

PZ288E User Manual

E-619 Modular High-Power Piezo Amplifier

Release: 1.1.1 Date: 05 November 2018



This document describes the following products:

- E-619.H
High-Power Piezo Amplifier Module, 1 Channel,
20 kHz Bandwidth, 1200 W Peak Power, -30 to
130 V,
- E-619.00
High-Power Piezo Amplifier Module, 1 Channel,
3 kHz Bandwidth, 1200 W Peak Power, -30 to
130 V
- E-619.S
Offset Voltage Source for Tip/Tilt Platforms,
1 Channel, 1200 W Peak Power, 100 V Fixed
Voltage
- E-619.R1
9.5" Housing for E-619 Amplifier Modules, 1 Slot
- E-619.R3
19" Housing for E-619 Amplifier Modules, 3 Slots

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About this Document

Definition of Terms

In this manual, "E-619 system" refers to at least one E-619 high-power piezo amplifier module installed in an E-619 housing.

Users of this Manual

This manual is designed to help the reader to install and operate the E-619 system. It assumes that the reader has a fundamental understanding of motion control concepts and applicable safety procedures. The manual describes the physical specifications and dimensions of the E-619 system as well as the procedures which are required to put the system into operation.

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.

Updated releases are available for download at www.pi.ws (<http://www.pi.ws>) or via e-mail: contact your Physik Instrumente Sales Engineer or write service@pi.de.

Related Documents

E-509_User_PZ77E
E518T0001 Technical Note
E-515_User_PZ68E

Documentation of the piezo actuator

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1 Introduction

1.1 Overview

The low-noise high-power amplifiers of the E-619 modular system are specifically designed for dynamic continuous operation of piezo actuators. They provide peak output currents up to 10 A and a peak power of 1200 W in a voltage range of -30 to 130 V.

Working Principle

E-619 modules are switching amplifiers with pulse width modulation (PWM) of the piezo output voltage. When the piezo actuator is discharged, a patented circuitry for energy recovery stores parts of the returning energy in a capacitor and makes it reusable for the next charging cycle. The amplifier runs cooler and provides better stability. Compared to the available output power, the power consumption of switching amplifiers is very low.

Piezo Overtemperature Protection

To protect the mechanics especially in high-dynamics applications, the E-619 system features a temperature sensor input and controller circuit that shuts down the amplifier if the piezo actuator exceeds the maximum temperature threshold.

Piezo Operation

The motion of the piezo actuator is controlled via an analog signal at the control input combined with the DC-offset potentiometer setting. The control signal directly determines the output voltage for the piezo actuator.

Closed-loop operation is possible via the E-509 sensor/servo-controller module which is available as an upgrade option. In closed-loop operation, the control signal gives the target position.

For remote control by a PC, the E-518 computer interface module is available as an upgrade option.

Special Piezo Connector Required

The high electrical currents require adequate connectors and cabling. Therefore, standard piezo systems and actuators have to be adapted.

1.2 Intended Use

Based on their design and realization, E-619 amplifier modules are intended to drive capacitive loads, in the present case, piezoceramic actuators with high-current termination electrodes. E-619 amplifier modules must not be used for applications other than stated in this manual, especially not for

driving ohmic (resistive) or inductive loads.

Observe the safety precautions given in this User Manual.

The E-619 system may only be used for applications suitable according to the device specifications. Operation other than instructed in this User Manual may affect the safeguards provided.

The verification of the technical specifications by the manufacturer does not imply the validation of complete applications. In fact the operator is responsible for the process validation and the appropriate releases.

The E-619 system is a laboratory apparatus as defined by DIN EN 61010. It meets the following minimum specifications for safe operation:

- Indoor use only
- Altitude up to 2000 m
- Operating temperature range 5 °C to 40 °C
- Storage temperature range 0 °C to 70 °C
- Transport temperature range -25 °C to 85 °C
- Max. relative humidity 80% for temperatures up to 31°C, decreasing linearly to 50% relative humidity at 40°C
- Line voltage fluctuations not greater than $\pm 10\%$ of the line voltage
- Transient overvoltages as typical for public power supply
Note: The nominal level of the transient overvoltage is the standing surge voltage according to the overvoltage category II (IEC 60364-4-443).
- Protection class I
- Degree of pollution: 2
- Degree of protection according to IEC 60529: IP20

These data are no limitations for the specifications in the technical data table (p. 22).

1.3 Safety Precautions

Install and operate the the E-619 system 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.

WARNING

E-619 amplifier modules and offset voltage modules are capable of generating high output voltages and high output currents. They may cause serious or even lethal injury if used improperly.

Working with high-voltage modules requires adequately trained operating personnel. Strictly observe the following:

- Do not touch the pins of the LEMO connector which carries the piezo output voltage. The high voltage output may be active whenever the device is turned on. Voltages between -30 V and +130 V can be present on the LEMO connector.
- E-619 amplifier modules and offset voltage modules do not contain any user-serviceable parts. Never disassemble the device. Hazardous voltage can be present on the internal components.



DANGER

All work done with and on the E-619 system requires adequate knowledge and training in handling high voltages and high currents.

- Allow operation of an E-619 system only if all components are installed properly.



WARNING

Connect the AC power cord of the E-619 system to the wall socket (220 VAC to 240 VAC or 100 VAC to 120 VAC). Both fuses are active



and have to be replaced or checked if there is a fault. See "AC Power and Line Fuses" (p. 19) for how to replace the line power fuses.

To disconnect the E-619 system from the power supply completely, remove the power plug from the wall socket, or remove the power cord from the E-619 system.

Install the E-619 system near the AC outlet and such that the AC power plug can be reached easily.



CAUTION

Do not cover the ventilation slots on the top side of the E-619 housing. Place the E-619 system in a location with adequate ventilation to prevent internal heat build-up. 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

Use only PICMA® piezo actuators with high-current termination electrodes. Standard piezo systems and actuators have to be adapted before they can be used with an E-619 system. Contact your PI sales engineer or write info@pi.ws.

For dynamic applications, or continuous operation, the use of a temperature sensor (PT1000) on the piezo actuator is recommended, to avoid destruction of the piezo due to heat generation. See p. 13 for details.

1.4 Model Survey

The following components are available for the E-619 system:

E-619.H	High-Power Piezo Amplifier Module, 1 Channel, 20 kHz Bandwidth, 1200 W Peak Power, -30 to 130 V
E-619.00	High-Power Piezo Amplifier Module, 1 Channel, 3 kHz Bandwidth, 1200 W Peak Power, -30 to 130 V
E-619.S	Offset-Voltage-Source Module for Tip/Tilt Platforms, 1 Channel, 1200 W Peak Power, 100 V Fixed Voltage
E-619.R1	9.5" Housing for E-619 Amplifier Modules, 1 Slot For one E-619 amplifier module.
E-619.R3	19" Housing for E-619 Amplifier Modules, 3 Slots For up to three E-619 amplifier modules.

1.5 Controller and Interface Upgrades

Upgrade options for the E-619 system:

- E-509 servo-control module, and/or E-518 computer interface module
- E-515 display module

All modules ordered come installed directly in the E-619 housing. If the servo-control module and a piezo actuator are ordered with the system, your E-619 system will be fully calibrated before being shipped.

Contact your PI sales engineer or write info@pi.ws, if you want to upgrade your E-619 system. Any additional modules are described in their own separate manuals.

The following modules are available:

E-509.C1A / .C2A / .C3A, E-509.E03 / .E3, E-509.S1 / .S3	Sensor / Servo-Controller Module for capacitive or SGS position sensors respectively, 1 / 2 / 3 channel/s to eliminate drift and hysteresis from positioning operations.
E-518.i3	Interface Module, 3 Channels, TCP/IP, USB, RS-232 and SPI Interfaces Communicates with a host PC for remote control of the E-619 system. DLL, drivers for NI LabVIEW software and convenient interactive user interface software are provided.
E-515.01 / .03	Display Module for PZT Voltage and Position, 1 / 3 channel/s

1.6 Accessories

Contact your PI sales engineer or write info@pi.ws, if you need one of the additional components listed below.

Extension cables for the piezo stages:

- | | |
|-----------|---|
| E-618.X11 | Piezo cable, 1 m, Lemo 2-pin/open end for soldering piezo actuators |
| E-618.X01 | Extension cable, Lemo 2-pin m/f, 1 m |
| E-618.X03 | Extension cable, Lemo 2-pin m/f, 3 m |

An E-619.H and E-619.00 amplifier module can be controlled via a signal connected to its analog input line (see p. 14 for more information). This signal can, for example, be generated using a D/A board in a PC. PI offers a driver set for use with NI LabVIEW software and certain D/A boards. Order number:

- | | |
|-----------|--|
| E-500.ACD | CD with analog driver set for use with NI LabVIEW software, available free of charge upon request. The PI drivers support all D/A converter boards from National Instruments that are compatible with NI DAQmx8.3. NI LabVIEW compatibility is given from version 7.1 upwards. |
|-----------|--|

1.7 Unpacking

Unpack the E-619 system with care. Compare the contents against the items covered by the contract and against the packing list.

The following components are included with an E-619 system:

PZ288E	User manual for E-619 (this document)
000016103	Dummy plug for the temperature sensor socket. One plug per E-619.H and E-619.00 amplifier module. Must be used when the piezo actuator connected to the E-619 amplifier module does not feature a temperature sensor.
E-692.SMB	SMB/BNC adapter cable, 1.5 m. One cable per E-619.H and E-619.00 amplifier module.
E500T0011	Technical Note for Analog Driver Set for use with NI LabVIEW software
3763	Line cord

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 case the product needs be shipped again.

2 Operation

2.1 Calibrated System

If an E-509 servo-control module is ordered together with the E-619 system and a piezo actuator, the system will be fully calibrated at PI according to your specifications before being shipped, and will come with a calibration information sheet.

Calibration should only be done by qualified authorized personnel after consultation with PI, otherwise internal configuration data may be destroyed by erroneous operation.

It is usually not necessary for you to do anything more than adjust the zero point before operating the system.

Do not interchange the E-619 system (whole device or individual modules) and/or piezo stages if they are matched and calibrated together. Respect the assignment of the piezo actuators to the individual 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.

2.2 Installation



CAUTION

Do not cover the ventilation slots on the top side of the E-619 housing. Place the E-619 system in a location with adequate ventilation to prevent internal heat build-up. 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.

23 Front Panel Elements



Figure 1: Front panel of E-619.H and E-619.00 amplifier modules

Name	E-619.H, E-619.00	E-619.S	Function
POWER	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	LED green / off. Green light indicates that the device is powered on.
OVERTEMP	<input checked="" type="checkbox"/>	-	LED red / off. Red light indicates that the temperature on the connected temperature sensor exceeds 150 °C. The output voltage for the piezo actuator is then deactivated (p. 13).
CONTROL INPUT -2 to +12 V 	<input checked="" type="checkbox"/>	-	SMB connector for control input voltage. -2 to 12 V is the recommended control input range, resulting in -20 to 120 V piezo output voltage (without DC-offset potentiometer usage). -3 to 13 V control input are possible and will result in -30 to 130 V output voltage (without DC-offset potentiometer usage), but working with increased output voltage will decrease actuator lifetime. See "Lifetime of PICMA® Actuators" on p. 29 for details.
DC-OFFSET	<input checked="" type="checkbox"/>	-	10-turn potentiometer for DC offset
TEMP SENSOR IN max. 4 V 	<input checked="" type="checkbox"/>	-	Lemo socket for connection of a PT1000 temperature sensor (p. 13). When the piezo actuator connected to the E-619 amplifier module does not feature a temperature sensor, the included dummy plug must be used.

Name	E-619.H, E-619.00	E-619.S	Function
PZT OUT -30 to +130 V 	<input checked="" type="checkbox"/>	-	Lemo socket that carries the output voltage for the piezo actuator (-30 to 130 V); with security cover
PZT OUT 100 V 	-	<input checked="" type="checkbox"/>	Lemo socket that carries the offset voltage (100 V) for the piezo actuators of a tip/tilt platform; with security cover

The E-619 system may be equipped with optional servo-control (E-509) and PC interface/display (E-518, E-515) modules. The controls of these modules are described in their own separate manuals.

24 Line Voltage Connection

The power connection is located on the rear panel of the E-619 housing. The E-619 housing 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.

Connect the included power cord from the E-619 housing's rear panel to an appropriate power outlet.

See "AC Power and Line Fuses" (p. 19) for how to replace the line power fuses if there is a fault. Note that both fuses are active and have to be replaced or checked.

25 Piezo Actuator Connection



CAUTION

Use only PICMA® piezo actuators with high-current termination electrodes. Standard piezo systems and actuators have to be adapted before they can be used with an E-619 system. Contact your PI sales engineer or write info@pi.ws.

For dynamic applications or continuous operation, the use of a temperature sensor (PT1000) on the piezo actuator is recommended, to avoid destruction of the piezo due to heat generation. See p. 12 for details.

Connect the piezo system or actuator to the E-619 amplifier module via the "PZT OUT" Lemo socket on the front panel.

DANGER

E-619 amplifier modules and offset voltage modules output high voltages and high currents which can cause death or injury!

Take special care if connecting products from other manufacturers. Follow general accident prevention rules!

Modifications of high voltage connectors must be carried out by adequately trained and educated personnel.



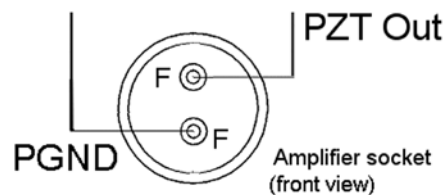
If your PICMA® piezo actuator with high-current termination electrodes is not equipped with a connector, you have to attach a suitable connector according to the type and pinout of the “PZT OUT” socket shown below. A connecting cable with open end for soldering piezo actuators can be ordered separately, order No. E-618.X11.

“PZT OUT” socket on E-619:

Type: LEMO
EGG.1B.302.CLL with 2 conductors
and a shield

Pin Assignments:

PZT Out: Piezo output, -30 to 130 V
(E-619.H, .00) or 100 V
(E-619.S)
PGND: Power ground
Housing: Cable shield, for
protective ground

**26 Temperature Sensor Connection**

E-619.H and E-619.00 amplifier modules are equipped with a temperature monitoring circuit to avoid overheating of the connected mechanics. It can be used with PT1000 temperature sensors.

Connect the PT1000 to the “TEMP SENSOR IN” Lemo socket on the front panel of the E-619 amplifier module. When the mechanics connected to the E-619 amplifier module does not feature a temperature sensor, the included dummy plug (order No. 000016103) must be used.

When a temperature of 150 °C is detected on the mechanics, the E-619 temperature monitoring circuit deactivates the output of the amplifier (“PZT OUT” socket), and the red “OVERTEMP” LED on the front panel of the module lights up. See p. 18 for how to proceed in this case.

To avoid overheating, you can reduce the maximum operating frequency and output voltage. The maximum operating frequency and output voltage (travel) depend on operating conditions such as thermal coupling (single- or double-ended, with or without air cooling) length-to-diameter ratio and, of course, on the driving waveform.

The maximum possible frequency for a particular system should be determined after the system is set up with the defined operating conditions by slowly running the system up to the point where the amplifier performs a thermal shutdown. It is important to take proper account of the temperature sensor time constant, the mechanical characteristics of the system, and the amplifier parameters.

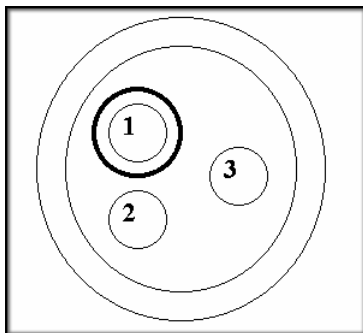


Figure 2: Temperature sensor connector of the E-619 amplifier, view from solder side

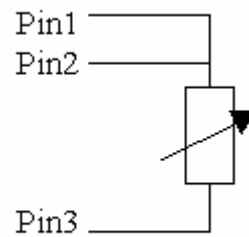


Figure 3: Temperature sensor diagram

Pin assignment:

- Pin 1: Temp_SA
- Pin 2: Temp_S
- Pin 3: GND/PE
- Housing: Shield/GND/PE

27 Control Signal Connection

27.1 Analog Operation

E-619.H and E-619.00 amplifier modules can be operated by an analog control signal. The output voltage (if in open-loop operation) or the actuator position (closed-loop operation) is directly proportional to this analog control signal. The analog control signal consists of two components:

$$\text{Analog control signal} = \text{CONTROL INPUT} + \text{DC OFFSET}$$

where

CONTROL INPUT is the voltage connected to the corresponding SMB connector on the front panel

DC OFFSET is the DC offset voltage set via the corresponding potentiometer on the front panel (0 to 10 V)

-2 to 12 V is the recommended range for the analog control signal, resulting in -20 to 120 V piezo output voltage. A range of -3 to 13 V is possible and will result in -30 to 130 V output voltage, but working with increased output voltage will decrease actuator lifetime. See "Lifetime of PICMA® Actuators" on p. 29 for details.

The signal applied to the CONTROL INPUT SMB connector can be generated using a DAC-board in a PC. PI offers a driver set for NI LabVIEW software which can be used with certain D/A boards (see "Accessories" p. 8).

27.2 Remote Control via Computer Interface

E-619 systems equipped with an E-518 computer interface module can be controlled from a host computer via the TCP/IP, USB, or RS-232 PC interface. See the E518T0001 Technical Note for details.

28 Modes of Operation

28.1 Open-Loop Operation

E-619.H and E-619.00 amplifier modules can be operated in open-loop mode. Open-loop operation means that any control input provided by the user determines the output voltage directly.

28.2 Closed-Loop Operation

Closed-loop operation requires a position sensor in the mechanics and a servo-control module, e.g., E-509, in the E-619 system. Closed-loop operation means that the user commands the piezo excursion. 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 sensor (see E-509 User Manual PZ77E).

Note: In closed-loop operation up to 10% of the amplifier output range may be required for compensating nonlinearity and drift.

29 First Steps

NOTE

If an E-619 amplifier module is turned on while no piezo actuator is connected, the output voltage on the PZT OUT socket will oscillate with its natural frequency.

The following instructions refer to analog operation (p. 14) of the system. If your E-619 system is equipped with an E-518 computer interface module and you want to control the system via the computer interface, only perform steps 1 to 4 of the instructions below and then operate the system as described in the E518T0001 Technical Note.

The following instruction assumes that the E-619 system contains a single E-619.H or E-619.00 amplifier module. If more than one E-619 amplifier module is present in your system, perform the respective steps for all amplifier modules. With E-619.S offset voltage modules, simply perform steps 1 and 2 before you turn on the E-619 system.

NOTE

Do not interchange the E-619 system (whole device or individual modules) and/or piezo stages if they are matched and calibrated together. Respect the assignment of the piezo actuators to the individual 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.

- 1 Make sure the E-619 system is connected to line voltage but powered down. See "Line Voltage Connection" (p. 12) for details.
- 2 Connect the piezo actuator to the PZT OUT socket of the E-619 amplifier module.
- 3 Connect the PT1000 temperature sensor of the piezo actuator to the TEMP SENSOR IN socket of the E-619 amplifier module. If the temperature sensor is not to be connected, the included dummy plug (order No. 000016103) must be connected to this socket.
- 4 For closed-loop systems only (E-619 system with E-509 servo-control module; see also the E-509 User Manual):
 - 4.1 Connect the sensor cable to the corresponding socket.
 - 4.2 If you are using the sensor monitor signal, connect your appropriate electronics to the SENSOR MONITOR socket.
 - 4.3 Set SERVO toggle switch on the servo module "OFF".
- 5 Turn the DC-OFFSET potentiometer of the E-619 amplifier module fully counterclockwise (CCW).
- 6 If desired, connect a suitable signal source to the CONTROL INPUT SMB connector. See "Control Signal Connection" (p. 14) for details on the analog control signal that results from DC-OFFSET and CONTROL INPUT.

- 7 Make sure that the voltage at CONTROL INPUT is set to 0 V.
- 8 Turn on the E-619 system. The green POWER LED of the amplifier module will light up.
- 9 Command the first motion of the piezo actuator by turning the offset potentiometer fully clockwise (CW) to run the actuator over the nominal travel range, then turn the potentiometer back fully CCW.

If an E-509 servo-control module is installed, the SENSOR MONITOR signal will show a voltage from about 0 up to 10 V and then 0 V again, proportional to the piezo extension.

Example: A piezo actuator with a nominal travel of 100 μm shows a sensor monitor signal of 1.5 V at 15 μm . For an actuator with 30 μm nominal travel, 1.5 V at sensor monitor would correspond to 4.5 μm (15% of 30 μm)

- 10 Command further motion by adjusting the DC-OFFSET potentiometer and / or the CONTROL INPUT signal.

E-619 systems equipped with E-509 servo-control modules:

If you switch to closed-loop operation (servo ON), the yellow OFL overflow LED on the E-509 module may light up. In this case, a zero-point adjustment is necessary. Follow the instructions for zero-point adjustment given below. To avoid an overflow of the amplifier in open-loop operation, do not exceed the allowable control input range (-3 to +13 V).

2.10 Zero-Point Adjustment in Closed-Loop Operation with E-509

Zero-point adjustment on the E-509 sensor and servo-control module has the following goals:

- Making the full travel range available: If the electrical zero point is adjusted properly, the full output voltage range of the amplifier can be used in closed-loop operation. This prevents overflow conditions from occurring.
- Preserving the piezo actuators in the mechanics: The point of zero sensor readout should correspond to zero or a (small) negative output voltage. This technique can reduce the average applied voltage without loss of displacement and thereby increase piezo lifetime.

There might be some small deviation of the electrical zero-point caused by thermal drift or changes in mechanical loading. Let the system warm up for several minutes before setting the zero point. See also the E-509 User Manual, PZ77E.

How to perform zero-point adjustment in open-loop operation:

- 1 Make sure the piezo actuator is mounted in the same way and with the same load as during normal operation in the application.
- 2 Make sure that the analog signal on CONTROL INPUT is 0 V and turn the DC-OFFSET potentiometer fully CCW.
- 3 Connect a precision voltmeter to the SENSOR MONITOR socket on the E-509 front panel.
- 4 Power up the system.
- 5 Set the SERVO toggle switch on the E-509 front panel to OFF.
- 6 Turn the DC-OFFSET potentiometer fully clockwise (10 V) and then back fully counterclockwise (0 V) to exercise the piezo actuator.
- 7 Adjust the ZERO potentiometer on the E-509 until a sensor-monitor signal of +1 V is measured by the precision voltmeter on the SENSOR MONITOR socket.

After successful zero-point adjustment, the “OFL” overflow LED on the E-509 module should no longer glow in closed-loop operation. Permanent glow of this LED in spite of zero-point adjustment may indicate hardware failure. To avoid an overflow of the amplifier in open-loop operation, do not exceed the allowable control input range (-3 to +13 V).

2.11 Protection Against Overheating

To protect the system against overheating, the piezo voltage output on the PZT OUT socket is deactivated automatically in the following case:

- A PT1000 temperature sensor connected to the E-619.H or E-619.00 amplifier module detects a temperature of 150 °C on the piezo actuator. In this case, the red OVERTEMP LED on the front panel of the module lights up.

If the piezo voltage output has been deactivated, the piezo actuator will no longer move. Proceed as follows:

1. Turn off the E-619 system for a cooling phase.
2. Wait until the temperature has dropped on the mechanics.
3. Power up the E-619 system again.

Permanent deactivation of the piezo output voltage due to overheating may indicate hardware failure.

3 Maintenance

3.1 AC Power and Line Power Fuses

DANGER

Risk of electric shock!

An E-619 system requires a supply voltage of 100 to 120 VAC or 220 to 240 VAC (line voltage). Touching the line voltage can result in serious or even lethal injury due to electric shock.

→ Remove the power cord from the E-619 housing before you change the line fuses.



NOTE

Both line fuses of the E-619 housing are active.

→ Check both fuses if there is a fault.

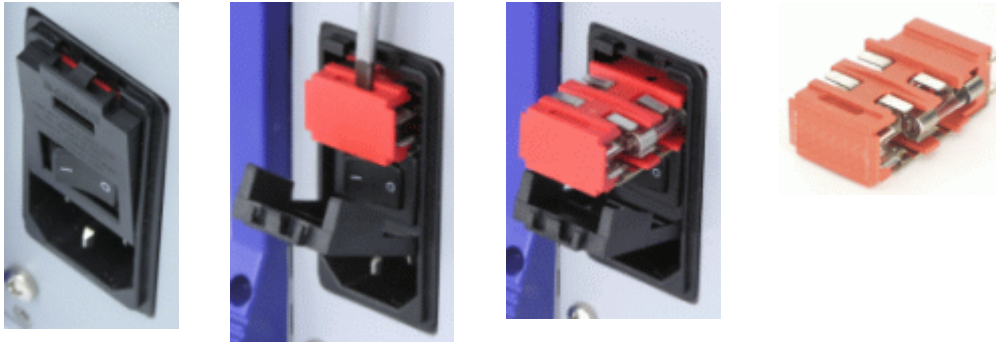
The power connection and line fuses are located on the rear panel of the housing. To access the line fuses, proceed as follows:

- 1 Switch off the E-619 system and remove the power cord.
- 2 Wait a minute to be sure that any residual voltage has dissipated.
- 3 Pry open the door that covers the fuse carrier and pry out the fuse carrier (see figures below).
- 4 Be sure to replace both fuses with fuses of the suitable type:

E-619.R1 9.5" housing: 100 to 240 V~	2 x IEC T2AH, 250 V
E-619.R3 19" housing: 100 to 240 V~	2 x IEC T4AH, 250 V

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

- 5 Reinstall the carrier and close the door



3.2 Cleaning



CAUTION

Short circuits or flashovers!

The E-619 system contains electrostatic sensitive devices that can be damaged by short circuits or flashovers when cleaning fluids penetrate the case.

- ➔ Before cleaning, remove the E-619 system from the power source by pulling the power plug.
- ➔ Prevent cleaning fluid from penetrating the case.

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

4 Troubleshooting

4.1 Mechanics Does not Move

- Check the connecting cables.
- Check the analog control signal (CONTROL INPUT and DC-OFFSET setting). See p. 14 for more information.
- The piezo voltage output (PZT OUT socket) may be deactivated due to overheating of the mechanics. See p. 18 for more information.

4.2 The OVERTEMP LED Lights

- The connected temperature sensor is reporting 150 °C and the piezo voltage output has thus been shut off. Turn off the E-619 system. Wait until the temperature at the mechanics has dropped before powering the E-619 system up again.

4.3 Customer Service

Still having problems? Call your local distributor or write to service@pi.de; please have the following information about your system ready:

- Product codes and serial numbers of all products in the system
- Current firmware version of the controller
- Software version of drivers and / or host software
- Operating system on host PC

5 Technical Data

5.1 Specifications

5.1.1 E-619 Amplifier Modules

	E-619.H / E-619.00	E-619.S
Function	High-Power Piezo Amplifier Module, 1 Channel, 1200 W Peak Power, -30 to 130 V	Offset Voltage Source for Tip/Tilt Platforms, 1 Channel, 1200 W Peak Power, 100 V Fixed Voltage
Amplifier		
Input voltage*	-3 to 13 V	-
Output voltage	-30 to 130 V	100 V
Peak output power (<5ms)	1200 W	1200 W
Average output power (>5 ms)	Equivalent to 800 VA reactive power	Equivalent to 800 VA reactive power
Peak current (<5 ms)	10 A	10 A
Average output current (>5 ms)	>5 A	>5 A
Current limitation	Short-circuit-proof	Short-circuit-proof
Voltage gain	10 ±0.1	-
Amplifier bandwidth, small signal	20 kHz / 3 kHz	-
Ripple, noise, 0 to 10 kHz	<2 mV _{rms} <20 mV _{pp}	<2 mV _{rms} <20 mV _{pp}
Capacitive base load (internal)**	2 µF / 1 µF	2 µF
Suggested capacitive piezo load**	>1 µF	>1 µF
Output impedance	0.1 Ω; 53 µH; 2 µF / 0.1 Ω; 1 mH; 1 µF	0.1 Ω; 53 µH; 2 µF
Amplifier resolution	<2 mV	<2 mV
Amplifier classification	Class D (switching amp) 400 kHz / 100 kHz	Class D (switching amp) 400 kHz
Input impedance	100 kΩ	-
Interfaces and operation		
Piezo connector (voltage output)	LEMO EGG.1B.302.CLL, with security cover	LEMO EGG.1B.302.CLL, with security cover
Analog input / control in	SMB	-
DC Offset	10-turn pot., adds 0 to +10 V to Control In	-
Temperature sensor (piezo actuator)	PT 1000; LEMO FFA.OS.303.CLAC32 Automatic deactivation of high voltage output at 150 °C	-
Display	Power, Overtemp LEDs	Power LED

	E-619.H / E-619.00	E-619.S
Miscellaneous		
Operating temperature range	5 to 40 °C	5 to 40 °C
Dimensions	21 HP/3 U	21 HP/3 U
Mass	3.5 kg	3.5 kg
Operating voltage	Provided by E-619 housing	Provided by E-619 housing
Max. power consumption	<150 W	<150 W
Max. power consumption without load	20 W	20 W

* -2 to 12 V is the recommended control input range, resulting in -20 to 120 V piezo output voltage (without DC-offset potentiometer usage).

-3 to 13 V control input are possible and will result in -30 to 130 V output voltage (without DC-offset potentiometer usage), but working with increased output voltage will decrease actuator lifetime. See “Lifetime of PICMA® Actuators” on p. 29 for details.

** The internal base load is required to obtain a stable amplifier output voltage when no external piezo load is connected. 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:

In the examples, it is assumed that the average output power to be allocated is 700 W.

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, 285 W will be allocated to the internal base load (2 µF / 1 µF), while approx. 230 W / 413 W will be available for the external piezo load.

With a small-signal capacitance of 10 µF, the piezo actuator would have a large-signal capacitance of 20 µF, and approx. 630 W / 648 W would be available for it. In this case, the internal loss due to the internal base load would be only 70 W / 52 W.

5.1.2 E-619.R1 9.5" Housing

Model	E-619.R1
Function	9.5"-Housing for E-619 Amplifier Modules
Slots	1 amplifier module; can be upgraded with servo-control module and/or computer interface module, or with display module
Dimensions	236 x 132 x 296 mm + handles + feet
Mass	10 kg
Operating Voltage	100 - 240 V~, 50 - 60 Hz
Max. power consumption	150 VA
Max. power consumption without load	30 VA
Internal power supply	E530B0008

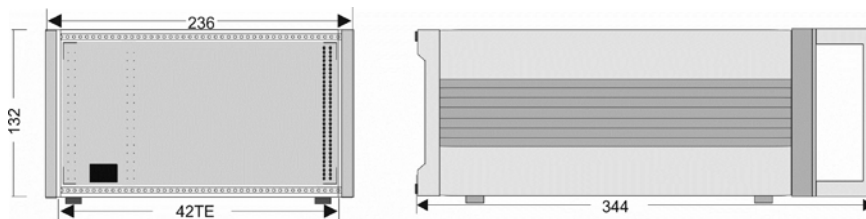


Fig. 1: E-619.R1 housing

5.1.3 E-619.R3 19" Housing

Model	E-619.R3
Function	19"-Housing for E-619 Amplifier Modules
Slots	Up to 3 amplifier modules; can be upgraded with servo-control module and/or computer interface module, or with display module
Dimensions	450 x 132 x 296 mm + handles +feet
Mass	18 kg
Operating Voltage	100 - 240 V~, 50 - 60 Hz
Max. power consumption	360 VA
Max. power consumption without load	80 VA
Internal power supply	GCU500PS24-EF

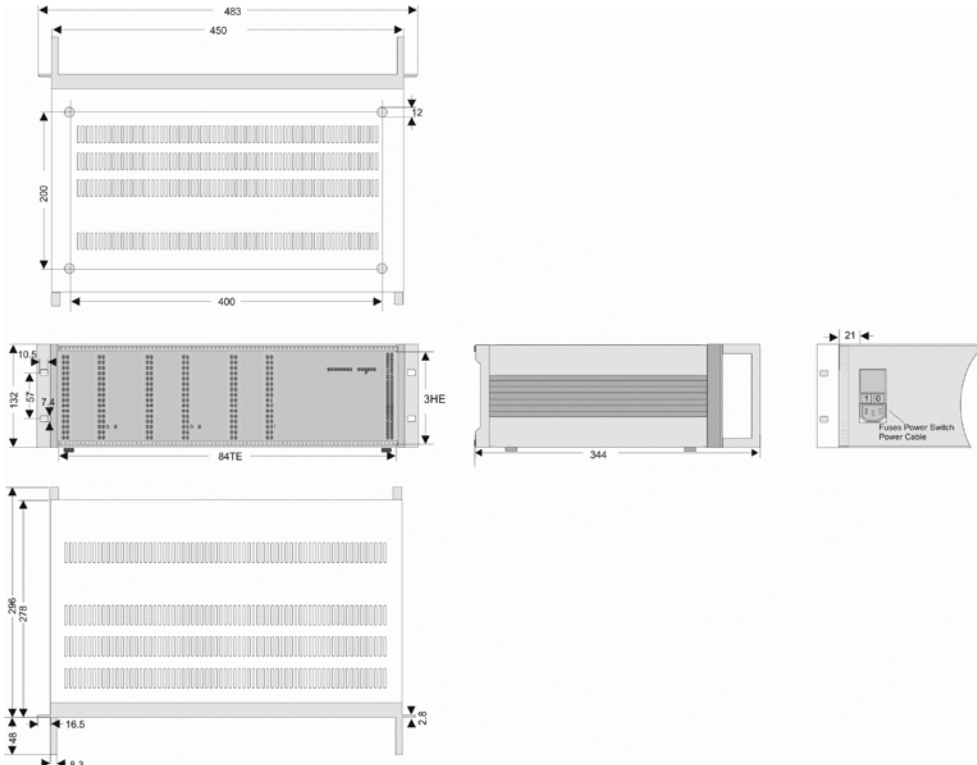


Fig. 2: E-619.R3 housing

5.2 Frequency Response Diagram

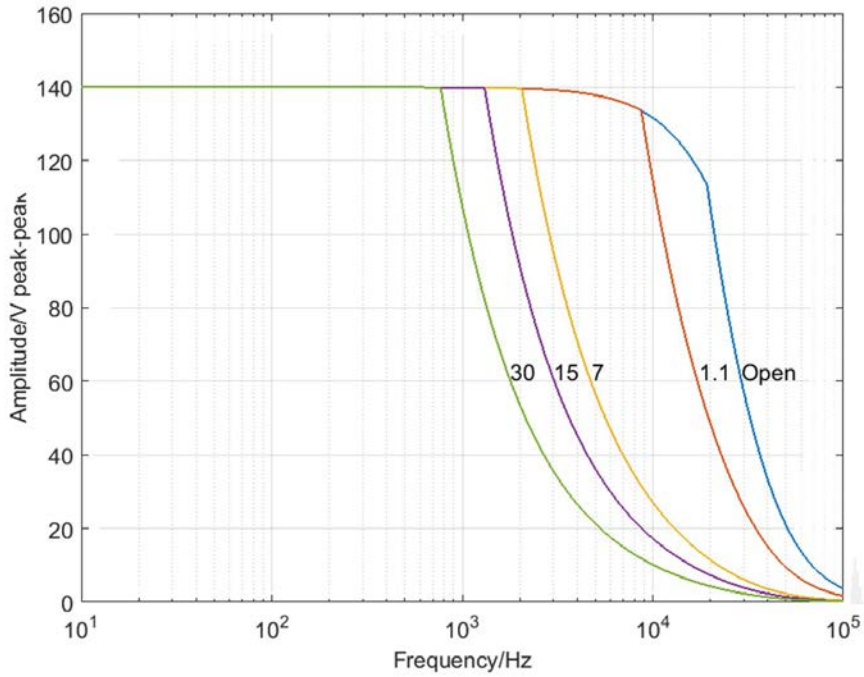


Figure 4: E-619.H operating limits with various piezo loads (open-loop), capacitance is measured in μF

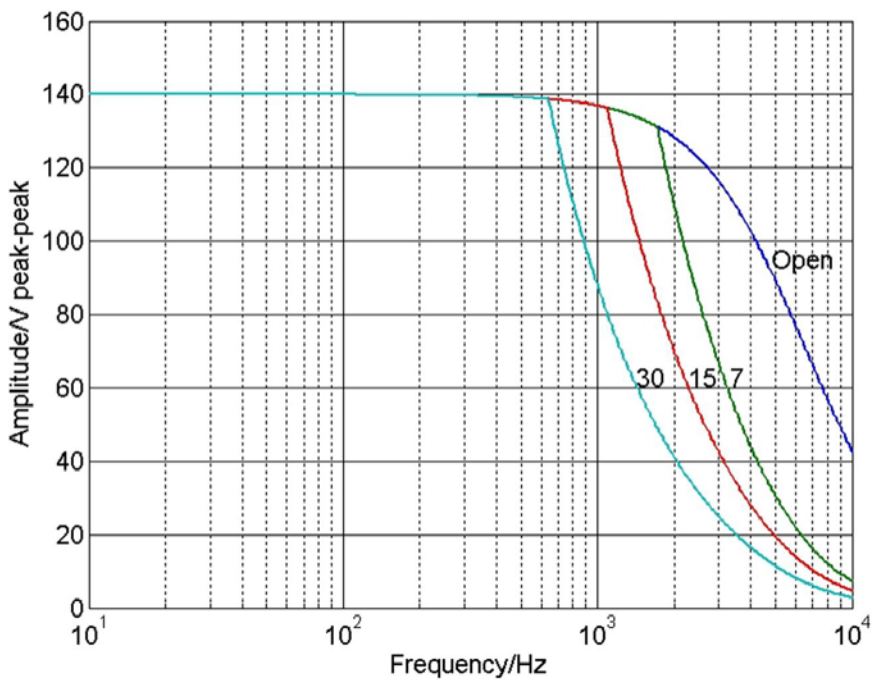


Figure 5: E-619.00 operating limits with various piezo loads (open-loop), capacitance is measured in μF

5.3 Signal Path

The block diagram below shows the signal path for the E-619 system with an E-509 servo-control module and an E-518 interface module.

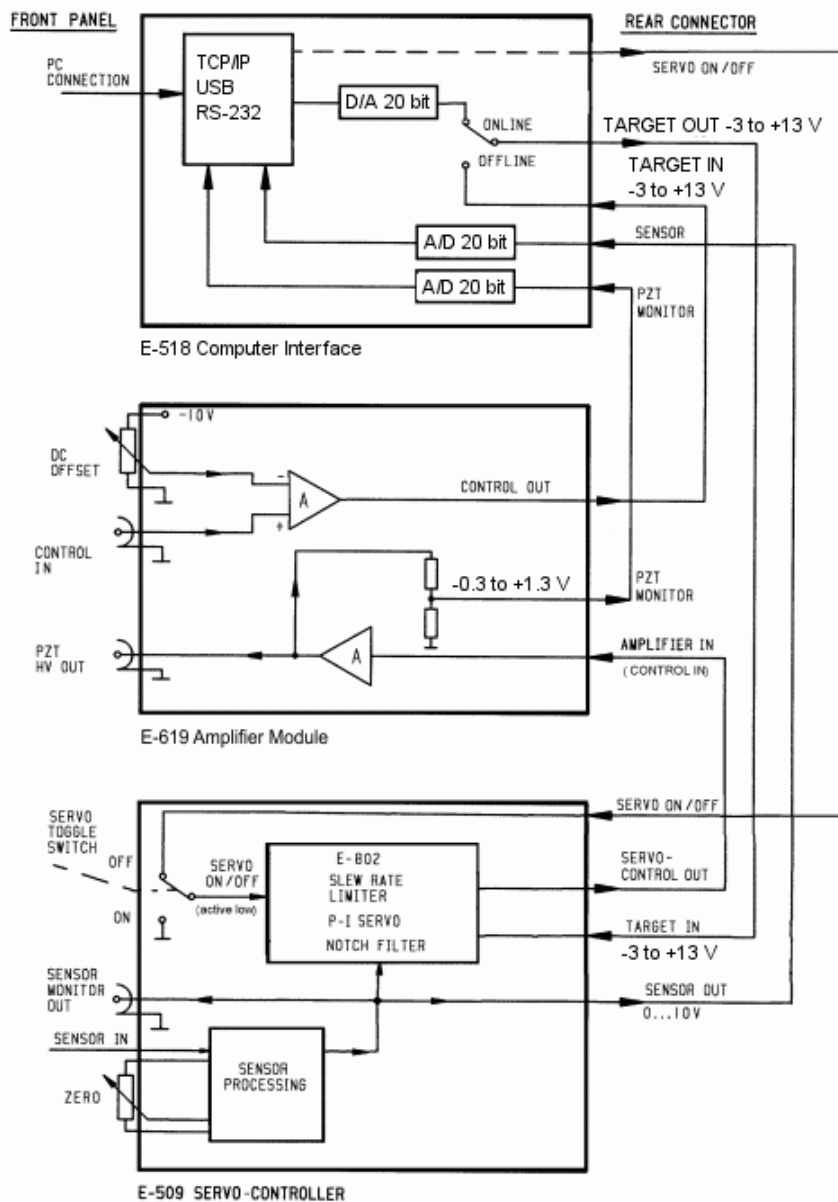


Figure 6: E-619 signal path with E-518 interface module

5.4 32-Pin Main Connector of the E-619 Amplifier Module

The pin assignment of E-619.H and E-619.00 amplifier modules is as follows:

Function		Function
PZT output	a 2 c	PZT output
PZT GND	a 4 c	PZT GND
Sync Input TTL Signal, E-619.H: 400 kHz / E-619.00: 100 kHz	a 6 c	Control Out, includes Offset Signal OUT
Monitor PZT out (100:1)	a 8 c	Amplifier In
OVN status signal (output)	a 10 c	Control In (also on SMB socket; use only one of the connections)
nc	a 12 c	nc
AGND	a 14 c	AGND
+VCC supply, +24 V	a 16 c	+VCC supply, +24 V
-VCC supply, 0 V	a 18 c	-VCC supply, 0 V (connect to 20c for minimum noise)
AGND	a 20 c	AGND
nc	a 22 c	AGND
nc	a 24 c	nc
nc	a 26 c	nc
nc	a 28 c	nc
nc	a 30 c	nc
Protective GND	a 32 c	Protective GND

nc = not connected

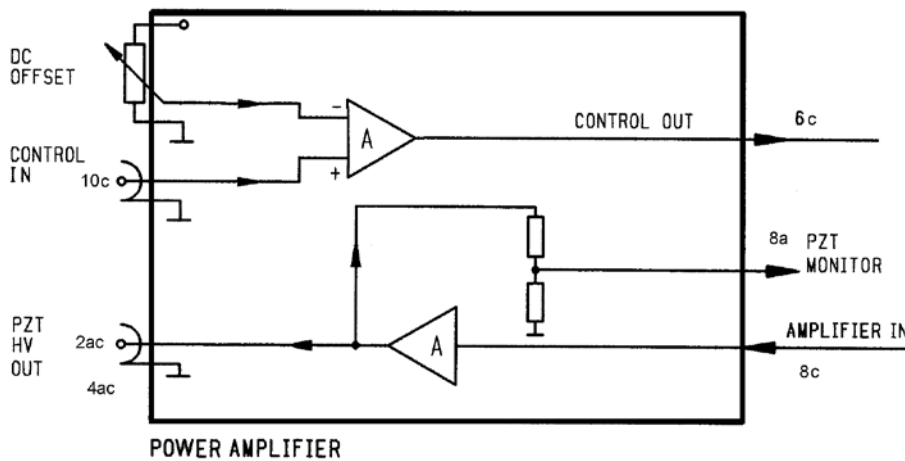


Figure 7: Signal path of the E-619 amplifier module with assignment of the corresponding main connector pins

6 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.

In order to fulfil its 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 Roemerstr. 1
D-76228 Karlsruhe, Germany



7 Appendix

7.1 Lifetime of PICMA® Actuators

The following factors can have an impact on the actuator lifetime and must be considered:

- Applied voltage
- Temperature
- Relative humidity

The effect of each individual factor on the lifetime can be read off the diagrams shown below. The lifetime calculated in hours simply results as the product of all three values read off the diagrams.

The impact of the applied voltage is particularly important. With decreasing voltage the lifetime increases exponentially. This must always be taken into consideration in an application. The recommended maximum range of the control input voltage for the E-619 amplifier module therefore is -2 to 12 V, resulting in a piezo voltage range of -20 to 120 V. A control input range of -3 to 13 V is possible (results in -30 to 130 V piezo voltage), but will reduce the actuator lifetime accordingly.

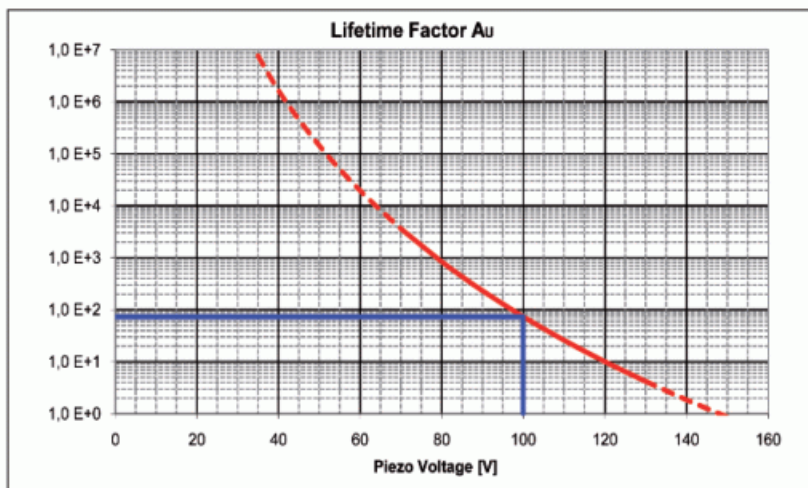


Fig. 3: Interdependency between the mean MTTF of a PICMA® actuator and the value of the voltage applied

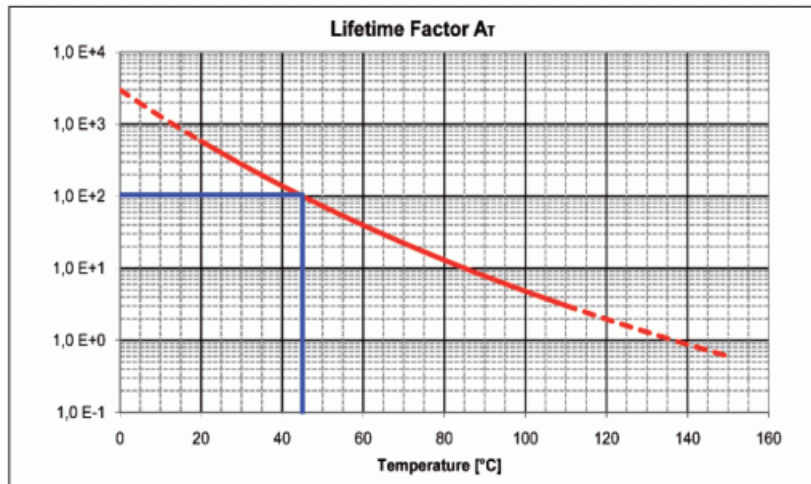


Fig. 4: Interdependency between the mean MTTF of a PICMA® actuator and the ambient temperature

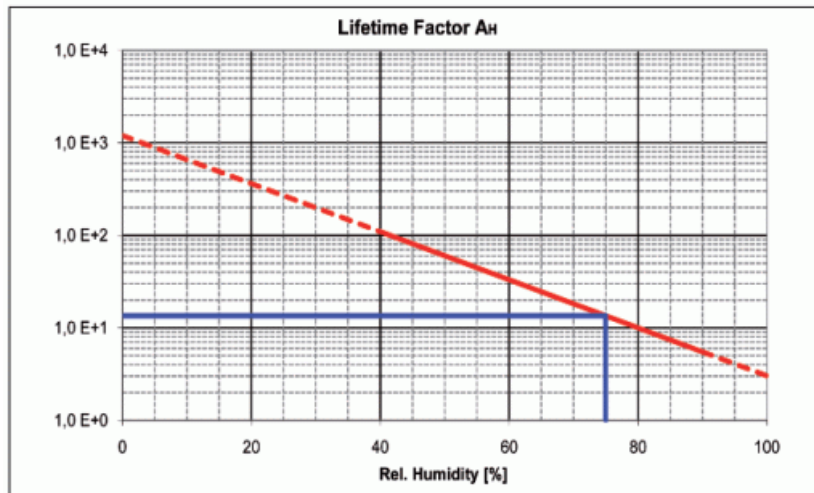


Fig. 5: Interdependency between the mean MTTF of a PICMA® actuator and the relative humidity

Example

The simple formula $MTTF = A_U * A_T * A_F$ provides a quick estimate of the reliability in hours.

For example, the values for 75% RH ($A_F=14$), 100 VDC ($A_U=75$) and 45 °C ($A_T=100$) result in an approximate MTTF of 105,000 h, i.e. more than 11 years (see markings on the diagrams).

7.2 How to Measure the Amplifier Output

The innovative, efficient circuitry of the E-619 amplifier module reduces power consumption and heat dissipation, especially in dynamic applications. Working with an internal switching frequency of 100 kHz (with E-619.00; 400 kHz with E-619.H), charge is transferred to the piezo actuator using low-loss PWM techniques. The ripple of the amplifier output is $<100 \text{ mV}_{pp}$ 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 than the original continuous signal when the sampling rate is too low. With the E-619 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).

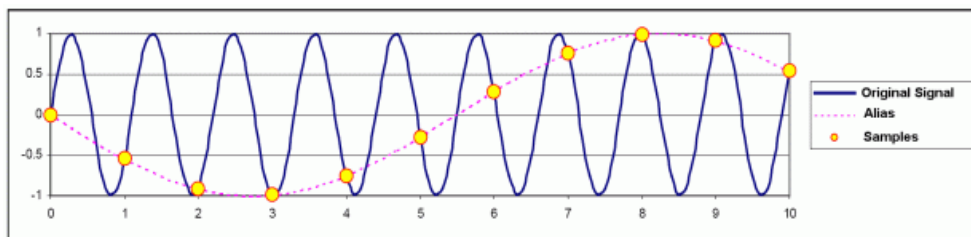


Fig. 6: Signal digitization with too low sample rate (time in 1/100 s): Original signal = 91 Hz and sampling rate = 100 Hz; the result is mistaken as a 9.1 Hz signal (“Alias”)

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. With E-619.H, the switching frequency is 400 kHz which requires a sampling rate of about 800 kHz.

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

