

5. Selection guide for piezo mechanisms based on piezo actuators

5.1 Introduction

Starting from standard Piezo Actuators, several mechanisms can be designed in order to control several degrees of freedom. Basically, all the APA® series can be used to build mechanisms providing several degrees of freedom. These mechanisms can integrate position sensors (Strain Gauges and Eddy Current Sensors) for closed loop control. The long travel mechanisms use an incremental magnetic sensor (MAG) based on the Hall effect.

- ◆ X: X guided stage with reduced out-of-plane Y and Z displacements,
- ◆ XY: XY stage with reduced out-of-plane Z displacement,
- ◆ XYZ: Scanner including three translations,
- ◆ OPP: Objective piezo positioner,
- ◆ FPS: Fast Piezo Shutter,
- ◆ SPA/SPS: Stepping Piezo Stage or Actuator.

Please do not hesitate to take a look at our web site, where you can download:

- The technical data sheet,
- The mechanical interface drawing,
- The 3D edrawings file.

Actuator serie	Mechanism
APA XS	XY, TT, DTT, SPA, SPS
APA S	XY, TT
APA SM	X, OPP, SPA
APA M	TT, XY, XYZ, FPS
APA ML	XY

Mechanism	Sensor option
X	SG, ECS
XY	SG, ECS
XYZ	SG, ECS (SG for Z axis)
TT	SG
DTT	SG
OPP	SG, ECS
FPS	SG

Table 5.1: Selection possibilities of piezo mechanisms

5.2 X piezoelectric stages

The piezoelectric stages X60S / X120S have a stroke up to 110 μm along the X axis and can be equipped with Strain Gauges for a very fine accuracy up to 10 nm. Parasitic rotations (along X and Y axis) are very limited. The moving frame can be custom designed (attachment points, holes ...).

References	Unit	X60S	X120S
Item Code		V-XS60	V-XS120
Notes		Preliminary data	Preliminary data
Sensors option		SG	SG
Active axis		TX	TX
Max. No-load displacement [Tx]	μm	55	115
Max. out of plane Z displacement	μm	0.50	0.50
Max. parasitic Z rotation	μrad	-	-
Max. parasitic X Y rotations	μrad	5	5
Voltage range	V	-20 ... 150	-20 ... 150
Stiffness	$\text{N}/\mu\text{m}$	1.82	0.33
Height (Z axis)	mm	12	12
Dimensions (X & Y axis)	mm	30*30	30*30
Resolution	nm	0.6	1.2
Mass	g	70	70
Unloaded resonance frequency (in the actuation's direction)	Hz	600	1200
Response time	ms	0.83	0.42
Capacitance (per electrical port)	μF	1.55	1.55
Mechanical interfaces (payload)		4 M3 threaded holes on \square 17*17	4 M3 threaded holes on \square 17*17
Mechanical interfaces (frame)		4 \varnothing 3.5 mm holes on \square 17*17	4 \varnothing 3.5 mm holes on \square 17*17
Electrical interfaces		2 PTFE insulated AWG30 wires 100 mm long with \varnothing 1 banana plug	2 PTFE insulated AWG30 wires 100 mm long with \varnothing 1 banana plug

Table 5.2: Characteristics of the X60S & 120S stages

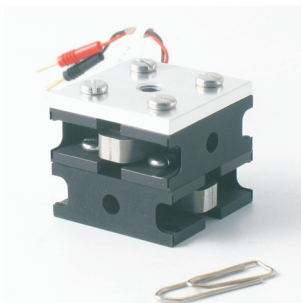


Figure 5.1: View of two XY120S stages

Other stages based on APA® from the XS, SM, M and ML serie can be defined

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5.3 XY piezoelectric stages

The piezoelectric stage XY200M has a stroke of 200 μm along the X and Y axis and is able to bear a high load up to 3 kg. Applications include Atomic Force or Scanning Tunneling Microscopes and mask positioning. This stage is based on APA 200M and shows a high stiffness. The stage can be equipped with Strain Gauges or Eddy Current Sensors (ECS option) for a very fine accuracy up to 10nm. Parasitic rotations (along X, Y and Z rotation) are very limited. The moving frame can be custom designed (attachment points, holes...). The compact XY25XS stage is well suited to integrated devices for fiber positioning, micro scanning...

References	Unit	XY25XS	XY200M
Item Code		V-XYXS25	V-XYM200
Notes		-	-
Sensors option		SG	SG, ECS
Active axis		TX, TY	TX, TY
Max. No-load displacement [Tx, Ty]	μm	25	200
Max. out of plane Z displacement	μm	0.50	1.00
Max. parasitic Z rotation	μrad	50	240
Max. parasitic X Y rotations	μrad	10	50
Voltage range	V	-20 ... 150	-20 ... 150
Stiffness	N/ μm	2.50	0.59
Height (Z axis)	mm	18.0	22.0
Dimensions (X & Y axis)	mm	50*50	100 *100
Resolution	nm	0.3	2.0
Mass	g	80	180
Unloaded resonance frequency (in the actuation's direction)	Hz	3000	580
Response time	ms	0.17	0.86
Capacitance (per electrical port)	μF	0.50	6.30
Mechanical interfaces (payload)		1 \varnothing 17 mm hole + 4 \varnothing 1.8mm on \varnothing 20 mm	3 \varnothing 2.7 mm holes on \square 38
Mechanical interfaces (frame)		4 \varnothing 2.8 mm holes on \square 45	4 \varnothing 4.5 mm holes on \square 84
Electrical interfaces		2 RG178B/U coaxial cables	2 RG178B/U coaxial cables

Table 5.3: Characteristics of the XY stages

Other stages based on APA® from the XS,S, SM, ML and L serie can be defined

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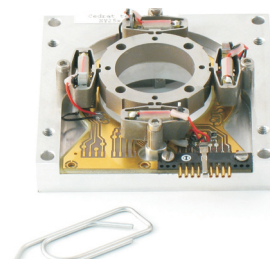


Figure 5.2: View of the XY25XS stage

5.4 XYZ piezoelectric stages

The piezoelectric stage XYZ200M has a stroke of 200 μm along the X, Y and Z axis and is able to bear a high load up to 3 kg. Applications include Confocal microscopy, mask positioning and inspection. This stage is based on APA 200M and shows a high stiffness. The stage can be equipped with Strain Gauges or Eddy Current sensors (ECS option) for a very fine accuracy up to 10nm. Parasitic rotations (along X, Y and Z rotation) are very limited. The moving frame can be custom designed (attachment points, holes...). This mechanism requires the Push-pull option on the first two channels of the driver.

References	Unit	XYZ200M
Item Code		V-XYZM200
Notes		-
Sensors option		SG, ECS
Active axis		TX, TY, TZ
Max. No-load displacement [Tx, Ty]	μm	180
Max. Z displacement [Tz]	μm	200
Max. parasitic Z rotation	μrad	240
Max. parasitic X Y rotations	μrad	50
Voltage range	V	-20 - 150
Stiffness	N/ μm	0.66
Height (Z axis)	mm	44.0
Dimensions (X & Y axis)	mm	100*100
Resolution	nm	1.8
Mass	g	540
Unloaded resonance frequency (in the actuation's direction)	Hz	380
Response time	ms	1.32
Capacitance (per electrical port)	μF	6.30
Mechanical interfaces (payload)		objective interface max 4/55*1.36 (to be specified)
Mechanical interfaces (frame)		4 \varnothing 4.5 mm holes on \square 84
Electrical interfaces		3 RG178B/U coaxial cables

Table 5.4: Characteristics of the XYZ stage

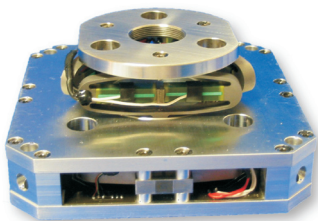


Figure 5.3: View of the XYZ200M stage

Other stages based on APA® from the XS, S, SM, ML and L serie can be defined

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5.5 Tilt translators TT for Θ X-Z motion

The tilt translator TT is based on 2 APA®. With the TT60SM, two types of movement can be generated:

- ◆ Z movement (translation) up to 80 μm , when the two actuators are simultaneously actuated,
- ◆ Θ X movement (tilt) up to $\pm 0.6^\circ$, when the two actuators are actuated in opposite phase.

The tilt translator mechanism TT60SM can be based on APA 60SM equipped with Strain Gauges to eliminate the hysteresis. If only the tilt movement is required, then only one channel is necessary. The TT60SM mechanism requires the Push-pull option on the driver.

References	Unit	TT60SM
Item Code		V-TTSM60
Notes		-
Sensors option		SG
Active axis		TZ, RX
Max. No-load displacement [Tz]	μm	80.0
Angular displacement [Rx]	mrad (+/-)	11.00
Out of plane Y displacement	μm	25.0
Voltage range	V	-20 ... 150
Stiffness	N/ μm	2.0
Height (Z axis)	mm	18.0
Width (Y axis)	mm	13.0
Length (X axis)	mm	25.0
Vertical Resolution [Tz]	nm	0.8
Angular resolution [Rx]	μrad	0.1
Mass	g	65
Unloaded resonance frequency (in the actuation's direction)	Hz	3000
Response time	ms	0.17
Capacitance (per electrical port)	μF	1.55
Mechanical interfaces (payload)		Flat surface 2.5*8 mm ²
Mechanical interfaces (frame)		2 M2 threaded holes
Electrical interfaces		4 PTFE insulated AWG30 wires 100 mm long with $\varnothing 1$ banana plug

Table 5.5: Characteristics of the tilt translator systems

Other double tilt system based on APA® from the XS, S, SM, M, ML and L serie can be defined

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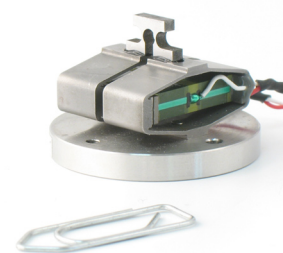


Figure 5.4: View of the Tilt Translator TT60SM

5.6 Double tilt translator DTT for Z- Θ X- Θ Y motion

The double tilt translator DTT is based on 2 pairs of APA35XS. Three types of movement can be generated:

- ◆ Z movement (translation) up to 35 μm , when the two pairs of APA35XS are simultaneously actuated,
- ◆ Θ X and/or Θ Y movements (tilt) up to +/- 2 mrad, when the two actuators of a pair are actuated in opposite phase.

The double tilt translator mechanism can be based on actuators equipped with strain gauges to eliminate the hysteresis. To obtain the three movements, four electrical channels are necessary. If only the two tilts are required, then only two channels are necessary (with the Push-pull mode from the 75 family of drivers).

References	Unit	DTT35XS
Item Code		V-DTTXS35
Notes		Preliminary data
Sensors option		SG
Active axis		RX, RY, TZ
Max. No-load displacement [Tz]	μm	35.0
Max. Angular displacement [Rx, Ry]	mrad (+/-)	2.00
Out of plane displacement [Tx, Ty]	μm	10.0
Voltage range	V	-20 ... 150
Stiffness	N/ μm	2.0
Height (Z axis)	mm	22.0
Diameter	mm	38.1
Vertical Resolution [Tz]	nm	0.4
Angular resolution [Rx, Ry]	μrad	0.02
Mass	g	35
Unloaded resonance frequency (in the tilt direction)	Hz	3200
Response time	ms	0.16
Capacitance (per electrical port)	μF	0.50
Mechanical interfaces (payload)		Flat surface \varnothing 15mm
Mechanical interfaces (frame)		Cylinder \varnothing 38.1mm
Electrical interfaces		PTFE insulated AWG32 wires 100 mm long and shield with sub D15 connector

Table 5.6: Characteristics of the DTT35XS

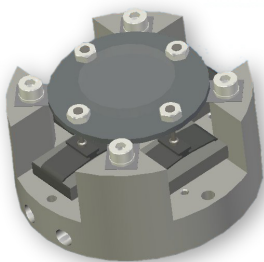


Figure 5.5: CAD view of the Double Tilt Translator DTT35XS

Other double tilt system based on APA® from the XS, S, SM, M, ML and L serie can be defined

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5.7 Objective Piezo Positioner OPP120SM

The objective piezo positioner OPP120SM uses the amplified piezo actuators from CEDRAT TECHNOLOGIES' standard range of actuators and an additional guiding for a vertical and accurate movement of the objective. The APA® achieves the trade-off between stroke and stiffness and is therefore well suited to rapid confocal microscopy. The interface with the objective can be customised. The piezo mechanism can integrate an eddy current proximity sensor (ECS option).

References Item Code	Unit	OPP120SM V-OPPSM120
Notes		-
Sensors option		SG, ECS
Active axis		TZ
Max. No-load displacement [Tz]	µm	140
Max. parasitic rotations [Rx, Ry]	µrad	25
Voltage range	V	-20 ... 150
Resolution	nm	14
Stiffness	N/µm	0.71
Height (Z axis)	mm	50.0
Dimensions	mm	65 * 40
Mass	g	180
Unloaded resonance frequency (in the actuation's direction)	Hz	600
Response time	ms	0.83
Loaded resonance frequency (in the actuation's direction) load = 50 g	Hz	440
Loaded response time	ms	1.14
Capacitance (per electrical port)	µF	3.15
Mechanical interfaces (payload)		objective interface max M25*0.75 (to be specified)
Mechanical interfaces (frame)		microscope interface (max M25*0.75) to be specified
Electrical interfaces		1 RG178B/U coaxial cable

Table 5.7: Characteristics of the OPP120SM

Other mechanisms based on APA® from the SM, M and L series can be defined

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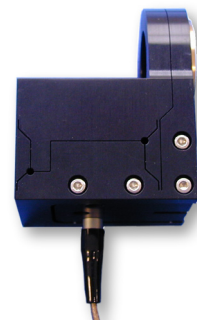


Figure 5.6: View of the OPP120SM

5.8 Fast Piezo Shutters FPS200M & FPS400M

The Fast Piezo shutters developed by CEDRAT TECHNOLOGIES are based on APA 200M or APA 400M with a special optical head (slits that can switch off the laser beam along the Z axis). It offers a compact shutter solution, which provides outstanding features such as fast operation, high repeatability... Other shutters can also be designed from different amplified piezo actuators.

References	Unit	FPS200M	FPS400M
Item Code		V-FPSM200	V-FPSM400
Notes		-	-
Sensors option		SG	SG
Active axis		TX	TX
Max. No-load displacement (Tx)	μm	400	800
Max. beam diameter	mm	0.3	0.7
Voltage range	V	-20 ... 150	-20 ... 150
Stiffness	N/ μm	3.17	0.10
Height (Z axis)	mm	21.0	21.0
Dimensions (X & Y axis)	mm	60 * 44	60 * 44
Mass	g	300	300
Unloaded resonance frequency (in the actuation's direction)	Hz	900	495
Response time	ms	0.56	1.01
Capacitance (per electrical port)	μF	3.15	3.15
Mechanical interfaces (payload)		4 slits (width 0.6 mm)	4 slits (width 0.6 mm)
Mechanical interfaces (frame)		4 holes \varnothing 3mm on \square 24*38 mm	4 holes \varnothing 3mm on \square 24*38 mm
Electrical interfaces		2 RG178B/U coaxial cables	2 RG178B/U coaxial cables

Table 5.8: Characteristics of the FPS200M and FPS400M

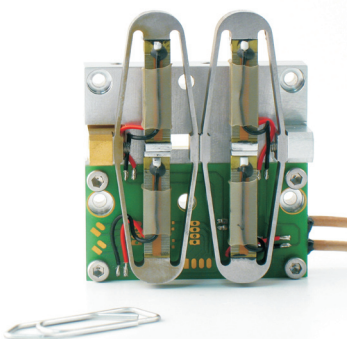


Figure 5.7: View of the FPS200M (courtesy of EMBL)

Other mechanisms based on APA® from the SM, M and L series can be defined

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5.9 Stepping Piezo Stage SPS35XS

The Stepping Piezo Stage SPS35XS is based on the Stepping Piezo Actuator's (SPA) principle. It provides both:

- ◆ A long stroke,
- ◆ A micro/nano positioning resolution.

It can be driven by a one-channel linear amplifier from the LA75 family. The stage can perform more than 10^{e6} cycles, thanks to a friction interface already used in several piezo motors. Stepping Piezo Stages can be used in micro positioning & valve applications. Other Stepping Piezo Stages can be designed with smaller or bigger APA®.

References	Unit	SPS35XS
Item Code		V-SPSXS35
Notes		Preliminary data
Sensors option		MAG
Active axis		TX
Max. No-load displacement [Tx]	mm	5
Max. out of plane Z displacement	μm	10
Max. parasitic Z rotation	μrad	0
Max. parasitic X Y rotations	μrad	5
Voltage range	V	-20 ... 150
Stiffness	N/ μm	0.5
Height (Z axis)	mm	15
Dimensions (X & Y axis)	mm	30*30
Resolution	nm	35.0
Mass	g	20
Unloaded resonance frequency (in the actuation's direction)	Hz	200
Response time	ms	2.50
Capacitance (per electrical port)	μF	0.25
Lifetime (nb of cycles)		1.E+06
Mechanical interfaces (payload)		4 M1.6 threaded holes on [] 17*27
Mechanical interfaces (frame)		4 M1.6 threaded holes on [] 17*22
Electrical interfaces		1 RG178B/U coaxial cable

Table 5.9: Characteristics of the Stepping Piezo Stage SPS35XS

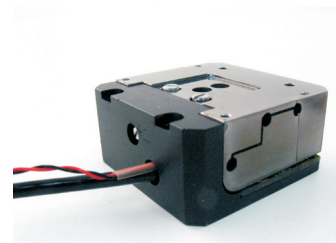


Figure 5.8: View of the SPS35XS stage

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5.10 Stepping Piezo Actuator SPA

Stepping Piezoelectric Actuators (SPA) are new long-stroke linear piezoelectric motors for micro/nano positioning applications benefiting from 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 also be operated in a deformation mode for a fine adjustTMent. In this case, the stroke is proportional to the applied voltage, which leads to a nanometre resolution and a high bandwidth. This actuator can be supplied with CEDRAT TECHNOLOGIES standard Linear Amplifiers CA45 or LA75.

Other stepping Piezo Actuators can be designed with smaller APA® (see § 3.1.5)

References	Unit	SPA35XS	SPA60SM
Item Code		V-SPAXS35	V-SPASM60
Notes		Preliminary data	Preliminary data
Sensors option		MAG	MAG
Base		APA35XS	APA60SM
Long stroke (M1)	mm	10.0	20.0
Stiffness1 (M1)	N/μm	88	88
Stiffness2 (M1)	N/μm	0.49	1.38
Max speed (M1)	mm/s	30	30
Blocking force at rest (M1, M2)	N	3	15
Max actuation force (M1)	N	1	5
Short high resolution stroke (M2)	μm	55	80
Resolution (M2)	nm	0.55	0.8
Bandwidth (M2)**	Hz	550	600
Capacitance (M1, M2)	μF	0.25	1.55
Height along active axis	mm	30	50
Base size	mm	16 * 16	27 * 27
Inertial mass	g	30	70
Mass	g	50	120
Max current consumption	mA	117	388
Max input power	W	11.25	37.1
Holding consumption	W	0	0
Electrical interfaces		1 RG178B/U coaxial cable	1 RG178B/U coaxial cable
LA75 types compatibility		A* - B - C	B - C
CA45 compatibility		yes	no

Table 5.10: Characteristics of the Stepping Piezo Actuators

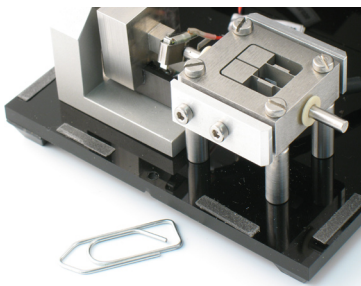


Figure 5.9: View of the SPA35XS

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