

Large Displacement Piezo-Compliant Actuators

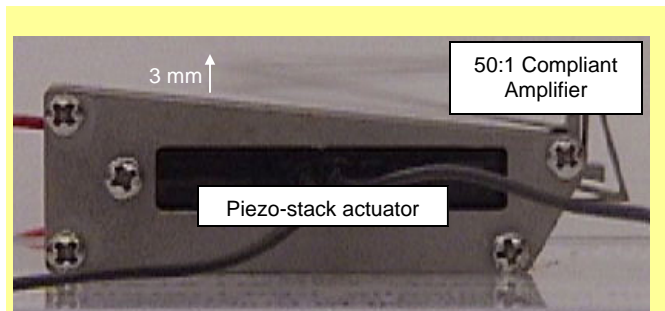
Integrating smart materials with novel compliant mechanisms leads to high-performance actuators

One of the primary uses for compliant mechanisms is displacement amplification, particularly when coupled with smart materials actuators such as piezoelectric devices. Compliant mechanisms can produce significant amplification of piezoelectric deflections, up to 60X in a compact, high-frequency system that does not rely on resonance to achieve desired displacement. This greatly extends the applicability of smart materials actuators, which by themselves are typically limited to 10 μm - 1000 μm deflection. By integrating a joint-less, backlash-free compliant mechanism with a piezoelectric actuator, the force and stroke can be tailored to suit specific needs.

FlexSys is currently exploring a range of applications for piezo-compliant actuators including: high-frequency mechanical vortex generators, harmonic rotary and linear actuators, compact fluidic pumps, and high pressure fluid valves.

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A piezo-compliant actuator approximately 1 x 2 x 0.25 inches in size generates 3 to 4 mm of displacement in the frequency range 0-300Hz, at 150V, consuming 25W peak power. The amplification mechanism is a monolithic structure machined in one-piece steel on a wire EDM machine.

Comparison of Bi-morph vs. Piezo-Compliant Actuators

Alternative methods for generating large deflections with piezoelectric actuators include uni-morph and bi-morph systems, which rely on expansion and contraction of piezo actuators to bend a passive substrate. The table at right compares a piezo-compliant actuator to bi-morph "C" and "S" bender configurations. The piezo-compliant actuator produces significantly more deflection and block-force and has a 1st natural frequency that is double the bender designs.

Actuator	Bi-morph "C" Bender*	Bi-morph "S" Bender*	Piezo-Compliant Actuator
Size (mm)	32 x 64 x 0.9	32 x 76 x 0.9	23 x 53 x 5
Weight (g)	9.7	10.8	17.8
1 st Nat. Frequency (Hz)	150	60	300
Block Force (N)	+/- 0.89	+/- 0.17	4.1
Free Disp. (mm)	+/- 0.66	+/- 0.65	2.97
Stiffness (N/m)	1.3E3	250	1.38E3
Capacitance (nF)	99	310	3600
Max Voltage	+/- 170	+/- 90	+150
Work/Volume (Nm/m ³)	169	26.5	510.5