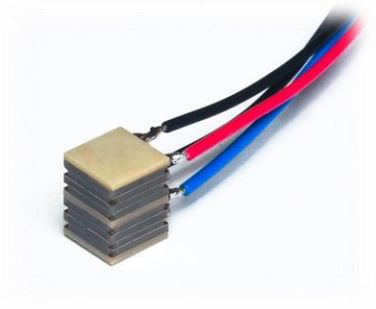
Shear Actuators

Shear Stack Actuators

Features

- Displacement up to 6 µm
- Operating voltage +/-320V
- X, XY or XYZ combined motion
- Very high stiffness for short response times (<1ms)
- Low capacitance
- Available in two cross-sections, 5*5 and 10*10mm



Applications

- Micro- and nanopositioning
- Laser systems
- Optical fiber scanning
- Scanning Probe Microscopy

Description

CTS piezoelectric shear actuators are ideal for a wide range of electronic designs requiring precise and fast movement. CTS shear stack actuators feature very high displacement at low operating voltages. Multiaxial actuators are available for independent motion in 2 or 3 directions.

Standard Product, add-ons or Custom Solution

This document contains information about the CTS standard shear stack actuators and available add-ons. All the CTS standard products can be custom designed to match specific requirements – find more information on www.ctscorp.com or contact your local sales representative.

Specifications

Product series	NAC2402-HXX	NAC2403-HXX	NAC2902-HXX	NAC2903-HXX	Unit
Shear motion axes	X		X-Y		-
Length (L)	5 +/-0.3	10 +/-0.4	5 +/-0.3	10 +/-0.4	mm
Width (W)	5 +/-0.3	10 +/-0.4	5 +/-0.3	10 +/-0.4	mm
Height (H)	1.7 to 3.4*		2.8 to 6.4*		mm
Operating voltage, V_{max}	320**				V
Max. operating temp.	150				°C
PZT material	NCE51				-
Electrode material	Gold on Nickel				-
Interconnection electrodes	Copper-Beryllium				

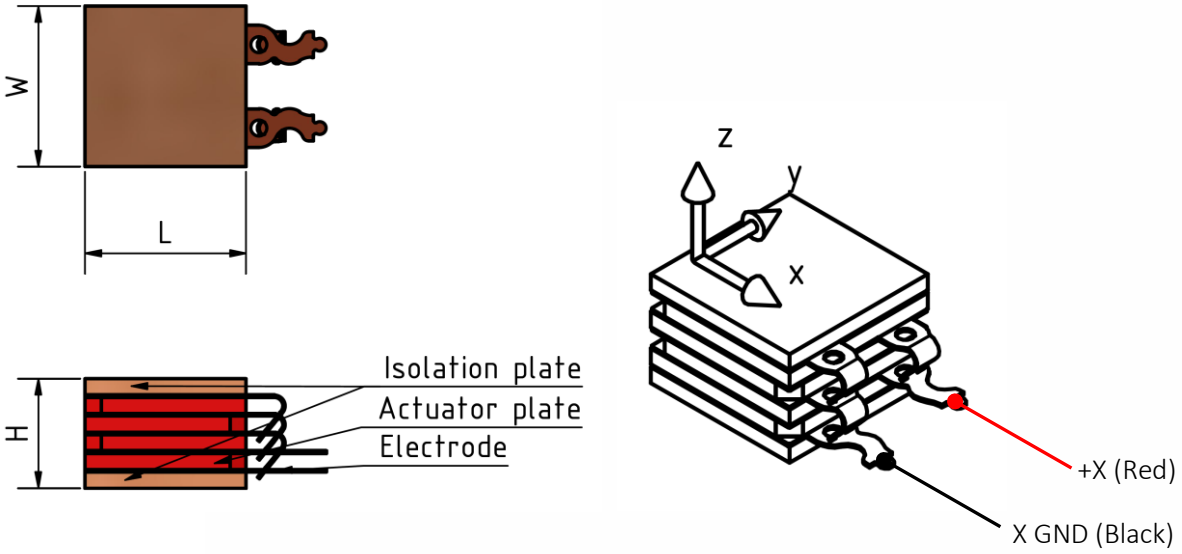
* See the different height options and the corresponding free displacement and capacitance data in the tables below.
** Operating voltage at room temperature. Voltage has to be reduced at elevated temperature

Product series	NAC3402-HXX	NAC3403-HXX	Unit
Motion axes	X-Y-Z		-
Length (L)	5 +/-0.3	10 +/-0.4	mm
Width (W)	5 +/-0.3	10 +/-0.4	mm
Height (H)	7.4 to 12.6*	7.4 to 21.3*	mm
Operating voltage, V_{max}	320**		V
Max. operating temp.	150		°C
PZT material	NCE51		-
Electrode material	Gold on Nickel		-
Interconnection electrodes	Copper-Beryllium		

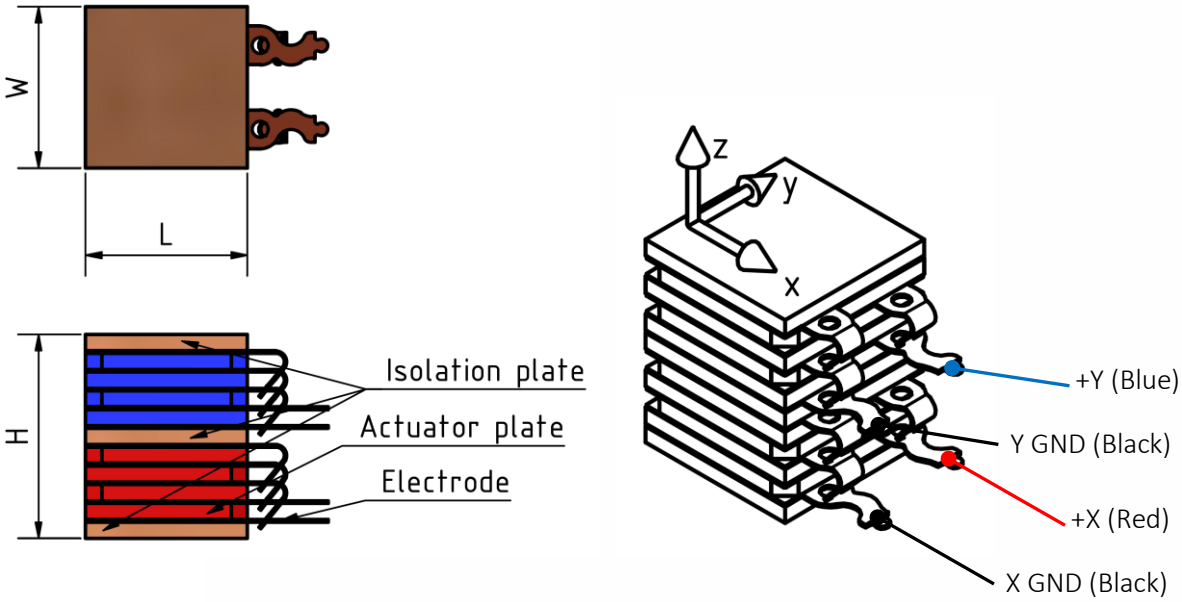
* See the different height options and the corresponding free displacement and capacitance data in the tables below.
** Operating voltage at room temperature. Voltage has to be reduced at elevated temperature
This product contains materials that present health hazards by inhalation or ingestion. Do not attempt to disassemble, grind or melt the product and dispose of according to local regulations.

Drawing (first angle projection)

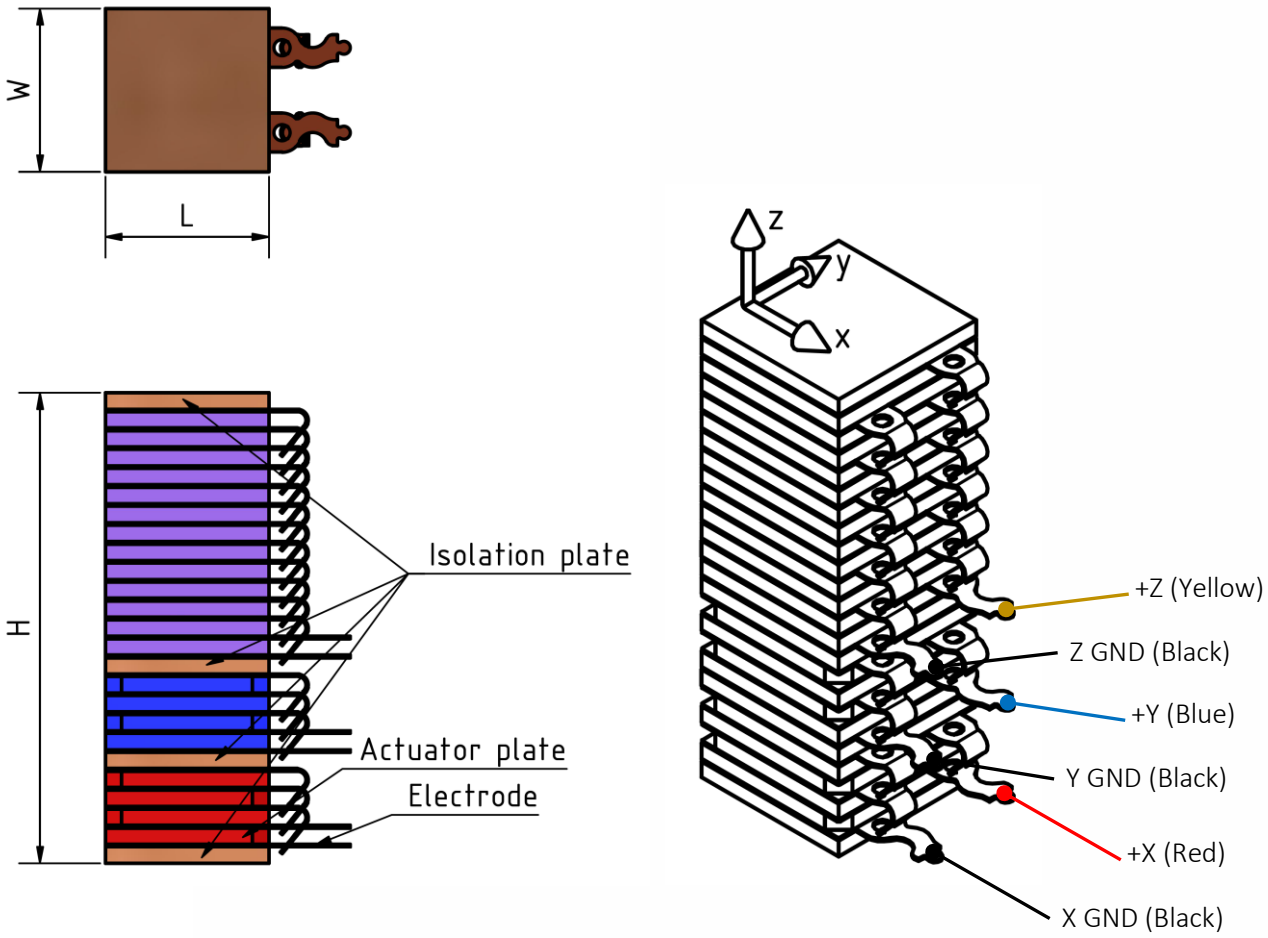
For NAC2402-HXX and NAC2403-HXX series (X motion):



For NAC2902-HXX and NAC2903-HXX series (X-Y motion):



For NAC3402-HXX and NAC3403-HXX series (X-Y-Z motion):



Stacking Options

For NAC2402-HXX series:

Product series	NAC2402-HXX			
Height H	Product Reference	Free Stroke	Capacitance	Shear stiffness
+/-0.2 mm		+/-15%	+/-15%	Typ.
mm		µm	nF	N/µm
1.7	NAC2402-H1.7	1.5	0.8	340
2.3	NAC2402-H2.3	3.0	1.7	250
3.4	NAC2402-H3.4	6.0	3.3	170

For NAC2403-HXX series:

Product series	NAC2403-HXX			
Height H	Product Reference	Free Stroke	Capacitance	Shear stiffness
+/-0.2 mm		+/-15%	+/-15%	Typ.
mm		µm	nF	N/µm
1.7	NAC2403-H1.7	1.5	3.3	1350
2.3	NAC2403-H2.3	3.0	6.6	1000
3.4	NAC2403-H3.4	6.0	13.3	680

For NAC2902-HXX series:

Product series	NAC2902-HXX			
Height H	Product Reference	Free Stroke X*Y	Capacitance X*Y	Shear stiffness
+/-0.2 mm		+/-15%	+/-15%	Typ.
mm		µm	nF	N/µm
2.8	NAC2902-H2.8	1.5*1.5	0.8*0.8	200
4.0	NAC2902-H4.0	3.0*3.0	1.7*1.7	140
6.4	NAC2902-H6.4	6.0*6.0	3.3*3.3	90

For NAC2903-HXX series:

Product series	NAC2903-HXX			
Height H	Product Reference	Free Stroke X*Y	Capacitance X*Y	Shear stiffness
+/-0.2 mm		+/-15%	+/-15%	Typ.
mm		µm	nF	N/µm
2.8	NAC2903-H2.8	1.5*1.5	3.3*3.3	830
4.0	NAC2903-H4.0	3.0*3.0	6.6*6.6	580
6.4	NAC2903-H6.4	6.0*6.0	13.3*13.3	360

For NAC3402-HXX series:

Product series	NAC3402-HXX			
Height H	Product Reference	Free Stroke X*Y*Z	Capacitance X*Y*Z	Shear stiffness
		+/-15%	+/-15%	Typ.
mm		µm	nF	N/µm
7.4 +/-0.2	NAC3402-H7.4	1.5*1.5*1.5	0.8*0.8*5.5	75
12.6 +/-0.3	NAC3402-H12.6	3.0*3.0*3.0	1.7*1.7*11.1	45

For NAC3403-HXX series:

Product series	NAC3403-HXX			
Height H	Product Reference	Free Stroke X*Y*Z	Capacitance X*Y*Z	Shear stiffness
+/-0.2 mm		+/-15%	+/-15%	Typ.
mm		µm	nF	N/µm
7.4 +/-0.2	NAC3403-H7.4	1.5*1.5*1.5	3.3*3.3*21.4	310
12.6 +/-0.3	NAC3403-H12.6	3.0*3.0*3.0	6.6*6.6*42.7	180
23.1 +/-0.4	NAC3403-H23.1	6.0*6.0*6.0	13.3*13.3*85.4	100

Add-ons

Wire Options

When ordering actuators from CTS, it is possible to have wires fitted to facilitate integration. For the selection of a wire for connection, these parameters must be considered:

- Operation voltage
- Intensity of current
- Operating temperature
- Environment for example vacuum

We recommend wires with PTFE insulation

PTFE wires can stand temperatures above 200 °C, whereas PVC wires only resist temperatures up to 80 °C. We recommend PTFE for the thermal and chemical resistance of the insulation.

For vacuum and cryogenic applications, we recommend Kapton wires, which offer superior outgassing properties and flexibility.

Standard wire option for shear stack actuators

One standard wire option is available:

	Option A01
Wire type	MIL-W-16878/4, 28 AWG, 7 strands
Length	200mm +/-10mm
Position	On electrode tabs (see drawing)
Orientation	Perpendicular to height

Standard wire option A01 has a temperature rating of 150°C.

Customized wire option for shear stack actuators

We stock several alternative wire types:

Wire type	Voltage rating [V]	Approx. outer diameter [mm]	Rec. max. current [A]	Min. operating temperature [°C]
32AWG, MIL-W-16878/6, 7 strands	250	0.6	0.53	-60
30AWG, MIL-W-16878/4, 7 strands	600	0.8	0.86	-60
28AWG, MIL-W-16878/4, 7 strands	600	0.9	1.4	-60
28AWG, Allectra 301-KAPM-035 (Kapton insulation, UHV)	7500*	0.6	1.0	-269
22AWG, BS3G210 Type A, 19 strands	300	1.1	8	-75

* In vacuum conditions

As part of our custom program, we can also stock specific wire.

UHV preparation

Ultra high vacuum (UHV) is the vacuum regime characterized by pressures lower than about 10^{-7} pascal or 100 nanopascals (~10^{-9} torr). Extreme cleanliness and low outgassing are essential parameters in sustaining the vacuum level in such systems. Elevated temperature compatibility is often needed since water vapor and other trace gasses are removed from the system during a "bake-out".

CTS piezoceramic components are designed to support system development and integration of piezo technology in UHV applications. Among many technical capabilities, CTS is competent in producing piezoelectric actuators meeting the demands on temperature compatibility and out gassing levels set by UHV operation.

For low outgassing, Kapton-insulated wires are recommended. In addition, with the UHV preparation the products will undergo a specific cleaning process and be packaged in sealed pouches.

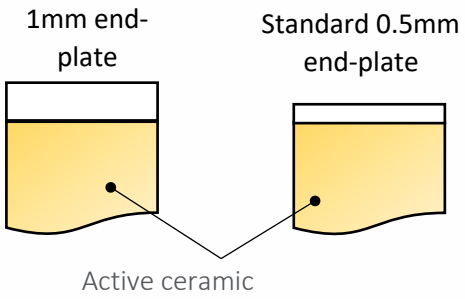
Non-magnetic design

Although piezoelectric ceramic and all accessories are non-magnetic, our shear stack actuators include a thin layer of Nickel under the gold electrodes. This can be a concern when shear stacks are applied in experiments where a homogeneous magnetic field or very accurate magnetic field measurements are required. If this is the case, CTS can provide special shear stacks that do not include Nickel.

End-plates

As a standard, shear stacks are supplied with 0.5mm thick ceramic end-plates. All our standard end-plates are produced with our piezoceramic material NCE51. Ceramic provides ideal electrical insulation properties, low thermal expansion mismatch as well as good mechanical properties to spread the load over the surface of the active piezoceramic. For shear stacks, a thickness of 0.5mm is sufficient for a good spread of the load.

It is nevertheless possible to apply thicker end-plates, for example if a longer isolation distance is required. This is illustrated below:



It is not possible to produce shear stacks without end-plates, as it would expose the live electrodes.

Storage

We recommend storing piezoelectric ceramic components in a cool and dry environment. The ceramic material itself is not affected by humidity, as long as no voltage is applied. If components have been stored in uncontrolled environment, we recommend drying them thoroughly before use. Heat drying is well adapted, for example 24h at 110°C, if possible in low-pressure environment.

Piezoelectric components can be stored for many years without problem. Piezoelectric ceramic is subject to aging from the date of poling, meaning that performance (capacitance, stroke) will decrease according to a logarithmic trend, typically 2-5% per decade (after 1 day, 10 days, 100 days…).

Handling

Piezoelectric ceramic components are fragile and must be handled with care. We recommend to:

- Prevent the components from hitting each other or hard surfaces, keep components separate
- Use plastic tweezers and tools rather than metallic ones
- Use gloves to avoid contamination
- Do not apply excessive force on the pre-attached wires
- Do not apply excessive bending, shear or pulling forces on the stack

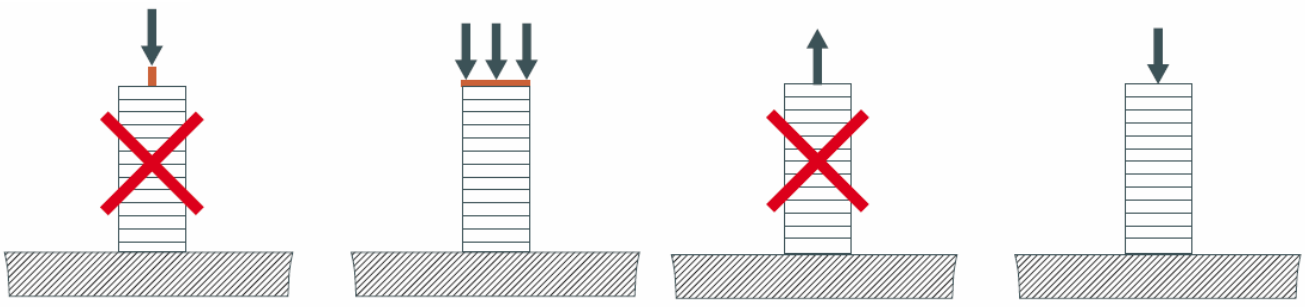
Shear elements do not generate charge (i.e. voltage when in open circuit) when submitted to temperature changes. However, it is good practice to ansure that the components are fully discharged before connecting them. Always discharge through a resistor rather than shorting the wires, as it would create high dynamic forces that can damage the component.

Cleaning

For the cleaning of ceramic components, we recommend isopropyl-alcohol (propanol) or ethanol. The components have to be thoroughly dried before use. If needed, shear stack actuators can be fully submerged in solvent, however we recommend to limit the exposure to a few seconds only, as it may weaken the epoxy.

Mounting

Shear stacks may be mounted either by mechanical clamping or using adhesive. In both cases, the force must be applied on the full surface of the actuator in order to ensure a good load distribution. In particular when applying the pressure, the contact surfaces have to be sufficiently flat or compliant. We recommend to avoid tensile stress, which could result from direct pulling, inertial forces or bending forces.



Clamping

In case of clamping, axial stress on shear stack actuators must be controlled. Too low pressure can lead to slippage whereas too high pressure can damage the ceramic. With the appropriate contact surface and in the case of low shear force, a pressure of 1 to 3 MPa can be recommended.

If clamping is used, the stiffness of the loading mechanism in the actuation direction shall be as low as possible in order not to hinder the movement of the actuator.

Bonding with adhesive

Epoxy adhesives are well suited for mounting piezoceramics. For shear stack actuators, we recommend using a hard (Shore D hardness 70-90), non-conductive, unfilled epoxy. If mounted with adhesive, it is important to ensure a very thin glue line between the actuators and the substrate. This is generally ensured by using low viscosity epoxy. A pressure, e.g. 2-3 MPa, should be applied during the curing process. To avoid significant loss of performance, the mounting should avoid adhesive on the sides of the actuator.

Connecting and Driving

Connecting

Shear stack actuators are easily connected using the standard supplied wires.

Alternatively, electrical connection to the external electrodes can be achieved by soldering on the electrode tabs or bonding with electrically conductive adhesive. Refer to our website for soldering guidelines.

Driving

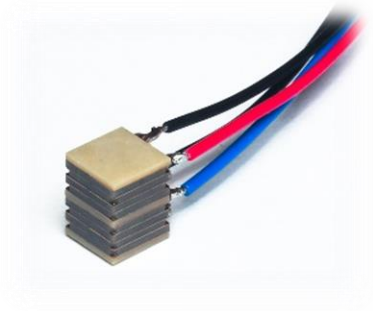
Since shear stack actuators can be used with bipolar symmetrical electrical supply, both wires are identical. The direction of operation is indicated by the arrows on the interface drawing. Sign convention: A positive voltage on the indicated termina leads to a relative displacement of the stack in the corresponding direction. For example: 320 V on “+X” (red wire) compared to “X GND” (black wire) causes a displacement in direction X.

The current capability of the driver must be adapted to the driving signal. Due to the capacitive nature of the piezoelectric actuator, fast motion will often require very high currents. Please refer to our online tutorial for guidance about current calculation. In particular with shear actuators, dissipation within the actuator increases rapidly and may cause thermal drift. When operating at high frequency, it is recommended to monitor temperature and adjust the driving conditions accordingly.

We recommend to add a resistance in series with the actuator to form a RC circuit to limit the peak current, bandwidth and eventual noise that may be generated by the driver.

Shear Actuators Product Families

Shear Plate Actuators



Shear Stack Actuators:

- X
- XY
- XYZ

Learn more about the different actuator product families on www.ctscorp.com.