Piezo · Nano · Positioning

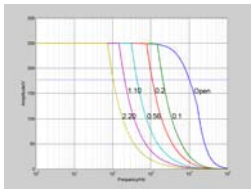
PZ173E User Manual

E-536 PicoCube® Controller

Release: 1.2.2 Date: 2007-03-29

This document describes the following product(s):

- E-536.3C
  PicoCube® Controller, 3 Channels, closed-loop
- E-536.30
  PicoCube® Controller, 3 Channels, open-loop
- E-536.3CH
  PicoCube® Controller High-Resolution, 3 Channels, closed-loop
- E-536.30H
  PicoCube® Controller High-Resolution , 3 Channels, open-loop



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Declaration of Conformity

according to ISO / IEC Guide 22 and EN 45014

Manufacturer: **Physik Instrumente (PI) GmbH & Co. KG**
Manufacturer´s Address: Auf der Römerstrasse 1
D-76228 Karlsruhe, Germany

CE

The manufacturer hereby declares that the product

Product Name: **PicoCube® Controller**
Model Numbers: **E-536**
Product Options: **all model types**

conforms to the following EMC Standards and normative documents:

Electromagnetic Emission: EN 61000-6-3, EN 55011

Electromagnetic Immunity: EN 61000-6-1

Safety (Low Voltage Directive) : EN 61010-1

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President

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About this Document

Users of this Manual

This manual is designed to help the reader to install and operate the E-536. It assumes that the reader has a fundamental understanding of basic electronics and, if applicable, servo and motion control concepts and the associated safety procedures.
This manual describes the physical specifications and dimensions of the E-536 as well as the procedures which are required to put the associated motion system into operation.
This document is available as PDF file. Updated releases are available via FTP or email: contact your PI sales engineer or write info@pi.ws.

Conventions

The notes and symbols used in this manual have the following meanings:

WARNING

Calls attention to a procedure, practice or condition which, if not correctly performed or adhered to, could result in injury or death.

DANGER

Indicates the presence of high voltage (> 50 V). Calls attention to a procedure, practice or condition which, if not correctly performed or adhered to, could result in injury or death.

CAUTION

Calls attention to a procedure, practice, or condition which, if not correctly performed or adhered to, could result in damage to equipment.

NOTE

Provides additional information or application hints.

Related Documents

The optional interface modules and the software tools which might be delivered with the E-536 are described in their own manuals. All documents are available as PDF files. Updated releases are available via FTP or email: contact your PI sales engineer or write info@pi.ws.

Only relevant if the E-536 comprises the covered hardware:

E-509_User_PZ77E
E-802_User_PZ113E
E-516_User_PZ102E

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Contents

1 Introduction

Fig. 1: E-536.3C with E-516 20-bit computer interface and display upgrade (rightmost module)

1.1 Features

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

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

Superior Resolution and High Dynamics

Open-loop position control is ideal for applications where the fastest response and highest bandwidth and resolution are essential. Here, commanding and reading the target position in absolute values is either not required or is handled by external sensors, as done in AFM applications. Together with the P-363 PicoCube® a resolution of 0.05 nm or better is achieved.

1.2 Prescribed Use

Based on their design and realization, E-536 PicoCube® Controllers are intended to drive capacitive loads, in the present case, piezoceramic actuators with a voltage range of -250 V to +250 V. E-536 must not be used for applications other than stated in this manual, especially not for driving ohmic (resistive) or inductive loads. E-536s can be operated in closed-loop mode using capacitive position sensors. Appropriate sensors are provided by PI and integrated in the mechanics according to the mechanics product specifications. Other sensors may be used as position sensors only with permission of PI.

Observe the safety precautions given in this User Manual. Operation other than instructed in this Manual may affect the safeguards provided.

E-536s meet the specifications of EN 61010 for safe operation under normal ambient conditions. See the specifications table on p. 32 for details.

1.3 Safety Precautions

Carefully read also the documentation of the included software components and of the mechanics used.
Ignoring the warning notices in the instructions can cause bodily injury of the user or damage to equipment or loss of warranty.
Note that the E-536 does not contain any user serviceable parts.

CAUTION—READ INSTRUCTION

Install and operate the E-536 PicoCube® Controller only when you have read the operating instruction. Keep the instruction readily available close to the device in a safe place. When the instruction is lost or has become unusable, ask the manufacturer for a new copy. Add all information given by the manufacturer to the instruction, e.g. supplements or Technical Notes.

DANGER—HAZARDOUS VOLTAGE

The high-voltage amplifiers used by the E-536 may cause serious or even lethal injury if used improperly. Working with high-voltage amplifiers requires adequately trained operating personnel.

The E-536 generates voltages between -250 V and +250 V for driving PicoCube® piezo stages. Never touch any part that might be connected to the high-voltage output. The high-voltage output is present on the "PZT Out 1", "PZT Out 2" and "PZT Out 3" LEMO sockets.

WARNINGS

- **LINE VOLTAGE**
  E-536s need to be installed in such a way that they can quickly and easily be separated from the line voltage. Before cleaning the E-536, changing the AC fuses and removing or installing modules, switch the device off and disconnect it from the line power.

- **INSTALLATION**
  Procedures which require removing or installing modules should be carried out by authorized, qualified personnel only.

!

CAUTION

- **AIR CIRCULATION**
  Do not cover the ventilation slots on the top side of the E-536. The device needs to be installed horizontally with 3 cm air circulation area. Vertical mounting prevents internal convection. Insufficient air flow will cause overheating and premature failure.

- **REPLACING FUSES**
  If you change the supply power voltage setting from 115 V to 230 V or vice-versa, you must also replace the 2 line fuses with fuses appropriate for the new voltage. Both fuses are active and have to be checked if there is a fault. See “AC Power and Line Power Fuses” p. 27.

- **TEMPERATURE**
  The high voltage output of the E-536 will be deactivated automatically if the hardware temperature is out of range (> 75 °C). In this case, the TOfl LED on the front panel lights up and the piezo stage does no longer move. If an E-516 interface and display module is present in the E-536, communication with the device will still be possible, but move commands are not executed.
  After a cooling-down period, at a hardware temperature of 60 °C, the high-voltage output is reactivated

automatically.
To avoid overheating, reduce the operating frequency and/or the load and/or the ambient temperature.

- **CONTROL INPUT**
  Control Input sockets which are not in use must be shorted using a jump plug for highest stability of piezo voltage output and axis position.

- **CLOSED CIRCUIT**
  If your E-536 contains dummy modules: Do not operate the E-536 when the dummy modules are removed. Without the dummy module(s), the system will malfunction because no Control In signal can be feed into the amplifier module due to the broken circuit.

- **SUITABLE ACTUATORS**
  Only connect PZT actuators designed for operation at -250 to +250 V (e.g. PicoCube® piezo stages) to the E-536. Other PZT actuators will be damaged or destroyed when operated with the E-536.

- **CALIBRATION**
  Calibration should only be done by qualified authorized personnel after consultation with PI, otherwise internal configuration data may be destroyed by erroneous operation.
  If you inform PI about your application, your E-536s will be fully calibrated before being shipped. It is usually not necessary for you to do anything more than adjust the zero point before operating the system.
  Do not interchange controller (whole devices or individual modules) and/or piezo stages when they are matched and calibrated together. Respect the assignment of the piezo stages to the individual controller channels, as indicated by the serial numbers on the labels affixed to the devices. With multi-axis stages respect the channel/axis assignments indicated by the cable labeling.

- **RESONANT FREQUENCY**
  Most piezo actuators that can be connected to the E-536 can be destroyed by uncontrolled oscillation near the mechanical resonant frequency. If you observe resonance while configuring your system, switch off power to the actuators concerned immediately and check the settings and servo-control parameters.

- **SENSOR MONITOR**
  Do not apply any input voltage to the SENSOR

MONITOR socket. This could cause damage to the electronics.

1.4 Model Survey & Additional Products

E-536 PicoCube® Controllers are available in the following model types:

Model Type	Specifications*
E-536.3C PicoCube® Controller	3-channel closed-loop version: 3 PZT channels (E-507.336 amplifier module) 3 sensor channels for capacitive sensors
E-536.30 PicoCube® Controller	3-channel open-loop version: 3 PZT channels (E-507.336 amplifier module)
E-536.3CH PicoCube® Controller	3-channel closed-loop version: 3 PZT channels high resolution (E-507.36H amplifier module) 3 sensor channels for capacitive sensors
E-536.30H PicoCube® Controller	3-channel open-loop version: 3 PZT channels high resolution (E-507.36H amplifier module)

*The complete specifications can be found in Section 8.2 on page 32.

Additional Products

E-500.ACD CD with Driver Set for Analog Controllers, available on request free of charge	Computer control of an E-536 can be realized using a DAC-board in a PC to generate the analog input signal. PI offers a LabVIEW™ driver set which can be used with certain D/A boards. This driver set is compatible with the PI General Command Set (GCS) LabVIEW™ driver set available for all newer controllers from PI. The Analog Controller LabVIEW™ Driver (E-500.ACD) is free of charge, but requires the LabVIEW™ environment from National Instruments for operation. The PI Analog Controller drivers support all D/A converter boards from National Instruments that are compatible with DAQmx8.3. LabVIEW™ compatibility is given from version 7.1 upwards. Connection of a sensor monitor signal from a sensor module (e.g. E-509) is required. The driver set is also available for download from the PI website (see p. 26).
E-500.HCD Hyperbit™ Functionality for Enhanced System Resolution	Hyperbit™ Functionality for Enhanced System Resolution access PI's patented Hyperbit™ technology for providing position resolution higher than that of the D/A board is in the E-500.ACD driver set. Activating Hyperbit™ requires purchase of the password, which can be obtained from PI under Order No. E-500.HCD.

1.5 Optional E-516 Interface and Display Module

Optionally, the E-516.i3 3-channel computer interface & display module with 20-bit DAC, IEEE 488 and RS-232 interfaces can be integrated in the E-536. If the E-516 was ordered with the E-536, the complete system comes ready for use. Otherwise the E-536 should be shipped back to PI for E-516 integration and system calibration—contact your PI sales engineer or write info@pi.ws, if you want to upgrade your E-536.

See the E-516 User Manual for hardware description and operation instructions.

1.6 Unpacking

Unpack the E-536 PicoCube® Controller with care. Compare the contents against the items ordered and against the packing slip.

The following items should be included:

- E-536 PicoCube® Controller
- 3 x E-692.SMB cables for control signal input
- 3763 line cord
- E-536 User Manual (this document, PZ173E)
- E500T0011 Technical Note for GCS LabVIEW driver set
- with E-536.3C and E-536.3CH closed-loop versions only: D-893.32 sensor monitor cable
  The purpose of this cable is simply to split up the SENSOR MONITOR output signal (6-pin LEMO) to three separate BNC connectors. The cable is also specially designed for the low-noise feature. The BNC connectors are each labeled with the channel number.
- with E-536.3C and E-536.3CH closed-loop versions only: E-509 User Manual (PZ77E) and E-802 User Manual (PZ113E)

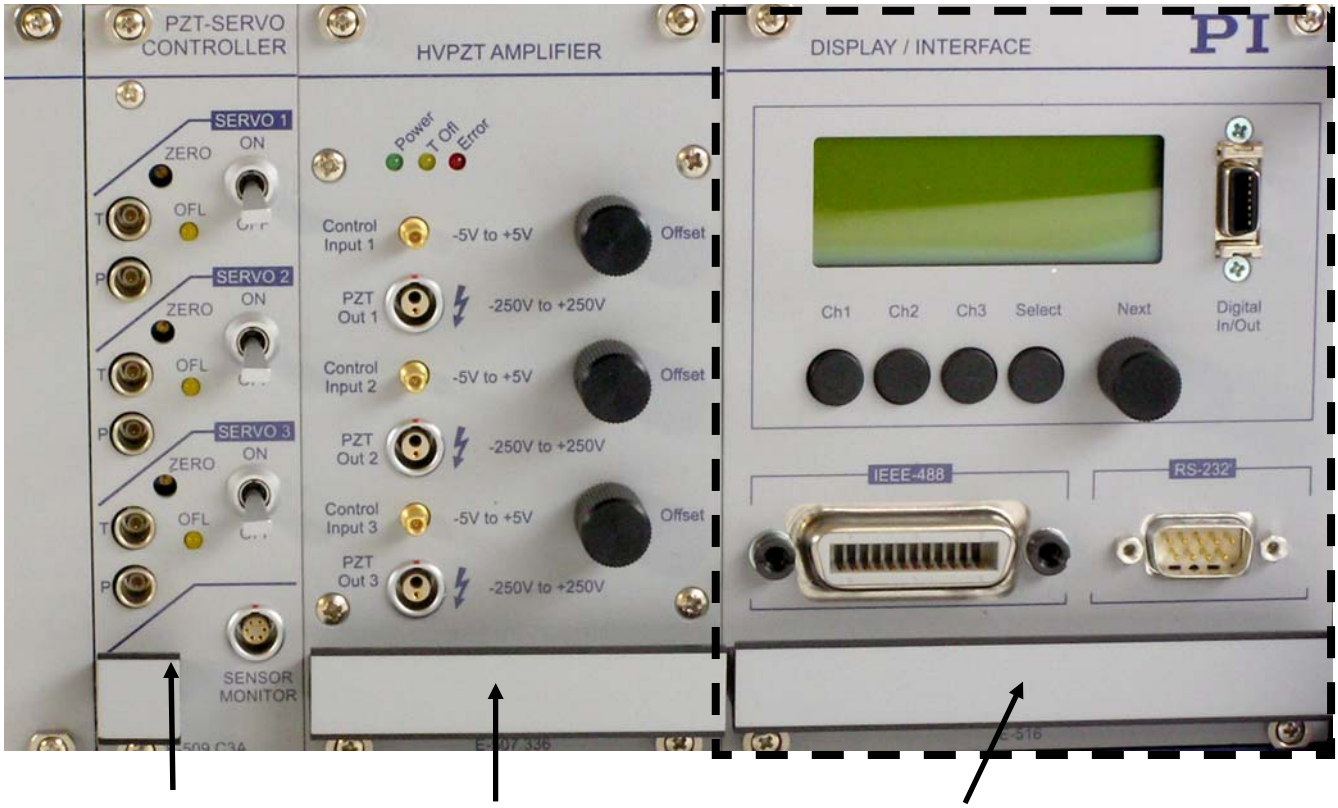
Inspect the contents for signs of damage. If parts are missing or you notice signs of damage, contact PI immediately.
Save all packing materials in the event the product need to be shipped elsewhere.

NOTE

A Sub-D-to-LEMO adapter cable for the connection of the mechanics comes either with the PicoCube® or can be ordered separately, order# P-893.1DPL.

2 Operation

2.1 Front and Rear Panel Elements



E-509 Sensor & Position Servo-Control Module, with E-536 closed-loop models only

E-507.336 HVPZT Amplifier Module (identical elements on E-507.36H)

Optional equipment: E-516.i3 Computer Interface and Display Module

Fig. 2: Front panel of E-536.3C 3-channel, closed-loop PicoCube® Controller

Common elements:

Power LED	Power on/off indicator
T Ofl LED	Lights up if the temperature on the amplifier heat sink exceeds 75 °C. In this case, the amplifier is automatically deactivated and activated again when the temperature falls below 60 °C.
Error LED	Provided for future applications

SENSOR MONITOR	closed-loop models only; LEMO connector for reading out the sensor input signal (0 to 10 V), for pinout see p. 34

CAUTION

Do not apply any input voltage to the SENSOR MONITOR socket. This could cause damage to the electronics.

Elements provided once per channel:

T	LEMO socket for sensor Target connector (E-536 closed-loop models only)
P	LEMO socket for sensor Probe connector (E-536 closed-loop models only)
ZERO	This potentiometer shifts the output of the sensor processing circuitry, see p. 22 for details. (E-536 closed-loop models only)
OFL LED	Lights up if the output voltage would be outside the nominal output voltage range of the controller (E-536 closed-loop models only)
SERVO ON/OFF	Switch for changing between open-loop (off) and closed-loop mode (on) (E-536 closed-loop models only)
Control Input	SMB connector for external analog control signal, -5 V to +5 V for open-loop operation, 0 V to +10 V for closed-loop operation (see also p. 13)
PZT Out	LEMO socket for high-voltage output, -250 V to +250 V
Offset	10-turn DC-offset potentiometer for analog control

E-516 Computer Interface and Display Module:

Framed with dashed line in Fig. 2. See the E-516 User Manual for a description of the front panel elements and operation instructions.

Fig. 3: Rear panel elements of E-536, without calibration label

The line voltage connection and the integrated fuse carrier are described in detail in Section 6.2 on p. 27.

2.2 Modes of Operation

2.2.1 Open Loop and Closed Loop

- Open loop: All E-536 versions can be operated in open-loop mode. Open-loop operation means that any control input done by the user determines the output voltage for the moving axis directly.

- Closed loop: E-536.3C and E-536.3CH models can also be operated in closed-loop mode. Closed-loop operation means that any control input done by the user determines a target position for the moving axis. The output voltage required to reach this target position is calculated internally by the servo-loop, based on the given target and the feedback of the position sensors.

For E-536 closed-loop models, the servo-control state can be set using the SERVO toggle switches on the front panel. When these devices are upgraded with an E-516 computer interface and display module, the servo state can also be set via

command from the host PC (see Section 2.2.3 and E-516 User Manual for details). In this case, all SERVO toggle switches on the front panel must be set to OFF.

2.2.2 Analog Operation

All E-536 versions can be operated by an analog control signal. In open-loop mode, this signal must be in the voltage range of -5 to +5 V. In closed-loop mode a voltage range of 0 to +10 V is required. The analog control signal can be provided as follows:

- External signal source: Depending on the servo state, the output voltage or the target position of a moving axis is set by a DC voltage applied to the Control Input SMB socket.
  Computer control of an E-536 can also be realized using a DAC-board in a PC to generate the analog input signal. PI offers a LabVIEW™ driver set which can be used with certain D/A boards. This driver set is compatible with the PI General Command Set (GCS) LabVIEW™ driver set available for all newer controllers from PI. In addition, PI's patented Hyperbit™ technology for providing position resolution higher than that of the D/A board is in the E-500.ACD driver set. See Sections 1.4, p. 7 and 5, p. 26, for information on PI support

- Offset potentiometer: Depending on the servo state, the output voltage or the target position of a moving axis can be set using the 10-turn offset potentiometer on the E-536 front panel. The offset potentiometer can also be used to add an offset to the signal applied on the Control Input socket.
  If a constant offset (e.g. 0 V) is required, make sure the knob stays at the appropriate position.

NOTE

For closed-loop operation, the controller is calibrated in such a way that any given voltage in the input range corresponds to the proportional displacement of the actuator in its nominal travel range (regardless of any non-linearities in the actual voltage required to obtain that displacement).

2.2.3 Remote Control via Computer Interface

E-536 models upgraded with an E-516 computer interface and display module can be controlled from a host computer. During remote control via the RS-232 or IEEE488 PC interface, any analog control input voltages and DC-offset settings described in Section 2.2.2 are ignored, and for closed-loop models all SERVO switches on the front panel must be set to OFF. Remote control is also referred to as Online mode, while the analog operation described in Section 2.2.2 is also referred to as Offline mode. See the E-516 User Manual for details.

2.3 Getting Started

DANGER

The high-voltage amplifiers used by the E-536 may cause serious or even lethal injury if used improperly. Working with high-voltage amplifiers requires adequately trained operating personnel.

The E-536 generates voltages between -250 V and +250 V for driving PicoCube® piezo stages. Never touch any part that might be connected to the high-voltage output. The high-voltage output is present on the "PZT Out 1", "PZT Out 2" and "PZT Out 3" LEMO sockets.

CAUTION

!

Most piezo actuators that can be connected to the E-536 can be destroyed by uncontrolled oscillation near the mechanical resonant frequency. If you observe resonance while configuring your system, switch off power to the actuators concerned immediately and check the settings and servo-control parameters.

2.3.1 How to Achieve Best Performance

Follow the instructions and recommendations below to achieve best performance of the system.

- Calibrated system:

  Do not interchange controller (whole devices or individual modules) and/or actuators/stages when they are matched

and calibrated together. Respect the assignment of the actuators/stages to the individual controller channels, as indicated by the serial numbers on the labels affixed to the devices. With multi-axis stages respect the channel/axis assignments indicated by the cable labeling.

- Voltage and position stability:

  For highest stability of piezo voltage output and axis position, the "Control Input" sockets must be closed with low impedance (use the E-692.SMB cables which come with the E-536 to connect a control signal). Control input sockets which are not in use must be shorted using a jump plug.

  A higher noise level in closed-loop operation (servo on) depends only on the capacitive sensor and the servo bandwidth.

- Measuring setup:

  Carefully design your measuring setup to avoid interferences and magnetic fields caused by external signal sources like function generators, measuring devices like oscilloscopes and any connecting cables.

- Amplifier bandwidth:

  For highest amplifier bandwidth (up to 10 kHz in small signal operation), the slew rate of the servo-control module must be set to the maximum value. A slew rate value optimized for closed-loop operation would also be active in open-loop and hence significantly limit the bandwidth.

- Control signal:

  The voltage range of the analog control signals connected to the Control Input SMB sockets differs depending on the servo state:
  open-loop operation (servo off): -5 V to +5 V
  closed-loop operation (servo on): 0 V to +10 V

2.3.2 Line Voltage Connection

WARNING

E-536s need to be installed in such a way that they can quickly and easily be separated from the line voltage.

Unless you request otherwise, upon delivery the E-536 will be set up for the voltage predominant in your country, either

115 V ~ / 45VA / 0.4A / 50-60 Hz

or

230 V ~ / 45VA / 0.2A / 50-60 Hz

To adapt the E-536 to a different line voltage, the line power fuses must be replaced. See p. 27 for instructions and for the required fuse types.

Connect the controller (rear panel) to an appropriate power outlet using the line cord which comes with the E-536.

2.3.3 How to Work with the System

CAUTION

Do not cover the ventilation slots on the top side of the E-536. The device needs to be installed horizontally with 3 cm air circulation area. Vertical mounting prevents internal convection. Insufficient air flow will cause overheating and premature failure.

CAUTION

The high voltage output of the E-536 will be deactivated automatically if the hardware temperature is out of range (> 75 °C). In this case, the TOfl LED on the front panel lights up and the piezo stage does no longer move. If an E-516 interface and display module is present in the E-536, communication with the device will still be possible, but move commands are not executed.

After a cooling-down period, at a hardware temperature of 60 °C, the high voltage output is reactivated automatically.

To avoid overheating, reduce the operating frequency and/or the load and/or the ambient temperature.

The following instructions refer to the analog operation of the system. If your E-536 is upgraded with an E-516 computer interface and display module and you want to control the system via the computer interface, only perform steps 1 to 3 of the instruction below and then go on working with the system as

described in the E-516 User Manual.

1 Make sure that the E-536 is connected to line power but powered down (see Section 2.3.2)—line cord socket and power switch are at the rear panel.

2 Connect the piezo stage to the E-536—when the piezo stage is equipped with a Sub-D connector, use a Sub-D-to-LEMO adapter cable (# P-893.1DPL). Respect the channel/axis assignment given by the label on the controller rear panel.

2.1 Connect the cables labeled "X-AXIS", "Y-AXIS" and "Z-AXIS" to the PZT Out sockets.

2.2 Closed-loop systems only: Connect the sensor cables labeled "Target" to the T sockets and the cables labeled "Probe" to the P sockets. Make sure that the "Target" and "Probe" cables are not interchanged— if you switch "Probe" and "Target", the sensor system will work but results will not be as accurate as specified.

3 Optionally: If you want to read out the sensor monitor signal, connect appropriate electronics to the SENSOR MONITOR socket using the D-893.32 sensor monitor cable.

4 Turn all Offset potentiometers CCW (zero offset) to avoid jumps of the mechanics when the controller is powered on.

5 With E-536.3Cand E-536.3CH closed-loop models only: Set the desired servo-control state using the SERVO toggle switches on the front panel.

6 If you want to operate the E-536 by external analog control signals, connect suitable signal sources to the Control Input SMB sockets. Use the E-692.SMB cables which come with the E-536, but do not yet apply any voltage to these lines.
The E-536 accepts control input signals in the following voltage ranges:
-5 V to +5 V are required for open-loop operation (servo off).
0 V to +10 V are required for closed-loop operation (servo on).

CAUTION

Control Input sockets which are not in use must be shorted using a jump plug for highest stability of piezo voltage output and axis position.

7 Switch the E-536 on. Now the green Power LED on the amplifier module lights up.

8 Command motion for the axes of the piezo stage by

- turning the Offset potentiometer
- applying an external analog control signal in the appropriate input range
- using a combination of Offset potentiometer setting and external analog control signal.

When an E-516 interface and display module is present in the system, watch the current voltage and position values on the display to check if the system operates properly.

When one ore more OFL LEDS should light up, the amplifier output is being clipped at one of its limits and the current piezo displacement no longer complies with the control signal. Follow the instructions for zero-point adjustment on p. 22 to re-adjust the system.

3 Design

3.1 Channels and Axes

Every moving axis of the mechanics is assigned to one PZT channel (amplifier output channel) and one sensor channel of the E-536. Due to this “one-axis/one-sensor/one-amplifier” design, the terms "axis" and "channel" can be used synonymously.

The assignment of axes and channels is done prior to shipment during calibration at PI and stated by a label on the E-536 rear panel.

3.2 Block Diagram

The block diagram below shows the signal path for E-536 closed-loop versions upgraded with an E-516 interface and display module. E-536 open-loop versions and models without E-516 module are equipped with dummy modules instead:

E-595.00 Replaces E-509.Cxx sensor modules

E-596.10 Replaces the E-516 computer interface and display module

The purpose of these dummies is to complete the internal circuitry and the front panel of the chassis.

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CAUTION

If your E-536 contains dummy modules: Do not operate the E-536 when the dummy modules are removed. Without the dummy module(s), the system will malfunction because no Control In signal can be fed into the amplifier module due to the broken circuit.

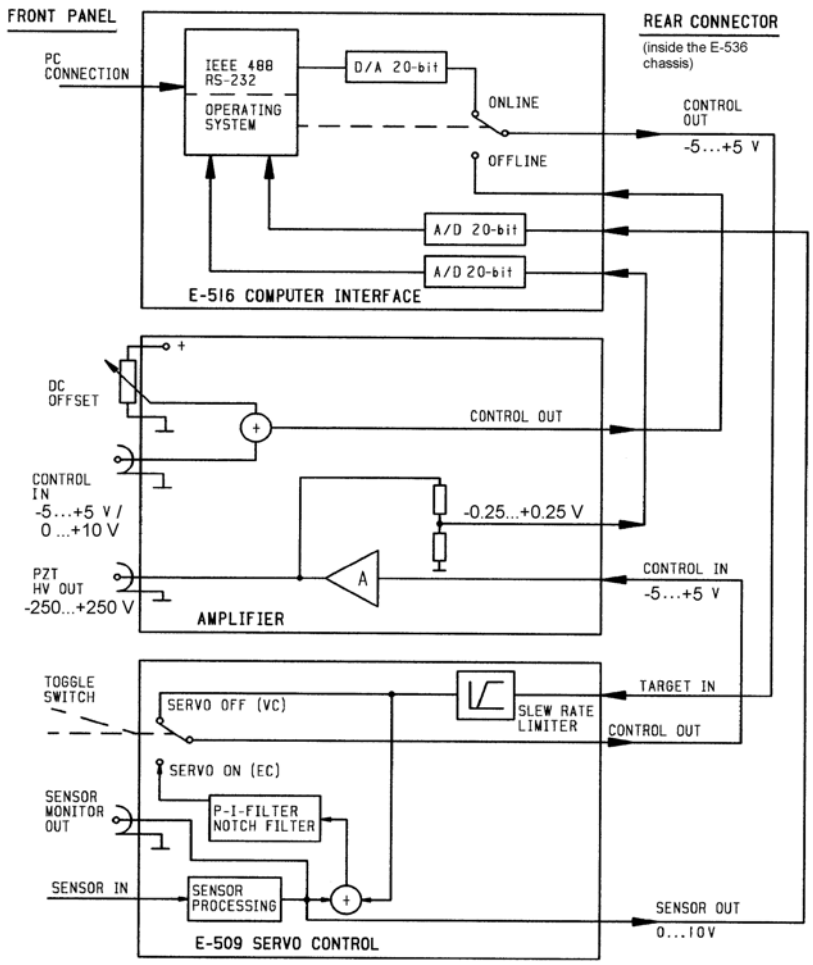

Fig. 4: Signal path for E-536 closed-loop versions with E-516 interface and display module

3.3 E-507 HVPZT Piezo Amplifier Module

E-507 HVPZT Amplifier Modules generate drive voltage for high-voltage PZTs. The output ranges from -250 to +250 V. One terminal of the HV output is held at system ground. The modules can be used for static and dynamic operations providing a peak current of 200 mA for < 3 ms (E-507.336) or 100 mA for < 1ms (E-507.36H) to allow fast PZT displacement changes. The modules are short-circuit and open-circuit protected.

The output voltage can be controlled by an analog input signal applied to the front-panel Control Input line, in combination with the DC-offset potentiometer, or by the

optional E-516 computer interface and display module. In closed-loop operation, the output voltage is controlled by the E-509.Cxx sensor & position servo-control module. See Section 2.2 on p. 12 for control details and Section 3.2 on p. 19 for the signal path.

3.4 E-509 Sensor & Position Servo-Control Module

The E-509 sensor & position servo-control module is part of the E-536.3C and E-536.3CH closed-loop models. Its servo-loop logic compares the control voltage input (target) and the sensor signal (current position) to generate the amplifier control signal using an analog proportional-integral (P-I) algorithm. Thus it compensates for drift and hysteresis of the PZT actuators. Note that control signal generation, slew rate limitation, notch filter and servo-control loop are all implemented on the E-802.52, a small PCB submodule which is implemented on the E-509 once per channel.

For hardware details and calibration procedures, see the User Manuals for the E-509 and E-802.52 modules.

4 Settings and Adjustments

4.1 General

All basic calibration adjustments are done in PI lab before shipment. The PZT system is delivered ready for operation. When system components are to be exchanged or modified, contact your Physik Instrumente sales engineer or write to info@pi.ws.

4.2 E-536 Closed-Loop Models Only

4.2.1 Zero-Point Adjustment

The zero points of the individual channels have to be realigned from time to time to compensate for temperature changes. Proper zero-point adjustment ensures that the full output voltage swing of the amplifier can be used without reaching the output voltage limits of the amplifier and causing overflow conditions. If an overflow condition occurs (OFL LED lights up for the channel), it can often be prevented by re-adjusting the ZERO point.

The zero-point for each channel is adjusted with the ZERO potentiometer, accessible through a labeled hole in the E-536 front panel (see Fig. 2 on p. 10). This potentiometer shifts the output of the sensor processing circuitry and hence the values on the "Sensor out," "Monitor out" and servo-loop sensor-input lines (see Fig. 4 on p. 20).

When an E-516 computer interface and display module is present in your E-536, at first decide whether you want to perform the zero-point adjustment in computer-controlled mode (online) or in analog mode (offline). Online and offline operation must not be mixed during calibration. If you choose offline operation, make sure that the E-516 computer interface module is set to "offline". The steps listed below describe offline operation—if you choose online operation, use computer commands in place of the analog control voltage and DC-offset to command voltages and position (you do not need an external voltage source for computer-controlled calibration).

Equipment needed:
For zero-point adjustment in analog (offline) operation an adjustable voltage source is needed which must be able to output
-5 to +5 V and
0 V to +10 V.
If an E-516 interface and display module is present in the system, zero-point adjustment can be performed without additional equipment. Otherwise, a precision voltmeter is required in addition.

WARNING

Be careful when connecting the voltmeter to the PZT Out socket during system operation. Voltages between -250 V and +250 V can be present on the "PZT Out 1", "PZT Out 2" and "PZT Out 3" LEMO sockets.

How to perform zero-point adjustment of one channel in analog operation:

1 Before powering up the system:

1.1 Make sure the PZT actuator is mounted in the same way and with the same load as during normal operations in the application. Respect the channel/axis assignment given by the label on the controller rear panel.

1.2 Make sure that the external analog control signal is 0 V.

1.3 Set the SERVO toggle switch on the front panel to OFF.

1.4 If no E-516 display module is installed, connect a voltmeter to the SENSOR MONITOR socket and, if present, a second voltmeter to the PZT Out socket in parallel with the PZT actuator.

2 Power up the system. If an E-516 is present, make sure that it is consistent with analog (offline) operation and "servo OFF" setting.

3 Turn the Offset potentiometer full clockwise and than back full counterclockwise (0 V) to exercise the appropriate axis of the mechanics.

4 Adjust the ZERO potentiometer so that a sensor-monitor signal of 5 V is measured by the voltmeter on

the SENSOR MONITOR socket. If present, you can alternatively read the display of the E-516 module where the position must be approx. half the nominal expansion of the axis. The zero adjustment is now close enough to allow switching on servo-control.

5 Switch the channel to closed-loop (SERVO ON).

NOTE

The axis should now make a jump from the mid position to the negative limit of its travel range because the expected range of the analog control signal now is 0 to +10 V (instead of the -5 to +5 V expected in open-loop operation). Set the external analog control signal to 5 V to get back to the axis' mid position.

6 If not already done so, connect the voltmeter to the PZT Out socket in parallel with the PZT actuator.

7 Again using the ZERO potentiometer, adjust the PZT output voltage to approx. 0 V.
The zero-point setting is now close enough to allow checking of the PZT output range.

8 Check the PZT output range by applying a voltage to the Control Input socket which goes from
0 V to +10 V
and watch the voltage at the PZT Out socket in parallel with the PZT actuator.

a) If the output voltage ranges from -250 V to +250 V, then zero-point adjustment is finished.

b) If the output voltage range differs from -250 V to +250 V, the zero point should be shifted so that the PZT-output voltage range is in the center of the amplifier output range. For this purpose, return the control input to the value which corresponds to the mid position (+5 V) and repeat step 7 adjusting the PZT output voltage to a slightly different value.

4.2.2 Further Procedures

All other calibration procedures—static gain adjustment[1] and dynamic calibration[2]—require special equipment and should only be done by qualified personnel and are required only in special circumstances. For details regarding those procedures, see the user manuals for the E-509 sensor & position servo-control module and for the E-802.52 submodule which is located on the E-509.

[1] The objective of static gain adjustment is to ensure that the actuator expands to its nominal expansion in "positive" direction when an appropriate control signal input is applied (with DC-offset disabled).
[2] Dynamic calibration optimizes step response and suppresses resonance, overshoot, and oscillation.

5 Download of the GCS LabVIEW Driver Set for Analog Controllers

Updated releases of GCS LabVIEW drivers for analog controllers from PI and the corresponding manuals are available for download at www.pi.ws. While the manuals are freely accessible, you need a password for the software download. This password is provided in a Technical Note delivered with the controller (E500T0011).
To download from the PI Website, proceed as follows:

9 On the www.pi.ws front page, click on "Download/Support" in the "Service" section on the left

10 On the "Download/Support" page, click on "Manuals and Software"

11 On the "PI Download Server" page, enter the Username and the Password which are provided in the separate Technical Note and click on "Login"

12 Click on "Download" in the navigation bar across the top

13 Click on the "General Software" category

14 Click on "Analog GCS LabVIEW drivers"

15 Click on "Release" (if you click on "Documents" you will get the latest manuals)

16 Click the "Download" button

6 Maintenance

WARNING

Before cleaning the E-536, changing the AC fuses and removing or installing modules, switch the device off and disconnect it from the line power.

6.1 Cleaning

The housing surfaces of the E-536 can be cleaned using mild detergents or disinfectant solutions. Organic solvents must not be used.

6.2 AC Power and Line Power Fuses

Unless you request otherwise, the unit will be set up for the power predominant in your country. New line power fuses are required when changing the supply voltage.

To access the line power fuses, proceed as follows:

1. Switch the E-536 off and remove the line cord.
2. Wait one minute to be sure that all electric circuits are discharged completely.
3. Pry open the door that covers the fuse carrier (see Fig. 5) and pry out the fuse carrier.
4. Be sure to replace both fuses with fuses of the type appropriate for the new voltage:
   230 VAC to 240 VAC 0.8 A, slow blow
   115 VAC to 240 VAC 1.6 A, slow blow
5. Rotate the fuse carrier so that the valid voltage setting (115 V or 230 V) can be seen through the window when the door is closed.
6. Reinstall the carrier and close the door.

CAUTION

Both fuses are active and have to be checked if there is a fault.

Fig. 5: Fuse location on the rear panel and in the carrier (1 of 2 fuses visible)

7 Troubleshooting

Problem	Possible Causes	Solutions
Stage does not move	Cable not connected or connected to wrong connector (if adapter cable is used)	Check the connecting cable.
	Adapter cable is defective	Connect the stage to a different adaptor cable to test its function. Do no longer use the defective cable.
	Stage or stage cable is defective	Contact your Physik Instrumente sales engineer or write info@pi.ws. Do no longer use the defective stage.
	The high voltage output is deactivated.	The high voltage output of the E-536 will be deactivated automatically if the hardware temperature is out of range (> 75 °C). In this case, the TOfl LED on the front panel lights up and the piezo stage does no longer move. If an E-516 interface and display module is present in the E-536, communication with the device will still be possible, but move commands are not executed. Wait a few minutes to let the device cool down. If the TOfl LED goes out, the high voltages output is activated again, otherwise the temperature is still out of range. To avoid overheating, reduce the operating frequency and/or the load and/or the ambient temperature. Do not cover the ventilation slots on the top side of the E-536. The device needs to be installed horizontally with 3 cm air circulation area. Vertical mounting prevents internal convection. Insufficient air flow will cause overheating and premature failure Remote control via E-516: Note that the wave generator output will continue even if the high voltage output is deactivated, i.e. if a certain number of output cycles was set, the output may be already finished when the high voltage output is reactivated. When using the wave generator, it is recommended to reduce the frequency and/or the amplitude and/or the output duration to avoid overheating.
	Broken circuit	If your E-536 contains dummy modules: Do not operate the E-536 when the dummy modules are removed. Check if all dummy modules are installed properly. Without the dummy module(s), the system will malfunction because no Control In signal can be feed into the amplifier module due to the broken circuit. See p. 19 for more information about the signal path.
	Wrong signal applied to the Control Input SMB socket	In open-loop mode, the external signal source used must provide a voltage range of -5 to +5 V. In closed-loop mode a voltage range of 0 to +10 V is required.

OFL LED lights up	Overflow condition: The full output voltage swing of the amplifier can not be used.	The amplifier output is being clipped at one of its limits and the current piezo displacement no longer complies with the control signal. Follow the instructions for zero-point adjustment on p. 22 to re-adjust the system.
Nonsatisfying voltage and position stability	"Control Input" sockets not closed; servo on	For highest stability of piezo voltage output and axis position, the "Control Input" sockets must be closed with low impedance (use the E-692.SMB cables which come with the E-536 to connect a control signal). Control input sockets which are not in use must be shorted using a jump plug. A higher noise level in closed-loop operation (servo on) depends only on the capacitive sensor and the servo bandwidth.
Remote control via E-516 fails	Wrong axis commanded	Check if commanded axis is that of the desired stage.
	Another program still uses the PCI interface	Close the other program.
	Specific software has problems with operating system.	Compare if another software is running, e.g. a terminal or development environment. You can, for example, test the communication by simply starting a terminal program, e.g. *WinTerm32*, and entering commands like *IDN? or HLP?. Note that the commands are transferred as terminated by a line feed LF character. The command is executed only after the LF is received.
Still problems? Please call your PI representative and know the following about your system: Product codes and serial numbers of all used products Current firmware version of the controller Software version of driver or host software Operating system		

8 Technical Data

8.1 Operating Limits

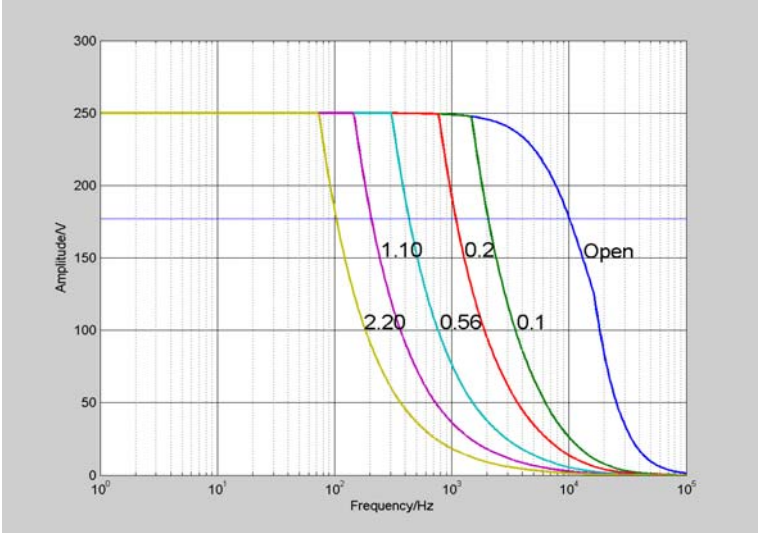

Fig. 6: E-536.3x: Operating limits with various PZT loads. Values shown are capacitance in µF, measured in actual PZT

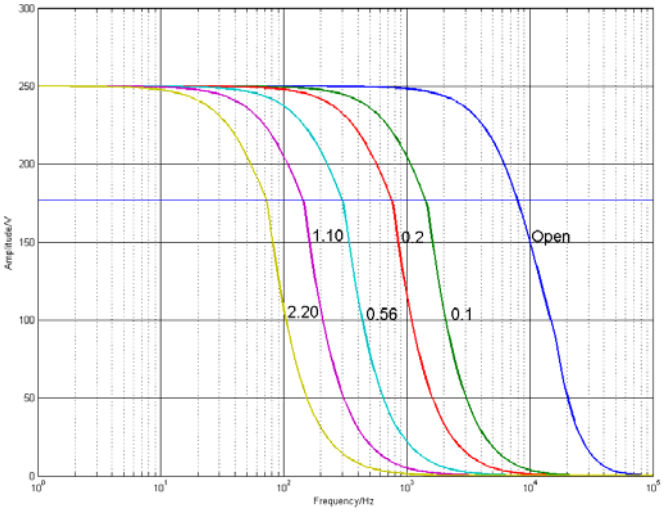

Fig. 7: E-536.3xH: Operating limits with various PZT loads. Values shown are capacitance in µF

The small-signal capacitance of P-363 PicoCube® piezo stages is 70 nF, the large-signal value is 0.1 µF.

8.2 Specifications

	E-536.3C / E-536.30	E-536.3CH / E-536.30H
Function	Power amplifier & servo-controller for P-363 PicoCube®	Power amplifier & servo-controller for P-363 PicoCube®
Amplifier		
Output voltage	-250 to +250	-250 to +250
Amplifier channels	3	3
Average output power per channel	10 W, limited by temperature sensor	6 W, limited by temperature sensor
Peak output power per channel, <·3·ms	100 W	50 W
Average current	30 mA	15 mA
Peak current per channel, < 3 ms	200 mA	100 mA
Amplifier bandwidth, small signal	10 kHz	2 kHz
Amplifier bandwidth, large signal, @ 100 nF	0.2 kHz	0.125 kHz
Ripple, noise 0 to 100 kHz	0.8 mV_{RMS} ≤ 5 mV_{P-P} (100 nF)	0.5 mV_{RMS} ≤ 3 mV_{P-P} (100 nF)
Current limitation	Short-circuit-proof	Short-circuit-proof
Voltage gain	+50	+50
Input impedance	100 kΩ	100 kΩ
Sensor*		
Servo characteristics	Analog proportional-integral (P-I) algorithm with notch filter	Analog proportional-integral (P-I) algorithm with notch filter
Sensor type	capacitive sensors	capacitive sensors
Sensor channels	3 / -	3 / -
Sensor bandwidth	1.5 kHz	1.5 kHz
Sensor Monitor output	0 to +10	0 to +10
Interfaces and operation		
PZT output sockets	LEMO EGG.0B.701.CJL.1173	LEMO EGG.0B.701.CJL.1173w
Sensor target and probe sockets	LEMO EPL.00.250.NTD	LEMO EPL.00.250.NTD
Control Input sockets	SMB	SMB
Sensor Monitor socket	LEMO FGG.0B.306.CLAD56	LEMO FGG.0B.306.CLAD56
Control input voltage	Servo off:-5 to +5 Servo on: 0 to +10	Servo off:-5 to +5 Servo on: 0 to +10

DC Offset	0 to 100% with 10-turn front-panel potentiometer	0 to 100% with 10-turn front-panel potentiometer
Miscellaneous		
Operating voltage	115 VAC / 50-60 Hz or 230 VAC / 50-60 Hz	115 VAC / 50-60 Hz or 230 VAC / 50-60 Hz
Mass	8.1 kg / 7.8 (with E-516 module)	8.1 kg / 7.8 (with E-516 module)
Dimensions	450 x 132 x 296 mm + handles	450 x 132 x 296 mm + handles

*only E-536.3Cx with capacitive sensors
Interfaces / communication: RS-232 and IEEE 488 (GPIB) (with optional E-516 computer interface and display module only)
Operating temperature range: +5 °C to +50 °C (over 40 °C, max. av. power derated 10%), high-voltage output is automatically deactivated if temperature is too high by internal temperature sensor (75 °C max.)

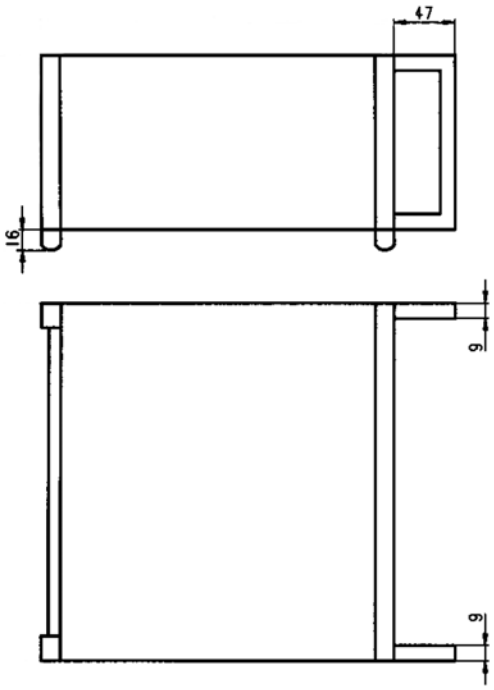

Fig. 8: Dimensions of the handles on the E-536 housing, in mm

8.3 Sensor Monitor LEMO Socket

LEMO Connector (FGG.0B.306.CLAD56), 6-pin

pin 1	ch1+
pin 2	ch1-
pin 3	ch2+
pin 4	ch2-
pin 5	ch3+
pin 6	ch3-
shield:	GND

The E-536.3C and E-536.3CH closed-loop models come with the D-893.32 Sensor-Monitor cable (2 m). The purpose of this cable is simply to split up the SENSOR MONITOR output signal (6-pin LEMO) to three separate BNC connectors. The BNC connectors are each labeled with the channel number.