

# Heart of Motion

Q-MOTION MINIATURE POSITIONING STAGES

# Why Q-Motion...?



"I'm pleased to now be able to offer positioning solutions to our customers where classical drive technologies could only fulfill expectations to a limited extent."

Mark Freyer, Head of Product Division Inertia Drives

Why did we develop this product line? Q-Motion stands for a series of miniaturized stages with piezomotor drive principle. Because PI received a large number of enquiries, we noted an increased demand for these very small positioning axes and manipulators, for example, in mobile applications for measuring and medical devices, in industrial microassembly or use for research in ultrahigh vacuums and strong magnetic fields.

With Q-Motion, we have succeeded in developing a series of the smallest drives yet available on the market that work precisely, reliably and dynamically. For example, the series consists of rotation stages with a rotary plate diameter of just 14 mm and a linear stage with 21 mm width and an integrated incremental encoder. Find more on the features and product versions on the following pages.



Small and fast: Q-614 miniaturized rotation stage with a turntable diameter of 14 mm only and a velocity up to 70°/s.

## Closes a Gap

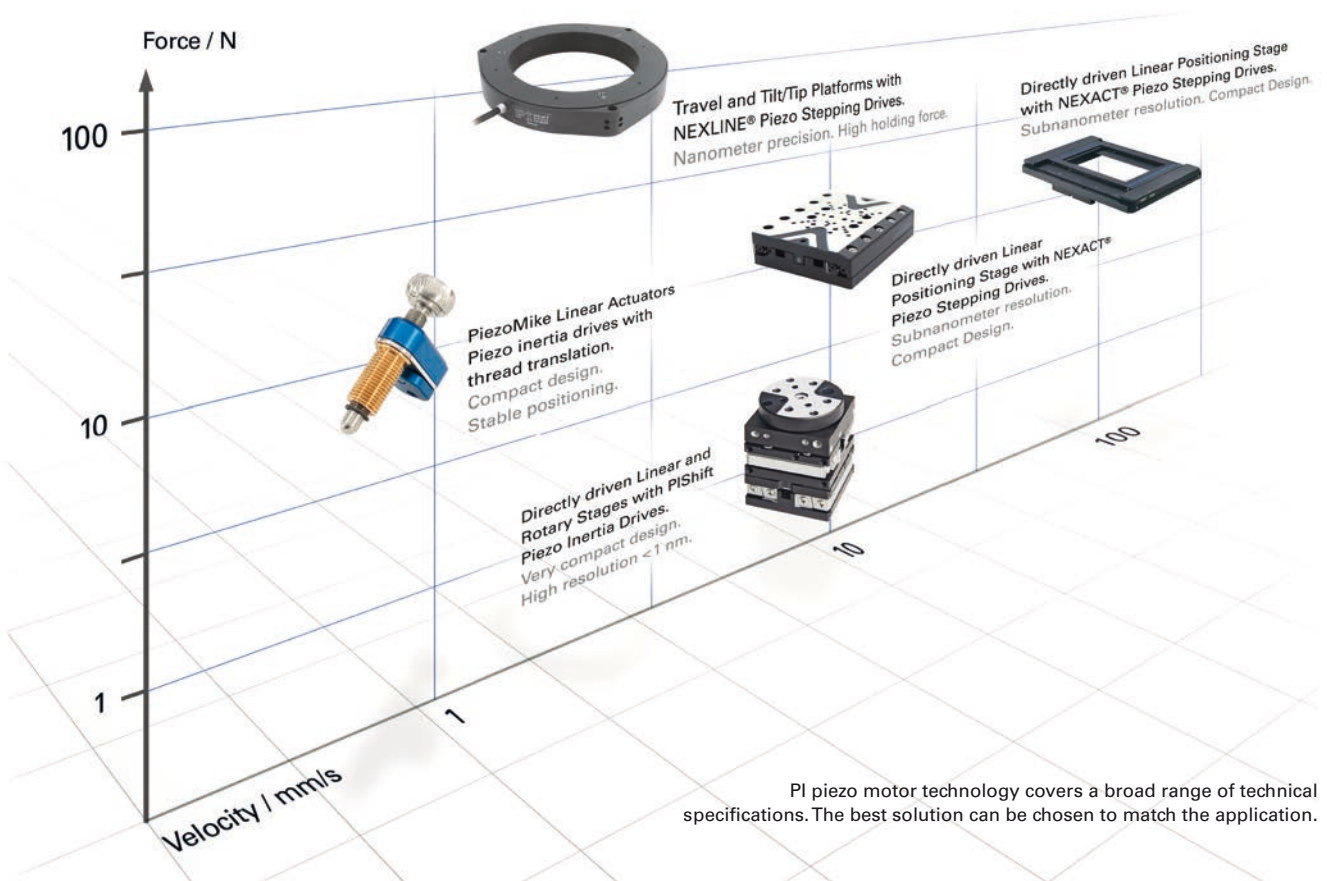
PI draws from a wealth of experience when it comes to implementing piezo ceramic drives in positioning systems. However, PI is certainly not restricted to a special drive technology, but is always able to offer the optimum solution for the many different requirements in the field of motion and positioning.

Piezo motors combine the high position resolution of the piezo actuators with the unlimited travel ranges of classical drives.

The drives in the Q-Motion series are based on one piezoelectric inertia drive that can now be more compactly integrated than an ultrasonic motor and is less expensive than a stepping drive.

**All piezomotor drive principles are distinguished by:**

- High resolution to <1 nm
- Self-locking at rest with maximum force, no heat generation at rest, no energy consumption, no servo jitter
- Compact design





## Maximum Flexibility

The piezoceramic actuators form the heart of the piezo inertia drive. It can be customized to the special installation conditions of the customer. The electronics are made available from the OEM module to the „intelligence on the chip“. This makes it easy to integrate the circuitry into customer-specific drivers.

Individual axes can be stacked for multi-axis applications such as sample manipulation and adjustment of optical elements, detectors and fiber arrays.

Parallel kinematic systems with six degrees of freedom that fit onto the palm of the hand are interesting with respect to the overall stiffness, accuracy and dynamics of all axes .

**Q-Motion products are available in various different configurations:**

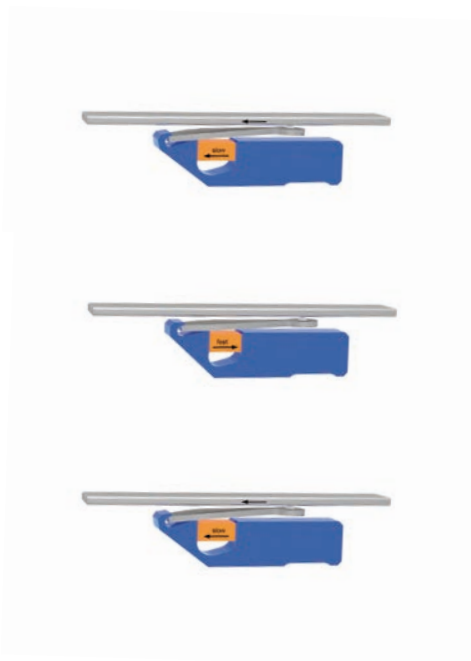
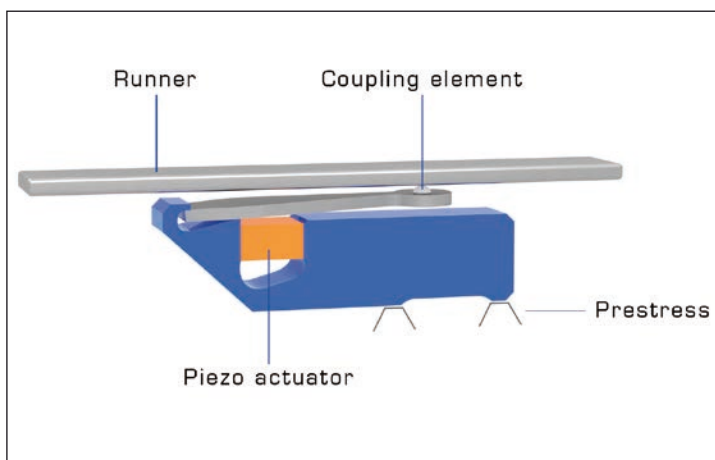
- Linear positioning stage with travel ranges up to 52 mm
- Rotation stages with platform  $\varnothing$  of 14 mm, 22 and 32 mm

The drive electronics can be designed as flexible as the motor. A motion-chip can be integrated into an existing circuit board.



## Operating Principle

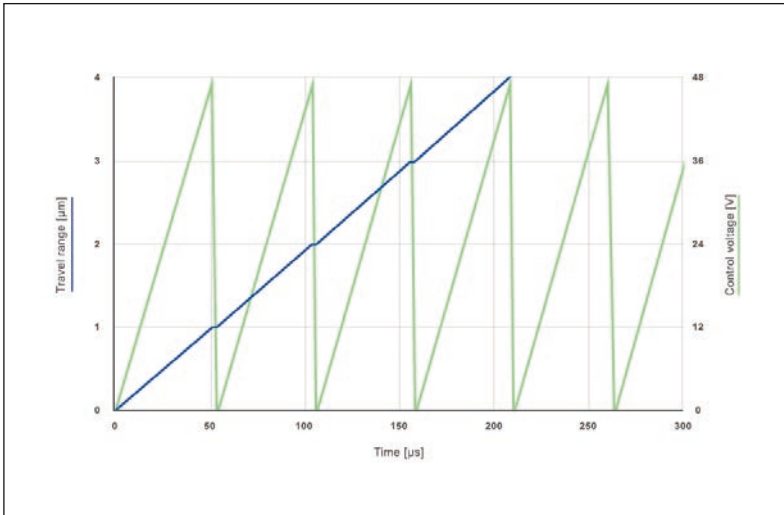
Piezo inertia drives are space-saving and inexpensive piezo-based drives with relatively high holding forces and a virtually unlimited travel range. They make use of the stick-slip effect (inertia effect) – a cyclical alternation of static and sliding friction between a moving runner and the drive element 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

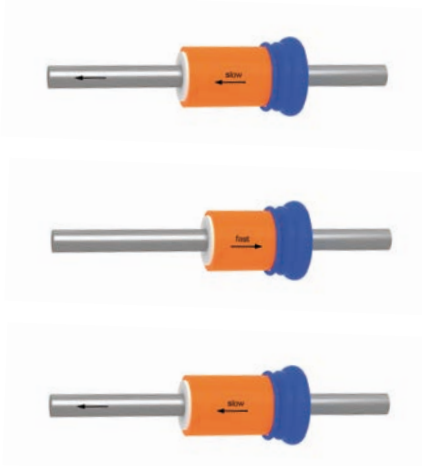
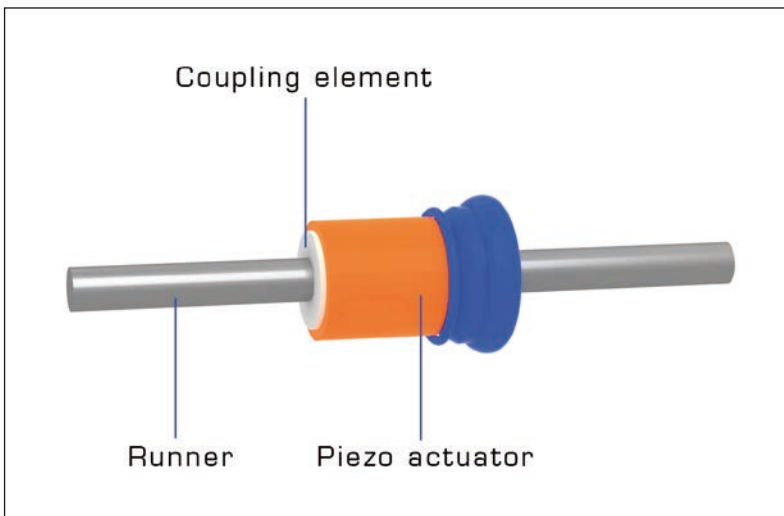
A drive element mounted on the side of the runner allows linear or rotary motion and a particularly small design of the stage. In conjunction with suitable incremental encoders, linear and rotation stages are possible with a width of just over 20 mm and a height of only 10 mm. The sizes are even smaller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

# Properties



## Nanometer Resolution

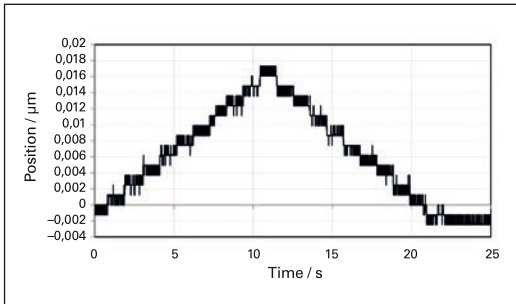
During the slow control phase (stick-phase), in which the runner is moved, the drive behaves in the same way as a classical piezoceramic actuator. By varying the voltage applied, the actuator can take any position and therefore achieves the high motion resolution that is typical for piezoceramics. Together 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.



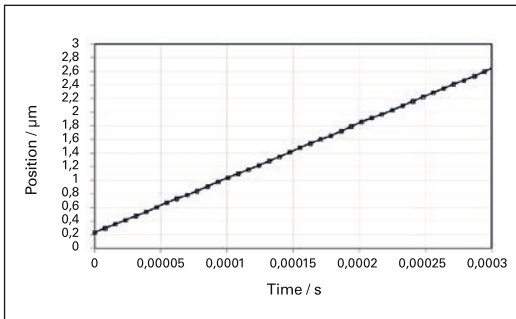
## PISHift Rod Drive

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.

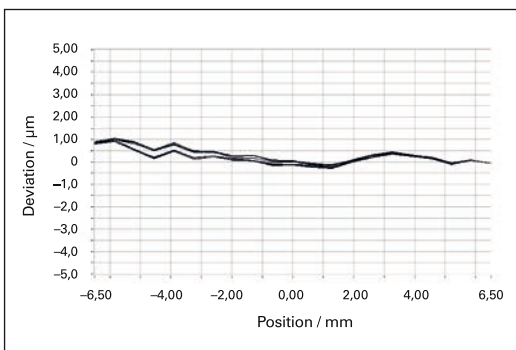




The minimum incremental motion is specified with 2 nm for closed-loop linear stages with incremental encoders (1 nm resolution). The small steps are performed reliably with the analog expansion of the piezoelectric actuator.



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.

### Cost-Effective

Piezo inertia drives are based on a cost-effective single actuator solution. Control is simple and can even be integrated into existing circuitry.



# Q-Motion Miniature Stages

HIGH RESOLUTION, AFFORDABLE PRICE



- Linear stages, rotary stages and parallel kinematic robots with six degrees of freedom
- Direct position measurement with incremental encoder with up to 1 nm resolution (optional)
- Piezomotor driving principle: Self-locking when at rest, therefore no holding current, no power consumption, no heat generation and no servo jitter

## Applications

Applications can be found in industry and research. The small form factor and the vacuum compatibility make Q-Motion stages ideal positioning tasks in Beamline Instrumentation or electron microscopy. Again

the small form factor, combined with the self-locking, Q-Motion stages can be integrated in mobile devices for metrology or medical applications.



## Q-Motion Linear Stages



**Q-521**

**Q-Motion Miniature Linear Positioning Stage**

Very Small Linear Positioning Stage with Position Control, High Resolution and Attractive Price



**Q-522**

**Q-Motion Miniature Linear Stage**

Piezomotors for Small Dimensions, High Resolution and a Favorable Price



**Q-545**

**Q-Motion Precision Linear Stage**

High Forces and Small Size Through Piezomotors

## Q-Motion Rotary Stages



**Q-614**

**Q-Motion Miniature Rotation Stage**

Minimum Dimensions: 14 mm Turntable Diameter



**Q-622**

**Q-Motion Miniature Rotation Stage**

Minimum Dimensions: 22 mm Turntable Diameter



**Q-632**

**Q-Motion Rotation Stage**

Compact Through Piezomotor: 30 mm Turntable Diameter

## Q-Motion Parallel Kinematic



**Q-821**

**Q-Motion Miniature SpaceFab Robot**

Piezo-Motorized Inertia Drive, only 80 mm Side Length



**Q-845**

**Q-Motion SpaceFAB Micro Robot**

Piezo-Motorized Inertia Drive, 1 nm Sensor Resolution



**E-873**

**Q-Motion Servo Controller**

1 Axis, for Positioners with Piezo Inertia Drives

# Q-Motion Miniature Linear Positioning Stage

WITH POSITION CONTROL, HIGH RESOLUTION AND ATTRACTIVE PRICE



## 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

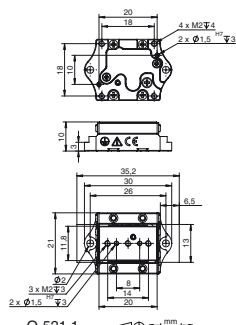
Versions with noncontact optical linear encoder available. Resolution 4 nm or 1 nm, depending on the version. Versions with encoder feature a reference point switch

### Fields of application

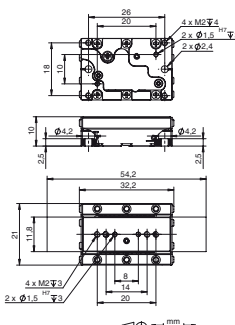
Industry and research. For metrology, microscopy, micro-manipulation, biotechnology and automation. Vacuum versions for  $10^{-9}$  hPa available. Nonmagnetic versions are available on request

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
<b>Motion and positioning</b>	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
<b>Mechanical properties</b>								
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
<b>Drive properties</b>								
Motor type	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	
<b>Miscellaneous</b>								
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	Stainless steel	Stainless steel	Stainless steel	Stainless steel	Stainless steel	Stainless steel	Stainless steel	
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	

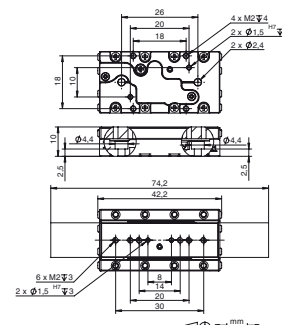
\* Typical velocity at a control frequency of 20 kHz



Q-521.1XX, dimensions in mm



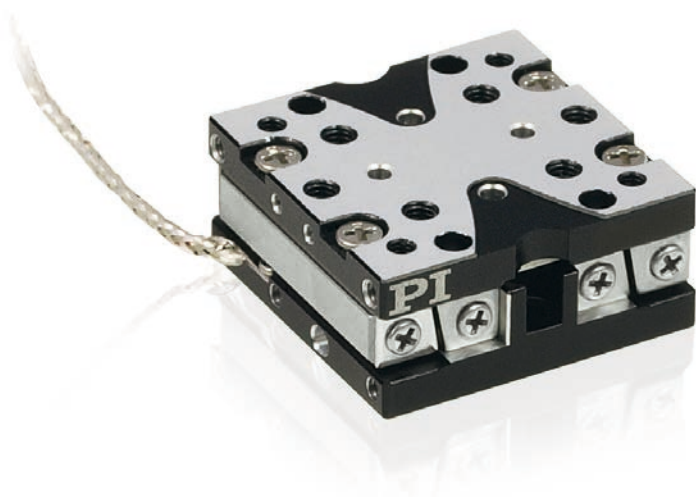
Q-521.2XX, dimensions in mm



Q-521.3XX, dimensions in mm

# Q-Motion Miniature Linear Stage

SMALL DIMENSIONS, HIGH RESOLUTION AND A FAVORABLE PRICE



## 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

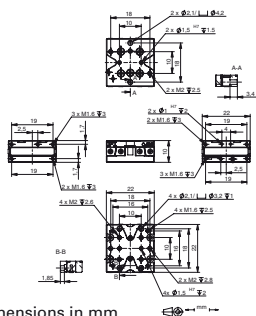
Industry and research. For metrology, microscopy, micro-manipulation, biotechnology and automation. Vacuum versions for  $10^{-9}$  hPa available. Nonmagnetic versions are available on request



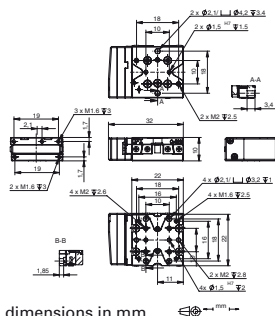
Q-522 linear stage with incremental position sensor

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
<b>Motion and positioning</b>	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
<b>Mechanical properties</b>								
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
<b>Drive properties</b>								
Motor type	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	
<b>Miscellaneous</b>								
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-545.2XX, dimensions in mm



Q-545.1XX, dimensions in mm

# Q-Motion Precision Linear Stage

HIGH FORCES AND SMALL SIZE THROUGH PIEZOMOTORS



## Q-545

- Only 45 mm wide
- 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

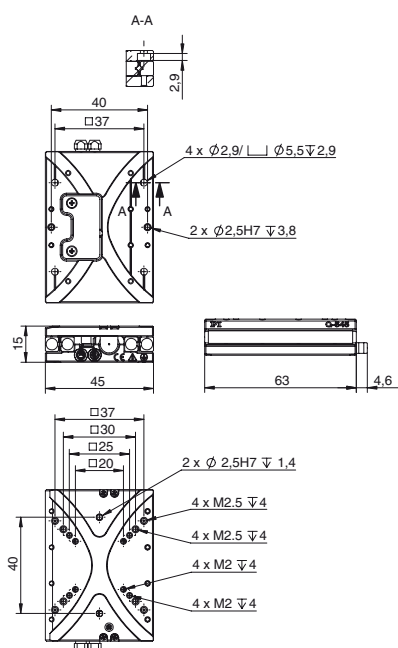
Versions with noncontact optical linear encoder available. Resolution 1 nm. Versions with encoder feature a reference point switch

### Fields of application

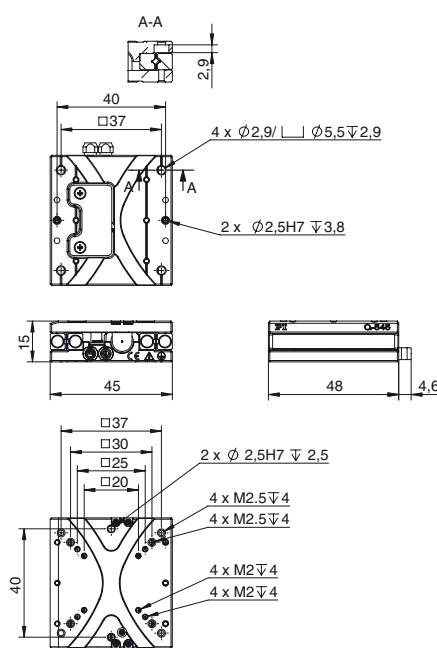
Industry and research. For optical metrology, laser technology, micromanipulation, biotechnology, photonics packaging. Vacuum versions down to  $10^{-9}$  hPa available. Nonmagnetic versions are available on request

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
<b>Motion and Positioning</b>	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		
<b>Mechanical Properties</b>						
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.
<b>Drive Properties</b>						
Motor Type	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive		
<b>Miscellaneous</b>						
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 Stage

MINIMUM DIMENSIONS: 14 MM TURNTABLE DIAMETER



## Q-614

- Only 18 mm wide and 10 mm high
- Rotation range >360°
- Velocity 70°/s
- Drive torque 5 mNm
- Versions vacuum-compatible to 10<sup>-9</sup> 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 at rest, thus no heat generation. Velocity to 70°/s. 6 mNm holding torque, 5 mNm drive torque

### Fields of application

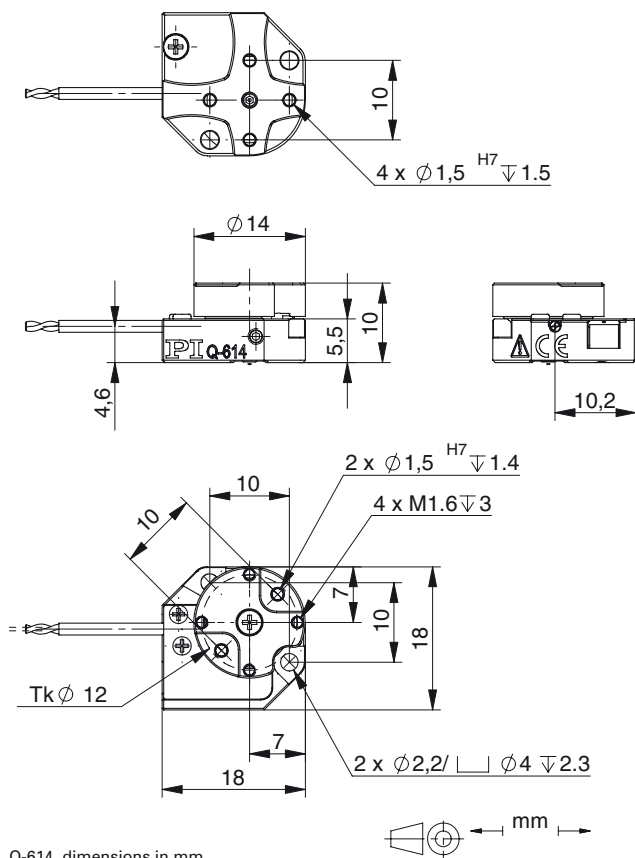
Industry and research. For metrology, microscopy, micro-manipulation, biotechnology and automation. Vacuum versions for 10<sup>-9</sup> hPa available. Nonmagnetic versions are available on request

Preliminary Data	Q-614.900	Q-614.90U	Unit	Tolerance
<b>Motion and positioning</b>				
Active axis	$\theta_z$	$\theta_z$		
Rotation range	>360	>360	°	
Resolution	1*	1*	μrad	
Min. incremental motion	100*	100*	μrad	typ.
Maximum velocity, open-loop	70	70	°/s	
<b>Mechanical properties</b>				
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	
<b>Drive properties</b>				
Motor type	Piezoelectric inertia drive	Piezoelectric inertia drive		
<b>Miscellaneous</b>				
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-Motion Miniature Rotation Stage

MINIMUM DIMENSIONS: 22 MM TURNTABLE DIAMETER



## Q-622

- Only 22 mm wide and 10 mm high
- Direct position measurement with incremental encoder with 0.55  $\mu$ rad resolution (optional)
- Up to 2.2  $\mu$ rad minimum incremental motion
- Rotation range  $>360^\circ$
- Velocity 70°/s
- Drive torque 5 mNm
- Mountable on the Q-522 linear stage without adapter
- 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 at rest, thus no heat generation. Velocity to 70°/s. 6 mNm holding torque, 5 mNm drive torque

### Fields of application

Industry and research. For metrology, microscopy, micro-manipulation, biotechnology and automation. Vacuum versions for  $10^{-9}$  hPa available. Nonmagnetic versions are available on request



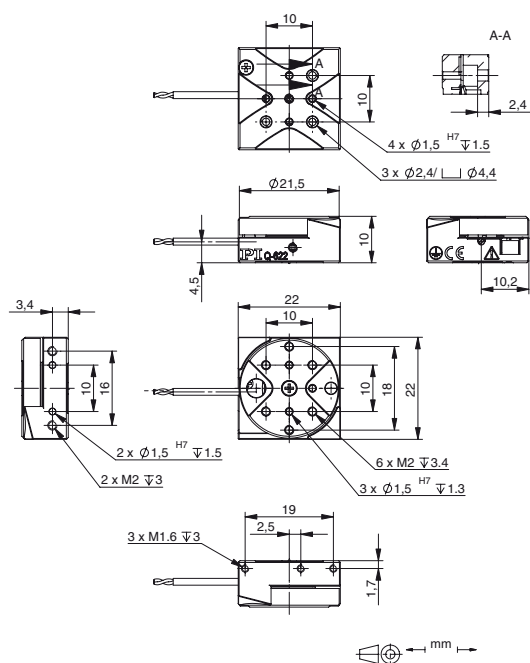
XY $\theta_z$ -stack consisting of Q-522.240, Q-522.00 and Q-622.900

Preliminary Data	Q-622.930	Q-622.900	Q-622.90U	Unit	Tolerance
<b>Motion and Positioning</b>	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	$\theta_z$	$\theta_z$	$\theta_z$		
Rotation range	>360	>360	>360	°	
Integrated sensor	Incremental encoder	–	–		
Sensor resolution	0.55	–	–	$\mu$ rad	
Min. incremental motion	2.2	100*	100*	$\mu$ rad	typ.
Unidirectional repeatability	3	–	–	$\mu$ rad	
Maximum velocity, open-loop	70	70	70	°/s	
<b>Mechanical Properties</b>					
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	
<b>Drive Properties</b>					
Motor Type	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive		
<b>Miscellaneous</b>					
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		

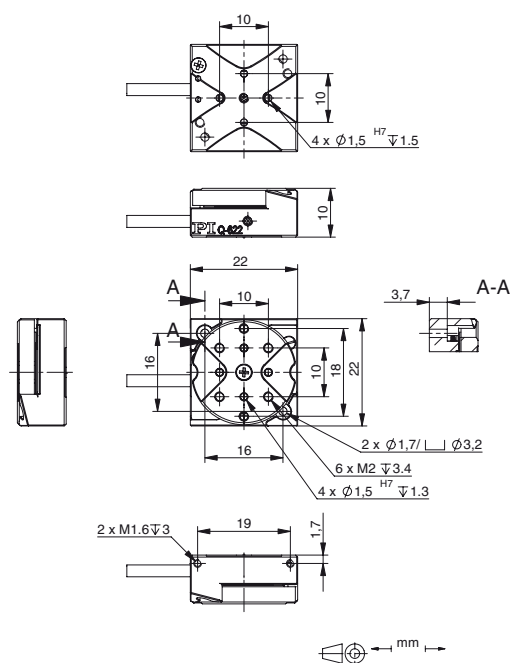
Ask about custom designs!

The Q-622 stage series replaces the RPS-22 series.

\* Open-loop



Q-622.90X, dimensions in mm



Q-622.930, dimensions in mm

# Q-Motion Rotation Stage

COMPACT THROUGH PIEZOMOTOR: 30 MM TURNTABLE DIAMETER



## Q-632

- Only 32 mm wide and 10 mm high
- Direct position measurement with incremental encoder with 0.75  $\mu$ rad resolution (optional)
- Up to 3  $\mu$ rad minimum incremental motion
- Rotation range  $>360^\circ$
- Velocity 45°/s
- Drive torque 6 mNm
- 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 at rest, thus no heat generation. Velocity to 45°/s. 7 mNm holding torque, 6 mNm drive torque

### Fields of application

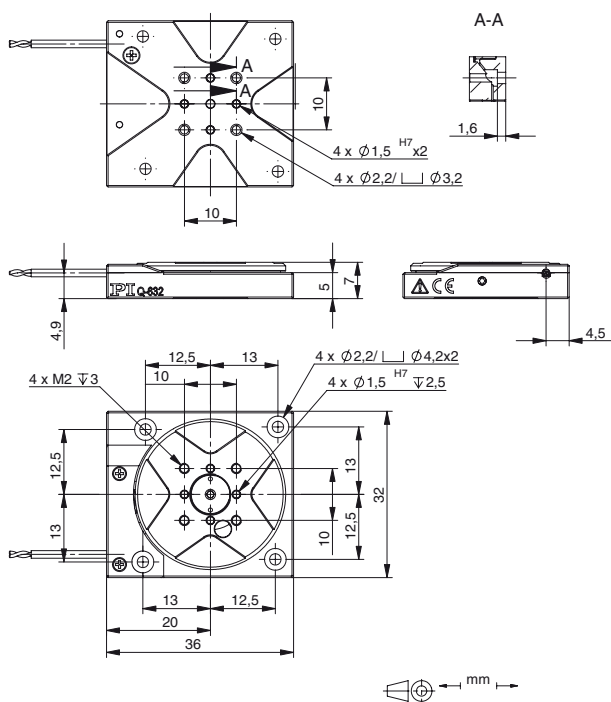
Industry and research. For metrology, microscopy, micro-manipulation, biotechnology and automation. Vacuum versions for  $10^{-9}$  hPa available. Nonmagnetic versions are available on request

Preliminary Data	Q-632.930	Q-632.900	Q-632.90U	Unit	Tolerance
<b>Motion and positioning</b>	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	$\theta_z$	$\theta_z$	$\theta_z$		
Rotation range	>360	>360	>360	°	
Integrated sensor	Incremental encoder	-	-		
Sensor resolution	0.75	-	-	$\mu$ rad	
Min. incremental motion	3	36*	36*	$\mu$ rad	typ.
Unidirectional repeatability	3	-	-	$\mu$ rad	typ.
Maximum velocity, open-loop	45	45	45	°/s	
<b>Mechanical Properties</b>					
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	
<b>Drive Properties</b>					
Motor Type	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive		
<b>Miscellaneous</b>					
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		

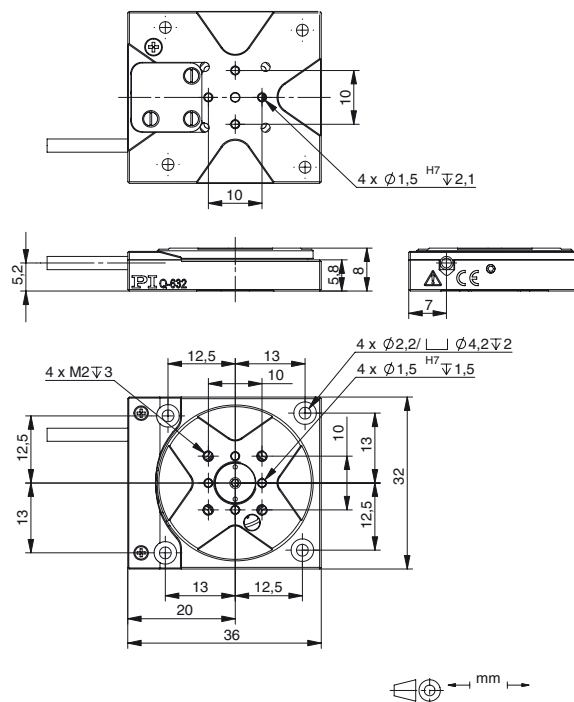
Ask about custom designs!

The Q-632 stage series replaces the RPS-32 series.

\* Open-loop



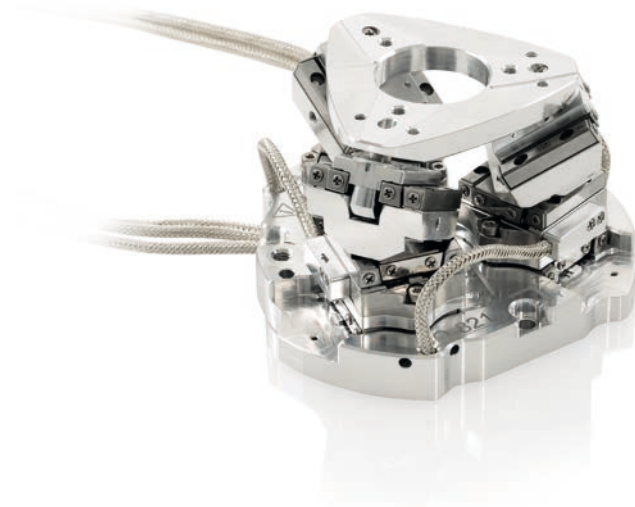
Q-632.90X, dimensions in mm



Q-632.930, dimensions in mm

# Q-Motion Miniature SpaceFAB Robot

PIEZO-MOTORIZED INERTIA DRIVE, ONLY 80 MM SIDE LENGTH



## Q-821

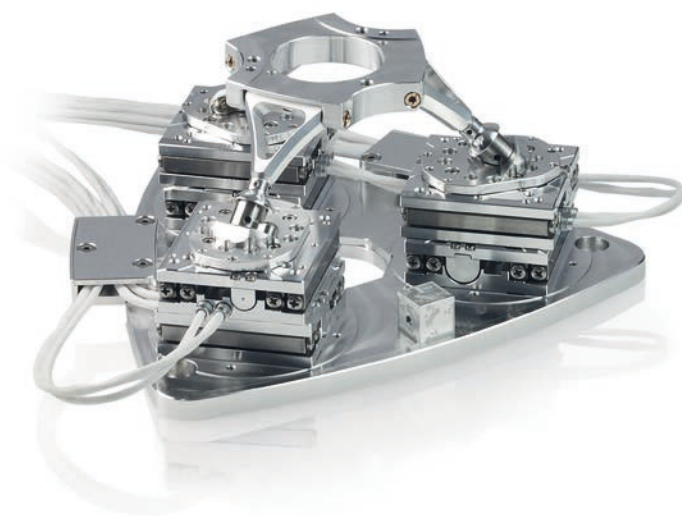
- Six-axis microrobotics system
- Dimensions in reference position  
80 mm × 73 mm × 48 mm
- Linear travel ranges to  
12 mm x 12 mm x 6 mm
- Rotary travel ranges to  
14° x 15° x 40°
- 1 nm sensor resolution

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



# Q-Motion SpaceFAB Micro Robot

PIEZO-MOTORIZED INERTIA DRIVE, 1 NM SENSOR RESOLUTION



## Q-845

- Six-axis microrobotics system
- Dimensions in reference position  
175 mm × 165 mm × 77 mm
- Linear travel ranges to  
13 mm × 13 mm × 10 mm
- Rotary travel ranges to  
14° × 14° × 14°
- Load capacity up to 5 N,  
center mounted

Preliminary Data	Q-845	Unit	Tolerance
Active axes	X, Y, Z, $\theta_x$ , $\theta_y$ , $\theta_z$		
<b>Motion and Positioning</b>			
Travel range X, Y, Z	±6.5, ±6.5, ±5	mm	
Travel range $\theta_x$ , $\theta_y$ , $\theta_z$	±7, ±7, ±7	°	
Sensor resolution	1	nm	
Bidirectional repeatability X, Y, Z	±0.25	μm	typ.
Bidirectional trajectory repeatability $\theta_x$ , $\theta_y$ , $\theta_z$	±17.5	μrad	typ.
Max. velocity X, Y, Z	10	mm/s	
Max. velocity $\theta_x$ , $\theta_y$ , $\theta_z$	5	°/s	
<b>Mechanical Properties</b>			
Stiffness X, Y	0.2	N/μm	
Stiffness Z	3.6	N/μm	
Load (base plate horizontal)	5	N	max.
Motor Type	Piezoelectric inertia drive		
<b>Miscellaneous</b>		°C	
Material	Aluminum		
Mass	1.5	kg	±5 %
Cable length	2	m	±10 mm

# Q-Motion Servo Controller

1 AXIS, FOR POSITIONERS WITH PIEZO INERTIA DRIVES



## E-873

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

### Digital servo controller for piezo inertia drives

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

### 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

### Interfaces

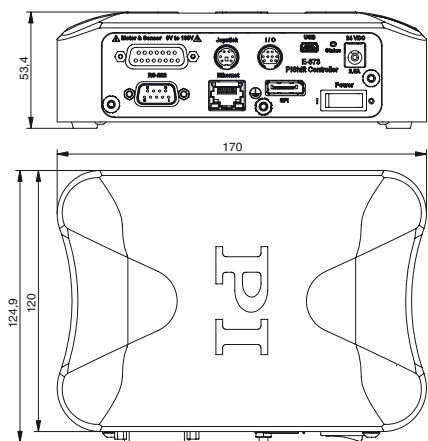
USB, RS-232 and TCP/IP (version-dependent) for commanding. Differential signal transmission for digital (A/B) or analog (sin/cos) encoder signals. BiSS interface for absolute encoders. TTL inputs for limit and reference point switches. I/O ports (analog / digital) for automation. Connection for analog joystick

Delivery scope including wide-range power supply, USB and RS-232 cable

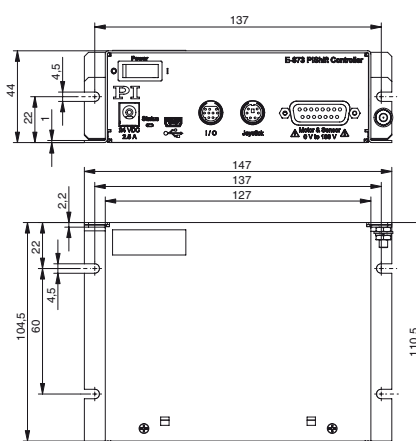
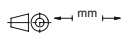
	E-873.1A1	E-873.1AR	E-873.1AT
Function	Q-Motion® controller for positioning systems with piezo inertia drives, benchtop device	Q-Motion® controller for positioning systems with piezo inertia drives, benchtop device with option for control cabinet mounting	Q-Motion® controller for positioning systems with piezo inertia drives, benchtop device with option for control cabinet mounting
Communication interfaces	TCP/IP, USB, RS-232	USB	TCP/IP, USB, RS-232

E-873.1Ax	
Channels	1
<b>Motion and Control</b>	
Servo characteristics	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; BiSS interface for absolute encoders
Stall detection	Servo off
Input limit switch	2 × TTL (pull-up / pull-down, programmable)
Input reference switch	1 × TTL for integrated reference in the encoder
<b>Electrical properties</b>	
Max. output power	30 W
Output voltage	0 to 100 V, drive-dependent selection
Max. current consumption	1.5 A
<b>Interfaces and operation</b>	
Interface / communication	USB, RS-232 9-pin (m) Sub-D, TCP/IP
Motor connection / sensor connection	Sub-D connector 15-pin (f)
I/O ports	4 analog / digital in, 4 digital out
Command set	PI General Command Set (GCS)
User software	PIMikroMove, PITerminal
Software drivers	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
Manual control (optional)	Joystick (for 2 axes), Y-cable for 2-D motions
<b>Miscellaneous</b>	
Operating voltage	24 V, in the scope of delivery: external power supply with 24 V / 2.0 A
Operating temperature range	0 to 50 °C

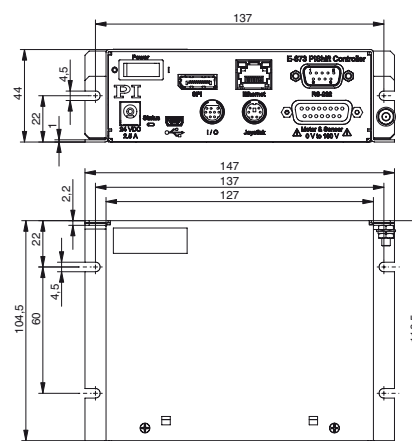
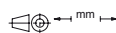
Ask about custom designs!



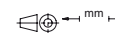
E-873.1A1, dimensions in mm



E-873.1AR, dimensions in mm



E-873.1AT, dimensions in mm



# Linear Stage with High Accuracy

0.5 NANOMETER RESOLUTION, PIEZO STEPPING DRIVE



## N-565

- Direct measurement with PIOne incremental encoder, 0.5 nm resolution
- Up to 2 nm minimum incremental motion
- 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 <math><1\text{ nm}</math> 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  $\mu\text{m}$  signal period, linearity error <math><1\text{ \%}</math>. Direction-sensing homing track. Compact design for easy integration in positioning systems. Patented technology

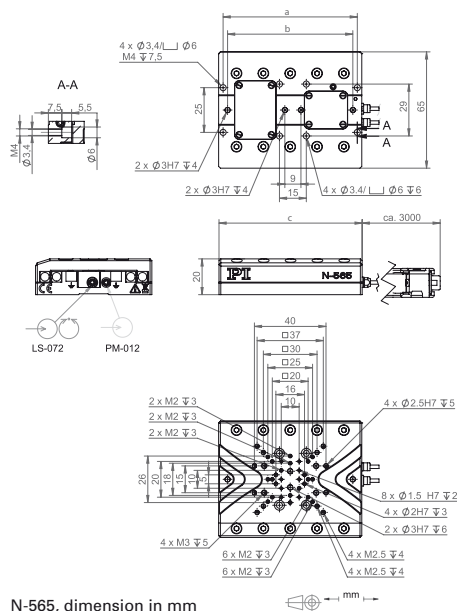
### Fields of application

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		
<b>Motion and Positioning</b>					
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.
<b>Mechanical Properties</b>					
Load capacity	20	20	20	N	max.
Feed force (active)	10	10	10	N	max.
Holding force (passive)	10	10	10	N	min.
<b>Drive Properties</b>					
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	
<b>Miscellaneous</b>					
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!

	a	b	c
N-565.160	75	70	80
N-565.260	100	100	110
N-565.360	150	150	160



N-565, dimension in mm

# Vertical Positioner with High Precision

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

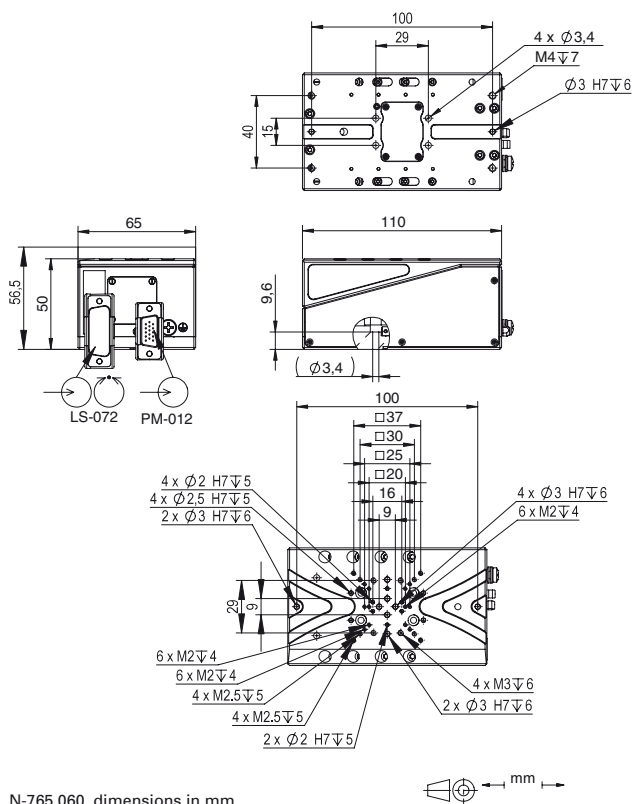
Direct position measurement. Based on interferometric measurement principle. 0.5  $\mu\text{m}$  signal period, linearity error <1%. Direction-sensing homing track. Compact design for easy integration in positioning systems. Patented technology

### 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	
<b>Motion and positioning</b>		
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
<b>Mechanical Properties</b>		
Load capacity	20	N
Feed force (active)	25	N
Holding force (passive)	25	N
<b>Drive Properties</b>		
Motor Type	NEXACT® piezo stepping drive	
Operating voltage	-10 to 45	V
<b>Miscellaneous</b>		
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-765.060, dimensions in mm



# PiezoWalk® NEXACT® 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

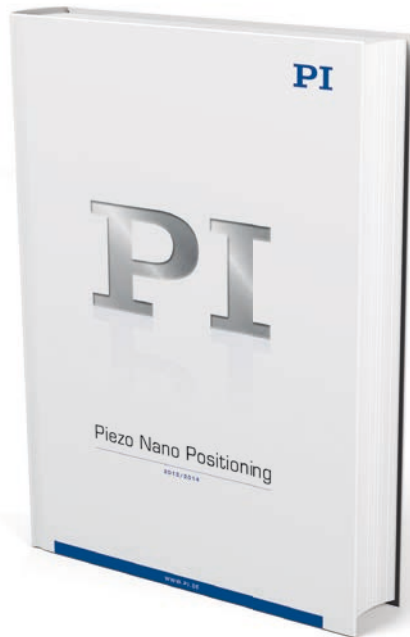
	E-861.1A1
Function	Controller for NEXACT® drives/systems
Drive type	NEXACT® linear drive
Channels	1
<b>Motion and control</b>	
Servo characteristics	P-I-D servo control, parameter change on-the-fly
Trajectory profile modes	Trapezoidal
Encoder input	Analog encoder input sine-cosine, interpolation selectable up to 1000; Interpolation circuit for differential transmission, 1 V <sub>pp</sub> 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
<b>Electrical properties</b>	
Max. output power	40 W
Output voltage	-10 to +45 V
Max. operating current	2 A
<b>Interfaces and operation</b>	
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
<b>Miscellaneous</b>	
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.

## Well-Positioned All Over the World



- 1970** PI founding year
- 1977** PI moved its headquarters to Waldbronn, Germany
- 1991** Market launch of 6-axis parallel-kinematics positioning systems (Hexapods)
- 1992** Foundation of PI Ceramic, Thuringia, Germany; crucial step towards market leadership in nanopositioning
- 1994** Market launch of capacitive position sensors
- 1998** Market launch of digital control electronics
- 2001** Market launch of PILine® ultrasonic piezomotors
- 2001** New company building in Karlsruhe, Germany
- 2002** PI Ceramic company building extended
- 2004** Market launch of PICMA® multilayer piezo stack actuators
- 2004** Market launch of NEXLINE® high-performance piezo linear drives
- 2007** Market launch of NEXACT® piezo linear drives
- 2010** More space for growth: Acquisition of the expansion site next to the PI headquarters
- 2011** Acquisition of the majority shares of miCos GmbH
- 2012** Extension of the PI headquarters and PI Ceramic company buildings
- 2012** Introduction of PIMag® 6D magnetic levitation positioning system
- 2013** Market launch of PiezoMike linear actuators based on PIShift inertia drives
- 2014** Market launch of the magnetic PIMag® direct drives
- 2014** Market launch of Q-Motion, miniature positioning stages based on piezo drive technology
- 2014** Building extension for PI miCos
- 2015** Market launch of air bearings
- 2015** Acquisition of Nelson Air Corp., USA



### PI Catalog – Finding the Right Solution, Quickly and Reliably

## Request Now!

The PI catalog 2014/2015 displays the PI Group's technical expertise in all precision positioning sectors on 270 pages. Here PI presents its wide range of high-performance precision positioning systems: Different drive technologies based on piezo elements as well as electrical and magnetic principles and their integration in positioning systems with up to six axes.

Get important background knowledge: Technical tutorials give you detailed information about the technologies used in the broad and deep product portfolio of PI (Physik Instrumente), PI miCos and PI Ceramic, expert in piezo-technology.

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**PI miCos GmbH**  
 Freiburger Str. 30  
 79427 Eschbach, Germany  
 Phone + 49 7634 5057-0  
 Fax +49 7634 5057-99  
 q-motion@pi.ws  
 www.q-motion.ws

