PZ62E

E-500/E-501 Series
Modular Piezo Amplifier / Controller

User Manual

Version: 2.16.0 Date: 4/26/2024

This document describes the following products:

- **E-500 and E-501**
  Housing with power supply
- **E-503, E-504, E-505, E-506, E-508**
  Amplifier modules
- **E-509**
  Sensor / servo controller modules
- **E-515**
  Display module
- **E-518**
  Interface module

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1 About this Document

1.1 Objective and Target Audience of this User Manual

This user manual contains the information required for using the E-500 / E-501 series piezo control electronics (referred to as “E-500 / E-501 system” in this manual) as intended.

It assumes that the reader has a fundamental understanding of basic servo systems as well as motion control concepts and applicable safety procedures.

1.2 Symbols and Typographic Conventions

The following symbols and typographic conventions are used in this user manual:

DANGER

Immediate threat of danger
Failure to comply could lead to death or serious injury.

➢ Precautions to avoid the risk.

NOTICE

Dangerous situation
Failure to comply could result in damage to the equipment.

➢ Precautions to avoid the risk.

INFORMATION

Information for easier handling, tricks, tips, etc.

Symbol / Label	Meaning
1. 2.	Action consisting of several steps with strict sequential order
➢	Action consisting of one or more steps without relevant sequential order
▪	Bullet point
p. 5	Cross-reference to page 5
RS-232	Label on the product indicating an operating element (example: RS-232 interface socket)
	Warning signs on the product referring to detailed information in this manual.

1.3 Figures

For better understandability, the colors, proportions, and degree of detail in illustrations can deviate from the actual circumstances. Photographic illustrations may also differ and must not be seen as guaranteed properties.

1.4 Other Applicable Documents

Some of the devices mentioned in this documentation are described in detail in separate manuals or technical notes. The user manuals and technical notes relevant for your configuration are included in the scope of delivery (p. 11).

Product	Document
E-518 digital interface and function unit	E518T0001 user manual
E-509 sensor / servo controller module	PZ77E user manual
E-802 servo-control submodule	PZ150E user manual
E-801 sensor submodule	PZ117E user manual
E-506 charge-controlled amplifier module	E506T0002 technical note
E530B0008 power supply module for E-500 housing	E530T0003 technical note
E531B0005 power supply module for E-501 housing	E531T0004 technical note
Analog control via driver library for NI LabVIEW	E500T0011 technical note with download instructions

The latest versions of the user manuals are available for download on our website (p. 2).

1.5 Downloading Manuals

INFORMATION

If a manual is missing or problems occur with downloading:

- Contact our customer service department (p. 61).

Downloading manuals

1. Open the website **www.pi.ws**.
2. Search the website for the product number (e.g., “E-500”).
3. In the search results, select the product to open the product detail page.
4. Select ***Downloads***.

   The manuals are shown under ***Documentation***. Software manuals are shown under ***General Software Documentation***.
5. For the desired manual, select ***ADD TO LIST*** and then ***REQUEST***.
6. Fill out the request form and select ***SEND REQUEST***.

   The download link will be sent to the email address entered in the form.

2 Safety

2.1 Intended Use

E-500 / E-501 system is a laboratory device according to DIN EN 61010. It is intended to be used in interior spaces and in an environment which is free from dirt, oil, and lubricants.

According to its design, the E-500 / E-501 system is intended for driving capacitive loads (e.g., piezo ceramic actuators).

The E-500 / E-501 system may not be used for purposes other than those stated in this user manual. In particular, the E-500 / E-501 system may not be used to drive ohmic or inductive loads.

The E-500 / E-501 system can be used for static as well as dynamic applications.

Capacitive sensors or strain gauge sensors must be used for closed-loop operation. PI stages intended for closed-loop operation already have the corresponding sensors. Other sensors can only be used with PI approval.

The E-500 / E-501 system may only be installed, operated, maintained, and cleaned by authorized and qualified personnel.

2.2 General Safety Instructions

The E-500 / E-501 system is built according to state-of-the-art technology and recognized safety standards. Improper use of the E-500 / E-501 system may result in personal injury and/or damage to the E-500 / E-501 system.

- Use the E-500 / E-501 system for its intended purpose only, and only when it is in perfect condition.
- Read the user manual.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for installing and operating the E-500 / E-501 system correctly.

The E-500 / E-501 system comes preinstalled and preconfigured. Removing modules from the housing can result in personal injury and/or damage to the E-500 / E-501 system.

- Only remove modules from the housing when you are authorized and have the corresponding qualifications.
- Before removing modules from the housing, disconnect the E-500 / E-501 system from the mains by pulling the power plug.

2.3 Safety Measures for Installation, Startup and Operation

Improper installation of the E-500 / E-501 system can result in personal injury and/or damage to the E-500 / E-501 system.

- Install the E-500 / E-501 system near the power supply so that the power plug can be quickly and easily disconnected from the mains.
- Use the supplied power cord to connect the E-500 / E-501 system to the mains. If the supplied power cord has to be replaced, use a sufficiently dimensioned component.
- Only use cables and connections that comply with local safety regulations.

High temperatures can overheat the E-500 / E-501 system.

- Install the E-500 / E-501 system horizontally with 3 cm clearance for air circulation.
- Do not install the E-500 / E-501 system vertically since this prevents internal convection.
- Ensure sufficient ventilation at the installation site.

The E-500.621 housing uses the same main connectors as the E-500.00 and E-501.00 but has incompatible pinouts.

- Do not use the modules described in this manual with the E-500.621 housing.

Oscillation can cause irreparable damage to the piezo actuator(s) connected to the E-500 / E-501 system. Oscillation is indicated by a humming noise and can be caused by the following:

- The load and/or dynamics of operation differ too much from the calibration settings.
- The piezo actuator is operated near to its resonant frequency.

If you notice oscillation:

- In closed-loop operation, switch to open-loop operation immediately.
- In open-loop operation, stop the piezo actuator immediately.

The E-500 / E-501 system performance can be reduced directly after power-on due to thermal instability.

- Switch the E-500 / E-501 system on at least one hour before working with it.

Applying a continuous high static voltage to piezo actuators can lead to leakage currents and flashovers that destroy the piezo ceramic.

When the E-500 / E-501 system is not used but should remain switched on to ensure temperature stability, proceed as follows:

1. Switch to open-loop operation.
2. Set the piezo voltage to 0 V:
   - Analog mode: The input voltage for the target value is 0 V.
   - Computer-controlled mode: Corresponding commanding.

2.4 Organizational Measures

User manual

- Always keep this user manual with the E-500 / E-501 system. The latest versions of the user manuals are available for download on our website (p. 2).
- Add all manufacturer information such as supplements or technical notes to the user manual.
- If you give the E-500 / E-501 system to other users, also include this user manual as well as other relevant information provided by the manufacturer.
- Always work according to the complete user manual. If your user manual is incomplete and is therefore missing important information, this can result in serious or fatal injury as well as damage to the equipment.
- Install and operate the E-500 / E-501 system only after you have read and understood this user manual.

Personnel qualification

The E-500 / E-501 system may only be installed, operated, maintained, and cleaned by authorized and qualified personnel.

3 Product Description

3.1 Component Overview

Figure 1: Example of a three-channel system: E-501 housing with E-509 sensor / servo controller module, E-503 piezo amplifier module and E-518 interface module

3.1.1 Housings

The E-500 and E-501 housings are based on an EMI-proven housing with multi-function power supply and a backplane carrying all connectors to the system amplifiers, servo controllers and interface modules. E-500 / E-501 systems are assembled according to order and tested with all your modules installed.

Product no.	Description
E-500.00	19-inch housing for modular piezo amplifier / controller, 1 to 3 channels, with E530B0008 power supply
E-501.00	9.5-inch housing for modular piezo amplifier / controller, 1 to 3 channels, with E530B0008 power supply

3.1.2 Amplifier Modules

Product no.	Description
E-503.00	Piezo amplifier module, -30 to 130 V, three channels
E-503.00S	Piezo amplifier module, -30 to 130 V, one of three channels is fixed (100 V)
E-504.00F	High-power piezo amplifier module, 1 channel, 280 W peak power, 100 W average power, -30 to 130 V
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	Piezo amplifier module, 1 channel, fixed voltage 100 V
E-506.10	High linearity piezo amplifier module, 30 W average output power, -30 to 130 V, 1 channel
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, 1 channel

3.1.3 Sensor / Servo Controller Modules

Product no.	Description
E-509.S1	Sensor / servo controller module, SGS sensor, 1 channel
E-509.S3	Sensor / servo controller module, SGS sensors, 3 channels
E-509.C1A	Sensor / servo controller module, capacitive sensor, 1 channel
E-509.C2A	Sensor / servo controller module, capacitive sensors, 2 channels
E-509.C3A	Sensor / servo controller module, capacitive sensors, 3 channels

3.1.4 Display and Interface Modules

Product no.	Description
E-515.01	Display module for piezo voltage and displacement, 1 channel
E-515.03	Display module for piezo voltage and displacement, 3 channels
E-518.I3	Interface module, 3 channels, TCP/IP, USB, and RS-232 interfaces

3.2 Configuration Example

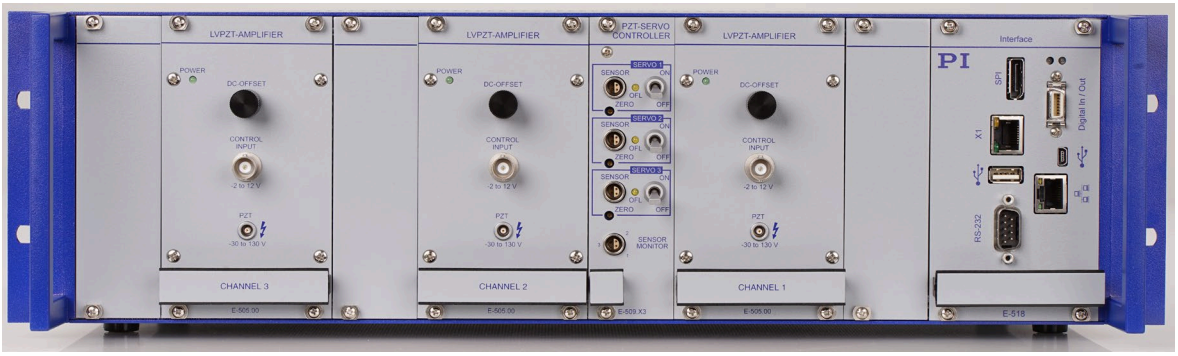


Figure 2: Configuration example of a modular three-channel controller

The figure above shows a three-channel configuration example consisting of the following components:

- 1 × E-500.00 housing with power supply
- 3 × E-505.00 piezo amplifier module, 1 channel (amplifier channels 1, 2, and 3)
- 1 × E-509.S3 sensor / servo controller module, 3 channels
  (labeled “E-509.X3” in the above figure)
- 1 × E-518.I3 interface module, 3 channels

3.3 Compatibility Note

NOTICE

Overheating or malfunction due to improper system configuration!

In March 2011, the backplane of the housing (E-500.00 or E-501.00) was changed. The modules of the E-500 / E-501 system were adapted accordingly.

- “New” housing and modules: date of manufacture is March 2011 or later
- “Old” housing and modules: date of manufacture is before March 2011

If old and new components are to be combined in one system, the housing and/or the modules by PI may need to be modified to ensure proper operation. Improper combination of old and new components in the E-500 / E-501 system can cause damage by overheating or malfunction of the system.

With systems assembled by PI, the proper configuration is ensured.

➢ If you want to replace the housing or the modules in your E-500 / E-501 system, contact our customer service department (p. 61).

3.4 Signal Path Diagram

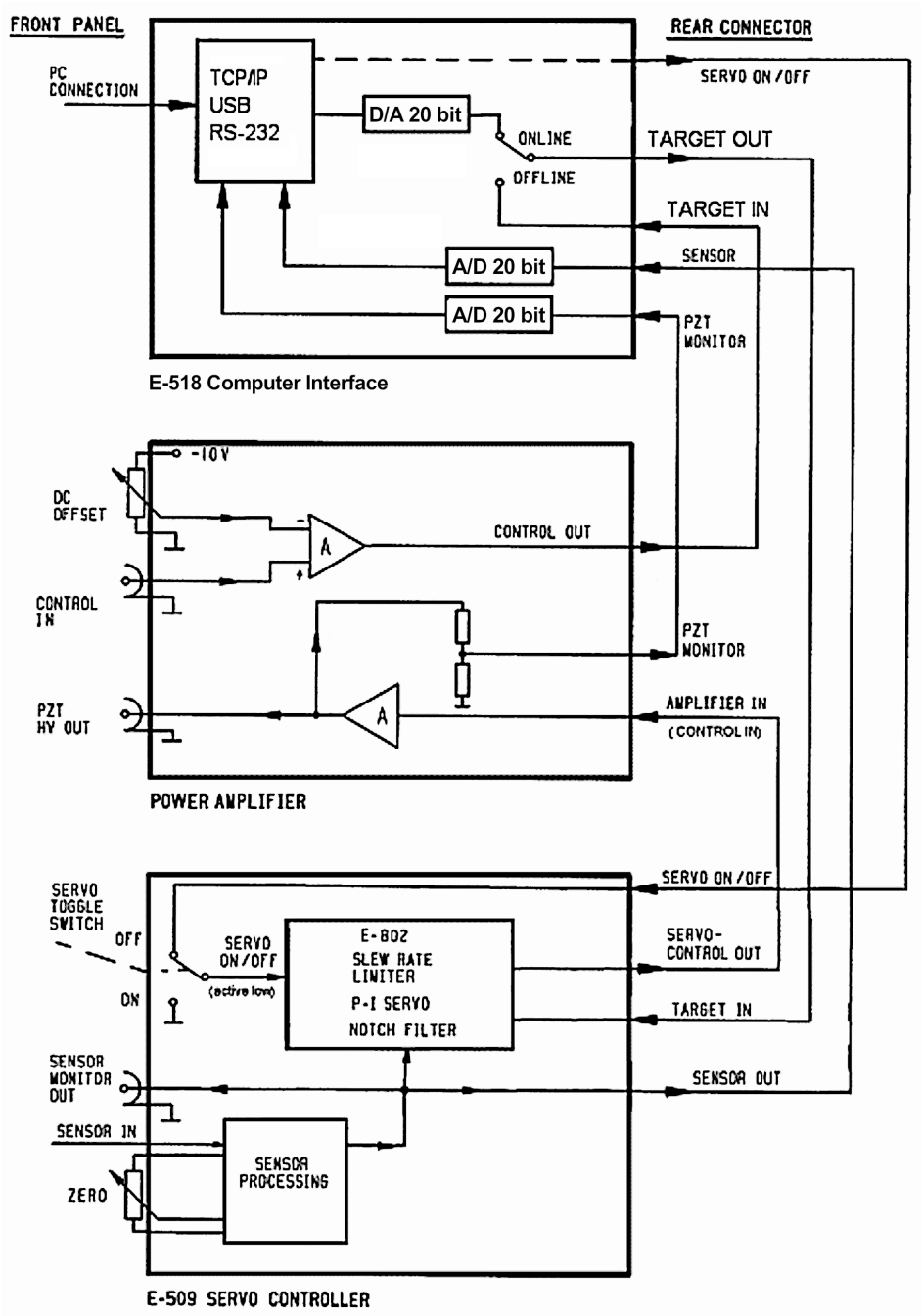


Figure 3: Interconnections between E-518 interface module, amplifier module and E-509 sensor / servo controller module

INFORMATION

The backplane of the housing (E-500.00 or E-501.00) carries all connectors to the modules of the system (amplifiers, sensor / servo controller modules, interface /display modules).

3.5 Servo Modes

E-500 / E-501 systems support the following servo modes:

- Open-loop operation
- Closed-loop operation (only if an E-509 sensor / servo controller module is included)

In closed-loop operation, the control input is interpreted as target position. The servo-control circuit is active and compares the sensor signal with the target position. Hysteresis effects, nonlinearities and drift effects are eliminated.

In open-loop operation, the control input determines the output voltage directly. The servo-control circuit is deactivated so that the E-500 / E-501 system works as an amplifier.

3.6 Scope of Delivery

The following items are shipped with every E-500 / E-501 system:

Product no.	Description
E-500.00 or E-501.00	Housing with controller modules installed
3763	Power cord
PZ62E	E-500 / E-501 user manual (this document)
E500T0011	Technical note “Analog Control via Driver Library for NI LabVIEW”

Additional scope of delivery if one or more E-509 modules are installed:

Product no.	Description	Included with
PZ77E	E-509 user manual	All models
PZ150E	User manual for E-802 servo-controller submodule	All models
PZ117E	User manual for E-801 sensor submodule	E-509.Sx
E-808.90	Sensor monitor cable	E-509.S3
PZ106E	User manual for capacitive sensors	E-509.CxA
D-893.32	Sensor monitor cable	E-509.CxA

Additional scope of delivery if an E-518 module is installed:

Product no.	Description
C-815.34	RS-232 null modem cable, 3 m, 9/9-pole
C-815.553	Straight-through network cable for connecting the PC via a TCP/IP network
000036360	USB cable (type A to Mini-B) for connection to the PC
4347	MDR connector, 14-pole, for I/O socket
4348	Protective shell for MDR connector
E518T0001	User manual for E-518 digital interface and function unit
C-990.CD1	Data storage device with PI Software Suite

4 Unpacking

1. Unpack the E-500 / E-501 system with care.
2. Compare the contents with the scope of delivery according to the contract and the delivery note.
3. Inspect the contents for signs of damage. If any parts are damaged or missing, contact our customer service department immediately (p. 61).
4. Keep all packaging materials in case the product needs to be returned.

5 Installing

5.1 Power Connection

The power connection is located on the rear panel of the housing. Unless requested otherwise, the E-500 / E-501 system will be set up for the line voltage we believe predominant in your country.

How to adapt E-500 / E-501 system to a different line voltage:

- If your system uses a 19-inch housing (E-500.00), it is equipped with a wide-range power supply and with fuses that are admissible for both 115 V and 230 V operation. No settings need be changed when connecting the device to a different line voltage.
- If your system uses a 9.5-inch housing (E-501.00), new fuses are required before connecting it to a different line voltage. Replace both fuses as described in “Changing Line Fuses” on p. 59.

5.2 First Electrical Checks

Check the E-500 / E-501 system electrically when using it for the first time after unpacking. Perform the following steps:

1. Connect the power cord.
2. Switch on the E-500 / E-501 system without any piezo actuators connected. The power switch is at the rear next to the power inlet.

   Now the green LED on the amplifier module lights up.

   If an E-515 display module is installed:

   The display shows the main screen, see E-515 user manual for details.
3. Set the SERVO switch on the E-509 module to OFF.
4. If an E-515 display module is installed:

   Turn the DC-OFFSET potentiometer and watch the voltage display. The voltage reading is the current output voltage at the PZT output sockets.

   The position values in the display have no meaning because the piezo actuators and sensors are not yet connected.

If the above steps could be performed without any unexpected results, the E-500 / E-501 system has passed the electrical checks.

5.3 Connecting Cables

INFORMATION

Each E-509 sensor / servo controller module is calibrated with one particular piezo actuator. That piezo actuator must always be connected to the same controller channel. Labels on the rear panel of the E-500 / E-501 system indicate the serial numbers of the piezo actuators that belong to each channel.

After the E-500 / E-501 system has passed the electrical checks, the piezo actuators can be connected. Proceed as follows:

1. Switch the E-500 / E-501 system OFF.
2. Connect the piezo actuators.

   Each piezo actuator is equipped with cables for the piezo operating voltage and for the sensor (if applicable). Connect the first cable to the PZT output socket on the amplifier module and the second cable with the sensor input socket on the sensor / servo controller module.

   If capacitive sensors are used, two sensor cables must be connected to the sensor / servo controller module. The cable labeled ´T´ must be connected to the T socket (target signal), and the cable labeled ´P´ must be connected to the P socket (probe signal).

6 Startup

6.1 Starting Analog Operation

1. Turn all DC-OFFSET potentiometers CCW (zero offset).
2. Turn all SERVO switches to OFF (open-loop operation).
3. Turn the power on.

   The standard screen appears on the display. The current output voltages and displacements derived from the sensor signals are displayed for all channels. Because the controller is set to open-loop operation, the sensor reading is not fed back to control the position. If external forces act on the piezo actuator, its length will change accordingly and so will the sensor reading.
4. Turn the SERVO switches to ON (closed-loop operation).

   Now the displacement is controlled using the servo-control circuit. The display shows the current displacement values, as before.
5. Change the displacement of the piezo actuator over the nominal range.

   The displacement of the piezo actuator can be controlled either by the DC-OFFSET potentiometer or by an analog control input voltage applied to the CONTROL INPUT socket. In the latter case, the potentiometer setting is used as an offset to the control input voltage. This allows generation of unipolar output voltages from bipolar control voltages.

   – Use the DC-OFFSET potentiometer.
   – Apply an external analog signal to the CONTROL INPUT socket.
6. Watch the yellow overflow LED on the sensor / servo controller module. If it lights up, the amplifier output is being clipped at one of its limits and the current displacement of the piezo actuator no longer complies with the control signal. Use the ZERO trim potentiometer to adjust the sensor reading window. Turn the potentiometer until the overflow LED extinguishes.

INFORMATION

The external analog signal can be generated by a computer (e.g., from a data acquisition board). To generate that signal, you can use PI's GCS driver library for use with NI LabVIEW software.

➢ See the E500T0011 technical note for how to download the driver set from our website.

6.2 Starting Computer-Controlled Operation

If an E-518 interface module is installed, remote control via TCP/IP, USB, or RS-232 interface is possible. A comprehensive command set allows controlling any motion of the piezo actuator with maximum resolution (depending on the sensor installed).

Refer to the user manual for the interface module for details.

7 Component Description

7.1 E-500.00 19-Inch Housing with Internal Power Supply

7.1.1 Specifications

Model	E-500.00
Function	19-inch housing for piezo controller system: Amplifier modules, sensor / servo controller modules, interface / display modules
Channels	1, 2, 3 (max. three amplifier modules)
Dimensions	450 mm × 132 mm × 296 mm + handles
Operating voltage	90-264 V AC, 50-60 Hz
Max. power consumption	180 W

7.1.2 Dimensions

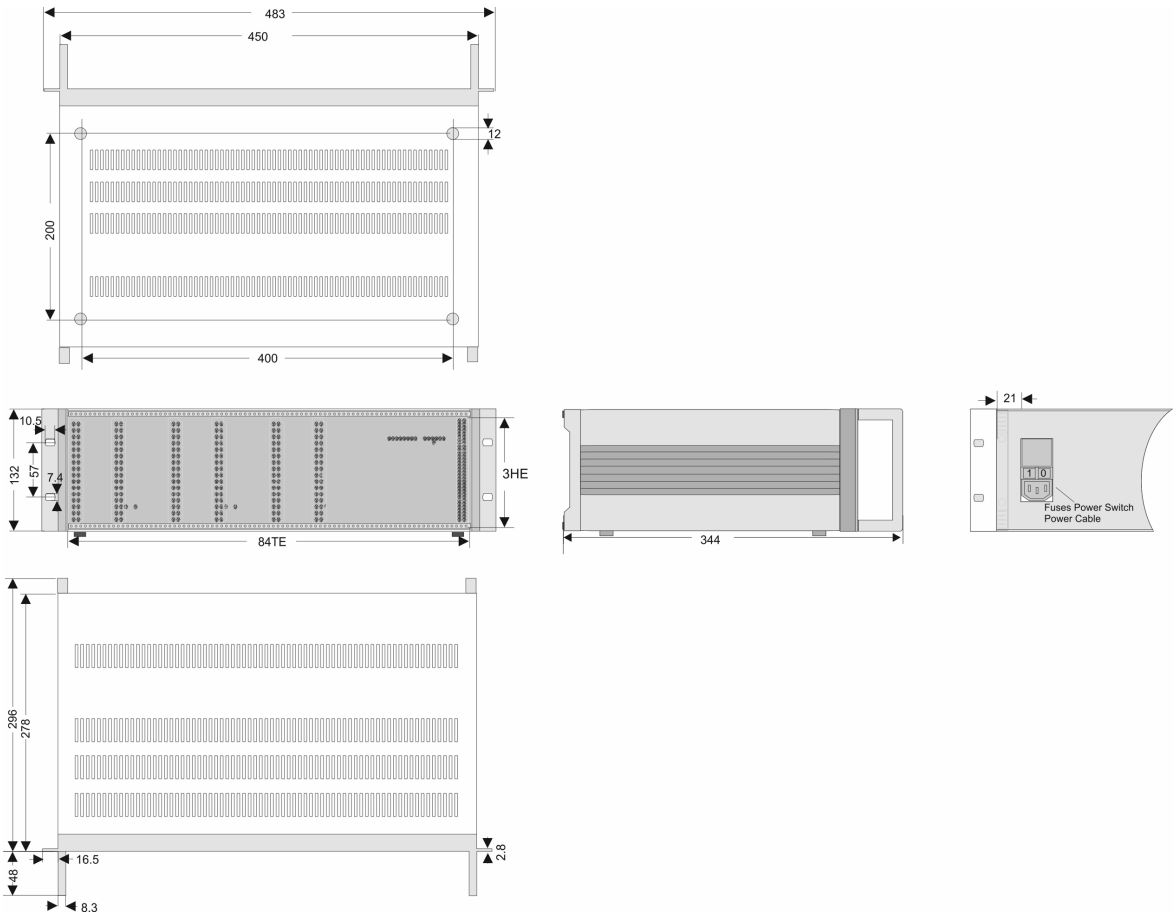


Figure 4: E-500.00 housing, dimensions in mm

7.2 E-501.00 9.5-Inch Housing with Internal Power Supply

7.2.1 Specifications

Model	E-501.00
Function	9.5-inch housing for piezo controller system: Amplifier modules, sensor / servo control modules, interface / display modules
Channels	1, 3 (max. one amplifier module)
Dimensions	236 mm × 132 mm × 296 mm + handles
Operating voltage	90-120 / 220-264 V AC, 50-60 Hz
Max. power consumption	80 W

7.2.2 Dimensions

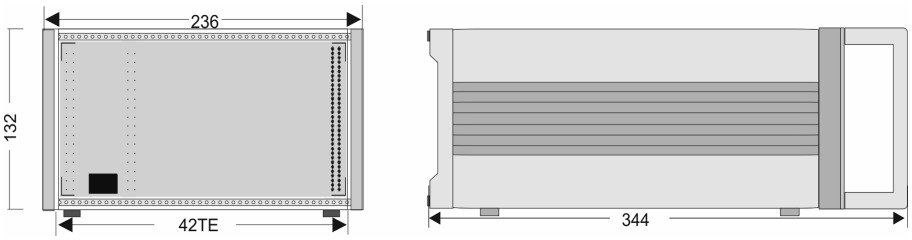


Figure 5: E-501.00 housing, dimensions in mm

7.3 E-503 3-Channel Piezo Amplifier

DANGER

Risk of electric shock!

The E-503 amplifier can output up to 130 V. Touching this high voltage can result in serious injury or death from electric shock.

- Operate a piezo actuator on a “PZT” socket only when it is connected to a protective earth conductor.

7.3.1 Front Panel Elements

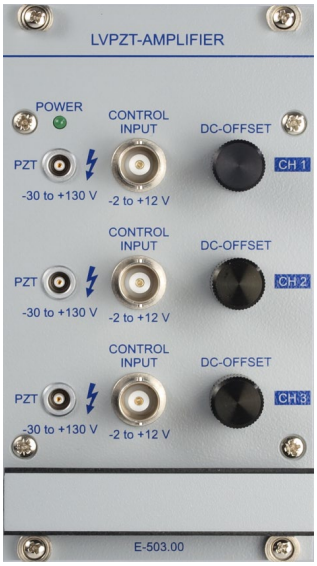


Figure 6: E-503.00 amplifier module

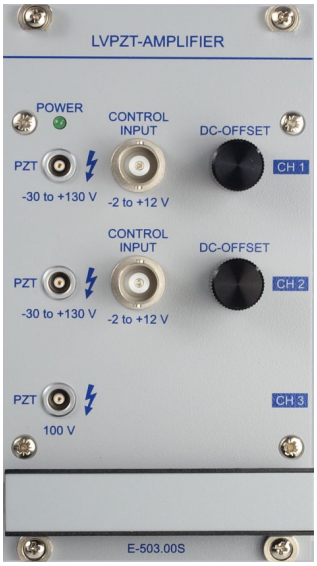


Figure 7: E-503.00S amplifier module

Labeling	Type	Function
POWER	LED Green/off	Amplifier state: ▪ Green: E-503 is ready for normal operation. ▪ Off: The E-500 / E-501 system is switched off.
PZT **-30 to 130 V**	LEMO ERA.00.250.CTL	Output of the piezo voltage for the piezo actuator in the stage. Voltage in the range of -30 to 130 V.
E-503.00S only: **PZT** **100 V**	LEMO ERA.00.250.CTL	Output of the piezo voltage for the piezo actuator in the stage. Fixed voltage of 100 V for piezo tip/tilt stages.
CONTROL INPUT **-2 to +12 V**	BNC	In analog operation, this control input voltage specifies the target (either as voltage or position, depending on the servo mode). The input signal should always be in the range of 0 to 10 V (excursions to -2 or +12 V may cause overflow, especially in closed-loop operation, and reduce actuator lifetime). The control input range can be shifted using the DC-OFFSET potentiometer. The control input voltage can also be a computer-generated analog signal (e.g., from a DAQ board). To generate that signal, you can use PI's GCS driver library for use with NI LabVIEW software. See "Starting Analog Operation" on p. 17 for details.
DC-OFFSET	10-turn potentiometer	Adds 0 to 10 V to the CONTROL INPUT signal (only relevant in analog operation, see p. 17 for details)

7.3.2 Operating Limits

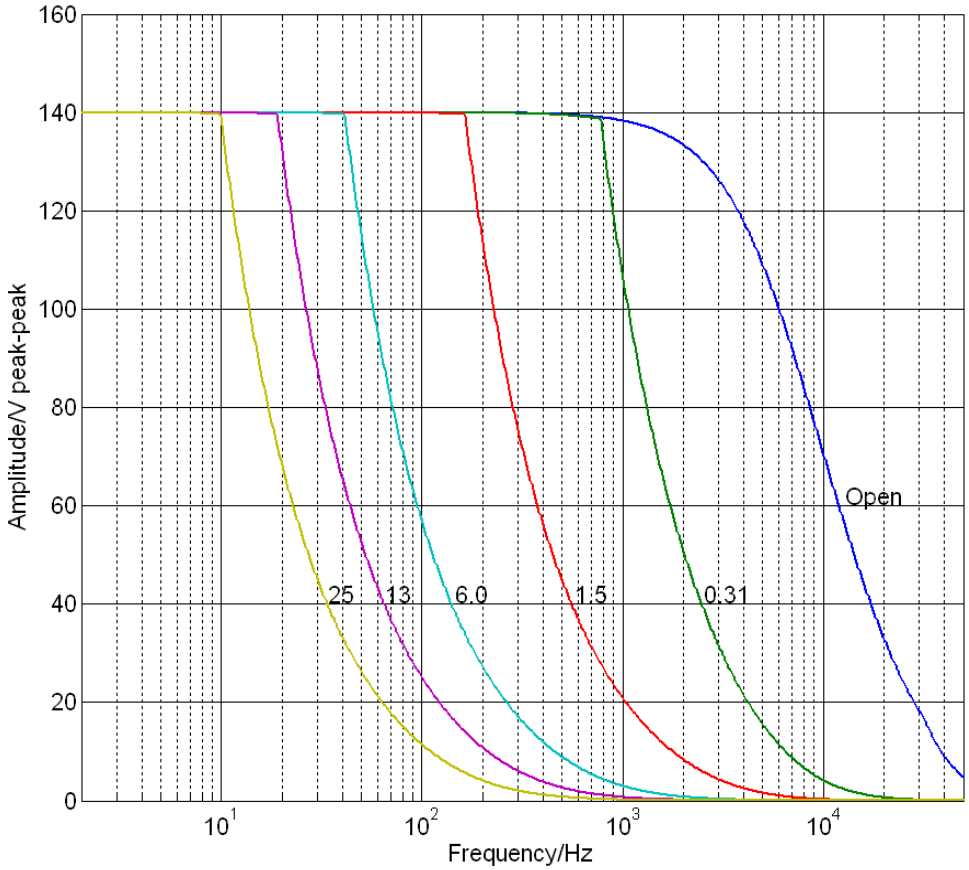


Figure 8: E-503 operating limits with various piezo loads (open-loop), capacitance is measured in µF

7.3.3 Specifications

	E-503.00 / E-503.00S
Function	Power amplifier
Channels	3 / 2
Amplifier	
Input voltage range	-2 to +12 V
Output voltage	-30 to 130 V (E-503.00S: Additional fixed voltage of 100 V)
Peak current / channel (<5 ms)	140 mA
Average output current / channel (> 5 ms)	40 mA
Current limitation	Short-circuit proof
Voltage gain	10 ±0.1
Input impedance	100 kΩ / 1 nF

	E-503.00 / E-503.00S
Interfaces and operation	
Piezo connection (voltage socket)	LEMO ERA.00.250.CTL
Analog input / control input socket	BNC
DC offset setting	10-turn potentiometer, adds 0 to 10 V to the input voltage
Miscellaneous	
Operating temperature range	5 to 50 °C
Overheat protection	Deactivation at 85 °C
Dimensions	14 HP / 3 RU
Mass	0.9 kg
Operating voltage	E-500 / E-501 system
Max. power consumption	40 W

7.3.4 Pin Assignment

32-pin connector, DIN 41612, male

Row	PIN a	PIN c
2	Power Fail	OUT: ch1 (BNC+Offset)
4	IN: ch1	OUT: ch1 (monitor of piezo voltage (PZT ÷100)
6	nc	nc
8	nc	nc
10	nc	OUT: ch2 (BNC+Offset)
12	IN: ch2	OUT: ch2 (monitor of piezo voltage (PZT ÷100)
14	internal use Bus_A	internal use Bus_B
16	internal use Bus_Vcc	internal use Bus_GND
18	nc	OUT: ch3 (BNC+Offset)*
20	IN: ch3*	OUT: ch3 (monitor of piezo voltage (PZT ÷100)
22	GND (measurement)	GND (measurement)
24	GND	GND
26	IN: +24 V to +27 V	IN: +24 V to +27 V
28	IN:-37 V	OUT: -10 V
30	IN:+137 V	IN: +137 V
32	Protective earth (housing)	Protective earth (housing)

* E-503.00S: nc

7.4 E-504 High-Power Piezo Amplifier, Energy Recovery

DANGER

Risk of electric shock!

The E-504 amplifier can output up to 130 V. Touching this high voltage can result in serious injury or death from electric shock.

- Operate a piezo actuator on the “PZT” socket only when it is connected to a protective earth conductor.

7.4.1 Front Panel Elements

Figure 9: E-504.00F amplifier module

Labeling	Type	Function
POWER	LED Green/off	Amplifier state: Green: E-504 is ready for normal operation. Off: The E-500 / E-501 system is switched off.
DC-OFFSET	10-turn potentiometer	Adds 0 to 10 V to the CONTROL INPUT signal (only relevant in analog operation, see p. 17 for details).

Labeling	Type	Function
CONTROL INPUT **-2 to +12 V**	SMB	In analog operation, this control input voltage specifies the target (either as voltage or position, depending on the servo mode). The input signal should always be in the range of 0 to 10 V (excursions to -2 or +12 V may cause overflow, especially in closed-loop operation, and reduce actuator lifetime). The control input range can be shifted using the DC-OFFSET potentiometer. The control input voltage can also be a computer-generated analog signal (e.g., from a DAQ board). To generate that signal, you can use PI's GCS driver library for use with NI LabVIEW software. See "Starting Analog Operation" on p. 17 for details.
PZT -30 to 130 V	LEMO ERA.00.250.CTL	Output of the piezo voltage for the piezo actuator in the stage. Voltage in the range of -30 to 130 V.

7.4.2 Operating Limits

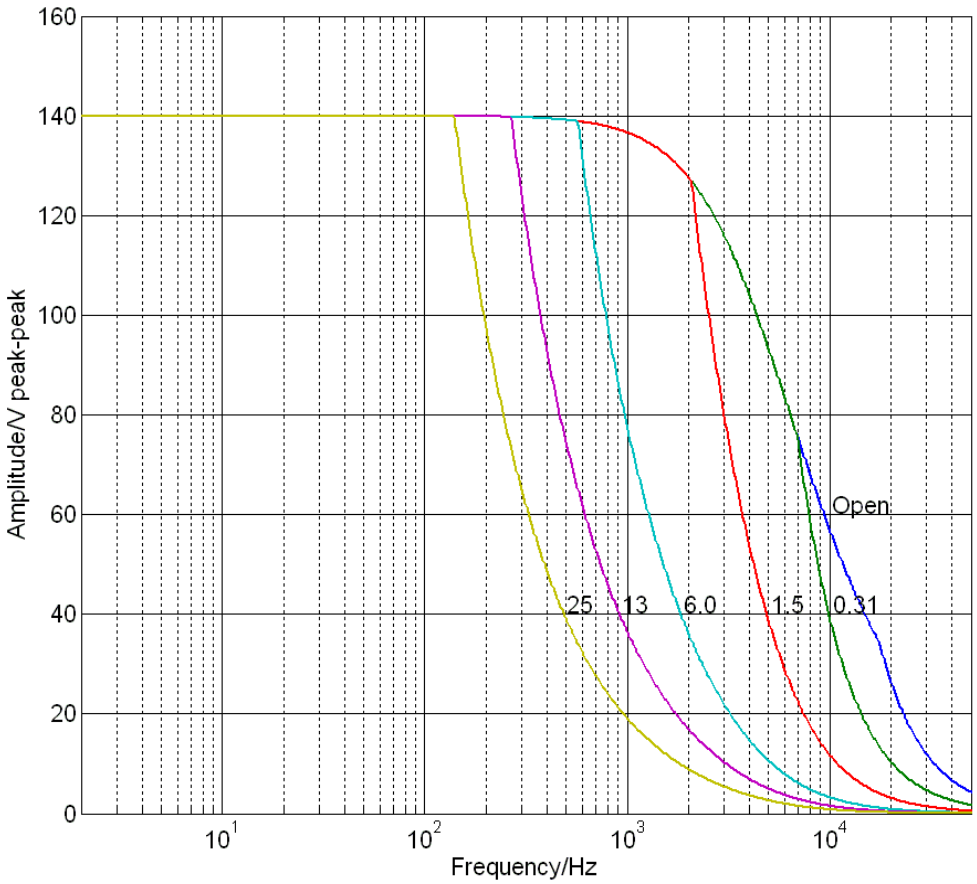


Figure 10: E-504 operating limits with various piezo loads (open-loop), capacitance is measured in µF

7.4.3 Specifications

	E-504.00F
Function	Power amplifier with energy recovery
Channels	1
Amplifier	
Input voltage range	-2 to 12 V
Output voltage	-30 to 130 V
Peak output power (<5 ms)	280 W
Average output power	100 W at full voltage range
Peak current (<5 ms)	2000 mA
Average output current	1000 mA
Current limitation	Short-circuit proof
Voltage gain	10 ±0.1
Amplifier bandwidth	4 kHz
Ripple, noise	5 mV_{rms} / <10 kHz 20 mV_{pp} / <10 kHz <30 mV_{rms} / <100 kHz <100 mV_{pp} / 100 kHz <150 mV_{pp} / 20 MHz
Capacitive base load (internal)*	1.5 µF
Recommended piezo load	1 to 100 µF
Amplifier resolution	10 mV
Amplifier classification	Class D, switched 100 kHz
Output impedance	0.5 Ω / 1 mH / 1.5 µF
Input impedance	100 kΩ
Interfaces and operation	
Piezo connection (voltage socket)	LEMO ERA.00.250.CTL
Analog input	SMB
DC offset setting	10-turn potentiometer, adds 0 to 10 V to the input voltage
Display and indicators	Power LED
Miscellaneous	
Operating temperature range	5 to 50 °C
Dimensions	14 HP / 3 RU
Mass	0.9 kg
Operating voltage	E-500 / E-501 system

* The internal base load is required to obtain a stable amplifier output voltage when no external piezo load is connected. The total load is the sum of internal base load and external piezo load. Note that the amplifier output power is allocated to the internal and external loads according to their capacitance values. This is of particular importance under large-signal conditions.

Examples: The small-signal capacitance of the connected piezo actuator is 550 nF, hence its large-signal capacitance is approx. 1.1 µF (2 * 550 nF). Under large-signal conditions, approx. 58 W will be allocated to the internal base load (1.5 µF), while approx. 42 W will be available for the external piezo load.

With a small-signal capacitance of 1 µF, the piezo actuator would have a large-signal capacitance of 2 µF, and approx. 57 W would be available for it.

7.4.4 Pin Assignment

32-pin connector, DIN 41612, male

Row	PIN a	PIN c
2	Power Fail	OUT: ch1 (SMB+Offset)
4	IN: ch1	OUT: ch1 (monitor)
6	Piezo voltage GND	Piezo voltage GND
8	OUT: piezo voltage	OUT: piezo voltage
10	n.c.	n.c.
12	n.c.	n.c.
14	IN: sync 200 kHz TTL	internal use, Bus_B
16	internal use, Bus_Vcc	internal use, Bus_GND
18	n.c.	n.c.
20	n.c.	n.c.
22	GND (measurement)	GND (measurement)
24	GND (power)	GND (power)
26	IN: +24 to +27 V	IN: +24 to +27 V
28	n.c.	n.c.
30	n.c.	n.c.
32	Protective earth (housing)	Protective earth (housing)

7.5 E-505 High-Power Piezo Amplifier

DANGER

Risk of electric shock!

The E-505 amplifier can output up to 130 V. Touching this high voltage can result in serious injury or death from electric shock.

- ➢ Operate a piezo actuator on the “PZT” socket only when it is connected to a protective earth conductor.

7.5.1 Front Panel Elements

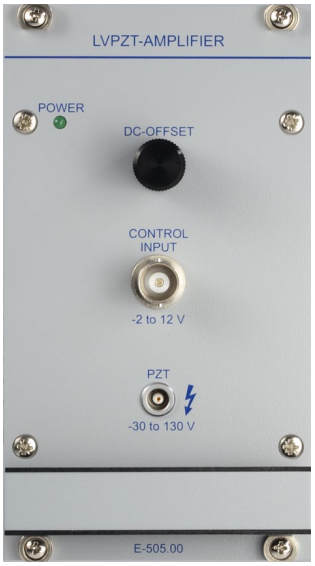


Figure 11: E-505.00 and E-505.10 amplifier modules

Figure 12: E-505.00S amplifier module

Labeling	Type	Function
POWER	LED Green/off	Amplifier state: ▪ Green: E-505 is ready for normal operation. ▪ Off: The E-500 / E-501 system is switched off.
E-505.00 and E-505.10 only: **DC-OFFSET**	10-turn potentiometer	Adds 0 to 10 V to the CONTROL INPUT signal (only relevant in analog operation, see p. 17 for details).
E-505.00 and E-505.10 only: **CONTROL INPUT** **-2 to +12 V**	BNC	In analog operation, this control input voltage specifies the target (either as voltage or position, depending on the servo mode). The input signal should always be in the range of 0 to 10 V (excursions to -2 or +12 V may cause overflow, especially in closed-loop operation, and reduce actuator lifetime). The control input range can be shifted using the DC-OFFSET potentiometer. The control input voltage can also be a computer-generated analog signal (e.g., from a DAQ board). To generate that signal, you can use PI's GCS driver library for use with NI LabVIEW software. See "Starting Analog Operation" on p. 17 for details.
E-505.00 and E-505.10 only: **PZT** -30 to 130 V	LEMO ERA.00.250.CTL	Output of the piezo voltage for the piezo actuator in the stage. Voltage in the range of -30 to 130 V.
E-505.00S only: **PZT** 100 V	LEMO ERA.00.250.CTL	Output of the piezo voltage for the piezo actuator in the stage. Voltage in the range of -30 to 130 V.

7.5.2 Operating Limits

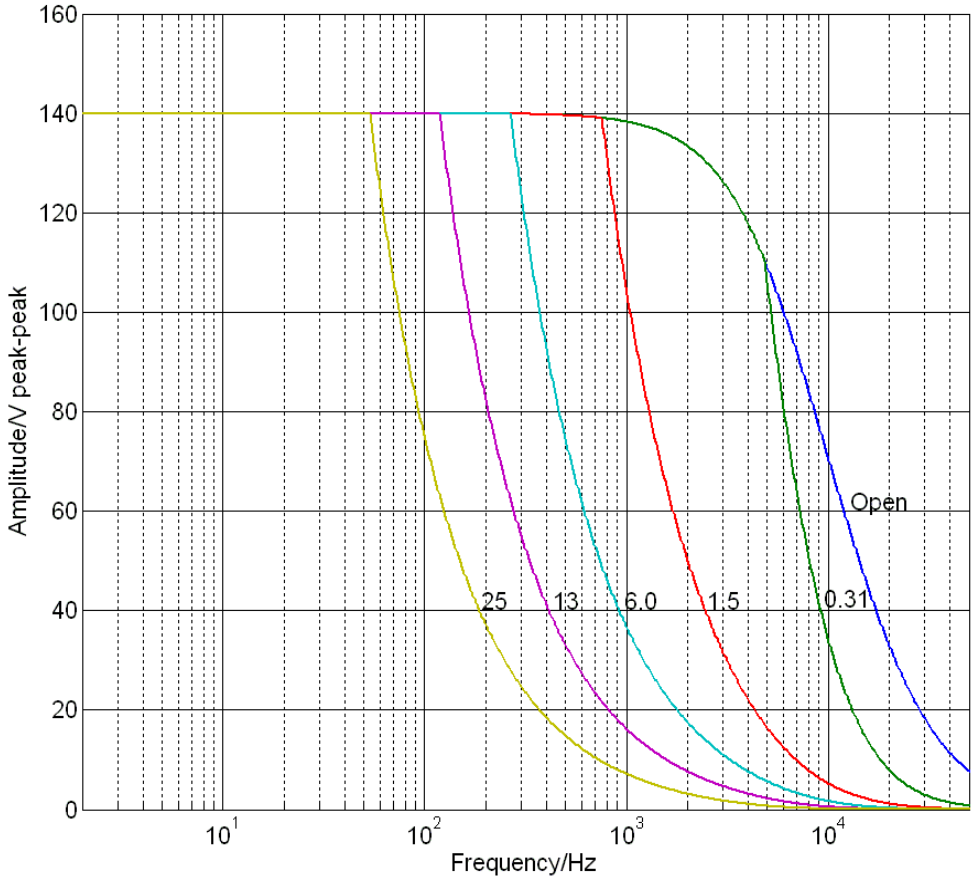


Figure 13: E-505 operating limits with various piezo loads (open-loop), capacitance is measured in µF

7.5.3 Specifications

	E-505.00	**E-505.10**	**E-505.00S**
Function	Power amplifier	Power amplifier for switching applications*	Offset voltage source for tip/tilt systems
Channels	1	1	1
Amplifier			
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 output 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 mV_{rms}	1.0 mV_{rms}	<0.7 mV_{rms}
Voltage gain	10 ±0.1	10 ±0.1	-
Input impedance	1 MΩ / 1 nF	1 MΩ / 1 nF	-

	E-505.00	E-505.10	E-505.00S
Interfaces and operation			
Piezo connection socket	LEMO ERA.00.250.CTL	LEMO ERA.00.250.CTL	LEMO ERA.00.250.CTL
Analog input	BNC	BNC	-
DC offset setting	10-turn potentiometer, adds 0 to 10 V to the input voltage	10-turn potentiometer, adds 0 to 10 V to the input voltage	-
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	14 HP / 3 RU	14 HP / 3 RU	14 HP / 3 RU
Mass	0.9 kg	0.9 kg	0.9 kg
Operating voltage	E-500 / E-501 system	E-500 / E-501 system	E-500 / E-501 system
Max. power consumption	55 W	55 W	55 W

* For piezo actuators with special equipment for high currents

7.5.4 Pin Assignment

32-pin connector, DIN 41612, male

Row	PIN a	PIN c
2	Power Fail	OUT: ch1 (BNC+Offset)*
4	IN: ch1*	OUT: ch1 (monitor)
6	Piezo voltage GND	Piezo voltage GND
8	OUT: piezo voltage	OUT: piezo voltage
10	n.c.	n.c.
12	n.c.	n.c.
14	internal use,Bus_A	internal use, Bus_B
16	internal use, Bus_Vcc	internal use, Bus_GND
18	n.c.	n.c.
20	n.c.	n.c.
22	GND (measurement)	GND (measurement)
24	GND (power)	GND (power)
26	IN: +24 to +27V	IN: +24 to +27 V
28	IN: -37 V	OUT: -10 V
30	IN: +137 V	IN: +137 V
32	Protective earth (housing)	Protective earth (housing)

* E-505.00S: Pins 2c and 4a are shorted.

7.6 E-506 Linearized Piezo Amplifier, Charge Control

DANGER

Risk of electric shock!

The E-506 amplifier can output up to 130 V. Touching this high voltage can result in serious injury or death from electric shock.

- Operate a piezo actuator on the “PZT” socket only when it is connected to a protective earth conductor.

INFORMATION

Standard nanopositioning stages are not suitable for operation with the E-506.10 and cannot be connected via an adapter.

See the E506T0002 technical note for a more detailed description of the E-506.10 charge-controlled amplifier module.

7.6.1 Front Panel Elements

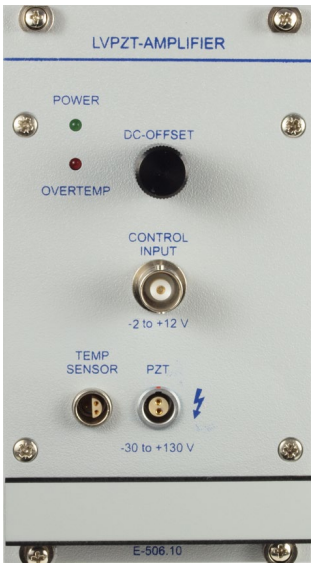


Figure 14: E-506.10 amplifier module

Labeling	Type	Function
POWER	LED Green/off	Amplifier state: ▪ Green: E-506 is ready for normal operation. ▪ Off: The E-500 / E-501 system is switched off.
OVERTEMP	LED Red/off	Overtemp state: ▪ Red: Piezo voltage output is deactivated due to overtemp condition at the piezo actuator (see below) ▪ Off: No overtemp condition
DC-OFFSET	10-turn potentiometer	Adds 0 to 10 V to the CONTROL INPUT signal (only relevant in analog operation, see p. 17 for details.
CONTROL INPUT **-2 to +12 V**	BNC	In analog operation, this control input voltage specifies the target (either as voltage or position, depending on the servo mode). The input signal should always be in the range of 0 to 10 V (excursions to -2 or +12 V may cause overflow, especially in closed-loop operation, and reduce actuator lifetime). The control input range can be shifted using the DC-OFFSET potentiometer. The control input voltage can also be a computer-generated analog signal (e.g., from a DAQ board). To generate that signal, you can use PI's GCS driver library for use with NI LabVIEW software. See "Starting Analog Operation" on p. 17 for details.
TEMP SENSOR	LEMO EPL.0S.303.HLN	Connection for PT1000 temperature sensor or dummy plug. Pinout on p. 34
PZT ⚠ **-30 to +130 V**	LEMO EGG.0B.302.CLL Pinout on p. 34	Output of the piezo voltage for the piezo actuator in the stage. Piezo voltage output is deactivated if a temperature of 150 °C is exceeded at the piezo actuator. Automatic reactivation at a temperature < 146 °C.

7.6.2 Operating Limits

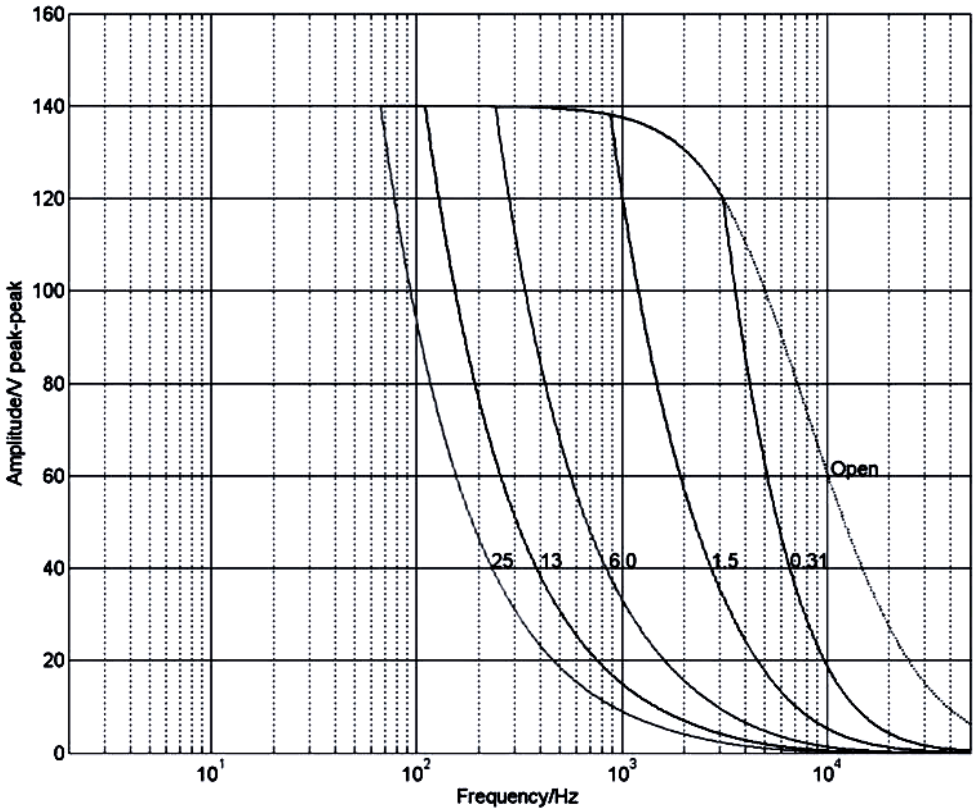


Figure 15: E-506 operating limits with various piezo loads (open-loop), capacitance is measured in µF. The minimum capacitive load is 0.3 µF.

7.6.3 Specifications

	E-506.10
Function	Linearized amplifier module, charge controlled
Channels	1
Amplifier	
Input voltage range	-2 to 12 V
Output voltage*	-30 to 130 V
Peak current, < 2.5 ms	2 A
Average output current	215 mA
Current limitation	Short-circuit proof
Noise	<0.6 mV_{rms}
Reference capacitance (adjustable)	1 to 280 µF
Suggested capacitive load	>0.3 µF
Input impedance	1 MΩ / 1 nF

Interfaces and operation	
Piezo connection (voltage socket)	LEMO 2-pin EGG.0B.302.CLL
Analog input / control input socket	BNC
DC offset setting	10-turn potentiometer, adds 0 to 10 V to the input voltage
Piezo temperature sensor (input)	PT 1000; LEMO socket; automatic deactivation of high voltage output at max. 150 °C
Miscellaneous	
Operating temperature range	5 to 50 °C
Dimensions	14 HP / 3 RU
Mass	0.9 kg
Operating voltage	E-500 / E-501 system
Power consumption	55 W

* Deactivation of the voltage output at 85 °C internally (overheat protection)

Minimum frequencies* for charge-controlled operation:

Capacitance (piezo actuator)	**f_{trans}**
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

7.6.4 Pin Assignment

PZT voltage socket

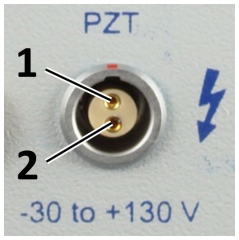


Figure 16: PZT voltage socket, LEMO, 2-pole, female

Pin	Signal
1	Plus
2	Return conductor (minus; the actuator connected must have a floating-ground construction!)

The housing is connected to protective earth.

PT1000 Temperature sensor

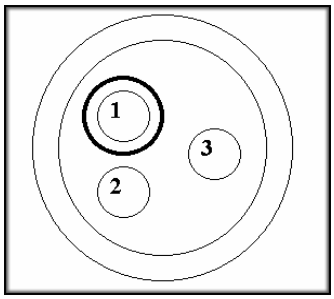


Figure 17: LEMO EPL.OS.303.HLN temperature sensor socket

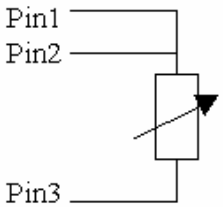


Figure 18: Schematic circuit diagram of temperature sensor

Pin 1: Temp_SA
Pin 2: Temp_S
Pin 3: GND/PE
Housing: Protective earth conductor/GND/PE

32-pin connector, DIN 41612, male

Row	PIN a	PIN c
2	Power Fail	OUT: ch1 (BNC+Offset)
4	IN: ch1	OUT: ch1 (monitor)
6	Piezo voltage GND	Piezo voltage GND
8	OUT: piezo voltage	OUT: piezo voltage
10	n.c.	n.c.
12	n.c.	n.c.
14	n.c.	n.c.
16	IN: -15 V	n.c.
18	n.c.	n.c.
20	n.c.	n.c.
22	GND (measurement)	GND (measurement)
24	GND (power)	GND (power)
26	IN:+24 to +27 V	IN: +24 to +27 V
28	IN: -37 V	OUT: -10 V
30	IN: +137 V	IN: +137 V
32	Protective earth (housing)	Protective earth (housing)

7.7 E-508 High-Power Piezo Amplifier with 1100 V Output Voltage

DANGER

Risk of electric shock!

The E-508 amplifier can output up to 1100 V. Touching this high voltage can result in serious injury or death from electric shock.

- Operate a piezo actuator on the “PZT HIGH VOLTAGE” socket only when it is connected to a protective earth conductor.

7.7.1 Front Panel Elements

Figure 19: E-508.00 amplifier module

Figure 20: E-508.OE amplifier module

Labeling	Type	Function
POWER	LED Green/off	Amplifier state: ▪ Green: E-508 is ready for normal operation. ▪ Off: The E-500 / E-501 system is switched off.
E-508.00 only: **DC-OFFSET**	10-turn potentiometer	Adds 0 to 10 V to the CONTROL INPUT signal (only relevant in analog operation, see p. 17 for details).

Labeling	Type	Function
CONTROL INPUT	E-508.00: BNC E-508.OE: SMB	In analog operation, this control input voltage specifies the target (either as voltage or position, depending on the servo mode). Input voltage range: ▪ Open-loop operation: ±1/100 of selected output range ▪ Closed-loop operation: 0 to 10 V With E-508.00, the control input range can be shifted using the DC-OFFSET potentiometer. The control input voltage can also be a computer-generated analog signal (e.g., from a DAQ board). To generate that signal, you can use PI's GCS driver library for use with NI LabVIEW software. See "Starting Analog Operation" on p. 17 for details. See the "Specifications" table below for the input voltage range.
PZT ⚠ **High Voltage**	LEMO EGG.0B.701.CJL.1173 Pinout on p. 39	Output of the piezo voltage for the piezo actuator in the stage. See the "Specifications" table below for the output voltage range.

7.7.2 Operating Limits

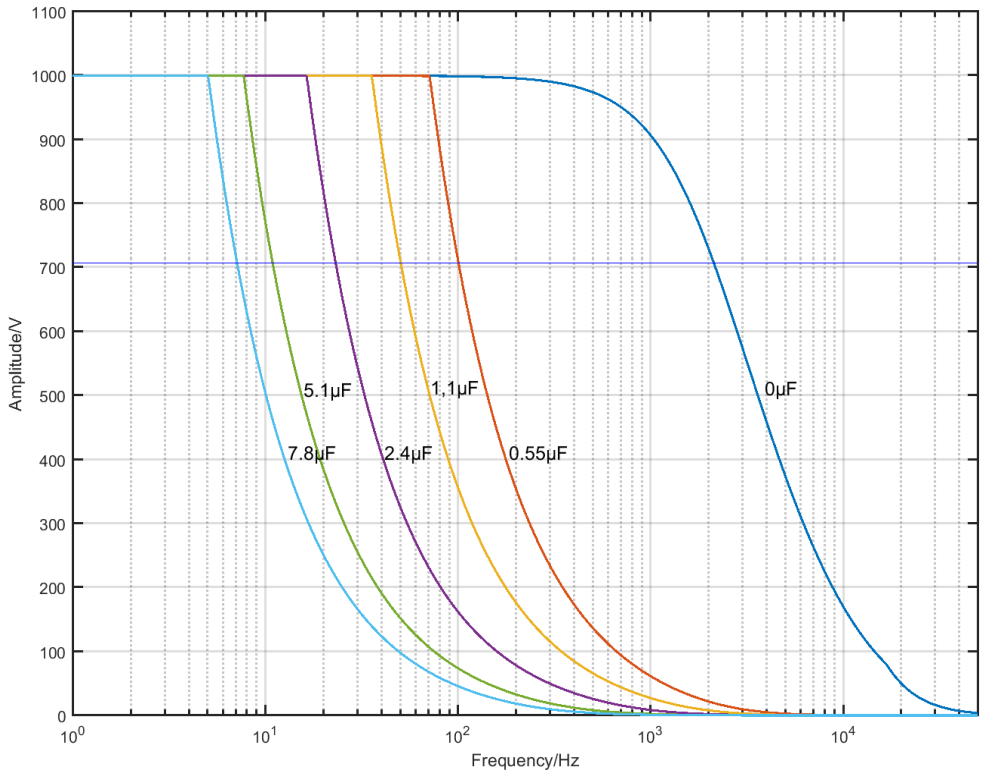


Figure 21: E-508 operating limits with various piezo loads (open-loop), capacitance is measured in µF

7.7.3 Specifications

	E-508.00	E-508.OE
Function	Power amplifier for PICA high-voltage piezo actuators	Power amplifier for PICA high-voltage piezo actuators
Amplifier		
Output voltage	3 to +1100 V (default) Adjustable: -260 to +780 V -550 to +550 V +260 to -780 V -3 to -1100 V	3 to 1100 V (default) Optional: -260 to +780 V -550 to +550 V +260 to -780 V -3 to -1100 V
Amplifier channels	1	1
Average output power	13 W	13 W
Peak power, < 5 ms	50 W	400 W
Average output current	12 mA	12 mA
Peak current, <5 ms	50 mA	400 mA
Bandwidth, small signal	6 kHz	10 kHz
Amplifier bandwidth, large signal	50 Hz (200 nF)	50 Hz (200 nF)
Ripple, noise, 0 to 100 kHz	5 mV_{rms} 50 mV_{pp} (100 nF)	20 mV_{rms} 200 mV_{pp} (100 nF)
Current limitation	Short-circuit proof	Short-circuit proof
Voltage gain	+100 ±1, -100 ±1 (selectable)	+100 ±1, -100 ±1 (selectable)
Control input voltage	Open-loop operation: ±1/100 of selected output voltage range Closed-loop operation: 0 to 10 V	Open-loop operation: ±1/100 of selected output voltage range Closed-loop operation: 0 to 10 V
Input impedance	100 kΩ	100 kΩ
Interfaces and operation		
Piezo output socket	LEMO EGG.0B.701.CJL.1173	LEMO EGG.0B.701.CJL.1173
Input	BNC	SMB
DC offset setting	10-turn potentiometer, adds 0 to 10 V to the input voltage	–
Miscellaneous		
Operating voltage	E-500 / E-501 system	E-500 / E-501 system
Operating temperature range	5 to 50 °C (above 40 °C, power derated)	5 to 50 °C (above 40 °C, power derated)
Mass	0.75 kg	0.75 kg
Dimensions	14 HP / 3 RU	14 HP / 3 RU

7.7.4 High-Voltage Actuator Types and Terminology

If you order the actuator and controller together, and/or provide PI with sufficient information about your application, then the actuator connector, output voltage range and gain polarity will be set up as required.

If you are connecting other actuators or wiring your own connector, read the below description of the different actuator types as well as any documentation that came with the actuator carefully.

Bipolar actuators

Here the output voltage swing is so chosen that the actuator sees both negative and positive high voltages. The output always has one lead at 0 V, and here the other is in a zero-crossing range, commonly·±500·V.

Unipolar actuators

The notation of “positive” and “negative” polarity of piezo actuators does not refer to their direction of motion. Unipolar piezos of any polarity will elongate when a higher voltage is applied to their (+) than to their (-) terminal.

“Positive” and “negative” refers to the sign of the voltage on the core of the cable.

All standard PI piezo actuators with 2-conductor LEMO connectors have positive polarity.

7.7.5 Pin Assignment

PZT High Voltage Socket

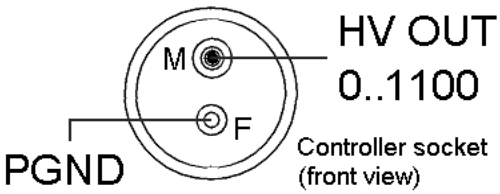


Figure 22: PZT high voltage socket, LEMO EGG.0B.701.CJL.1173, 2-pole

HV OUT: High-voltage output

PGND: Power ground

Housing: Cable shield

32-pin connector, DIN 41612, male

Row	PIN a	PIN c
2	IN: Power Fail*	OUT: control (E-508.00: BNC+Offset / E-508.OE: SMB)
4	IN: control	OUT: monitor of piezo voltage (PZT ÷1000)
6	nc	nc
8	nc	nc
10	nc	nc
12	nc	nc
14	internal use (Bus_A)*	internal use (Bus_B)*
16	internal use (Bus_Vcc)*	internal use (Bus_GND)*
18	nc	nc
20	nc	nc
22	GND (measurement)	GND (measurement)
24	GND	GND
26	IN: +24 V to +27 V	IN: +24 V to +27 V
28	nc	nc
30	nc	nc
32	Protective earth (housing)	Protective earth (housing)

* no connection on E-508.OE

7.7.6 E-508.00 Gain Polarity and Output Range Settings

NOTICE

Electrostatic hazard!

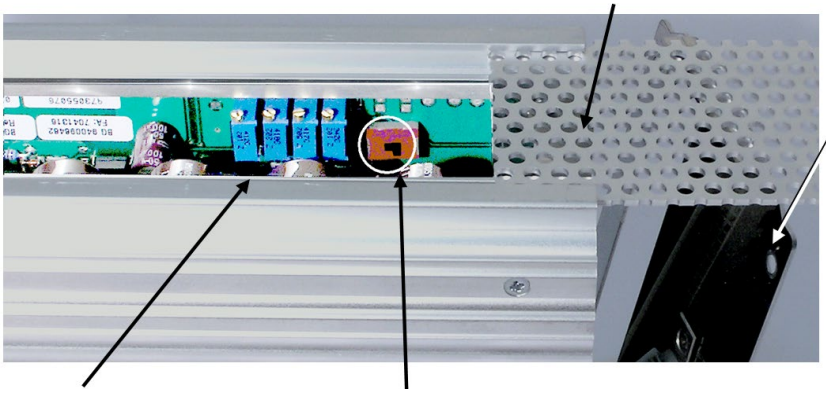
The E-500 / E-501 system contains electrostatic-sensitive devices (ESD) and can be damaged if handled improperly.

- Avoid touching components, pins, and PCB traces.
- Before touching an electronic component, discharge yourself of any electric charges:
  - While working, wear an antistatic wrist strap
    or
  - Briefly touch a conducting, grounded object.

Making the gain polarity switch and output range jumper accessible

Only remove modules from the housing when you are authorized and have the corresponding qualifications.

1. Disconnect the E-500 / E-501 system from the mains by pulling the power plug.
2. Wait a minute to be sure that any residual voltage has dissipated.
3. Remove the E-508.00 module from the housing:
   a) Loosen the four Phillips screws on the front panel.
   b) Using the grip at the bottom of the front panel, pull the module out of the housing.
4. To access settings for gain polarity and output range, remove the rear cover plate from the E-508.00 module and slide back the perforated aluminum top.



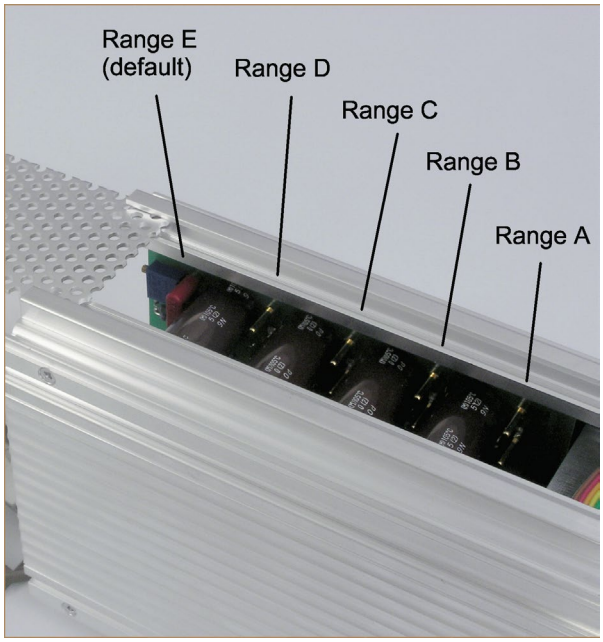
Setting the Gain Polarity Switch

It is important to understand the relation between gain and the control input range.

With DC-OFFSET = 0 (full CCW), the control input range is equal to output range (as set below) divided by the gain.

For example, in open-loop operation, the output range +3 to +1100 V and gain +100 yield a control input range of 0 to +11 V.

Setting the Output Range Jumper



Ranges	
E	+3 to +1100 V (factory setting)
D	-260 to +780 V
C	-550 to +550 V
B	-780 to +260 V
A	-1100 to -3 V

To change the setting, remove the red cap (shown in Range E position) and place it on the pins for the desired range.

7.8 E-509 Sensor / Servo Controller Module

INFORMATION

- See the E-509 user manual (PZ77) for a detailed description.
- See also the user manuals for the E-802 servo-controller submodule (with all E-509 versions) and the E-801 sensor submodule (only with LVDT and strain gauge sensor versions).

7.8.1 Front Panel Elements of Modules for Capacitive Sensors

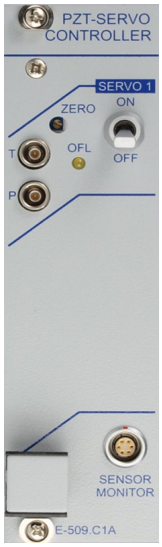


Figure 23:
E-509.C1A sensor / servo controller module

Figure 24:
E-509.C2A sensor / servo controller module

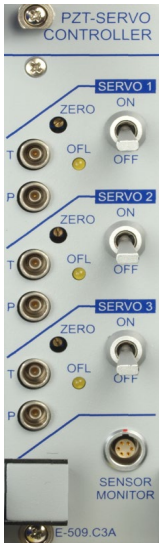


Figure 25:
E-509.C3A sensor / servo controller module

Labeling	Type	Function
T	LEMO EPL.00.250.NTD	Input for the Target sensor signal from the piezo stage.
P	LEMO EPL.00.250.NTD	Input for the Probe sensor signal from the piezo stage.
ZERO	Trim potentiometer	A trimmer adjustment tool can be used on the ZERO potentiometer for a zero-point adjustment of the sensor. A zero-point adjustment can be necessary after longer operation (changes in temperature) or if the load on the piezo stage is changed.
OFL	LED Yellow/off	Overflow state: ▪ Yellow: Overflow condition, i.e., the amplifier is near its range limit. ▪ Off: No overflow condition When the OFL LED comes on, a zero-point adjustment of the sensor can be necessary. See p. 17 and the E-509 user manual (PZ77E) for details.
SERVO *x* ON/OFF *x* stands for the channel number	Toggle switch	Switch for the servo mode selection of the corresponding channel: ▪ ON: Closed-loop operation ▪ OFF: Open-loop operation See also “Servo Modes” on p. 11 for details.
SENSOR MONITOR	LEMO EGG.0B.306.CLL	Output of the monitor signal(s) for the sensor channel(s). Pinout on p. 45.

7.8.2 Front Panel Elements of Modules for Strain Gauge Sensors

Figure 26:
E-509.S1 sensor / servo controller module

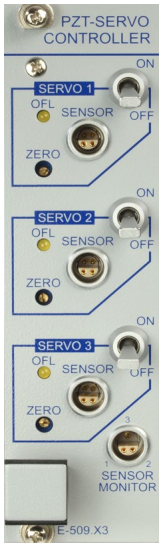


Figure 27:
E-509.S3 sensor / servo controller module

INFORMATION

In the labeling of E-509.S1 and E-509.S3 modules, *X* stands for *S*.

Labeling	Type	Function
OFL	LED Yellow/off	Overflow state: ▪ Yellow: Overflow condition, i.e., the amplifier is near its range limit. ▪ Off: No overflow condition When the OFL LED comes on, a zero-point adjustment of the sensor can be necessary. See p. 17 and the E-509 user manual (PZ77E) for details.
SERVO ON/OFF **1**, **2,** and **3** stand for the channel numbers	Toggle switch	Switch for the servo mode selection of the corresponding channel: ▪ ON: Closed-loop operation ▪ OFF: Open-loop operation See also “Servo Modes” on p. 11 for details.
ZERO	Trim potentiometer	A trimmer adjustment tool can be used on the ZERO potentiometer for a zero-point adjustment of the sensor. A zero-point adjustment can be necessary after longer operation (changes in temperature) or if the load on the piezo stage is changed.
SENSOR	LEMO ERA.0S.304.CLL	Input for the signals of the strain gauge sensor of the piezo stage. Pin assignment on p. 45.

Labeling	Type	Function
SENSOR MONITOR	E-509.S1: BNC E-509.S3: LEMO ERA.0S.303.CLL	Output of the monitor signal(s) for the sensor channel(s). Pin assignment for E-509.S3 on p. 45.

7.8.3 Specifications

	E-509.C1A / E-509.C2A / E-509.C3A	**E-509.S1 / E-509.S3**
Function	Sensor evaluation and position servo control electronics for piezo mechanics	Sensor evaluation and position servo control electronics for piezo mechanics
Axes	1 / 2 / 3	1 / 3
Sensor		
Controller type	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 (jumper selectable); to 10 kHz on request	0.3; 1; 3 kHz
Noise factor	0.115 ppm/√Hz	-
Thermal drift	<0.3 mV/°C	<3 mV/°C
Linearity error	<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.)
Linearization	ILS (Integrated Linearization System)	On E-801 submodule
Display and indicators	Overflow LED	Overflow LED
Miscellaneous		
Operating temperature range	5 to 50 °C	5 to 50 °C
Dimensions	7 T / 3 H	7 T / 3 H
Mass	0.35 kg	0.35 kg
Operating voltage	E-500 / E-501 system	E-500 / E-501 system
Max. power consumption	4 to 8 W	4 to 8 W

7.8.4 Pin Assignment

SENSOR socket of E-509.S3 and E-509.S1

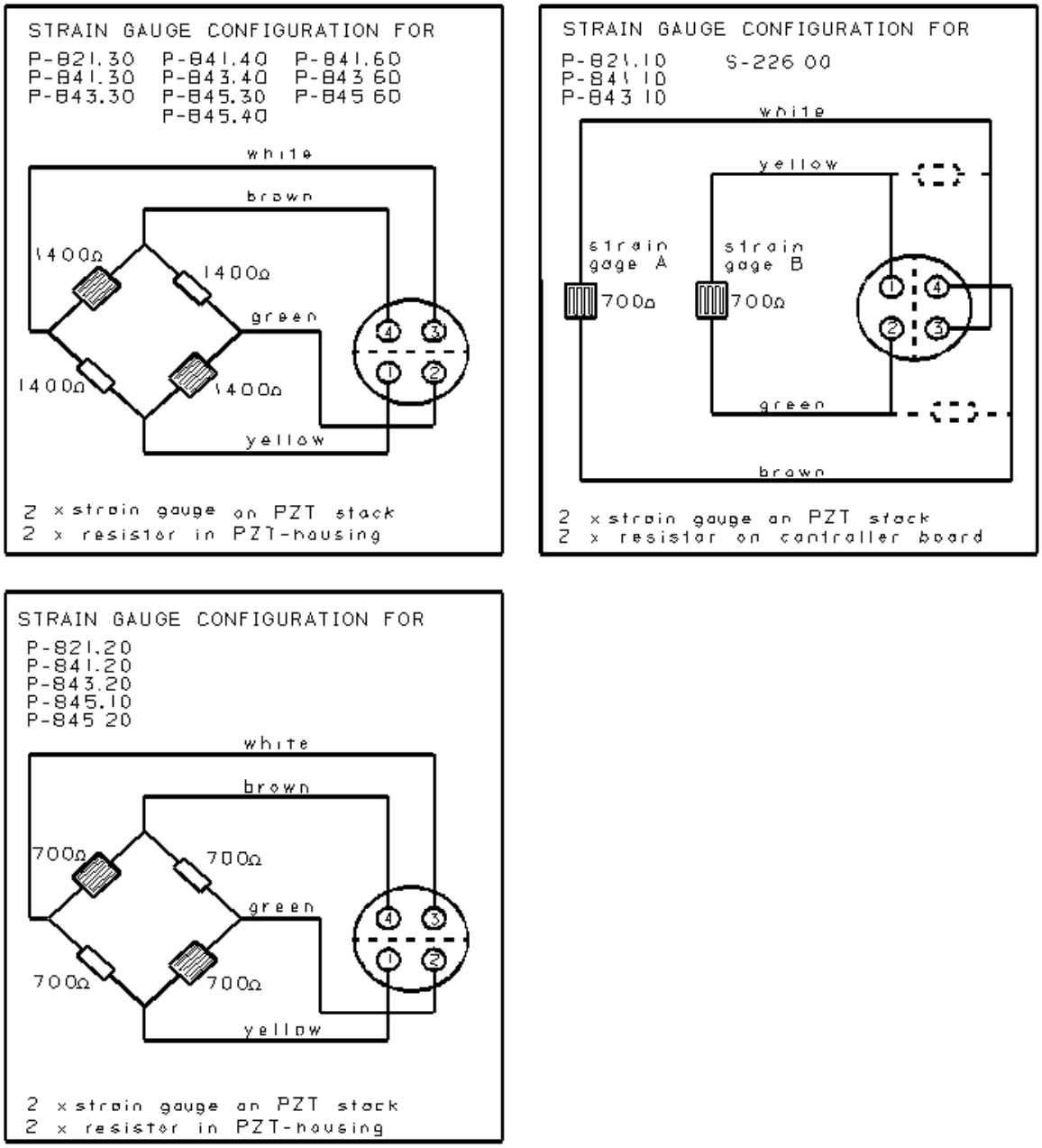


Figure 28: Strain gauge sensor wiring for various piezo actuators

SENSOR MONITOR socket of E-509.S3

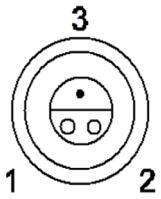


Figure 29: LEMO ERA.0S.303.CLL sensor monitor socket, 3-pole

The SENSOR MONITOR socket carries the signals from all three channels.

Each E-509.S3 comes with the E-808.90 sensor-monitor cable. The purpose of this cable is simply to split up the signals of the SENSOR MONITOR socket for the three channels.

The leads of this open-ended cable are color coded:

Wire color	Signal
White	Channel 1
Brown	Channel 2
Green	Channel 3

The shield is connected to ground (GND).

SENSOR MONITOR socket of E-509.CxA

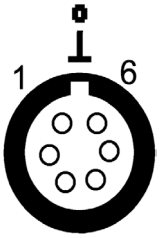


Figure 30: LEMO FGG.0B.306.CLAD56 sensor monitor socket, 6-pole

Pin	Signal
1	ch1+
2	ch1-
3	ch2+
4	ch2-
5	ch3+
6	ch3-

The shield is connected to ground (GND).

Each capacitive sensor version comes with the D-893.32 sensor monitor cable (2 m). The purpose of this cable is simply to split up the signals of the SENSOR MONITOR socket onto three separate BNC connectors. The BNC connectors are each labeled with the channel number.

E-509.S3 32-pin connector, DIN 41612, male

Pin	Function	Pin	Function
2a	GND	2c	GND
4a	internal use	4c	OUT: ch1 (control)
6a	IN: +15 V	6c	IN: +15 V
8a	IN: -15 V	8c	IN: -15 V
10a	internal use*	10c	internal use
12a	internal use (Bus_A)	12c	OUT: ch2 (control)
14a	OUT: Display ch2	14c	OUT: Display ch1
16a	internal use (Bus_B)	16c	OUT: Display ch3
18a	internal use (BUS_Vcc)	18c	internal use (BUS_GND)
20a	IN: Control ch1	20c	OUT: ch3 (control)
22a	IN: Control ch3*	22c	IN: Control ch2
24a	internal use	24c	internal use
26a	IN: VC/EC ch2	26c	IN: VC/EC ch1
28a	OUT: Overflow ch1	28c	IN: VC/EC ch3*
30a	OUT: Overflow ch3	30c	OUT: Overflow ch2
32a	nc	32c	nc

Note: Pins labeled with "nc" may be used internally and must not be connected externally.

E-509.S1 32-pin connector, DIN 41612, male

Pin	Function	Pin	Function
2a	GND	2c	GND
4a	internal use	4c	OUT: ch1 (control)
6a	IN: +15 V	6c	IN: +15 V
8a	IN: -15 V	8c	IN: -15 V
10a	internal use	10c	internal use
12a	internal use (Bus_A)	12c	nc
14a	nc	14c	OUT: Display ch1
16a	internal use (Bus_B)	16c	nc
18a	internal use (BUS_Vcc)	18c	internal use (BUS_GND)
20a	IN: Control ch1	20c	nc
22a	nc	22c	nc
24a	internal use	24c	internal use
26a	nc	26c	IN: VC/EC ch1
28a	OUT: Overflow ch1	28c	nc
30a	nc	30c	nc
32a	nc	32c	nc

Note: Pins labeled with "nc" may be used internally and must not be connected externally.

E-509.C1A, E-509.C2A, E-509.C3A

32-pin connector, DIN 41612, male

Pin	Function on			Pin	Function on		
	.C3A	.C2A	.C1A		.C3A	.C2A	.C1A
2a	GND	*	*	2c	GND	*	*
4a	n.c.	*	*	4c	Control signal output CH1	*	*
6a	+ 15 V	*	*	6c	+ 15 V	*	*
8a	- 15 V	*	*	8c	- 15 V	*	*
10a	n.c.	*	*	10c	n.c.	*	*
12a	internal use	*	*	12c	Control signal output CH2	*	n.c.
14a	Display CH2	*	n.c.	14c	Display CH1	*	*
16a	internal use	*	n.c.	16c	Display CH3	n.c.	n.c.
18a	internal use	n.c.	n.c.	18c	internal use	*	*
20a	Control signal input CH1	*	*	20c	Control signal output CH3	to JP210, pin 1	n.c.
22a	Control signal input CH3	to JP210, pin 2	n.c.	22c	Control signal input CH2	*	n.c.
24a	n.c.	*	*	24c	SYNC	*	*
26a	Servo ON/OFF, ch2	*	n.c.	26c	Servo ON/OFF, ch1	*	*
28a	overflow CH1	*	*	28c	Servo ON/OFF, ch3	n.c.	n.c.
30a	overflow CH3	n.c.	n.c.	30c	overflow CH2	*	n.c.
32a	n.c.	*	*	32c	n.c.	*	*

* Same as on E-509.C3A

n.c. : No Connection: may be used on the backplane and must not be connected.

JP210 shorted on E-509.C2A (default): connects CH3 input to CH3 output (i.e., CH3 bypassed)

7.9 E-515 Display Modules

7.9.1 Front Panel Elements

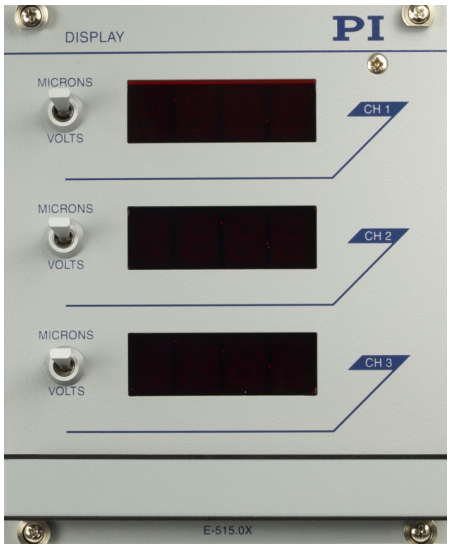


Figure 31: E-515.03 display module

Figure 32: E-515.01 display module

INFORMATION

In the labeling of E-515.01 and E-515.03 display modules, *X* stands for the number of channels.

Labeling	Type	Function
MICRONS / VOLTS	Toggle switch	Switch for selection of the signal to be displayed for the channel: ▪ MICRONS: Position (displacement) measured by the sensor ▪ VOLTS: Piezo voltage as output by the amplifier
-	Display with 3 ½ digits	If adjustment of the display should be necessary, see p. 51.

7.9.2 Specifications

Model	**E-515.01**	**E-515.03**
Function	Display module for piezo voltage and position	Display module for piezo voltage and position
Channels	1	3
Display linearity	0.1 %	0.1 %
Display	1 × 3½ digits	3 × 3½ digits
Dimensions	21 HP / 3 RU	21 HP / 3 RU
Mass	0.3 kg	0.3 kg
Operating voltage	E-500 / E-501 system	E-500 / E-501 system
Operating temperature range	5 to 50 °C	5 to 50 °C

7.9.3 Pin Assignment

E-515.01 and E-515.03 32-pin connector, DIN 41612, male

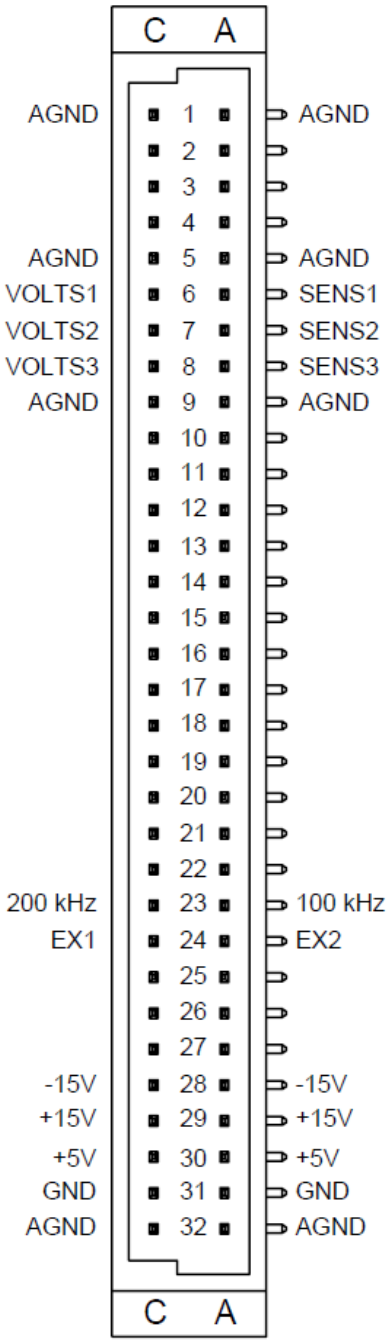


Figure 33: Pin assignment for E-515.01 and E-515.03

7.9.4 Display Adjustment

NOTICE

Electrostatic hazard!

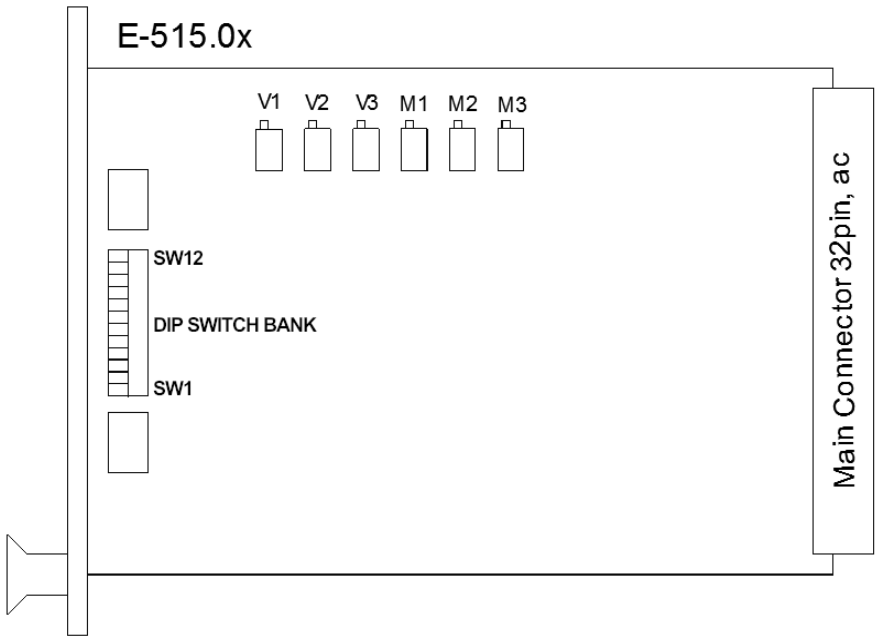
The E-500 / E-501 system contains electrostatic-sensitive devices (ESD) and can be damaged if handled improperly.

- Avoid touching components, pins, and PCB traces.
- Before touching an electronic component, discharge yourself of any electric charges:
  - While working, wear an antistatic wrist strap

    or
  - Briefly touch a conducting, grounded object.

INFORMATION

If ordered as part of a E-500 / E-501 system or if PI is informed about the application, E-515.01 and E-515.03 display modules come preset (range, decimal places).



Potentiometers:	
Reading adjustments:	
V1–V3:	Voltage channels 1–3
M1–M3	Microns channels 1–3

DIP switch settings	
Setting the decimal point:	
S1–S3:	Micron channel 3
S4:	Volt channel 3
S5–S7:	Micron channel 2
S8:	Volt channel 2
S9–S11:	Micron channel 1
S12:	Volt channel 1

Figure 34: Location of display adjustment elements on the E-515.0x display module

Making the display adjustment elements accessible

Only remove modules from the housing when you are authorized and have the corresponding qualifications.

1. Disconnect the E-500 / E-501 system from the mains by pulling the power plug.
2. Wait a minute to be sure that any residual voltage has dissipated.
3. Remove the E-515 module from the housing:
   a) Loosen the four Phillips screws on the front panel.
   b) Using the grip at the bottom of the front panel, pull the module out of the housing.

7.10 E-518 Interface Module

7.10.1 Front Panel Elements

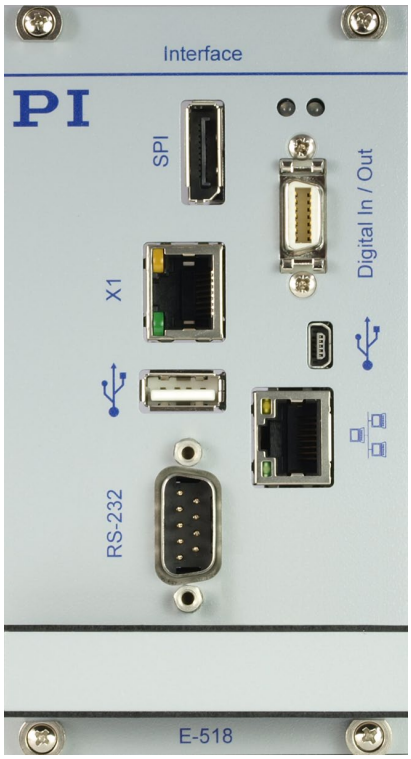
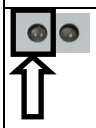
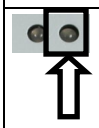
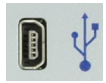


Figure 35: E-518 interface module

Labeling / appearance	Type	Function
SPI	Display port	Without function
X1	RJ45 socket	Reserved for future functionality
	USB-A socket	Connection for a USB slave device, reserved for future functionality.

Labeling / appearance	Type	Function
RS-232	D-sub 9 panel plug (p. 54)	Serial connection to PC. Default baud rate: 115200 Refer to “Establishing Communication via the RS-232 Interface” in the E-518 user manual (E518T0001) for details.
	Left LED Green/red/off	Shows the status of the GCS parser: ▪ Continuously green: E-518 is ready for normal operation ▪ Continuously red: Error (error code ≠ 0)* ▪ Flashing green: E-518 searches for a DHCP server *The error code can be queried with the ERR? command. The query resets the error code to zero, and the LED color changes to green.
		During power-on/reboot sequence: Switch-on: Off > Booting: Red > Parser ready: Green
	Right LED Green/red/off	Shows the DSP status: ▪ Continuously green: E-518 is ready for normal operation ▪ Continuously red: DSP is busy with a time-consuming task (e.g., autocalibration procedure) ▪ Continuously off: DSP is not running
		During power-on/reboot sequence: Switch-on: Off > Booting: Off > DSP ready: Green
Digital In / Out	MDR14 socket (p. 54)	Digital lines: ▪ Outputs: Triggering of external devices in conjunction with the axis motion ▪ Inputs: Triggering of wave generator, use in macros
	Mini-USB type B	Universal serial bus for connection to the PC. Refer to “Establishing Communication via the USB Interface” in the E-518 user manual (E518T0001) for details.
	RJ45 socket	Ethernet interface for communication via TCP/IP. Factory default settings: ▪ IP address (parameter ID 0x11000600): 192.168.168.10:50000 ▪ IP mask (parameter ID 0x11000700): 255.255.255.0 ▪ IP start (parameter ID 0x11000800): 1 (IP address is obtained via DHCP or automatically configured using AutoIP) Refer to “Establishing Communication via the TCP/IP Interface” in the E-518 user manual (E518T0001) for details.

7.10.2 Specifications

	E-518.I3
Function	Digital interface module for the E-500 system (E-500, E-470, E-481, E-482)
Channels	3
Supported functions	Wave generator. Data recorder. Macro programming.
Processor	DSP 376 MHz
Sampling rate, sensor	200 kHz
Servo control rate	25 kHz
Sensor resolution	ADC: 20 bits, oversampling + filter
Voltage resolution	DAC: 20 bits, oversampling + filter, 16 bit @ 1 MHz
Interfaces and operation	
Communication interfaces	TCP/IP, USB, RS-232
I/O lines	3 digital inputs, 3 digital outputs 3.3 V, MDR14 connector
Command set	PI General Command Set (GCS)
User software	PIMikroMove
Application programming interfaces	C, C++, C#, MATLAB, NI LabVIEW, Python
Miscellaneous	
Operating voltage	Via the power supply of the E-500 / E-501 system
Operating temperature range	5 to 50 °C
Dimensions	14HP / 3RU
Mass	0.26 kg

7.10.3 Pin Assignment

Digital In / Out Interface

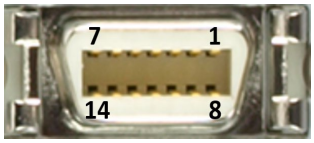


Figure 36: MDR14 socket

Pin	Function
1	GND
2	Reset input (active low)
3	DIO_O3 digital output 3
4	DIO_O2 digital output 2
5	DIO_O1 digital output 1
6	Reserved
7	Not connected

Pin	
8	Reserved
9	Reserved
10	Not connected
11	DIO_I3 digital input 3
12	DIO_I2 digital input 2
13	DIO_I1 digital input 1
14	Reserved

Digital inputs 1 to 3 (pins 13, 12, 11): TTL, 3.3 V, 5 V compatible

Reset input (pin 2): Internal pull-up to 3.3 V

- low (0 V) = reset (same behavior as with the RBT command)
- high (3.3 V) = on (default)

Digital outputs 1 to 3 (pins 5, 4, 3): TTL, 3.3 V

RS-232 Interface

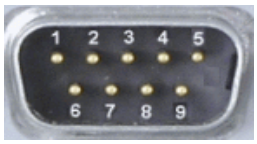


Figure 37: D-sub 9 (m) panel plug

Pin	Function
1	Not connected
2	RXD receive data
3	TXD send data
4	Not connected
5	DGND ground
6	Not connected
7	RTS Hardware handshake, output
8	CTS Hardware handshake, input
9	Not connected

7.11 Dummy Modules

7.11.1 Overview

Your E-500 / E-501 system may be equipped with one or several dummy modules. The purpose of these dummy modules is to complete the internal circuitry and the front panel of the housing. They are installed in your E-500 / E-501 system at the factory if necessary.

Product no.	Description
E-595.00	Dummy module; replaces E-509.xx sensor modules (all types); no operating elements
E-596.00	Dummy module with monitor function; replaces the E-518 interface module (or the E-515 display module) if E-509 modules for SGS sensors are installed
E-596.10	Dummy module with monitor function; replaces the E-518 interface module (or the E-515 display module) if E-509 modules for capacitive sensors are installed

INFORMATION

Do not operate your E-500 / E-501 system when the dummy modules are removed. Without these modules, the system will malfunction because no control signal can be fed into the amplifier module due to the broken circuit.

7.11.2 Front Panel Elements of E-596 Modules

Figure 38: E-596.xx dummy module with monitor function

Name	Function
PZT Monitor 1 PZT Monitor 2 PZT Monitor 3 max. ±15 V ⚠	SMB connectors for monitor channels 1 to 3 1 V monitor voltage corresponds to 10 V piezo output voltage. The monitor channels are assigned to the amplifier modules as follows when viewed from the front: ▪ Monitor 1 belongs to the amplifier module on the far left ▪ Monitor 2 belongs to the middle amplifier module ▪ Monitor 3 belongs to the amplifier module on the far right

8 Integrating Modules in Third-Party Systems

8.1 Safety Measures for Integration in Third-Party Systems

DANGER

Risk of electric shock!

The amplifier modules of the E-500 / E-501 series output up to 130 V (E-503, E-504, E-505, E-506) or up to 1100 V (E-508). Touching any parts carrying this high voltage can result in serious injury or death from electric shock.

- ➢ Disconnect the third-party system from the power source before integrating E-500 / E-501 series modules.
- ➢ Operate an amplifier module only when it is installed in a suitable housing and connected to a protective earth conductor via pins 32a and 32c of the 32-pin connector, DIN 41612, male.
  - – Make sure that the contact resistance of the protective earth conductor is <0.1 Ω at 25 A at all connection points relevant for the function of the protective earth conductor.
  - – If the protective earth conductor has to be removed temporarily (e.g., in the case of system modifications), reconnect the protective earth conductor before starting up the module again.
- ➢ When you operate E-504, E-505, or E-506 amplifier modules, do not touch pins 6a, 6c, 8a and 8c of the 32-pin connector since the piezo voltage is output on these pins (in addition to the output on the PZT socket of the front panel).

NOTICE

Electrostatic hazard!

The E-500 / E-501 system contains electrostatic-sensitive devices (ESD) and can be damaged if handled improperly. When operated without housing, the E-500 / E-501 modules can emit electrical, magnetic, or electromagnetic fields which interfere with the environment.

- ➢ Avoid touching components, pins and PCB traces.
- ➢ Before touching an electronic component, discharge yourself of any electric charges:
  - – While working, wear an antistatic wrist strap

    or
  - – Briefly touch a conducting, grounded object.
- ➢ When E-500 / E-501 series modules are installed in a third-party housing, make sure that the system complies with the EMC requirements.

8.2 Supply Power for the Modules

The supply power must be stable within a range of 2 % of the nominal value.

For stable supply power with dynamic operation of high piezo loads, the power supply must be equipped with a sufficiently dimensioned buffer capacitor. The required capacitance of the buffer can be approximated as follows:

Buffer capacitance = 10 × piezo load

8.3 Amplifier Modules: Closing the Circuit

In order to feed the control signal (DC-OFFSET potentiometer and/or CONTROL INPUT signal) into the amplifier, short the following pins:

E-504, E-505, E-506, E-508: pin 2c to 4a

E-503: pin 2c to 4a; pin 10c to 12a; pin 18c to 20a

Otherwise, the output voltage of the amplifier would go to its positive / negative limit.

9 Maintenance

9.1 Cleaning the E-500 / E-501 system

NOTICE

Short circuits or flashovers!
The E-500 / E-501 system contains electrostatic-sensitive devices that can be damaged by short circuits or flashovers when cleaning fluids get into the housing.

- ➢ Before cleaning, disconnect the E-500 / E-501 system from the mains by pulling the power plug.
- ➢ Prevent cleaning fluid from getting into the housing.

NOTICE

Wrong cleaning agent!
The E-500 / E-501 system can be damaged if wrong cleaning agents are used.

- ➢ Do not use any organic solvents for cleaning.

- ➢ When necessary, clean the housing surfaces of the E-500 / E-501 system using a cloth dampened with a mild cleanser or disinfectant.

9.2 Changing Line Fuses

The power connection and line fuses are located on the rear panel of the housing.

DANGER

Risk of electric shock!
The E-500 / E-501 system requires a supply voltage of 100 to 120 V AC or 220 to 240 V AC (line voltage). Touching the line voltage can result in serious injury or death from electric shock.

- ➢ Remove the power cord from the E-500 / E-501 system before you change the line fuses.

INFORMATION

Both line fuses of the E-500 / E-501 system are active.

- ➢ Check both fuses if there is a fault.

Tools and accessories

- Slot screwdriver
- Two suitable fuses:

Model	Line voltage ranges and fuse values	
E-500.00	100 to 240 V AC 2 × IEC T2AH, 250 V	
E-501.00	100 to 120 V AC 2 × IEC T2AH, 250 V	220 to 240 V AC 2 × IEC T1AL, 250 V
E-500Kxxx	See the product-specific documentation or the nameplate label on the device.	
E-501Kxxx		

Note: IEC-standard fuses are designed to carry the nominal current indefinitely. Other fuse rating standards differ.

Changing line fuses

1. Switch off the power supply using the line switch on the rear panel of the E-500 / E-501 system and remove the power cord.
2. Wait a minute to be sure that any residual voltage has dissipated.
3. Using a slot screwdriver, pry open the fuse holder from the power inlet (see Figure 39 below).
4. Be sure to replace both fuses with fuses of the suitable type (see the table above).
5. Reinstall the fuse holder in the power inlet.

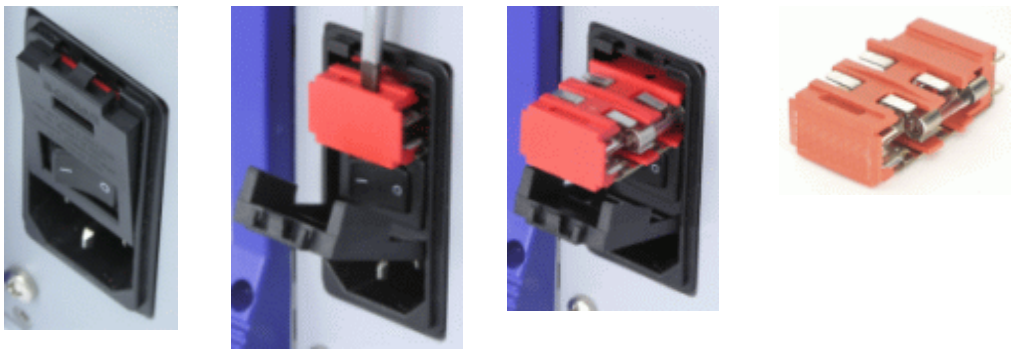


Figure 39: Accessing the line fuses (only permitted when the power cord is removed)

10 Customer Service Department

For inquiries and orders, contact your PI sales engineer or send us an email (service@pi.de).

- If you have questions concerning your system, provide the following information:
  - Product and serial numbers of all products in the system
  - Firmware version of the controller (if applicable)
  - Version of the driver or the software (if applicable)
  - PC operating system (if applicable)
- If possible: Take photographs or make videos of your system that can be sent to our customer service department if requested.

The latest versions of the user manuals are available for download on our website (p. 2).

11 Technical Data

11.1 Maximum Ratings

The E-500 / E-501 system is designed for the following operating data:

Model	Maximum operating voltage 	Operating frequency 	Maximum power consumption 
System in E-500.00 housing	100 to 240 V AC (fuses: 2 × T2AH, 250 V)	50-60 Hz	180 W
System in E-501.00 housing	100 to 120 V AC (fuses: 2 × T2AH, 250 V)	50-60 Hz	80 W
	220 to 240 V AC (fuses: 2 × T1AL, 250 V)	50-60 Hz	80 W

11.2 Ambient Conditions and Classifications

Pay attention to the following ambient conditions and classifications for the E-500 / E-501 system:

Area of application	For indoor use only
Maximum altitude	2000 m
Air pressure	1100 to 0.1 hPa
Relative humidity	Highest relative humidity 80 % for temperatures up to 31 °C Decreasing linearly to 50 % relative humidity at 40 °C
Storage temperature	5 to 70 °C
Transport temperature	-25 to 85 °C
Overvoltage category	II
Protection class	I
Degree of pollution	2
Measurement category	I
Degree of protection according to IEC 60529	IP20

12 Old Equipment Disposal

In accordance with EU law, electrical and electronic equipment may not be disposed of in EU member states via the municipal residual waste.

Dispose of your old equipment according to international, national, and local rules and regulations.

To fulfill the responsibility as the product manufacturer, Physik Instrumente (PI) GmbH & Co. KG undertakes environmentally correct disposal of all old PI equipment made available on the market after 13 August 2005 without charge.

Any old PI equipment can be sent free of charge to the following address:

Physik Instrumente (PI) GmbH & Co. KG

Auf der Römerstraße 1

76228 Karlsruhe, Germany

13 European Declarations of Conformity

For the E-500 / E-501 modular piezo amplifier controller, declarations of conformity were issued according to the following European statutory requirements:

Low Voltage Directive

EMC Directive

RoHS Directive

The standards applied for certifying conformity are listed below.

Safety (Low Voltage Directive): EN 61010-1

EMC: EN 61326-1

RoHS: EN IEC 63000

14 Appendix

14.1 Lifetime of PICMA® Actuators

The lifetime of a PICMA® piezo actuator can be influenced by the following factors:

- Applied voltage
- Temperature
- Relative humidity

The following diagrams show how the individual factors influence the lifetime of the actuator.

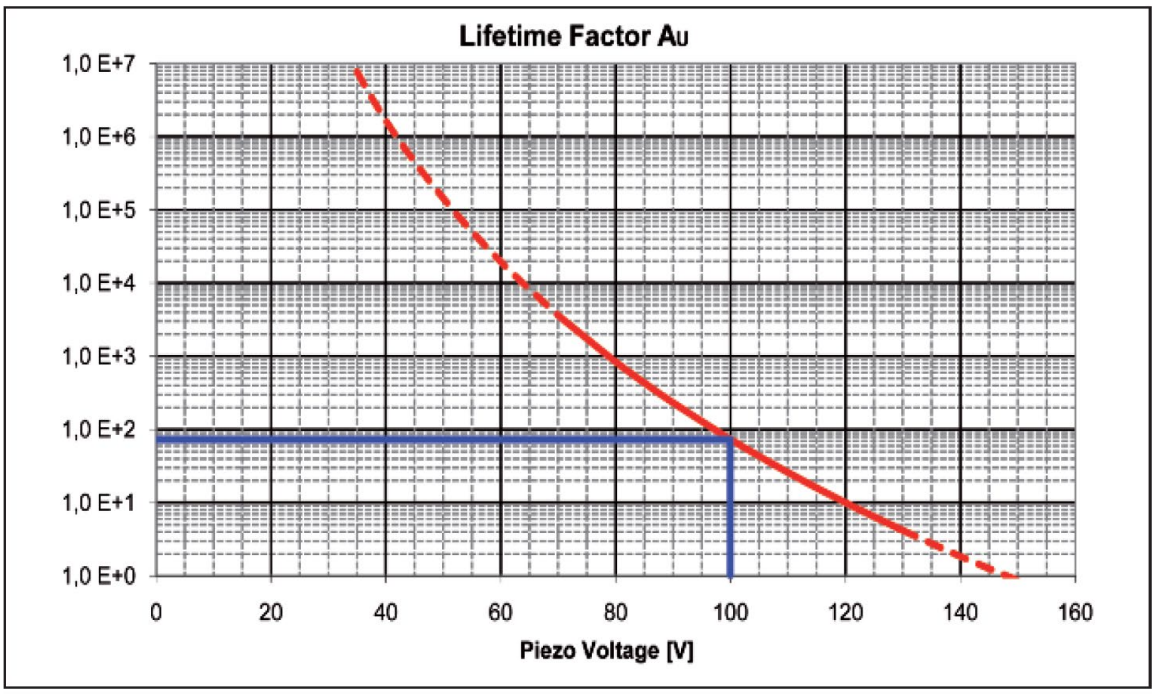


Figure 40: Dependency of the mean time between failure (MTTF) of a PICMA® actuator on the applied voltage

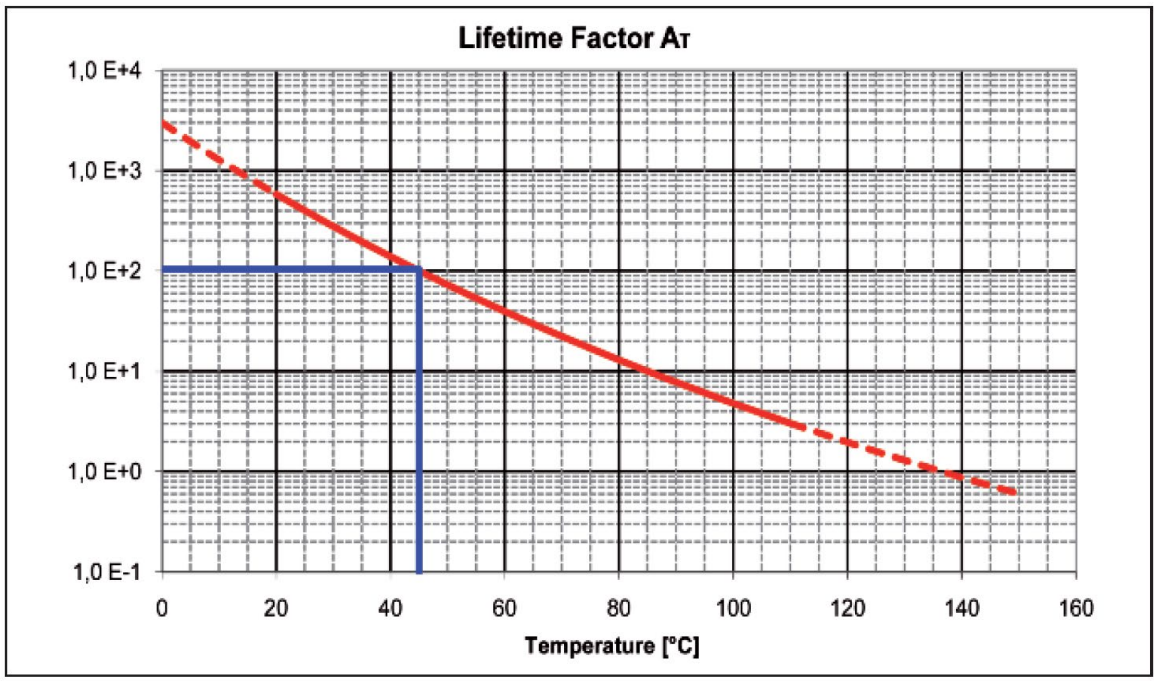


Figure 41: Dependency of the mean time between failure (MTTF) of a PICMA® actuator on the ambient temperature

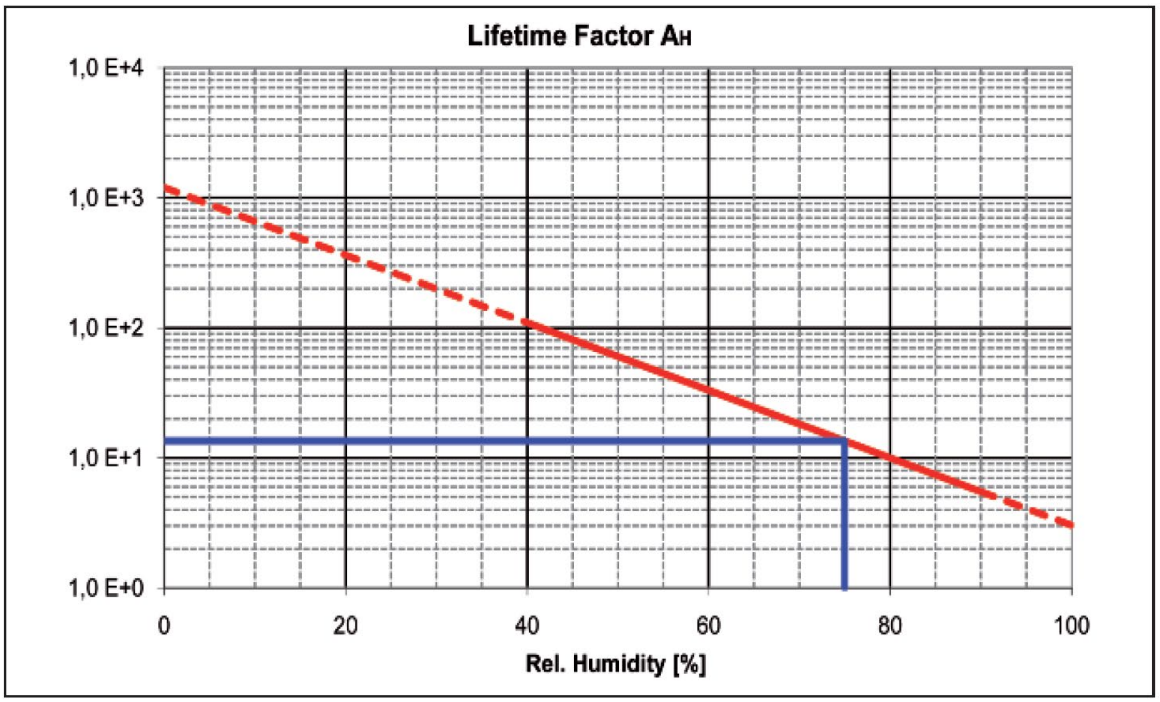


Figure 42: Dependency of the mean time between failure (MTTF) of a PICMA® actuator on the relative humidity

The calculated lifetime in hours results from the product of the values for the individual contributions:

$MTTF = A_U \times A_T \times A_F$

A_U: Contribution of the applied voltage

A_T: Contribution of the ambient temperature

A_F: Contribution of the relative humidity

The contribution of the applied voltage is especially important for applications. The lifetime increases exponentially with decreasing voltage. The recommended maximum range for the amplifier input voltage is therefore -2 to +12 V. This results in a piezo voltage range of -20 to 120 V (in open-loop operation). The input voltage range can be expanded from -3 to +13 V (the piezo voltage is then in the range of -30 to +130 V), which however reduces the lifetime of the actuator.

Example (see markings in the diagrams)

Applied voltage:	100 V DC	$\Rightarrow A_U = 75$
Ambient temperature:	45 °C	$\Rightarrow A_U = 100$
Relative humidity:	75 %	$\Rightarrow A_F = 14$

MTTF = 14 × 75 × 100 h = 105000 h (approx. 12 years)

14.2 How to Measure the Amplifier Output of E-504 Modules

The innovative, efficient circuitry of the E-504 amplifier module reduces power consumption and heat dissipation, especially in dynamic applications. Working with an internal switching frequency of 100 kHz, charge is transferred to the piezo actuator using low-loss PWM techniques. The ripple of the amplifier output is <100 mVpp at 100 kHz. But when measuring the amplifier output signal with low sampling rate and small bandwidth (e.g., with a digital oscilloscope), aliasing will occur and distort the measurement result. In digital signal processing, aliasing refers to an effect that the signal reconstructed from samples is different from the original continuous signal when the sampling rate is too low. With the E-504 amplifier output, this means that a low-frequency signal seems to be measured which is not present at all.

Example:

When a 91 Hz signal is sampled with 100 Hz sampling rate, the result seems to be a 9.1 Hz signal (see figure below).

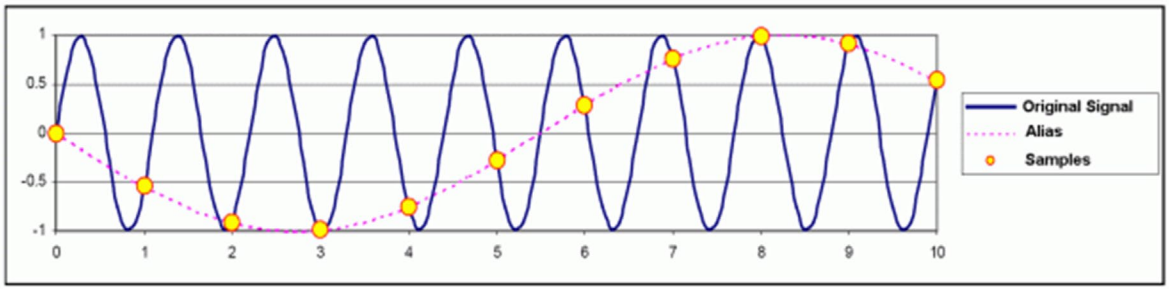


Figure 43: Signal digitization with too low sample rate (time in 1/100 s): Original signal = 91 Hz and sampling rate = 100 Hz; the result is mistaken for a 9.1 Hz signal (“Alias”).

To avoid aliasing, the sampling rate must be at least twice as high as the highest frequency in the signal to be sampled (according to the Nyquist–Shannon sampling theorem). I.e. with an amplifier switching frequency of 100 kHz, the sampling rate must be 200 kHz or higher. If the

sampling rate provided by your oscilloscope is not high enough, use a low-pass filter at the oscilloscope input to eliminate frequencies above 100 kHz. Alternatively, you can use an analog oscilloscope or perform high-resolution measurements in the lower frequency range.

When following those instructions, you will obtain valid measurement results.