Piezo Nanopositioning

From Design to Production

nanoFAKTUR

piezo · positioning · systems

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Applications and Markets

Jacques and Pierre Curie discovered the piezo-electric effect in 1880. Certain solid-state materials generate electric charge when set under pressure (sensor-effect). The brothers described the inverse effect, which is the actuator-effect, one year later. Both piezo-effects have rapidly conquered applications and markets since 1954, when the ideal material PZT (lead-zirconate-titanate) was found. The sensor-effect of PZT is being used for e.g. maritime sonars, force-sensors and ultrasonic parking-sensors. nanoFaktur´s expertise is about piezo-materials, sensors and mainly about actuation and positioning.

Here are some of the manifold of applications and markets for PZT-actuators and -positionings:

Beam-Steering

Surface-Inspection

SEM

Lithography

Nano-Indentation

Semi-Conductor

Disc-Drive-Test

Dispensing

Optical Trapping

Inspection-Systems

Z-Stacking

Interferometry

White-Light-Interferometers

Dithering

Pixel-Interpolation

Sample-Scanning

Wafer-Stages

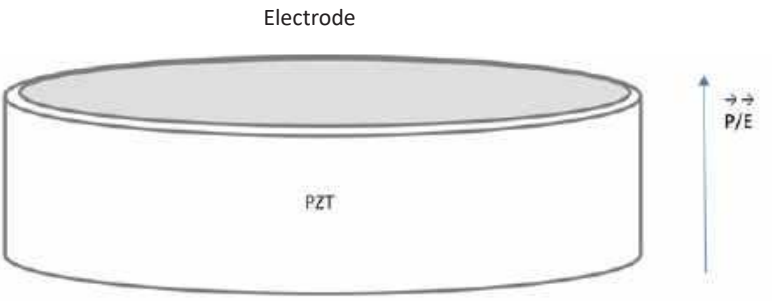
Nano-Alignment

Autofocus

AFM

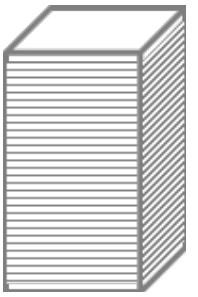
Properties of PZT d_{33} Elements

PZT solid-state ceramics must be polarized to exhibit a piezo-effect. At nanoFaktur, we mostly use the versatile d_{33}-coupling. This coupling means, that polarization, electrical field and the desired expansion are all in parallel.



Typical d_{33} Disc

In order to save voltage, the PZT-elements are manufactured to be thin. Stacking them means multiplying the strokes (multilayer-technology).

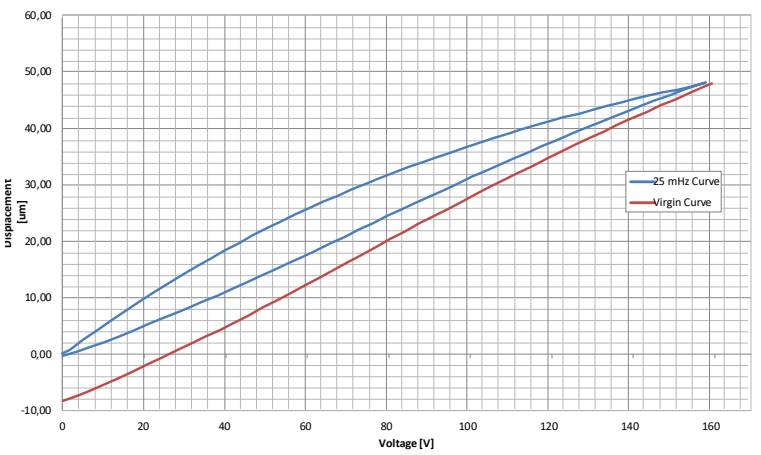


Cuboid d_{33} Multilayer Piezo-Stack

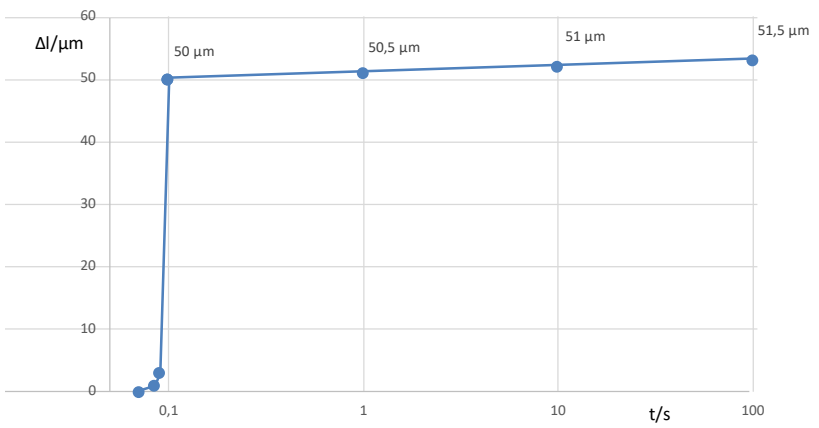
Open Loop

A typical d_{33} PZT-element has the following expansion characteristics in field-direction:

Typical Voltage Behavior of nanoFaktur MPO-050050



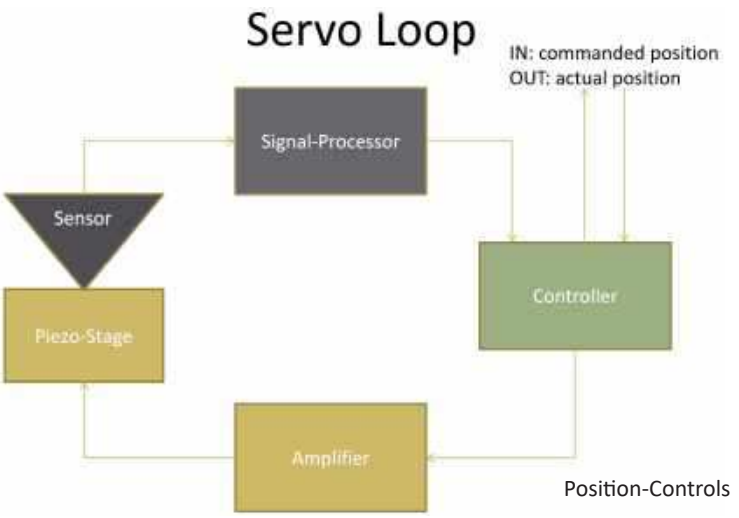
Another feature is the drift of position over time (1% per decade):



If the application of a piezo-actuator can do with those effects, just a driver supplying electrical power is needed. This mode is called “open-loop”.

Closed Loop

If stable and repeatable positioning is required, PZT-drives are combined with position-sensors. Actuators and sensors are connected in a circuit with electronics, which periodically compare commanded positions with actual positions to generate corrected voltages for the actuators. The standard P-I-D calculation method is typically applied. It can be optimized by additional algorithms, if digital controllers are used.



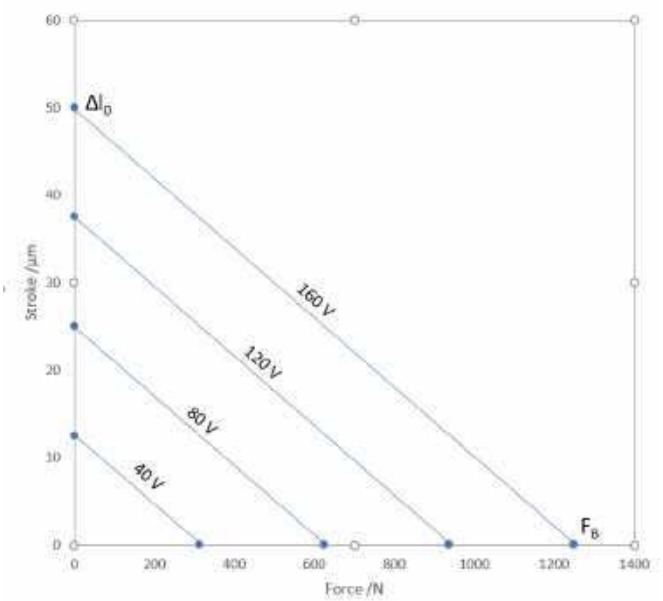
Position-Controls

Integration of Piezo-Stacks

Piezo-stacks can generate pressures of up to 50 MPa. Which means for example, that a stack with 5x5 mm cross-section can generate 1250 N of force. On the other hand, they are not able to bear much pulling-force, lateral force or torque. This is due to the laminated structure. So, integration is optimally done using application-adequate preloads (2 to 30 MPa) and mechanical decoupling. High preload-pressures increase strokes: E.g. +30% at 25 MPa. Spring-constants c_s of the preload reduce strokes if they are in the same magnitude as the stiffnesses c_T of the stacks. Relevant equations:

1. Stiffness: $c_T = \frac{F_B}{\Delta l}$
2. Stroke reduction against spring: $\Delta l' = \Delta l \frac{c_T}{c_T + c_s}$

F_B: Blocking-force; Δl: Free stroke



Work-Space of a Multilayer Piezo-Stack

Force and Stroke

Piezo-actuators generate force F and expansion Δl when voltage U is applied. The blocking-force F_B is delivered when an actuator is fully inhibited in expansion. The nominal displacement Δl_0 is provided when actuators do not have to generate more force than initially applied.

Dynamic Considerations

Piezo-Stacks can be mechanically regarded as controllable springs. The spring-constant is the stiffness. Stacks with their own masses m (relevant: 1/3 of the stacks´ mass) plus external loads M are spring-mass systems and behave like those. $m + M = m_{eff}$.
Relevant equations:

1. Stiffness: $c_T = \frac{F_B}{\Delta l}$ F_B: Blocking-force; Δl: Free stroke
2. Lowest resonance: $f_0 = \frac{1}{2\pi}\sqrt{\frac{c_T}{m_{eff}}}$
3. Shift of resonance with additional mass m´: $f_0' = f_0\sqrt{\frac{m_0}{m_0+m'}}$
4. Phase-Shift: $\varphi \approx 2\ atn(\frac{f}{f_0})$
5. Max. dynamic force during harmonic oscillation: $F_{dyn} = \pm 4\pi^2 f^2 \frac{\Delta l}{2}\ m_{eff}$
6. Fastest step-response: $\Delta t \approx \frac{1}{3f_0}$
7. Fastest smooth step-response: $\Delta t = \frac{1}{f_0}$

Driving Power and Heating

Piezo-Stacks are made like ceramic capacitors and mainly behave like those electrically. There is a specialty to mind: The capacitances of piezo-ceramics are depending on the amplitudes of driving voltages. The nominal capacitances C_0 are given at U = 1V, f = 1 kHz sine-wave. The effective capacitances C increase continuously with voltages to about 80% higher at the maximum voltages.
Relevant equations:

1. Driving current, harmonic: $I = UCf$
2. Driving power, harmonic: $P = UI = U^2Cf$
3. Heating power: $P_W \approx 0.15\ P$
4. Driving current, step: $I = \frac{\Delta U}{\Delta t}C$

MPa Piezo-Stacks

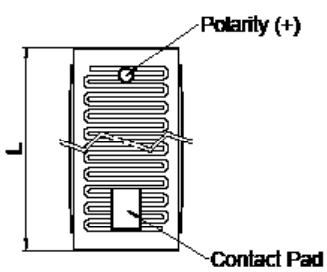
The latest industry-standard

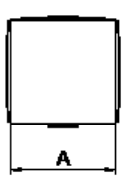
· Higher Displacements
· Longer Lifetimes
· Tighter Tolerances

MPa stacks deliver strain of up to 2 ‰! The consequently laminated structures and monolithic sintering guarantee best possible dimensional tolerances and straightness of motion. Micro-cracks and pillow-effect are excluded by µm-precise drawn back electrodes in combination with an elastic isolation. The life-time of MPa stacks is outstanding and industry-standard.

Product-Number	MPO-050015	MPO-050030	MPO-050050	MPO-050100	Un it
Expansion (0..150 V)	15	30	45	90	µm
Expansion (-45..180 V)	24	48	69	138	µm
Expansion at 800 N Preload	+20%				
Max. Pressure	50				MPa
Stiffness	75	38	25	12	N/µm
Resonance, unloaded	90	65	52	37	kHz
el. Capacitance	1.1	2.2	3.3	6.6	µF
Cross Section, End-Pieces, A	5.0 x 5.0				mm
Cross-Section incl. Contacts and Insulation	6.0 x 6.0				mm
Length, L	10	20	30	60	mm
Parallelism/Flatness	2				µm
Operation-Temperature (Stack)	-40..+180				°C

Options:
- Spherical End-Pieces
- Connection Wires, PTFE, 200 mm
- Housing, Encapsulation, Preload
- Suitable Electrical Driver, e.g. EBO-050100





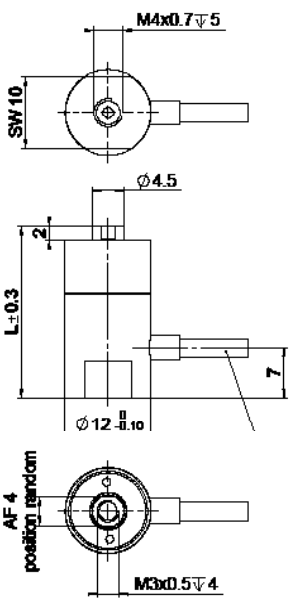
HPa Encapsulated Piezo-Actuators

Direct-Drives, ready to use

HPa piezo-actuators incorporate stacks for direct and stiff actuation inside stainless-steel encapsulations. A preload of 100 N allows for high-dynamic oscillations. Integrated position-sensors are optional. Water-proof versions are available. HPa have decisively shorter lengths than other products on the market.

Product-Number	HPa-b50015	HPa-b50030	HPa-b50050	HPa-b50100	HPa-b50150	Unit
Expansion (0..150 V)	15	30	45	90	135	µm
Expansion (-45..180 V)	22	44	67	134	216	µm
Push/Pull, max.	1000/100					N
Stiffness	70	37	25	15	10	N/ µm
Torque, max., head-piece to body	0.4					Nm
Resonance, unloaded	20	16	12	9	7.3	kHz
el. Capacitance	1.1	2.2	3.3	6.6	9.9	µF
Overall Length, L	24	34	44	74	104	mm
Material, Encapsulation, Endpieces	stainless steel					
Operating-Temperature	-40..+80					°C
Connection Wire, 1.5 m, w/o Socket	a=P, e.g. HPO-P50015					
Connection Wire, 1.5 m, w/ Lemosa	a=L, e.g. HPO-L50015					

Options:
- Versions with position-sensors
- Versions with 60 V max. voltage
- Spherical End-Pieces
- Suitable Electrical Drivers, e.g. EBO-050100



PPa Parallel Levers

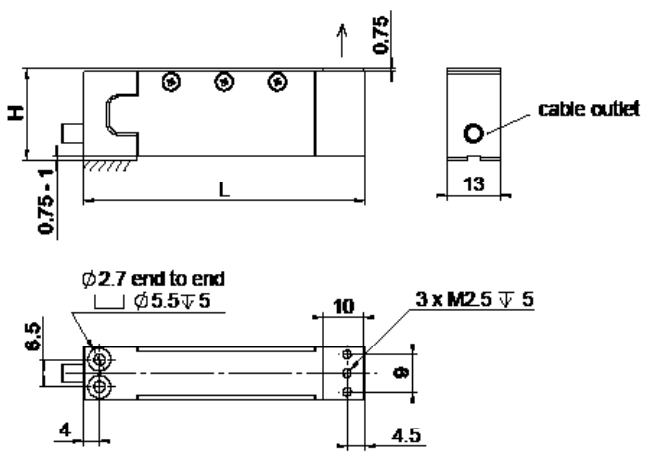
Up to 1mm Travel with Guidance

The high strain of our MPO stack-actuators allows for smaller constructions at the same displacements. PPa levers are equipped with electro-eroded flexures. Flexures avoid friction (wear, non-accuracies) and micro-cracks, which would reduce life-time. The moving platforms are being guided in parallel. Thus PPO and PPS are not just simple drives, but also guidances. The PPS versions are equipped with strain-gage sensors, which care for temperature-compensated measurement and control.

Product-Number	PPa-b00100	PPa-b00250	PPa-b00500	PPa-b01000	Unit
Displacement (0..150 V)	100	250	500	1000	µm
Displacement (-45..180 V)	145	365	730	1400	µm
Resolution, open loop	0.2	0.3	0.5	1	nm
Resolution, closed loop	2	6	12	25	nm
Linearity, closed loop	0.1		0.2		%
Repeatability	7	10	30	60	nm
Push/Pull, maximum	50/20		30/15		N
Lateral Force, maximum	40		30		N
Stiffness	0.85	0.5	0.22	0.11	N/µm
Resonance, unloaded	850	600	340	210	Hz
El. Capacitance	1.2	3.6	4.8	8.4	µF
Body-Material	stainless-steel				
Lenght L	45	59	69	99	mm
Hight H	20	20	22.5	22.5	mm
Operating Temperature	-20..80				°C

Product-Name: PPa-b.....
a = O for the open-loop version
a = S for the version with position-sensor
b = P for pigtails (wires without socket)
b = L for Lemosa-socket (option for the open-loop version)
b = D for DSub-socket, 15 pins (option for the version with sensor)

Options:
- Vacuum-Compatibility
- Suitable driver, open-loop, EBO-050100
- Suitable controller, closed-loop, EBD-060100



DPa Double Levers

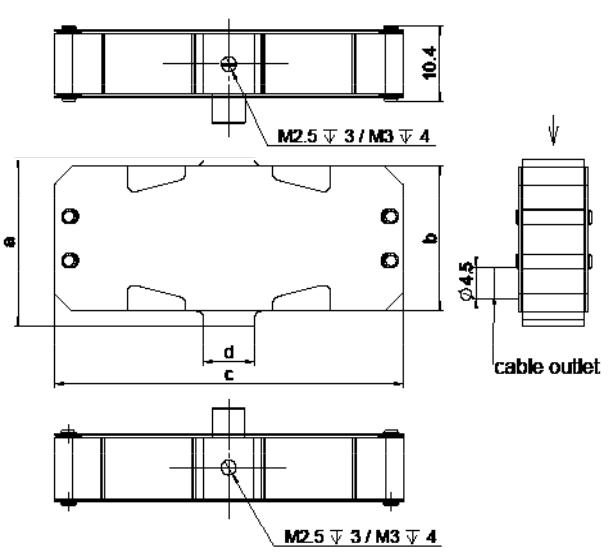
Up to 1mm driven by Piezo

The large strain of our MPO stacks allows for the compact constructions of our DPa lever-drives. The guidances and joints are made of electro-eroded flexures, which are avoiding friction, wear and micro-cracks.
The life-times are in the order of 10 billion full-stroke cycles.
The versions DPS are equipped with strain-gage sensors full-bridges for temperature-compensated measurement and controls.

Product-Number	DPa-b00075	DPa-b00100	DPa-b00250	DPa-b00500	DPa-b01000	Unit
Displacement (0..150 V)	75	100	250	500	1000	µm
Displacement (-45..180 V)	105	140	330	700	1400	µm
Resolution. open loop	0.15	0.2	0.3	0.5	1	nm
Resolution. closed loop	1.5	2	6	12	25	nm
Linearity. closed loop		0.1		0.2		%
Repeatability	6	7	10	30	60	nm
Push/Pull. maximum	200/30		150/10	100/10		N
Stiffness	4.5	3.2	0.55	0.37	0.15	N/µm
Resonance. unloaded	1150	1000	550	300	200	Hz
El. Capacitance	2.2	3.3	3.3	6.6	9.9	µF
Body-Material			stainless-steel			
Lenght c	30	48	48	82	112	mm
Height a	16	23	23	26	26	mm
Operating Temperature			-20..+80			°C

Product-Name: DPa-b.....
a = O for the open-loop version
a = S for the version with position-sensor
b = P for pigtails (wires without socket)
b = L for Lemosa-socket (option for the open-loop version)
b = D for DSub-socket. 15 pins (option for the version with sensor)

Options:
- Vacuum-Compatibility
- Suitable driver. open-loop. EBO-050100
- Suitable controller. closed-loop. EBD-060100



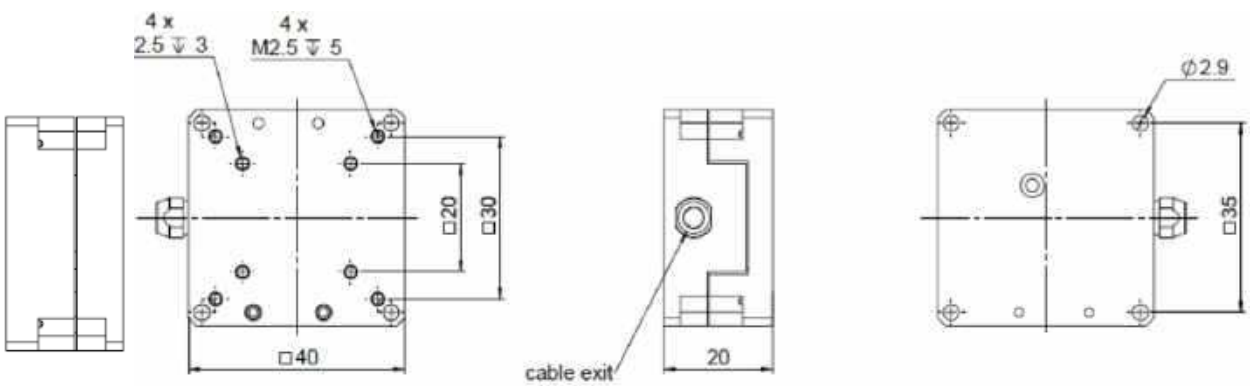
C1a X-Stages 100/250µm

High Dynamics and Small

C1a 100/250 stages offer long displacements at small dimensions. Two different ranges are available: 100 and 250 µm. The 100 µm stage is stiff and so has a high first resonance. It can be used well for dynamic applications. The other version offers 250 µm of range, which is unique at such small dimensions. Both versions are sized 40x40x20 mm^3 only.

Product-Number	C1O-L00100	C1S-D00100	C1O-L00250	C1S-D00250	Unit
Position-Sensor		SGS		SGS	
Range (-45..180 V)	130	130	330	330	µm
Range, closed loop		100		250	µm
Resolution, open loop	0.5	0.5	1	1	nm
Resolution, closed loop		1		3	nm
Linearity, closed loop		0.2		0.2	%
Repeatability, closed loop		10		25	nm
Load	500		150		g
Push/Pull	15/10				N
Stiffness	1.5		0.4		N/µm
Lowest Resonance, unloaded	370		210		Hz
Lowest Resonance, w/ load 30g	310		190		Hz
El. Capacitance	2.2				µF
Body-Material	aluminum, stainless steel				
Operating Temperature	-20..+80				°C

Options:
- Vacuum-Compatibility and/or Non-Magnetic
- Suitable driver, open-loop, EBO-050100
- Suitable controllers, closed-loop, EBD-060100



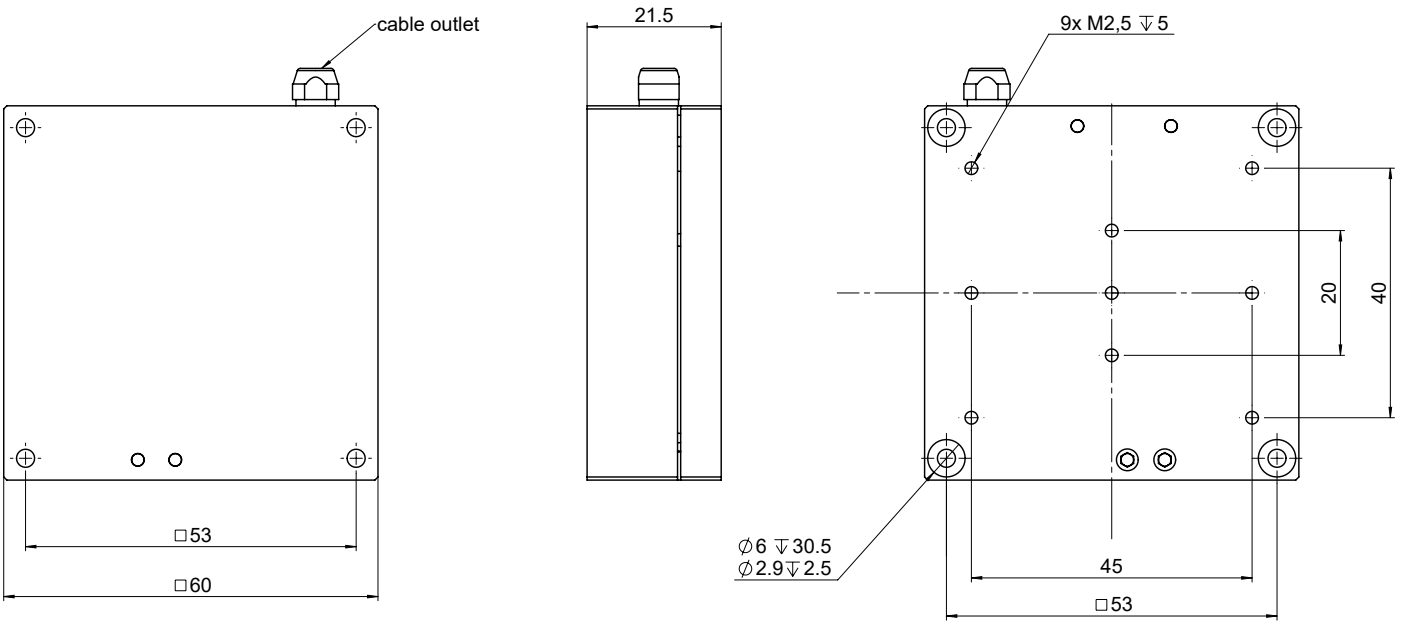
C1a X-Stages 600µm

Long Range and Small

C1a 600 stages offer up to 900 µm range at smallest dimensions. The size is 60x60x21.5 mm³ only. The stages are available with or without sensors. The version with sensor allows for repeatable and drift-less positioning. Target positions can be reached in 10 ms magnitude. The linearity of positioning is better than 0.2%. Versions for UHV and high magnetic fields are available.

Product-Number	C1O-L00600	C1S-D00600	Unit
Position-Sensor		SGS	
Range (-45..180 V)	900	900	µm
Range, closed loop		600	µm
Resolution, open loop	4	4	nm
Resolution, closed loop		6	nm
Linearity, closed loop		0.2	%
Repeatability, closed loop		50	nm
Load, max.	200		g
Push/Pull, max.	50/20		N
Stiffness	0.15		N/µm
Lowest Resonance, unloaded	190		Hz
El. Capacitance	4.4		µF
Body-Material	aluminum, stainless steel		
Operating Temperature	-20..+80		

Options:
-Vacuum-Compatibility and/or Non-Magnetic
-Suitable driver, open-loop, EBO-050100
-Suitable controller, closed-loop, EBD-060100



LPa Linear Stages

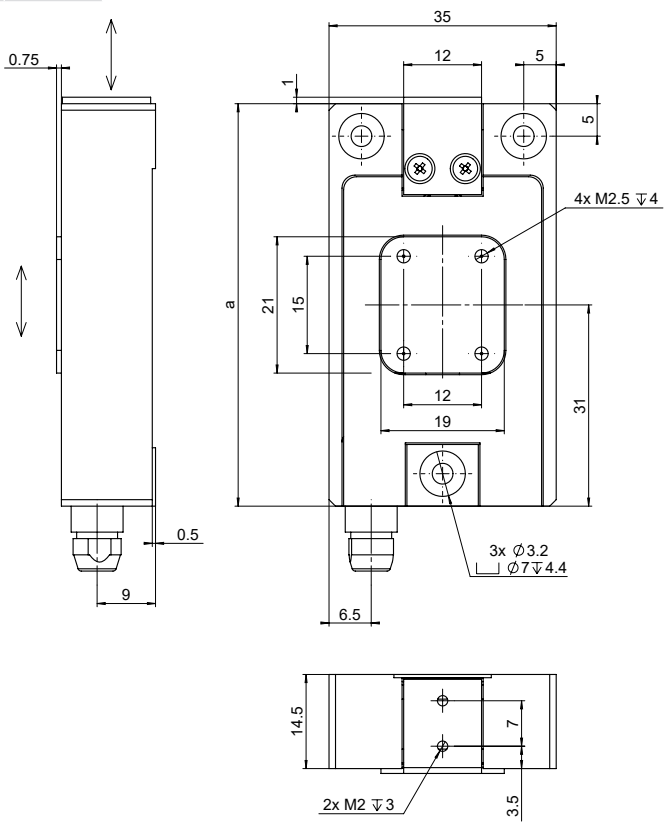
High Dynamics and versatile Mounting

LPa linear stages are directly driven by piezo-stack actuators. The direct drives keep the first resonances enormously high, so that dynamic applications can be served. Dynamic actuators are optimally employed in-line with their loads in order to avoid torque and possible tilt-oscillation. Thus LPa do have an extra piston-platform, so that LPa can be either used as standard X-stages or as piston stages (Z-stages).

Product-Number	LPa-b0045	LPa-b0090	Unit
Displacement (0..150 V)	45	90	µm
Displacement (-45..180 V)	70	140	µm
Resolution, open loop	0.1	0.2	nm
Resolution, closed loop	1	2	nm
Linearity, closed loop	0.1	0.2	%
Repeatability, closed loop	5	6	nm
Push/Pull	200/100	200/100	N
Stiffness	21	10	N/µm
Resonance, unloaded	3000	2000	Hz
El. Capacitance	3.3	6.6	µF
Length, a	62	92	mm
Body-Material	stainless steel		
Operating Temperature	-20..80		°C

Product-Name: LPa-b.....
a = O for the open-loop version
a = S for the version with position-sensor
b = P for pigtails (wires without socket)
b = L for Lemosa-socket (option for the open-loop version)
b = D for DSub-socket. 15 pins (option for the version with sensor)

Options:
- Vacuum-Compatibility
- Suitable driver, open-loop, EBO-050100
- Suitable controller, closed-loop, EBD-060100



LPa Long Range Linear Stages

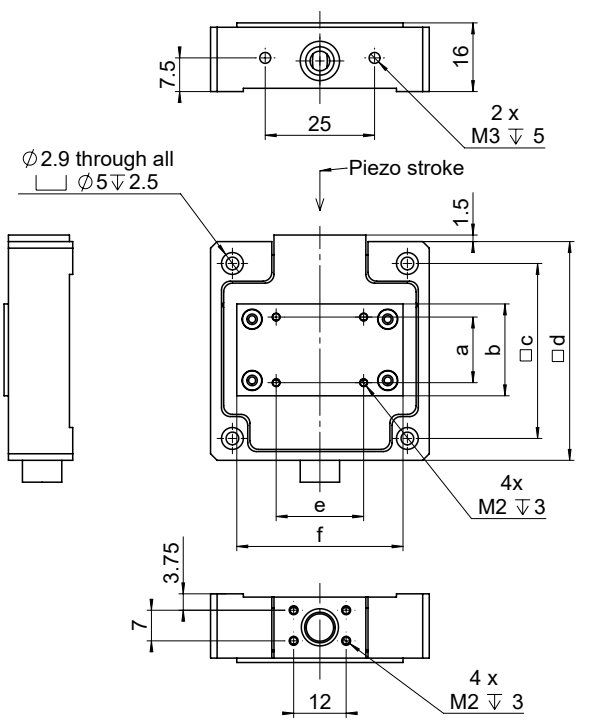
High Dynamics and versatile Mounting

LPa LR linear stages are driven by amplified piezo-stack actuators, so that long ranges of 100, 300 and 600 µm respectively are achieved at compact dimensions. Linear positioning stages in general are optimally employed in-line with their loads in order to reach best positioning results. Thus LPa LR do have an extra piston-platform, so that they can be used either as standard X-stages or as piston stages (Z-stages).

Product-Number	LPa-b00100	LPa-b00300	LPa-b00600	Unit
Displacement (0..150 V)	100	300	600	µm
Displacement (-45..180 V)	160	480	960	µm
Resolution, open loop	0.5	1.5	3	nm
Resolution, closed loop	1	2.5	4	nm
Linearity, closed loop		0.2		%
Repeatability	10	25	50	nm
Push/Pull, maximum		100/20		N
Stiffness	1.6	0.3	0.15	N/µm
Resonance, unloaded	900	425	225	Hz
El. Capacitance	2.2	3.3	8.8	µF
Body-Material		stainless-steel		
Operating Temperature		-20..+80		°C

Product-Name: LPa-b.....
a = O for the open-loop version
a = S for the version with position-sensor
b = P for pigtails (wires without socket)
b = L for Lemosa-socket (option for the open-loop version)
b = D for DSub-socket, 15 pins (option for the version with sensor)

Options:
- Vacuum-Compatibility
- Suitable driver, open-loop, EBO-050100
- Suitable controller, closed-loop, EBD-060100



	a	b	c	d	e	f
LPa-b00100	12	19	34	40	15	30
LPa-b00300	15	21	50	50	20	38
LPa-b00600	15	21	60	60	20	38

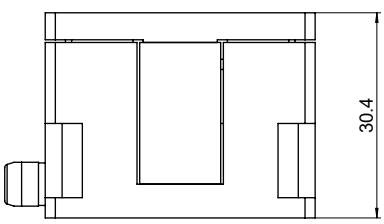
CPa Z-Stages 100/250µm

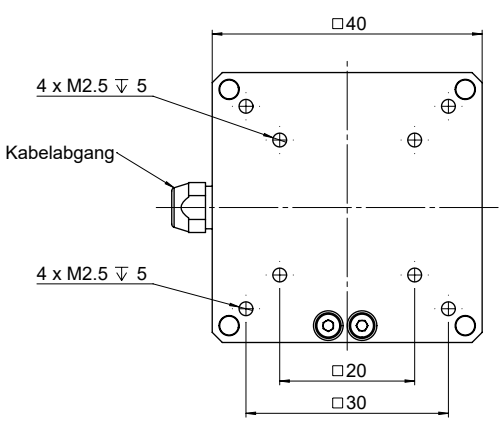
Dynamic and Long-Range Lift

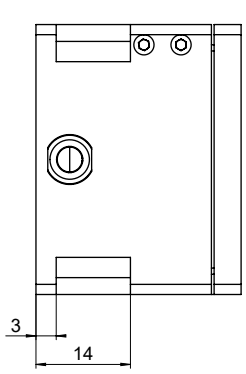
CPa 100/250 stages offer long displacements at small dimensions. Two different ranges are available: 100 and 250 µm. The 100 µm stage is stiff and so has a high first resonance. It can be used well for dynamic applications. The other version offers 250 µm of range, which is unique at such small dimensions. Both versions are sized 40x40x30 mm³ only.

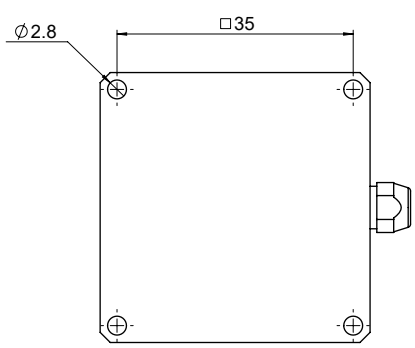
Product-Code	CPO-L00100	CPS-D00100	CPO-D00250	CPS-D00250	Unit
Position-Sensor		SGS		SGS	
Range, Open Loop, -45..+180 V	130	130	320	320	µm
Range, Closed Loop		100		250	µm
Resolution, open loop	0.5		1		nm
Resolution, closed loop		1		2.5	nm
Linearity, closed loop		0.2		0.2	%
Repeatability		10		25	nm
Load	500		150		g
Push/Pull	15/10				N
Lateral Force	10				N
Stiffness	1.5		0,2		N/µm
Resonance, unloaded	370		210		Hz
Resonance, with 100 g load	310		190		Hz
Electrical Capacitance	2.2				µF
Body-Material	aluminium, stainless steel				
Operating Temperature	-20..+80				°C

Options:
-Vacuum-Compatibility
-Suitable driver, open-loop, EBO-050100
-Suitable controller, closed-loop, EBD-060100

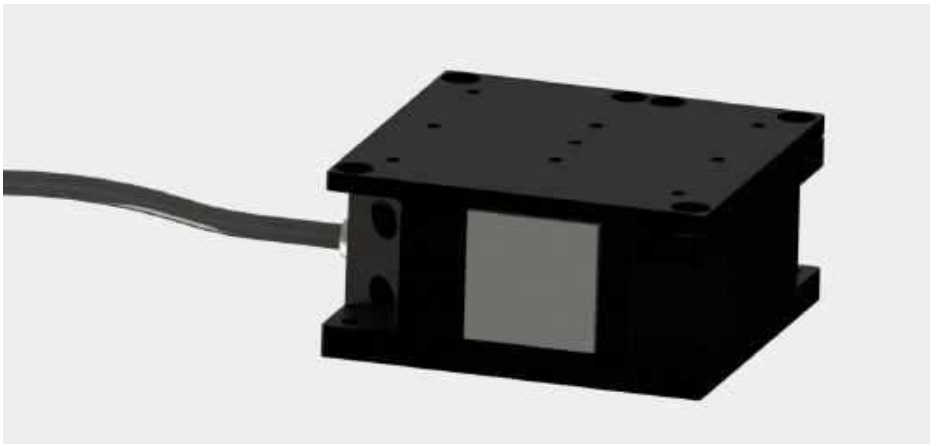








CPa Z-Stages 500µm

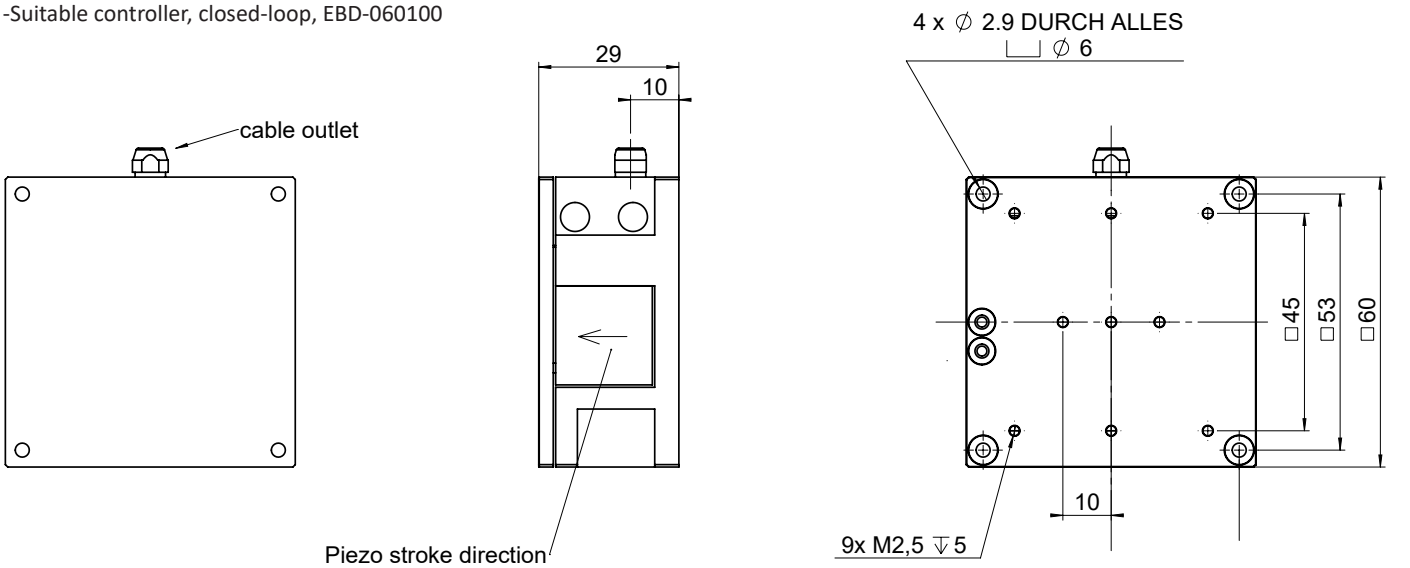


High Lift

CPa 500 stages offer 500 µm Z-range at smallest dimensions. The size is 60x60x29 mm³ only. The stages are available with or without sensor. The version with sensor allows for repeatable and drift-less positioning. Target positions can be reached in 10 ms magnitude. The linearity of positioning is better than 0.2%. Versions for UHV and high magnetic fields are available.

Product-Number	CPO-L00500	CPS-D00500	Unit
Position-Sensor		SGS, Full-Bridge	
Range, Open Loop (-45..180 V)	600	600	µm
Range, Closed Loop		500	µm
Resolution, open loop	3	3	nm
Resolution, closed loop		5	%
Linearity, closed loop		0,2	nm
Repeatability		50	nm
Push/Pull, maximum	40/20		N
Lateral Force, maximum	10		N
Stiffness	0.15		N/µm
Resonance, unloaded	260		Hz
Resonance, with 100 g load	180		Hz
Electrical Capacitance	4.4		µF
Body-Material	aluminum/stainless-steel		
Connector	Lemo	DSub15	
Operating Temperature	-20..+80		°C

Options:
-Vacuum-Compatibility
-Suitable driver, open-loop, EBO-050100
-Suitable controller, closed-loop, EBD-060100

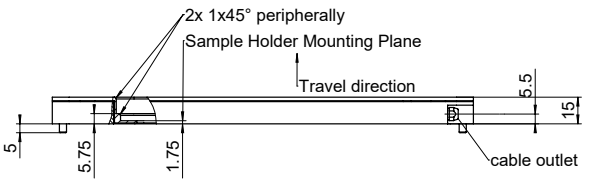


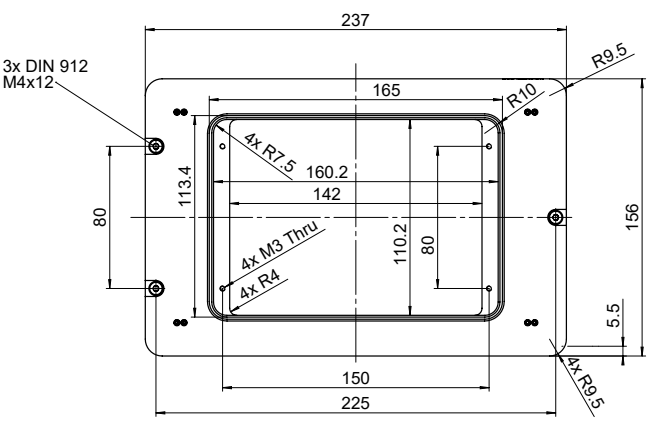
SPa Microscopy Sample Z-Stages

Long Displacements - Extremely Flat (15mm)

SPa sample stages are designed for scanning and positioning tasks along the optical axes in microscopy setups. Microscopy generally needs flat design to facilitate handling. SPS stages meet this requirement optimally by measuring only 15 mm in height. Another microscopy-typical specification that SPa meet is a large aperture, which can optionally be equipped with sample- and/or petri-dish-holders. SPa stages perform lifting-ranges of up to 650 microns.
SPa stages can optionally be delivered with mounting patterns compatible with Nikon, Zeiss, Olympus, Leica, etc. bases or stages.

Product-Number	SPS-D00120	SPS-D00450	SPS-D00650	Unit
Displacement Sensor	strain gages, full-bridge			
Displacement, closed loop	120	450	650	µm
Displacement (-30..160 V)	170	580	820	µm
Resolution, open loop	0.4	1	2	nm
Resolution, closed loop	0.6	2	3	nm
Linearity, closed loop	0.1			%
Repeatability, closed loop	6	14	21	nm
Push/Pull	50/20	50/20	40/15	N
Resonance, unloaded	380	250	130	Hz
El. Capacitance	4.4	13.2	13.2	µF
Electrical Connection	D-Sub 15			
Body-Material	aluminum, black anodized			
Operating Temperature	-20..+80			°C





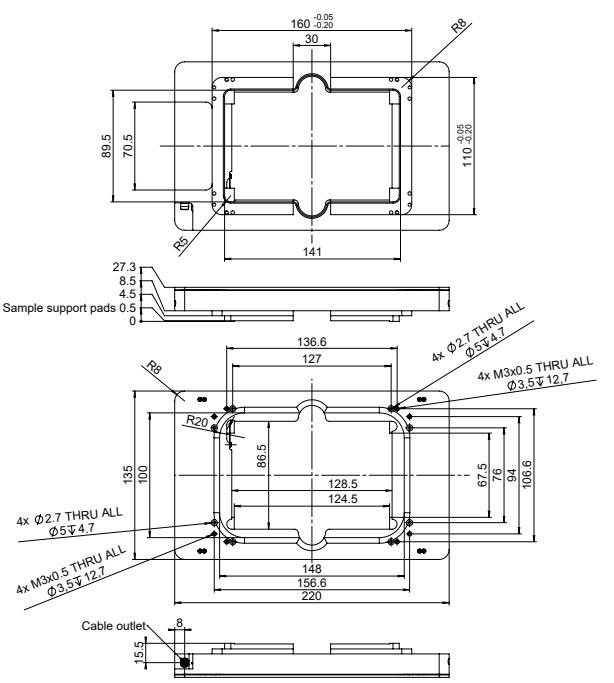
SPa Inserts

Z-Nanostages as Microscope Upgrades

SPa inserts are piezo-driven Z-stages for upgrading inverted microscopes. SPa inserts fit onto bases or into standard XY-stages of microscopes. They provide most precise positioning along the optical axes. 3 different ranges are available: 120, 250 and 500 µm. The dimensions are the same for all ranges. Standard sample- and petri-dish-holders can be born in the aperture close to the objectives of the inverted microscopes.

Product-Number	SPS-D10120	SPS-D10250	SPS-D10500	Unit
Displacement Sensor	strain gages, full-bridge			
Displacement, closed loop	120	250	500	µm
Displacement (-30..160 V)	150	320	650	µm
Resolution, open loop	0.4	0.8	2	nm
Resolution, closed loop	0.6	1.3	3	nm
Linearity, closed loop	0.1			%
Repeatability, closed loop	6	13	25	nm
Push/Pull	50/20	40/15	40/15	N
Resonance, unloaded	380	250	150	Hz
Resonance, 125g load	270	180	110	Hz
Resonance, 250g load	220	140	90	Hz
El. Capacitance	4.4	8.8	13.2	µF
Electrical Connection	D-Sub 15			
Dimensions, L x W x H	220 x 135 x 27.3			mm
Aperture, L x W	128.5 x 86.5			mm
Body-Material	aluminum, black anodized			
Operating Temperature	-20..80			°C

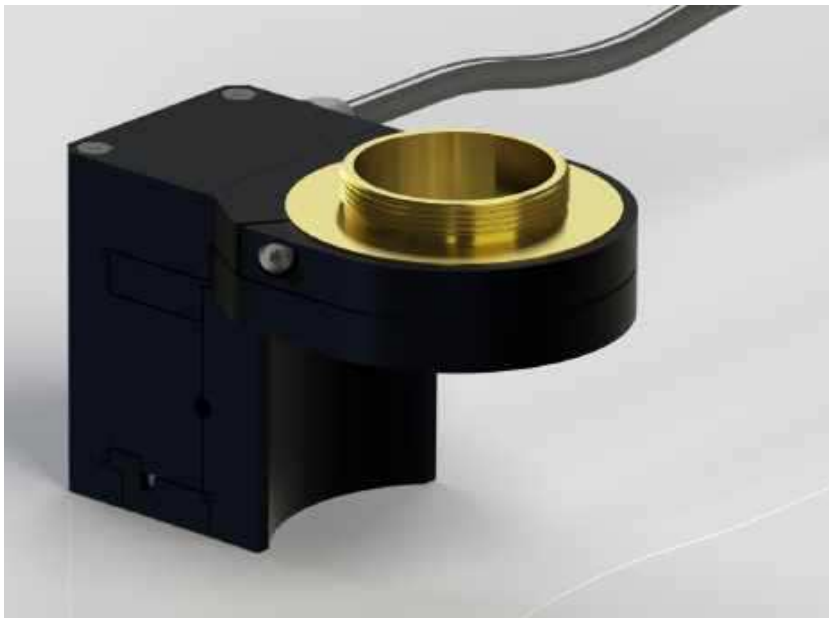
Options:
-Suitable driver, open-loop, EBO-050100
-Suitable controller, closed-loop, EBD
-Sample- and Petri-Dish-Holder



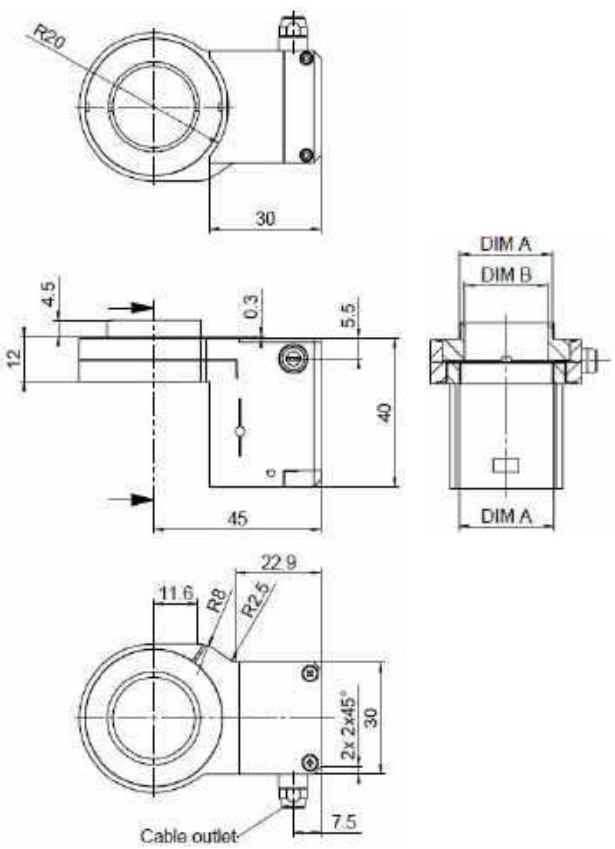
SFa QuickFocus

Objective Positioner

The new designed SFa-D00100 Quick-Focus comes with great improvements. The body is only 40 mm long and so 10 mm shorter than comparable products. The stiffness and the resonance-frequencies are higher for users to save scanning-time. The parallel flexure guidance gives highest positioning accuracy and stability. Thread-adapters are available in many different sizes and can be exchanged in a minute. Versions with and without sensors are available.



Product-Number	SFa-b00100	Unit
Displacement (closed loop)	100	µm
Displacement (-45..180 V)	160	µm
Resolution, open loop	0.5	nm
Resolution, closed loop	1	nm
Linearity, closed loop	0.2	%
Repeatability	10	nm
Push/Pull, maximum	20/10	N
Stiffness	0.5	N/µm
Resonance, with thread-adapter	620	Hz
Resonance, with 150g objective	260	Hz
El. Capacitance	3.3	µF
Body-Material	aluminum	
Operating Temperature	-20..+80	°C



Product-Name: SFa-b.....
a = O for the open-loop version
a = S for the version with position-sensor
b = P for pigtails (wires without socket)
b = L for Lemosa-socket (option for the open-loop version)
b = D for DSub-socket, 15 pins (option for the version with sensor)

Options:
- Vacuum-Compatibility
- Suitable driver, open-loop, EBO-050100
- Suitable controller, closed-loop, EBD-060100

OBJECTIVE INTERFACE		
SIZE	THREAD SIZE (DIM A)	DIAMETER (DIM B)
O1	M19x0.75	14.0
O2	M25x0.75	22.0
O3	M26x0.75	23.0
O4	M27x0.75	24.0
O5	M28x0.75	25.0
O6	M32x0.75	29.0
O7	M26x1/36"	22.0
O8	W0.8x1/36"	14.0
O9	W26x1/36"	22.0

SFa SlimFocus

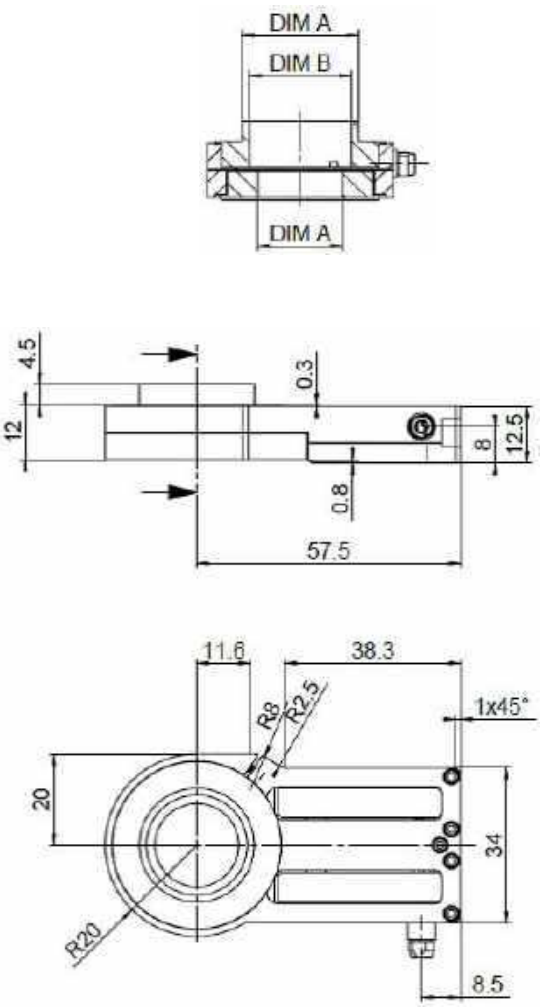
Thinnest Objective Positioner

SlimFocus objective positioners are adapted between microscope-turrets and -objectives.
The space around the objectives stays completely free. Adapters for all standard threads are available.
SlimFocus can shift objectives up to 150 µm relative to the samples. Defined displacements can be programmed with the assigned controllers.

Product-Number	SFa-b00150	Unit
Displacement (closed loop)	150	µm
Displacement (-45..180 V)	240	µm
Resolution. open loop	0.8	nm
Resolution. closed loop	1.5	nm
Linearity. closed loop	0.2	%
Repeatability	15	nm
Push/Pull. maximum	20/10	N
Stiffness	0.3	N/µm
Resonance, with thread-adapter	200	Hz
Resonance, with 125g objective	80	Hz
El. Capacitance per axis	2.2	µF
Body-Material	aluminum, stainless-steel	
Operating Temperature	-20..+80	°C

Product-Name: SFa-b.....
a = O for the open-loop version
a = S for the version with position-sensor
b = P for pigtails (wires without socket)
b = L for Lemosa-socket (option for the open-loop version)
b = D for DSub-socket. 15 pins (option for the version with sensor)

Options:
- Vacuum-Compatibility
- Suitable driver, open-loop, EBO-050100
- Suitable controller, closed-loop, EBD-060100



SFa RangeFocus

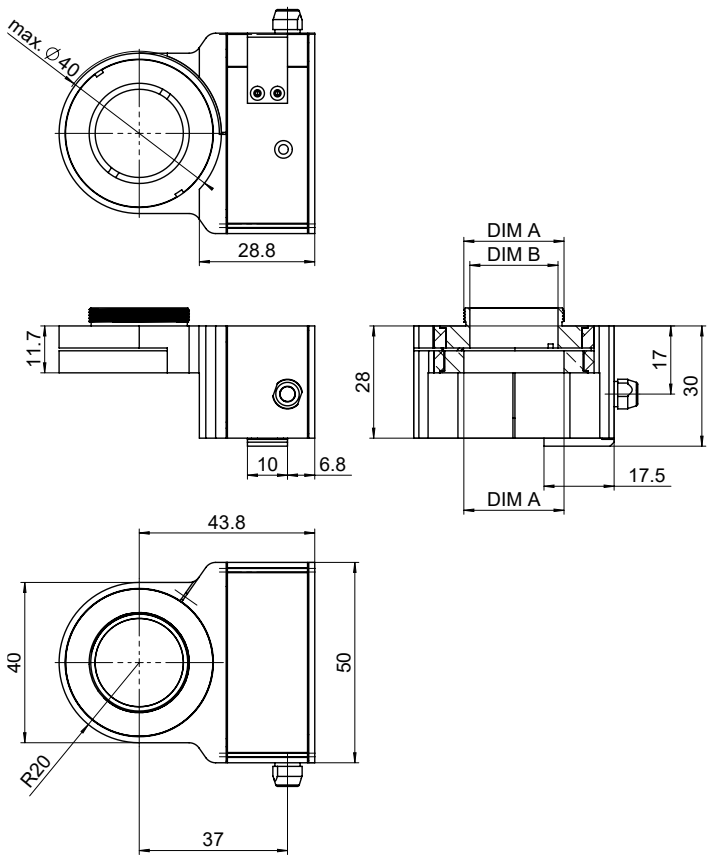
More Range for Objectives

SFa RangeFocus is a series of positioners/scanners with long ranges for microscope objectives. The available displacements are 100 µm to 600 µm. The body-height is short, so that space is saved in the important direction towards the samples. Mounting and exchange is made simple by clamping the unit to the top adapter by a standard screw (Allen-key). RangeFocus positioners are equipped with position-sensors for defined positioning with high linearity and repeatability. Of course, open-loop versions are available.

Product-Number	SFS-D10100	SFS-D10300	SFS-D10600	Unit
Position-Sensor	SGS, Full-Bridge			
Range, Closed Loop	100	300	600	µm
Range, Open Loop (-45..180 V)	130	370	680	µm
Resolution, open loop	0.5	1	2	nm
Resolution, closed loop	1.0	3	6	nm
Linearity, closed loop	0.2	0.2	0.2	%
Repeatability	10	28	50	nm
Push/Pull, maximum	20/15	20/15	20/10	N
Stiffness	0.38	0.22	0.2	N/µm
Resonance, with thread-adapter	470	310	250	Hz
Electrical Cap.	1.1	3.3	6.6	µF
Body-Material	aluminum/stainless-steel			
Operating Temperature	-20..+80			°C

Product-Name: SFa-b.....
a = O for the open-loop version
a = S for the version with position-sensor
b = P for pigtails (wires without socket)
b = L for Lemosa-socket (option for the open-loop version)
b = D for DSub-socket, 15 pins (option for the version with sensor)

Options:
- Vacuum-Compatibility
- Suitable driver, open-loop, EBO-050100
- Suitable controller, closed-loop, EBD-060100



OBJECTIVE INTERFACE		
SIZE	THREAD SIZE (DIM A)	DIAMETER (DIM B)
O1	M19x0.75	14.0
O2	M25x0.75	22.0
O3	M26x0.75	23.0
O4	M27x0.75	24.0
O5	M28x0.75	25.0
O6	M32x0.75	29.0
O7	M26x1/36"	22.0
O8	W0.8x1/36"	14.0
O9	W26x1/36"	22.0

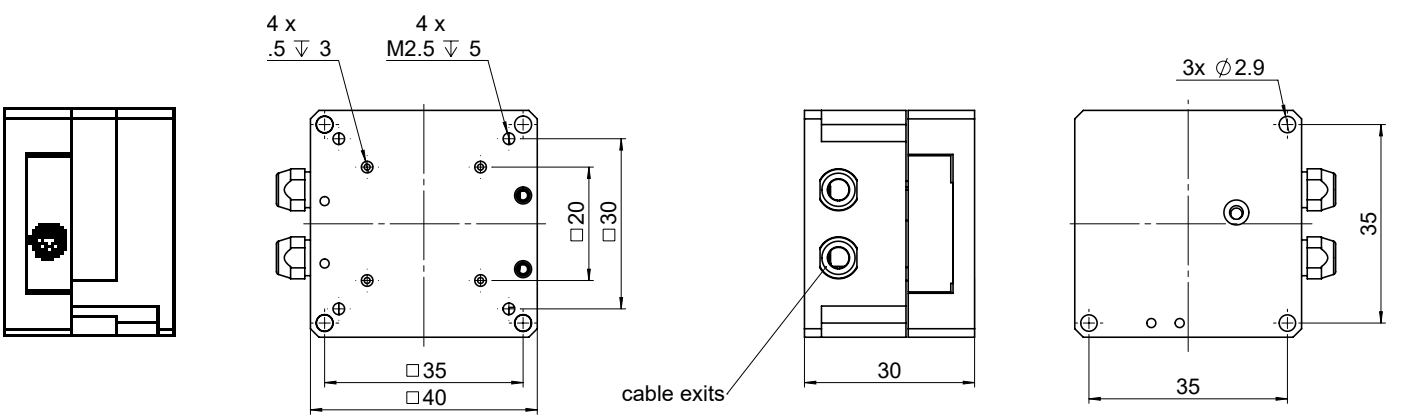
C2a XY-Stages 100/250µm

Small Dimensions, Long Ranges

C2a 100/250 are as small as 40x40x30 mm³ only. Both versions, the 100 µm and the 250 µm, are available with or without sensors. The sensors are strain-sensors, which grant high repeatability and linearity. The 100 µm version is built to be stiff, so that dynamic operation and quite heavy loads are possible. The 250 µm version offers unique long displacements at such small size.

Product-Number	C2O-L00100	C2S-D00100	C2O-L00250	C2S-D00250	Unit
Position-Sensor		SGS		SGS	
Range (-45..180 V)	120x120	120x120	330x330	330x330	µm
Range, closed loop		100x100		250x250	µm
Resolution, open loop	0.5	0.5	1	1	nm
Resolution, closed loop		1		3	nm
Linearity, closed loop		0.2		0.2	%
Repeatability, closed loop		10		25	nm
Load, max.	500		150		g
Push/Pull, max.	15/10				N
Stiffness	1.5		0.4		N/µm
Lowest Resonance, unloaded	370		210		Hz
Lowest Resonance, w/ load 30g	310		190		µF
El. Capacitance	2.2/axis				µF
Body-Material	aluminum, stainless steel				
Operating Temperature	-20..+80				°C

Options:
- Vacuum-Compatibility and/or Non-Magnetic
- Suitable driver, open-loop, EBO-050100
- Suitable controller, closed-loop, EBD-060100



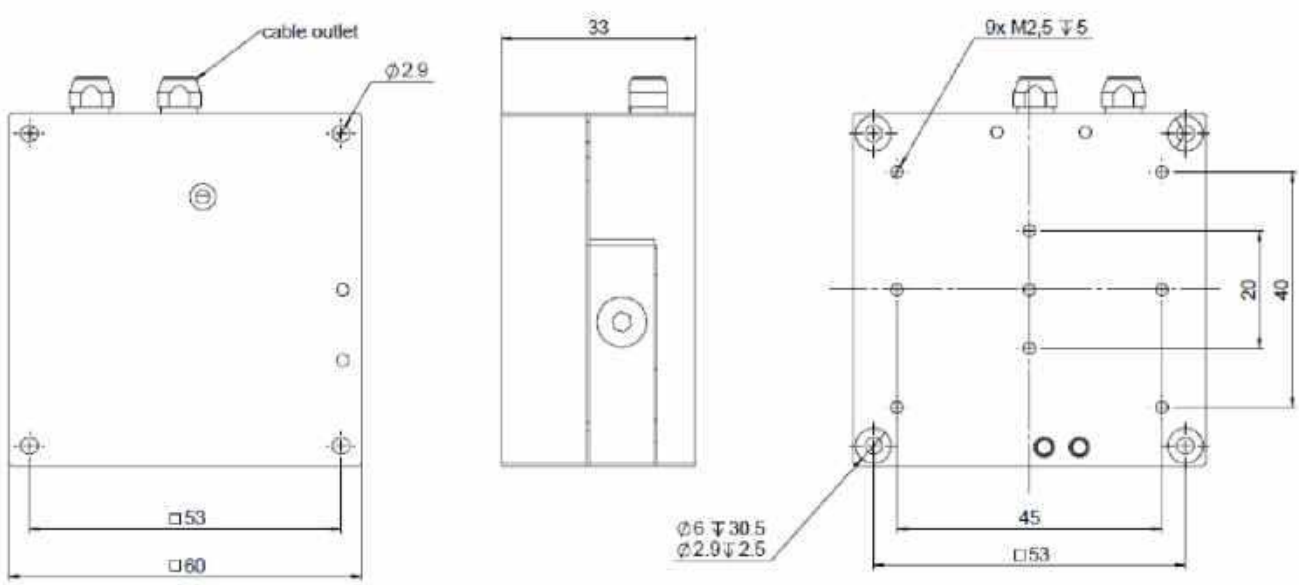
C2a XY-Stages 600µm

Small Stage – Long Range

C2a 600 stages offer up to 900 µm range in XY at smallest dimensions. The size is 60x60x33 mm³ only. The stages are available with or without sensor. The version with sensor allows for repeatable and drift-less positioning. Target positions can be reached in 10 ms magnitude. The linearity of positioning is better than 0.2%. Versions for UHV and high magnetic fields are available.

Product-Number	C2O-L00600	C2S-D00600	Unit
Position-Sensor		SGS	
Range (-45..180 V)	900x900	900x900	µm
Range, closed loop		600x600	µm
Resolution, open loop	4	4	nm
Resolution, closed loop		6	nm
Linearity, closed loop		0.2	%
Repeatability, closed loop		50	nm
Push/Pull	50/20		N
Stiffness	0.15		N/µm
Lowest Resonances, unloaded	190/145		Hz
El. Capacitance	4.4/axis		µF
Body-Material	aluminum, stainless steel		
Operating Temperature	-20..+80		°C

Options:
- Vacuum-Compatibility and/or non-magnetic
- Suitable drivers, open-loop, EBO-050100
- Suitable controllers, closed-loop, EBD-060100

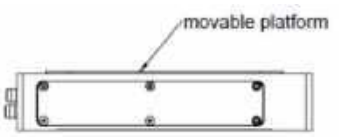


L2a XY-Stages with Aperture 300/600µm

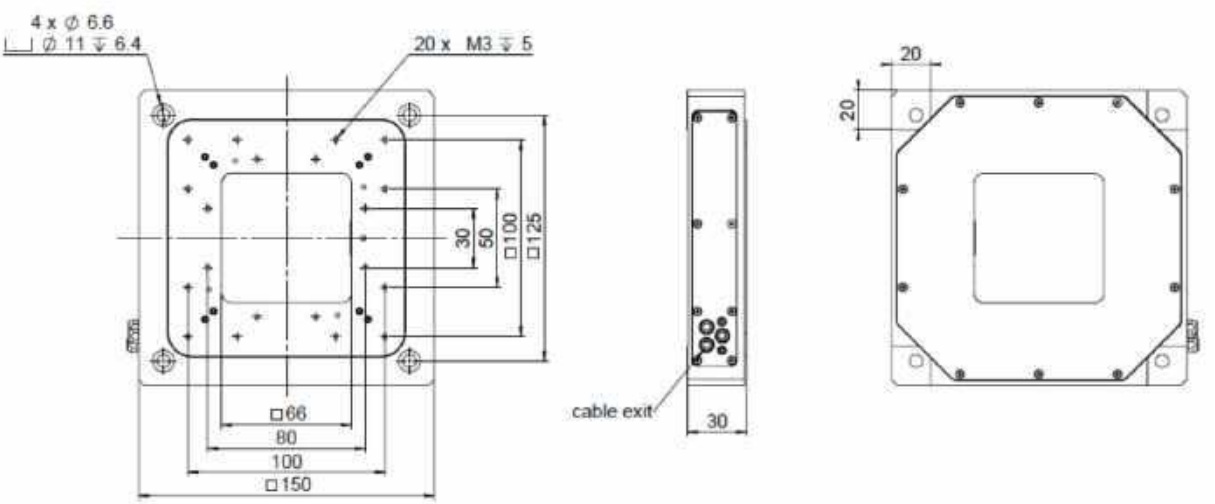
Scanners for Microscopy

L2a Stages are made for scanning. The positioning-ranges are 300 µm or 600 µm. These stages are only 30 mm high and offer 66x66 mm² apertures. High precision frictionless flexure guiding leaves close to zero cross-talk and results in excellent flatness of motion. The large aperture allows for access to the samples from top and bottom. L2a stages are also available with integrated Z-axes. These are described further in this catalog and on the nanoFaktur-website.

Product-Number	L2S-D10300	L2S-D10600	Unit
Position-Sensors	Strain-Gage (SGS), Full-Bridge		
Range, closed loop	300	600	µm
Range, open loop (-45..+180V)	420	720	µm
Resolution, closed loop	3	6	nm
Resolution, open loop	1	2	nm
Linearity, closed loop	0.2		%
Repeatability, closed loop	30	60	nm
Stiffness	1		0.5
Resonance, XY, unloaded	210		175
Resonance, Rot Z, unloaded	270		215
El. Capacitance	13.2		µF
Dimensions (LxWxH)	150x150x30		mm
Aperture, Dimensions (LxW)	66x66		mm
Body/Platform-Material	aluminum, black		
Operating Temperature	-20..+80		°C



Options:
- Vacuum-Compatibility and/or non-magnetic
- Suitable driver, open-loop, EBO-050100
- Suitable controller, closed-loop, EBD-120230



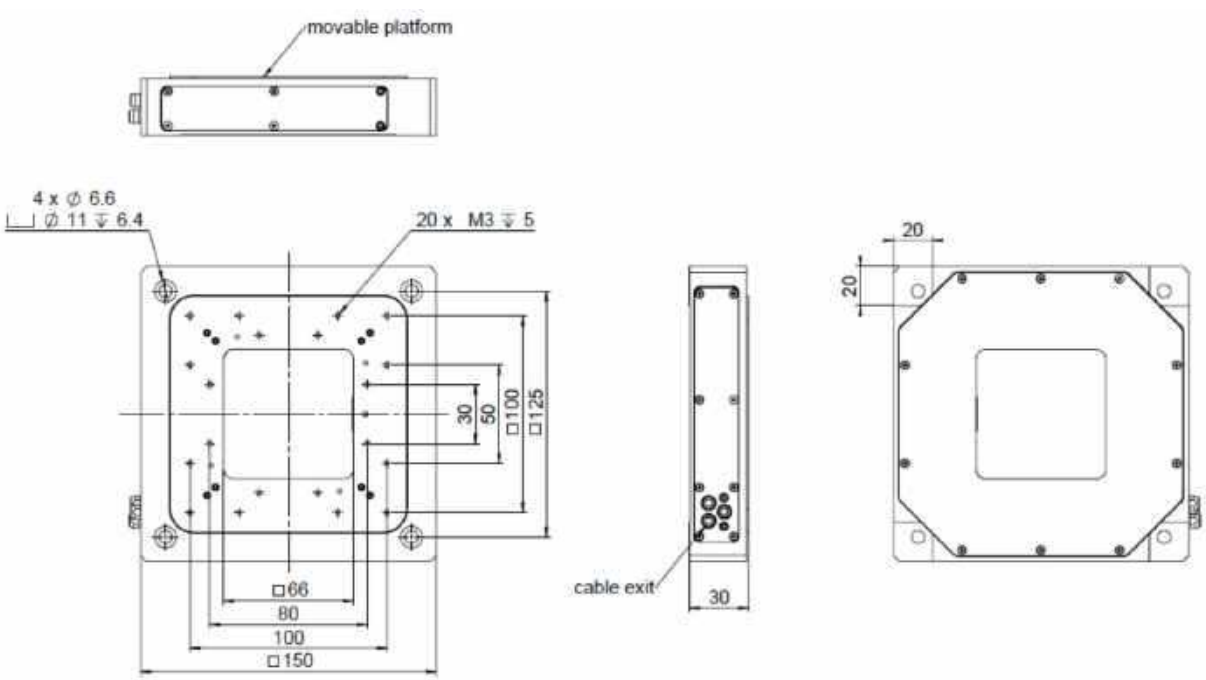
L2C XY-Stages with Capacitive Sensors

Fast Scanning

L2C stages are made for highest dynamics of scanning. They offer 100 µm of directly driven travel-range. L2C have a 66x66 mm² clear aperture. High precision frictionless flexure guiding leaves close to zero cross-talk and results in excellent flatness of motion. L2C stages are equipped with non-contact capacitive sensors. The systems are designed as parallel-kinematics, which means: The position of the moving platform is measured in 2D simultaneously, so that even the last rest of cross-talk can be actively eliminated. There are versions with integrated Z-axes available – see them further in this catalog or on the nanoFaktur website.

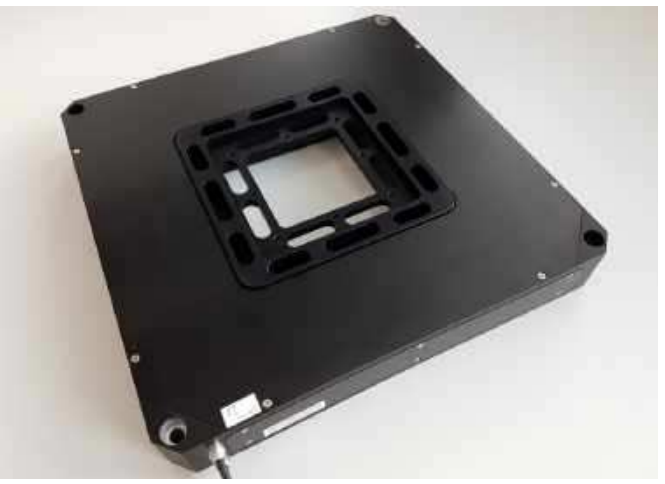
Product-Number	L2C-D10100	Unit
Position-Sensors	Capacitive (Cap)	
Ranges, closed loop	100x100	µm
Ranges, open loop (-45..+180V)	140x140	µm
Resolution, closed loop	0.5	nm
Resolution, open loop	0.3	nm
Linearity, closed loop	0.02	%
Repeatability	5	nm
Resonance, unloaded	1100	Hz
El. Capacitance	XY13.2/Z4.4	µF
Body/Platform-Material	Aluminum, black	
Operating Temperature	-20..+80	°C
Body-Material	aluminum, stainless steel	
Operating Temperature	-20..+80	°C

Options:
- Vacuum-Compatibility and/or non-magnetic
- Suitable drivers, open-loop, EBO-050100
- Suitable controller, closed-loop, EBD-120230



L2a XY-Stage 1x1mm²

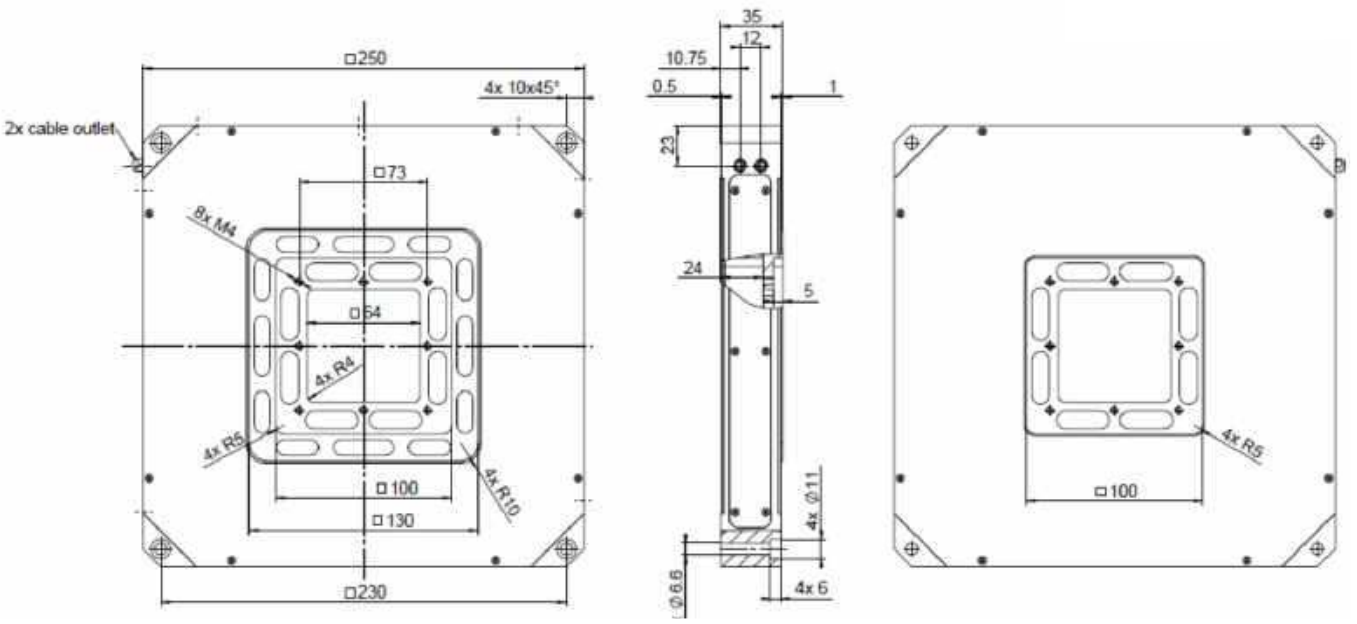
Long Range Parallel-Kinematics



The L2a XY stage was designed to provide travel-ranges of 1 mm in the X and Y axes while allowing dynamic operation of up to 20 Hz with load. The inner moving platform is light-weighted. The drives for both, X and Y axes, directly act to the inner moving platform, so that the load for both is little and the resonances are high.

Product-Code	L2S-D01000	Unit
Position-Sensor	SGS, Full-Bridge	
Range, Open Loop (-45..180 V)	1600	µm
Range, Closed Loop	1000	µm
Resolution, open loop	5	nm
Resolution, closed loop	10	nm
Linearity, closed loop	0.2	%
Repeatability	50	nm
Push/Pull	10	N
Load	0.2	kg
Lateral Force	10	N
Stiffness	0.2	N/µm
Resonance, unloaded	105	Hz
Resonance, with 200 g load	80	Hz
Electrical Capacitance	19.8/axis	µF
Body-Material	aluminum/stainless-steel	
Operating Temperature	-20..+80	°C

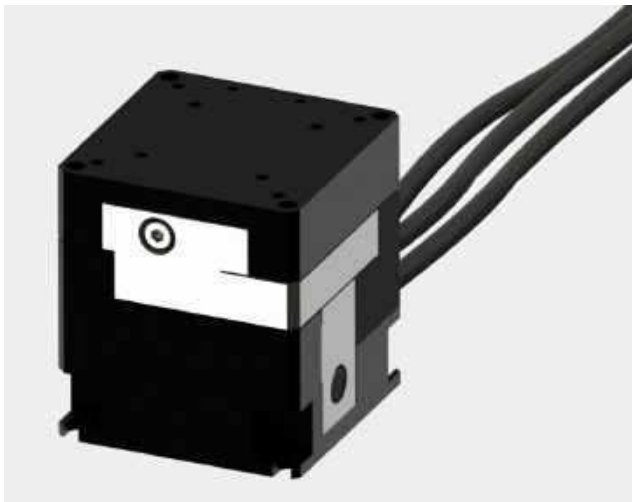
Options:
- Vacuum-Compatibility and/or non-magnetic
- Suitable drivers, open-loop, 2x EBO-300100
- Suitable controller, closed-loop, EBD-120220



C3a Cube 100/250µm

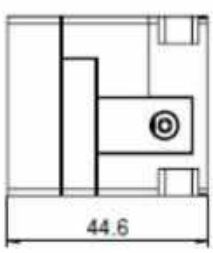
3D Compact

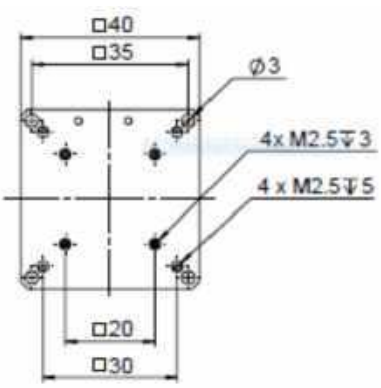
C3a 100/250 are as small as 40x40x44 mm³ only. Both versions, the 100 µm and the 250 µm, are available with or without sensors. The sensors are strain-sensors, which grant high repeatability and linearity. The 100 µm version is built to be stiff, so that dynamic operation and quite heavy loads are possible. The 250 µm version offers unique long displacements at that small size. Vacuum- and non-magnetic versions are available.

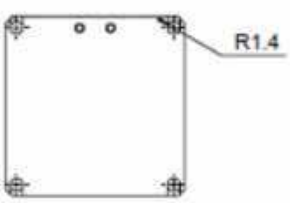


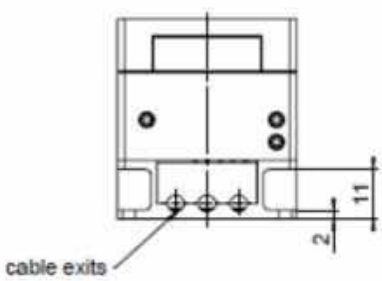
Product-Number	C3O-L00100	C3S-D00100	C3O-L00250	C3S-D00250	Unit
Position-Sensor		SGS		SGS	
Range, open loop, -45..180 V	130	130	330	330	µm
Range, closed loop		100		250	µm
Resolution, open loop	0.5	0.5	1.5	1.5	nm
Resolution, closed loop		1		2.5	nm
Linearity, closed loop		0.2		0.2	%
Repeatability, closed loop		10		25	nm
Load	500		150		g
Push/Pull	15/10				N
Stiffness	1.5		0.4		N/µm
Lowest Resonance, unloaded	370		210		Hz
Lowest Resonance, w/ load 30g	310		190		Hz
El. Capacitance	2.2/axis				µF
Body-Material	aluminum, stainless steel				
Operating Temperature	-20..+80				°C

Options:
- Vacuum-Compatibility and/or non-magnetic
- Suitable drivers, open-loop, EBO-050100
- Suitable controller, closed-loop, EBD-120230









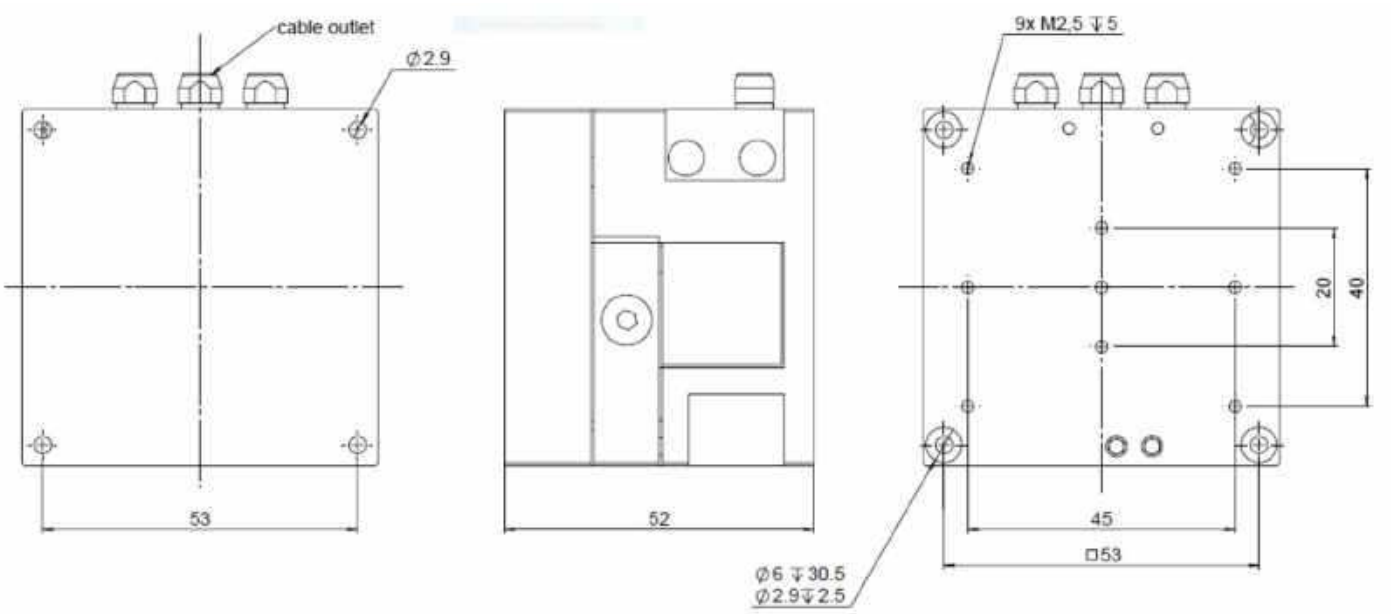
C3a Cube 600µm

Compact XYZ-Stage - Long Range

C3a Cube 600 stages offer up to 600x600x500 µm³ closed-loop range in XYZ at the very compact size of 60x60x52 mm³. The stages are available with or without sensors. The version with sensors allows for repeatable and drift-less positioning. Target positions can be reached in 10 ms magnitude.
The linearity of positioning is better than 0.2%. Versions for UHV and high magnetic fields are available.

Product-Number	C3O-L00600	C3S-D00600	Unit
Position-Sensor		SGS	
Range (-45..180 V)	900x900x600	900x900x600	µm
Range, closed loop		600x600x500	µm
Resolution, open loop	4	4	nm
Resolution, closed loop		6	nm
Linearity, closed loop		0.2	%
Repeatability, closed loop		50	nm
Load	200		g
Push/Pull	50/20		N
Stiffness	0.15		N/µm
Lowest Resonances, unloaded	190/145/130		Hz
El. Capacitance	4.4/axis		µF
Body-Material	aluminum, stainless steel		
Operating Temperature	-20..+80		°C

Options:
- Vacuum-Compatibility and/or non-magnetic
- Suitable drivers, open-loop, EBO-050100
- Suitable controller, closed-loop, EBD-120230



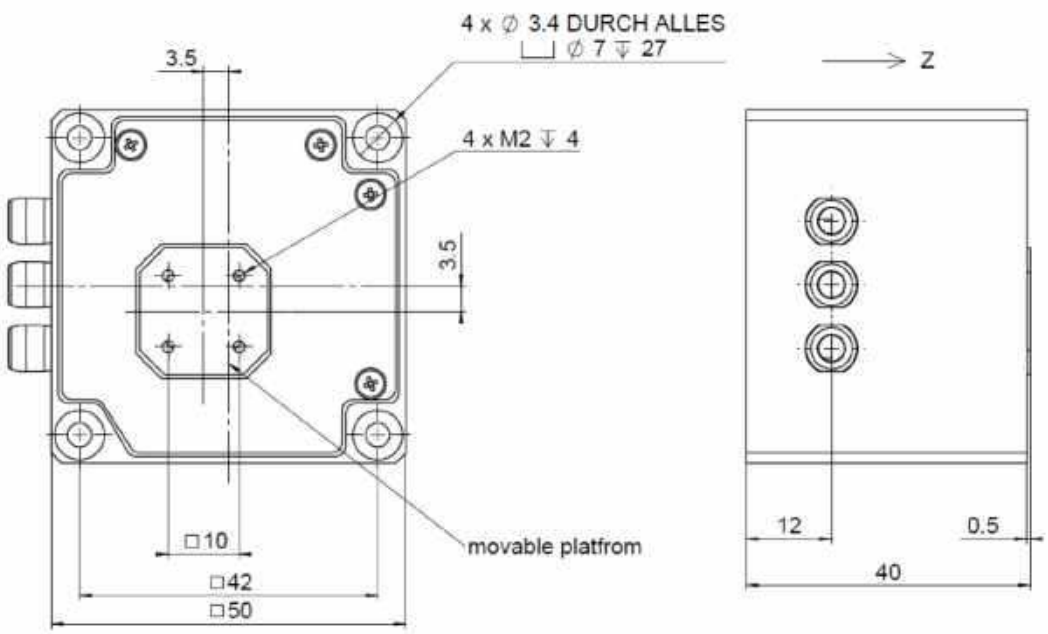
C3C Tick Cube

Fast Scanning and Tracking

The C3C Stage is made for the absolute highest dynamics and precision of scanning and tracking. The stages are ideal for near-field microscopy. The size is only 50x50x40 mm³. The stage is equipped with non-contact capacitive sensors. The system is designed as parallel-kinematics, which means: the position of the moving platform is measured in 3D simultaneously, so that the cross-talk can be actively eliminated.
The platform is small and light-weighted. The driving piezo-levers have low amplifications. Thus the lowest resonances of all axes are tremendously high.

Product-Number	C3C-D00120	Unit
Position-Sensor	Capacitive	
Ranges, closed loop, XY/Z	120/20	µm
Ranges, open-loop (-45..180 V)	150/24	µm
Resolution, closed loop	1/0.2	nm
Resolution, open loop	0.5/0.1	nm
Linearity, closed loop	0.03	%
Repeatability, XY/Z	10/2	nm
Push/Pull, max.	15/10	N
Resonance, XY, unloaded	2200	Hz
Resonance, Z, unloaded	5100	Hz
El. Capacitance @ 1V eff. 1kHz	3.3/3.3/1.1	µF
Body-Material	aluminum, stainless steel	
Operating Temperature	-20..+80	°C

Options:
- Vacuum-Compatibility and/or non-magnetic
- Suitable drivers, open-loop, EBO-050100
- Suitable controller, closed-loop, EBD-120230

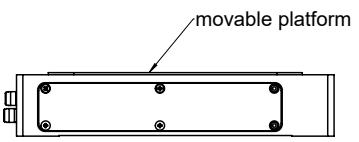


L3C XYZ-Stages with Capacitive Sensors

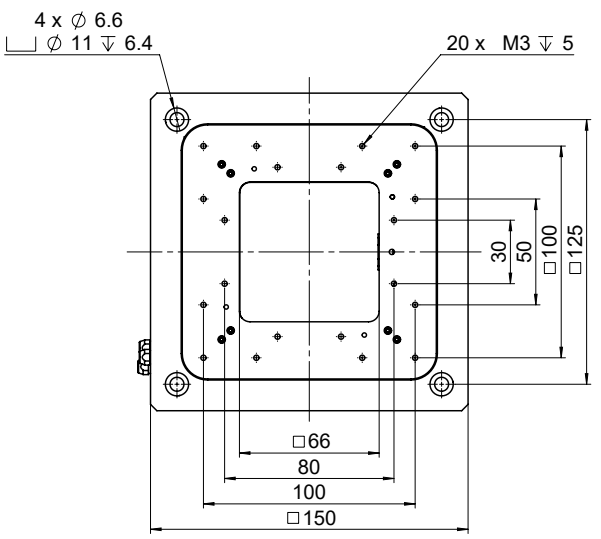
Fast Scanning and Tracking

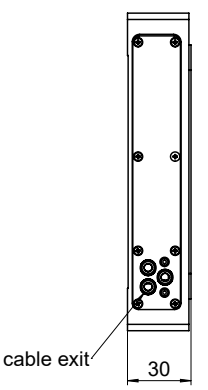
L3C Stages are made for highest dynamics of scanning and tracking. These stages are ideal for near-field microscopy. They are only 30 mm high and offer 66x66 mm² apertures. High precision frictionless flexure guiding leaves close to zero cross-talk and results in excellent flatness of motion. L3C stages are equipped with non-contact capacitive sensors. The systems are designed as parallel-kinematics, which means: the position of the moving platform is measured in 3D simultaneously, so that cross-talk can be actively eliminated. Versions with different Z-ranges are available, in order to serve those applications that require more dynamics and higher resolution, as well as those that have to cover larger height-variations.

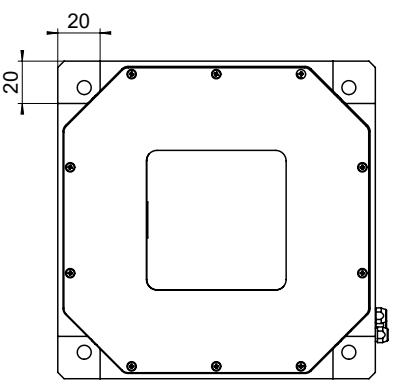
Product-Number	L3C-D10100-XY100Z20	L3C-D10100-XY100Z50	L3C-D10100-XY100Z100	Unit
Position-Sensors	Capacitive (Cap)			
Ranges, closed loop	100/100/20	100/100/50	100/100/100	µm
Ranges, open loop (-45..+180V)	140/140/24	140/140/60	140/140/120	µm
Resolution, closed loop, XY/Z	0.5/0.1	0.5/0.3	0.5	nm
Resolution, open loop, XY/Z	0.3/0.1	0.3/0.2	0.3	nm
Linearity, closed loop	0.02			%
Repeatability, XY/Z	5/1	5/3	5	nm
Resonance, XY, unloaded	1100			Hz
Resonance, Z, unloaded	1200	760	730	Hz
El. Capacitance	XY13.2/Z4.4	XY13.2/Z4.4	XY13.2/Z8.8	µF
Dimensions (LxWxH)	150x150x30			mm
Aperture, Dimensions (LxW)	66x66			mm
Body/Platform-Material	Aluminum, black			
Operating Temperature	-20..+80			°C



Options:
-Vacuum compability, and/or non-magnetic
-Suitable drivers, open-loop, EBO-050100
-Suitable controller, closed-loop, EBD-120230







L3a XYZ-Stages

Scanners for Microscopy

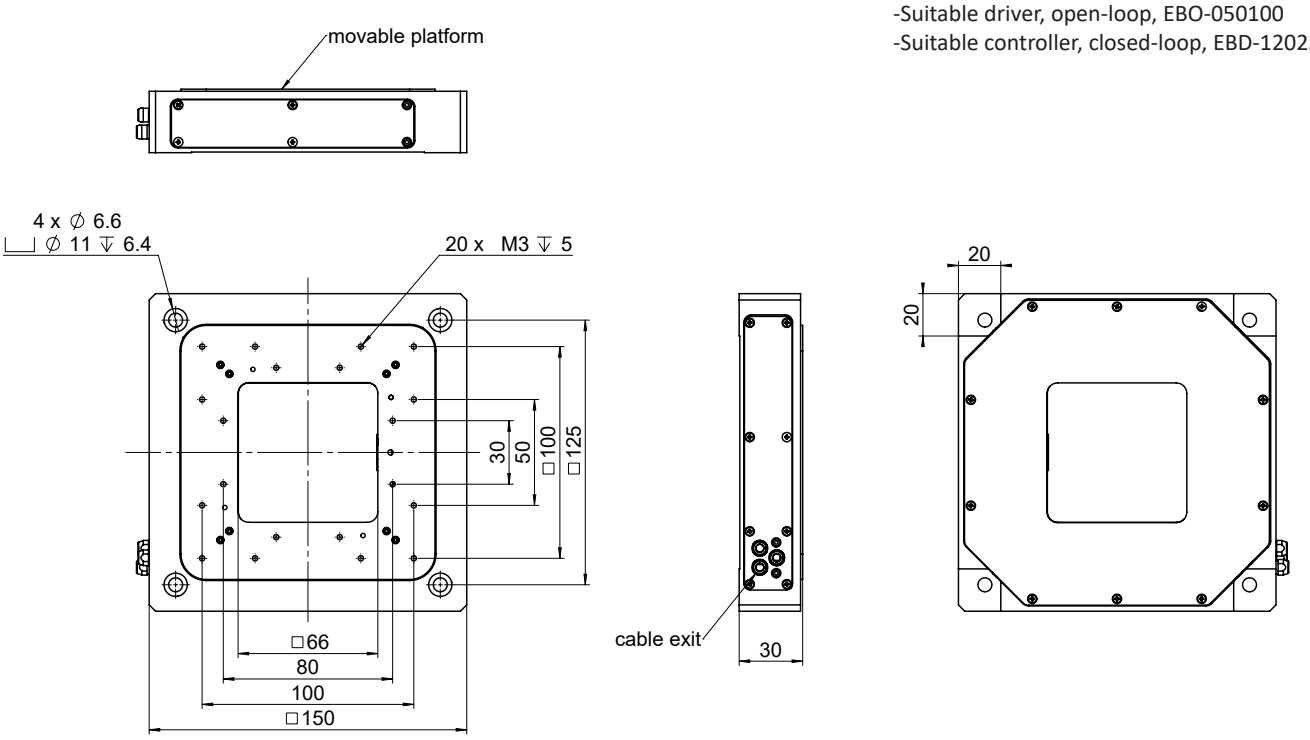
L3a Stages are made for scanning and tracking. The basic positioning-ranges are 300 µm or 600 µm. These stages are ideal for atomic-force and near-field microscopy. They are only 30 mm high and offer 66x66 mm^2 apertures. High precision frictionless flexure guiding leaves close to zero cross-talk and results in excellent flatness of motion. Versions with different Z-ranges are available, in order to serve those applications that require more dynamics and higher resolution, as well as those that have to cover larger height-variations.

Product-Number	L3S-D10300-XY300Z20	L3S-D10300-XY300Z50	L3S-D10300-XY300Z100	L3S-D10300-XYZ300	Unit
Position-Sensors	Strain-Gages, Full-Bridge (Capacitive Sensors optional)				
Ranges, closed loop	300/300/20	300/300/50	300/300/100	300/300/300	µm
Ranges, open loop (-45..+180V)	480/480/24	480/480/60	480/480/120	480/480/360	µm
Resolution, closed loop, XY/Z	3/0.2	3/0.3	3/0.5	3/1.5	nm
Resolution, open loop, XY/Z	1.5/0.1	1.5/0.3	1.5/0.5	1.5/1.5	nm
Linearity, closed loop	0.2				%
Repeatability, XY/Z	30/2	30/5	30/10	30/30	nm
Resonance, XY, unloaded	185				Hz
Resonance, Z, unloaded	680	600	580	450	Hz
El. Capacitance	XY13.2/Z4.4		XY13.2/Z8.8	XY13.2/Z13.2	µF
Body/Platform-Material	Aluminum, black				
Operating Temperature	-20..+80				°C

Options:
-Vacuum compability, and/or non-magnetic
-Suitable drivers, open-loop, EBO-050100
-Suitable controller, closed-loop, EBD-120230

Product-Number	XY600Z20	XY600Z50	XY600Z100	XY600Z300	Unit
Position-Sensors	Strain Gages, Full Bridge (Capacitive Sensors optional)				
Ranges, closed loop	600/600/20	600/600/50	600/600/100	600/600/300	µm
Ranges, open loop (-45..+180V)	720/720/24	720/720/60	720/720/120	720/720/360	µm
Resolution, closed loop, XY/Z	6/0.2	6/0.3	6/0.5	6/1.5	nm
Resolution, open loop, XY/Z	3/0.1	3/0.3	3/0.5	3/1.5	nm
Linearity, closed loop	0.2				%
Repeatability, XY/Z	60/1	60/3	60/5	60/15	nm
Resonance, XY, unloaded	160				Hz
Resonance, Z, unloaded	550	520	510	410	Hz
El. Capacitance	XY13.2/Z4.4		XY13.2/Z8.8	XY13.2/Z13.2	µF
Body/Platform-Material	Aluminum, black				
Operating Temperature	-20..+80				°C

Options:
-Vacuum compability, and/or non-magnetic
-Suitable driver, open-loop, EBO-050100
-Suitable controller, closed-loop, EBD-120230



T2a Tip/Tilt-Platform

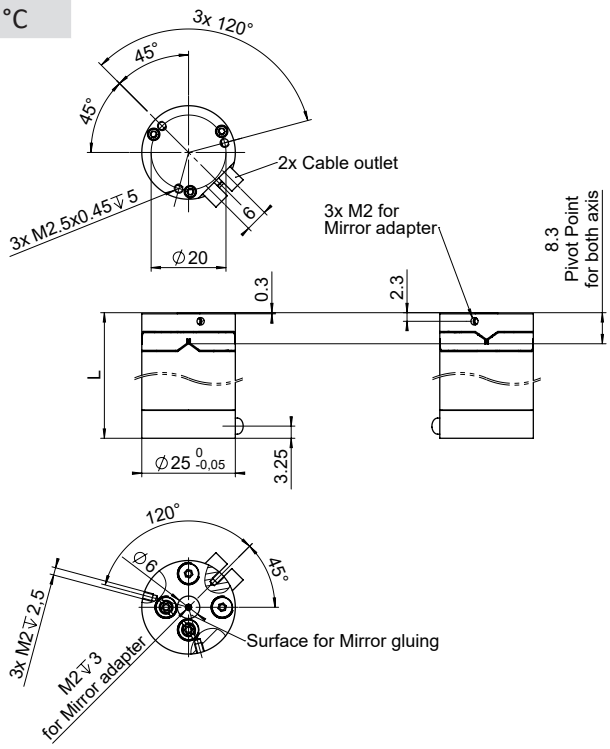
Mirror-Positioners

T2a piezo tip/tilt-platforms perform angular displacements of reflective optics in milliseconds. Resolutions are in the nrad-magnitude. The versions for 6 mrad and 12 mrad deflection are destined for optics up to 3” diameters. Tip and tilt axes lay in the same plane, 8.3 mm underneath the mounting-plane.
Single-axis platforms and special designs are available. Please contact us for your specific needs.

Product-Number	T2a-b00003	T2a-b00006	Unit
Angle/Deflection, closed loop	3 / 6	6 /12	mrad
Angle/Deflection, open loop	4 / 8	8 / 16	mrad
Resolution, open loop	40	80	nrad
Resolution, closed loop	80	160	nrad
Linearity, closed loop	0.2	0.2	%
Repeatability	150	300	nrad
Pivot Point, underneath ø 6 mm mounting platform	8,3		mm
Resonance, unloaded	2.4	1.9	kHz
Resonance, w/ ø25 x 8 mm mirror	1.7	1.4	kHz
El. Capacitance	2.2	4.4	µF
Lengh L	33.5	53.5	mm
Body-Material	aluminum or invar or stainless steel		
Operating Temperature	-20..+80		°C

Product-Name: T2a-b…..
a = O for the open-loop version
a = S for the version with position-sensor
b = P for pigtails (wires without socket)
b = L for Lemosa-socket (option for the open-loop version)
b = D for DSub-socket, 15 pins (option for the version with sensor)

Options:
- Vacuum-Compatibility
- Suitable driver, open-loop, EBO-050100
- Suitable controller, closed-loop, EBD-120220



Valve-Drives

Precise and Fast Dispensing

Piezo-drives as solid-state actuators are ideal for driving valves. They are fast, precise and need no more than electrical power. Dynamics up to 500 Hz at 300 µm amplitudes are possible. Of course: Also higher frequencies at smaller strokes and higher strokes at smaller frequencies.

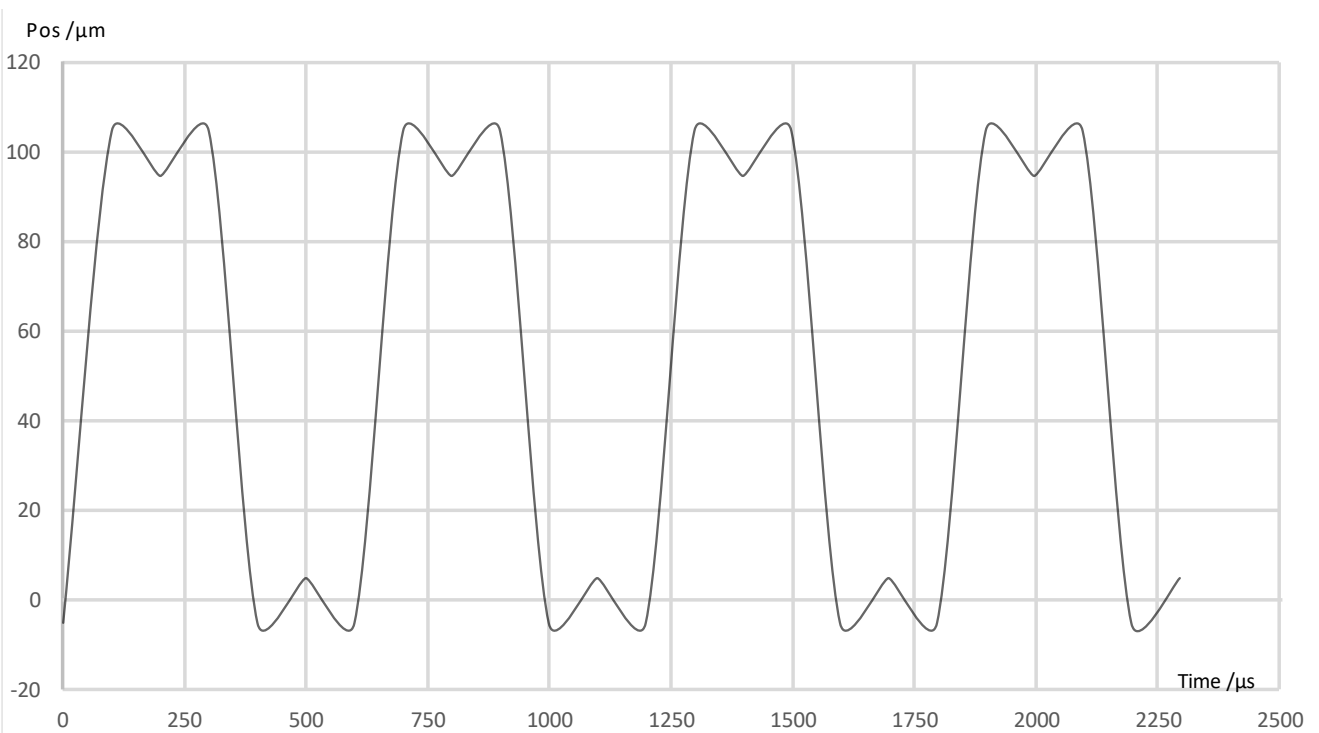
The mechanics for high dynamics must be built stiff in order to keep resonances much higher than the application frequencies. Lever amplifications are reduced to the actual necessary.

The demanded displacements, frequencies, rise-, fall- and dwell times determine the requirements for the driving-electronics. Linear amplifiers give the greatest flexibility, while pulse-generators are ideal for rectangular signals. nanoFaktur offers both.

The heating of the piezo-actuators must be taken into special consideration, if these are in continuous usage at high dynamics. At nanoFaktur we have experience of many years and many different applications. We design and combine the components for customers´ successful valve-drive applications.

5 Channel-Pulser, 100V 18 A

Analog Amplifier, 100V 3 A



Typical switching behaviour of a valve driving lever with a resonance of 5 kHz

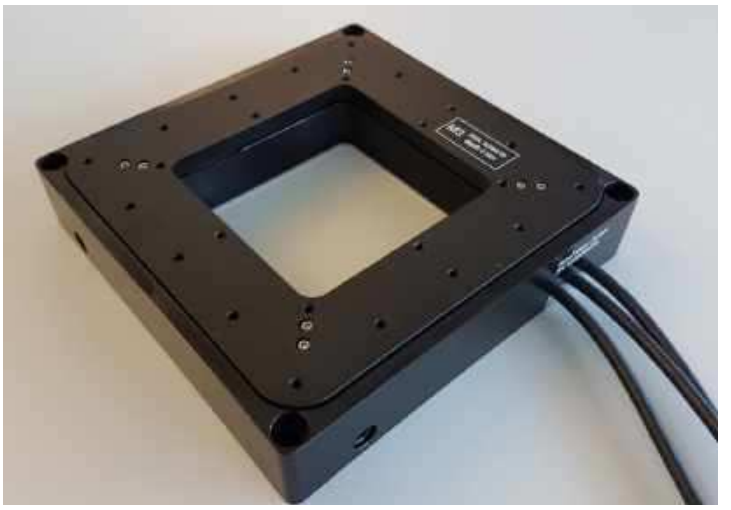
Custom Piezo-Systems

Flexible up to 6 Degrees of Freedom

At nanoFaktur, we are aware that quantity- and OEM-business mostly requires design-adaption of standard products or even complete new designs. New applications or research can usually only be satisfied by custom solutions.
In most cases, special designs bring our customers and us forward: New products to meet new markets´ demands and thus new and more business. There are so many custom-designed products already, that we can´t show them all here. Let us discuss the special product for your company or institute!

PPS-D08300 is a 300 µm linear stage (piston-motion). It is designed to actuate a small mirror into defined target positions in less than a millisecond. This has been achieved by employing a long laterally stabilized piezo-stack and a moderate lever-amplification. The integrated sensor grants a position-repeatability of 30 nm. The first resonance is as high as 2.5 kHz.

L3S-D90050 is a high-dynamics stage for confocal microscopy. It offers 50 µm range in 3 dimensions. The lowest resonances are close to 1 kHz. This allows for fast scanning of the samples. A large aperture gives access from both sides of the samples.



In a special project we have developed a piezo-stage combined with a load-cell. Forces up to 1 N can be defined and resolved in µN. In case of position-drifts the forces can be held constant by the 500 µm range of the piezo-drive.

The MegaFocus objective-positioner has been concepted and offered to customers. It will have a travel-range of 1.5 mm. The standard RangeFocus-Line positioners go up to 600 µm of displacement already. The MegaFocus-Line will conquer the ranges 1 mm and 1.5 mm.

Holder-frame for XRay-gratings. Manual micrometer-screw for initial angular fine-adjustments. Lateral displacement of 45 µm for shifting piezo-driven grating-lines.

Encapsulated Piezo Direct-Drive for tooling-machines. The encapsulated piezo-stack delivers 50 µm stroke at 150 V. Generated force is 4 kN. The encapsulation is hermetically sealed, in order to keep away cooling-liquids, lubricants and gas from the piezo-stack. These elements do their 24/7 job at high oscillation-frequencies. The number of cycles reached at full strokes is at magnitude 10^{10}, at smaller strokes even more.

T2S-D90010 is an asymmetric mirror-mount with closed-loop piezo-driven ranges of 12 mrad and 1.5 mrad. The elliptical mirror to be combined is 120x85x15 mm^3 of size. The application is pointing of LASER-beams for remote velocimetry.

ExO Piezo Drivers

High Power - Low Noise

Piezo-Actuators are supposed to deliver finest resolutions. Sometimes they must switch between positions at shortest response. Forces are to be generated in defined times. Application-optimized drivers are required for the above or additional specific needs. nanoFaktur offers such electronics according to current standards and cost-effective. Modifications and special-designs are of course possible. There are 2 standard product lines: ExO-050100 target static to medium-dynamic applications. ExO-300100 deliver strong currents for high dynamics. ExO-electronics are available as PCBs, rack-mount-modules or encapsulated versions.

	ExO Driver Electronics by Driving Power		
Product-Number	ExO-050100	ExO-300100	Unit
Channels	1		
Output-Voltage	-45 bis +180		V
Input-Voltage	-3 bis +12		V
Offset-Adjust-ment	0 bis 10		V
Amplification	15		
Noise, Output	0.3		mV
Max. Current	100	600	mA
Max. Average Current	50	300	mA
Protection	Short Circuit Proof		
Supply-Voltage	24		VDC
Supply-Current, max.	0.8	4	A
Analog Input	BNC		
Working-Tem-perature	-5 bis +50		°C
Standards	2006/95/EC, Low Voltage Directive 2004/108/EC, EMC Directive 2011/65/EU, RoHS Safety (Low Voltage Directive): EN 61010-1:2010 EMC: EN 61326-1:2013 RoHS: EN 50581:2012		

	ExO Driver Electronics by Layout		
Product-Number	EOO Board	EBO Encapsulated	EMO Module
Layout	PCB with heat-sink	Aluminum Box with Mounting-Shackles	Plug-In Module for 19” Rack-Mount
Output Interface	3way spring-type terminal	Lemosa, EPL.0S.302.HLN (Fitting Socket: FFA.0S.302.CLADxx)	
Analog Input	5way Phoenix ter-minal	BNC	
Connection, Power-Supply		24VDC, Tube-Plug, 5.5mm x 2.1mm	Phoenix terminal
Offset Adjustment		Potentiometer/Knob	

ExD-060100 Digital Controllers

Versatile and OEM-Compatible

nanoFaktur digital controllers are decisive parts of highest accuracy nanopositioning systems. These controllers drive piezo-actuators with low-noise of less than 5 ppm (rms). Strain-sensors as well as capacitive sensors can be driven and evaluated. Internal algorithms allow for linearization after characterizing with reference measurement-systems. Highest-accuracy probes obeying to official standards are being employed as references. Thus systems can be linearized to better than 0.01% of their respective full displacements.

EOD-060100

The OEM-version of EBD-060100 is called EOD-060100. It has the same specifics and comes as a PCB mounted on a cooling-plate.

All digital controllers of nanoFaktur have the ID-Chip feature: Characteristic data of the mechanics are stored on a chip in the connector of the mechanics. The controller detects, if a connection has been changed, then reads the data from the chip and the newly connected mechanics can be controlled. The main advantage of this feature is: All mechanics with the same kind of sensor and the same voltage range for the piezo-drive can be exchanged.

nanoFaktur digital controllers can be tuned easily by the users. System characteristics under specific conditions (load, orientation) can be measured with the included graphical user interface (GUI) software. P-I-D gain parameters and 2 notch-filters can be set to achieve optimum behavior and fastest response.

ExD-060 controllers are equipped with analog control and sensor monitor BNC connectors. The standard USB and RS232 interfaces can also be used to command and monitor the position of a stage. LabVIEW drivers facilitate the integration of nanoFaktur nanopositioning systems into a variety of customer applications. Software compatibility is given to EPICS, ScanImage, Nikon Elements, µManager.

EBD-060100

Product Number	ExD-060100	Unit
Channels	1	
Output Voltage for Piezo	-40 to +160	V
Input Voltage	-10 to +10, 0 to 10 V optional	V
Sensors	Strain-Gages (optional capacitive)	
Control Parameters	PID, Notch Filters	
Control Loop Time	24	µs
Software	nFControl Basic	
Software Requirements	Microsoft ® Windows™ XP/Vista/7/8/10	
Resolution	20 bit	
Max. Current	60	mA
Max. Average Current	25	mA
Protection	short circuit proof	
Supply	24 (1A max.)	VDC
Digital Interfaces	USB 2.0, RS232	
Connection, Piezo and Sensor	DSub15 f	
Connection, P/S	Tube-Plug, 5.5 x 2.5 mm, 9 mm insertion	
Connection, Input Voltage	BNC	
Connection, Monitor Out	BNC	

EBD-1202x0 Digital Controllers

2nd Generation Controls

nanoFaktur introduces its new line of digital controllers. Customers´ demands have consequently been realized with this. Starting with the encapsulation: All interfaces are placed on the front side, so that wiring- and access space can be saved decisively. There are shackles on both the back and on the bottom, so that the most practical integration can be chosen.
The second-generation EBDs are available for driving and reading strain-sensors and capacitive sensors. The achievable resolution is 5 ppm (rms) of the systems´ maximum ranges. Internal algorithms allow for linearization after characterizing with reference measurement-systems. At nanoFaktur, highest-accuracy probes referring to official standards are being employed as references. Thus systems can be linearized to better than 0.01% of their respective full displacements.
All digital controllers of nanoFaktur have the ID-Chip feature: Characteristic data of the mechanics are stored on a chip in the connector of the mechanics. The controller detects, if a connection has been changed, then reads the data from the chip and the newly connected mechanics can be controlled. The main advantage of this feature is: All mechanics with the same kind of sensor and the same voltage range for the piezo-drive can be exchanged.

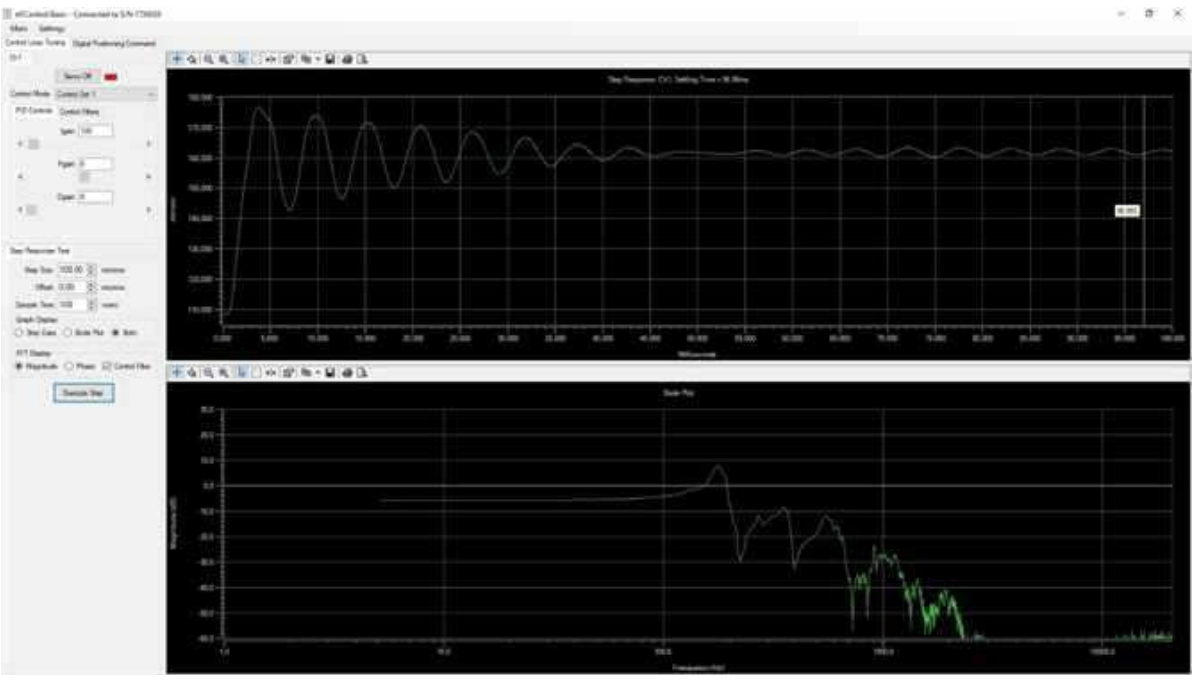
The controllers offer several ways of communication. The digital ones are Ethernet, USB, RS232 by default, plus the optional real-time parallel I/O. Also, real-time analog interfaces are integrated as standard: position inputs and sensor-monitor outputs. Programmable digital I/Os allow for generating trigger-signals in order to assign positions to time.
nanoFaktur digital controllers can be tuned easily by the users. System characteristics under specific conditions (load, orientation) can be measured with the included graphical user interface (GUI) software nFControl. P-I-D gain parameters and 2 notch-filters can be set to achieve optimum behavior and fastest response. Besides the GUI, there is a DLL for integration of the communication with nanoFaktur systems into customers´ software or other platforms like LabView™.

Product Numbers	EBD-1202x0 (x=number of channels)	Unit
Channels	1-3	
Output Voltage for Piezo	-45 to +180	V
Sensors	Strain-Gages (SGS) or Capacitive (Cap)	
Control Parameters	PID, 2 Notch Filters per channel	
Control Loop Time	10	µs
Software	nFControl, Windows™ GUI	
GUI Operating System Requirements	Microsoft ® Windows™ 7/8/10	
Resolution	20 bit	
Wave-Generators	arbitrary, 1..3 generators, up to 1024 tables	
Data-Recorders	up to 16	
Memory	16M points for wave-/recorder-tables	
Current / Average Current	300 / 120	mA
Protection	short circuit proof	
Supply	24 (2A min.)	VDC
Digital Interfaces	Ethernet, USB 2.0, RS232, Parallel (optional)	
Analog Interfaces I/O	settable, -10 to +10, -5 to +5, 0 to 10	V
Connection, Piezo and Sensor	DSub15f (1 CH), DSub25f (2, 3 CH)	
Connection, Analog I/O	2x BNC (1 CH), DSub15f (2, 3 CH versions)	
Power Supply	external, included	
Design	aluminum black	
Dimensions, H x W x D	73 x 200 (215 incl. shackles) x 157.5 (plus interfaces)	mm

Software

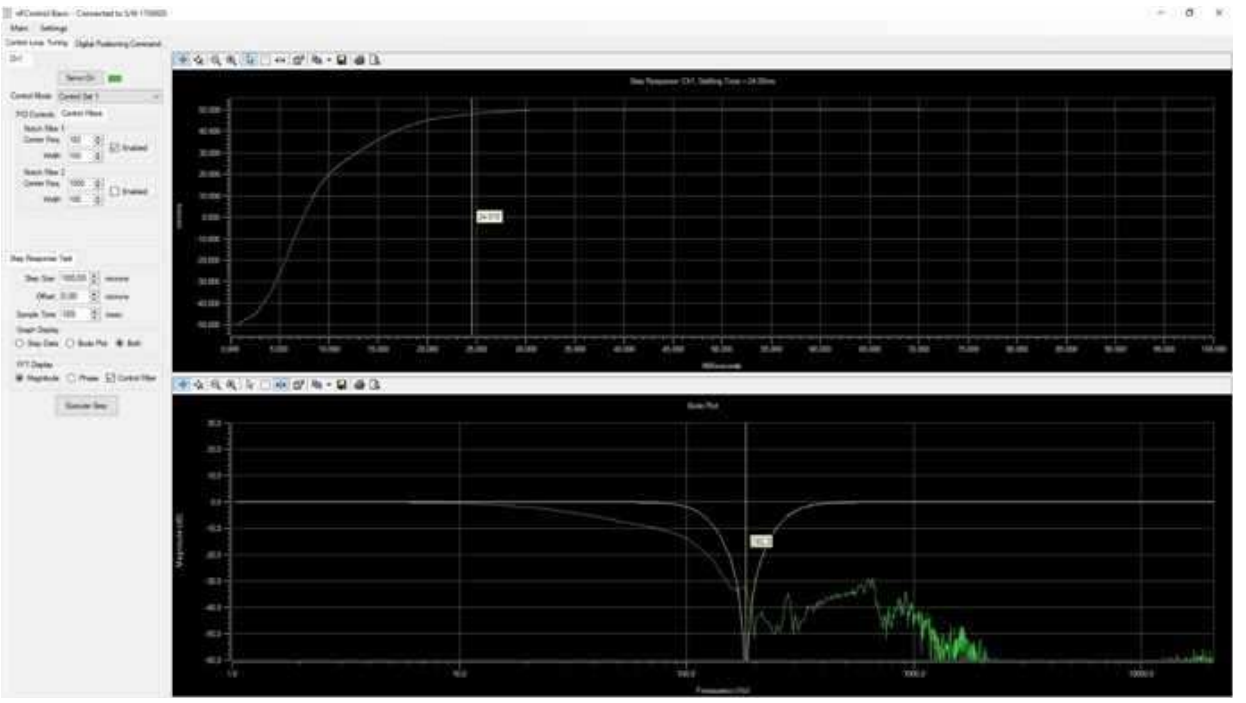
Analyse and Optimize

Control is made easy with nanoFaktur's Windows™-based software nFControl. Graphical displays for step-response and bode-plots facilitate the analysis of systems, the adjustments of control parameters, and the use of advanced control modes. Features such as waveform and trajectory generation simplify system integration and enhance the capabilities of nano-positioning systems. Sine, triangle and sawtooth are the default wave-forms. Arbitrary tables can be stored and run periodically at desired frequencies. For rectangular operations velocities and dwell-times can be programmed. The triggers can be given via GUI or from via digital I/O from outside.



System Analysis

The control loop tuning window allows the response of nano-positioning systems to be optimized for various applications via adjustable control parameters. This may be necessary when external factors change the dynamic characteristics, such as load or orientation. Users can adjust the P-I-D gains to achieve the desired response. 2 notch-filters per channel can be set in order to suppress resonance-effects.



Step-Response, tuned System

Persons and Governance

nanoFaktur

nanoFaktur was founded in Villingen-Schwenningen, Germany, in 2012. Each one of the three founders had had experience in designing and applying piezo-technology for many years already. We have taken active and decisive part in piezo-actuators and piezo-sensors conquering their importance in high-tech industries. The progress in many fields is depending on piezo-components, like in automotive, semi-conductor, surface-metrology, optics, astronomy, machine-tooling, etc.

Ralf Stamm has begun his relation to piezo in 1990 when building a tunable LASER-system. The tuning was of course the task of a piezo-stack. Ralf Stamm is physicist and has been a professional in application and sales of piezo-technology since 1992.

Klaus Pollak graduated as engineer at the Karlsruhe Institute of Technology (KIT). He is specialist for FEM-design of piezo-actuators and piezo-systems. He has been responsible on one hand for piezo-systems becoming smaller at the same properties and on the other hand on piezo-systems performing at higher strokes or other improvements.

Klaus Müller got his PhD of mechanical engineering also at the KIT. After that he has directly begun to FEM-design piezo-systems like a miniaturized 3D-scanner or all kinds of piezo-levers. Klaus Müller took a few years excurse into the solar-technology. During that time, he acquired an extensive knowledge in project- and supplier-management.

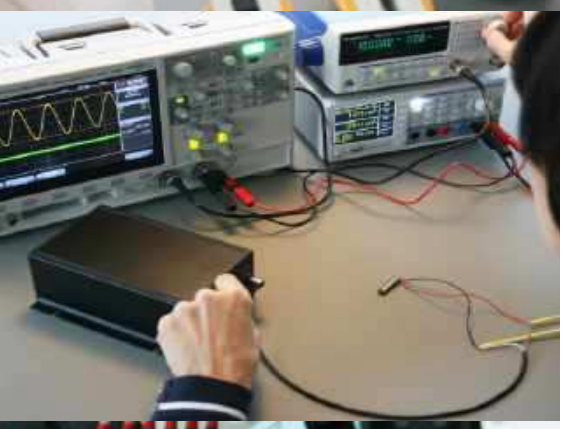
Highly and long-time qualified partners are representing nanoFaktur in all parts of the world.

Our team is dedicated to technology. Enthusiasm for new discoveries is driving us. We are curious to get to know applications, in which our piezo-solutions can accelerate innovation. The Kaizen principle is important for us: Try to find something to improve every day.

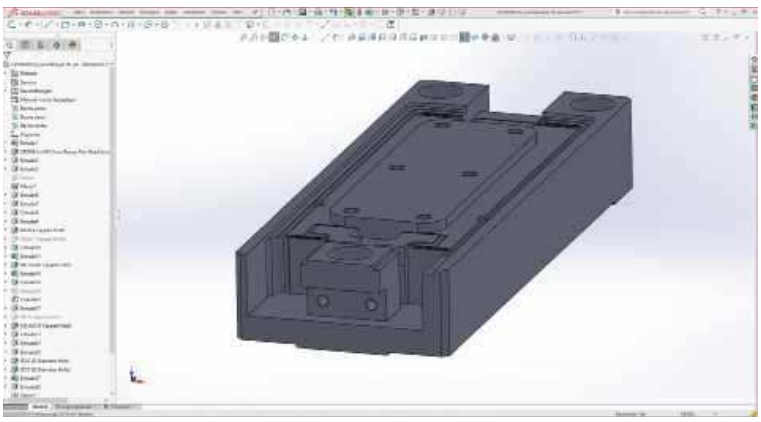
Environment: nanoFaktur-products are sold to many places all over the globe. We ship them well protected with neutral packing materials, so that the packaging can be easily used again. Equally, we reuse packing-material of arriving goods. All litter is separated and recycled as far as possible. Dangerous materials are handled with adequate and prescribed care.

Expertise

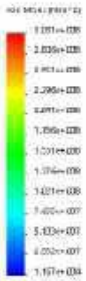
From Design to Production

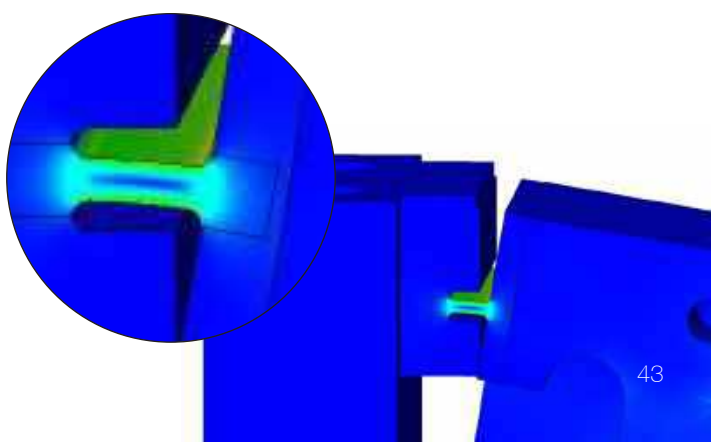


Engineers at nanoFaktur design piezo-systems with help of the finite-elements-method (FEM). This in combination with our decades-long experience guarantees for the products having the specified properties even after complete new designs and first makings.
Engineers´ and operators´ knowledge about material-processing, electronics, gluing, welding, soldering is the base for highest-quality production.
All products are tested, measured and calibrated with state-of-the-art metrology equipment (linear gages, interferometers) before shipment.



Custom designs with latest design tools for:
- UHV
- non-magnetic
- temperature range
- rugged external environments





nanoFAKTUR

piezo · positioning · systems

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