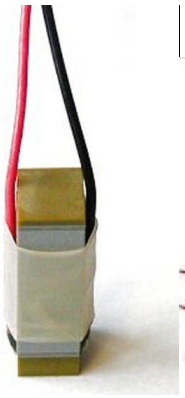
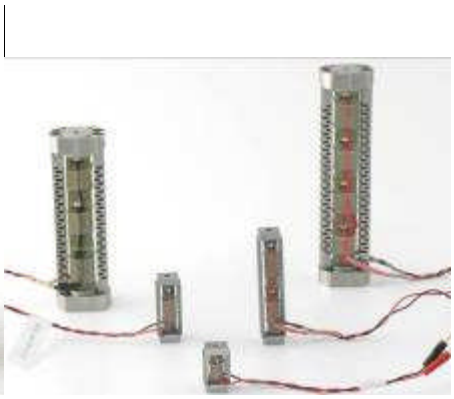
CEDRAT TECHNOLOGIES
Innovation in Mechatronics

PIEZOELECTRIC ACTUATORS
PRODUCT AND WARRANTY INFORMATION





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CAUTION: READ BEFORE OPENING

For safety purposes these instructions must be read before use of this product.

Piezoelectric products are not warranted against mechanical damage resulting from improper use, where excessive forces or voltages (outside specified ranges) are applied. A diagnostic on the failure of origin has to be made by Cedrat Technologies experts based on customer data acquisition (temperature, hygrometry, applied force, frequency …). This data monitoring is required to activate the warranty.

Piezo component are driven with High voltage.

The successful and safe operation of this equipment is dependent on proper handling, installation and operation.

Only qualified personnel should work on or around this equipment and only after becoming thoroughly familiar with all warnings, safety notices, and procedures contained herein.

A "qualified person" is one who is familiar with the installation, construction and operation of the equipment and the hazards involved. In addition, he/she has the following qualifications :

- **is trained and authorized to energize, de-energize, clean, and ground equipment in accordance with established practices,**
- **is trained in the proper care and use of protective equipment in accordance with established safety practices.**

Summary

1. INTRODUCTION 4

2. CONDITIONS OF USE & WARRANTY 5

2.1. TEMPERATURE 5
2.2. SELF-HEATING 5
2.3. HUMIDITY 5
2.4. DYNAMIC 6
2.5. ENVIRONMENTS (SHOCKS, VIBRATIONS…) 7
2.6. POWER SUPPLY AND CONTROL 7
2.6.1. Electrical Connections 7
2.6.2. Over Voltages 10
2.6.3. Nature of the power amplifier 10
2.6.4. Nature of the driving signal 10
2.7. RADIATIONS 11
2.8. CHEMICAL AND ABRASIVE ENVIRONMENT 11
2.9. PASCHEN EFFECT 11
2.10. MOUNTING PROCEDURE & INTEGRATION BIASES 12
2.10.1. Amplified Piezo Actuator (APA®) 12
2.10.2. Parallel Pre-stressed Actuator (PPA) 13
2.10.3. Multi-Layer Actuator (MLA) 14
2.11. COMBINED EFFECTS 14

3. WARRANTY CONDITIONS AND EXCEPTIONS 15

4. INSPECTION UPON RECEIPT 15

5. AFTER-SALE SERVICE 16

6. DISPOSAL 16

ANNEX 1: UNDERSTANDING THE FACTORY VERIFICATION SHEET 17

ANNEX 2: TROUBLE SHOOTING FORM 18

1. INTRODUCTION

Since 1990, CEDRAT TECHNOLOGIES SA has developed a wide range of piezoelectric actuators. They are divided in three categories:

- Multilayer actuators, which are not mechanically pre-stressed,
- Parallel pre-stressed actuators (PPA), which are mechanically pre-stressed multilayer actuators and offer mechanical interfaces,
- Amplified piezo actuators (APA®), which are using the elastic properties of a metallic shell to both pre-stress the piezoelectric ceramic and amplify the displacement.

Piezoelectric actuators' performances are given for standard products at 20°C with maximum 60% humidity and without loading. Theses performances may change with the following parameters:

- Loading (spring, mass, damper)
- Temperature
- Humidity
- Dynamic

If you need more information, please contact actuator@cedrat-tec.com

Piezoelectric Actuators must be handled carefully. Lifetime of Piezoelectric Multilayer actuators is not limited by wear. They can perform millions of cycles without loss of performance provided they are operated under suitable conditions. The following elements are reducing the actuator lifetime and may induce some performances variations:

- Temperature
- Self-Heating
- Humidity
- Dynamic
- Environments (Shocks, Vibrations,…)
- Power supply and control
    - Electrical connections
    - Continuous Voltage
    - Over Voltages
    - Nature of the power amplifier
    - Nature of the driving signal
- Radiations
- Chemical and abrasive environment
- Paschen effect
- Mounting procedure & Integration Biases
- Combined effects

More details on each phenomenon are given here after.

2. CONDITIONS OF USE & WARRANTY

2.1. TEMPERATURE

Performances in technical datasheet of Cedrat technologies actuators are given for a temperature between 15°C and 25°C.

Typical operational temperature range is from -40°C to 80°C.
For maximum lifetime, operating voltage should be minimized, especially when actuators are used with constant voltage.

Actuator height is varying because of thermal expansion. The actuator height is given in laboratory conditions of temperature (20°C).

2.2. SELF-HEATING

An important self heating of the piezo ceramic may occur during a long use in dynamic (high frequency) operation.

This can lead to depolarization or electrical breakdown of the piezo ceramic.

If you have some doubts on your operating conditions please contact actuator@cedrat-tec.com for more information before starting the device.

2.3. HUMIDITY

Performances in technical datasheet of Cedrat technologies actuators are given for a humidity rate of max 60% with non condensed water.

Driving ceramic with a DC voltage above 60% of relative humidity is technically possible but it leads to a reduced life time. Standard actuator can perform more than 1000h supplied at their maximum voltage in a 60% humidity level.
The piezo component fails under humidity mainly if it is driven with a DC voltage (ie a constant electric field). Some water is absorbed by the ceramic and generates a migration of metallic ions form the internal electrodes. This migration leads to a progressive loss of isolation between these electrodes. The power consumption increases up to electric breakdown.

Please do not supply the ceramic with a DC voltage above 60% of relative humidity without Cedrat technologies agreement.

In this particular case the data monitoring is very important to activate the warranty especially on the following data:

- Hygrometry
- Voltage

If needed an analysis should be performed by Cedrat technologies on a specific design. Most common solution is encapsulation. Then please contact actuator@cedrat-tec.com

2.4. DYNAMIC

The dynamic behaviour is meet when inertial forces (acceleration of masses) are not negligible (> 10%) compared to the actuator blocked force.
It is complex and requires some precautions.

In harmonic case, an actuator is working in dynamic conditions if the applied frequency is higher than one third of the natural resonance frequency in the same conditions (loading and boundary conditions).

Many Cedrat technologies standard actuators are designed to withstand their full static stroke below and at the resonance.

Approaching the resonance frequency the displacement will be amplified. Then the driving voltage has to be decreased to not exceed the maximum stroke. Cedrat technologies could deliver actuators with displacement sensors and a closed loop to drive the actuator at a given stroke. That solves the issue.

In this particular case the data monitoring is very important to activate the warranty especially on the following data:

- Stroke
- Voltage
    - Frequency
    - Amplitude
    - Signal Shape

If you have some doubts on your operating conditions please contact actuator@cedrat-tec.com for more information before starting the device.

2.5. ENVIRONMENTS (SHOCKS, VIBRATIONS…)

Shocks and Vibrations are very dependant of the operating conditions (loading and boundary conditions).

If the actuator must withstand shocks or vibrations an analysis has to be performed by Cedrat technologies.

If needed, please contact actuator@cedrat-tec.com before doing the tests.

2.6. POWER SUPPLY AND CONTROL

2.6.1. Electrical Connections

Since piezoelectric actuators behave also as pyroelectric materials, voltage can appear, even without any power supply, due to temperature changes.

The red wire corresponds to the positive electrode; the black wire corresponds to the negative electrode, which must be connected to the electrical ground. For some actuator series, the longest wire corresponds to the positive electrode.

CAUTION: *It is recalled that the actuator must be excited between –20 V and 150 V. A higher voltage will damage the actuator.*

The Strain Gauges used by CEDRAT TECHNOLOGIES display an Ohmic resistance of 350Ω for all the actuators.

For the strain gauges 350Ω the driving voltage (Vcc-GND) should not be higher than 10V.

The reduction of the driving voltage reduces the dissipated power and the related thermal effect, but also reduces the sensitivity of the bridge.

2.6.1.1.SG Option

The piezoelectric actuator can be delivered with a full bridge of strain gauges (SG option).

If the SG option is sold with the sensing electronic, the linkage cable will be provided as shown below to link the conditioner to the actuator.

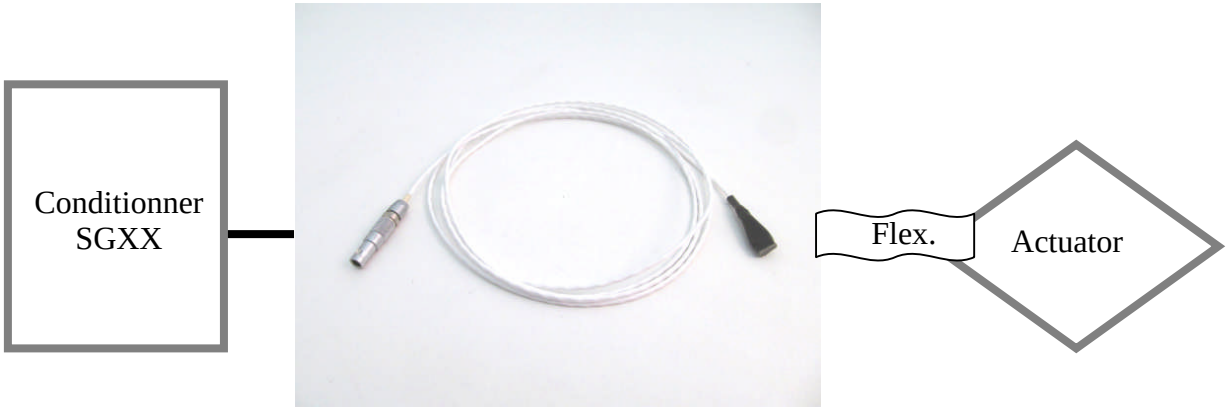


Figure 1 Strain gauges cable

Circumspection of use of these cables has to be respect not to damage the flex. It is necessary to take the flex at the chock of thickness that is to say the nearest of the links when inserting it in the cable. Besides, there is no polarizing slot on the flex, if you have no signal on gauges, check that the flex is in the right side.

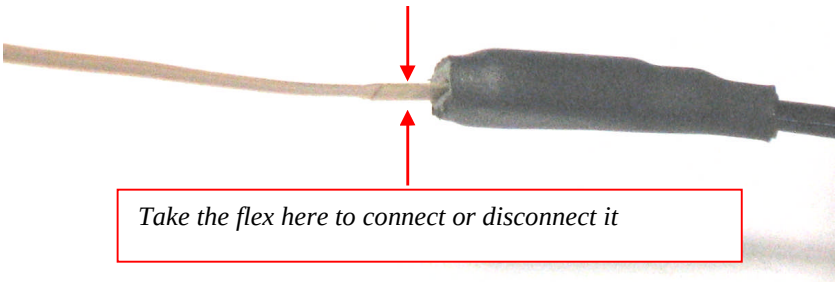


Figure 2-2 : Strain Gauge connections

If the SG option is sold without the sensing electronic, the linkage cable will not be provided and the customer needs to perform the linkage himself. In that case the following schematics must be respected.

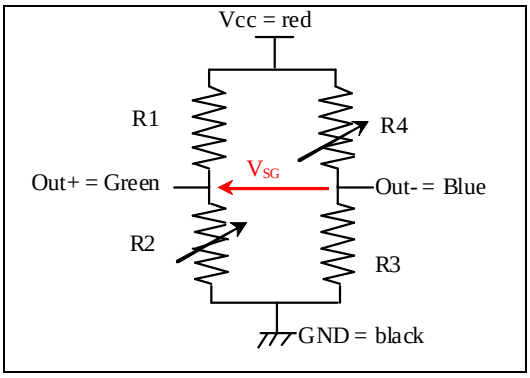


Figure 2-3 : Schematic of the Strain Gauges bridge

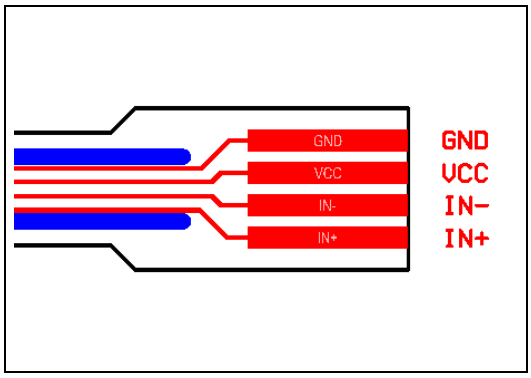


Figure 2-4 : schematic of the flexible pcb end (FFC 4 points 1 mm)

2.6.1.2.SG Option + VAC option

If the vacuum option is sold in addition to the SG option with the electronic then the cable may be cut to go through the vacuum chamber electrical interface. Then please respect the following scheme.

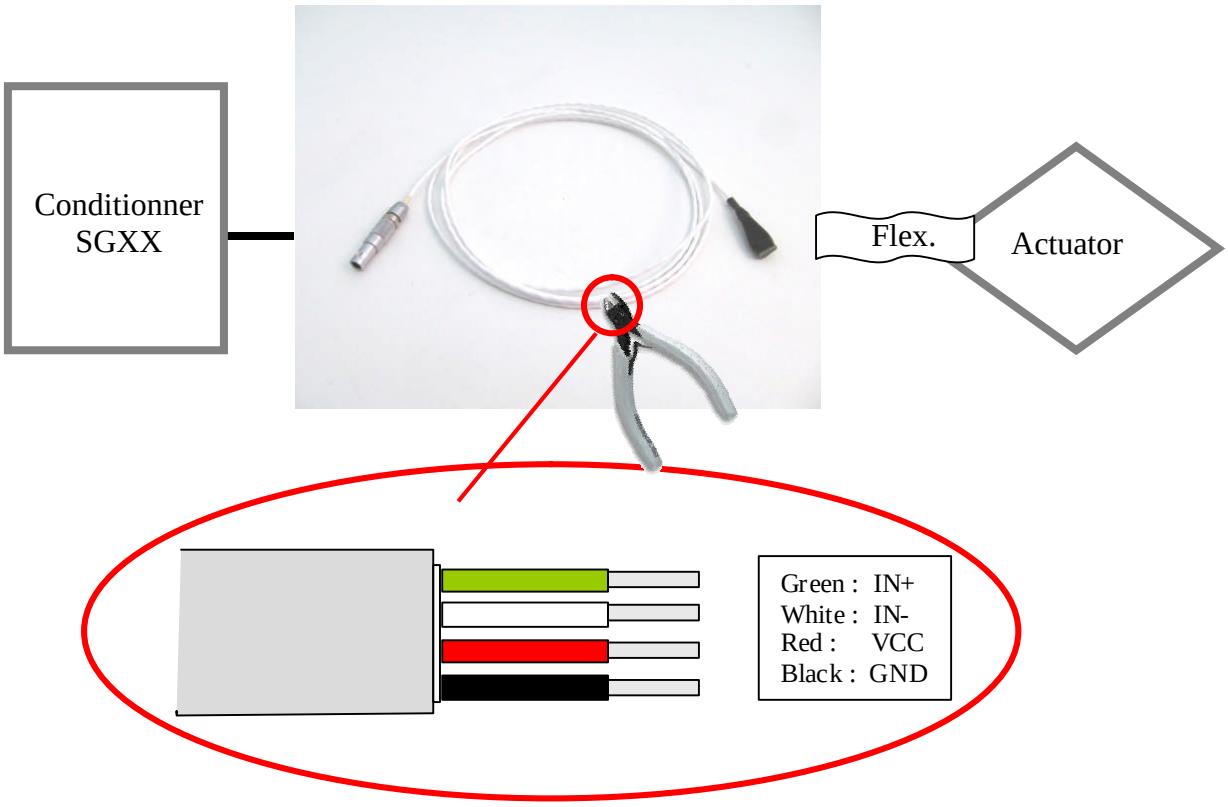


Figure 5 Strain gauges cable

2.6.2. Over Voltages

When driving the piezo actuator, it is important not to create over voltages through improper drivers or parasitic inductances.

Standard actuators have performed billions of cycles on Cedrat technologies linear amplifier, which includes management of over voltages and over currents.

2.6.3. Nature of the power amplifier

Standard actuators have performed billions of cycles on Cedrat technologies linear amplifier, which includes management of over voltages and over currents.

If Cedrat technologies actuators are driven with other electronics the guaranty will not apply even if they have the same characteristics.

Only few cycling tests have been performed with Cedrat technologies switching power amplifiers (SA75X, X=A,B,D) as they are available only since Jan 1, 2014.
For application of actuator warrantee with SA75X, please refer to SA75X user manual or contact actuator@cedrat-tec.com

2.6.4. Nature of the driving signal

In harmonic case, Standard actuators should preferably used with sine signals with the following characteristics:

- Max Amplitude : 85 V 0-pk
- Offset : + 65 V

Some precautions are needed if the command signal is not a C1 function. Those functions have a Fourier Transform with high frequencies. Those frequencies could be damageable for the actuator especially if it meets the resonance frequency. Cedrat technologies developed many solutions to face those issues.

If needed please contact actuator@cedrat-tec.com before starting the device.

2.7. RADIATIONS

So far, components of piezo actuators are not really sensitive to any radiations. In some specific projects piezo components were qualified up to 100krad levels.Cedrat technologies can not guarantee its standard actuators without qualification phase.

If required, an analysis or some tests could be performed by Cedrat technologies.

Please contact actuator@cedrat-tec.com for more information.

2.8. CHEMICAL AND ABRASIVE ENVIRONMENT

Standard actuators are not designed to withstand any chemical or abrasive environments.

If needed an analysis should be performed by Cedrat technologies on a specific design. Most common solution is encapsulation.

Please contact actuator@cedrat-tec.com for more information.

2.9. PASCHEN EFFECT

The dielectric constant of insulation materials is sensitive to pressure temperature and humidity.

The dielectric constant is sensitive to the pressure this effect is called Paschen effect.

Standard actuators need a specific VAC option to be compatible with vacuum applications. Then Paschen effect is analyzed and the warranty will apply only if the VAC option is ordered.

2.10. MOUNTING PROCEDURE & INTEGRATION BIASES

The mechanical integration or the induced moments under operation by the mechanism are the main sources of failure

2.10.1.Amplified Piezo Actuator (APA®)

In order to obtain good results, the mechanical interfaces along the small axis must be used. The screw is dimensioned to bear the maximum blocking force of the actuator (assuming that the screw material has an elastic limit equal or higher than 800 MPa).

During the mounting procedure, electrical charges can appear on the actuator, due to external applied forces, through the direct piezoelectric effect. It is therefore recommended to mount the actuator in short-circuited conditions.

Care must be taken to avoid excessive torque in the actuator's shell.

Only tensile forces can be exerted along the APA's shell small axis. A pushing force higher than the blocked force may dismount the actuator.

PROPERTIES	SPECIFIC STANDARD TECHNICAL CONDITIONS	UNITY	INDICATIVE VALUES
Max. Pulling force along the small axis	static effort, blocked - free	(N)	correspond to the blocked force

It is furthermore recommended not to touch with hands or with any kind of tool, the Multilayer Actuator component (although it is insulated). The insulating polish can indeed be damaged, leading to a destroying electric arc.

An additional specific care needs to be taken when tightening the screw: the screw shall not in any way touch (including under actuation) the piezo material (Figure 2-6).

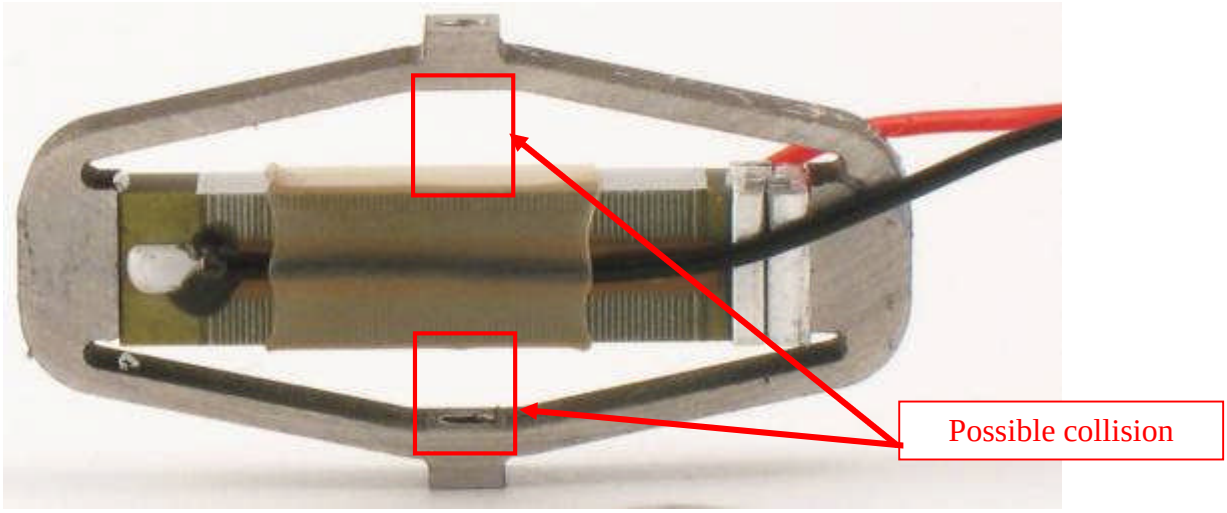


Figure 2-6: Care to be taken about the length of the screw

2.10.2.Parallel Pre-stressed Actuator (PPA)

In order to obtain the best possible results, the mechanical interfaces provided on the PPA axis have to be used.

Excessive moments must be avoided during the mounting. To avoid lateral forces, it is highly recommended to use flexural hinges as end pieces, as illustrated here:

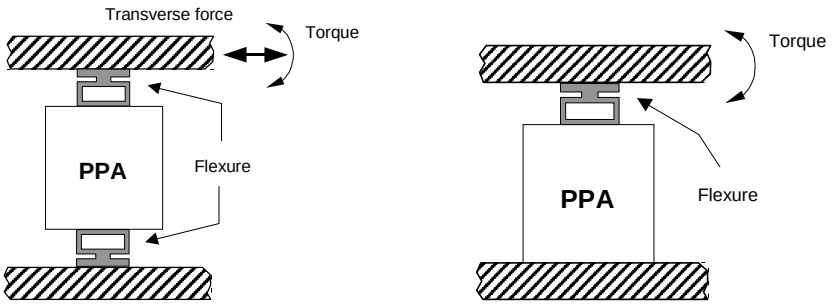


Figure 2-7: Flexural hinges must be added to PPAs if a torque or a transverse force can occur

Indicative values of maximal lateral forces given hereinafter are not guaranteed. Please note that these values cannot be taken as combined forces. Acceptable dynamic forces can be lower.

PROPERTIES	SPECIFIC STANDARD TECHNICAL CONDITIONS	UNIT	INDICATIVE VALUES
Max. twisting torque at the end piece	static effort, blocked - free	(N.cm)	100
Max. flexural torque at the end piece	static effort, blocked - free	(N.cm)	100
Max. pulling force along the actuation direction axis	Static or dynamic effort, blocked - free	(N)	400 N (M series) 1500 N (L series) 3000 N (XL series)

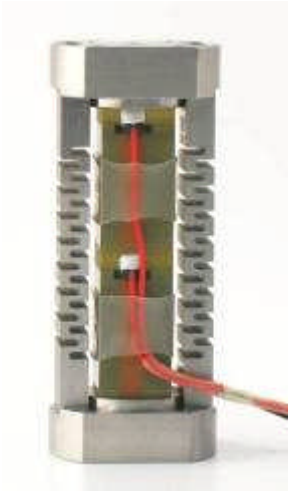


Figure 8 Parallel pre-stressed actuator

PPA actuators can bear a pulling force along the actuation direction axis only equal to a third of the blocked force. An excessive pulling force applied to the actuator could damage it.

During the mounting procedure, electrical charges can appear on the actuator, due to external applied forces, through the direct piezoelectric effect. It is therefore recommended that the actuator be short-circuited during all assembling operations.
It is furthermore recommended not to touch with hand the Multilayer Actuator component (although it is insulated).

2.10.3.Multi-Layer Actuator (MLA)

It is expressly recommended to avoid all transverse mechanical loads on the MLA. We obtain much better results by using the ceramic under mechanical pre-stress (10-30 Mpa). It is therefore advised to use a mechanical pre-stress, whenever it is possible.

Without any pre-stress, the multiplayer actuator can be used neither in dynamic nor in traction. There is no applicable warranty if the MLA is use in those conditions.

During the mounting procedure, electrical charges can appear on the actuator, due to external applied forces, through the direct piezoelectric effect. It is therefore recommended to mount the actuator in short-circuited conditions.

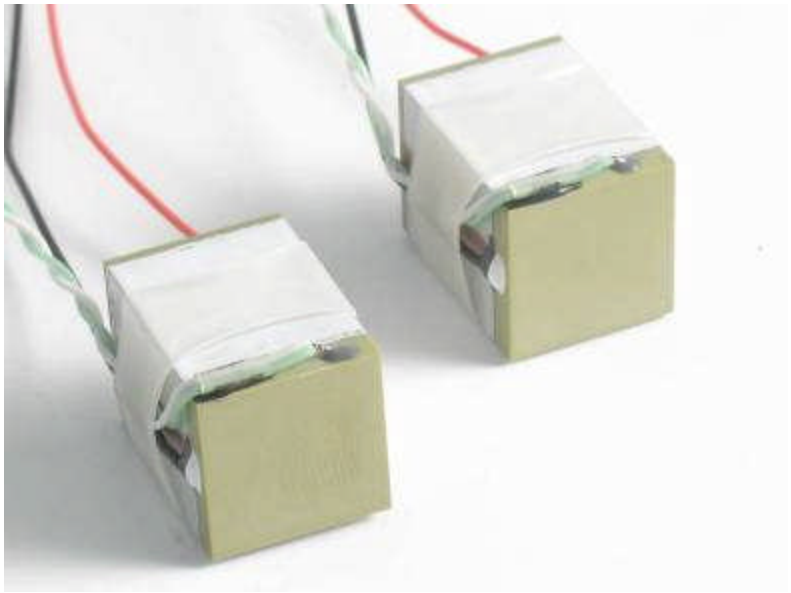


Figure 9 Multilayer actuator equiped with thermal sensors

2.11. COMBINED EFFECTS

The performances given in the actuator datasheet are given without loading. No combined effects are given.

An analysis must be done to anticipate those effects, please contact actuator@cedrat-tec.com for more information.

3. WARRANTY CONDITIONS AND EXCEPTIONS

The equipment is warranted for a period of one year from date of shipment, including parts and labor, and only under standard technical conditions as outlined above and expressly mentioned in the technical data sheet. Repairs will be carried out at Cedrat Technologies or through your vendor. During the warranty period, Cedrat Technologies will, at its option, either repair or replace products which prove to be defective.

Interventions or attempts to service or repair the Actuators by any unauthorized persons will invalidate this warranty.

In addition, this warranty will not apply if the actuator is subjected to any of the following:

- improper handling, including, but not limited to, shocks and abrasions
- improper installation, including, but not limited to, excessive mechanical forces and moments, failure to use the standard electrical and mechanical interfaces
- excessive voltage, including, but not limited to, peak values outside the recommended operating range, DC values applied for excessive time periods
- inappropriate environmental conditions, including, but not limited to, high temperatures or high humidity
- attempt to modify the standard electrical connection of the APA (soldering out of electrical wires, plugs change,…) or the standard mechanical interfaces

This warranty will not apply is the proper use is not at least partially justified by the following data acquisition:

- Number of cycles (frequency,shape and duration)
- Temperature
- Hygrometry

Depending on your application some additional data has to be recorded. Please refer to previous paragraphs to see which data is relevant to monitor to activate the warranty.

No other warranty is expressed or implied. Cedrat Technologies specifically disclaims the implied warranties of merchantability and fitness for a particular purpose

4. INSPECTION UPON RECEIPT

This product has been inspected and shown to operate correctly at the time of shipment, as verified by the Factory Verification form which is delivered with the actuator.

Immediately upon receipt, the product should be inspected carefully for any signs of damage that may have occurred during shipment. If any damage is found, a claim should be filed with the carrier.

The package should also be inspected for completeness according to the enclosed packing list. If an order is incorrect or incomplete, contact your distributor.

5. AFTER-SALE SERVICE

If a device requires service, please contact Cedrat Technologies or your local vendor.

Please include the device model and serial number in all correspondence with Cedrat Technologies or your vendor.

6. DISPOSAL

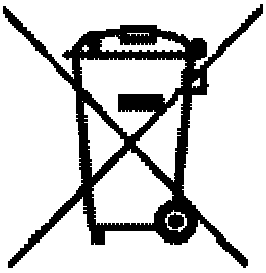
In accordance with the applicable EU law, electrical and electronic equipment may not be disposed of with unsorted municipal wastes in the member states of the EU.

When disposing of your old equipment, observe the international, national and local rules and regulations.

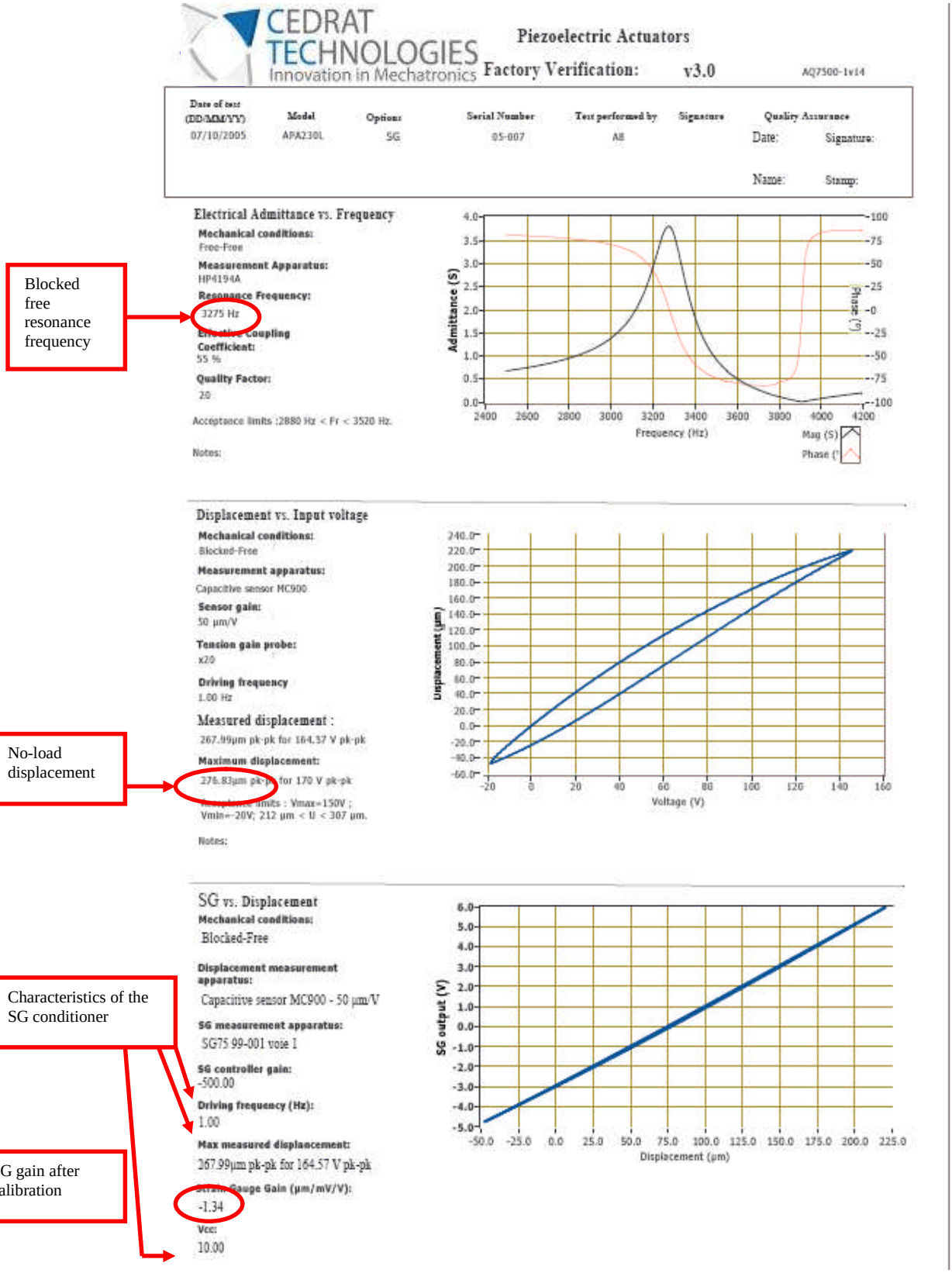
To meet the manufacturer's product responsibility with regard to this product, Cedrat Technologies (CTEC) SA ensures environmentally correct disposal of old CTEC equipment that was first put into circulation after 13 August 2005, free of charge.

If you have old CTEC equipment, you can send it to the following address (please contact CTEC prior expedition):

CEDRAT TECHNOLOGIES S.A.
59 Chemin du Vieux Chêne - Inovallée - 38246 MEYLAN cedex - FRANCE



ANNEX 1: UNDERSTANDING THE FACTORY VERIFICATION SHEET



Blocked free resonance frequency

No-load displacement

Characteristics of the SG conditioner

SG gain after calibration

ANNEX 2: TROUBLE SHOOTING FORM

In case of trouble or breakdown with the piezo actuator, please check the electrical impedance (capacitance and insulation resistance) of the actuator and communicate it to your vendor.

This form must be completed by the customer in order to:

- allow Cedrat Technologies to authorise the product return back to the factory,
- help Cedrat Technologies in repairing it.

Product: Please give mention here the references and delivery date,

History: Please summarize here every action which has been performed with the device since the delivery,

Problem description: Please describe here the problems

Please join your data acquisition of: temperature, hygrometry, number of cycle. If external forces are applied please mention it.