

OBJECTIVE

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),
- 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 (see APA® data at www.cedrat.com),
- A front mass, a clamp and a rod.

The principle of operation is described below:

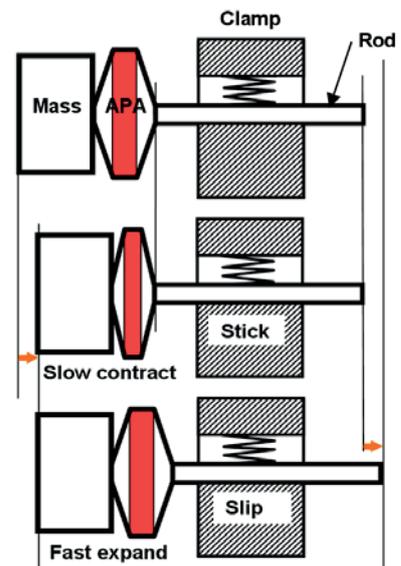
The long stroke stepping Mode M1 is produced by step accumulation with an appropriate 0-150V saw tooth voltage. The short stroke deformation Mode M2 is produced by deformation of the APA®, which is simply proportional to the excitation voltage between -20 to +150V.

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 closed loop operations 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 μ XS, XXS, S,

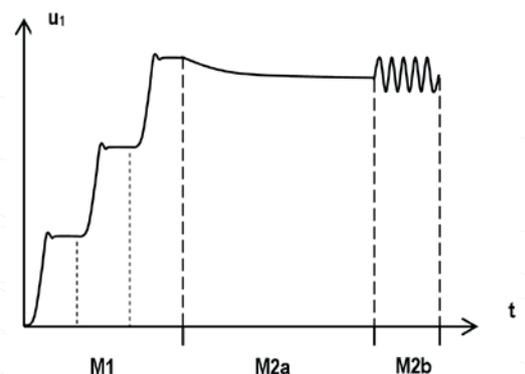


Fig. 1.a: view of the APA μ XS



One step of the SPA inertial motor One step realized by two operations :

- Slow contract: Mass moves. Rod standstill
- Fast expand: Mass standstill. Rod moves



Displacement of the Mass

- Long stroke stepping Mode M1 (mm): Series of steps
- Short stroke deformation Mode M2 (μ m): (Rod standstill. Actuator moves)
 - M2a: quasi-static
 - M2b : dynamic.

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 $+80^{\circ}\text{C}$, but it can be extended to cryogenic (77K) or warm (140°C) temperatures upon request (HT option) Hence, some vacuum and cryogenic tests have been run on the SPA showing a really good behavior in these conditions.

PERFORMANCES

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.

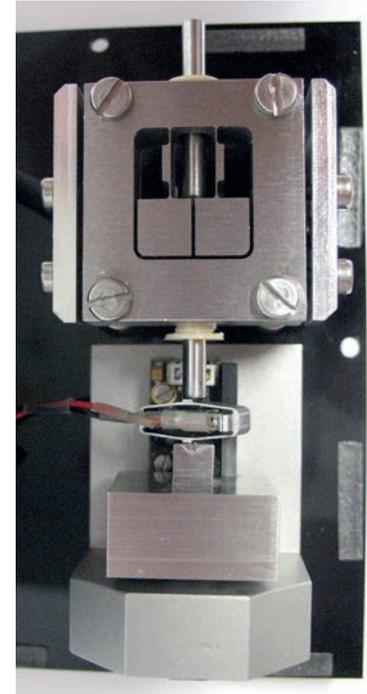


Fig. 1.b: Force and stroke test bench

APPLICATIONS

REGERENCES	UNIT	SPA XS	SPA XS-S	SPA XS-F	SPA SM-S	SPA SM-F
Notes			Preliminary			
Base		APA μ XS	APA35XS	APA35XS	AOA60SM	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)	kHz	1.13	0.8	0.8	0.57	0.57
Resolution (M2)	nm	<6	<5.5	<5.5	<8	<8
Capacitance (M1, M2)	μF	0.02	0.25	0.25	1.55	1.55
Heigh along active axis	mm	13	20	20	40	40
Base size	mm^2	3x13	9x13	9x13	12x27	12x27
LA75 types compatibility		A-B-C	A-B-C	A-B-C	B-C	B-C
CA45 compatibility		yes	yes	yes	no	no

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. SPA is a complement to the Amplified Piezoelectric Actuators (APA®) 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. Ultrasonic piezo motors such as the LPM 20 or the RPA are based on an ultrasonic vibration from a piezo stator working at resonance to induce a relative motion into a second body. Quasi static stepping piezo motors such as the RPMHPP are based on a combination of normal and tangential displacements from a piezo stator made of customized APA® and requires 2 channels electronics.

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® an one channel.
- A low cost solution, based on the APA® proven technology, which is in favor of industrial applications.