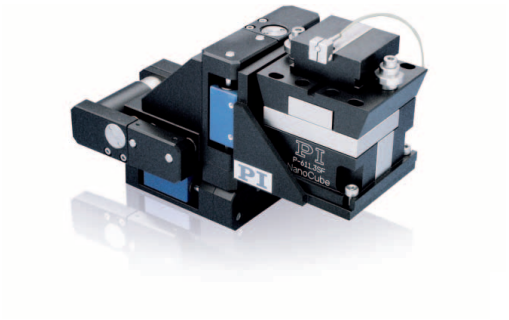
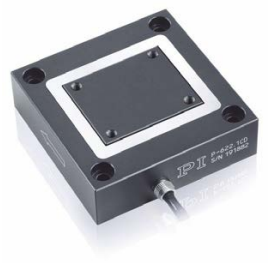
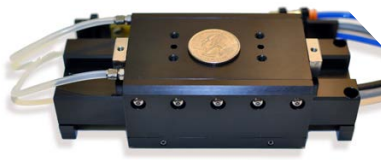




Miniature Precision Positioning Stages

SERVO, STEPPER, LINEAR, AND PIEZO MOTORS
CROSSED ROLLERS, FLEXURES, AND AIR BEARINGS

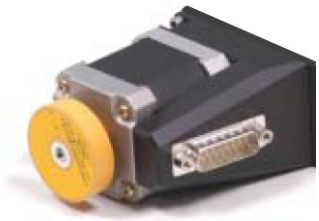
Contents

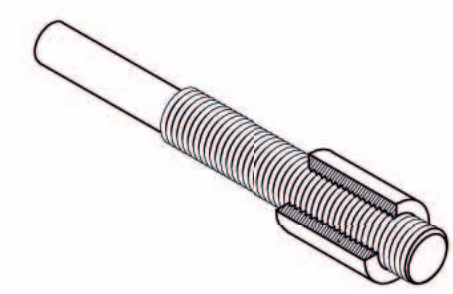
Other PI Product Lines

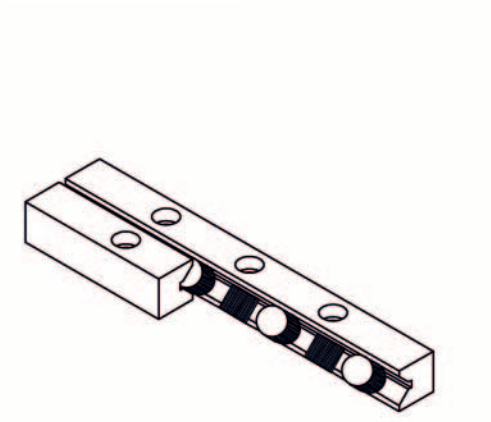
For long travel, high load positioning stages and other motion control products, go to www.pi-usa.us/products.

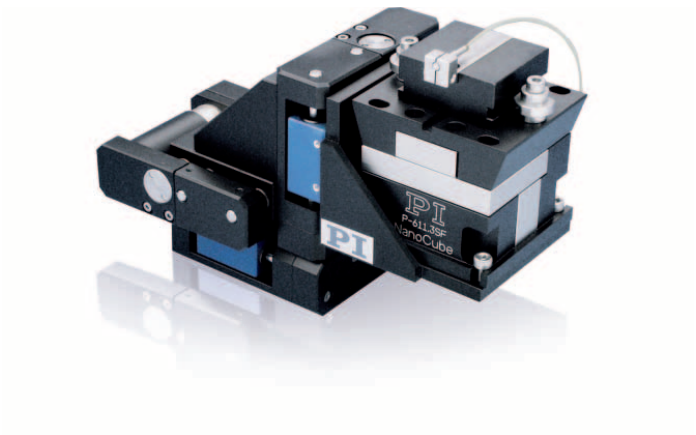
Motorized Miniature Positioning Systems

SERVO/STEPPER-DRIVEN







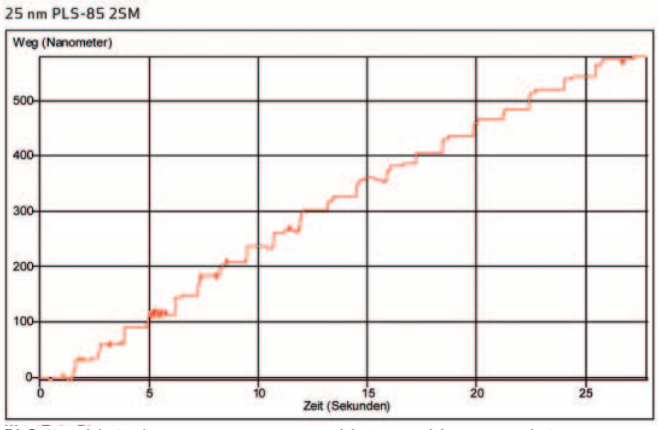


Servo & Stepper Motor Basics

Rotating Electric Motors

DC Motor / Servo Motor

A DC motor with position measurement is called servo motor. The typical characteristics of DC servo motors are uniform, vibration-free operation, a large velocity range and high torques at low velocity. To benefit in a best possible way from these properties, a motor controller with proportional, integral and differential control (PID) and suitable filters is required. The servo motor has numerous advantages, such as good dynamics, fast addressing, high torques at low velocities, reduced heat generation and low vibration.



PLS-85 with 2-phase stepper motor, without position control, 25 nm steps

ActiveDrive DC Motors

Some of the advantages of DC motor drives are good dynamic performance with a large control range, high torque at low revolutions, low heat dissipation and low vibration with a high position resolution. The cost of a high-performance linear amplifier, however, is generally higher than that for a stepper motor.

The ActiveDrive system reduces this cost considerably by integrating a PWM (pulse width modulation) driver-amplifier in the motor case. The operating voltage of normally 24 V for ActiveDrive motors is supplied by a separate power supply included in the scope of delivery. The ActiveDrive concept provides several advantages:

- Increased efficiency by eliminating power losses between the amplifier and motor
- Reduced cost, more compact system, and improved reliability, because no external driver and cabling are required
- Elimination of PWM amplifier noise radiation by mounting the amplifier and motor together in a single shielded case

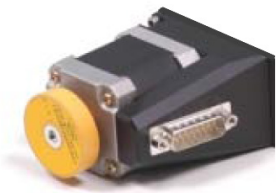
DC servo motors require an operating voltage of up to 12 VDC. The rotational velocity of the motor is directly proportional to the voltage; the sign determines the direction. Repeatable positioning requires an additional position feedback system.

Brushless DC Motor

PI uses more and more electronically commuted, brushless DC motors. Optimized hollow shaft or torque motors achieve high torques. At the same time, the drive train can be shorter for the same travel range because the drive shaft is located inside the motor.

Stepper Motor Drives

Contrary to DC motors, stepper motor drives only take up discrete positions in a revolution. As these steps have a constant distance, a position may be commanded using the number of steps without any need of a position sensor. Normally, there are 200 to 1000 full steps in each revolution. The actually achievable step width is determined by the stepper motor control, which electronically interpolates up to several hundred thousand microsteps in between the full steps depending on the version. PI uses smoothly running 2-phase stepper motors.

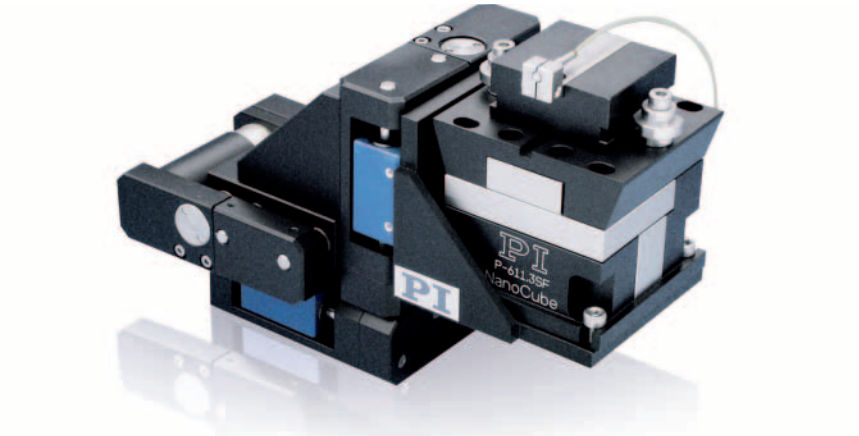


Stepper motors have very long lifetimes and, compared to DC motors, are especially suited for applications with reduced dynamics and in a vacuum. A mechanical damper on the motor shaft, which also works as handwheel, enhances running smoothness.

Combinations of Piezo & Electric Motors

Combinations of Piezo Actuator and and Electric Motor

In micropositioning, PI offers combinations of piezo-driven and motorized or manual stages. The motorized drive screw provides long travel ranges, and the additional piezo drive ensures accuracy to the nanometer and fast response behavior. The closed-loop control of such stacked systems works independently using separate position sensors, and the piezo starts to work when the motor stops. The positioning accuracy (not the design resolution) of such a structure is limited by the motorized system. Ideally, this combination is completed by an external control loop.



This 3-axis fiber positioning system combines motorized stages for rough positioning over 15 mm with a step width of 50 nm with a fast piezo scanner for fine adjustment over a travel range of 100 µm with 1 nm resolution. The intensity of the light in the fiber determines the optimum position and is used as external control variable

Miniature Servo/Stepper Motor Linear Stage

XY(Z) COMBINATIONS

M-110, M-111, M-112

- Travel Ranges 5, 15 and 25 mm
- Very Cost Effective
- Min. Incremental Motion to 50 nm
- Max. Velocity 2 mm/s
- Closed-Loop DC Motors and Stepper Motors
- Non-Contact Limit and Reference Switches rotation axis
- Optional Recirculating Ball Screw Drives Provide High Speeds & Long Lifetimes
- Vacuum-Compatible Versions Available to 10-6hPa

M-110, M-111 and M-112 are ultra-high resolution motorized translation stages providing linear motion of 5 to 25 mm in an extremely compact package. They feature a precision lead-screw with sub-micron resolution and precision linear ball bearings guaranteeing <0.5 µm straightness of travel.

Compact Dimensions, High Performance
To meet industrial demands, the M-11x.2 linear translation stages are equipped with a re-circulating ball screw for precise motion with reduced friction. This allows 24/7 duty cycles. M-110, M-111 and M-112 can be combined to XY and XYZ systems for multi axis alignment applications.

Stepper and Servo Motors
A miniature DC or stepper motor actuates motion via a backlash-compensated screw/nut system and gearhead. Both drive options provide a cost-effective solution for industrial and OEM environments. To meet the most critical positioning demands, the DC motor is equipped with a high resolution encoder featuring resolution down to 0.007 µm per count.

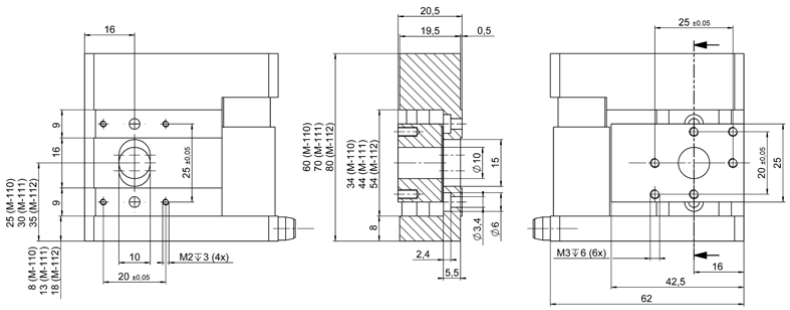
Limit and Reference Switches
For the protection of your equipment, non-contact Hall-effect limit and reference switches are installed. The direction-sensing reference switch supports advanced automation applications with high precision.

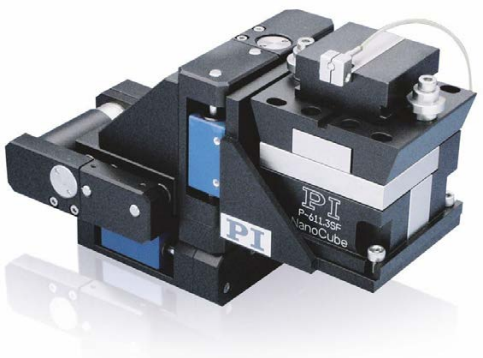
All stages include an integral 0.5 m cable with 15-pin sub-D connector and come with a 3 m extension cable. On the DC servo versions, the connector features integrated line drivers for cable lengths up to 10 meters between stage and controller (DC-motors only).

Low Cost of Ownership
The combination of these positioners with the networkable, single-channel C-863 Mercury™ or C-663 Mercury™ Step controller offers high performance for a very competitive price in both single- and multiaxis configurations. For 3 or 4 axes, the C-843 PC plug-in board for DC motors can also be recommended.

	M-110.1DG / M-111.1DG / M-112.1DG	M-110.12S / M-111.12S / M-112.12S	M-110.2DG / M-111.2DG / M-112.2DG	M-110.22S / M-111.22S / M-112.22S	Unit	Tolerance
Motion and positioning						
Travel range	5 / 15 / 25	5 / 15 / 25	5 / 15 / 25	5 / 15 / 25	mm	
Integrated sensor	Rotary encoder	–	Rotary encoder	–		
Sensor resolution	2048		2048		Cts./ rev.	
Design resolution	0.0069	0.038*	0.0086	0.046*	µm	
Incremental motion	0.05	0.05	0.2	0.2	µm	min.
Backlash	2	2	4	4	µm	
Unidirectional repeatability	0.1	0.1	0.5	0.5	µm	
Pitch / yaw	±50 / ±150 / ±150	±50 / ±150 / ±150	±50 / ±150 / ±150	±50 / ±150 / ±150	µrad	
Velocity	1 / 1.5 / 1.5	1 / 1 / 1	1.5 / 2 / 2	1 / 1 / 1	mm/ s	max.
Mechanical properties						
Drive screw	Leadscrew	Leadscrew	Recirculating ball screw	Recirculating ball screw		
Thread pitch	0.4	0.4	0.5	0.5	mm	
Gear ratio	28.44444:1	28.44444:1	28.44444:1	28.44444:1		
Motor resolution*	–	384*	–	384*		
Load capacity	30 / 30 / 20	30 / 30 / 20	30 / 30 / 20	30 / 30 / 20	N	max.
Push / pull force	10	10	10	10	N	max.
Holding force	10	10	10	10	N	max.
Lateral force	15 / 10 / 10	15 / 10 / 10	15 / 10 / 10	15 / 10 / 10	N	max.
Drive properties						
Motor type	DC gear motor	2- phase stepper motor	DC gear motor	2- phase stepper motor		
Operating voltage	0 to ±12	24	0 to ±12	24	V	
Motor power	0.52 / 1.75 / 1.75	1.5	0.52 / 1.75 / 1.75	1.5	W	
Current consumption	160 / 320 / 320**		160 / 320 / 320**		mA	
Reference point and limit switches	Hall effect	Hall effect	Hall effect	Hall effect		
Miscellaneous						
Operating temperature range	-20 to 65	-20 to 65	-20 to 65	-20 to 65	°C	
Material	Al (black anodized)	Al (black anodized)	Al (black anodized)	Al (black anodized)		
Mass	0.3 / 0.4 / 0.5	0.3 / 0.4 / 0.5	0.3 / 0.4 / 0.3	0.3 / 0.4 / 0.5	kg	
Recommended controller / driver	C-863 (single- axis) C-843 PCI board, for up to 4 axes	C-663 single- axis	C-863 single- axis C-843 PCI board, for up to 4 axes	C-663 (single- axis)		

* 2- phase stepper motor, 24 V chopper voltage, max. 0.25 A/ phase, 24 full steps/ rev., motor resolution with C-663 stepper motor controller.
** thermally limited.





This 3- axis fiber positioning system combines motorized stages for rough positioning over 15 mm with a step width of 50 nm with a fast piezo scanner for fine adjustment over a travel range of 100 µm with 1 nm resolution. The intensity of the light in the fiber determines the optimum position and is used as external control variable.

Compact Linear Stage with Linear Encoder

FAST, COMPACT, DIRECT POSITION MEASUREMENT

M-122

- Travel Range 25 mm
- 0.1 µm Optical Linear Encoder for Highest Accuracy & Repeatability
- Min. Incremental Motion to 0.2 µm
- Max. Velocity 20 mm/s
- Cross-Roll Bearings
- Recirculating Ball Screw Drives Provide High Speeds & Long Lifetimes

The M-122 palm-top-sized translation stage combines small dimensions, high speeds and very high accuracy at a competitive price. It features a space-saving, folded drive train with the servo motor and drive screw side-by-side. Equipped with a non-contacting optical linear encoder and a preloaded, precision-ground, ball-screw, these stages can provide much higher accuracy and better repeatability than conventional stepper motor stages or rotary encoder-equipped servo motor stages.

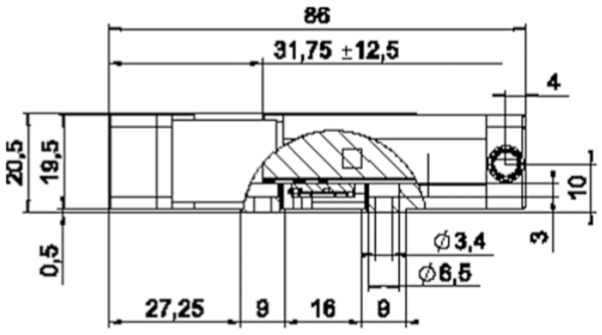
Low Friction, High Speed, Maintenance-Free
Due to its low-friction, the backlash-free ball screw yields significantly higher mechanical efficiency than lead screws, and allows maintenance-free, high duty-cycle operation at high velocities up to 20 mm/sec.

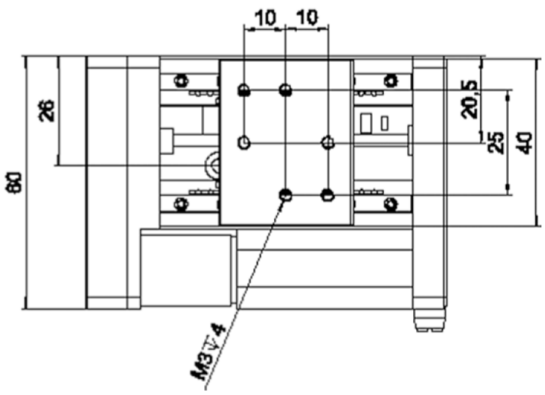
XY and XYZ Combinations
M122 stages can be combined to very compact XY and XYZ systems. The M-122.AP1 mounting bracket is available to mount the Z-axis.

Limit and Reference Switches
For the protection of your equipment, non-contact Hall-effect limit and reference switches are installed. The direction-sensing reference switch supports advanced automation applications with high precision.

Low Cost of Ownership
The combination of these positioners with the networkable, single-channel C-863 Mercury™ servo motor controller offers high performance for a very competitive price in both single and multi-axis configurations. For multi-axis applications, the C-848 controller with onboard servo amplifiers is another cost-effective alternative.

	M-122.2DD	Unit	Tolerance
	High- Precision Translation Stage		
Motion and positioning			
Travel range	25	mm	
Integrated sensor	Linear encoder		
Sensor resolution	0.1	µm	
Design resolution	0.1	µm	
Incremental motion	0.2	µm	min.
Backlash	0.2	µm	
Unidirectional repeatability	0.15	µm	
Pitch	±150	µrad	
Yaw	±150	µrad	
Velocity	20	mm/ s	max.
Reference point switch repeatability	1	µm	
Mechanical properties			
Drive screw	Recirculating ball screw		
Thread pitch	0.5	mm	
Stiffness in motion direction	0.25	N/ µm	
Load capacity	50	N	max.
Push / pull force	20	N	max.
Lateral force	25	N	max.
Drive properties			
Motor type	DC motor		
Operating voltage	0 to 12 (differential)	V	
Motor power	2.25	W	
Reference point and limit switches	Hall effect		
Miscellaneous			
Operating temperature range	-20 to 65	°C	
Material	Aluminum, steel		
Dimensions	86 mm × 60 mm × 20.5 mm		
Mass	0.22	kg	
Recommended controller / driver	C-863 (single- axis) C-848 for up to 4 axes		





Miniature Rotation Stage with Servo/Stepper Motor

COMPACT, MULTI AXIS COMBINATIONS

M-116

- Compact Design
- Continuous Rotation Range
- Encoder resolution 2.5 µrad
- Clear aperture for transmission applications
- Max. velocity 20°/ s
- Preloaded Worm Drive for Zero
- Fits directly on M-110 micro translation stages
- Non- contact reference point switch
- Repeatability to ±10 µrad

M-116 rotation stages are equipped with low-friction, spring-preloaded worm gear drives allowing unlimited rotation in either direction in an extremely compact package.

Stepper and Servo Motors
Both drive options provide a cost-effective solution for industrial and OEM environments. A miniature DC or stepper motor actuates motion via a spring-preloaded worm gear drive and zero-backlash (with M-116.xxH versions) gearhead.

To meet the most critical positioning demands, the DC motor is equipped with a high-resolution encoder featuring resolution of 2 048 counts per revolution. The combination of the extremely low-stiction/low-friction construction and high-resolution encoder allows for minimum incremental motion of 25 µrad at speeds up to 20 degrees/second.

Multi-Axis Combinations
M-116 rotary stages can be combined with the M-110, M-111 and M-112 micro linear stages without an additional adapter plate to keep the total height at a minimum.

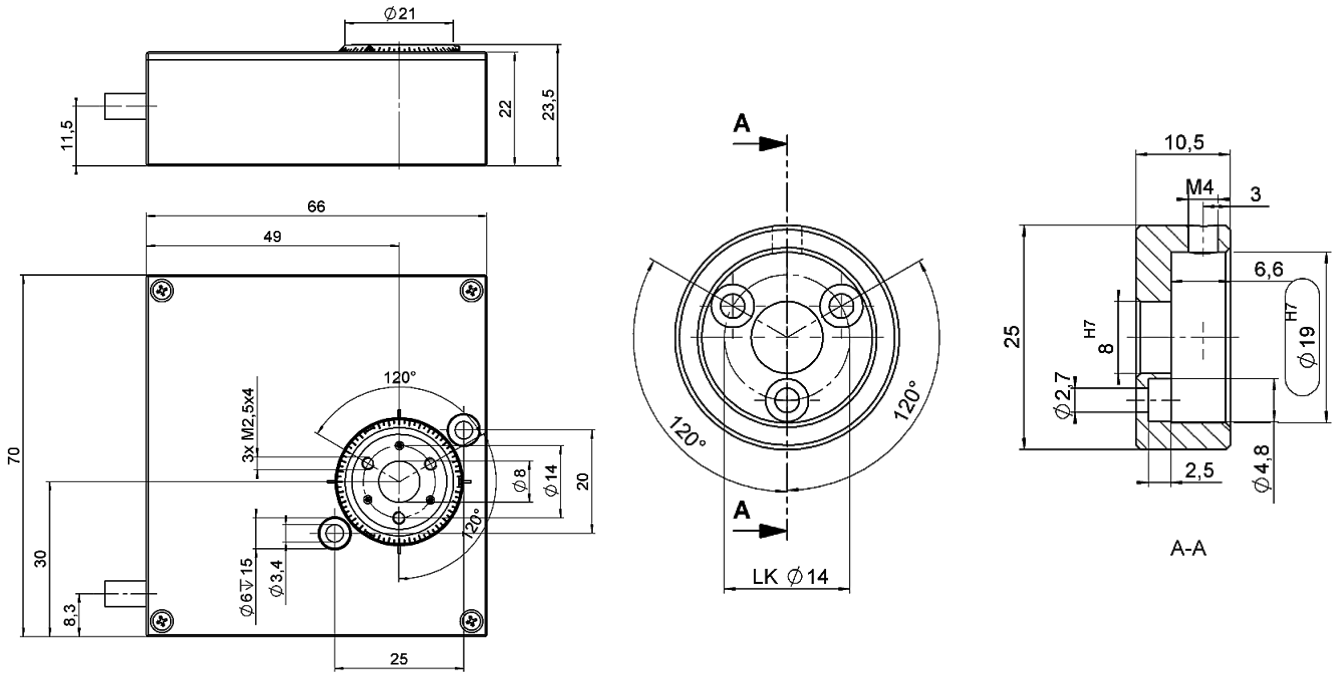
Clear Aperture, Lens Adapter
The M-116 is designed with a clear aperture for extended versatility in optics applications. The M-116.AL1 lens adapter is available to accommodate 0.5" optics such as polarizers.

Non-Contact Limit and Reference Switches
Motorized models are equipped with an integrated Hall-effect origin switch. To protect your equipment and increase versatility in automation applications, the rotary stage can optionally be equipped with Hall-effect limit switches. Travel can be limited to a range between 0° and 330° ±2°.

For ease of operation and setup, all models come with a scale ring on the outer edge of the turntable.

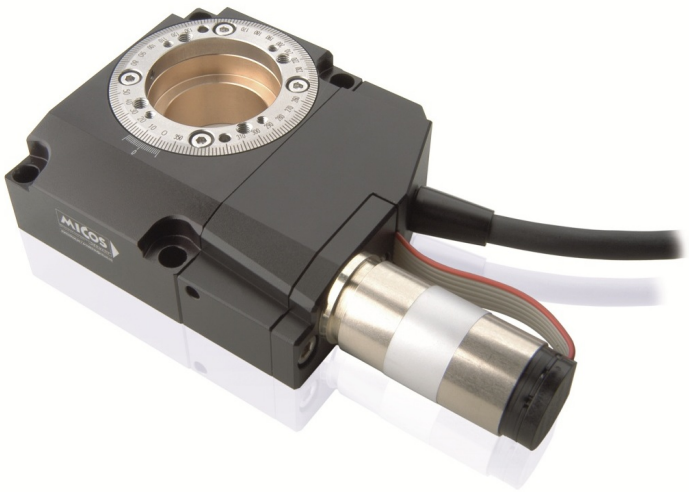
	M-116.DG	M-116.DGH	M-116.2SH	Unit	Tolerance
Active axes	Rotation	Rotation	Rotation		
Motion and positioning					
Rotation range	>360	>360	>360	°	
Integrated sensor	Rotary encoder	Rotary encoder	–		
Sensor resolution	2048	2048	–	Cts./ rev.	
Design resolution	2.45 (0.00013)	3.16 (0.00018)	16.9* (0.00097)	µrad (°)	
Incremental motion	50	25	30	µrad	min.
Backlash	1000	500	500	µrad	
Unidirectional repeatability	12	10	10	µrad	
Velocity	20	20	20	°/ s	max.
Mechanical properties					
Worm gear ratio	44:1	44:1	44:1		
Gear ratio	28.444:1	22.0335:1	22.0335:1		
Motor resolution	–	–	384*	steps/ rev.	
Load capacity / axial force	±15	±15	15	N	
Torque (θ_X, θ_Y)	±1.5	±1.5	±1.5	Nm	max.
Torque clockwise (θ_Z)	0.4	0.4	0.4	Nm	max.
Torque counterclockwise (θ_Z)	0.8	0.8	0.8	Nm	max.
Drive properties					
Motor type	DC gear motor	DC gear motor	2- phase stepper motor*		
Operating voltage	0 to ±12	0 to ±12	24	V	
Motor power	1.75	1.75		W	
Reference point switch	Optical	Optical	Optical		
Miscellaneous					
Operating temperature range	-20 to 65	-20 to 65	-20 to 65	°C	
Material	Aluminum	Aluminum	Aluminum		
Mass	0.4	0.4	0.4	kg	
Recommended controller / driver	C-863 (single- axis) C-843 PCI board, for up to 4 axes	C-863 (single- axis) C-843 PCI board, for up to 4 axes	C-663 (single- axis)		

* Max. 0.25 A/ phase; 24 full steps/ rev., motor resolution with C-663 stepper motor controller.



Miniature Rotation Stage with Servo/Stepper Motor

POSITION CONTROL, HIGH RESOLUTION, AFFORDABLE



RS-40

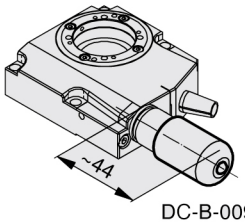
- Clear aperture 20 mm
- Uni-directional repeatability down to 0.005°
- Maximum speed 7°/sec
- Load capacity up to 1kg
- Integrated hall reference switch
- Optionally rotary encoder on the rotation axis

The RS-40 rotation stage is very compact but offers a big 20 mm (25 mm holding diameter) aperture. A precision bearing guarantees a perfectly smooth move. The RS-40 rotation stages have nearly zero backlash worm gear reduction. All RS-40 motorized rotation stages are equipped with a hall reference switch and are offered with a DC or geared stepper motor.

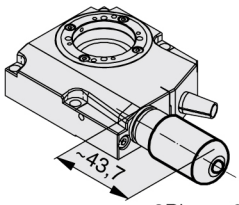
Load characteristics	Fx(N)	Fx(N)	Mx(Nm)	Mx(Nm)	k÷x(µrad/Nm)
DC-B-009	1	20	2	0.2	270
2Phase-010	5	10	1	0.2	270

Model	DC-B-009	2Phase-010
Travel range (°)	360, endless	
Flatness (Bearings) (µm)	± 5	
Eccentricity (Bearings) (µm)	± 5	
Wobble (Bearings) (µrad)	± 35	
Weight (kg)	0.4	
Speed max. (°/sec)	7	5
Resolution calculated (°)	0.00003 (RE)	0.0021961 (FS)
Resolution typical (°)	0.005	0.005
Bi-directional Repeatability (°)	± 0.04	± 0.04
Uni-directional Repeatability (°)	0.005	0.005
Nominal Current (A)	0.16	0.25
Voltage Range (V)	12	
Worm gear reduction	90:1	
Accuracy	on request	
Velocity range (°/sec)	0.002 ... 7	
Material	Aluminum, black anodized, stainless steel, red brass	

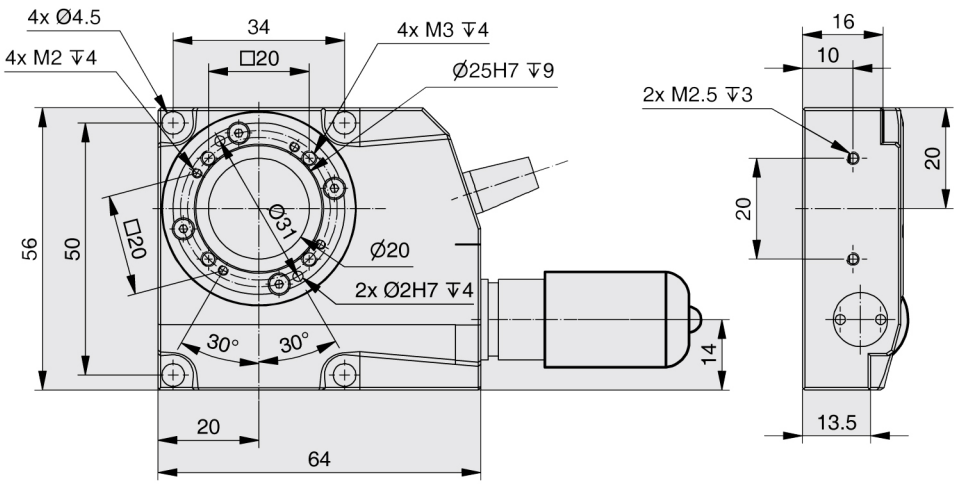
* FS = full step, RE = rotary encoder

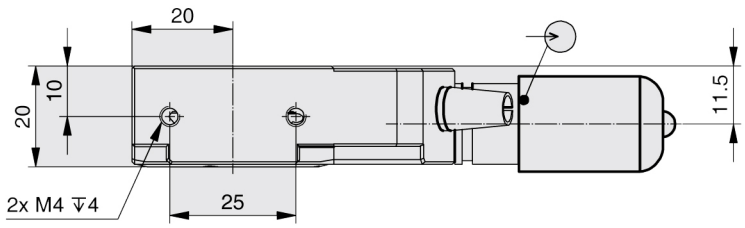


DC-B-009



2Phase-010





mm

Mercury Motion Controller

DIGITAL MOTION CONTROLLER FOR STEPPER AND DC SERVO MOTORS

C-863, C-663

- Compact, Powerful and Cost Effective Single Axis Controllers
- Up to 16 units Networkable
- Macro programmable for stand-alone functionality
- Digital I/O ports (TTL)
- Control signal for motor brake
- Interfaces: RS-232 and USB
- Optional joystick for manual control
- Data recorder
- Non-volatile EEPROM for macros and parameters

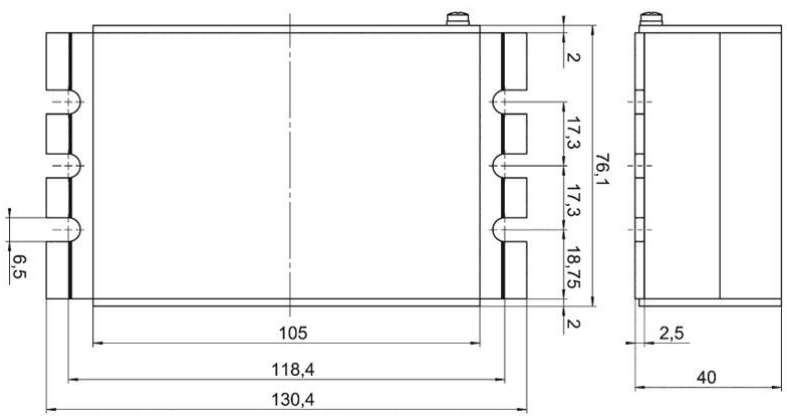
C-863 and C-663 are compact, low-cost digital motion controllers for DC servo and stepper motors, respectively: The servo motor version provides direct motor control (analog out) and PWM output for fast PI stages with integrated ActiveDrive amplifiers or with brushless motors and integrated block commutation.

Extensive functionality
Powerful macro command language. Non-volatile macro storage, e. g. for stand-alone functionality with autostart macro. Data recorder. Parameter changes on the fly. Extensive software support, e.g. for LabVIEW, shared libraries for Windows and Linux.

Mercury class motion controller
Daisy-chain networking for up to 16 axes operated via a common computer interface. Interfaces: USB and RS-232 for commands. A/B (quadrature) encoder input. TTL inputs for limit and reference point switches, motor brake output, I/O ports (analog / digital) for automation. Interface for analog joystick. Delivery scope including wide-range power supply, USB and RS-232 cable, daisy-chain network cable.

Model	C-863.11	C-663.11
Function	DC servo-motor controller, stand-alone capability	2 Phase Stepper motor controller, stand-alone capability
Channels	1	1
Motion and control		
Servo characteristics	PID controller, parameter changes on the fly	
Servo cycle time	50 µs	
Microstep resolution		1/16 full step
Profile generator	Trapezoid velocity profile	Trapezoidal, point-to-point
Encoder input	AB (quadrature) single-ended or differential TTL signal acc. to RS-422; 60 MHz	
Stall detection	Servo off, triggered by programmable position error	
Limit switches	2 × TTL (polarity programmable)	2 × TTL (polarity programmable)
Reference point switch	1 × TTL, programmable	1 × TTL, programmable
Motor brake	1 × TTL, software controlled	1 × TTL, software controlled
Electrical properties		
Max. output voltage*	0 to ±15 V for direct control of DC motor	15 to 30 V
Current limitation	2 A	1 A per motor phase
Interface and operation		
Communication interfaces	USB, RS-232 (bus architecture), Sub-D 9-pin (m)	USB, RS-232 (bus architecture), Sub-D 9-pin (m)
Motor connector	Sub-D 15-pin (f)	Sub-D 15 (f)
Controller network	Up to 16 units** on a single interface	Up to 16 units** on single interface
I/O ports	4 analog/digital in, 4 digital out (TTL), 5 V TTL	4 analog/digital in, 4 digital out (TTL), 5 V TTL
Command set	PI General Command Set (GCS)	PI General Command Set (GCS)
User software	PIMikroMove	PIMikroMove
Software drivers	LabVIEW driver, shared libraries for Windows and Linux	LabVIEW driver, shared libraries for Windows and Linux
Supported functionality	Point-to-point motion, start-up macro, data recorder for recording parameters as motor input voltage, velocity, position or position error; internal safety circuitry: watchdog timer	Start-up macro, data recorder for recording parameters as motor input voltage, velocity, position or position error
Manual control	Optional: Pushbutton box, joystick (for 2 axes), Y-cable for 2-D motion	Optional: Pushbutton box, joystick (for 2 axes), Y-cable for 2-D motion
Miscellaneous		
Operating voltage	15 to 30 V, in the scope of delivery: external power supply 15 V / 2 A	24 V (external wide range power supply)
Max. operating current	80 mA plus motor current (max. 3 A)	80 mA plus motor current (max. 3 A)
Operating temperature range	5 to 50 °C	5 to 50 °C
Mass	0.3 kg	0.3 kg
Dimensions	130 mm × 76 mm × 40 mm	130 mm × 76 mm × 40 mm

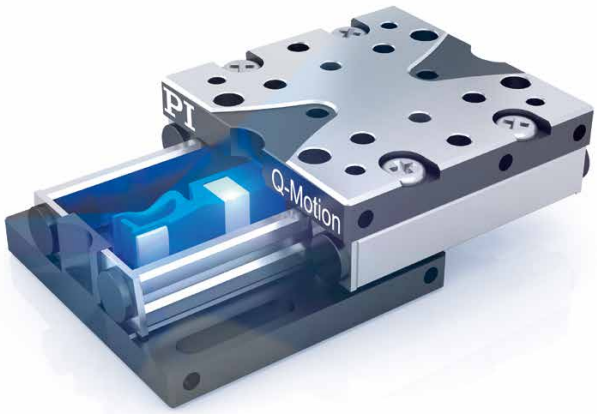
* The output voltage depends on the connected power supply.
** 16 units via USB; 6 units via RS-232.



C-863, dimensions in mm

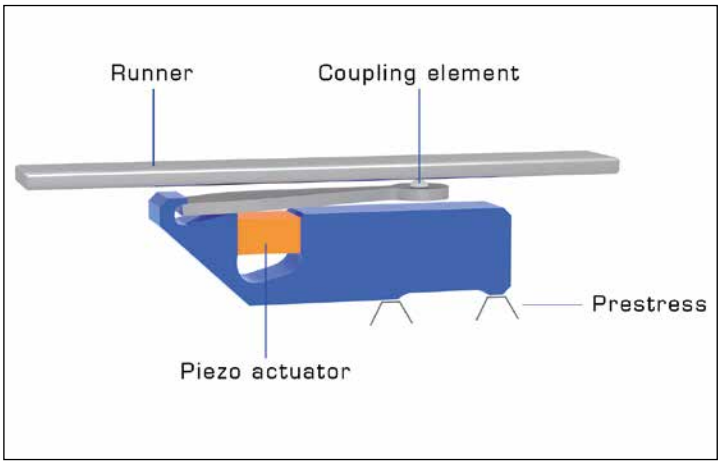
Piezo Inertia Miniature Positioning Systems

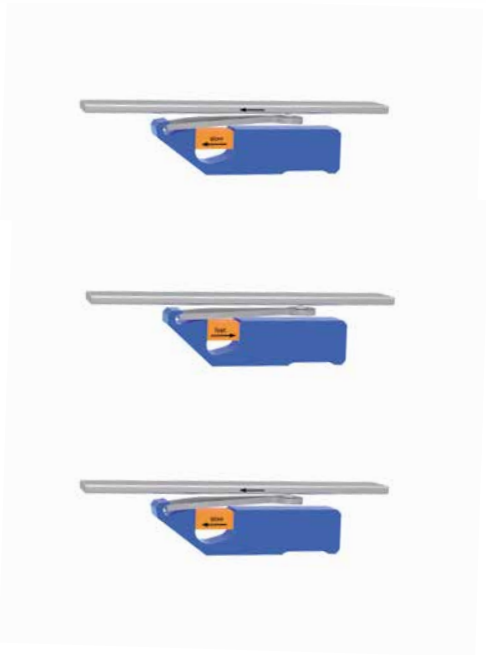
POSITION CONTROL, HIGH RESOLUTION, AFFORDABLE



Q-Motion Inertia Tangential Drive Operating Principle

Piezo inertia drives are space-saving and inexpensive piezo-based drives with relatively high holding forces and a virtually unlimited travel range. They make use of the stick-slip effect (inertia effect) – a cyclical alternation of static and sliding friction between a moving runner and the drive element generated by the piezo element – for a continuous feed of the runner. The operating frequency of more than 20 kHz enables the runner to be directly driven at velocities in excess of 10 mm/s (70°/s).

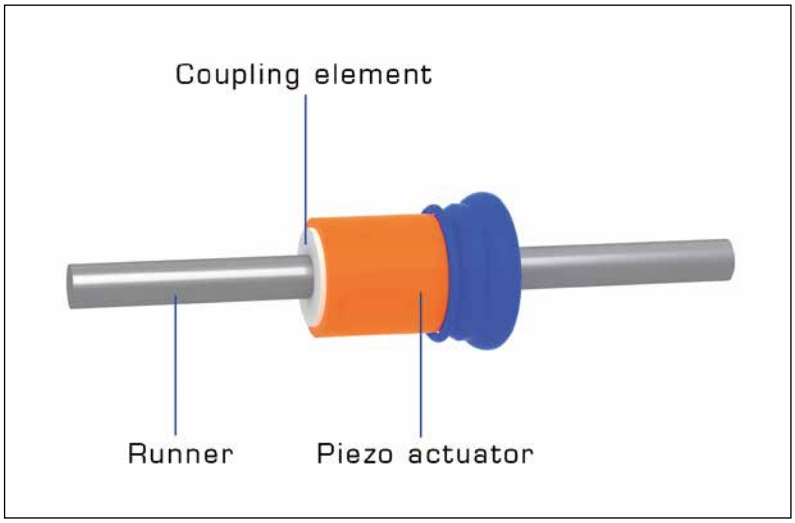


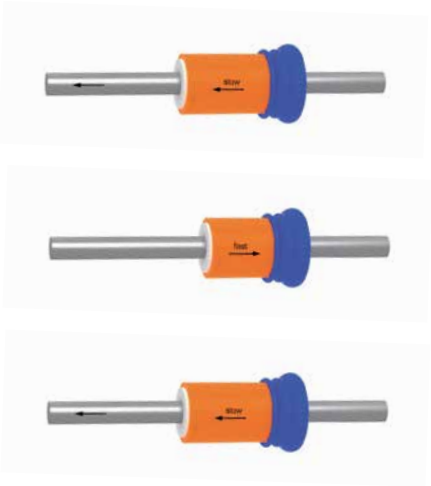


Tangential Drive

A drive element mounted on the side of the runner allows linear or rotary motion and a particularly small design of the stage. In conjunction with suitable incremental encoders, linear and rotation stages are possible with a width of just over 20 mm and a height of only 10 mm. The sizes are even smaller for open-loop operation without sensor.

Q-Motion Inertia Mini-Rod Drive Operating Principle





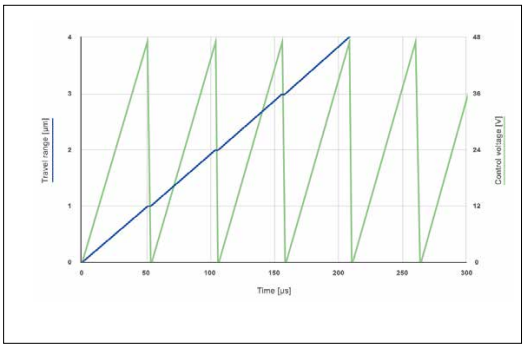
PIShift Rod Drive

Compared with tangential drives, rod drives provide a larger coupling surface between the piezoceramic actuator and runner. This results in relatively high holding forces of up to 10 N. The runner is guided through the inner hole of the actuator, which still allows a very compact drive design. The rod drive is in products such as the position-controlled Q-545 linear stage with a width of 45 mm.

Digital servo controller for piezo inertia drives

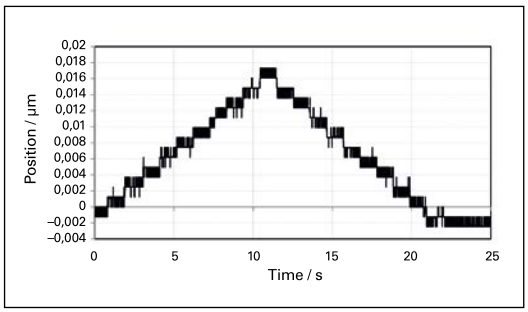
Integrated power amplifier and voltage generator for piezo inertia drives. Point-to-point motion, actuator mode for nanometer-precise positioning at the target position.

Properties

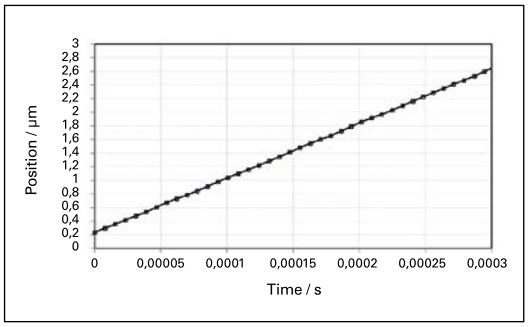


Nanometer Resolution

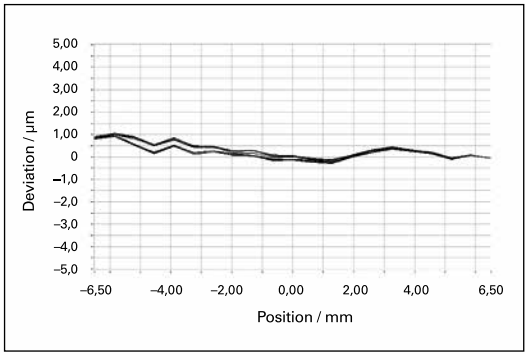
During the slow control phase (stick-phase), in which the runner is moved, the drive behaves in the same way as a classical piezoceramic actuator. By varying the voltage applied, the actuator can take any position and therefore achieves the high motion resolution that is typical for piezoceramics. Together with an incremental encoder for measuring the position, it is possible to achieve high positioning accuracy and repeatability of the motion over long travel ranges.



The minimum incremental motion is specified with 2 nm for closed-loop linear stages with incremental encoders (1 nm resolution). The small steps are performed reliably with the analog expansion of the piezoelectric actuator.



The maximum velocity is 10 mm/s with 20 kHz operating frequency. The graph shows position vs. time over a short range of 0.3 ms and 3 µm travel. Even with a sample frequency of 133 kHz, the profile is linear and the velocity constant.



The unidirectional repeatability of a Q-522 with 1 nm encoder resolution is 25 nm.

Q-Motion Miniature Linear Positioning Stage

POSITION CONTROL, HIGH RESOLUTION, LOW COST

Q-521

- Only 21 mm wide and 10 mm high
- Direct position measurement with integrated incremental encoder (optional)
- Up to 1 nm encoder resolution
- Up to 2 nm minimum incremental motion
- XY mounting without adapter
- Travel range 12, 22 or 32 mm
- Velocity 10 mm/s
- Feed force 1 N
- Versions vacuum-compatible to 10^{-9} hPa

Precision-class micropositioning stage
Q-Motion stages are distinguished by their extremely small design and high position resolution in the nanometer range. The piezomotor drive principle and the electrical operation are cost-efficient and can be customized

PIShift piezo inertia drives
Self-locking when at rest, therefore no heat generation and no servo jitter. Velocity to 10 mm/s. 1 N holding force, 1 N feed force

Direct-measuring principle
Versions with noncontact optical linear encoder available. Resolution 4 nm or 1 nm, depending on the version. Versions with encoder feature a reference point switch

Fields of application
Industry and research. For metrology, microscopy, micromanipulation, biotechnology and automation. Vacuum versions for 10^{-9} hPa available. Nonmagnetic versions are available on request

Preliminary Data	Q-521.130	Q-521.140/ Q-521.14U	Q-521.230	Q-521.240/ Q-521.24U	Q-521.330	Q-521.340/ Q-521.34U	Q-521.x00/ Q-521.x0U	Unit
Motion and positioning	12 mm travel range, resolution 4 nm	12 mm travel range, resolution 1 nm, UHV version Q-521.14U	22 mm travel range, resolution 4 nm	22 mm travel range, resolution 1 nm, UHV version Q-521.24U	32 mm travel range, resolution 4 nm	32 mm travel range, resolution 1 nm, UHV version Q-521.34U	12 mm to 32 mm travel range, open-loop, UHV versions Q-521.x0U	
Active axis	X	X	X	X	X	X	X	
Travel range	12	12	22	22	32	32	12 to 32	mm
Integrated sensor	Linear encoder	Linear encoder	Linear encoder	Linear encoder	Linear encoder	Linear encoder	–	
Sensor resolution	4	1	4	1	4	1	–	nm
Min. incremental motion	8	2	8	2	8	2	–	nm
Unidirectional repeatability over entire travel range	25	25	25	25	30	30	–	nm
Bidirectional repeatability over entire travel range	40	40	40	40	50	50	–	nm
Unidirectional repeatability over 100 µm travel range	12	12	12	12	12	12	–	
Bidirectional repeatability over 100 µm travel range	24	24	24	24	24	24	–	nm
Pitch / yaw over entire travel range	100	100	100	100	100	100	100	µrad
Pitch / yaw over 100 µm travel range	1	1	1	1	1	1	1	µrad
Maximum velocity*	10	10	10	10	10	10	10	mm/s
Mechanical properties								
Load capacity	10	10	10	10	10	10	10	N
Push / pull force	1	1	1	1	1	1	1	N
Length	30	30	32.5	32.5	42.5	42.5	30 to 42.5	mm
Width	21	21	21	21	21	21	21	mm
Height	10	10	10	10	10	10	10	mm
Drive properties								
Motor type	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	
Miscellaneous								
Operating temperature range	0 to 40	0 to 40	0 to 40	0 to 40	0 to 40	0 to 40	0 to 40	°C
Material	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum	
Cable length	1	1	1	1	1	1	1	m
Connector	Sub-D	Sub-D	Sub-D	Sub-D	Sub-D	Sub-D	Sub-D	
Recommended controller	E-871, E-873	E-871, E-873	E-871, E-873	E-871, E-873	E-871, E-873	E-871, E-873	E-870	

* Typical velocity at a control frequency of 20 kHz

Q-Motion Miniature Linear Stage

SMALL DIMENSIONS, HIGH RESOLUTION, AFFORDABLE

Q-522

- Only 22 mm wide and 10 mm high
- Direct position measurement with Incremental encoder with up to 1 nm resolution (optional)
- XY mounting without adapter
- Up to 2 nm minimum incremental motion
- Q-622 rotation stage mountable without adapter
- Travel range 6.5, 13 or 26 mm
- Velocity 10 mm/s
- Feed Force 1 N
- Versions vacuum-compatible to 10^{-9} hPa

Precision-class micropositioning stage
Q-Motion stages have very small dimensions and a high position resolution in the nanometer range. The piezomotor drive principle and the electrical operation are cost-efficient and can be customized

PIShift piezo inertia drives
Self-locking when at rest, therefore no heat generation and no servo jitter. Velocity to 10 mm/s. 1 N holding force, 1 N feed force

Direct-measuring principle
Versions with noncontact optical linear encoder available. Resolution 4 nm or 1 nm, depending on the version. Versions with encoder feature a reference point switch

Fields of application
Industry and research. For metrology, microscopy, micromanipulation, biotechnology and automation. Vacuum versions for 10^{-9} hPa available. Nonmagnetic versions are available on request

Preliminary Data	Q-522.030	Q-522.040/ Q-522.04U	Q-522.130	Q-522.140/ Q-522.14U	Q-522.230	Q-522.240/ Q-522.24U	Q-522.x00/ Q-522.x0U	Unit
Motion and positioning	6.5 mm travel range, resolution 4 nm	6.5 mm travel range, resolution 1 nm, UHV version Q-522.04U	13 mm travel range, resolution 4 nm	13 mm travel range, resolution 1 nm, UHV version Q-522.14U	26 mm travel range, resolution 4 nm	26 mm travel range, resolution 1 nm, UHV version Q-522.24U	6.5 mm to 26 mm travel range, open-loop, UHV versions Q-522.x0U	
Active axis	X	X	X	X	X	X	X	
Travel	6.5	6.5	13	13	26	26	6.5 to 26	mm
Integrated sensor	Linear encoder	Linear encoder	Linear encoder	Linear encoder	Linear encoder	Linear encoder	–	
Sensor resolution	4	1	4	1	4	1	–	nm
Min. incremental motion	8	2	8	2	8	2	–	nm
Unidirectional repeatability over entire travel range	25	25	25	25	30	30	–	nm
Bidirectional repeatability over entire travel range	40	40	40	40	50	50	–	nm
Unidirectional repeatability over 100 µm travel range	12	12	12	12	12	12	–	
Bidirectional repeatability over 100 µm travel range	24	24	24	24	24	24	–	nm
Pitch / yaw over entire travel range	100	100	100	100	100	100	100	µrad
Pitch / yaw over 100 µm travel range	1	1	1	1	1	1	1	µrad
Maximum velocity*	10	10	10	10	10	10	10	mm/s
Mechanical properties								
Load capacity	10	10	10	10	10	10	10	N
Push / pull force	1	1	1	1	1	1	1	N
Length	22	22	32	32	42	42	22 to 42	mm
Width	32	32	32	32	32	32	22	mm
Height	10	10	10	10	10	10	10	mm
Drive properties								
Motor type	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	
Miscellaneous								
Operating temperature range	0 to 40	0 to 40	0 to 40	0 to 40	0 to 40	0 to 40	0 to 40	°C
Material	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum	
Mass, including cabling	107	107	118	118	128	128	68 to 88	g
Cable length	1	1	1	1	1	1	1	m
Connector	Sub-D	Sub-D	Sub-D	Sub-D	Sub-D	Sub-D	Sub-D	
Recommended controller	E-871, E-873	E-871, E-873	E-871, E-873	E-871, E-873	E-871, E-873	E-871, E-873	E-870	

* Typical velocity at a control frequency of 20 kHz
The Q-522 stage series replaces the LPS-22 series.

Q-522 linear stage with incremental position sensor

Q-Motion Precision Linear Stage

HIGH FORCES, SMALL SIZE THROUGH PIEZOMOTORS

Q-545

- Feed force 8 N
- Direct position measurement with incremental encoder with 1 nm resolution (optional)
- XY mounting without adapter
- Travel range 13 or 26 mm
- Velocity 10 mm/s
- Versions vacuum-compatible to 10^{-9} hPa

Precision-class micropositioning stage
Q-Motion stages have a compact design and a high position resolution in the nanometer range. The piezomotor drive principle and the electrical operation are cost-efficient and can be customized

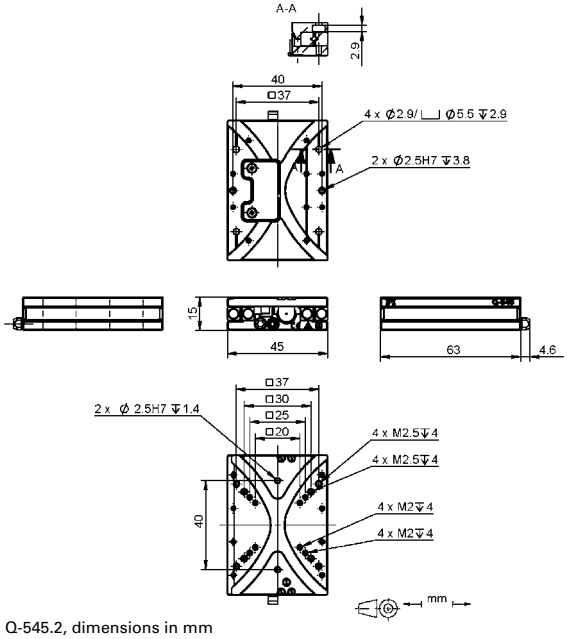
PIShift piezo inertia drives
Self-locking when at rest, therefore no heat generation and no servo jitter. Velocity to 10 mm/s. 8 N holding force, 8 N feed force

Direct-measuring principle
Versions with noncontact optical linear encoder available. Resolution 1 nm. Versions with encoder feature a reference point switch

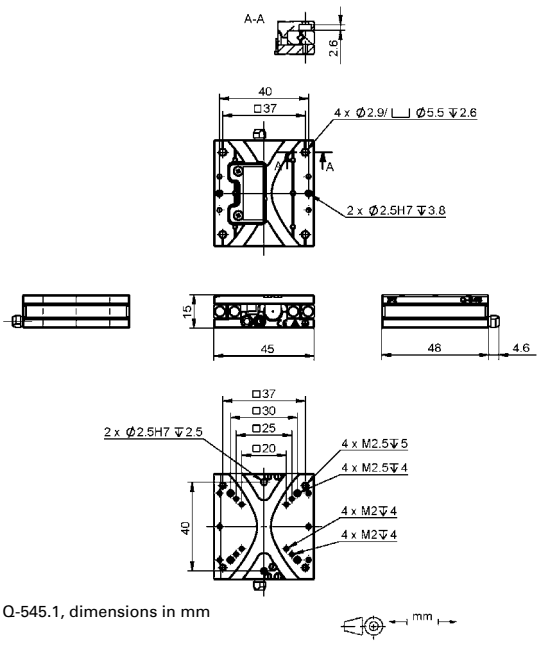
Fields of application
Industry and research. For optical metrology, laser technology, micromanipulation, biotechnology, photonics packaging. Vacuum versions down to 10^{-9} hPa available. Nonmagnetic versions are available on request

Preliminary Data	Q-545.100/ Q-545.10U	Q-545.140/ Q-545.14U	Q-545.200/ Q-545.20U	Q-545.240/ Q-545.24U	Unit	Tolerance
Motion and Positioning	13 mm travel range, open-loop, UHV version Q-545.10U	13 mm travel range, 1 nm resolution, UHV version Q-545.14U	26 mm travel range, open-loop, UHV version Q-545.20U	26 mm travel range, resolution 1 nm, UHV version Q-545.24U		
Active axis	X	X	X	X		
Travel	13	13	26	26	mm	
Integrated sensor	–	Linear encoder	–	Linear encoder		
Sensor resolution	–	1	–	1	nm	
Min. incremental motion	500 (open-loop)	6	500 (open-loop)	6	nm	typ.
Unidirectional repeatability	–	0.018	–	0.018	µm	
Angular crosstalk	+/-50	+/-50	+/-80	+/-80	µrad	
Linear crosstalk	+/-1	+/-1	+/-2	+/-2	µm	
Maximum velocity	10	10	10	10	mm/s	min.
Reference point switch	–	Optical	–	Optical		
Mechanical Properties						
Load capacity	10	10	10	10	N	
Holding force, deenergized	8	8	8	8	N	min.
Push / pull force	8	8	8	8	N	typ.
Drive Properties						
Motor Type	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive		
Miscellaneous						
Operating temperature range	0 to 40	0 to 40	0 to 40	0 to 40	°C	
Material	Aluminum	Aluminum	Aluminum	Aluminum		
Cable length	Q-545.100: 2 Q-545.10U: 1	Q-545.140: 2 Q-545.14U: 1	Q-545.200: 2 Q-545.20U: 1	Q-545.240: 2 Q-545.24U: 1	m	
Connector	Sub-D 15	Sub-D 15	Sub-D 15	Sub-D 15		
Recommended controller / driver	E-870	E-871, E-873	E-870	E-871, E-873		

Ask about custom designs!
The Q-545 stage series replaces the LPS-45 series.



Q-545.2, dimensions in mm



Q-545.1, dimensions in mm

Q-Motion Miniature Rotation Stages

MINIMUM DIMENSIONS: FROM 14 MM TURNTABLE DIAMETER

Q-Motion rotation stage Q-632, Q-622, Q-614, from left to right

- 14 mm to 32 mm diameter
- Rotation range >360°
- Velocity to 70°/s
- Versions vacuum-compatible to 10^{-9} hPa
- Direct position measurement with incremental encoder with 0.55 µrad resolution (optional)

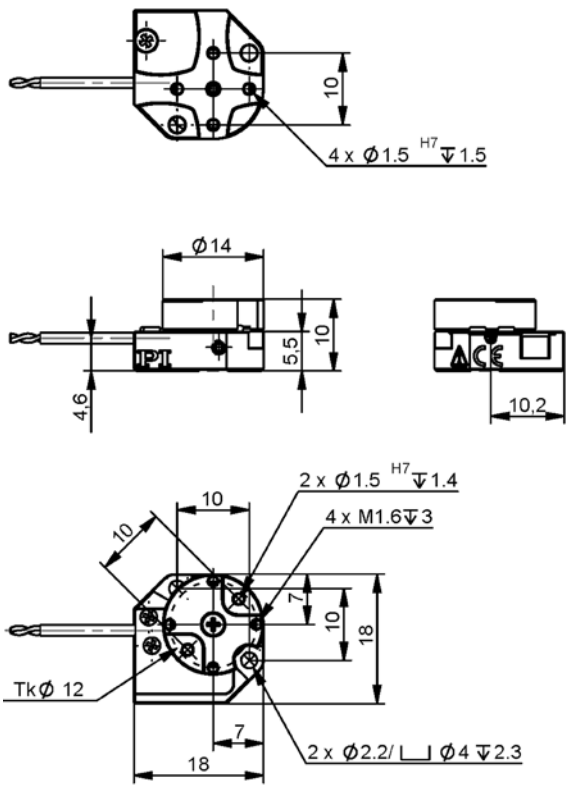
Precision-class micropositioning stage
Q-Motion stages have very small dimensions and a high position resolution in the nanometer range. The piezomotor drive principle and the electrical operation are cost-efficient and can be customized

PIShift piezo inertia drives
Self-locking at rest, thus no heat generation. Velocity to 70°/s.

Fields of application
Industry and research. For metrology, microscopy, micromanipulation, biotechnology and automation. Vacuum versions for 10^{-9} hPa available. Nonmagnetic versions are available on request

Preliminary Data	Q-614.900	Q-614.90U	Unit	Tolerance
Motion and positioning				
Active axis	θ_z	θ_z		
Rotation range	>360	>360	°	
Resolution	1*	1*	µrad	
Min. incremental motion	100*	100*	µrad	typ.
Maximum velocity, open-loop	70	70	°/s	
Mechanical properties				
Load capacity	1	1	N	
Holding torque, de-energized	6	6	mNm	min.
Torque	5	5	mNm	typ.
Length	18	18	mm	
Width	18	18	mm	
Height	10	10	mm	
Turntable diameter	14	14	mm	
Drive properties				
Motor type	Piezoelectric inertia drive	Piezoelectric inertia drive		
Miscellaneous				
Operating temperature range	0 to 40	0 to 40	°C	
Material	Aluminum	Aluminum		
Mass without cable	9	9	g	
Cable length	1	1	m	
Connector	Sub-D	Sub-D		
Recommended controller	E-870	E-870		

Ask about custom designs!
The Q-614 stage series replaces the RPS-14 series.
* Open-loop

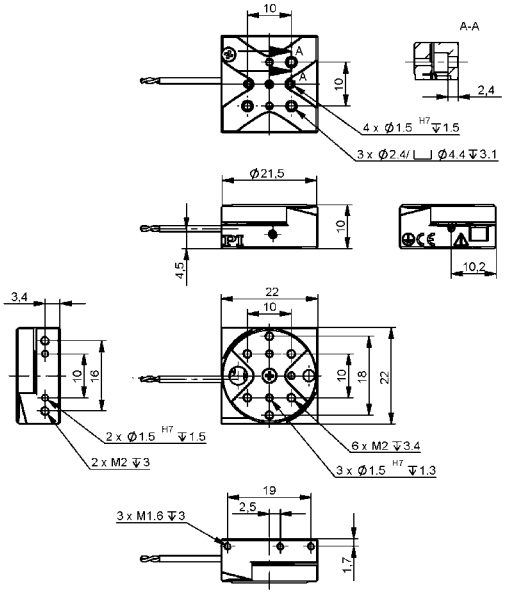


Q-614, dimensions in mm

Q-614.900

Preliminary Data	Q-622.930	Q-622.900	Q-622.90U	Unit	Tolerance
Motion and positioning	Miniature rotation stage with position sensor for closed-loop operation	Miniature rotation stage without position sensor	Miniature rotation stage, without position sensor for ultrahigh vacuum up to 10^{-9} hPa		
Active axis	θ_z	θ_z	θ_z		
Rotation range	>360	>360	>360	°	
Integrated sensor	Incremental encoder	–	–		
Sensor resolution	0.55	–	–	µrad	
Min. incremental motion	2.2	100*	100*	µrad	typ.
Unidirectional repeatability	3	–	–		
Maximum velocity, open-loop	70	70	70	°/s	
Mechanical Properties					
Load capacity	1	1	1	N	
Holding torque, deenergized	6	6	6	mNm	min.
Torque	5	5	5	mNm	typ.
Length	22	22	22	mm	
Width	22	22	22	mm	
Height	10	10	10	mm	
Turntable diameter	22	22	22	mm	
Drive Properties					
Motor Type	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive		
Miscellaneous					
Operating temperature range	0 to 40	0 to 40	0 to 40	°C	
Material	Aluminum	Aluminum	Aluminum		
Mass without cable	15	12	12	g	
Cable length	1	1	1	m	
Connector	Sub-D	Sub-D	Sub-D		
Recommended controller	E-871, E-873	E-870	E-870		

Ask about custom designs!
The Q-622 stage series replaces the RPS-22 series.
* Open-loop

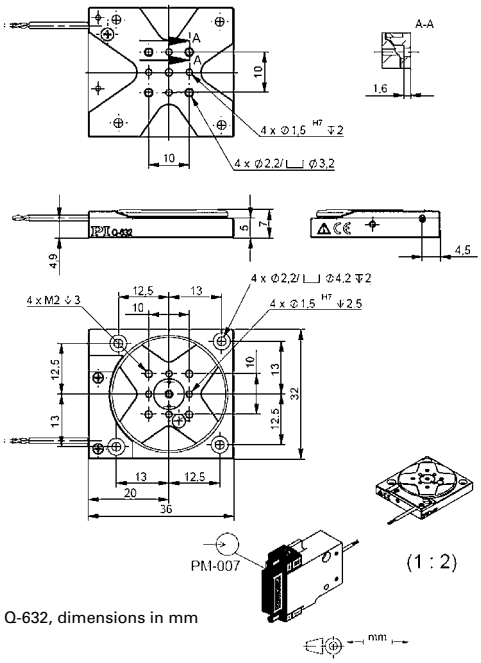


Q-622, dimensions in mm

Q-622.900

Preliminary Data	Q-632.930	Q-632.900	Q-632.90U	Unit	Tolerance
Motion and positioning	Rotation stage with position sensor for closed-loop operation	Rotation stage without position sensor	Rotation stage, without position sensor for ultrahigh vacuum up to 10^{-9} hPa		
Active axis	θ_z	θ_z	θ_z		
Rotation range	>360	>360	>360	°	
Integrated sensor	Incremental encoder	–	–		
Sensor resolution	0.75	–	–	µrad	
Min. incremental motion	3	36*	36*	µrad	typ.
Unidirectional repeatability	3	–	–	µrad	typ.
Maximum velocity, open-loop	45	45	45	°/s	
Mechanical Properties					
Load capacity	1	1	1	N	
Holding torque, deenergized	7	7	7	mNm	min.
Torque	6	6	6	mNm	typ.
Length	32	32	32	mm	
Width	32	32	32	mm	
Height	7	7	7	mm	
Turntable diameter	30	30	30	mm	
Drive Properties					
Motor Type	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive		
Miscellaneous					
Operating temperature range	0 to 40	0 to 40	0 to 40	°C	
Material	Aluminum	Aluminum	Aluminum		
Mass without cable	25	21	21	g	
Cable length	1	1	1	m	
Connector	Sub-D	Sub-D	Sub-D		
Recommended controller	E-871, E-873	E-870	E-870		

Ask about custom designs!
The Q-632 stage series replaces the RPS-32 series.
* Open-loop



Q-632, dimensions in mm

Q-632.900

Q-Motion Miniature 6-Axis Positioner

PIEZO-MOTORIZED INERTIA DRIVE, ONLY 80 MM SIDE LENGTH

Q-821

- Six-axis microrobotics system
- Dimensions in reference position 80 mm × 73 mm × 48 mm
- Linear travel ranges to 12 mm x 12 mm x 6 mm
- Rotary travel ranges to 14° x 15° x 40°
- 1 nm sensor resolution

Preliminary Data	Q-821	Unit	Tolerance
Active axes	X, Y, Z, θ_X, θ_Y, θ_Z		
Motion and Positioning			
Travel range X, Y, Z	±6, ±6, ±3	mm	
Travel range θ_X, θ_Y, θ_Z	±7, ±7.5, ±20	°	
Sensor resolution	1	nm	
Max. velocity X, Y, Z	10	mm/s	
Max. velocity θ_X, θ_Y, θ_Z	5	°/s	
Mechanical Properties			
Stiffness X, Y	0.2	N/µm	
Stiffness Z	3.6	N/µm	
Load (base plate horizontal)	1	kg	max.
Motor Type	Piezoelectric inertia drive		
Miscellaneous			
Material	Aluminum		
Mass	0.55	kg	±5 %
Cable length	2	m	±10 mm

Q-Motion Servo Controller

1 AXIS, FOR POSITIONERS WITH PIEZO INERTIA DRIVES

Extensive functionality

Powerful macro command language. Nonvolatile macro storage, e. g. for stand-alone functionality with autostart macro. Data recorder. ID chip for quick start-up, parameter changes on-the-fly. Extensive software support, e. g. for LabVIEW, shared libraries for Windows and Linux

E-873

- Broadband encoder input
- Macro programmable for stand-alone functionality
- Data recorder
- Digital I/O ports (TTL)
- ID chip support
- Interfaces: USB, RS-232 TCP/IP and Joystick

Preliminary data	E-873.1A1	E-873.1AR / E-873.1AT
Function	Q-Motion Controller for positioning systems with piezo inertia drives and USB, RS-232 and TCP/IP interface. Bench-Top Device	Q-Motion Controller for positioning systems with piezo inertia drives and USB, RS-232 (E-873.1AR) or TCP/IP (E-873.1AT) interface. Bench-Top Device with option for control cabinet mounting
Channels	1	1
Motion and Control		
Servo characteristics	PID controller, parameter change on-the-fly	PID controller, parameter change on-the-fly
Encoder input	Analog encoder input sine-cosine, interpolation selectable up to 20000; Interpolation circuit for differential transmission, 1 Vpp amplitude and 2.5 V offset of the encoder signal	Analog encoder input sine-cosine, interpolation selectable up to 20000; Interpolation circuit for differential transmission, 1 Vpp amplitude and 2.5 V offset of the encoder signal
Stall detection	Servo off	Servo off
Input limit switch	2 × TTL (pull-up / pull-down, programmable)	2 × TTL (pull-up / pull-down, programmable)
Input reference switch	1 × TTL and Zero+ & Zero- for integrated reference in the encoder	1 × TTL and Zero+ & Zero- for integrated reference in the encoder
Electrical properties		
Max. output power	30 W	30 W
Output voltage	0 to 100 V, drive-dependent selection	0 to 100 V, drive-dependent selection
Max. current consumption	1.5 A	1.5 A
Interfaces and operation		
Interface / communication	USB, RS-232 9-pin (m) Sub-D, TCP/IP	USB, RS-232 9-pin (m) Sub-D (E-873.1AR), TCP/IP (E-873.1AT)
Motor connection / sensor connection	Sub-D connector 15-pin (f)	Sub-D connector 15-pin (f)
I/O ports	4 analog / digital in, 4 digital out	4 analog / digital in, 4 digital out
Command set	PI General Command Set (GCS)	PI General Command Set (GCS)
User software	PIMikroMove, PITerminal	PIMikroMove, PITerminal
Software drivers	LabVIEW drivers, shared libraries for Windows and Linux	LabVIEW drivers, shared libraries for Windows and Linux
Supported functions	Point-to-point motion, start-up macro, data recorder for recording operating data such as motor voltage, position or position error; internal safety circuitry: Watchdog timer; ID chip	Point-to-point motion, start-up macro, data recorder for recording operating data such as motor voltage, position or position error internal safety circuitry: Watchdog timer; ID chip
Manual control (optional)	Joystick (for 2 axes), Y-cable for 2-D motions	Joystick (for 2 axes), Y-cable for 2-D motions
Miscellaneous		
Operating voltage	24 V, in the scope of delivery: external power supply with 24 V / 2.0 A	24 V, in the scope of delivery: external power supply with 24 V / 2.0 A
Operating temperature range	0 to 50 °C	0 to 50 °C

Ask about custom designs!

OEM Drive Electronics

VERSATILE, COST-EFFECTIVE

E-870

- For PIShift and PiezoMike piezo inertia drives
- Ideal for OEM applications
- One to four actuators, serial control (through demultiplexing)
- With digital USB interface

Drive electronics for one to four axes

OEM module with solder pins or on carrier board with connectors and terminal strips for the operation of open-loop PIShift piezo inertia drives

Operating modes

Full-step mode, max. piezo voltage 0 to 100 V (configurable). Various command modes. Configuration of the operating parameters can be programmed via USB or via hardware settings. Serial control of up to 4 actuators by one unit

Interfaces

USB for control, configuration and for firmware updates. Interfaces for TTL and analog control. Optional SPI interface

Fields of application

Lab automation, medical technology, handling

E-870.10: Single-channel driver for piezo inertia drives (to be plugged in or soldered)

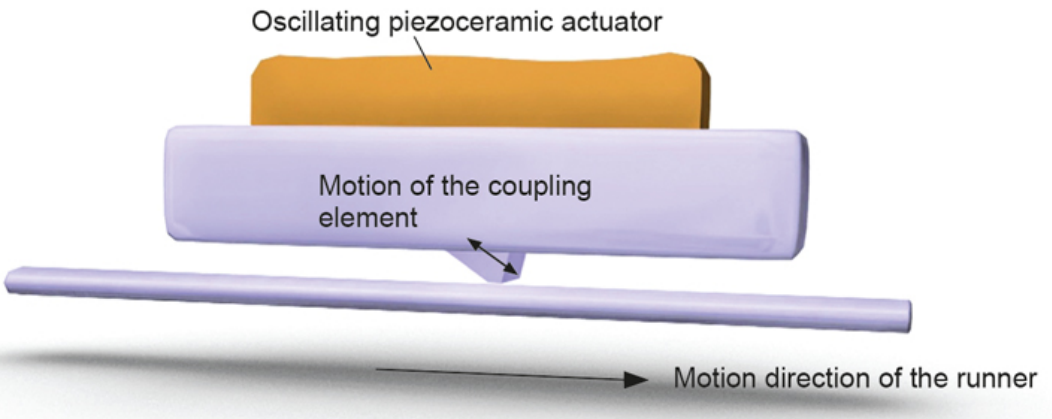
The E-870.41 allows the serial control of up to four PIShift or PiezoMike actuators through demultiplexing

Related products

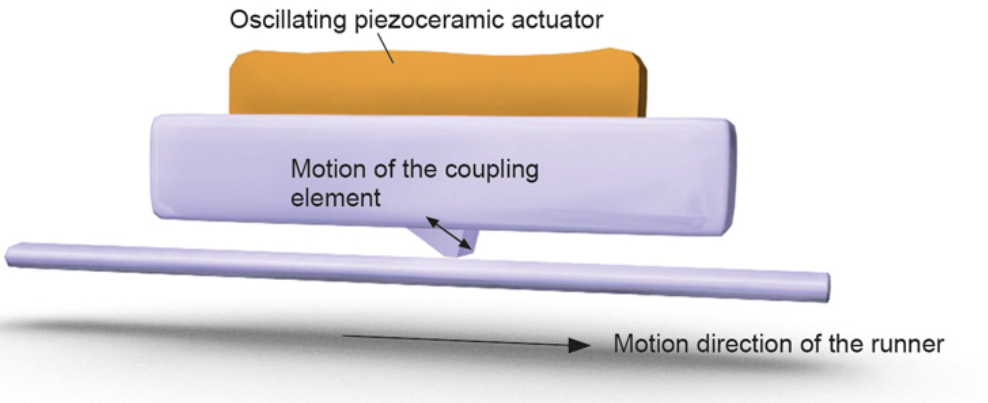
N-412 • N-422 PIShift linear actuator

Miniature Stages wtih Ultrasonic Motors

HIGH SPEED, FAST START/STOP, SELF-CLAMPING



PILine® Ultrasonic Piezomotors



The piezoceramic actuator is excited with a high frequency electric signal (100 to 200 kHz). The deformation of the actuator leads to a periodic diagonal motion of the coupling element to the runner. The created feed is roughly 10 nm per cycle; the high frequencies lead to the high velocities

- Integration levels from economical OEM motors to multi-axis positioning systems
- Excellent dynamic properties, fast step & settle
- Basically unlimited travel ranges
- Easy mechanical integration
- Self-locking at rest
- Holding force up to 15 N
- Velocity up to 500 mm/s
- Resolution to 0.05 µm (50 nm)

Direct-driven PILine® linear motors

These linear drives dispense with the mechanical complexity of classical rotary motor/gear/leadscrew combinations. These components can be very susceptible to wear, especially in miniaturized systems.

The simplicity of the ultrasonic linear motor promotes its precision, reliability and cost efficiency. An integral part of the ultrasonic piezomotor is a piezo ceramic that is preloaded against a moving runner with a coupling element. The piezo element is electrically excited to produce high-frequency oscillations that cause the runner to move.

Piezomotors are self-locking

The preload of the piezoceramic actuator against the runner ensures that the drive self-locks at rest and when powered down. As a result, it does not consume any power, it does not heat up and keeps the position stable mechanically. Applications with a short duty cycle, that are battery-operated or heat-sensitive benefit from these characteristics.

Lifetime and reliability

The motion of the piezoceramic actuator is based on crystalline effects and is not subject to any wear. The coupling to the runner, on the other hand, is subject to friction effects. Depending on the operating mode, running distances of several 1000 km or a MTBF of 20000 hours are achieved.

Dynamics in use

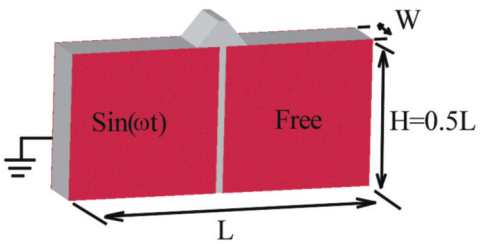
The stiff design, direct coupling and fast response of the piezo ceramics to electric inputs allows for very fast start / stop behavior and velocities to hundreds of mm/sec.

Patented technology

The products described in this document are in part protected by the following patents:

US Pat. No. 6,765,335B2

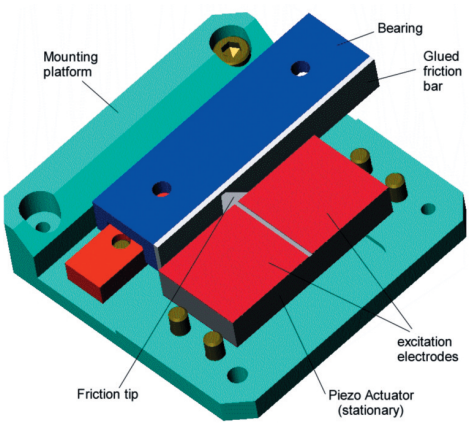
European Patent No. 1267425B1



State-of-the-art PILine® ultrasonic motors are based on a simple construction allowing for the design of low-cost drive units and extremely compact, high-speed micro-positioning stages smaller than a matchbox

Piezomotors for all applications – e. g. in vacuum environments and strong magnetic fields

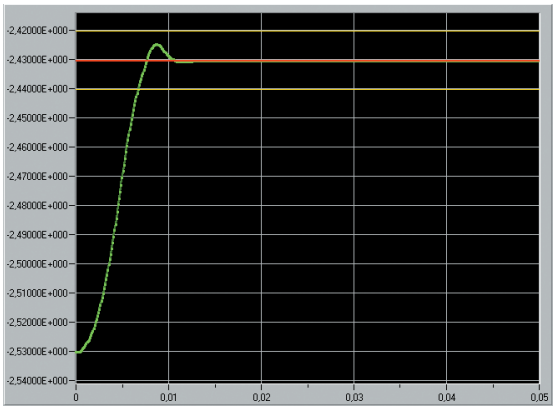
Piezomotors from PI are intrinsically vacuum-compatible and suitable for operation in strong magnetic fields. Special versions are offered for this purpose. Nanometer resolution or forces up to several 100 N can be achieved with PiezoWalk® linear motors.



Principle design of a PILine® ultrasonic piezomotor stage

Implementation of rotary motion:
PILine® motors act on a ring-shaped runner

Variety of PILine® ultrasonic piezomotors



Settling behavior of a PILine® M-663 linear stage, 100 µm step. A stable position to within 0.1 µm can be reached in only 10 ms.

The benefit of the low profile PILine® drives becomes apparent with positioning systems such as the M-660 rotation stage (left, 14 mm high) or the M-687 microscopy XY stage (right, 25 mm high): a consistently flat design without lead screw ducts or flanged motors

Compact Linear Stage

FAST PILINE® DIRECT DRIVE, INCREMENTAL ENCODER

U-521

- Only 35 mm wide and 10 mm high
- Integrated, direct-measuring incremental encoder with up to 100 nm resolution
- Up to 0.3 µm minimum incremental motion
- Travel range 18 mm
- Velocity 200 mm/s
- Feed force 2 N
- Versions vacuum-compatible to 10^{-6} hPa

Precision-class micropositioning stage
Piezoelectric ultrasonic direct drive for high velocities and small design. Centered ball bearings. The piezomotor drive principle and the electrical operation are cost-efficient and can be customized

Direct-measuring principle
Integrated, direct-measuring incremental encoder. Resolution depending on version, 400 nm or 100 nm. Optical reference point switch

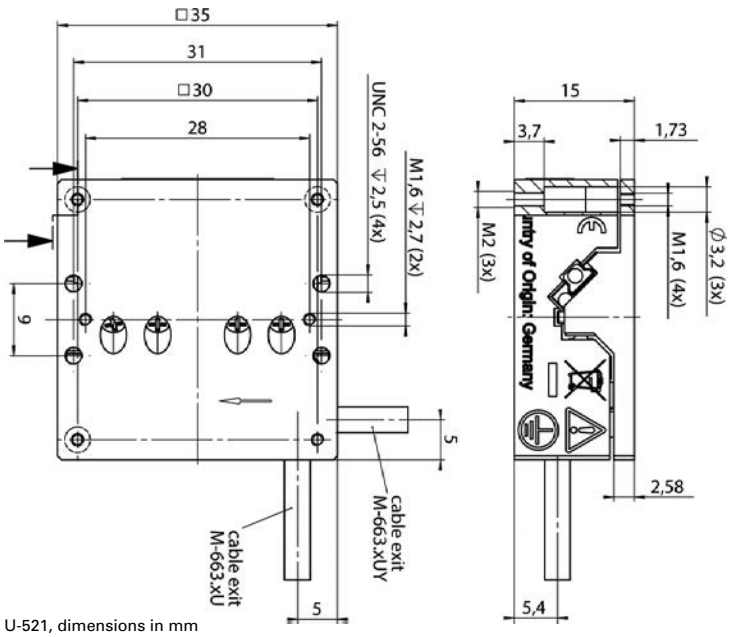
PILine® ultrasonic piezo motor
Oscillating piezoceramic actuators act directly on a linear-guided runner. Self-locking at rest, therefore no heat generation. No drive noises. High velocity up to 200 mm/s. Dynamic start / stop behavior. Holding force 2 N.

Valid patents
US patent no. 6,765,335B2
European patent no. 1267425B1

Fields of application
Industry and research. For micromanipulation, automation, biotechnology, sample manipulation, sample positioning. Use in limited space. Vacuum version for 10^{-6} hPa optional

Preliminary Data	U-521.23; U-521.23V	U-521.24; U-521.24V	Unit	Tolerance
	Linear stage with 0.4 µm sensor resolution U-521.23V for vacuum to 10^{-6} hPa	Linear stage with 0.1 µm sensor resolution U-521.24V for vacuum to 10^{-6} hPa		
Active axes	X	X		
Motion and Positioning				
Travel Range	18	18	mm	
Integrated sensor	Incremental encoder	Incremental encoder		
Design resolution	0.4	0.1	µm	typ.
Minimum incremental motion	2	0.3	µm	typ.
Bidirectional repeatability	±2	±0.5	µm	
Velocity	200	200	mm/s	max.
Mechanical Properties				
Load capacity	2	2	N	max.
Holding force	2	2	N	max.
Drive force	2	2	N	max.
Drive Properties				
Motor Type	PILine® ultrasonic piezomotor, performance class 1	PILine® ultrasonic piezomotor, performance class 1		
Reference point switch	Optical	Optical		
Miscellaneous				
Operating temperature range	0 to 40	0 to 40	°C	
Material	Aluminum, anodized	Aluminum, anodized		
Mass	150	150	g	±5 %
Cable length	1.5	1.5	m	±10 mm
Connector	Sub-D 15-pin (m)	Sub-D 15-pin (m)		
Recommended controller/driver	C-867.1U: 1 channel C-867.2U: 2 channels C-877.1U11: 1 channel, affordable compact device C-877.2U12: 2 channels, affordable bench-top	C-867.1U: 1 channel C-867.2U: 2 channels C-877.1U11: 1 channel, affordable compact device C-877.2U12: 2 channels, affordable bench-top		

Ask about custom designs!
The U-521 stage series replace the M-663 series



U-521, dimensions in mm

Precision Stage with Linear Piezo Drive

FAST, SELF-LOCKING, LOW PROFILE

M-664

- Travel range 25 mm
- Only 15 mm profile height
- Linear encoder with 100 nm resolution
- Max. velocity 400 mm/s
- Self-locking at rest, no heat generation, no servo jitter

Precision-class micro translation stage
Integrated piezo-ceramic direct drive. Compact XY combinations available

PILine® piezo ultrasonic drive
Self-locking, with no heat generation at rest. Excellent start/stop dynamics. Crossed roller bearings. Non-contact limit and reference point switches

Direct-metrology linear encoder
High accuracy and repeatability

Application fields
Research and industry. For micromanipulation, quality assurance testing, biotechnology

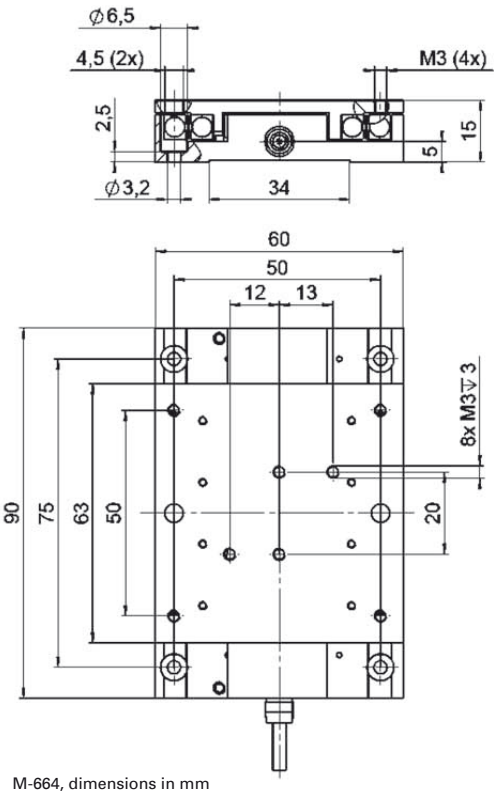
Valid patents
US Pat. No. 6,765,335B2
European Patent No. 1267425B1

Accessories
M-664.AP1 Adapter Plate for XY-mounting of M-664, 4 mm high

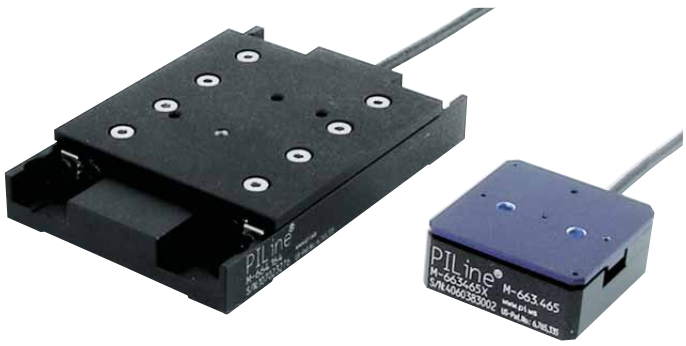
Related Products
M-663 Ultra-compact Linear Stage
M-683 Dynamic Micropositioning Stage
M-122 Miniature Linear Stage
M-126 Precision Micro-Translation Stage
C-867 Controller for PILine®

	M-664.164	Tolerance
Active axes	X	
Motion and positioning		
Travel range	25 mm	
Integrated sensor	Linear encoder	
Sensor resolution	0.1 µm	
Min. incremental motion	0.6 µm	typ.
Bidirectional repeatability	±1 µm	typ.
Unidirectional repeatability	±0.2 µm	typ.
Pitch	±75 µrad	typ.
Yaw	±50 µrad	typ.
Velocity	400 mm/s	max.
Reference point switch repeatability	1 µm	typ.
Mechanical properties		
Load capacity	25 N	max.
Push/pull force	2.5 N	max.
Holding force	2.5 N	max.
Drive properties		
Motor type	P-664 PILine® Ultrasonic Piezo Drive	
Limit and reference point switches	Hall-effect	
Miscellaneous		
Operating temperature range	0 to +50 °C	
Material	Al (black anodized)	
Dimensions	90 x 60 x 15 mm	
Mass	0.225 kg	±5 %
Cable length	1.5 m	±10 mm
Connector	MDR, 14-pin	
Recommended controller/driver	C-867 controller/driver	

Ask about custom designs!



M-664, dimensions in mm



The smallest closed-loop linear stages with self-locking PILine® drive: M-664 (right) and M-663 (left)

Miniature Rotation Stages

LOW PROFILE, HIGH SPEED, FAST START/STOP

Ultrasonic miniature rotation stages U-622, U-624 (top), U-628, U-651 (bottom)

U-622, U-624, U-628, U-651

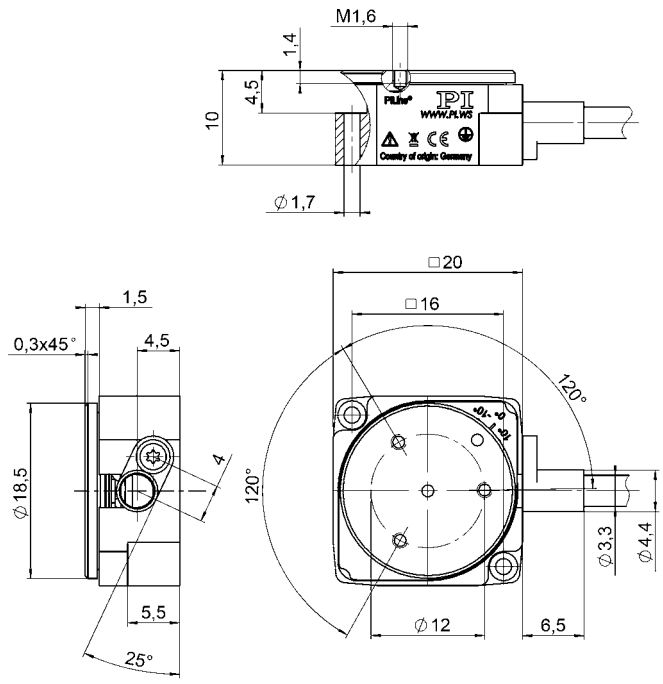
- 18 - 100 mm diameter
- 10 - 19 mm height
- Integrated, direct-measuring incremental encoder (U-651: up to 4 µrad resolution)
- Rotation range >360°
- High velocity 720 °/s

Precision-class miniature rotation stage
Integrated, direct-measuring incremental encoder. Rotation range >360°. Optical reference point switch

PILine® ultrasonic piezo motor
The piezoceramic ring-shaped motor acts directly on the rotating platform. Self-locking at rest, therefore no heat generation. No drive noises. High velocity to 720 °/s.

Fields of application
Sample handling and positioning in research and industry for installations limited in space. Vacuum version for 10^{-6} hPa optional

	U-622.03	Unit	Tolerance
Active axes	θ_z		
Motion and Positioning			
Rotation range	>360	°	
Integrated sensor	Incremental encoder		
Design resolution	175	µrad	
Min. incremental motion	525	µrad	typ.
Bidirectional repeatability	±1050	µrad	
Velocity	720	°/s	max.
Mechanical Properties			
Load capacity / axial force	0.3	N	max.
Holding torque	0.005	Nm	max.
Torque cw / ccw (θ_z)	0.005	Nm	max.
Drive Properties			
Motor Type	PILine® ultrasonic piezomotor, performance class 1		
Reference point switch	Optical		
Miscellaneous			
Operating temperature range	0 to 40	°C	
Material	Al (black anodized)		
Mass	120	g	±5 %
Cable length	1.5	m	±10 mm
Connector	Sub-D connector, 15-pin (m)		
Recommended controller/driver	C-877.1U11: 1 channel, affordable compact device C-877.2U12: 2 channels, affordable bench-top C-867.1U: 1 channel C-867.2U: 2 channels		

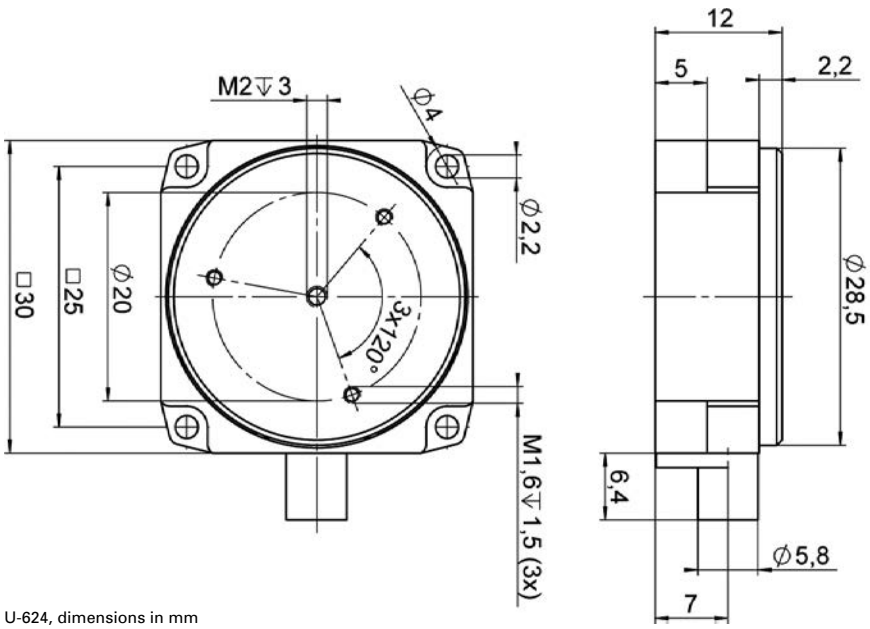


U-622, dimensions in mm

U-622

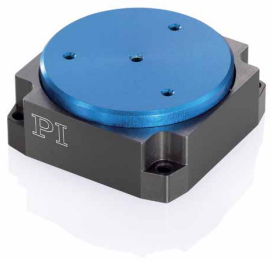
Preliminary Data	U-624.03	Unit	Tolerance
Active axes	θ_z		
Motion and Positioning			
Rotation range	>360	°	
Integrated sensor	Incremental encoder		
Design resolution	35	µrad	
Min. incremental motion	105	µrad	typ.
Bidirectional repeatability	±210	µrad	
Velocity	720	°/s	max.
Mechanical Properties			
Load capacity / axial force	1	N	max.
Holding torque	0.01	Nm	max.
Torque cw / ccw (θ_z)	0.01	Nm	max.
Drive Properties			
Motor Type	PILine® ultrasonic piezomotor, performance class 1		
Reference point switch	Optical		
Miscellaneous			
Operating temperature range	0 to 40	°C	
Material	Al (black anodized)		
Mass	130	g	±5 %
Cable length	1.5	m	±10 mm
Connector	Sub-D connector, 15-pin (m)		
Recommended controller/driver	C-877.1U11: 1 channel, affordable compact device C-877.2U12: 2 channels, affordable bench-top C-867.1U: 1 channel C-867.2U: 2 channels		

Ask about custom designs!



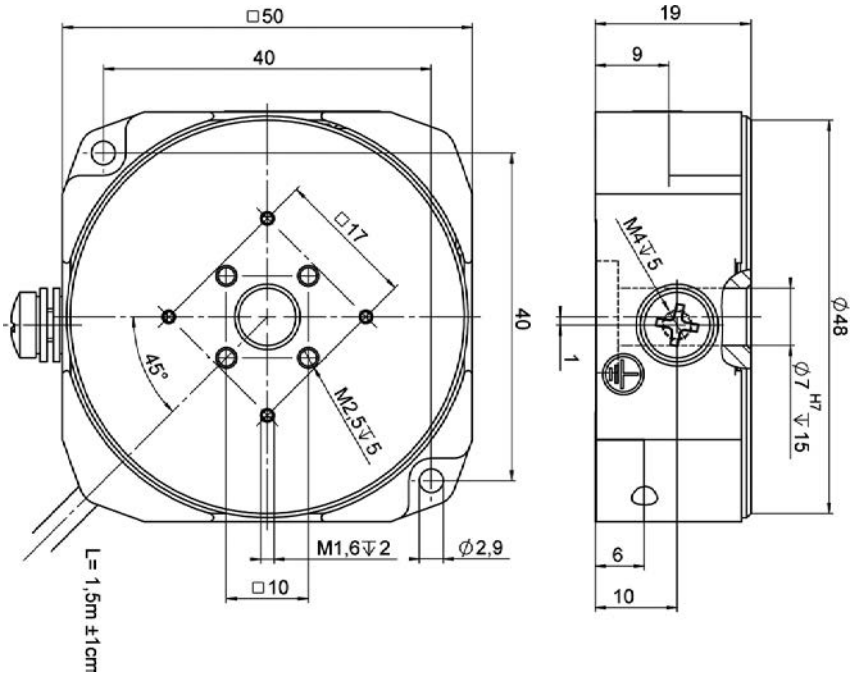
U-624, dimensions in mm

U-624



	U-628.03	Unit	Tolerance
Active axes	θ_z		
Motion and Positioning			
Rotation range	>360	°	
Integrated sensor	Incremental encoder		
Design resolution	17	µrad	
Min. incremental motion	51	µrad	typ.
Bidirectional repeatability	±102	µrad	
Velocity	720	°/s	max.
Mechanical Properties			
Load capacity / axial force	5	N	max.
Holding torque	0.03	Nm	max.
Torque cw / ccw (θ_z)	0.025	Nm	max.
Drive Properties			
Motor Type	PILine® ultrasonic piezomotor, performance class 1		
Reference point switch	Optical		
Miscellaneous			
Operating temperature range	0 to 40	°C	
Material	Al (black anodized)		
Mass	300	g	±5 %
Cable length	1.5	m	±10 mm
Connector	Sub-D connector, 15-pin (m)		
Recommended controller/driver	C-877.1U11: 1 channel, affordable compact device C-867.1U: 1 channel C-867.2U: 2 channels, C-877.2U12: 2 channels, affordable bench-top		

Ask about custom designs!

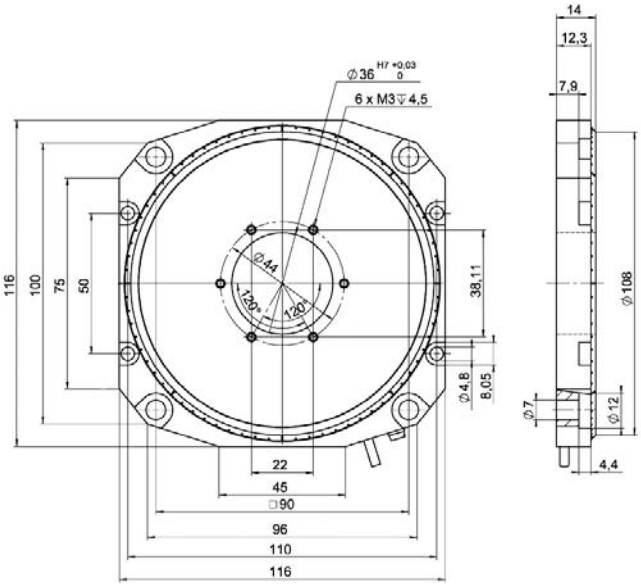


U-628, dimensions in mm

U-628

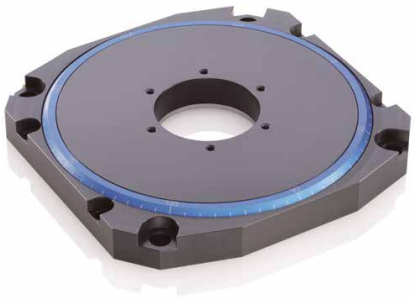
Preliminary Data	U-651.03	U-651.04	Unit	Tolerance
Active axes	θ_z	θ_z		
Motion and Positioning				
Rotation range	>360	>360	°	
Integrated sensor	Incremental encoder	Incremental encoder		
Design resolution	9	4	µrad	
Min. incremental motion	27	12	µrad	typ.
Bidirectional repeatability	±54	±24	µrad	
Velocity	720	720	°/s	max.
Mechanical Properties				
Load capacity / axial force	20	20	N	max.
Holding torque	0.3	0.3	Nm	max.
Torque cw / ccw (θ_z)	0.3	0.3	Nm	max.
Drive Properties				
Motor Type	PILine® ultrasonic piezomotor, performance class 2	PILine® ultrasonic piezomotor, performance class 2		
Reference point switch	Optical	Optical		
Miscellaneous				
Operating temperature range	0 to 40	0 to 40	°C	
Material	Al (black anodized)	Al (black anodized)		
Mass	500	500	g	±5 %
Cable length	1.5	1.5	m	±10 mm
Connector	Sub-D connector, 15-pin (m)	Sub-D connector, 15-pin (m)		
Recommended controller/driver	C-867.1U: 1 channel C-867.2U:2 channels C-877.2U12: 2 channels, affordable bench-top	C-867.1U: 1 channel C-867.2U: 2 channels, C-877.2U12: 2 channels, affordable bench-top		

Ask about custom designs!
The U-651 stage series replace the M-660 series



U-651, dimensions in mm

U-651



PILine® ultrasonic piezo motor

Oscillating piezoceramic actuators act directly on the ring-shaped runner. Self-locking at rest, therefore no heat generation. No drive noises. High velocity up to 720 °/s. Dynamic start / stop dynamics. Holding torque 0.3 Nm

Valid patents

US patent no. 6,765,335B2
European patent no. 1267425B1

Fields of application

Industry and research. For micromanipulation, automation, optical metrology

Precision-class rotation stage

Integrated, direct-measuring incremental encoder. Rotation range >360°. Optical reference point switch. High guiding accuracy due to crossed roller bearings. Clear aperture center load capacity to 20 kg

PILine® Motion Controller

FOR ULTRASONIC PIEZOMOTORS, COST-EFFICIENT, COMPACT

C-877

- Integrated power amplifier with dynamic frequency control
- PID servo control with dynamic parameter switching
- Data recorder
- Powerful macro programming language, e.g., for stand-alone operation
- Extensive software support, e.g., for LabVIEW, shared libraries for Windows and Linux

Servocontroller and power amplifier

One and two channels, bench-top, special PID controller for ultrasonic piezomotors. Integrated power amplifier for PILine® drives and stages in performance classes 1 and 2 (C-877.1U11, only class 1). Dynamic frequency control for optimum control

Incremental encoders

Differential signal transmission (A/B). TTL signal inputs for limit and reference point switches

Digital communication

USB and RS-232 interfaces (e.g., for a joystick). Data recorder. Powerful macro programming language, e.g., for stand-alone operation. Extensive software support, e.g., LabVIEW, dynamic libraries for Windows and Linux

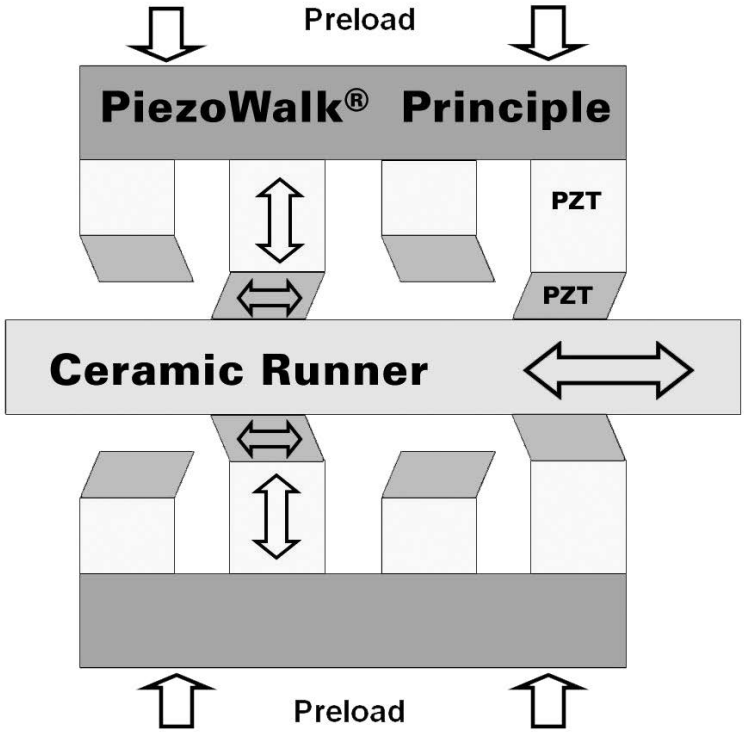
The C-877.1U11 miniature controller is the size of a deck of cards.

	C-877.1U11	C-877.2U12
Function	Controller for single-axis positioning or scanning stages with PILine® ultrasonic piezomotors (performance class 1)	Controller for single-axis positioning and scanning stages with PILine® ultrasonic piezomotors (performance class 1 and 2)
Channels	1	2
Motion and control		
Servo characteristics	PID controller, parameter change on-the-fly	PID controller, parameter change on-the-fly
Servo cycle time	100 µs	100 µs
Profile generator	Trapezoidal velocity profile	Trapezoidal velocity profile
Encoder input	A/B quadrature TTL level, differential according to RS-422	A/B quadrature TTL level, differential according to RS-422
Stall detection	Servo off, triggered by programmable position error	Servo off, triggered by programmable position error
Limit switches	2 × TTL (polarity programmable)	2 × TTL (polarity programmable)
Reference point switch	1 × TTL	1 × TTL
Electrical properties		
Max. output power per channel	15 W	24 W
Max. output voltage per channel	200 V_{pp}, 71 V_{eff}	200 V_{pp}, 71 V_{eff}
Interface and operation		
Interface / communication	USB	USB; RS-232
Motor connector	Sub-D 15-pin (f)	2 x Sub-D 15-pin (f)
Command set	PI General Command Set (GCS)	PI General Command Set (GCS)
User software	PIMikroMove	PIMikroMove
Software drivers	LabVIEW drivers, dynamic libraries for Windows and Linux	LabVIEW drivers, dynamic libraries for Windows and Linux
Supported functionality	Point-to-point motion, startup macro, data recorder for recording parameters such as motor voltage, velocity, position or position errors; internal safety circuitry: Watchdog timer; ID chip	Point-to-point motion, startup macro, data recorder for recording parameters such as motor voltage, velocity, position or position errors; internal safety circuitry: Watchdog timer; ID chip
Manual control	–	–
Miscellaneous		
Operating voltage	24 VDC from external power supply (included)	24 VDC from external power supply (included)
Max. operating current	300 mA plus motor current (max. 0.8 A)	600 mA plus motor current (max. 4 A)
Operating temperature range	5 to 40 °C	5 to 40 °C
Mass	0.13 kg	2.4 kg
Dimensions	95 mm × 71 mm × 24 mm (incl. mounting rails)	320 mm × 150 mm × 80.5 mm (incl. mounting rails)

Ask about custom designs!

PiezoWalk® Motors / Positioners

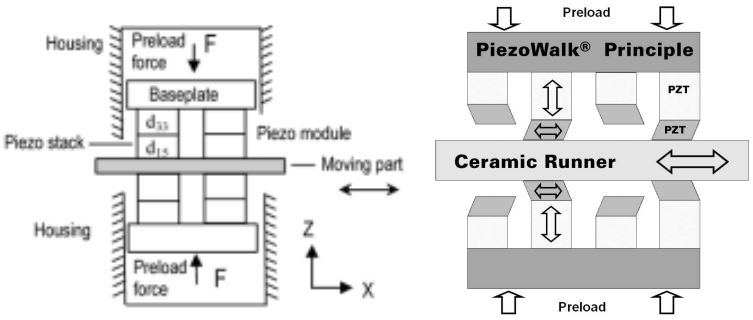
HIGH FORCE, HIGH RESOLUTION, SELF-CLAMPING



Piezo Stepping Motor Basics

PiezoWalk® Precision Drives – Millimeter Travel, Nanometer Resolution, High Forces

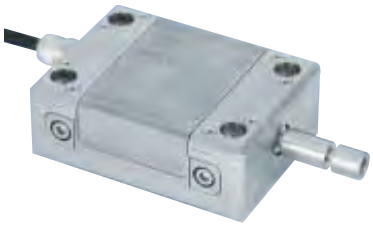
PiezoWalk® drives break away from the limitations of conventional Nanopositioning actuators. They offer a basically unlimited travel range and still provide the characteristic features of a piezoelectric actuator: an open-loop resolution down to 30 picometers and a very high stiffness for dynamic operation and force generation. PI offers two product lines based on different versions of the PiezoWalk® principle: NEXLINE® and NEXACT®. Both provide specific advantages depending on the application.



NEXLINE® linear actuator principle

PiezoWalk® piezo stepping drives usually consist of several individual piezo actuators and generate motion through succession of coordinated clamp / unclamp and shear motion cycles (steps). Each cycle provides only a few microns of movement, but running at hundreds of hertz, the drive achieves continuous motion in the mm/second range.

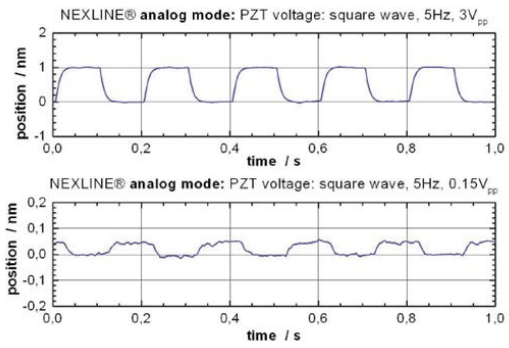
The PiezoWalk® working principle provides high force capabilities, resolution and repeatability. These properties are typically better for piezo stepping actuators compared to inertia drives or ultrasonic motors. The operation is possible in two different modes: a high-resolution, high dynamics analog mode within a single step, and a step mode with virtually unlimited travel range.



Custom PiezoWalk® linear actuator

Features and Advantages of PiezoWalk® Drives

- Very high resolution, limited typically only by the sensor. In fine-adjustment, analog mode, resolution of 30 picometers has been demonstrated.
- High force generation and stiffness. NEXLINE® drives can hold and generate forces to 600 N, NEXACT® to 15 N.
- PiezoWalk® drives hold a stable position to nanometer level in power-off mode. Due to the actuator design, the maximum clamping force is applied at rest.
- Because a position can be held with zero operating voltage, leakage currents cannot affect the integrity of the piezo drive.
- PiezoWalk® drives are available for non-magnetic applications such as super-conductivity experiments. They do not create magnetic fields nor are they influenced by them.
- The active parts in PiezoWalk® drives are made of vacuum-compatible ceramics. The drives also work in UV-light environments.
- NEXLINE® drives can survive shock loads of several g during transportation.
- PiezoWalk® drives are available in three levels of integration to provide flexibility for OEMs: OEM drives, packaged actuators and integrated into complex positioning systems such as multi-axis translation stages or 6-DOF Hexapods.



50 picometer steps with a NEXLINE® drive, measured with external ultra-high-resolution capacitive sensor. This performance provides a big safety margin for next generation nanotechnology applications

Miniature Linear Stage

NANOMETER RESOLUTION

LPS-24

- Only 24 mm width
- With integrated linear encoder with 150 or 2 nm resolution
- Holding force 5 N
- NEXACT® piezomotors

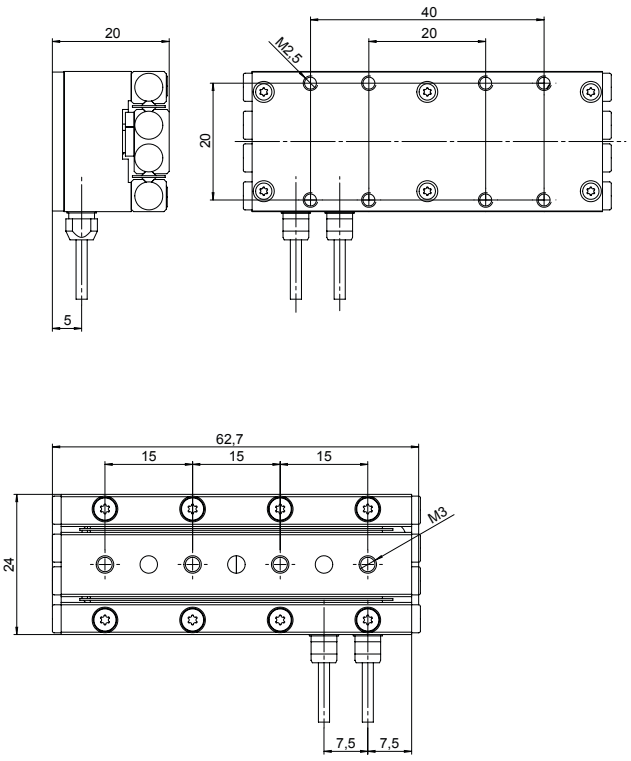
Reference-class linear positioning system
Direct metrology with linear encoder

NEXACT® piezo stepping drive
High-resolution piezoelectric linear drive. Compact design, holding force up to 5 N. Nanostepping mode with <1 nm resolution. Constant velocity motion. Long lifetime, drive principle based exclusively on mechanical stiction

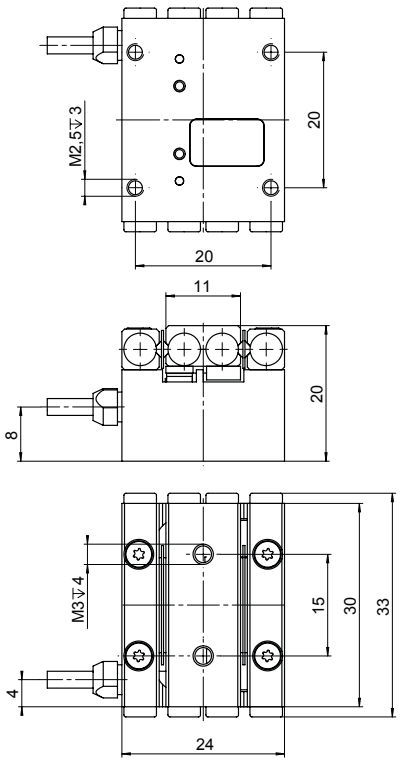
PIOne linear encoder
Optional. Based on interferometric measurement principle. 2 or 0.5 nm designs. Direction-sensing homing track. Compact design for easy integration in positioning systems. Patented Technology

Fields of application
Sample handling, positioning of samples and optical or mechanical components for installations limited in space. For use in research and industry. Vacuum versions available on request

Preliminary data	LPS-24 5862-9-1110	LPS-24 5862-9-1230	Unit	Tolerance
Active axes	X	X		
Motion and positioning				
Travel range	15	15	mm	
Integrated sensor	optical linear encoder	optical linear encoder PIOne		
Sensor resolution	150	2	nm	
Open-loop resolution	0.03	0.03	nm	typ.
Min. incremental motion	300	4	nm	
Velocity, closed-loop	10	10	mm/s	max.
Unidirectional repeatability	± 250	± 50	nm	typ.
Crosstalk, angular error	±100	±100	µrad	typ.
Mechanical properties				
Stiffness in motion direction	1	1	N/µm	±20 %
Load capacity	10	10	N	max.
Feed force (active)	5	5	N	max.
Holding force (passive)	5	5	N	max.
Drive properties				
Motor type	NEXACT® linear drive	NEXACT® linear drive		
Operating voltage	-10 to +45	-10 to +45	V	
Miscellaneous				
Operating temperature range	0 to 50	0 to 50	°C	
Material	Steel	Steel		
Dimensions	24 mm × 33 mm × 20 mm	24 mm × 63 mm × 20 mm		
Cable length	1.5	1.5	m	±10 mm
Connector	HD Sub-D (m) 15-pin (motor) HD Sub-D 15 (f) 15-pin (sensor)	HD Sub-D (m) 15-pin (motor) HD Sub-D 15 (f) 15-pin (sensor)		
Recommended controller/driver	E-861.1A1	E-861.1A1		



LPS-24 with 2 nm resolution, dimensions in mm



LPS-24 with 150 nm resolution, dimensions in mm

High Accuracy Linear Stage

0.5 NANOMETER RESOLUTION, PIEZO STEPPING DRIVE

N-565

- Direct measurement with PIOne incremental encoder, 0.5 nm resolution
- Travel ranges 13 mm, 26 mm or 52 mm
- Compact design, 65 mm width, 20 mm height
- UHV-compatible versions to 10^{-9} hPa on request

Reference class linear positioner
Direct measurement with linear encoder. High guiding accuracy due to crossed roller guide with cage force guidance

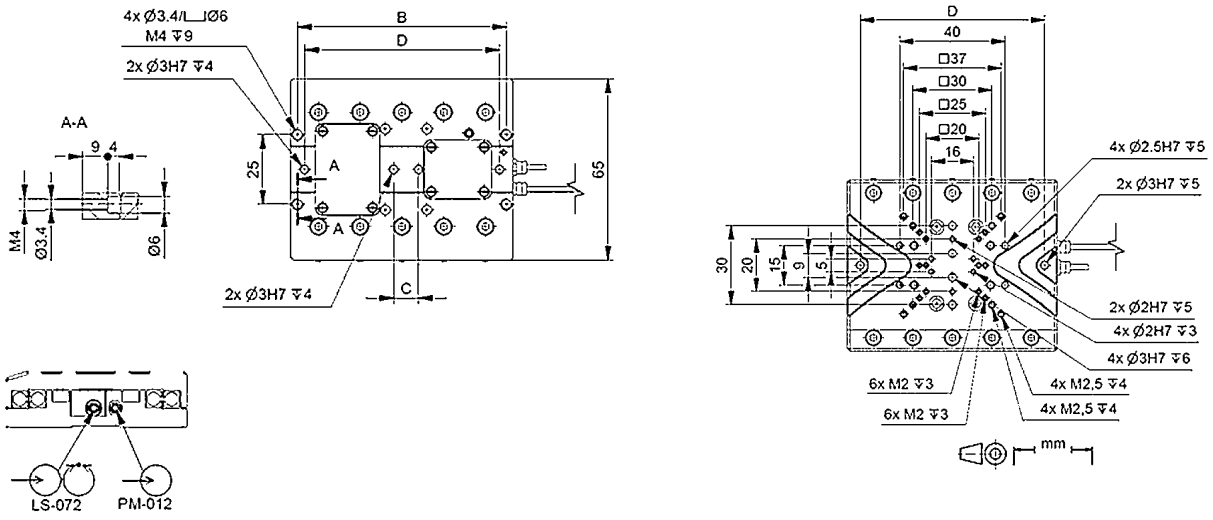
NEXACT® piezo stepping drive
High-resolution piezoelectric linear drive. Compact design, holding forces up to 10 N. Nanostepping mode with <1 nm resolution. Constant velocity motion. Maximum velocity 10 mm/s. Long lifetime, drive principle based only on mechanical stiction. Self-locking when at rest, therefore no heat generation and no servo jitter

PIOne linear encoder
Direct position measurement. Based on interferometric measurement principle. 0.5 µm signal period, linearity error <1 %. Direction-sensing homing track. Compact design for easy integration in positioning systems. Patented technology

Fields of application
Sample handling, positioning of samples and optical or mechanical components for installations limited in space. For use in research and industry

Preliminary data	N-565.160	N-565.260	N-565.360	Unit	Tolerance
Active axes	X	X	X		
Motion and Positioning					
Travel	13	26	52	mm	
Integrated sensor	Optical linear encoder PIOne	Optical linear encoder PIOne	Optical linear encoder PIOne		
Sensor resolution	0.5	0.5	0.5	nm	
Minimum incremental motion	2	2	2	nm	
Velocity, closed-loop	10	10	10	mm/s	max.
Unidirectional repeatability	±5	±5	±5	nm	typ.
Crosstalk, angular error at full travel range	±30	±40	±80	µrad	typ.
Straightness and flatness of motion at full travel range	±1	±2	±3	µm	typ.
Mechanical Properties					
Load capacity	20	20	20	N	max.
Feed force (active)	10	10	10	N	max.
Holding force (passive)	10	10	10	N	min.
Drive Properties					
Motor Type	NEXACT® piezo stepping drive	NEXACT® piezo stepping drive	NEXACT® piezo stepping drive		
Operating voltage	-10 to 50	-10 to 50	-10 to 50	V	
Miscellaneous					
Operating temperature range	10 to 50	10 to 50	10 to 50	°C	
Material	Al (black anodized)	Al (black anodized)	Al (black anodized)		
Mass	0.3	0.4	0.6	kg	±5 %
Dimensions	65 × 80 × 20	65 × 110 × 20	65 × 160 × 20	mm	
Cable length	3	3	3	m	±10 mm
Connector	HD Sub-D (m) 15-pin (motor) HD Sub-D (f) 15-pin (sensor)	HD Sub-D (m) 15-pin (motor) HD Sub-D (f) 15-pin (sensor)	HD Sub-D (m) 15-pin (motor) HD Sub-D (f) 15-pin (sensor)		
Recommended controller/driver	E-861.1A1: single-axis motion controller E-712: modular controller system for up to 6 axes	E-861.1A1: single-axis motion controller E-712: modular controller system for up to 6 axes	E-861.1A1: single-axis motion controller E-712: modular controller system for up to 6 axes		

* The N-565 stage series replaces the LPS-65 series.
Ask about custom designs!



N-565, dimensions in mm

High Precision Vertical Positioner

0.5 NANOMETER RESOLUTION, PIEZO STEPPING DRIVE

N-765

- Direct measurement with PIOne incremental encoder, 0.5 nm resolution
- Up to 1 nm minimum incremental motion
- Travel range 6.5 mm
- Load capacity to 2.5 kg
- Direct mounting on N-565 precision linear stage

Reference class vertical linear positioner
Direct measurement with linear encoder. Motion displacement and force reduction by moving wedge. High load capacity

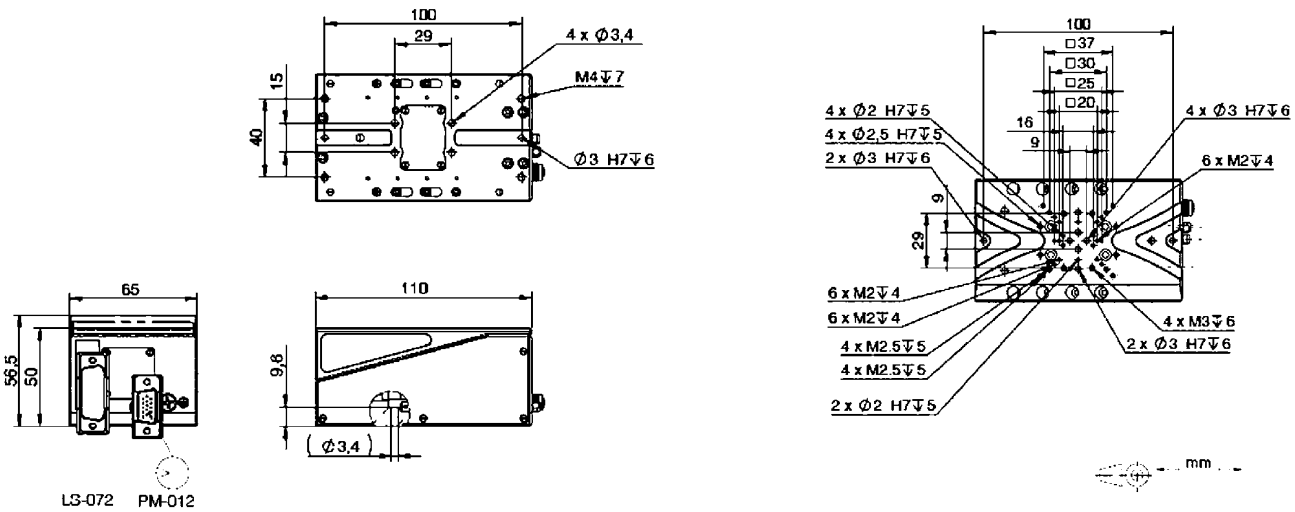
NEXACT® piezo stepping drive
High-resolution piezoelectric linear drive. Compact design, holding forces up to 10 N. Nanostepping mode with <1 nm resolution. Constant velocity motion. Maximum velocity 10 mm/s. Long lifetime, drive principle based only on mechanical stiction. Self-locking when at rest, therefore no heat generation and no servo jitter

PIOne linear encoder
Direct position measurement. Based on interferometric measurement principle. 0.5 µm signal period, linearity error <1 %. Direction-sensing homing track. Compact design for easy integration in positioning systems. Patented technology

Fields of application
Sample handling, positioning of samples and optical or mechanical components for installations limited in space. For use in research and industry

Preliminary Data	N-765.060	Unit
Active axes	Z	
Motion and positioning		
Travel	6.5	mm
Integrated sensor	Optical linear encoder PIOne	
Sensor resolution	0.5	nm
Min. incremental motion	1	nm
Velocity, closed-loop	2.5	mm/s
Unidirectional repeatability	±20	nm
Crosstalk, angular error at full travel range	±75	µrad
Mechanical Properties		
Load capacity	20	N
Feed force (active)	25	N
Holding force (passive)	25	N
Drive Properties		
Motor Type	NEXACT® piezo stepping drive	
Operating voltage	-10 to 45	V
Miscellaneous		
Operating temperature range	10 to 50 °C	
Mass	0.8	kg
Material	Al (black anodized)	
Dimensions	65 × 80 × 20	mm
Cable length	3	m
Connector	HD Sub-D (m) 15-pin (motor) HD Sub-D (f) 15-pin (sensor)	
Recommended controller/driver	E-861.1A1: single-axis motion controller E-712: modular controller system for up to 6 axes	

Ask about custom designs!



N-765, dimensions in mm

PiezoWalk® Controller / Driver

NETWORKABLE CONTROLLER FOR NEXACT® LINEAR DRIVES AND POSITIONERS

E-861

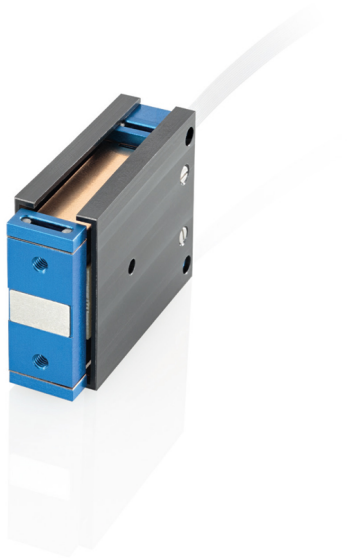
- High-speed encoder input
- Macro programmable for stand-alone functionality
- Data recorder
- Non-volatile EEPROM for macros and parameters

	E-861.1A1
Function	Controller for NEXACT® drives/systems
Drive type	NEXACT® linear drive
Channels	1
Motion and control	
Servo characteristics	P-I-D servo control, parameter change on-the-fly
Trajectory profile modes	Trapezoidal
Encoder input	Analog encoder input sine-cosine, interpolation selectable up to 1000; Interpolation circuit for differential transmission, 1 V_{pp} amplitude and 2.5 V offset of the encoder signal
Stall detection	Servo off, triggered by programmable position error
Input limit switch	2 × TTL (pull-up / pull-down, programmable)
Input reference switch	1 × TTL
Electrical properties	
Max. output power	40 W
Output voltage	-10 to +45 V
Max. operating current	2 A
Interfaces and operation	
Communication interfaces	USB 1.0, RS-232 (9-pin (m) sub-D)
Motor connector	HD Sub-D 15-pin (f)
Sensor connection	HD Sub-D 15-pin (m)
Controller network	Up to 16 units on single interface*
I/O ports	4 analog / digital in, 4 digital out (TTL)
Command set	PI General Command Set (GCS)
User software	PIMikroMove, PITerminal
Software drivers	GCS DLL, LabVIEW driver
Supported functionality	Start-up macro; data recorder for recording parameters as motor input voltage, velocity, position or position error; internal safety circuitry: watchdog timer
Manual control (optional)	Pushbutton box, joystick (for 2 axes), Y-cable for 2-D motion
Miscellaneous	
Operating voltage	24 V; included: external power supply, 24 V; 2.0 A
Operating temperature range	0 to 50 °C
Mass	1.1 kg
Dimensions	206 mm × 130 mm × 66 mm (incl. mounting rails)

* 16 units with USB; 6 units with RS-232.

Miniature Stages with Linear Motors and Voice Coil Drives

HIGH SPEED, HIGH RESOLUTION, HIGH DUTY CYCLES



Linear Motors and Voice Coil Drives

Linear Drives

Linear drives basically allow for unlimited travel ranges. They are direct-drive systems; they do not use drive screws or gearheads and are backlash-free. The positioning accuracy of the overall system is only affected by the position measurement and the guides.

Electromagnetic Linear Drives

Linear servo motors are used both for very high and for very low feed velocities. They work precisely in a range from 0.1 µm/s to more than 5 m/s. If combined with air bearings, a position resolution down to a few nanometers is possible.

Voice-Coil Linear Drives

These friction-free electromagnetic linear drives are characterized by their good dynamics, albeit with relatively low holding force. They are used primarily in scanning applications with travel ranges from several ten millimeters. To maintain a stable position, the voice-coil linear drive, just as any other linear drive, has to be operated in closed-loop, or alternatively combined with brakes.

Very compact designs are possible with voice-coil linear drives of the PIMag series

The Step Ahead with Air Bearing Technology

Frictionless High-Precision Positioning

A direct-drive motor and high-resolution encoder can position a moving carriage supported by an air bearing to within nanometers in a linear application or within tenths of arc-seconds in rotational applications. The lack of friction and mechanical contact means there is minimal hysteresis or reversal error, making it highly repeatable and ideal for many inspection and manufacturing operations. Stiction is virtually eliminated, improving resolution capabilities, position repeatability can be obtained within a few fundamental encoder counts. Similar precision can be obtained by piezo flexure guided stages, however over much smaller travel ranges.

Velocity Stability and Scanning

The lack of mechanical bearing elements means there is nothing to get in the way of smooth, controlled velocity (stability to better than 0.01%). Experiments and processes like inertial sensor testing, tomography, wafer scanning, and surface profiling require continuous motion at a tightly controlled speeds are best served by air bearing systems.

High Guiding Accuracy

Linear air bearing stages have incredibly straight and flat travels, measured in the 100's or 10's of nanometers and sub-arc-second pitch, roll, and yaw errors. Rotary stages have tilt (wobble) errors less than 1 arc-second. Additionally, the angular performance of an air bearing is remarkably repeatable. This guarantees optimal part quality and measurement reliability for applications such as optics inspection, semiconductor inspection, and medical device manufacturing.

PIglide MB: Miniature Linear Air Bearing Stage

HIGH PERFORMANCE, CLEANROOM COMPATIBLE, CUSTOMIZABLE

A-141 Series

- Table size 57mm x 83mm
- Overall height 38mm
- Travel lengths to 40 mm
- 3.5 kg max payload
- Non-contact fully preloaded air bearings
- Ironless cog-free linear motor
- Integral optical linear encoder
- Resolutions to 20nm
- Velocity to 0.5 m/sec
- Acceleration to 0.75 g

Overview

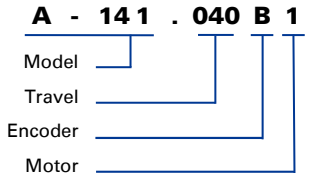
The PIglide MB air bearing stage is linear servo motor driven with fully preloaded air bearings and an integral optical linear encoder. This stage offers ultra-precision in a miniature package. The combination of non-contact components results in a frictionless motion platform that offers the highest performance, quality, and life. This stage is ideally suited for many high precision applications, such as metrology, photonics alignment, optics positioning, and scanning. The non-contact design also makes these stages ideal for cleanroom applications. There are no moving electrical cables to manage. The air bearing offers a locking design for the ultimate in position stability.

Accessories and Options

- Air preparation kits
- Single or multi-axis motion controller and servo drives
- Additional accessories available upon request

Model	A-141.040B1
Travel	40 mm
Drive System	Brushless linear servo motor, 3-phase
Feedback System	Non-contact optical linear encoder
Motor Bus Voltage	Up to 80 VDC
Motor Force Constant	2.1 N/A
Motor Back EMF	0.7 V/m/sec
Motor Resistance (@25°C, phase-to-phase)	22.4 ohms
Limit Switches	Differential, at each end of travel
Home Index	Near center of travel, repeatable to +/- 1 encoder count
Maximum Velocity [1]	Up to 0.5 m/sec
Maximum Acceleration [1]	Up to 0.75 g
Maximum Payload [2]	3.5 kg
Accuracy [3]	+/-3.0 µm
Repeatability	+/-0.2 µm
Encoder Resolution [4]	20 nm
Straightness & Flatness [5]	< 1µm TIR over full travel
Pitch & Yaw [5]	< 2 arc-sec TIR over full travel
Stage Mass	0.6 kg
Moving Mass	0.3 kg
Cabling	Internal, non-moving
Operating Pressure [6]	65 +/-5 psi (450 +/-35 kPa)
Air Consumption	< 1.0 SCFM (28 SLPM)
Air Quality	Clean (filtered to 1.0 µm or better) / Oil-free / Dry (-15 °C dew point)
Construction	Hardcoat Aluminum / SS Fasteners

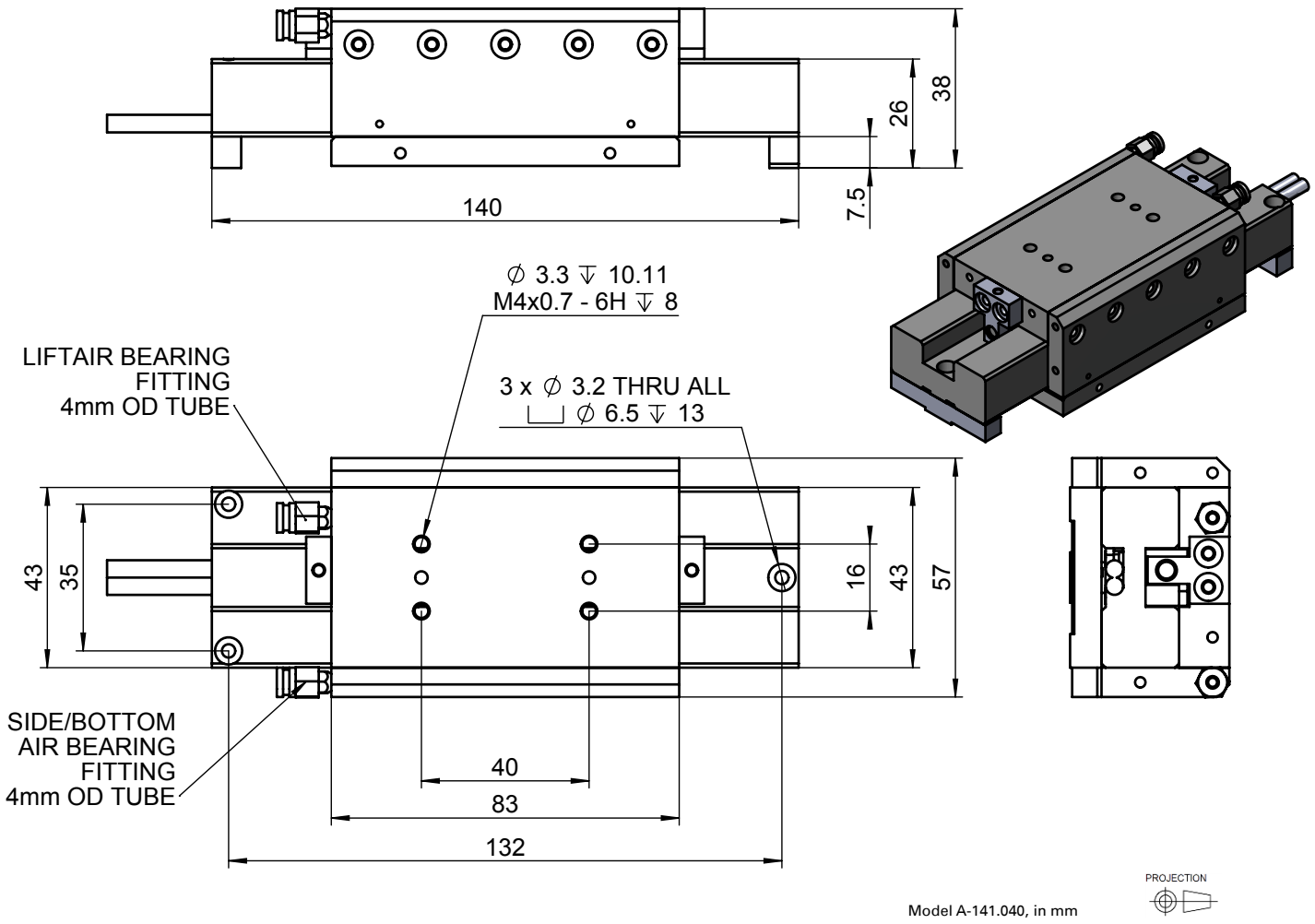
1. Maximum velocity and acceleration based on stage capability, may be limited by controller or drive performance.
2. Assumes payload CG is centered no more than 50mm above the stage table.
3. Improved accuracy can be obtained with controller-based error compensation.
4. Encoder resolution can be changed upon request, please contact PI for a quote.
5. Dependent on the flatness of the surface to which the stage is mounted.
6. To protect stage from damage, an under-pressure air sensor tied to the controller E-stop input is recommended.



Model	Travel	Encoder [1]	Motor Wiring
A-141	040 = 40 mm	B = 20 nm/count TTL A-quad-B output	1 = Standard motor option, 48 VDC

1. Alternate encoder resolutions available on request.

Ordering Example
Part# A-141.040B1 is a
Model: A-141 (PIglide MB miniature linear motorized air bearing stage)
Travel: 40 mm
Encoder: B (20 nm/count TTL A-quad-B output)
Motor Wiring: 1 (48 VDC)



Model A-141.040, in mm

PIMag® Voice Coil Linear Positioner

COMPACT, INTEGRATED POSITION SENSOR

V-900KPIC

- Travel range 1.5 mm
- High scanning frequencies, fast step-and-settle
- Integrated linear encoder, 0.1 µm resolution
- Wear-free flexure guiding for long lifetime
- Compact design

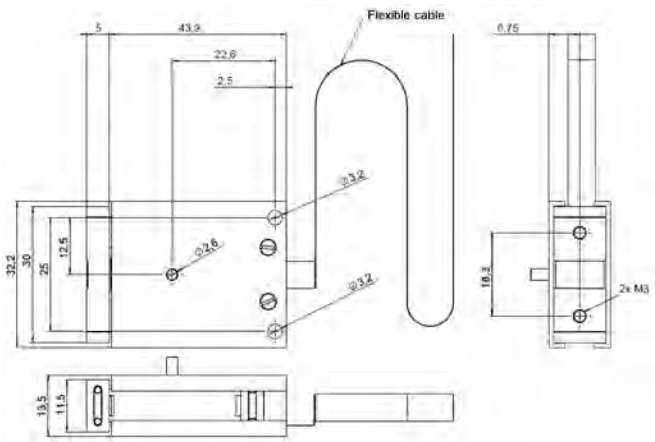
OEM linear actuator
PIMag voice coil magnetic drive, high velocity and high dynamics. Low wear and high lifetime. Integrated linear encoder for reliable position control and repeatable accuracy. 10 kHz servo update rate. Optional force sensor for applying defined forces. Easy integration by coupling the guided load to the moving runner

PIMag C-413 digital motion controller for position and force control
2 channels (position control) or 1 channel (simultaneous position and force control). Controlled output current up to 1.5 A at 24 V, 150 kHz. USB interface for sending commands, digital I/Os, SPI interface. Plug&Play: ID chip for reading stage parameters. Available as OEM board or bench-top device. PIMikroMove user software, compatible with PI General Command Set (GCS)

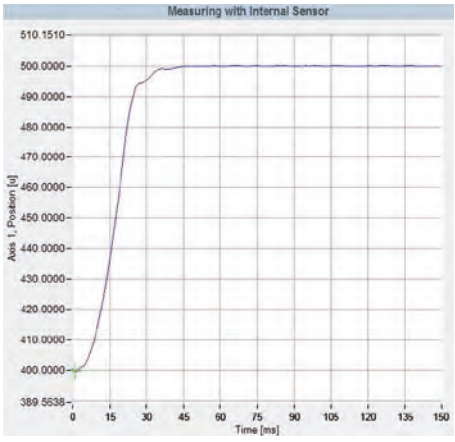
Fields of application
OEM drives in automation. For fast handling tasks and precision positioning in the micrometer range, micromanipulation

Preliminary data	V-900KPIC	Unit	Tolerance
Active axes	Z		
Motion and positioning			
Travel range	1.5	mm	
Integrated sensor	Optical linear encoder		
Servo update rate	10*	kHz	
Open-loop resolution	10*	nm	typ.
Closed-loop resolution	100	nm	typ.
Closed-loop linearity error	±1	%	typ.
Repeatability	±500	nm	typ.
Straightness of travel	±5	µm	±5
Maximum velocity, open-loop	250	mm/s	
Velocity, closed-loop	45	mm/s	
Mechanical properties			
Moved mass	10	g	typ.
Average push / pull force	0.5	N	nominal
Maximum push / pull force	0.8	N	max.
Force constant	4	N/A	typ.
Drive properties			
Motor type	PIMag™ voice coil drive		
Magnet material	NdFeB (N38SH)		
Coil resistance	8.8	Ω	typ.
Coil inductance	0.8	mH	typ.
Average continuous current	120**	mA	max.
Peak current (max. 3 s)	200	mA	
Miscellaneous			
Operating temperature range	10 to 45	°C	
Material	Aluminum		
Mass	40	g	±5 %
Cable length	0.2	m	
Motor / sensor connection	Molex 12-pin		
Lifetime	>10^8	cycles	min.
Recommended controller	C-413 (plug adapter required)		

* With C-413 controller.
** Allowable average value for continuous operation, not to be exceeded.



V-900KPIC, dimensions in mm



The settling time for a 100 µm step is approx. 50 ms.

QuickScan™ High Dynamics Scanner

VOICE COIL DRIVE, DIRECT POSITION MEASUREMENT

V-106

- Fast scanning and positioning
- Travel ranges 20 mm and 6 mm
- Resolution 0.1 µm
- Scanning frequencies to tens of Hz
- Max. velocity 270 mm/s
- Crossed- roller bearings for highest precision

QuickScan micropositioning stages of the V-106 series were designed for high-dynamics precision scanning and positioning applications, like those in biotechnology and fiber optics. They are based on zero friction voice coil drives (linear motors), which, combined with high-precision linear encoders, offer a position resolution of 0.1 µm and minimal step size of 0.2 µm.

V-106 micropositioning stages achieve significantly higher dynamics than lead screw-based units. The specially designed voice coil drive system makes possible scanning frequencies of some tens of hertz. With an applied load of 90 grams, the scan frequency of the V-106.11S is still 20 Hz over a travel range of 1 mm. The excellent dynamic characteristics are advantageous not only for scanning applications: positioning tasks see them as short settling times like 75 ms for 5 mm with a 90 gram load.

Direct Drive and Direct Metrology—Precise Motion

The design of the V-106 is based on three key precision components:

- A frictionless voice-coil (linear motor) drive
- A non-contacting direct motion metrology linear encoder for sub-micron repeatability
- Precision cross-roller bearings for ultra-straight and smooth motion

Unlike lead screw-driven translation stages, the voice-coil linear motor in the V-106 is frictionless, quiet and not subject to wear and tear. In addition, it provides higher dynamics, speed, acceleration and responsiveness (step-and-settle) — ideal features for high-throughput applications. The embedded drive also reduces the length considerably compared to conventional motor/screw driven stages.

For highly repeatable motion, a non-contacting optical linear encoder with 0.1 µm resolution is mounted inside the stage and feeds position information back to the motion controller. The integrated, non-contact reference switch increases versatility in automation applications.

Versatile PCI Board Controller

V-106 voice coil stages can be controlled by the C-843 digital controller in PCI plug-in-board format. C-843 controllers are equipped with on-board linear servo-amplifiers for precise control of up to four axes. This lowers system costs and simplifies setup by eliminating additional external amplifiers and cables.

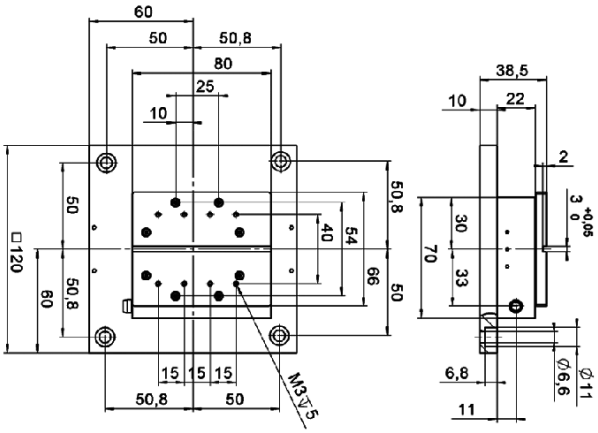
Frictionless Voice Coil Linear Drives

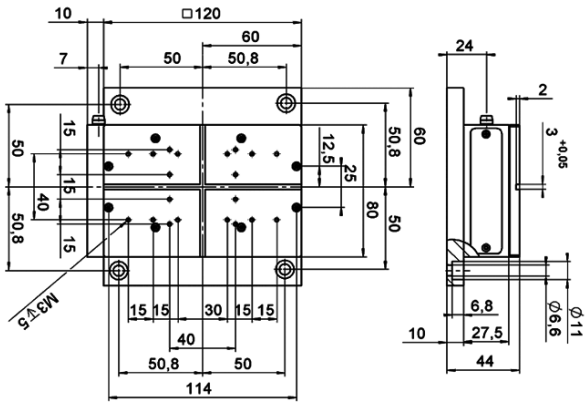
High-accuracy voice coil linear drives work on the same principle as electromagnetic loudspeakers. However, for precision positioning applications, they must provide much higher forces and high stability to hold a position without jitter. They must also be designed for closed-loop operation to allow for precise positioning.

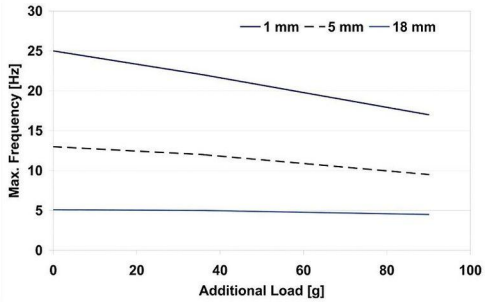
These zero-friction magnetic linear drives, characterized by their excellent dynamics, are ideally suited for scanning applications requiring travel ranges in the millimeter to centimeter range. PI offers voice coil drives in V-106 standard systems; custom systems are available on request.

	V-106.11S	V-106.14S	Unit	Tolerance
Active axes	X	X		
Motion and positioning				
Travel range	6	20	mm	
Integrated sensor	Linear encoder	Linear encoder		
Sensor resolution	0.1	0.1	µm	
Design resolution	0.1	0.1	µm	
Min. incremental motion	0.2	0.2	µm	typ.
Backlash	0.2	0.2	µm	
Unidirectional repeatability	0.2	0.2	µm	typ.
Pitch	50	50	µrad	typ.
Yaw	50	50	µrad	typ.
Velocity*	240	270	mm/ s	max.
Reference point switch repeatability	1	1	µm	typ.
Mechanical properties				
Moved mass	102	172	g	typ.
Load capacity	36	81	N	max.
Push / pull force**	5	3.3	N	max.
Push / pull force with C-843**	2.3	1.5	N	max.
Lateral force	18	40	N	max.
Drive properties				
Drive type	Voice Coil	Voice Coil		
Average current	0.42	0.42	A	nominal
Peak current	1.8	1.8	A	max. (3s)
Average force	1.2	0.8	N	nominal
Coil resistance	10	10	W	typ.
Coil inductance	100	100	µH	typ.
Force constant	2.88	1.92	N/ A	
Voltage generation constant	36.1	24	Vs/ m	
Miscellaneous				
Operating temperature range	0 to 55	0 to 55	°C	
Material	Al	Al		
Mass	800	1000	g	±5 %
Cable length	1.5	1.5	m	±10 mm
Connector	Sub- D 15 (m)	Sub- D 15 (m)		
Recommended controller / driver				

* With C-843 controller.
** The C-843 controller provides 8 V and 0.8 A max. per channel and therefore limits the push / pull force.







V-106.14S maximum scanning frequency for different loads and scan amplitudes for example 18 mm scans with up to 90 g load at >4 Hz frequency are feasible. The velocity is up to 270 mm/ s

PIMag® Voice Coil Actuator

COST-EFFECTIVE, HIGH DYNAMICS

V-273

- Travel ranges to 20 mm
- Velocity to 250 mm/s
- Integrated linear encoder, 0.1 µm resolution
- Optional force sensor with 5 mN resolution
- Optional: Weight force compensation

OEM linear actuator

PIMag voice coil magnetic drive, high velocity and high dynamics. Low wear and high lifetime. Integrated linear encoder for reliable position control and repeatable accuracy. 10 kHz servo update rate. Optional force sensor for applying defined forces. Easy integration by coupling the guided load to the moving runner

C-413 digital PIMag motion controller for position and force control

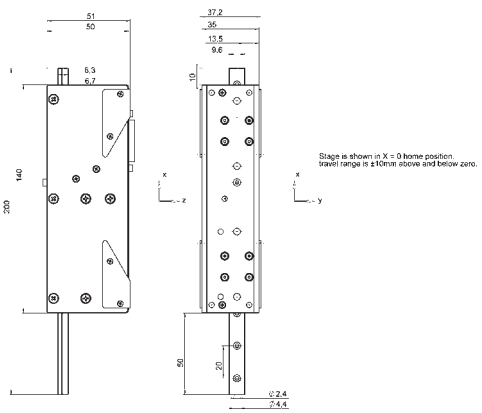
2 channels (position control) or 1 channel (simultaneous position and force control). Controlled output current up to 1.5 A at 24 V, 150 kHz. USB interface for sending commands, digital I/Os, SPI interface. Plug & Play: ID chip for reading stage parameters. Available as OEM board or bench-top device. PIMikroMove user software, compatible with PI General Command Set (GCS)

Fields of application

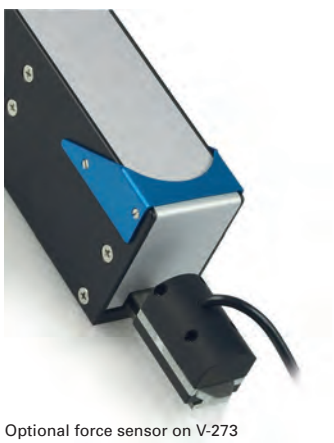
OEM drives in automation. For fast handling tasks and precision positioning in the micrometer range, micromanipulation

Preliminary data	V-273	Unit	Tolerance
Active axes	X		
Motion and positioning			
Travel range	20	mm	
Integrated sensor	Optical linear encoder		
Servo update rate	10*	kHz	
Open-loop resolution	10*	nm	typ.
Closed-loop resolution	100	nm	typ.
Linearity error, closed-loop	1	%	typ.
Repeatability	±500	nm	typ.
Straightness of travel	±20	µm	±5
Velocity, open-loop	250	mm/s	max.
Velocity, closed-loop	200	mm/s	
Mechanical properties			
Bearing / guiding	Linear guiding		
Moved mass	56 (59 with force sensor)	g	typ.
Drive properties			
Motor type	PIMag™ voice coil drive, moving coil		
Magnet material	N52 (NdFeB)		
Coil resistance	16	Ω	typ., at 20 °C
Coil inductance	6	mH	typ., at 20 °C
Time constant	0.375	ms	
Mutual inductance	8	Vs/m	
Force constant	8	N/A	typ.
Motor constant	2	$N/W^{1/2}$	
Current constant	0.125	A/N	
Average continuous current	400**	mA	max.
Peak current (max. 3 s)	800	mA	
Average push / pull force	3	N	nominal
Power dissipation with 100 % duty cycle	2.25	W	
Maximum push / pull force	8	N	max.
Power dissipation with 10 % duty cycle	16	W	
Miscellaneous			
Operating temperature range	10 to 60	°C	
Material	Aluminum		
Mass	565	g	±5 %
Cable length	1	m	
Motor / sensor connection	Sub-D 15 (m)		
Lifetime	$>10^7$	cycles	min.
Recommended controller	C-413		

* With C-413 controller.
** Allowable average value for continuous operation, not to be exceeded.



V-273, dimensions in mm



Optional force sensor on V-273

Motion Controller for Voice Coil Positioners

CONTROL OF FORCE, POSITION, VELOCITY

C-413

- 2 motor channels
- USB interface for sending commands and for configuration
- Real-time SPI interface for sending commands
- Digital in- and outputs
- Optional analog inputs and outputs
- Auto zero function for holding current
- ID chip support
- Extensive software support

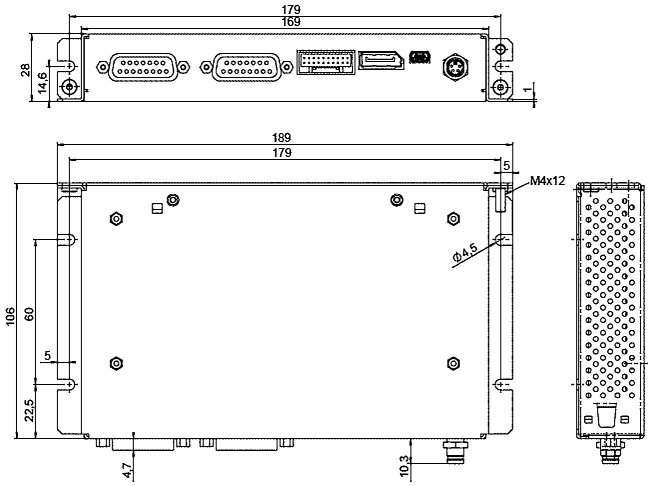
Digital motion controller for PIMag® Voice Coil drives
2 motor channels, 4 sensor channels. PID controller for force, position and velocity. Servo update rate selectable-between 5 to 10 kHz

Force control
With the force control, PIMag® actuators and stages can be operated at a defined holding and feed force. Force and position sensors are read and the sensor values are processed simultaneously. Thus it is possible to add a secondary position or velocity control loop to the force control. PI offers PIMag® actuators with additional force sensor. The models C-413.20A / .2GA provide analog input sockets for external force sensors

Extensive functionality
Data recorder: Recording of operating data such as motor current, velocity, position or position error. Wave generator: Saves and outputs periodical motion profiles. Auto zero function defines holding current level at which the drive in open-loop operation outputs a force of 0 N , e.g. for compensating gravity. ID chip support: Identifies the connected stages and simplifies configuration and exchange of stages. Supports direction-sensing reference point switches. Extensive software support, e.g. for LabVIEW, dynamic libraries for Windows and Linux

Interfaces
USB 2.0, SPI for sending commands. Digital inputs and outputs for automation. Optional analog inputs and outputs, e.g. for sensors, for sending commands or for position feedback

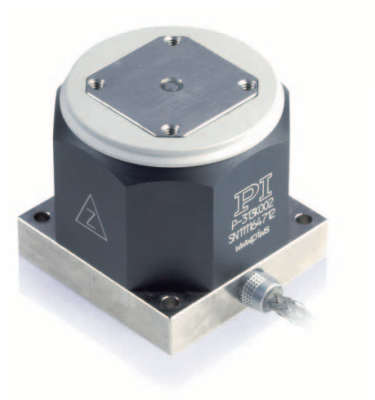
Preliminary data	C-413.20 / C-413.20A C-413.2G / C-413.2GA	Unit
Function	PIMag® motion controller for voice coil drives, 2 channels C-413.20 / .20A: OEM board C-413.2G / .2GA: Device with case	
Motor channels	2	
Sensor channels	4	
Motion and control		
Servo characteristics	PID controller for force, position and velocity; parameter change on-the-fly	
Servo cycle time	100 µs to 200 µs, selectable in 4 steps	
Profile generator	Trapezoidal velocity profile, setting of maximum velocity and acceleration	
Encoder input	SPI sensor interface	
Reference point switches	4 × TTL, direction- sensing	
Electrical properties		
Max. output voltage	24	V
Max. output current	±1.5	A, closed-loop
Interface and operation		
Communication interfaces	USB 2.0, real time SPI	
Motor connector	Sub-D 15-pin (f)	
Drive Properties	2 x analog inputs, -10 to 10 V, 16 bit, 1 kHz (only C-413.20A and C-413.2GA) 2 x analog outputs, -10 to 10 V, 17 bit, 1 kHz (only C-413.20A and C-413.2GA) 6 x digital outputs (open collector, voltage range 5 V to 24 V, 33 k internal pull-up to 5 V) 4 x digital input (5 V TTL level, to 24 V max. input voltage, 10 k input resistance)	
Command set	PI General Command Set (GCS)	
User software	PIMikroMove	
Software drivers	LabVIEW driver, dynamic libraries for Windows and Linux	
Supported functionality	Point-to-point motion; data recorder; wave generator; auto zero; ID chip detection	
Miscellaneous		
Operating voltage	External power supply 24 V, included in scope of delivery	
Max. operating current	2	A
Operating temperature range	5 to 50	°C
Max. mass	0.3	kg
Dimensions	188 × 28 × 105 (C-413.2G / .2GA) 160 × 18 × 100 (C-413.20 / .20A)	mm



C-413 with case, dimensions in mm

Piezo Flexure Nanopositioning Stages

ULTRA-HIGH PERFORMANCE, SHORT TRAVEL, ZERO FRICTION, ZERO WEAR



Piezo Flexure Nanopositioning Stages

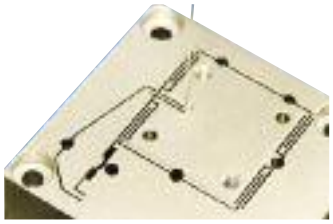
Low-profile two-axis piezo scanner

Piezo actuators have excellent drive properties:

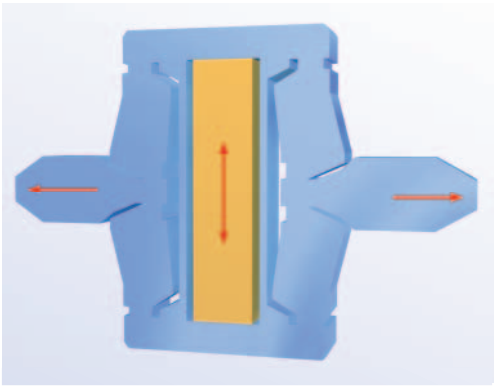
- The motion of piezo actuators is based on solid-state effects, which makes their resolution in general unlimited
- Their stiffness is very high, enabling high force generation by piezo stepping drives
- Their rapid response time in the microsecond range is a result of their high resonant frequency of several hundred kilohertz

Flexure Levers

The displacement of a piezo actuator can also be multiplied by integrating a lever mechanism. The actuator is mechanically integrated in a flexure joint in such a way that the travel range is extended to up to 2 mm. Since simple lever structures lose a considerable amount of guiding accuracy and stiffness, however, the design requires much more complex geometries.



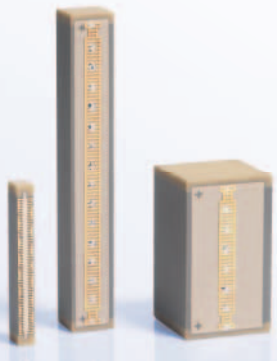
Flexure guiding systems of the highest accuracy class are manufactured with a wire cut discharge process



This lever mechanism with flexure guides transforms the actuator travel range (vertical) to an even, straight motion (horizontal)

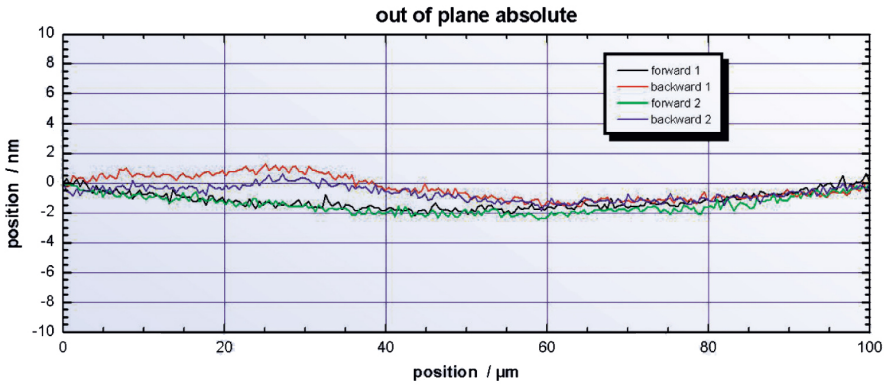
Highly Reliable PICMA® Piezo Actuators

PICMA® piezo actuators from PI are the only monolithic, multilayer piezo actuators in the world which are completely encapsulated in a ceramic insulation layer. Decades of experience with PICMA® series in various applications show that the lifetime has been increased by at least a factor of 10 compared to conventional, polymer-coated, multilayer piezo actuators. In lifetime tests, more than 100 billion cycles without a single failure have been demonstrated. The PICMA® technology is patented.



Due to their ultra-high performance and reliability, PICMA® piezo actuators with all-ceramic insulation were chosen for tests carried out by NASA on Mars

Excellent Guiding Accuracy Through Flexure Joints



A piezo stage with integrated flexure guide achieves a guiding accuracy of only a few nanometers or microradians and excellent flatness

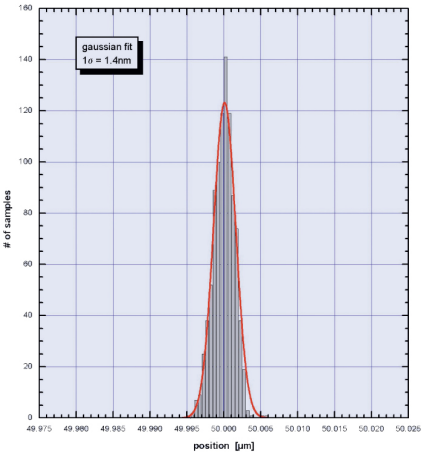
Sub-Nanometer Accuracy

Flexures allow motions with extremely high path accuracy. In order to compensate for height or transversal offset, PI uses special multi-link flexure guides. These guiding systems, which are implemented in most nanopositioning systems from PI, allow a flatness and straightness in the sub-nanometer or microradian range.

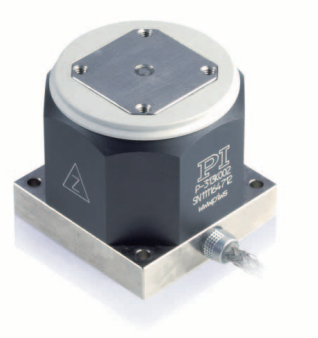
The motion of a flexure joint is based on the elastic deformation of a solid. Therefore, there is no static, rolling or sliding friction.

No Wear

Their advantages are the high stiffness, load capacity and wear-resistance. Flexures are maintenance-free, can be manufactured from nonmagnetic materials, require no lubricants or consumables and hence also function in a vacuum without any problem.



Measurements have confirmed the excellent repeatability of the piezo positioning system with capacitive sensors with 1.4 nm (1 σ value) of standard deviation



PicoCube® XYZ Piezo Scanners for AFM

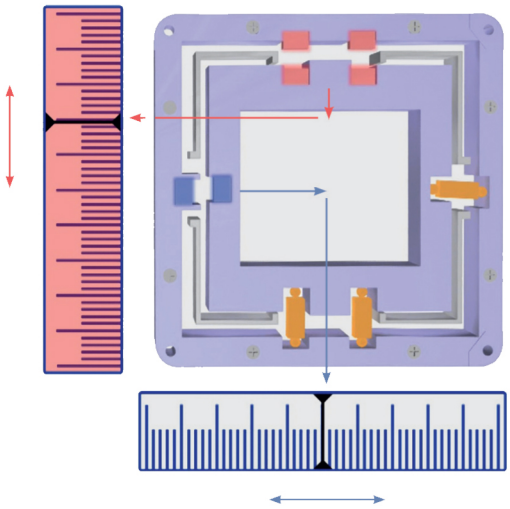
Maximum Accuracy through Direct Metrology

When directly measuring positions with noncontact sensors, each change in position of the moving platform is directly captured by the controller relatively to the base body. There are no drive or guiding elements, which would affect the measurement, between measured point and moving platform. This method allows a bandwidth in kilohertz range, resolution in sub-nanometer range and excellent stability.

Parallel Kinematics Optimizes Motion in Multiple Axes

Direct Parallel Metrology: Multi-Axis Measurements using a Fixed Reference

A multi-axis stage design with parallel kinematics allows you to use direct parallel metrology, measuring all degrees of freedom of the moving platform in relation to a fixed reference. Unintended crosstalk of the motion into a different axis, e.g. as a result of an external force, can thus be detected and actively corrected in real time. This so-called active guiding can keep the deviation from the trajectory down to a few nanometers, even in dynamic operation.



Parallel-kinematic nanopositioning system with capacitive sensors, parallel-metrology arrangement and reduced inertia. The arrows show the signal flow from the sensor to the closed-loop control. Red: X axis, blue: Y axis

PI Piezomotors Compared to Piezo Actuators

Piezo flexure or stack actuators	PiezoWalk® piezo stepping drive	PILine® ultrasonic piezomotor	PIShift piezo inertia drive
Sub-nanometer resolution	Sub-nanometer resolution	Sub-micrometer resolution	Sub-nanometer resolution
Fast response within a few microseconds	Velocity up to 10 mm/s High-dynamics scan mode	Very high operating frequency Noiseless drive High velocity of up to several 100 mm/s	Very high operating frequency Noiseless drive Velocity of more than 10 mm/s
Travel ranges of up to approx. 300 µm directly and 2 mm with lever amplification	Long travel ranges, only limited by the runner length	Long travel ranges, only limited by the runner length	Long travel ranges, only limited by the runner length
High stiffness Force generation of up to 100 kN	Very high forces of up to 800 N (NEXLINE®) Self-locking at rest	Forces up to 40 N Self-locking at rest	Forces up to 10 N Self-locking at rest
Control via analog voltage Voltage range 150 V (PICMA® multilayer actuators), 1 100 V (PICA high-load actuators)	Multi-actuator drive generates stepping motion Voltage range 55 V (NEXACT®), 500 V (NEXLINE®)	Single-actuator drive Control via high-frequency alternating voltage (sinus) Voltage range 120 V, 200 V. Minimotors substantially lower	Single-actuator drive Control via high-frequency alternating voltage (modified sawtooth) Voltage range <48 V
Ideal for:			
■ Nanometer-precise positioning with high dynamics ■ Lever-amplified and guided systems ■ Piezo scanners ■ Fine adjustment ■ Force generation ■ Active vibration insulation	■ Nanometer-precision positioning ■ Quasi-static applications at high holding force ■ Travel ranges of up to a few mm ■ Coarse and fine adjustment ■ Force generation ■ Active vibration insulation ■ Operation at constant, low velocity	■ Positioning with sub-µm accuracy ■ Fast step-and-settle ■ Scan mode with high velocities ■ Operation at constant low, velocity	■ Nanometer-precision positioning stable over a prolonged period ■ Quasi-static applications at low to medium holding force

PIHera® Compact Piezo Flexure Nanopositioning Stage Family

PIHera stages P-620.1, P-620.2, P-620.Z (left to right)

- Reference Class Nanopositioning System
- X-, XY-, Z-, XYZ Versions
- Outstanding Lifetime Due to PICMA Piezo Technology
- Travel Ranges 50 to 1800 µm
- High-Precision, Cost-Efficient
- Resolution to 0.1 nm
- Direct Metrology with Capacitive Sensors
- 0.02% Positioning Accuracy
- Zero-Wear, Zero Friction High-Precision Flexure Guiding System
- Vacuum-Compatible Versions Available

The PIHera® family of compact piezo flexure nanopositioning stages is available in single and multi-axis versions, closed- and open loop, standard and vacuum compatible -- with a total of 60 variations featuring advanced, stiff flexure designs and motion amplifiers; travel ranges up to 1800 µm are feasible. Despite the large positioning ranges, the stages are extremely compact and provide rapid response and high guiding precision. This and the long travel range is achieved

Nanometer Precision in Milliseconds
One of the advantages of PIHera® stages over servo or stepper motor-driven positioning stages is the rapid response to input changes and the fast and precise settling behavior. The P-622.1CD, for example, can settle to an accuracy of 10 nm in only 30 m/sec (other PI piezo stages settle even faster)

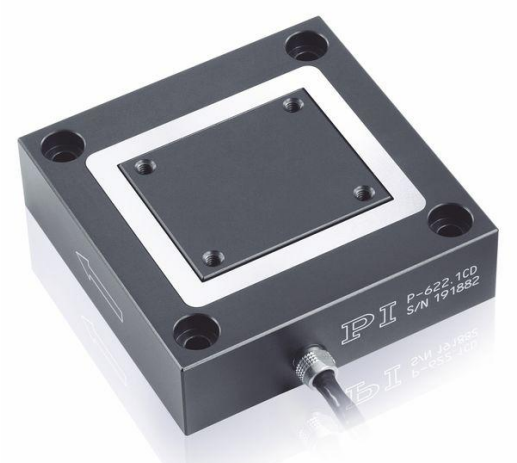
Superior Accuracy with Direct-Metrology Capacitive Sensors
Applications such as optical path adjustment interferometry, sample positioning in microscopy, precision alignment or optical tracking require the scanning ranges and nanometer precision offered by PIHera® nanopositioning stages. PI's proprietary capacitive sensors measure position directly and without physical contact. They also provide superior position stability and linearity compared to other nanopositioning sensors. Direct metrology sensors also provide high bandwidth and phase fidelity.

Designed for Precision
40 years of experience with piezo technology combined with FEA-optimized design of the frictionless flexure elements, results in high stiffness, dynamics, and excellent guiding accuracy with straightness and flatness in the nanometer range

Digital Control
A number of digital servo controllers with advanced algorithms such as DDL and APC is available to get the maximum performance out of these compact precision positioning stages.

PIHera® Piezo Flexure Linear Stage

VARIABLE TRAVEL RANGES, AXIS CONFIGURATIONS



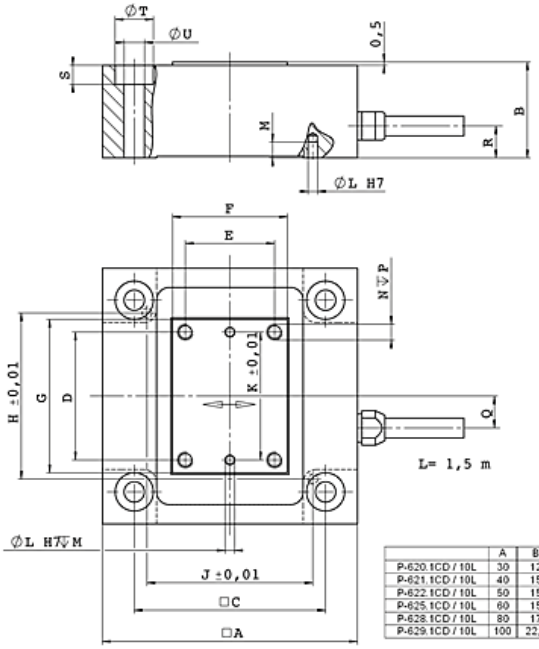
P-620.1 - P-629.1

- Travel Ranges 50 to 1800 µm
- Resolution to 0.1 nm
- 0.02% Positioning Accuracy
- Direct Metrology with Capacitive Sensors
- X-, XY-, Z-, XYZ Versions

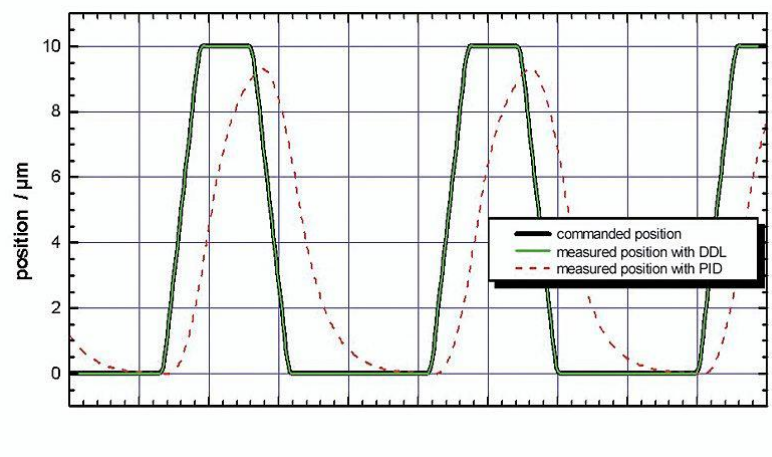
	P-620.1CD P-620.1CL	P-621.1CD P-621.1CL	P-622.1CD P-622.1CL	P-625.1CD P-625.1CL	P-628.1CD P-628.1CL	P-629.1CD P-629.1CL	Unit	Tolerance
Active axes	X	X	X	X	X	X		
Motion and positioning								
Integrated sensor	Capacitive	Capacitive	Capacitive	Capacitive	Capacitive	Capacitive		
Open- loop travel, -20 to 120 V	60	120	300	600	950	1800	µm	min. (20 % / -0 %)
Closed- loop travel	50	100	250	500	800	1500	µm	
Closed- loop / open- loop resolution	0.2 / 0.1	0.4 / 0.2	0.7 / 0.4	1.4 / 0.5	1.8 / 0.5	3 / 2	nm	typ.
Closed- loop linearity error	0.02	0.02	0.02	0.03	0.03*	0.03**	%	typ.
Repeatability	±1	±1	±1	±5	±10	±14	nm	typ.
Pitch / yaw	±3	±3	±3	±6	±6	±30 / ±10	µrad	typ.
Mechanical properties								
Stiffness in motion direction	0.42	0.35	0.2	0.1	0.12	0.13	N/ µm	±20 %
Unloaded resonant frequency	1100	800	400	215	125	125	Hz	±20 %
Resonant frequency @ 20 g	550	520	340	180	115	120	Hz	±20 %
Resonant frequency @ 120 g	260	240	185	110	90	110	Hz	±20 %
Push / pull force capacity in motion direction	10	10	10	10	10	10	N	max.
Load capacity	10	10	10	10	10	10	N	max.
Lateral force	10	10	10	10	10	8	N	max.
Drive properties								
Piezo ceramic	PICMA® P-883	PICMA® P-885	PICMA® P-885	PICMA® P-885	PICMA® P-887	PICMA® P-888		
Electrical capacitance	0.35	1.5	3.1	6.2	19	52	µF	±20 %
Dynamic operating current coefficient	0.9	1.9	1.9	1.6	3	4.3	µA / (Hz × µm)	±20 %
Miscellaneous								
Operating temperature range	-20 to 80	-20 to 80	-20 to 80	-20 to 80	-20 to 80	-20 to 80	°C	
Material	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum		
Dimensions	30 mm × 30 mm × 12 mm	40 mm × 40 mm × 15 mm	50 mm × 50 mm × 15 mm	60 mm × 60 mm × 15 mm	80 mm × 80 mm × 17 mm	100 mm × 100 mm × 22.5 mm		
Mass	0.11	0.16	0.2	0.24	0.38	0.72	kg	±5 %
Cable length	1.5	1.5	1.5	1.5	1.5	1.5	m	±10 mm
Sensor / voltage connection	CD versions: Sub- D special CL versions: LEMO							

Versions without sensor are available under the P-62x.10L ordering number; operating temperature range -20 to 150 °C. Sensor / voltage connection LEMO.
Vacuum versions to 10^{-9} hPa are available as P-62x.1UD.
The resolution of PI piezo nanopositioners is not limited by friction or stiction. Value given as noise with E-710 digital controller.
* With digital controller. With analog controllers 0.05 %
** With digital controller. With analog controllers 0.07 %

Drawings / Images



	A	B	C	D	E	F	G	H	J	K	⌀L	M	N	P	Q	R	S	⌀T	⌀U
P-620.1CD / 10L	30	12	24	15	12	15	18	19	24	15	1,01	1,5	M2	4	4,5	6	2	4,4	2,2
P-621.1CD / 10L	40	15	30	20	14	18	24	26	26	20	1,51	2,5	M2,5	5	5	5	3	6	3,2
P-622.1CD / 10L	50	15	40	24	20	25	30	35	35	24	1,51	2,5	M2,5	5	5,5	5	3	6	3,2
P-625.1CD / 10L	60	15	50	40	27	32	44,5	46	46	40	1,51	2,5	M2,5	5	5,5	5	3	6	3,2
P-628.1CD / 10L	80	17	70	58	41	45	63	66	66	58	1,51	2,5	M2,5	5	5,5	5	3	6	3,2
P-629.1CD / 10L	100	22,5	90	60	40	60	84	82	82	60	2,01	3,5	M2,5	5	10	7,5	4	8	4,3



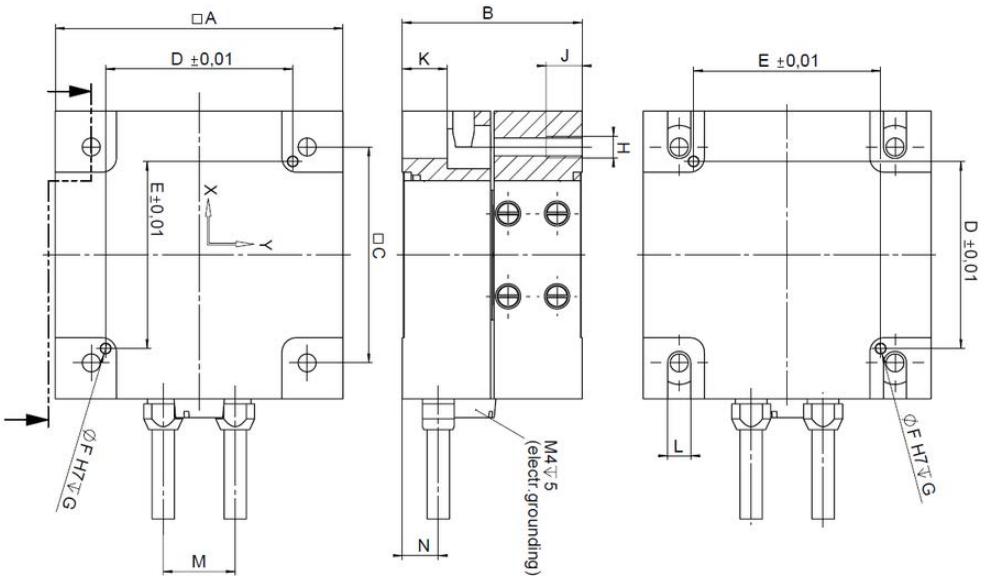
Rapid scanning motion of a P-621.1CD (commanded rise time 5 ms) with the E-710 controller and Digital Dynamic Linearization (DDL) option. DDL virtually eliminates the tracking error (<20 nm) during the scan. The improvement over a classical PI controller is up to 3 orders of magnitude, and increases with the scanning frequency

PIHera® XY Piezo Stage

HIGH PRECISION, VARIABLE TRAVEL RANGES

P-620.2 - P-629.2

- Travel Ranges 50 to 1800 µm
- Resolution to 0.1 nm
- 0.02% Positioning Accuracy
- Direct Metrology with Capacitive Sensors
- X-, XY-, Z-, XYZ Versions



P-62x.2CD/.2CL/.20L
dimensions in mm

	A	B	C	D	E	⌀F	G	H	J	K	L	M	N
P-620.2CD /20L	30	21,5	24	24	19	1,01	1,5	M2	3,5	5,1	2,2	9	6
P-621.2CD / 20L	40	25	30	26	26	1,51	2,5	M3	5	6,25	3,2	10	5
P-622.2CD / 20L	50	25	40	35	35	1,51	2,5	M3	5	6,25	3,2	11	5
P-625.2CD / 20L	60	25	50	46	46	1,51	2,5	M3	6	6,25	3,2	11	5
P-628.2CD / 20L	80	30	70	66	66	1,51	2,5	M3	6	6,75	3,2	11	5
P-629.2CD / 20L	100	40	90	82	82	2,01	3,5	M4	7	9,75	4,3	16	7,5

	P-620.2CD P-620.2CL	P-621.2CD P-621.2CL	P-622.2CD P-622.2CL	P-625.2CD P-625.2CL	P-628.2CD P-628.2CL	P-629.2CD P-629.2CL	Unit	Tolerance
Active axes	X, Y	X, Y	X, Y	X, Y	X, Y	X, Y		
Motion and positioning								
Integrated sensor	Capacitive	Capacitive	Capacitive	Capacitive	Capacitive	Capacitive		
Open- loop travel X, Y, -20 to 120 V	60	120	300	600	950	1800	µm	min. (20% / -0%)
Closed- loop travel in X, Y	50	100	250	500	800	1500	µm	
Open- loop resolution in X, Y	0.1	0.2	0.4	0.5	0.5	2	nm	typ.
Closed- loop resolution in X, Y	0.2	0.4	0.7	1.4	3.5	3.5	nm	typ.
Linearity error in X, Y	0.02	0.02	0.02	0.03	0.03*	0.03**	%	typ.
Repeatability X, Y	±2	±2	±2	±5	±10	±14	nm	typ.
Pitch / yaw	±3	±3	±3	±3 / ±5	±20 / ±5	±30 / ±5	µrad	typ.
Mechanical properties								
Stiffness X, Y	0.22	0.25	0.2	0.1	0.05	0.1	N/ µm	±20 %
Unloaded resonant frequency X	575	420	225	135	75	60	Hz	±20 %
Unloaded resonant frequency Y	800	535	300	195	105	100	Hz	±20 %
Loaded resonant frequency in X, 50 g	270	285	180	120	60	55	Hz	±20 %
Resonant frequency in Y @ 50 g	395	365	215	150	85	85	Hz	±20 %
Resonant frequency in X @ 100 g	285	220	160	105	55	50	Hz	±20 %
Loaded resonant frequency in Y @ 100 g	300	285	175	125	75	80	Hz	±20 %
Push / pull force capacity in motion direction	10 / 5	10 / 8	10 / 8	10 / 8	10 / 8	10 / 8	N	max.
Load capacity	10	10	10	10	10	10	N	max.
Lateral force	10	10	10	10	10	10	N	max.
Drive properties								
Piezo ceramic	PICMA® P-883	PICMA® P-885	PICMA® P-885	PICMA® P-885	PICMA® P-887	PICMA® P-888		
Electrical capacitance in X, Y	0.35	1.5	3.1	6.2	19	52	µF	±20 %
Dynamic operating current coefficient in X, Y	0.9	1.9	1.9	1.6	3	4.3	µA / (Hz × µm)	±20 %
Miscellaneous								
Operating temperature range	-20 to 80	-20 to 80	-20 to 80	-20 to 80	-20 to 80	-20 to 80	°C	
Material	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum		
Dimensions	30 mm × 30 mm × 21.5 mm	40 mm × 40 mm × 25 mm	50 mm × 50 mm × 25 mm	60 mm × 60 mm × 25 mm	80 mm × 80 mm × 25 mm	100 mm × 100 mm × 40 mm		
Mass	0.195	0.295	0.348	0.43	0.7	1.37	kg	±5 %
Cable length	1.5	1.5	1.5	1.5	1.5	1.5	m	±10 mm
Sensor / voltage connection	CD versions: Sub- D special CL versions: LEMO							

Lower axis: X; upper axis: Y.
Versions without sensor are available under the P-62x.20L ordering number; operating temperature range -20 to 150 °C. Sensor / voltage connection LEMO
Vacuum versions to 10^{-9} hPa are available as P-62x.2UD.
The resolution of PI piezo nanopositioners is not limited by friction or stiction. Value given as noise with E-710 digital controller.
* With digital controller. With analog controllers 0.05 %
** With digital controller. With analog controllers 0.07 %

PIHera® Piezo Flexure Z Stage

VARIABLE TRAVEL RANGES, AXIS CONFIGURATION

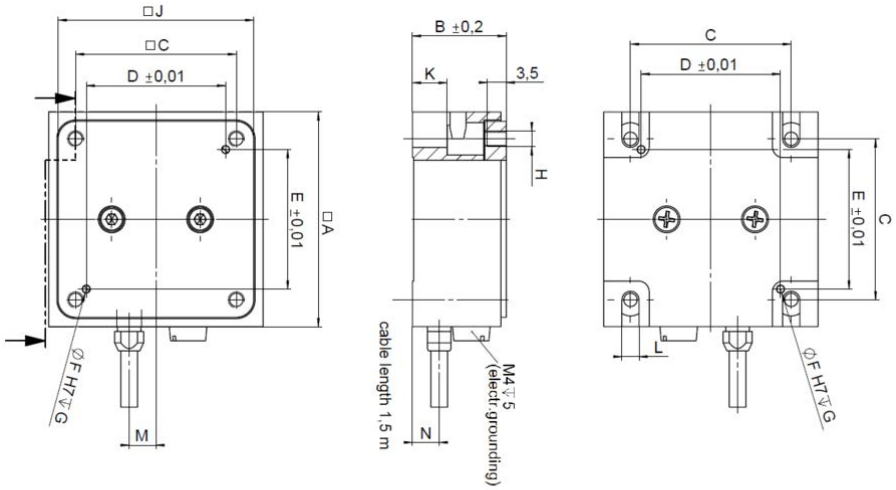
P-620.Z - P-629.Z

- Travel Ranges 50 to 250 µm (400 µm open- loop)
- Resolution to 0.1 nm
- 0.02% Positioning Accuracy
- Direct Metrology with Capacitive Sensors
- X-, XY-, Z-, XYZ Versions

	P-620.ZCD P-620.ZCL	P-621.ZCD P-621.ZCL	P-622.ZCD P-622.ZCL	Unit	Tolerance
Active axes	Z	Z	Z		
Motion and positioning					
Integrated sensor	Capacitive	Capacitive	Capacitive		
Open- loop travel, -20 to 120 V	65	140	400	µm	min. (20 % / -0 %)
Closed- loop travel	50	100	250	µm	
Open- loop resolution	0.1	0.2	0.5	nm	typ.
Closed- loop resolution	0.2	0.3	1	nm	typ.
Linearity error	0.02	0.02	0.02	%	typ.
Repeatability	±1	±1	±1	nm	typ.
Runout θ_X, θ_Y	<20	<20	<80	µrad	typ.
Mechanical properties					
Stiffness	0.5	0.6	0.24	N/ µm	±20 %
Unloaded resonant frequency	1000	790	360	Hz	±20 %
Resonant frequency @ 30 g	690	500	270	Hz	±20 %
Push / pull force capacity	10 / 5	10 / 8	10 / 8	N	max.
Load capacity	10	10	10	N	max.
Lateral force	10	10	10	N	max.
Drive properties					
Ceramic type	PICMA® P-883	PICMA® P-885	PICMA® P-885		
Electrical capacitance	0.7	3	6.2	µF	±20 %
Dynamic operating current coefficient	1.8	3.8	3.1	µA / (Hz × µm)	±20 %
Miscellaneous					
Operating temperature range	-20 to 80	-20 to 80	-20 to 80	°C	
Material	Aluminum	Aluminum	Aluminum		
Dimensions	30 mm × 30 mm × 15 mm	40 mm × 40 mm × 17.5 mm	50 mm × 50 mm × 17.5 mm		
Mass	0.12	0.17	0.24	kg	±5 %
Cable length	1.5	1.5	1.5	m	±10 mm
Sensor / voltage connection	CD versions: Sub- D special CL versions: LEMO				

Versions without sensor are available as P-62x.Z0L; operating temperature range -20 to 150 °C. Sensor / voltage connection LEMO.

Drawings / Images



P-62x.ZCD / .ZCL / .Z0L
dimensions in mm

	A	B	C	D	E	∅F	G	H	J	K	L	M	N
P-620.ZCD / Z0L	30	15	24	19	24	1,01	2	M2	28	5	2,2	4,5	6
P-621.ZCD / Z0L	40	17,5	30	26	26	1,51	2,5	M3	36,5	6,5	3,2	5	5
P-622.ZCD / Z0L	50	17,5	40	35	35	1,51	2,5	M3	46,5	6,5	3,2	5	5

PI USA

USA and Canada (East)

PI (Physik Instrumente) L.P.
16 Albert St.
Auburn, MA 01501
Phone +1 508 832-3456
Fax +1 508 832-0506
info@pi-usa.us
www.pi-usa.us

USA (West) / Mexico

PI (Physik Instrumente) L.P.
5420 Trabuco Rd., Suite 100
Irvine, CA 92620
Phone +1 949 679-9191
Fax +1 949 679-9292

San Francisco Bay Area Office

PI (Physik Instrumente) L.P.
1 Harbor Drive, Suite 108
Sausalito, CA 94965
Phone +1 408-351-4086
Fax +1 949-679-9292

Headquarters

GERMANY

Physik Instrumente (PI) GmbH & Co. KG
Auf der Roemerstr. 1
76228 Karlsruhe
Phone +49 721 4846-0
Fax +49 721 4846-1019
info@pi.ws
www.pi.ws

PI miCos GmbH
Eschbach
info@pimicos.com
www.pi.ws

PI Ceramic GmbH
Lederhose
info@piceramic.com
www.piceramic.com

JAPAN

PI Japan Co., Ltd.
Tokyo
info@pi-japan.jp
www.pi-japan.jp

PI Japan Co., Ltd.
Osaka
info@pi-japan.jp
www.pi-japan.jp

FRANCE

PI France S.A.S.
Montrouge
info.france@pi.ws
www.pi.ws

UK & IRELAND

PI (Physik Instrumente) Ltd.
Cranfield, Bedford
uk@pi.ws
www.physikinstrumente.co.uk

ITALY

Physik Instrumente (PI) S. r. l.
Bresso
info@pionline.it
www.pionline.it

SOUTHEAST ASIA

PI (Physik Instrumente) Singapore LLP
Singapore
info-sg@pi.ws
www.pi-singapore.sg
For ID / MY / PH / SG / TH / VNM / TW

KOREA

PI Korea Ltd.
Seoul
info-kr@pi.ws
www.pikorea.co.kr

CHINA

Physik Instrumente (PI Shanghai) Co., Ltd.
Shanghai
info@pi-china.cn
www.pi-china.cn