Bit D/A, TCP / IP, USB, RS-232, 1 Channel

E-517.i3

Interface / Display Module, 24-Bit D/A, TCP / IP, USB, RS-232, 3 Channels

E-515.01

Display Module for Piezo Voltage and Displacement, 1 Channel

E-515.03

Display Module for Piezo Voltage and Displacement, 3 Channels


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E-505, p. 2-147


E-503, p. 2-146


E-515, p. 2-154


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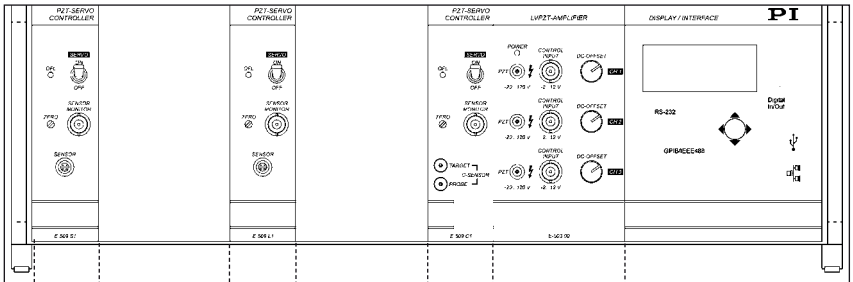
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E-500 · E-501 Modular Piezo Controller

System Configuration

E-500, 19" Chassis Models

E-501, 9.5" Chassis



E-500 chassis with the following optional modules: E-503 LVPZT amplifier, three E-509 piezo servo-controllers (E-509.S1: strain gauge; E-509.C1A: capacitive sensor) and DAC interface/display.

	Contr. Slot 3	Amplifier Slot 3	Contr. Slot 2	Amplifier Slot 2	Contr. Slot 1	Amplifier Slot 1	Display/ Interface Slot
Installable Amplifier Modules							
E-503.00 (-20 to 120 V, 3 ch) / E-503.00S*						◢	
E-504.00 (-30 to 135 V, 1 ch) / E-504.00S*		■		■		◢	
E-505.00 (-20 to 120 V, 1 ch) / E-505.00S*		■		■		◢	
E-508.XX (+3 to 1100 V, 1 ch)		■		■		◢	
Installable Sensor & Position Servo-Control Modules							
E-509.C1A (Capacitive, 1 ch)	■		■		◢		
E-509.S1 (SGS, 1 ch)	■		■		◢		
E-509.C2A (Capacitive, 2 ch)					◢		
E-509.C3A (Capacitive, 3 ch)					◢		
E-509.S3 (SGS, 3 ch)					◢		
Installable Display/Interface Modules							
E-515 (1 / 3 ch)							◢
E-517 (1 / 3 ch)							◢
Minimal Configuration, Piezo Amplifier Function only							
		■		■		◢	
Extended Configuration, Piezo Amplifier with additional Position Servo-Controller							
	■	■	■	■	◢	◢	
Extended Configuration, Piezo Amplifier with additional Display/Interface, no Servo-Controller							
		■		■		◢	◢
Extended Configuration, Piezo Amplifier with additional Servo-Controller and Display/Interface							
	■	■	■	■	◢	◢	◢

■ Can be installed in E-500 ◢ Can be installed in E-501 or E-500

* For differential tip/tilt systems with one fixed voltage of +100 V.

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Configuration Examples

- **Low-Voltage Piezo Amplifiers, 3 Channels (14 W), Medium Dynamics, No Display:**

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

  1 x E-503.00
  Piezo Amplifier Module, -20 to 120 V, 3 Channels

- **High-Voltage Piezo Amplifier for PICA™, 3 Channels, with PC Interface and Display:**

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

  3 x E-508.00
  HVPZT-Piezo Amplifier Module, +3 to +1100 V, 1 Channel

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

- **High-Voltage Piezo Amplifier / Servo-Controller (Strain Gauge Sensors), 3 Channels, with PC Interface and Display:**

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

  3 x E-508.00
  HVPZT-Piezo Amplifier Module, +3 to +1100 V, 1 Channel

  1 x E-509.S3
  Sensor / Piezo Servo-Control Module, SGS-Sensors, 3 Channels

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

- **Position Feedback Control of a P-734.2CL XY Nanopositioning Stage (Capacitive Position Sensors), Minimum Response Time, Analog Control:**

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

  2 x E-505.00
  Piezo Amplifier Module, 200 W, -20 to 120 V, 1 Channel

  1 x E-509.C2A
  Sensor / Piezo Servo-Control Module, Capacitive Sensors, 2 Channels

- **Position Feedback Control of a P-733.2CL XY Nanopositioning Stage (Capacitive Position Sensors) and P-721.CLQ PIFOC® Objective Positioner (Capacitive Position Sensor), Medium Dynamics, PC Control, Compact Design:**

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

  1 x E-503.00
  Piezo Amplifier Module, -20 to 120 V, 3 Channels

  1 x E-509.C3A
  Sensor / Piezo Servo-Control Module, Capacitive Sensors, 3 Channels

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

- **Position Feedback Control of a S-325 Tip/Tilt Platform (Strain Gauge Sensors), Minimum Response Time, Analog Control:**

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

  2 x E-505.00
  Piezo Amplifier Module, 200 W, -20 to 120 V, 1 Channel

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

  1 x E-509.S3
  Sensor / Piezo Servo-Control Module, SGS-Sensors, 3 Channels

- **Position Feedback Control of a P-733.2CL XY Nanopositioning Stage (Capacitive Position Sensors) and a P-721.SL2 PIFOC® Objective Positioner (Strain Gauge Position Sensor), Minimum Response Time, Analog Control:**

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

  3 x E-505.00
  Piezo Amplifier Module, 200 W, -20 to 120 V, 1 Channel

  1 x E-509.C2A
  Sensor / Piezo Servo-Control Module, Capacitive Sensors, 2 Channels

  1 x E-509 .S1
  Sensor / Piezo Servo-Control Module, SGS Sensor, 1 Channel

- **Position Feedback Control of 3 P-841.10 Piezo Translators (Strain Gauge Position Sensors), Medium Dynamics, Analog Control, with Future Upgrade Option for High-Power, High-Dynamics Amplifiers E-505 (Large Chassis):**

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

  1 x E-503.00
  Piezo Amplifier Module, -20 to 120 V, 3 Channels

  1 x E-509.S3
  Sensor / Piezo Servo-Control Module, SGS-Sensors, 3 Channels

  Option:

  1 x E-515.03
  Display Module for Piezo Voltage and Displacement, 3 Channels

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E-517 Digital Piezo Controller Operation Module

Wave Generator, Data Recorder, Display, Multiple Interfaces, for E-500 System



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

- **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**
- **Module for E-500 Piezo Controller Rack**

The E-517 is a microprocessor controlled interface and display module for the E-500 piezo controller system (see p. 2-142). It is equipped with low-noise, 24-bit D/A converters and can be controlled through four digital interfaces: TCP/IP, USB, RS-232 and IEEE 488 (GPIB).

Alternatively, stand-alone operation is possible by uploading macro command sequences to the internal non-volatile memory. For manual control a trackball interface is provided. An LCD display indicates position or operating voltages of the individual channels / axes.

Wave Generator

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.

Extensive Software Support

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

Ordering Information

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

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Technical Data

Model	E-517.i1	E-517.i3
Function	Digital operation module	Digital operation module
Channels	1	3
Processor	DSP 60 MHz	DSP 60 MHz
Sampling rate, sensor	25 kHz, 8-times oversampling	25 kHz, 8-times oversampling
Thermal drift	Stability: 0.2 mV	Stability: 0.2 mV
Linearity @ nominal range	0.01%	0.01%
Resolution	DAC: 24 bit, ±12 V ADC: 18 bit, sampling	DAC: 24 bit, ±12 V ADC: 18 bit, sampling
Interfaces and operation		
Interfaces/communication	Ethernet (TCP/IP), USB, RS-232, IEEE 488	Ethernet (TCP/IP), USB, RS-232, IEEE 488
I/O ports	1 trigger input 1 trigger output 5 V MDR14 connector	3 trigger inputs 3 trigger outputs 5 V MDR14 connector
Command set	PI General Command Set (GCS)	PI General Command Set (GCS)
User software	PIMikroMove™	PIMikroMove™
Software drivers	Lab VIEW drivers, Windows and Linux Libraries (DLL)	Lab VIEW drivers, Windows and Linux Libraries (DLL)
Supported functionality	Wave generator, data recorder, macro programming	Wave generator, data recorder, macro programming
Display	LCD display for monitor signals (position and voltage), states and trackball menus	LCD display for monitor signals (position and voltage), states and trackball menus
Manual control	Operation via trackball	Operation via trackball
Miscellaneous		
Operating temperature range	+5 to +50° C	+5 to +50° C
Dimensions	21HP / 3U	21HP / 3U
Mass	0.37 kg	0.37 kg
Operating voltage	E-500 system	E-500 system

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E-509 Signal Conditioner / Piezo Servo Module

3-Channel Servo-Controller Module for E-500 Piezo Controller System



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

Ordering Information

E-509.C1A
Sensor / Piezo Servo-Control Module, Capacitive Sensor, 1 Channel

E-509.C2A
Sensor / Piezo Servo-Control Module, Capacitive Sensors, 2 Channels

E-509.C3A
Sensor / Piezo Servo-Control Module, Capacitive Sensors, 3 Channels

E-509.S1
Sensor / Piezo Servo-Control Module, SGS Sensor, 1 Channel

E-509.S3
Sensor / Piezo Servo-Control Module, SGS-Sensors, 3 Channels

Ask about custom designs!

- **Position Servo-Control for Piezo Mechanics with SGS or Capacitive Sensors**
- **1-, 2- and 3-Channel Versions**
- **Improves Linearity**
- **Eliminates Drift and Hysteresis**
- **Notch Filter for Higher Bandwidth**
- **Increases Piezo Stiffness**
- **ILS Circuitry Maximizes Capacitive Sensor Linearity**
- **Plug-In Module for E-500 System**
- **Prepared for Interfaces / Display Modules (optional)**

The E-509 module is both a signal conditioner for high-resolution capacitive and SGS displacement sensors and a servo-controller for closed-loop piezo nanopositioning mechanics. It compensates for the drift and hysteresis inherent in PZT materials and quickly adjusts the operating voltage on the PZT as soon as a change in force or load occurs. Single- and multi-channel versions for strain gauge and capacitive sensors are available.

Nanometer-Precise Piezo Positioning

The proportional-integral (P-I) algorithm used by the E-509 servo-controller is optimized for piezo operation. Both P and I parameters as well as the control bandwidth can be set internally. The integrated notch filters (adjustable for each axis) improve the stability and allow high-bandwidth operation closer to the piezomechanics' resonant frequency. Closed-loop piezo mechanics from PI can provide positioning accuracy and repeatability down to the nanometer range and below.

Two Types of Sensors

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.

For PISeca™ single-plate high-resolution capacitive sensors (see p. 3-8), the E-509.E3 or E-509.E03 versions are available (see p. 3-12).

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The E-509 controller module installed in an E-501 9½-inch chassis together with E-516 digital interface and E-503 three-channel amplifier modules

Technical Data

Model	E-509.C1A/E-509.C2A/E-509.C3A	E-509.S1/E-509.S3
Function	Signal conditioner & servo-controller for piezo mechanics	Signal conditioner & servo-controller for piezo mechanics
Channels	1/2/3	1/3
Sensor		
Servo characteristics	P-I (analog), notch filter	P-I (analog), notch filter
Sensor type	Capacitive	SGS
Sensor channels	1 / 2 /3	1 / 3
Sensor bandwidth	0.3 to 3 kHz (selectable with jumper); up to 10 kHz on request	0.3; 1; 3 kHz
Noise factor	0.115 ppm/Hz½	
Thermal drift	<0.3 mV / C°	<3 mV / C°
Linearity	<0.05%	<0.2%
Interfaces and operation		
Sensor connection	LEMO EPL.00.250.NTD	LEMO ERA.0S.304.CLL
Sensor monitor output	0–10 V	0–10 V
Sensor monitor socket	LEMO 6-pin FGG.0B.306.CLAD56	BNC (1-ch.) / 3-pin. LEMO (3-ch.)
Supported functionality	ILS (Integrated Linearization System)	ILS (Integrated Linearization System)
Display	Overflow LED	Overflow LED
Miscellaneous		
Operating temperature range	+5 to +50 °C	+5 to +50 °C
Dimensions	7HP/3U	7HP/3U
Mass	0.35 kg	0.35 kg
Operating Voltage	E-500 System	E-500 System
Max. power consumption	4 to 8 W	4 to 8 W

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E-503 Piezo Amplifier Module

3 Channels, for E-500 Piezo Controller System

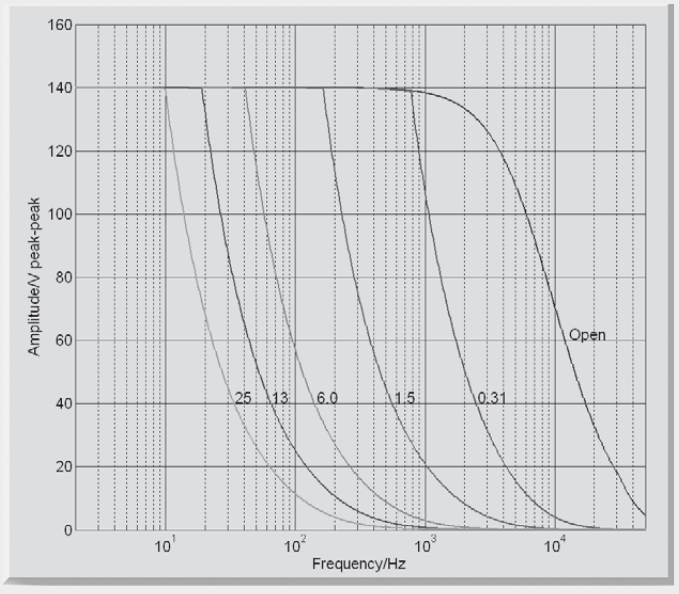


E-503.00 Piezo amplifier module

- **Module for E-500 Piezo Controller Rack**
- **3 x 140 mA Peak Current**
- **Output Voltage Range -30 to 130 V**
- **Prepared for Position Servo-Control Upgrade (optional)**
- **Prepared for Interfaces / Display Modules (optional)**

The E-503 is a piezo driver module for low-voltage piezo actuators and positioners. It contains three independent amplifiers that can output and sink a peak current of 140 mA in the -30 to 130 V voltage range. For frequency response with selected capacitive loads, see graph below. The piezo amplifier module is designed to work in the E-500 Controller system (see p. 2-142).

The units are designed to provide high-resolution operation of piezo actuators and positioning systems in voltage-controlled mode (open-loop) and optionally in position-controlled mode (closed-loop).



E-503: operating limits with various PZT loads (open-loop), capacitance is measured in µF

Modular Design for Flexibility: Optional Servo Controller Upgrade

The E-503 amplifier module can be installed in the E-500 / E-501 controller chassis. The modular design makes the E-500 piezo controller system very flexible. An optional E-509 piezo servo-controller module can be installed along with the E-503 amplifier module, for closed-loop piezo position control. In this configuration, the E-503 output voltage is set by the servo-control loop.

Voltage Controlled Piezo Positioning

In open-loop (voltage-controlled) piezo operation the amplifier output voltage is determined by an analog signal at the Control Input optionally combined with the DC-offset potentiometer. 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. The precision 10-turn potentiometer can also be used alone to set the output voltage manually.

Ordering Information

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

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Technical Data

Model	E-503.00	E-503.00S
Function	Power amplifier	Power amplifier
Channels	3	2
Amplifier		
Control input voltage range	-2 to +12 V	-2 to +12 V
Output voltage	-30 bis 130 V	-30 bis 130 V; one additional fixed voltage of +100 V
Peak current per channel, <5 ms	140 mA	140 mA
Average current per channel, >5 ms	40 mA	40 mA
Current limitation	Short-circuit-proof	Short-circuit-proof
Voltage gain	10 ±0.1	10 ±0.1
Input impedance	100 kΩ / 1 nF	100 kΩ / 1 nF
Interfaces and operation		
Piezo connector	LEMO ERA.00.250.CTL	LEMO ERA.00.250.CTL
Analog input	BNC	BNC
DC Offset	10-turn pot., adds 0 to 10 V to Control In	10-turn pot., adds 0 to 10 V to Control In
Miscellaneous		
Operating temperature range	5 to 50 °C	5 to 50 °C
Overheat protection	Deactivation at 85 °C	Deactivation at 85 °C
Dimensions	14HP/3U	14HP/3U
Mass	0.9 kg	0.9 kg
Operating Voltage	E-500 System	E-500 System
Max. power consumption	40 W	40 W

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E-505 Piezo Amplifier Module

High Power, E-500 Piezo Controller System



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

- **Up to 10 A Peak Current**
- **Output Voltage Range -30 to 130 V**
- **Module for E-500 Piezo Controller Rack**
- **Prepared for Position Servo-Control Upgrade (optional)**
- **Prepared for Interfaces / Display Modules (optional)**

The E-505 piezo amplifier module is designed to work in the E-500 Controller system (see p. 2-142). It features a low-noise, high-power amplifier for low-voltage piezo actuators and positioners, that can output and sink a peak current of up to 2000 mA in the -30 to 130 V voltage range. The E-505 units are designed to provide high-resolution operation of piezo actuators and positioning systems in voltage-controlled mode (open-loop) and optionally in position-controlled mode (closed-loop).

For switching applications the E-505.10 version provides a peak output current of up to 10 A.

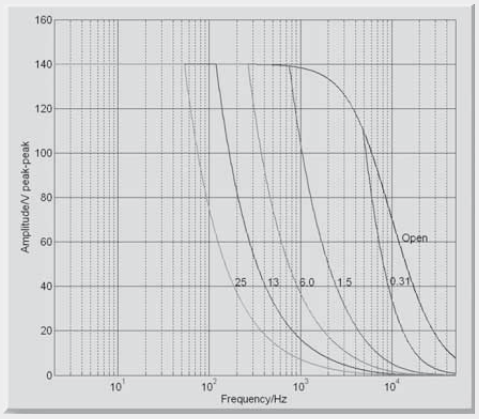
For frequency response with selected capacitive loads, see graph below.

Ordering Information

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-505: operating limits with various PZT loads (open-loop), capacitance is measured in µF

Technical Data

Model	E-505.00	E-505.10	E-505.00S
Function	Power amplifier	Power Amplifier for Switching Applications*	Offset Voltage Supply for Tip/Tilt Systems
Channels	1	1	1
Amplifier			
Control input voltage range	-2 to +12 V	-2 to +12 V	–
Output voltage	-30 to +130 V	-30 to +130 V	100 V
Peak current	2 A (<3 ms)	10 A (<200 µs)	2 A (<5 ms)
Average current	215 mA	215 mA	300 mA
Current limitation	Short-circuit-proof	Short-circuit-proof	Short-circuit-proof
Noise, 0 to 100 kHz	0.6 mVrms	1.0 mVrms	<0.7 mVrms
Voltage gain	10 ±0.1	10 ±0.1	–
Input impedance	1 MΩ / 1 nF	1 MΩ / 1 nF	–
Interfaces and operation			
Piezo connector	LEMO ERA.00.250.CTL	LEMO ERA.00.250.CTL	LEMO ERA.00.250.CTL
Analog input	BNC	BNC	–
DC-Offset	10-turn pot., adds 0 to 10 V to Control In	10-turn pot., adds 0 to 10 V to Control In	–
Miscellaneous			
Operating temperature range	+5 to +50 °C	+5 to +50 °C	+5 to +50 °C
Overheat protection	Deactivation at +85 °C	Deactivation at +85 °C	Deactivation at +85 °C
Dimensions	14HP/3U	14HP/3U	14HP/3U
Mass	0.9 kg	0.9 kg	0.9 kg
Operating Voltage	E-500 System	E-500 System	E-500 System
Max. power consumption	55 W	55 W	55 W

* For piezo actuators with special high-current layout

Modular Design for Flexibility: Optional Servo Controller Upgrade

Up to three E-505 amplifier modules can be installed in one E-500 chassis. The flexible, modular design of the E-500 piezo servo-controller system allows easy installation of an optional E.509 sensor- / servo-controller module for closed-loop operation. The output voltage is then set by the servo-control loop. Closed-loop piezo mechanics from PI can provide positioning accuracy and repeatability down to the nanometer range and below.

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E-506 Linearized Piezo Amplifier

Charge Control for High Dynamics



E-506.10 charge-controlled Piezo driver module

- **Highly Linear Amplifier Module**
- **280 W Peak Power**
- **Output Voltage Range -30 to 130 V**
- **Module for E-500 Piezo Controller Rack**
- **Prepared for Position Servo-Control Upgrade (optional)**
- **Prepared for Interfaces / Display Modules (optional)**

The E-506.10 piezo amplifier module uses a charge control principle. Here, the input signal controls the amount of electrical charge which is transferred to the piezo actuator. The result is a highly precise, linear displacement of the piezo actuator in high-dynamics operation.
The typical hysteresis which piezo actuators show when operated with a voltage-controlled piezo amplifier can such be reduced to 2% only. An additional position feedback is not required.
The E-506.10 piezo amplifier module is designed to work in the E-500 Controller system (s. p. 2-142). It features a low-noise high-power amplifier for low-voltage piezo actuators and positioners, that can output and sink a peak current of up to 2A in the -30 to 130 V voltage range.

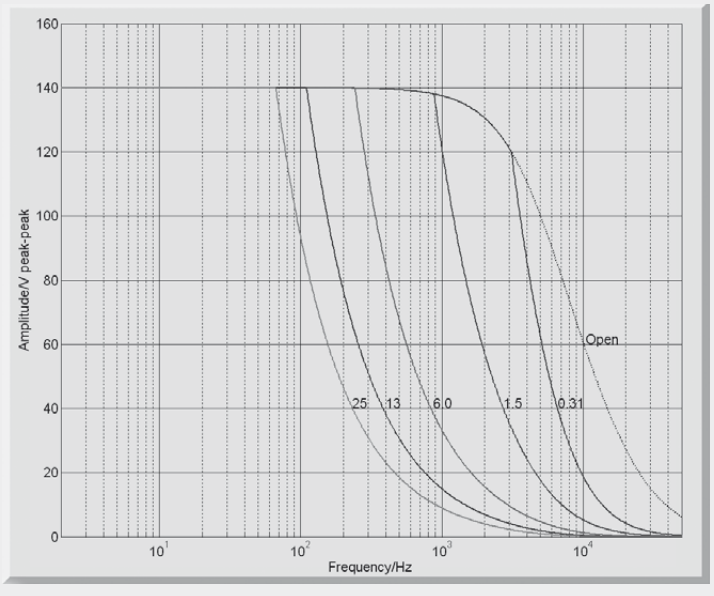
Ordering Information

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

Ask about custom designs!

Piezo Over Temperature Protection

The E-506 can evaluate a temperature sensor on the piezo actuator in order to protect the actuators, especially when used in dynamic applications. Automatic switch-off then reliably prevents the pre-set temperature threshold from being exceeded.
For frequency response with selected capacitive loads, see graph below.



E-506.10: operating limits with various PZT loads (open-loop), capacitance is measured in µF. The minimum capacitive load is 0.3 µF

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Index

Technical Data

Model	E-506.10	
Function	Linearised amplifier module, charge-controlled	
Channels	1	
Amplifier		
Input voltage	-2 to +12 V	
Output voltage*	-30 to 130 V	
Peak output power, < 2.5 ms	280 W	max.
Average output power	30 W	max.
Peak current, < 2.5 ms	2 A	
Average current	215 mA	
Current limitation	Short-circuit-proof	
Ripple, noise	<0.6 mV_{rms}	
Reference capacitance (adjustable)	1 to 280 µF	
Input impedance	1 MΩ / 1 nF	
Interfaces and operation		
Piezo connector (voltage output)	LEMO 2-pin EGG.0B.302.CLL	
Analog input	BNC	
DC Offset	10-turn pot., adds 0 to 10 V to Control In	
Piezo temperature sensor (input)	PT 1000; LEMO socket; deactivation of the piezo voltage output at 150°C	
Miscellaneous		
Operating temperature range	+5 to +50 °C	
Dimensions	14HP / 3U	
Mass	0.9 kg	
Operating voltage	E-500 System	
Power consumption	55 W	max.

* Max. 85 °C, deactivation of the piezo voltage output (internal overtemp protection)

Minimum frequencies* for charge-controlled operation

Capacitance (piezo actuator)	ftrans
0.33 µF	250 mHz
1.06 µF	80 mHz
6.2 µF	9 mHz
14 µF	4 mHz

* Voltage-controlled operation for lower frequencies

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E-508 PICA™ Piezo Amplifier Module

High-Power Module with 1100 V Output Voltage, E-500 Piezo Controller System



E-508.00 Piezo amplifier plug-in module

- **Peak Power up to 400 W**
- **Output Voltage Range 3 to ±1100 V or bipolar**
- **Plug-In Module for E-500 System**
- **E-508.OE for Switching Applications**
- **Prepared for Position Servo-Control Upgrade (optional)**
- **Prepared for Interfaces / Display Modules (optional)**

The E-508 plug-in module is a piezo driver / amplifier for the E-500 / E-501 piezo controller systems suitable for PICA™ piezo actuators (HVPZT). Its low-noise, 4-quadrant amplifiers can output and sink peak currents of 50 mA (E-508.OE: up to 400 mA) over an 1100 V range. The units are designed to provide high-resolution operation of piezo actuators and positioning systems in voltage-controlled mode (open-loop) and optionally in position-controlled mode (closed-loop).

Modular Design for Flexibility: Optional Servo Controller Upgrade

Up to three E-500 piezo amplifier modules can be installed in one E-500 chassis. The flexible, modular design of the E-500 piezo controller system allows easy installation of an optional E.509 sensor- / servo-controller module for closed-loop operation. The output voltage is then set by the servo-control loop. Closed-loop piezo mechanics from PI can provide positioning accuracy and repeatability down to the nanometer range and below.

Voltage Controlled Piezo Positioning

In open-loop (voltage-controlled) piezo operation the amplifier output voltage is determined by an analog signal at the Control Input optionally combined with the DC-offset potentiometer. 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 (see p. 2-104). The precision 10-turn potentiometer can also be used alone to set the output voltage manually.

OEM Version for Fast Switching Applications

The E-508.OE is the high-current OEM version, especially designed for switching applications. It can output a peak current of 400 mA for 5 ms. The E-508.OE is directly controlled by an analog signal.

For extensions, adapter cables and connectors, see “Accessories” in the piezo electronics chapter (see p. 2-168 *ff*).

Ordering Information

E-508.00
HVPZT Piezo Amplifier Module, +3 to +1100 V, 1 Channel

E-508.OE
HVPZT Piezo Amplifier Module, OEM Version, 400 mA Peak Current

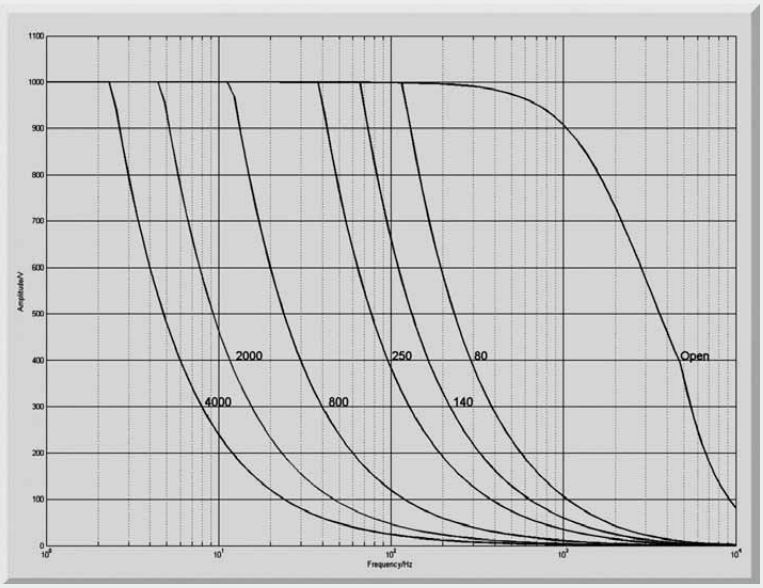
Ask about custom designs!



The E-508.00 plug-in module (right) and the E-508.OE, OEM module optimized for switching applications

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E-508: operating limits with various PZT loads (open-loop), capacitance is measured in nF

Technical Data

Model	E-508.00	E-508.OE	Unit
Function	Power amplifier for PICA™ high-voltage piezos	Power amplifier for PICA™ high-voltage piezos	
Amplifier			
Output voltage	3 to +1100 (Standard) (-260 to +780 -550 to +550 +260 to -780 -3 to -1100) (jumper selectable)	3 to +1100 (Standard) (-260 to +780 -550 to +550 +260 to -780 -3 to-1100) (factory-settable)	V
Amplifier channels	1	1	
Average output power	13	13	W
Peak output power, <5 ms	50	400	W
Average current	12	12	mA
Peak current, <5 ms	50	400	mA
Amplifier bandwidth, small signal	6	10	kHz
Amplifier bandwidth, large signal	50 (200 nF)	50 (200 nF)	Hz
Ripple, noise 0 to 100 kHz	5 50 (100 nF)	20 200 (100 nF)	mV_{RMS} mV_{P-P}
Current limitation	Short-circuit-proof	Short-circuit-proof	
Voltage gain	+100 ±1, -100 ±1 (selectable)	+100 ±1, -100 ±1 (selectable)	
Control input voltage	Servo off: ±1/100 of selected output range Servo on: 0 to 10 V	Servo off: ±1/100 of selected output range Servo on: 0 to 10 V	
Input impedance	100	100	kΩ
Interfaces and operation			
Piezo voltage output	LEMO EGG.0B.701.CJL.1173	LEMO EGG.0B.701.CJL.1173	
Input	BNC	SMB	
DC-Offset	10-turn pot., adds 0 to 10 V to Control In	–	
Miscellaneous			
Operating voltage	E-500 System	E-500 System	
Operating temperature range	+5 to +50 °C (10 % derated over 40 °C)	+5 to +50 °C (10 % derated over 40 °C)	°C
Mass	0.75	0.75	kg
Dimensions	14 HP/3 U	14 HP/3 U	

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E-504 Piezo Amplifier Module

High Power through Energy Recovery, E-500 Piezo Controller System



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

- **Peak Power 280 W**
- **High Average Output Power 100 W**
- **Very Energy Efficient Through Energy Recovery**
- **Output Voltage Range -30 to 130 V**
- **Module for E-500 Piezo Controller Rack**
- **Prepared for Position Servo-Control Upgrade (optional)**
- **Prepared for Interface / Display Modules (optional)**

The E-504 power amplifier extends the E-500 modular piezo controller system with a high-output amplifier for low-voltage actuators and positioners.

The innovative, efficient energy recovery circuitry reduces power consumption and heat dissipation, especially in dynamic applications. This makes possible peak output currents up to 2000 mA and a peak power of 280 W, with an average output power of up to 100 W.

Working Principle

Charge is transferred to the piezo actuator using low-loss PWM techniques. When the actuator is discharged, the energy not consumed is fed through the energy recovery circuitry for reuse in the next charging cycle.

The working principle of the E-504 series is perfectly qualified for high-dynamics scanning and switching applications. For applications where static position stability in the sub-nanometer range is essential, the E-505 (see p. 2-147) amplifier module is recommended.

Modular Design for Flexibility: Optional Servo-Controller Upgrade

Up to three E-504 amplifier modules can be installed in one E-500 controller chassis. The flexible, modular design of the E-500 piezo controller system allows easy installation of an optional E-509 sensor- / servo-controller module for closed-loop operation. The output voltage of the E-504 is then set by the servo-control loop. Closed-loop piezo mechanics from PI can provide positioning accuracy and repeatability down to the nanometer range and below.

Open-Loop Operation

In open-loop (voltage-controlled) piezo operation the amplifier output voltage is determined by an analog signal at the Control Input, optionally combined with the DC-offset potentiometer. 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. The precision 10-turn potentiometer can also be used alone to set the output voltage manually.

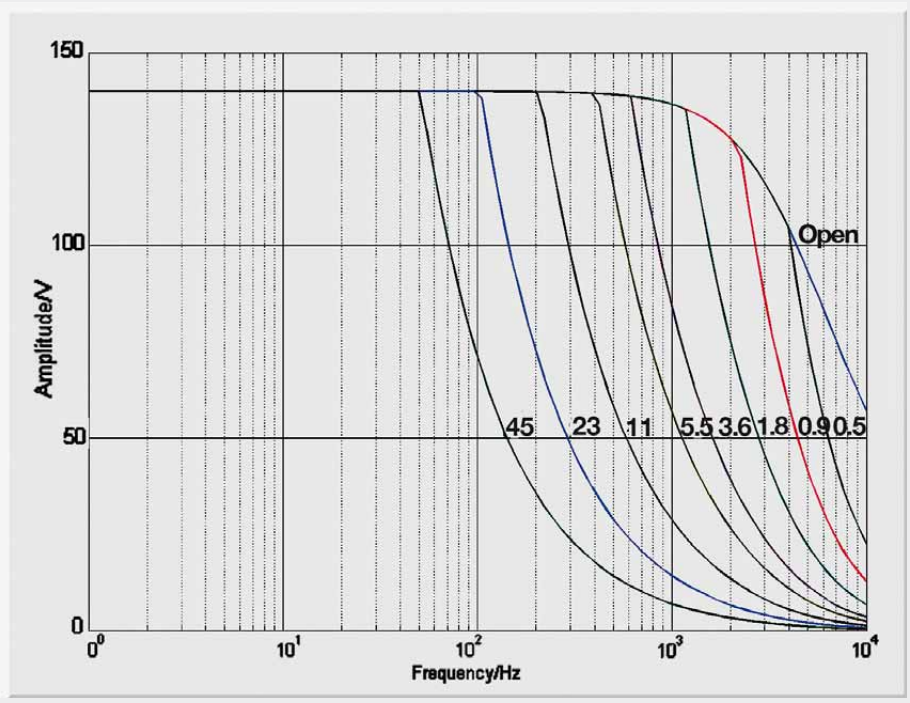
The same functionality and specifications are available in the E-617 amplifier module. (see p. 2-112).

Ordering Information

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

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E-504: operating limits with various PZT loads (open-loop), capacitance is measured in µF

Technical Data

Model	E-504.00F
Function	Power amplifier with energy recovery, 1 channel
Amplifier	
Control input voltage range	-2 to +12 V
Output voltage	-30 V to 130 V
Peak output power <5 ms	280 W
Average output power	Equivalent to 100 W reactive power
Peak output current <5 ms	2000 mA
Average current	1000 mA
Current limitation	Short-circuit-proof
Voltage gain	10 ±0.1
Ripple, noise, 0 to 100 kHz	5 mV_{RMS} 20 mV_{P-P}
Output impedance	0,5 Ω / 2,5 µF
Interfaces and operation	
Piezo connector	LEMO ERA.00.250.CTL
Analog input	SMB
DC-Offset	10-turn pot., adds 0 to +10 V to Control In
Miscellaneous	
Operating temperature range	+5 to +50°C
Dimensions	One 14T slot wide, 3H high
Mass	0.9 kg
Operating voltage	E-500 System
Max. power consumption	<30 W

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