Linear Actuators

Ring Stacks

Features

- Displacement up to 128.7 µm
- Very high force in the kN range
- High stiffness for short response times (<1ms)
- Height up to 80 mm

Applications

- Micro- and nanopositioning
- Industrial equipment
- Active vibration control
- Valves
- Laser tuning
- Shaker

Description

CTS tape cast multilayer piezoelectric linear actuators are ideal for a wide range of electronic designs requiring precise and fast movement. CTS Ring Stacks are offered in stacked solutions in heights from 4 mm to 80 mm with a stroke up to 128.7 µm and capacitance up to 31240 nF depending of the height of the stack. The specific stroke and capacitance of each product can be found below.

Standard Product, add-ons or Custom Solution

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

Product designation

NAC2121-H20-A01

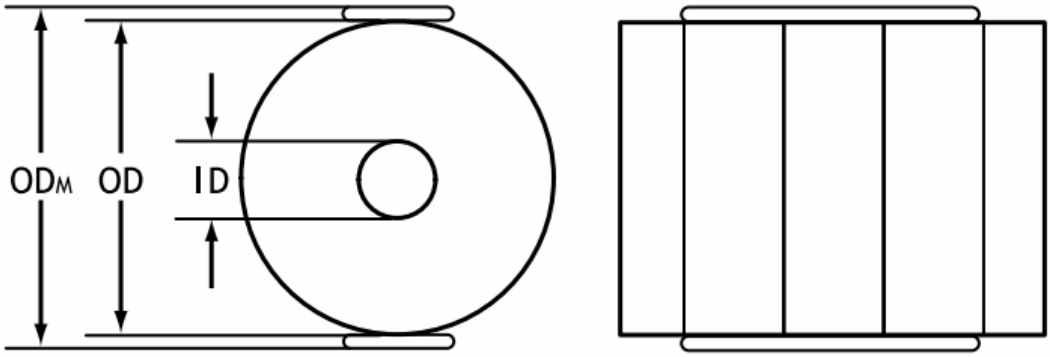
Specifications

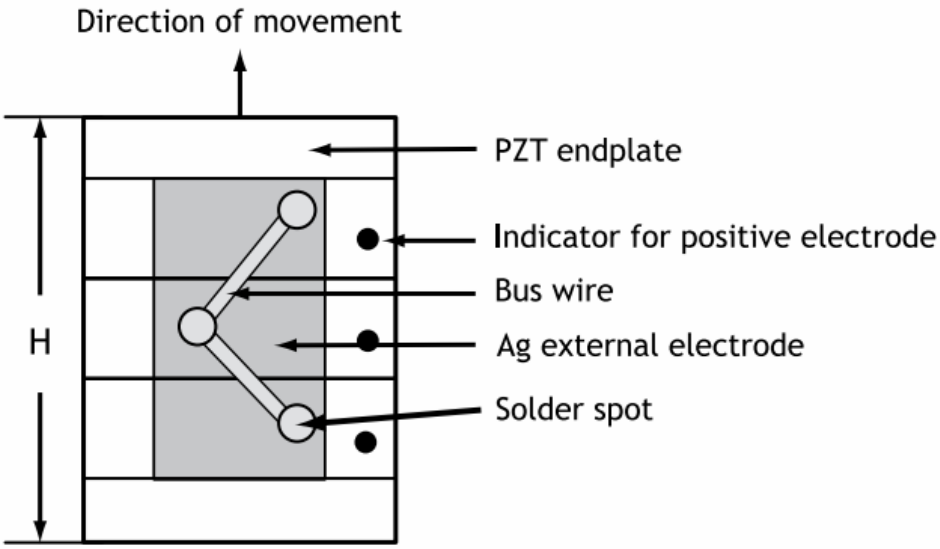
Common parameters for the product series:

Product series	NAC2121-HXX	NAC2122-HXX	NAC2123-HXX	NAC2124-HXX	NAC2125-HXX	Unit
Outer Diameter (OD)	6 +0.40/-0.20	8 +0.45/-0.25	12 +0.60/-0.40	15 +0.65/-0.45	20 +0.80/-0.60	mm
Inner Diameter (ID)	2 +0.10/-0.30	3 +0.10/-0.30	6 +0.20/-0.40	9 +0.30/-0.50	12 +0.40/-0.60	mm
Max Outer Diameter (OD_M)	7.8	9.8	13.8	16.8	21.8	mm
Height (H)	4 to 60*	4 to 80*	4 to 80*	4 to 80*	4 to 80*	mm
Operating voltage, V_{max}	200					V
Blocking force, 0 to V_{max}	1060 +/-20%	1810 +/-20%	3560 +/-20%	4750 +/-20%	8450 +/-20%	N
Max. operating temp.	150					°C
Material	NCE51F					-
External electrodes	Silver, soldered tinned copper bus-wire					-

* See the different height options and corresponding free displacement and capacitance in the tables below.

Drawing





Stacking Options

NAC2121-Hxx		
Height	Free Stroke	Capacitance
+/-0,2 mm or 1%*	+/-15%	+/-15%
mm	µm	nF
4	3.3	90
6	6.6	180
8	9.9	270
10	13.2	360
12	16.5	450
14	19.8	540
16	23.1	630
18	26.4	720
20	29.7	810
22	33.0	900
24	36.3	990
26	39.6	1080
28	42.9	1170
30	46.2	1260
32	49.5	1350
34	52.8	1440
36	56.1	1530
38	59.4	1620
40	62.7	1710
42	66.0	1800
44	69.3	1900
46	72.6	1990
48	75.9	2080
50	79.2	2170
52	82.5	2260
54	85.8	2350
56	89.1	2440
58	92.4	2530
60	95.7	2620

* whichever is largest

NAC2122-Hxx		
Height	Free Stroke	Capacitance
+/-0,2 mm or 1%*	+/-15%	+/-15%
mm	µm	nF
4	3.3	180
6	6.6	360
8	9.9	540
10	13.2	720
12	16.5	900
14	19.8	1080
16	23.1	1260
18	26.4	1440
20	29.7	1620
22	33.0	1800
24	36.3	1980
26	39.6	2160
28	42.9	2340
30	46.2	2520
32	49.5	2700
34	52.8	2880
36	56.1	3060
38	59.4	3240
40	62.7	3420
42	66.0	3600
44	69.3	3780
46	72.6	3960
48	75.9	4140
50	79.2	4320
52	82.5	4500
54	85.8	4680
56	89.1	4860
58	92.4	5040
60	95.7	5220
62	99.0	5400
64	102.3	5580
66	105.6	5760
68	108.9	5940
70	112.2	6120
72	115.5	6300
74	118.8	6480
76	122.1	6660

78	125.4	6840
80	128.7	7020

* whichever is largest

	NAC2123-Hxx		NAC2124-Hxx	
Height	Free Stroke	Capacitance	Free Stroke	Capacitance
+/-0,2 mm or 1%*	+/-15%	+/-15%	+/-15%	+/-15%
mm	µm	nF	µm	nF
4	3.3	340	3.3	460
6	6.6	680	6.6	920
8	9.9	1030	9.9	1380
10	13.2	1370	13.2	1840
12	16.5	1710	16.5	2300
14	19.8	2050	19.8	2750
16	23.1	2390	23.1	3210
18	26.4	2740	26.4	3670
20	29.7	3080	29.7	4130
22	33.0	3420	33.0	4590
24	36.3	3760	36.3	5050
26	39.6	4100	39.6	5510
28	42.9	4450	42.9	5970
30	46.2	4790	46.2	6430
32	49.5	5130	49.5	6890
34	52.8	5470	52.8	7340
36	56.1	5810	56.1	7800
38	59.4	6160	59.4	8260
40	62.7	6500	62.7	8720
42	66.0	6740	66.0	9180
44	69.3	7180	69.3	9640
46	72.6	7520	72.6	10100
48	75.9	7870	75.9	10560
50	79.2	8210	79.2	11020
52	82.5	8550	82.5	11480
54	85.8	8890	85.8	11930
56	89.1	9230	89.1	12390
58	92.4	9580	92.4	12850
60	95.7	9920	95.7	13310
62	99.0	10260	99.0	13770
64	102.3	10600	102.3	14230
66	105.6	10940	105.6	14690

68	108.9	11290	108.9	15150
70	112.2	11630	112.2	15610
72	115.5	11970	115.5	16070
74	118.8	12310	118.8	16520
76	122.1	12650	122.1	16980
78	125.4	13000	125.4	17440
80	128.7	13340	128.7	17900

* whichever is largest

NAC2125-Hxx		
Height	**Free Stroke**	**Capacitance**
+/-0,2 mm or 1%*	+/-15%	+/-15%
mm	µm	nF
4	3.3	800
6	6.6	1600
8	9.9	2400
10	13.2	3200
12	16.5	4010
14	19.8	4810
16	23.1	5610
18	26.4	6410
20	29.7	7210
22	33.0	8010
24	36.3	8810
26	39.6	9610
28	42.9	10410
30	46.2	11210
32	49.5	12020
34	52.8	12820
36	56.1	13620
38	59.4	14420
40	62.7	15220
42	66.0	16020
44	69.3	16820
46	72.6	17620
48	75.9	18420
50	79.2	19220
52	82.5	20030
54	85.8	20830
56	89.1	21630
58	92.4	22430

60	95.7	23230
62	99.0	24030
64	102.3	24830
66	105.6	25630
68	108.9	26430
70	112.2	27230
72	115.5	28040
74	118.8	28840
76	122.1	29640
78	125.4	30440
80	128.7	31240

* whichever is largest

Stack heights exceeding listed values on request.

Add-ons

Wire Options

When you order actuators from CTS, you can have wires fitted to save time and money. However, you should consider these parameters, when you select a wire for connection:

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

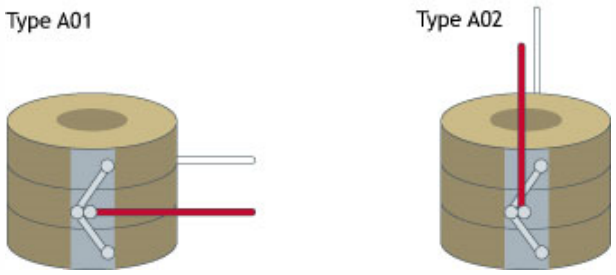
We recommend wires with PTFE insulation

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 wire, which offer superior outgassing and flexibility.

Standard wire options for Ring Stacks

	Option A01	Option A02
Type	MIL-W-16878/4, 28 AWG, 7 strands	
Length	200mm +/-10mm	
Position	Middle of the actuator	
Direction	Perpendicular to the height	Toward the top



Wire gauge (AWG)

The wire gauge (AWG) and insulation type should be determined according to the voltage, current and operating environment. Should the standard –A01 or –A02 configuration not suit your application, we offer 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 311-KAPM-035 (Kapton insulation, UHV)	1000*	0.5	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 vapour 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.

Strain-gauge

A strain gauge is a simple way of obtaining feedback on the deformation of a piezoelectric actuator, typically to achieve closed-loop control. Strain gauges are recommended for experimental setups and small series. CTS offers a standard version for piezo ring actuators (single and stacked) which is designed as a half bridge with two grids at 90°. The strain gauge is a very compact solution and can therefore be fitted to actuator series NAC2123 and above.

The characteristics of the strain gauge are:

Strain gauge parameters	
Nominal resistance	350 Ω
Nominal sensitivity	1 mV/V
Maximal range of deformation	2%
Deformation range of the actuator	0.1– 0.2 % Depending on the actuator type
Temperature range	-40 – +150 °C
Recommended supply voltage	5 V AC or DC Depending on temperature range and heating of the gauge

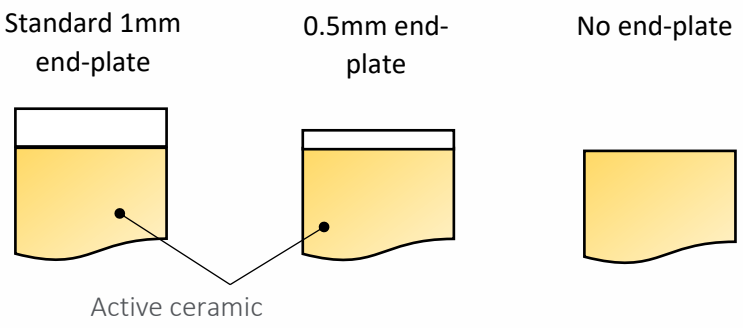
The bandwidth of the measurement system will depend on the signal conditioner that is used. A conditioner with a carrier frequency will typically have a cutoff frequency below 200Hz. “DC” type conditioners have a wider bandwidth but are more sensitive to noise.

The strain gauge has a range of 2% strain while the stack typically generates 0.18% strain (at room temperature). Therefore the output range will be about 9% of the full range. The nominal gauge factor specified by the manufacturer is 1,99+/-2%. However if quantitative measurements are required, it is recommended to perform an initial characterization of the strain-gauge directly in the application using an external sensor.

End-plates

As a standard, ring stacks are supplied with 1mm 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. We recommend a thickness of 1mm for a good spread of the load.

It is nevertheless possible to use different configurations as illustrated below:



Note that stacks without end-plates must not be mounted against a conductive surface, to avoid the risk of short-circuits between the surface electrodes.

Storage

We recommend storing piezoelectric ceramic components in a cool and dry environment to avoid tarnishing of the silver electrodes. 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
- Particularly for tall, narrow stacks, make sure that no bending is induced
- Use plastic tweezers and tools rather than metallic ones
- Use gloves to avoid contamination
- Do not apply excessive force on the pre-attached wires

When submitted to a force or to temperature changes, be aware that piezoelectric components will generate charge (i.e. voltage when in open circuit), so they must be properly discharged before use. Always discharge through a resistor rather than shorting the wires, as it would create high dynamic forces that can damage the component. It is recommended to keep larger components short-circuited during shipment and storage to avoid charge build-up.

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, ring stacks can be fully submerged in solvent, however we recommend to limit the exposure to a few seconds to avoid weakening of the epoxy.

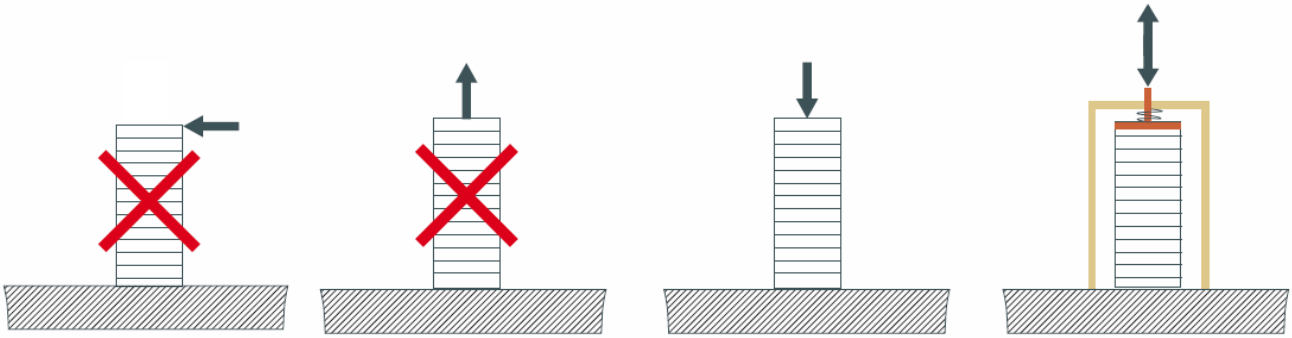
Mounting

Linear stacks offer flat and parallel surfaces for mounting. The actuators may be mounted either by mechanical clamping or using adhesive.

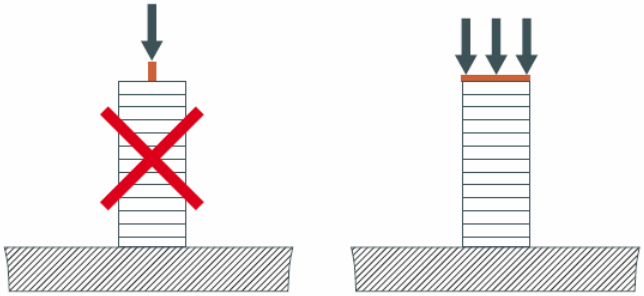
General recommendations

Piezoelectric ceramics can tolerate high compressive stress, but only limited tensile stress. CTS actuators can be safely operated without preload in quasi-static conditions, however preload is required to achieve the specified stiffness and dynamic performance. We recommend 5 MPa preload for quasi-static applications, 10 MPa for dynamic applications and up to 40 MPa in specific high loading conditions.

We recommend to avoid tensile stress, which could result from direct pulling, inertial forces or bending forces. If pull or bending forces cannot be avoided, the actuator must be properly pre-stressed to ensure tensile stress is eliminated. Refer to our online tutorial for additional information on the estimation of stack loads.

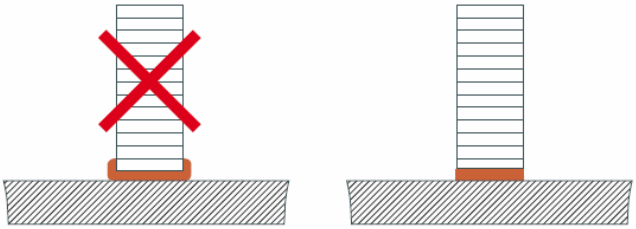


The mechanical load must be applied on the full surface of the actuator in order to avoid stress concentrations.



Mounting using adhesive

Epoxy adhesives are well suited for mounting piezoceramics. For linear actuators, we recommend using a semi-soft (Shore D hardness 50-70), non-conductive, unfilled epoxy. When bonding, it is important to ensure a very thin glue line between the actuator and the substrate. It is recommended to apply a pressure, e.g. 2-5 MPa, during the curing process. To avoid significant loss of performance, the mounting should avoid adhesive on the sides of the actuator.



Connecting and Driving

Linear actuators are easily connected using the optional wires. Alternatively, soldering, conductive epoxy, conductive film or mechanical contacting can be used. Refer to our website for soldering guidelines.

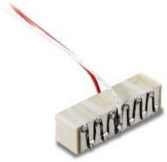
Ensure that the stacks are properly discharged and that there is no voltage on the output when connecting to a driver. Voltage differences will generate current peaks that can damage the actuator or the driver.

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.

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.

Linear Actuators Product Families


Plate and Ring Actuators




Stacked Actuators:

- Plate Stacks
- Plate Stacks, Compact
- Ring Stacks
- High Temperature Stacks
- Damage Tolerant Stacks

Preloaded Actuators

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