Stepping Piezo Actuators: For micro and nano-positioning applications.

Frank CLAEYSSEN - Cedrat Technologies.

Stepping Piezoelectric Actuators (SPA) are new long-stroke linear piezoelectric motors for micro/nano positioning applications benefiting of the APA heritage. They operate by accumulation of small steps. Between each step the actuator is locked in position. When the long stroke is performed, it can be also operated in a deformation mode for a fine adjustment. In this case, the stroke is proportional to the applied voltage, which leads to a nanometer resolution and a high bandwidth. This actuator can be supplied with Cedrat Technologies standard Linear Amplifiers. In summary, SPAs offer:

- A blocking at rest in any position (locking without power supply), leading to a high stiffness,
- A nano positioning resolution all along the stroke
- Non magnetic behavior

Structure & operation modes

The SPA relies on few parts:

- The well-established Amplified Piezoelectric Actuators (APA) (see APA data at **www.cedrat.com**),
- A front mass, a clamp and a rod.

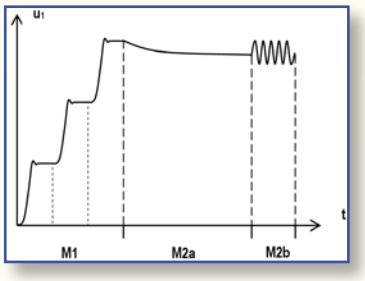
The load may be fixed on different positions leading to different motor capabilities thanks to different modes. In configuration C1, the mass can be replaced by the load. The long stroke stepping mode M1 is produced by step accumulation with an appropriate 0-150V saw tooth voltage. The short stroke deformation mode M2 is produced by deformation of the APA, which is simply proportional to the excitation voltage between –20 to +150V. SPA can be driven by CEDRAT TECHNOLOGIES lab linear amplifiers such as the LA75 family, ordered by a signal generator, or by specific electronics. Only one channel per SPA is required. Different position sensors can be implemented for close loops operation thanks to UC75 numerical controller. Please ask CEDRAT TECHNOLOGIES for further details about electronics and signals. All standard APAs from CEDRAT TECHNOLOGIES can be operated as a SPA with appropriate add parts. Therefore the SPA concept can be considered as a way to expand the limited stroke of the APA. However smaller APAs (series µXS, XXS, S, SM, M) are of higher interest, because they allow to realize very small flat piezo motors. Non magnetic actuators APAs (NM option) can be selected for non magnetic actuation. Temperature range is typically –40°C to +80°C, but it can be extended to cryogenic (77K) or warm (140°C) temperatures upon request (HT option).

Performance

Typical performances are given in the following table. This table is not exhaustive as many other actuators can be designed by CEDRAT TECHNOLOGIES using its design tools, lab facilities and technological know-how.

Application

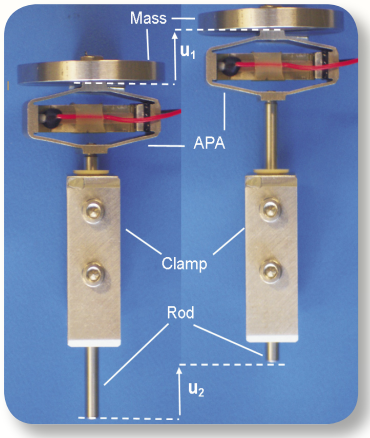
Stepping Piezoelectric Actuators (SPA) find applications as micro/nano positioning, locking mechanism, valves actuators. They can be used in Instrumentation, especially microscopes (AFM, STM), non-magnetic equipment (MRI), space telescopes. Multi-axis OEM devices can be developed.



Displacement u_1 of the Mass
M1 : Long stroke stepping mode
M2 : Short stroke deformation mode
(M2a : quasi-static ; M2b : dynamic).

References	Unit	SPA µXS	SPA XS-S	SPA XS-F	SPA SM-S	SPA SM-F
Notes		Preliminary	Preliminary	Preliminary	Preliminary	Preliminary
Base		APA µXS	APA35XS	APA35XS	APA60SM	APA60SM
Blocking force at rest (M1, M2)	N	0,3	3	6	15	30
Long stroke (M1)	mm	5	10	10	20	20
Actuation force (M1)	N	0,1	1	2	5	10
Max speed (M1)	mm/s	20	20	5	20	5
Short high resolution stroke (M2)	µm	60	55	55	80	80
Bandwidth (M2)	kH	7	5	5	4	4
Resolution (M2)	nm	< 6	< 5,5	< 5,5	< 8	< 8
Capacitance (M1, M2)	µF	0,02	0,25	0,25	1,55	1,55
Height along active axis	mm	13	20	20	40	40
Base size	mm2	3 x 13	9 x 13	9 x 13	12 x 27	12 x 27
LA75 types compatibility		A - B - C	A - B - C	A - B - C	B - C	B - C
CA45 compatibiliy		yes	yes	yes	no	no

Case	Load fixation	Modes	Motor fixation	Modes Motor capabilities
C1	Mass	Clamp	M1, M2	Long stroke micro positioning + nano positioning : u1
C2	Clamp	Mass	M1, M2	Long stroke micro positioning + nano positioning : u1
C3	Rod	Clamp	M1	Long stroke micro positioning + high stiffness at rest : u2



SPA SM-S based on the APA60SM before (a) and after (b) 10mm stroke actuation with the mode M1.

$u_1 = u_2 + uAPA$
u_1 = *Displacement of the Mass*
u_2 = *Displacement of the Rod*
u_{APA} = *Fine stroke due to the APA.*

APA µXS (m = 0.15gr)

(continued on page 13)

Stepping Piezo Actuators: For micro and nano-positioning applications. (continue)

Frank CLAEYSSEN - Cedrat Technologies.

SPA is a complement to the Amplified Piezoelectric Actuators (APAs) from CEDRAT TECHNOLOGIES.

Comparison with other piezomotors

CERAT TECHNOLOGIES has developed other kinds of piezoelectric motors for OEM applications, such as the space qualified LPM20, the RPA or the RPMHPP.

The advantages of the SPA versus other kinds of piezoelectric motors:

- A high degree of miniaturization & a firm connection between the load and the motor.
- A strong heritage from the APA (robustness, long life time, space qualification, vacuum qualification …).
- A fine adjustment with nanometer resolution on a large range due to the APA amplified stroke.
- A fine adjustment with a high bandwidth due to the APA large bandwidth.
- A great simplicity as it uses only one standard Amplified Piezo Actuator APA and one channel.
- A low cost solution, based on the APA proven technology, which is in favor of industrial applications.

Contactless Torque Sensor.

Alexandre PAGES - Cedrat Technologies.

The torque measurement usually comes from stain gauges bonded on a shaft. The main concern in this measurement is due to the fact that these gauges are also rotating and the integration of electronic on rotating parts is definitely a blocking point. New magnetic methods such as differential transformer, magnetostrictive or hall effect allow contactless torque measurement with stationary electronic. However their performances are limited: magnetic shaft required, limited speed, limited resolution…

Objective

A new generation of contactless sensor has been developed and patented to capture the torque in a stationary axle or rotating shaft. The measurement is done with stationary electronic components. This unique compact structure measures torque with low-cost standard eddy current sensor. This torque sensor concept has convinced automotive industry due to its good performances and other advantages. Since it is based on low number of parts, Its price appears compatible with the market expectation for this application.

Structure

The architecture of the device is mainly composed of two targets, one or two position sensors, a proof body and a compact body (Fig.1). In principle, the angular shift between two rotary targets along the shaft is converted into amplified axial shift between the targets. Only one sensor is required to measure the target motion. However two sensors perform a differential measurement in the stationary frame (Fig.2) for temperature compensation.

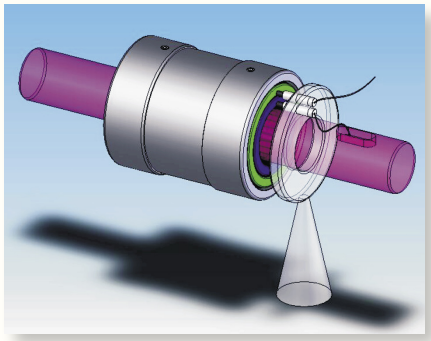


Fig.1: Contactless torque sensor mechanical design.

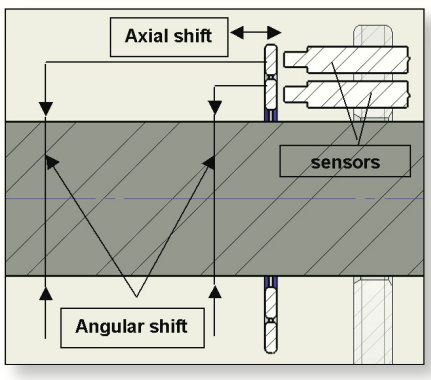


Fig.2: Contactless torque sensor principle

For more information about this contactless torque sensor, feel free to contact us at:

actuator@cedrat.com.

Release of the second MESEMA NewsLetter.

Mesema is a Specific Targeted Reseach Project within the thematic priority of Aeronautics and Space of the 6th Framework Programme of the European Commission. MESEMA stands for «Magnetoelastic Energy Systems For Even More Electric Aircraft».
As an active member of this project, CEDRAT TECHNOLOGIES invites you to discover the other european partners, the contents of each work package and 3 articles introducing the technological aspects through the reading of this 2nd Mesema Newsletter (***http://www.mesema.info***).

Feel free to express your interest at: ***actuator@cedrat.com***.