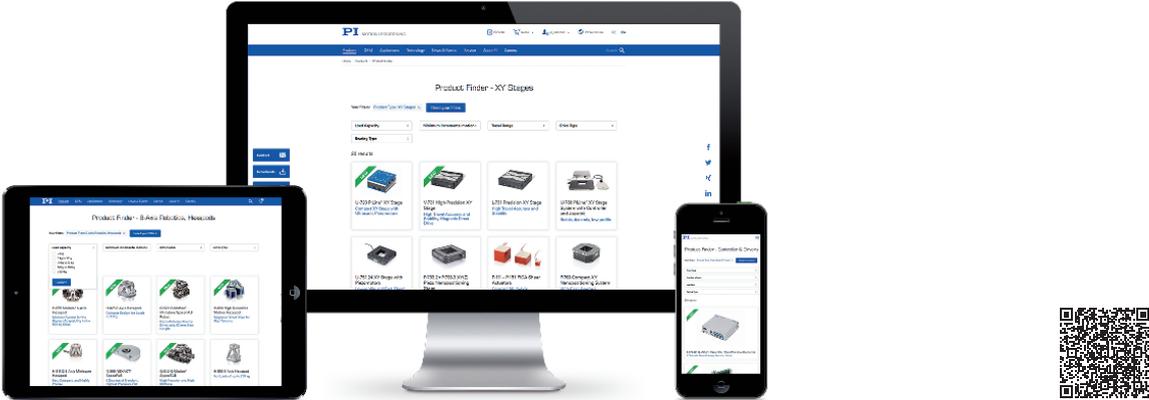


CUSTOM DESIGNS  
CONSTANT VELOCITY  
REPEATABILITY  
SUBNANOMETER  
VACUUM  
RELIABLE  
PILINE®  
Q-MOTION®  
**PRECISION AND DYNAMICS  
WITH PIEZO MOTOR STAGES**  
MOTION CONTROL  
PIEZOMIKES  
COST EFFECTIVE  
COMPACT  
PARALLEL KINEMATICS  
PRECISION  
PIEZOWALK®  
HIGH DYNAMICS  
MULTI-AXIS SOLUTIONS

# Precision and Dynamics with Piezo Motor Stages



**Product Finder Online – What is the easiest way for you to find the best positioning solution?**

The printed catalog is a major showcase for PI and, as well as presenting the entire product range, it also acts as a reference for all of our motion solutions. However, to take advantage of the latest products and developments, we recommend using the product finder on the PI website [www.pi.ws](http://www.pi.ws).

How to use the product finder:

Select the product type specified by the axes of motion required. Selection of more criteria expands or shortens the list of results. Select more than one filter at a time, for example, to find positioning stages designed for higher load capacity, too.

## INTRODUCTION

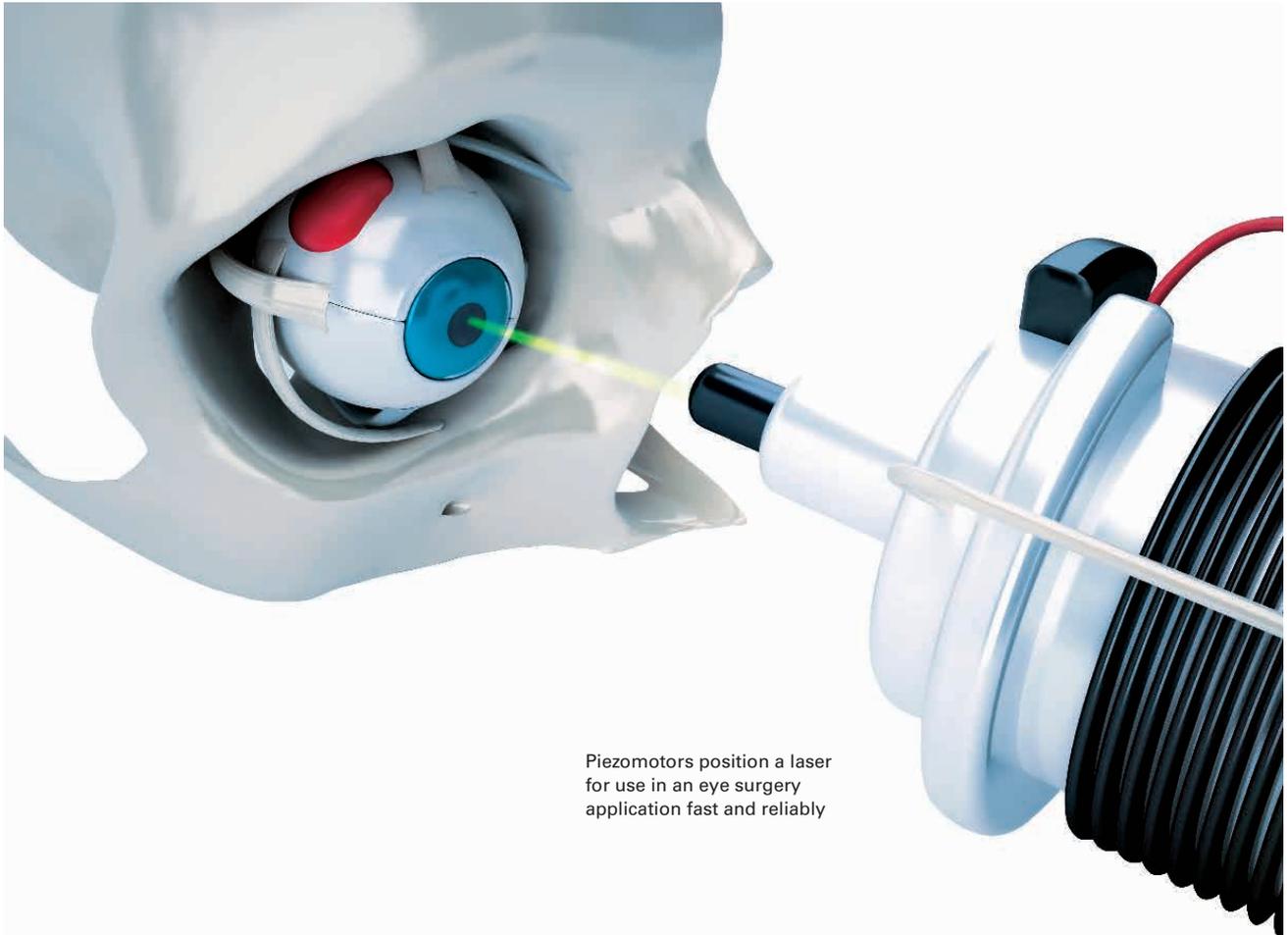
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More information, step-files and downloads are available from our website [www.pi.ws](http://www.pi.ws).  
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# Markets and Applications



Piezomotors position a laser for use in an eye surgery application fast and reliably



The XY stage with PLine® technology ensures fast probing scans in microscopy (Image: ©ZEISS)

## LIFESCIENCE AND MICROSCOPY

Optical methods have been relying on PI positioning systems for years, e.g. for aligning optical systems or samples. Piezo motors and actuators are best for replacing conventional motor/spindle driven systems because they are more compact, more precise and faster. Other non-optical microscopic processes, such as SEM (scanning electron microscope) and AFM (atomic force microscope), use PI systems due to their high accuracy and dynamics.

## AUTOMATION OF HANDHELD OR PORTABLE DEVICES

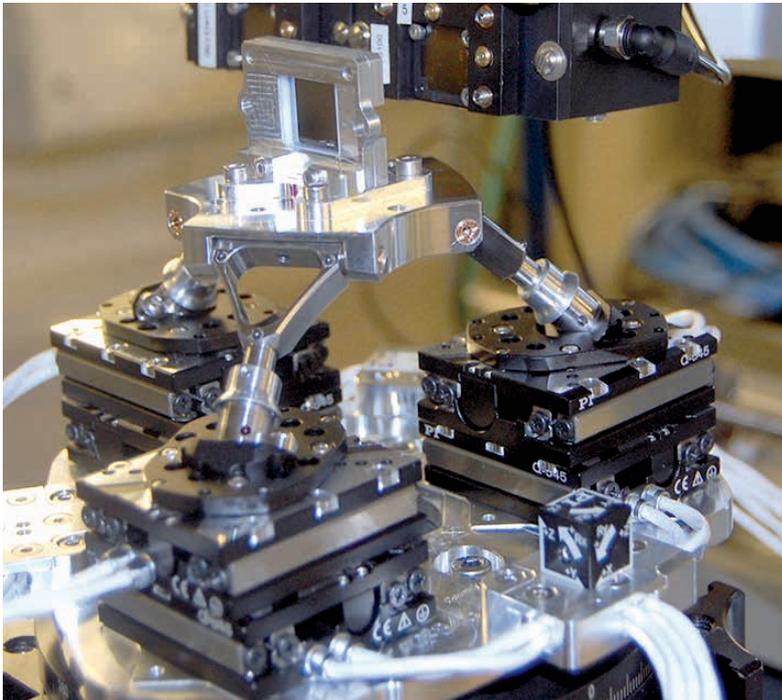
Leica Geosystems, a leading manufacturer of high-precision surveying instruments, relies on PLine® direct drive technology in their new total station product line. Total stations are used for angle and distance measurement in geodesy. Customer requirements included an extensive increase of the rotation speed and the angular resolution compared to the previously used conventional drive. The typical usage of the device consists of rotating a mass of 6 kg (15,000 kg/m<sup>2</sup>) in alternating directions, with a total of 7,000 h or 2,500 km of operation.

Several thousands of PLine® piezomotors are currently in the field where they are used for automated measurement routines. Battery-driven operation is essential here, which is made possible with the very low energy requirement of PLine® stages (Image: DMT, Essen, Germany).



# Markets and Applications

## SCIENTIFIC INSTRUMENTATION



From small-scale laboratory automation to experimental endstations of beamlines in synchrotrons and other particle accelerators, a large variety of applications in the scientific environment benefits from piezo based, sub-nanometer precision scanning and positioning. The conditions of use vary, and include ultrahigh vacuum, nonmagnetic or cryogenic.

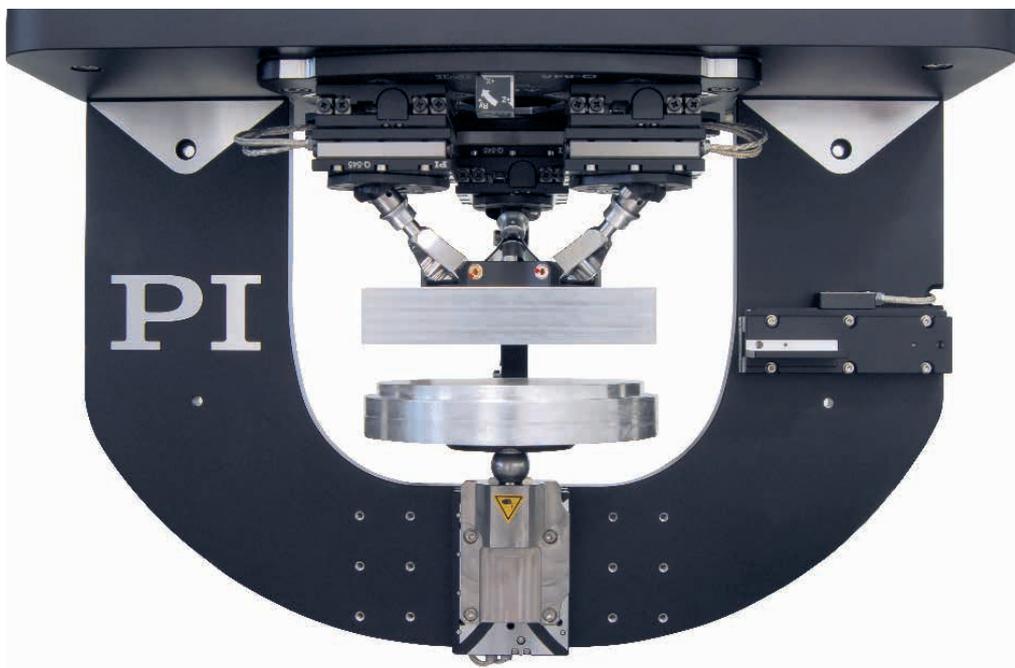
The miniature parallel-kinematic Q-845 aligns the probe extremely flexibly in all 6 degrees of freedom. The requirements are the lowest possible weight and an angular accuracy of up to  $0.001^\circ$  respectively, an error of less than  $1\ \mu\text{m}$  when positioning the probe during the rotation process. (Image: D. Hänschke, KIT Karlsruhe, Germany)

## INDUSTRIAL SOLUTIONS

The six-axis parallel kinematics align a wafer with high precision and stability relative to an optical measuring system. The PIFOC<sup>®</sup> objective positioner takes over the focusing. The system is controlled via a common interface on a customized controller.



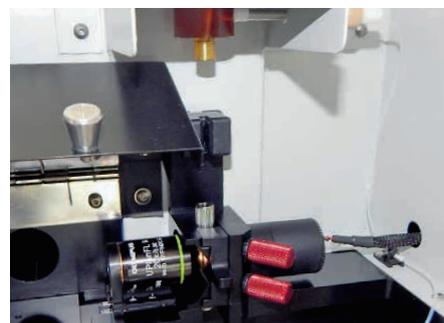
## MICROMANIPULATION



Eight Q-Motion® axes position components precisely to each other in this system. The six-axis hexapod aligns micrometer-sized components relative to the manipulator with an angular resolution under 10  $\mu$ rad. Even the feeds from below and the side are moved by customized Q-Motion® linear stages. (Image: VUB Vrije University Brussels, Belgium)

## OPTOMECHANICS

High throughput and high resolution are essential for optical particle analysis technology. Particle of different sizes are detected in liquids of all kind, ranging from monitoring of pipelines to ecological environments such as rivers or sea water. The application puts strong demands on the moving components in the optical path. A customized Q-motion® stage is fully integrated into the machine and positions the objective with high-precision positioning with excellent time stability. (Image: Fluid Imaging Technologies)



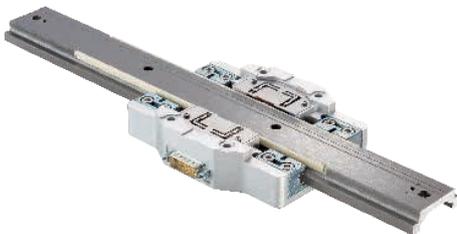
# Custom Examples Picture Wall



This customized, nonmagnetic, and HV-compatible hexapod is only 130 mm in height and has a diameter of 140 mm. Modified PiezoMike inertia drives serve as drives. With 5 mm/s, they are considerably faster than the classical PiezoMikes. A special joint construction ensures the necessary stiffness and at the same time, a long travel range of up to 10 mm.



This customized tripod with PiezoMike inertia drives is used for adjusting a mirror. The mirror can be moved along an axis linearly and tilted in two further orthogonal axes. The constructive challenge was to realize a relatively long travel range of several millimeters in a compact installation space of 110 mm x Ø 50 mm.



It is possible to develop inexpensive customized products with PLine® ultrasound motors that allow travel ranges up to 250 mm. The example shows a linear axis for positioning a measuring head along a travel range of 150 mm. The principle of the holding force in a power off condition allows virtually drift-free measuring at any position.



This miniature XYZ setup is based on the smallest Q-Motion® Q-521 linear stages and is used in industrial environments for microadjusting. To enable higher duty cycles, the guide is supported laterally. The vertical axis is equipped with a mass-compensated spring preload to relieve forces.



This miniature hexapod was developed on the basis of fast PILine® ultrasonic motors to enable fast motion in all six spatial directions (three linear, three rotational). The parallel-kinematic SpaceFAB design makes a particularly low overall height of only 80 mm possible. The individual axes can be commanded with up to 120 mm/s.



This three-axis system integrates two linear axes and a rotational axis and is used for aligning and fast, surface area scanning of photo-sensitive sensors. The use of PILine® ultrasonic motors makes shorter process times and a small installation space possible.



PiezoWalk® piezo-based drives combine excellent long-term stability and repeatability with a small form factor. This positioner is used for precise readjustment of monochromator crystals in an X-ray spectrometer.



In addition to the fast PILine® ultrasonic motors and high resolution sensor technology, this XY stage also has a fully-fledged controller and can therefore be operated directly with a USB joystick without additional external electronics. It provides an inexpensive solution for automating object motion under benchtop microscopes.

# Custom Examples Picture Wall



PILine® ultrasonic motors are suitable for directly driven rotary motion. This special product has a clear aperture of  $\varnothing 53$  mm for accommodating 2" lenses and is also made completely of nonmagnetic materials. Even the rotation bearing is a proprietary development from PI. The low-profile design allows stacking of several rotational axes while maintaining small distances between the lenses.



It is also important that the control unit for motion axes is designed according to customer specifications, in particular for highly integrated solutions in mobile end devices. This example shows the functionality of a C-867.1U controllers for PILine® ultrasonic motors shrunk down to  $50 \times 50$  mm<sup>2</sup> for easy insertion into the main board in the application.



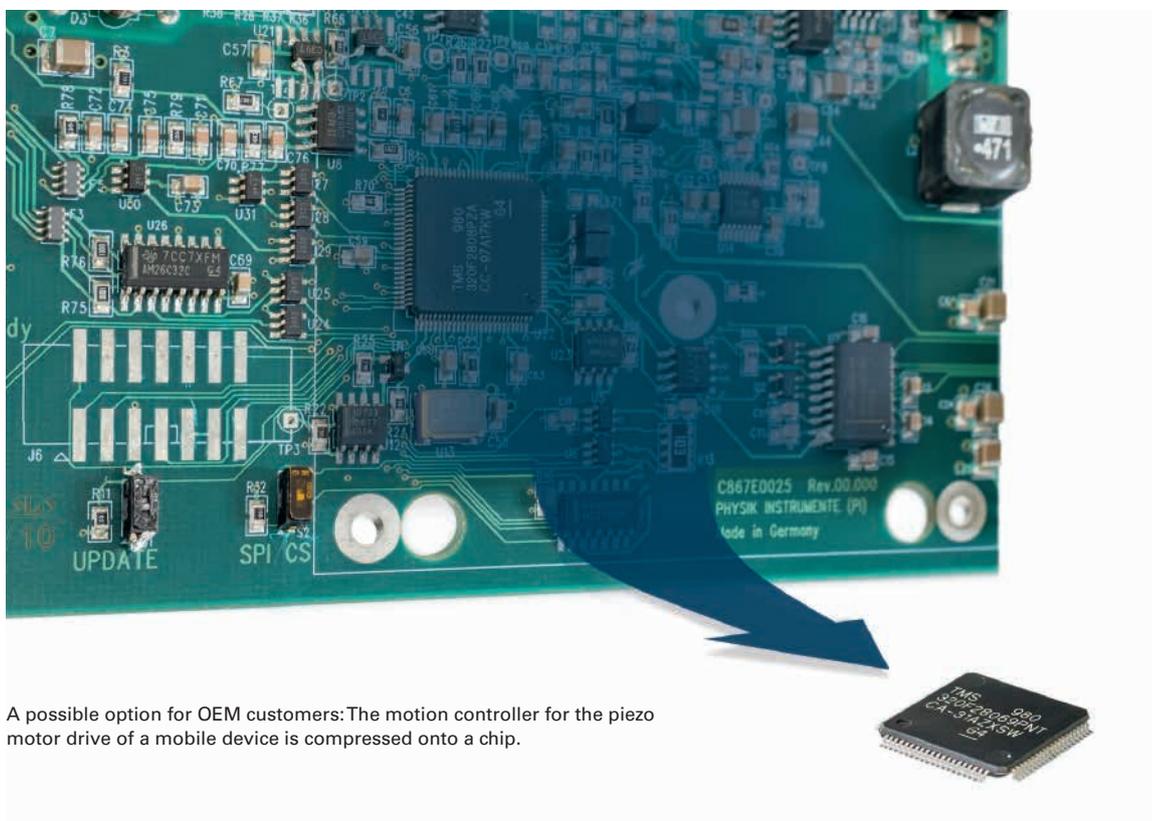
This extremely compact and highly integrated rotational axis with PILine® ultrasonic motors has a clear aperture of  $\varnothing 12.5$  mm. It is a customized development to rotate a measuring instrument in a battery-operated, mobile medical device. The speed of up to 2 revolutions per second make it possible to achieve shorter process times and the holding force principle in a power-off state also conserves the battery.



The miniaturized N-472 PiezoMike with inertia drive is used in the semiconductor industry for remote adjustment of optical components in ultrahigh vacuum. The actuators have a travel range of 8 mm and a resolution in the nanometer range, and are accommodated in a space of only  $40 \times 32 \times 15$  mm<sup>3</sup>.

# Options of Customizations / OEM Capabilities

PILine® ultrasonic motors can be designed in different sizes, to generate various forces, and for different axes of motion. This makes it possible to develop custom-fit, customer-specific solutions that allow linear or rotary motion with velocities up to 400 mm/s, forces to 20 N, and minimum incremental motion to 10 nm. PI has the entire manufacturing chain at its disposal for manufacturing piezo actuators. The latest development is an ultrasonic piezo motor that can be operated with allow voltage of less than 12 volts and is particularly suitable for use in the medical sector, where high, dangerous contact voltages must be prevented for safety reasons.



A possible option for OEM customers: The motion controller for the piezo motor drive of a mobile device is compressed onto a chip.



Miniature piezo ultrasonic drive elements in different sizes, to generate various forces, and for different axes of motion.

# Facts on Piezomotors

## NANOPOSITIONING WITH PIEZOMOTORS OVER LONG TRAVEL RANGES

Piezomotors are optimally suited for using the specific properties of piezo actuators to achieve longer travel ranges. Adapted to the required force and velocity development, PI provides a series of different piezomotor technologies, each of which focuses on different features. For example, PI piezomotors that feature high stiffness and resolutions in the nanometer range are used for nanometer-precision stages with travel ranges over 1 mm.

### General Properties of Piezomotor Drives

- Self-locking when powered off with maximum holding force
- Piezomotors do not generate magnetic fields nor are they affected by them
- Scalable travel ranges
- Nanometer-precision resolution
- Easy mechanical integration
- Different technologies optimized for high velocities or for high forces

### Overview of Drive Types for Miniature Piezo Stages and Actuators



#### Q-Motion® Inertia Drives

Smallest piezomotor drive principle. Cost-effective single-actuator, single-phase drive concept. Used for miniaturized positioners with nanometer resolution.



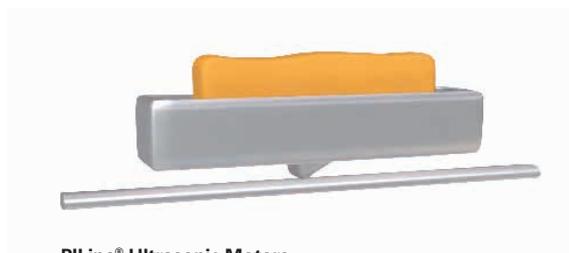
#### PiezoMike Actuators

Adapted piezo inertia drive used for linear actuators. Ideal for set-and-forget applications. High force, high stability, low velocity.



#### PiezoWalk® NEXACT®

Multi-actuator, multi-phase drive concept. High-precision positioners with nm-resolution. Offer high force at low velocities and are intended for low duty cycles.



#### PILine® Ultrasonic Motors

Fastest piezomotor drive principle to several 100 mm/s. Cost-effective single-actuator, single-phase drive concept. Multi-phase drive concept optional for nanometer precision and best constant velocity. PILine® systems typically reach 2,000 h of operation, 2,000 km or 20 million cycles.

## WHY USE PIEZOMOTORS INSTEAD OF ELECTRO MOTORS?

Motor-lead screw combinations transform the rotational motion of the motor into linear motion. Due to play in the mechanical components responsiveness is limited. Linear motors such as PLine® generate linear motion directly and provide much faster response and better stability. Furthermore, they allow significantly smaller designs. All piezomotor drives, independent from the technology used, are self-locking when powered off. This is due to their design where the piezoactuator is preloaded orthogonally to the direction of motion. Thus, piezomotors are ideal for precise and stable positioning even over a long standstill.

## TRAVEL, FORCE, LIFETIME: BASIC SPECS OVERVIEW

Motion, Positioning		Q-Motion® Inertia Drives	PLine® Ultra- sonic Motors	PiezoMike Actuators	PiezoWalk® NEXACT®
Travel range	<1 mm	•	•	•	•
	1 to 100 mm	•	•	~25 mm	•
	>100 mm		~200 mm		
Feed force	≤10 N	•	•	•	•
	~25 N			•	
Velocity	≤1 mm/s	•	••*	•	•
	~10 mm/s	•	•		•
	>100 mm/s		••		
Lifetime	≤1 km			•	•
	~100 km	•			
	>1000 km		••		
Small dimensions	••	•	•	•	
Self-locking at rest	•	•	•	••	•
Ultra-high vacuum	••**				•
Non-magnetic	•	•	•		•

\* Highly constant velocity at low velocity.

\*\* Q-Motion® stages are available as UHV-compatible versions.

# Facts on Piezomotors

## APPLICATION OVERVIEW

Applications	Major requirements	Q-Motion® Inertia Drives	PILine® Ultra-sonic Motors	PiezoMike Actuators	PiezoWalk® NEXACT®
Mobile devices	Battery driven	x	x		
	Self-locking at rest	x	x	x	x
	Small dimensions	x	x	x	x
Semiconductor manufacturing and inspection stability	High-force position			x	
	High-class clean room	x	x		x
	Ultra-high vacuum	x			x
Optical superresolution microscopy	Fast settling	x	x		x
	Long-range motion	x	x		x
	High resolution	x	x		x
	Constant, low velocity	x	x		x
Electron microscopy / Beamline instrumentation	Scanning mode with high velocities		x		
	Ultra-high vacuum	x			x
	Non-magnetic	x			x
OEM capabilities	Small dimensions	x	x		x
	Low price	x	x	x	
	In-house engineering	x	x	x	x
	High-volume manufacturing	x	x	x	x

# The PI Group – A Strong Partner for Industry and Research



The PI headquarters in Karlsruhe, Germany, manifests the continuous growth. In front, the 2017 Technology Center

Over the last four decades, PI (Physik Instrumente) has developed into the leading manufacturer of nanopositioning technology. The key element and motivation of the entrepreneurial behavior have always remained the same: Finding the best possible solution for the customer.

PI is well known for the quality of its products and has been one of the leading players in the global market for precision positioning technology for many years. One of the most important building blocks for this is the team spirit within the international PI family, which is based on mutual understanding and support that goes beyond international borders and functional restrictions.

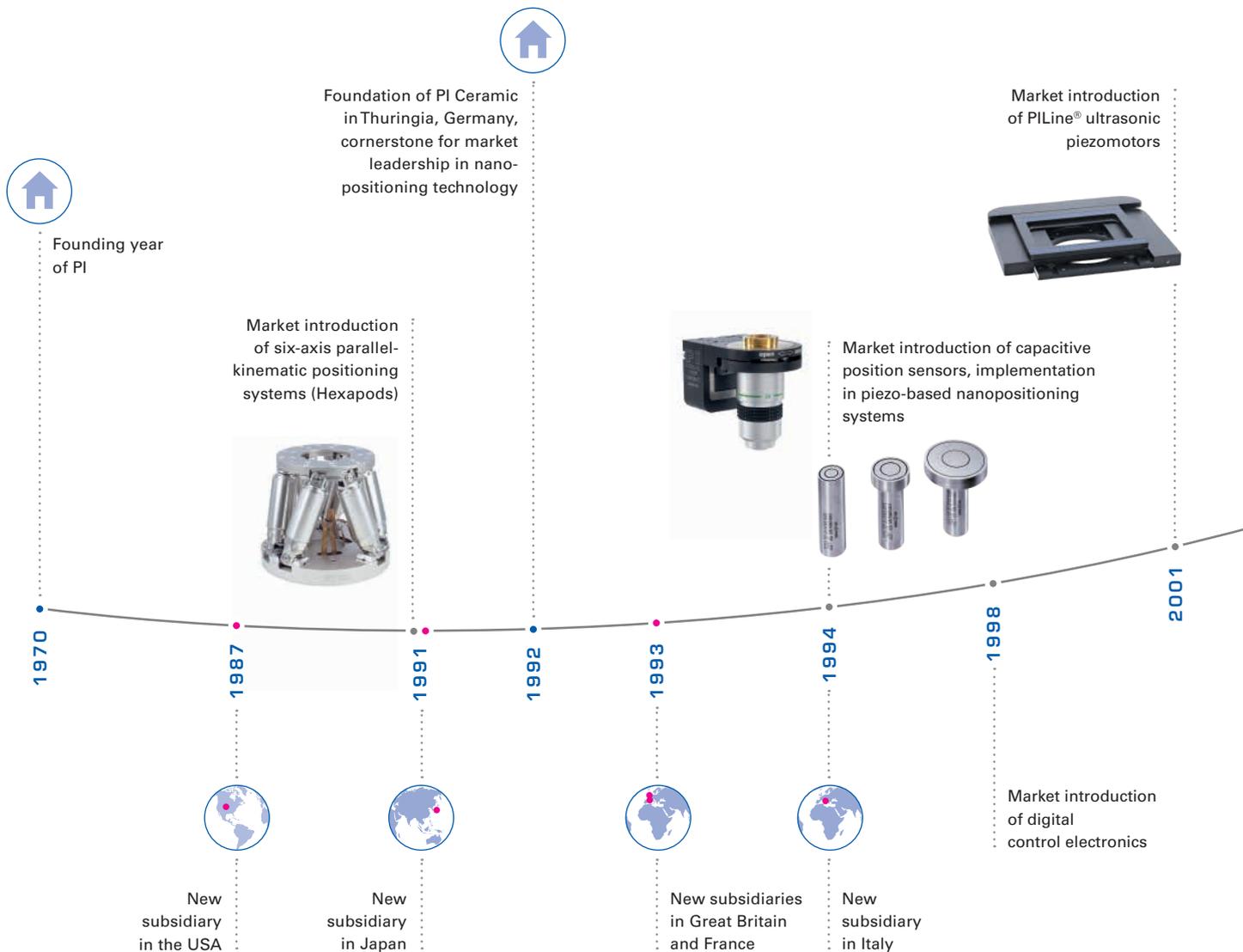
PI is a privately owned company with healthy growth, more than 1000 employees worldwide and a flexible, vertically integrated organization, which enables PI to fulfill almost any request in the field of innovative precision positioning technology. The foremost priority for PI is to be a reliable and highly qualified partner for the customer.

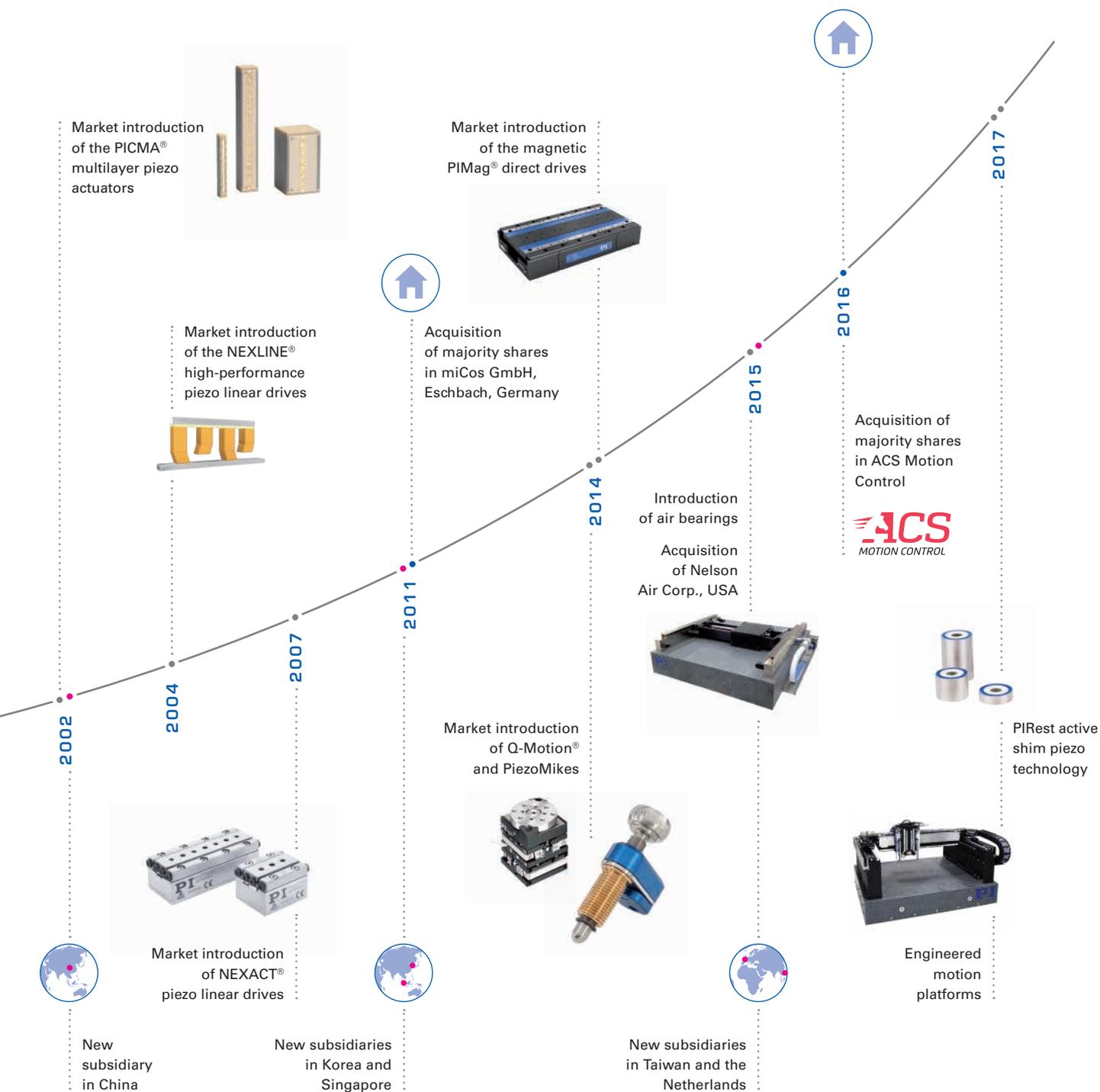
# The PI Group Milestones

## A Success Story

Well known for the high quality of its products, PI (Physik Instrumente) has been one of the leading players in the global market for precision positioning technology for many years. PI has been developing and manufacturing standard and OEM

products with piezo or motor drives for more than 40 years. In addition to four locations in Germany, the PI Group is represented internationally by fifteen sales and service subsidiaries. All of our customers worldwide can rely on this.





# Expert Consulting



Time for qualified technical consultation is crucial for the success of high-tech projects

The PI Group can respond precisely to what customers want: Specific requirements can often only be satisfied by customized solutions – solutions that can be found by unconventional and creative thinking. Together with the customers, PI plans and realizes individual solutions for the most varied applications and integration levels. And that means that PI's customers can always be sure that they will get the best solution every time.

Customers directly benefit from:

### **Highly Qualified Consultancy Through Trained Specialists**

Individual advice often is key to solve a complex problem. PI sales engineers are ready to come on site with all the time necessary for a solid understanding of the topic. Or they will gladly meet at the PI head office. All PI sales engineers have a background in natural sciences or engineering, and have up to 20 years of experience in optical, micro- or nanopositioning technology.

### **International Support**

PI subsidiaries and distributors in many countries across the world guarantee global support – a decisive advantage, especially for globally operating customers. PI has its own sales and service offices in all important markets. Moreover, the company maintains testing devices for nanometrology on three continents. PI Shanghai and PI USA have additional development and manufacturing resources that allow rapid local reaction to custom-engineered specifications.

# Engineering Design Expertise and Customization

## Unique Technological Breadth

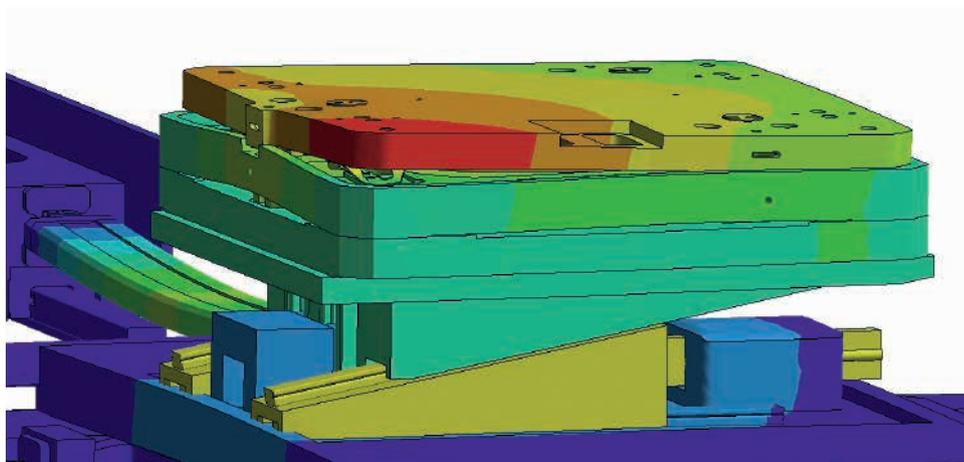
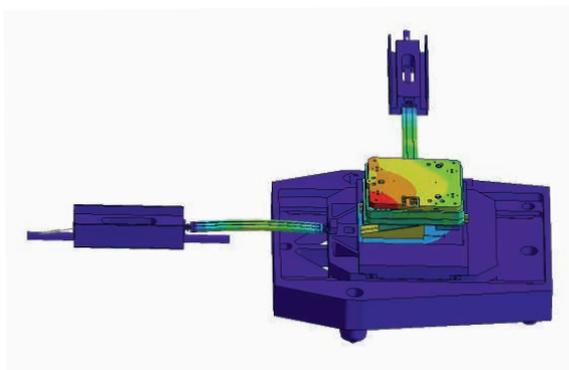
The technological diversity of the PI Group is unrivalled all over the world. PI develops, manufactures, and qualifies all its core technologies itself. PI is therefore not dependent on components available on the market. That puts PI in a position to offer its customers the most advanced products for motion and positioning tasks – without technological restriction.

## Customized Solutions

With this background, PI develops positioning solutions with innovative drive technologies for high-tech applications worldwide. PI covers the whole motion range from finger-tip sized nanopositioners to large-scale stages with long travel ranges, through their plethora of different drive and guiding systems.

## Core Technologies

- In-house manufacturing of piezo components and piezo actuators
- Magnetic direct drives: linear motors and voice coil
- Air bearings, magnetic and flexure guides
- Comprehensive range of piezo motor technologies
- Nanometrology sensors
- Parallel-kinematic systems for positioning in six axes (Hexapods)
- Motion control technology
- Software



Maximum performance of precision systems is achieved through extensive design and analysis expertise, using equipment built in-house with proprietary techniques. See here the modal analysis of a complex multi-axis system that includes linear guide elements as well as mixed piezo drive technologies like PICMA® multilayer actuators and PiezoWalk® walking drives, and PIMag® magnetic drives

# Production Capabilities



PI's flexibility in serial production allows for fast adaptation of both processes and quantities

A modern production management and an integrated management system allow PI to guarantee the high quality of its products, processes, and services. The continual improvement of organization and processes is an integral part of the corporate culture. KAIZEN workshops and an active innovation management are important elements for achieving this.

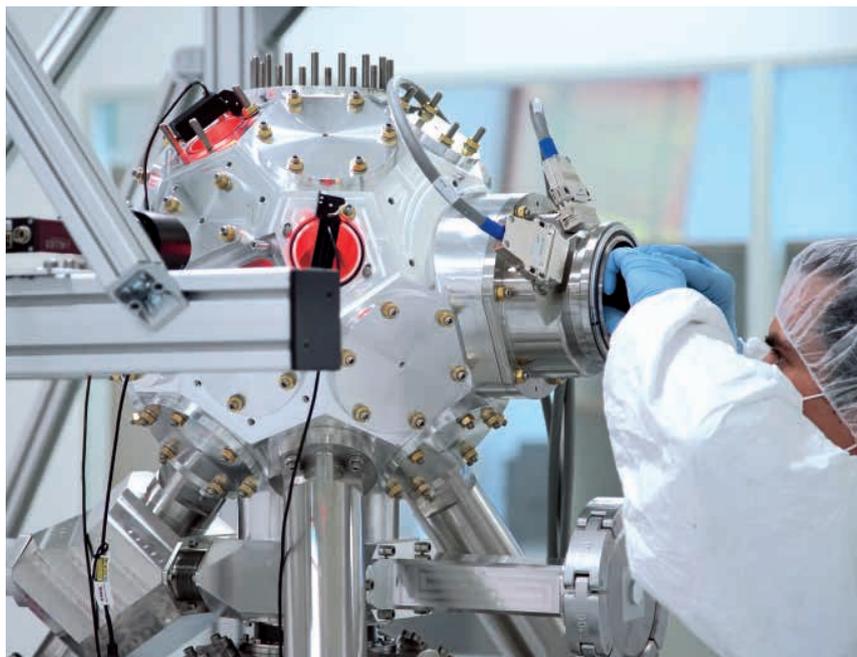
The production processes for the standard range are made flexible by the fractal production structure and it is therefore possible to manufacture even large series with full process control. Active, system-based requirements management makes it possible to dispense with comprehensive storage facilities.

## **Vertical Production Range and Production Capacity**

The product spectrum ranging from the two-ton hexapod to the 10-gram nanopositioner requires PI to have the equipment and technologies at its disposal that allow the systems to be manufactured, assembled, and qualified.

- 13,000 m<sup>2</sup> of overall production space
- 5,000 m<sup>2</sup> for cleanrooms
- Air-conditioned and vibration-proof measuring conditions
- Vacuum chambers for startup and residual gas analysis
- Measuring technology with traceable, calibrated measuring equipment
- Monitoring of piezo actuator technology from material composition to final inspection
- In-house manufacturing of positioning sensors
- Production hall with measuring technology for heavy loads
- Fractal production organization

# Vacuum Know-How



PI offers high-precision solutions for positioning in vacuum conditions to  $10^{-10}$  hPa. Positioning solutions in a vacuum follow clearly defined constraints. This applies to the limited installation space, as well as prevention of contamination and excessive heat input.

Selection of the optimum drive technology for the respective application and the mechanical design must be matched exactly to the required load capacity and velocity as well as the intended operating and planned duty cycles.

The handling regulations for vacuum positioning systems are just as important as the design principles. Cleanrooms are available for assembling larger parts. Suitable packaging and the corresponding instructions for the recipient are part of shipping.

Vacuum chambers are available in several sizes with vacuum levels down to  $10^{-10}$  hPa, where start-up and measurement of outgassing, but also interferometric measuring of position accuracy under real operating conditions is possible.



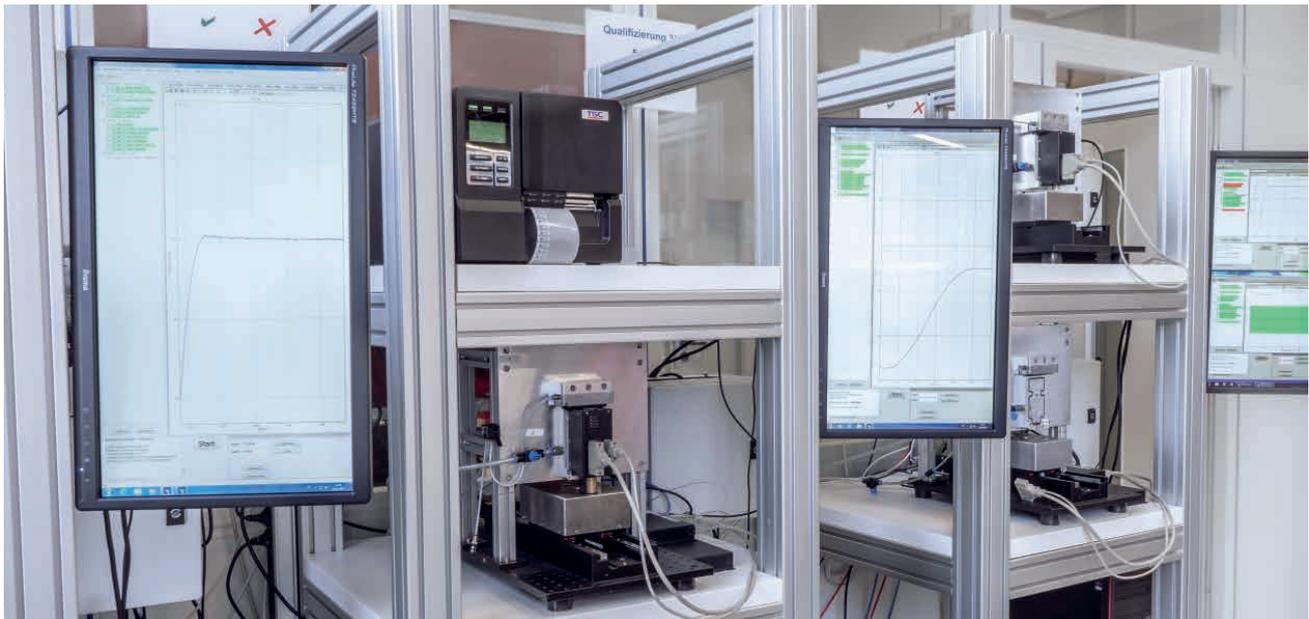
At PI, several vacuum chambers are available in various sizes

# From 1-off to Series: OEM Users Benefit From Maximum Flexibility

PI serves both the research and industrial markets. The complete control over the design and manufacturing process provides our customers with significant competitive advantages. Optimized processes allow PI to deliver customized products in quantities up to several 100,000 units per year at low cost and right on time. The range of OEM products offered by the PI Group varies widely, ranging from “bare” actuators and sensors to highly integrated parallel-kinematic positioning systems. Evaluation of pre-production run samples, test procedures, production processes and quality management are all included in the development process.

## Services

- Global account management: Close proximity to the customer thanks to international presence
- Risk assessment from design to delivery
- Depending on the task: From the drive to the turnkey system
- Copy exactly policy
- Preparation of internal and external certification
- Production of series of several 10,000 units in the shortest time
- Sustainable spare parts service
- Manufacturing and testing capacities from functional samples to mass production



Standardized performance control with full documentation of individual measurement charts

# Global Service and After-Sales



On-site training is key to optimize and maximize the potential of new PI systems

## Start-Up, User Training and Life Long Support

PI is dedicated to supporting its customers right from the initial consultation through to when a customer has purchased a PI system. Beyond that, PI's services division is committed to ensuring that every aspect of owning a PI system is catered for.

### Global Coverage

Supported by 4 Global Service Hubs in Asia, China, Europe and USA, with field product specialists working from these hubs, PI is able to support all technologies and customer applications via this global services team.

### PI's Standard On-Site Services

- Set up and Commissioning – On-site support to un-box, set-up and commission the PI system
- Training Program – User training on software and programming, through to optimization of system performance
- Maintenance Systems Health Check – Preventative maintenance to prolong the life of the motion device
- Support – Ongoing remote and on-site support to maximize system uptime and provide maintenance for the whole life of any system

## Contracted Services

Customers subscribing to Contractual Support Services will receive commitment from PI to achieving agreed Service Levels. These include responding to the customer's first contact and providing remote technical support, through to response times for a PI expert to be on site, either to repair or replace a defective unit.

### Extended Warranty

Most customer applications require PI's systems to be operational beyond the standard warranty period. Extending the warranty for additional year(s), is simply extending the customers peace of mind and PI's commitment that the product will not fail due to poor workmanship or faulty materials. Should a customer's system then fail due to these conditions, PI will cover the costs to repair or replace it.

# Linear Stages



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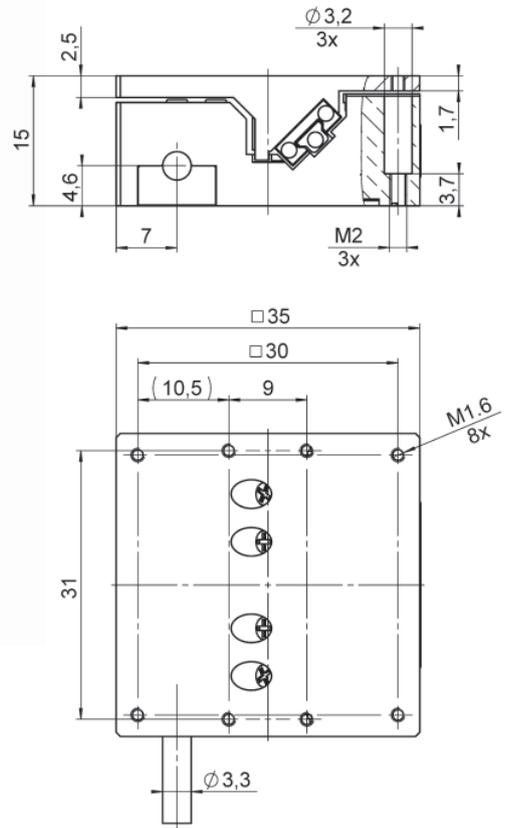
# U-521 PLine® Linear Stage

Compact Linear Stage with Ultrasonic Piezo Motor



- Positions small loads quickly and with precision: Velocity to 200 mm/s, minimum incremental motion to 0.3 μm
- Space-saving: Only 35 mm in width and 15 mm in height
- Self-locking when switched off: Saves energy and reduces generation of heat
- Silent
- Customized versions on request

U-521, dimensions in mm



## Applications

- Autofocus systems
- Micro manipulators
- Sample positioning
- Scanning Imaging
- Handheld device automation

- >> Linear Encoder
- >> PLine® Ultrasonic Piezomotors
- >> Vacuum-Compatible Versions

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	U-521.23	U-521.24	Unit	Tolerance
<b>Motion</b>				
Active axes	x	x		
Travel range	18	18	mm	
Velocity, closed loop	200	200	mm/s	max.
Minimum incremental motion	2	0.3	µm	typ.
System resolution	0.4	0.1	µm	
Bidirectional repeatability	±2	±0.2	µm	
Linearity error (over the entire travel range)	8	4	µm	
Pitch	±300	±300	µrad	
Yaw	±300	±300	µrad	
<b>Positioning</b>				
Sensor type	Incremental encoder	Incremental encoder		
Measuring principle	Optical	Optical		
Measuring method	Direct measuring	Direct measuring		
Sensor resolution	0.4	0.1	µm	typ.
<b>Mechanical properties</b>				
Compressive stress capacity	2	2	N	max.
Pull force capacity	2	2	N	max.
<b>Drive properties</b>				
Motor type	PILine® ultrasonic piezo motor, performance class 1	PILine® ultrasonic piezo motor, performance class 1		
Drive force	2	2	N	max.
Holding force	2	2	N	max.
<b>Connectors</b>				
Motor / sensor	1 × Sub-D 15 (m)	1 × Sub-D 15 (m)		
<b>Miscellaneous</b>				
Reference point switch	Optical	Optical		
Operating temperature	0 to 40	0 to 40	°C	
Material	Aluminum, anodized	Aluminum, anodized		
Mass (stage without cable and connector)	40	40	g	
Mass (stage with cable and connector)	160	160	g	
Cable length	1.5	1.5	m	typ.

Specifications determined with the C-867.1U controller.  
 All specifications based on room temperature (22 °C ±3 °C).  
 Vacuum versions to 10<sup>-6</sup> hPa available on request. Specifications for vacuum versions can differ.  
 Ask about custom designs!



Multi-axis setup consisting of two U-521 linear stages and a U-624 rotation stage, without adapter plate

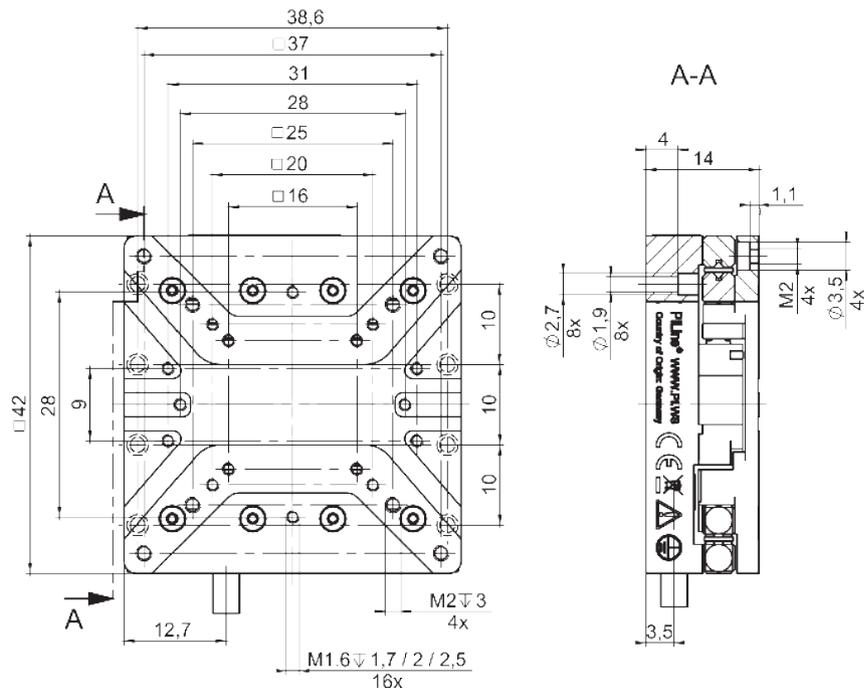
# U-523 PLine® Linear Stage

Compact Linear Stage with Ultrasonic Piezo motor



- Fast positioning
- Space-saving and light
- High guiding accuracy
- High sensor resolution of 10 nm
- Self-locking, no heat generation at rest
- Low-noise operation
- Integrated XY-stage U-723

U-523, dimensions in mm



## Applications

- Autofocus systems
- Micro manipulators
- Sample positioning
- Linescan imaging

- >> Linear Encoder
- >> PLine® Ultrasonic Piezomotors
- >> Vacuum-Compatible Versions

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	U-523.25	Unit	Tolerance
<b>Motion</b>			
Active axis	x		
Travel range	22	mm	
Velocity	200	mm/s	max.
<b>Mechanical properties</b>			
Load capacity in z	5	N	max.
Mass without cable	70	g	
Linear guide	Crossed roller bearing with anti-creep system		
<b>Drive properties</b>			
Drive type	PILine® ultrasonic piezo motor, performance class 1		
Nominal force	2	N	typ.
Holding force	2	N	typ.
<b>Positioning</b>			
Integrated sensor	Optical, incremental sensor		
Sensor resolution	10	nm	
Minimum incremental motion	0.1	µm	typ.
Reference point switch	Direction-sensing optical reference point switch		
<b>Miscellaneous</b>			
Operating temperature range	0 to 40	°C	
Humidity	20 – 90 % rel., not condensing		
Material	Aluminum, anodized		
Motor / sensor connection	Sub-D 15 (m)		
Cable length	1.5	m	

Ask about custom designs!

Technical data specified at room temperature (22±3 °C) with C-867.1U.

# Q-521 Q-Motion® Miniature Linear Stage

Smallest Linear Stage with Position Control, High Resolution and Affordable Price



- Only 21 mm in width and 10 mm in height
- Direct position measurement with integrated incremental encoder
- Encoder resolution up to 1 nm
- Minimum incremental motion up to 2 nm
- Multi-axis system setups with adapter plate or bracket (available as an option)
- Suitable for vacuum to  $10^{-6}$  hPa, versions to  $10^{-9}$  hPa available

## Piezoelectric inertia drive

Piezo inertia drives are space-saving and affordable piezo-based drives with relatively high holding forces and a virtually unlimited travel range. The inertia drive principle is based on a single piezoelectric actuator that is controlled with a modified sawtooth voltage provided by special driver electronics. The actuator expands slowly and moves the runner. Due to its inertia, the runner is unable to follow the subsequent fast contraction of the actuator and remains at its position. With an operating frequency of up to 20 kHz, the drives acting directly on the runner and achieve velocities of max. 10 mm/s.

## Direct-measuring principle

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

## Vacuum and nonmagnetic environments

All Q-Motion® linear stages are suitable for operation in high vacuum to  $10^{-6}$  hPa. Furthermore, ultrahigh vacuum variants for  $10^{-9}$  hPa are also available. Non-magnetic versions are available on request.



Q-521 stages make for most compact multi-axis setups.

## Applications

- Fine adjustment of the smallest components during assembly
- Photonics / Alignment Applications
- Microscopy
- Beamline systems
- Semiconductor technology
- Test laboratories

>> Linear Encoder

>> Q-Motion® Piezoelectric Inertia Drive

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	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
Minimum 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
Length	30	30	32.2	32.2	42.2	42.2	30 to 42.2	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	Piezo-electric inertia drive	Piezo-electric inertia drive	Piezo-electric inertia drive	Piezo-electric inertia drive	Piezo-electric inertia drive	Piezo-electric inertia drive	Piezo-electric inertia drive	
Push / pull force	1	1	1	1	1	1	1	N
Holding force, power off	1.3	1.3	1.3	1.3	1.3	1.3	1.3	N

\* Typical velocity at a control frequency of 20 kHz

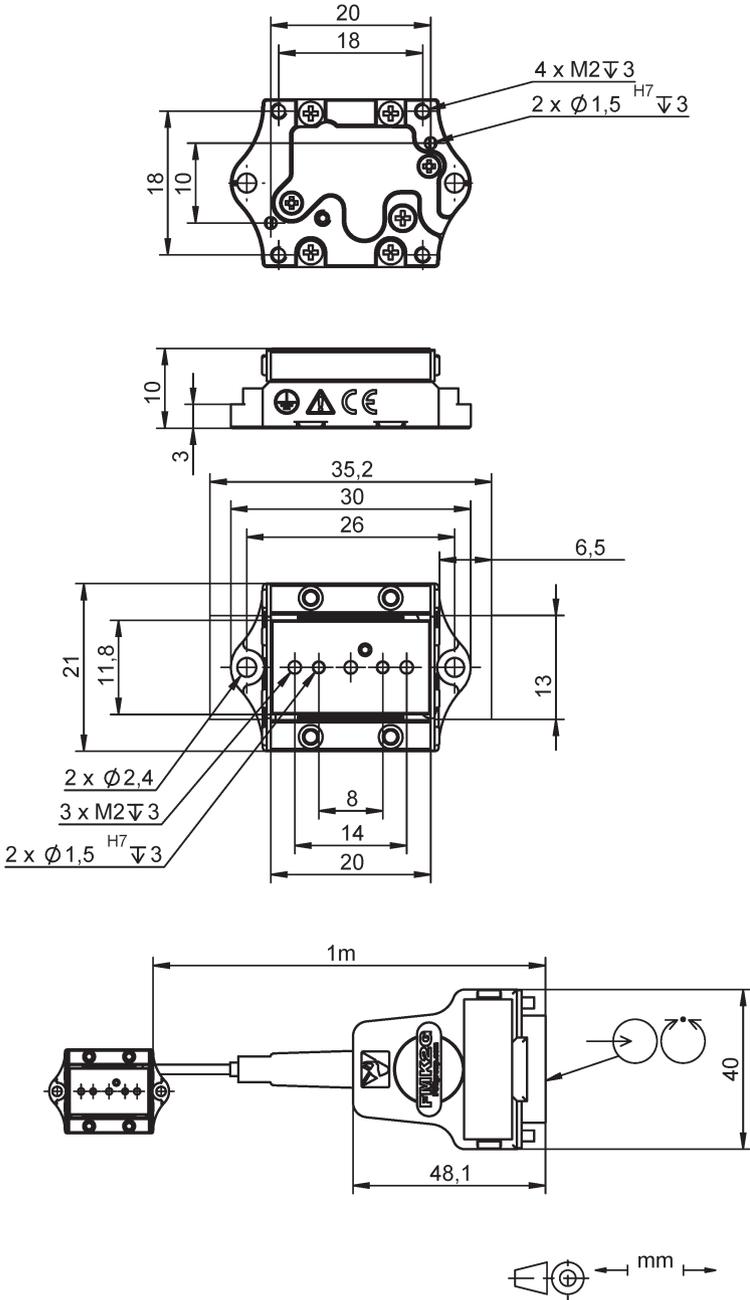
For operation in a vacuum, we recommend a reduced duty cycle of 20 % and a maximum motor push / pull force of 30 % compared to a standard environment. The intrinsic mass of the slider plate must be considered accordingly. Ask about custom designs!

	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>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	
Mass incl. cable and connector	110	Q-521.140: 110 Q-521.14U: 66	126	Q-521.240: 126 Q-521.24U: 78	135	Q-521.340: 135 Q-521.34U: 92	Q-521.100: 110 Q-521.200: 126 Q-521.300: 135 Q-521.10U: 66 Q-521.20U: 78 Q-521.30U: 92	g
Mass without cable and connector	24	Q-521.140: 24 Q-521.14U: 24	126	Q-521.240: 24 Q-521.24U: 34	48	Q-521.340: 48 Q-521.34U: 48	Q-521.100: 24 Q-521.200: 34 Q-521.300: 48 Q-521.10U: 24 Q-521.20U: 34 Q-521.30U: 48	
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-872	

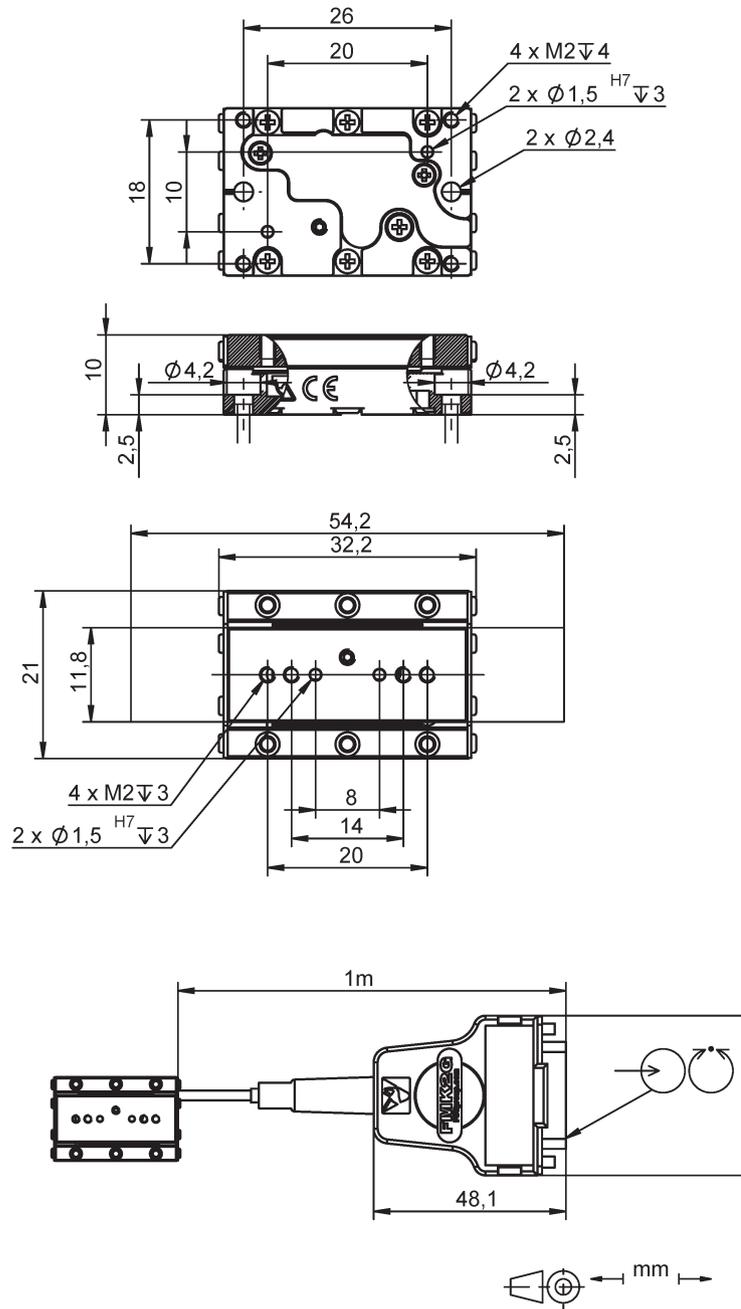
\*Typical velocity at a control frequency of 20 kHz

For operation in a vacuum, we recommend a reduced duty cycle of 20 % and a maximum motor push / pull force of 30 % compared to a standard environment. The intrinsic mass of the slider plate must be considered accordingly. Ask about custom designs!

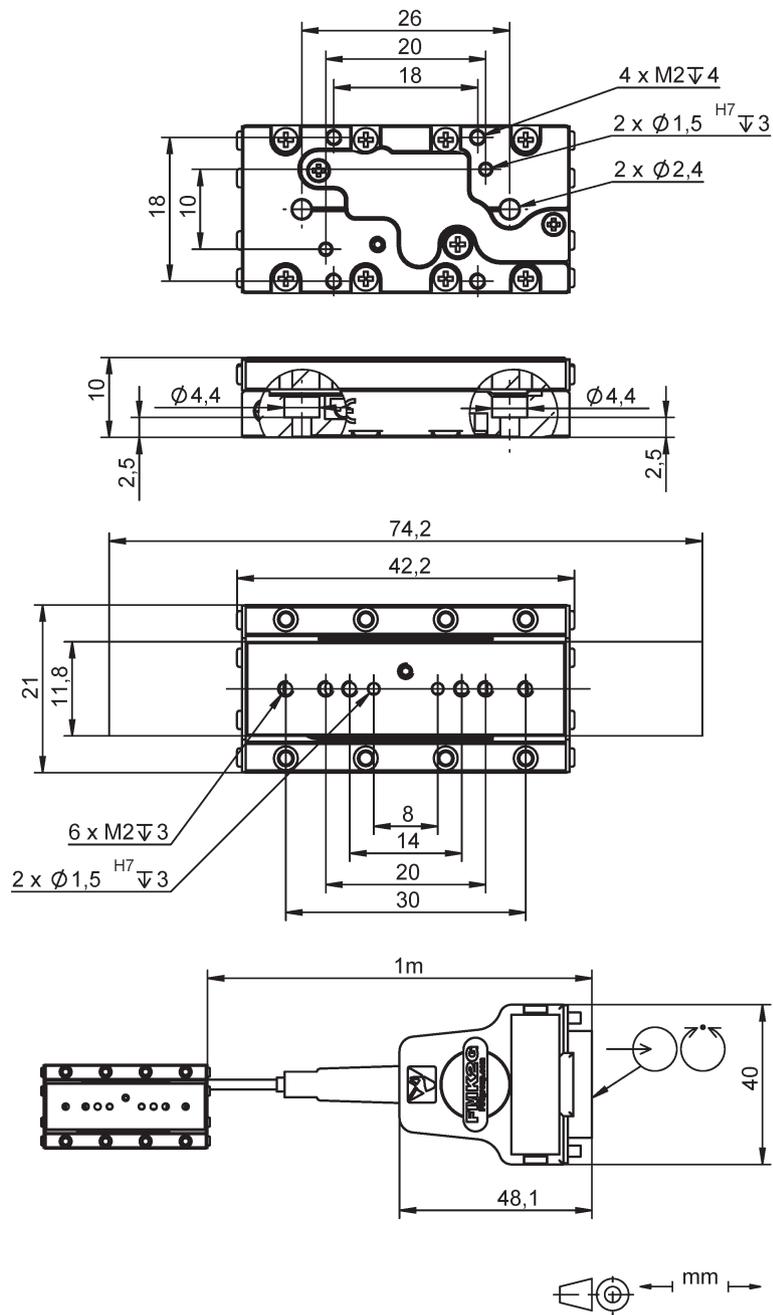
Q-521.1xx, dimensions in mm. Note that the decimal places are separated by a comma in the drawings.



Q-521.2xx, Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.



Q-521.3xx, Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.



# Q-522 Q-Motion® Miniature Linear Stage

Piezo Motors for Small Dimensions, High Resolution, and a Favorable Price



- Only 22 mm in width and 10 mm in height
- Direct position measurement with incremental encoder with up to 1 nm resolution
- Minimum incremental motion up to 2 nm
- XY mounting without adapter
- Q-622 rotation stage mountable without adapter
- Suitable for vacuum to 10<sup>-6</sup> hPa, versions to 10<sup>-9</sup> hPa available

## Piezoelectric inertia drive

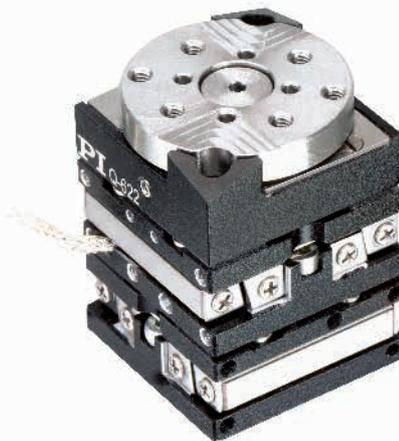
Piezo inertia drives are space-saving and affordable piezo-based drives with relatively high holding forces and a virtually unlimited travel range. The inertia drive principle is based on a single piezoelectric actuator that is controlled with a modified sawtooth voltage provided by special driver electronics. The actuator expands slowly and moves the runner. Due to its inertia, the runner is unable to follow the subsequent fast contraction of the actuator and remains at its position. With an operating frequency of up to 20 kHz, the drives acting directly on the runner and achieve velocities of max. 10 mm/s.

## Direct-measuring principle

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

## Vacuum and nonmagnetic environments

All Q-Motion® linear stages are suitable for operation in high vacuum to 10<sup>-6</sup> hPa. Furthermore, ultrahigh vacuum variants are also available for 10<sup>-9</sup> hPa. Non-magnetic versions are available on request.



This 3-axis setup of Q-522 linear and Q-622 rotation stages offers XY and yaw motion on a 22 mm x 22 mm footprint.

## Applications

- Fine adjustment of the smallest components during assembly
- Photonics / Alignment Applications
- Microscopy
- Beamline systems
- Semiconductor technology
- Test laboratories

- >> Linear Encoder
- >> Q-Motion® Piezoelectric Inertia Drive
- >> Vacuum-Compatible Versions

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	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 range	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
Minimum 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

\*Typical velocity at a control frequency of 20 kHz

For operation in a vacuum, we recommend a reduced duty cycle of 20 % and a maximum motor push / pull force of 30 % compared to a standard environment. The intrinsic mass of the slider plate must be considered accordingly.

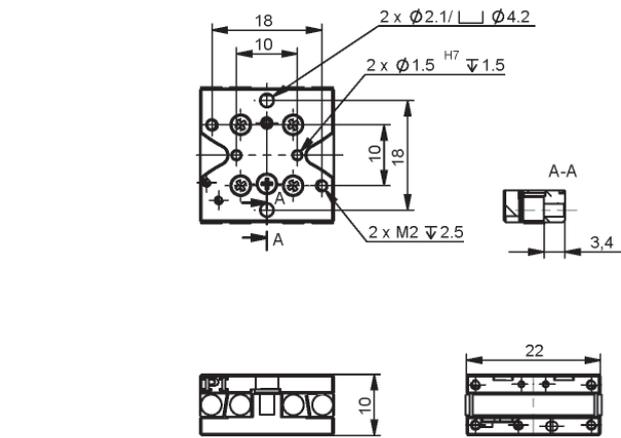
Ask about custom designs!

	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>Drive properties</b>								
Motor type	Piezo-electric inertia drive							
<b>Miscellaneous</b>								
Operating temperature range	0 to 40	°C						
Material	Aluminum, steel							
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							
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-872	

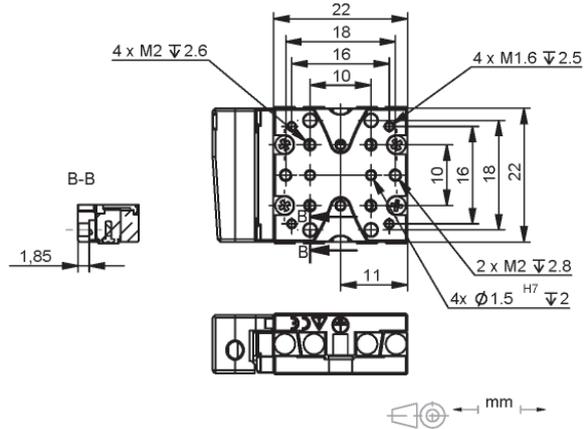
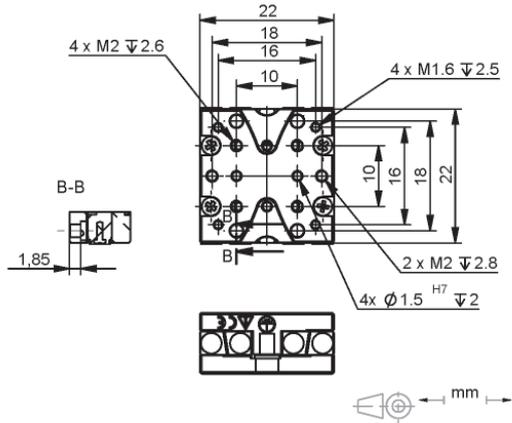
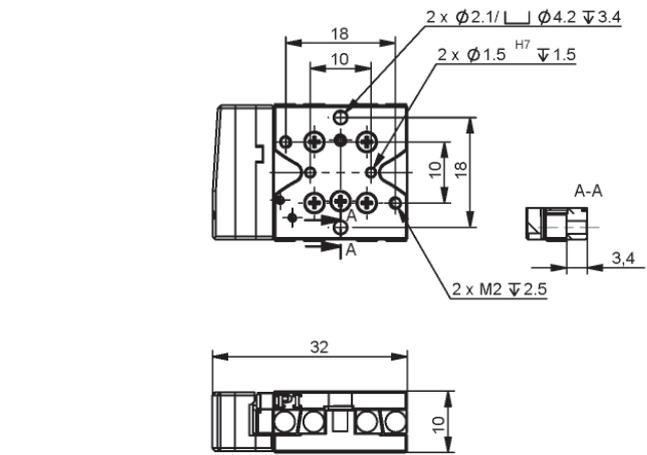
\* Typical velocity at a control frequency of 20 kHz

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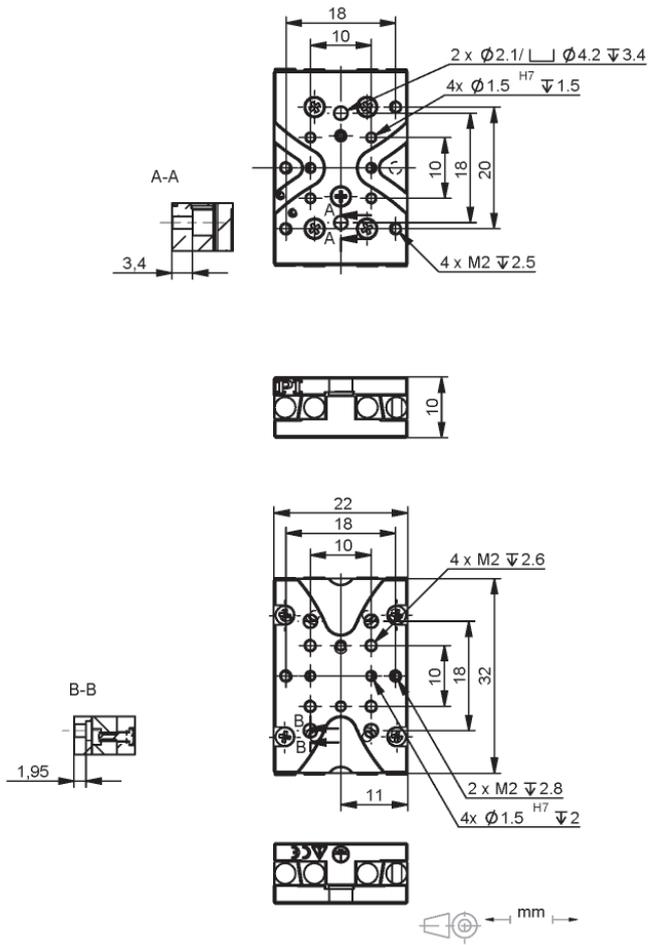
Q-522,000, dimensions in mm



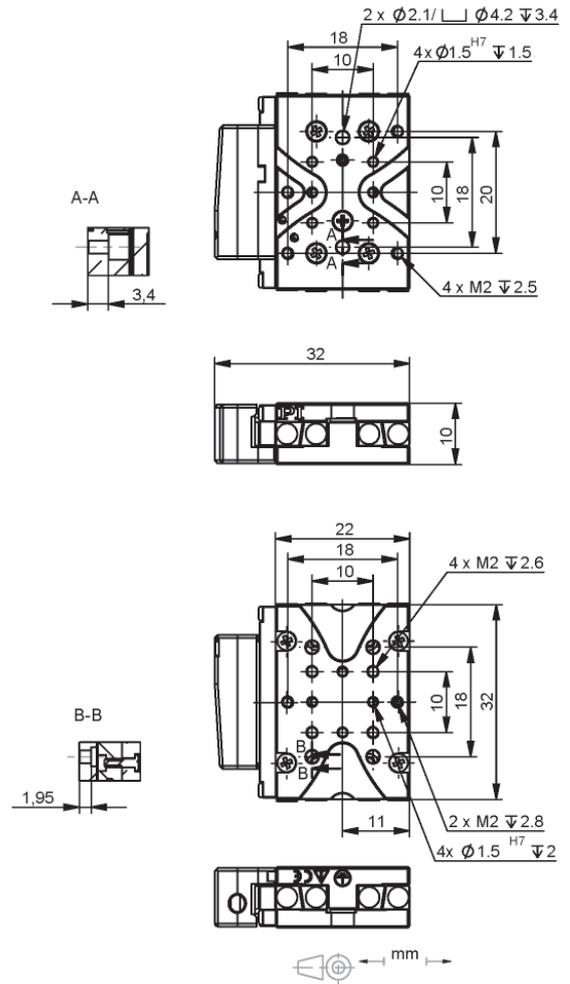
Q-522,040, dimensions in mm



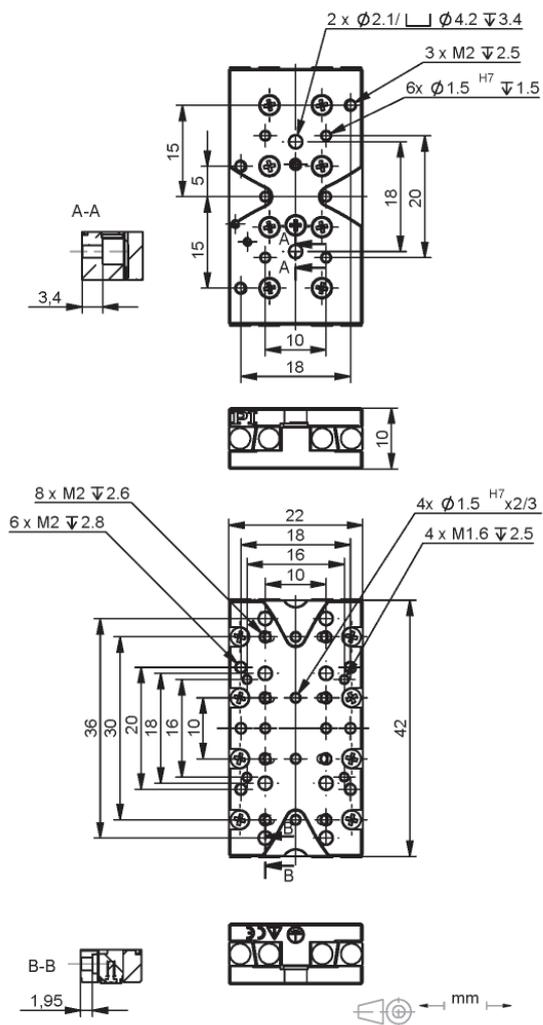
Q-522,100, dimensions in mm



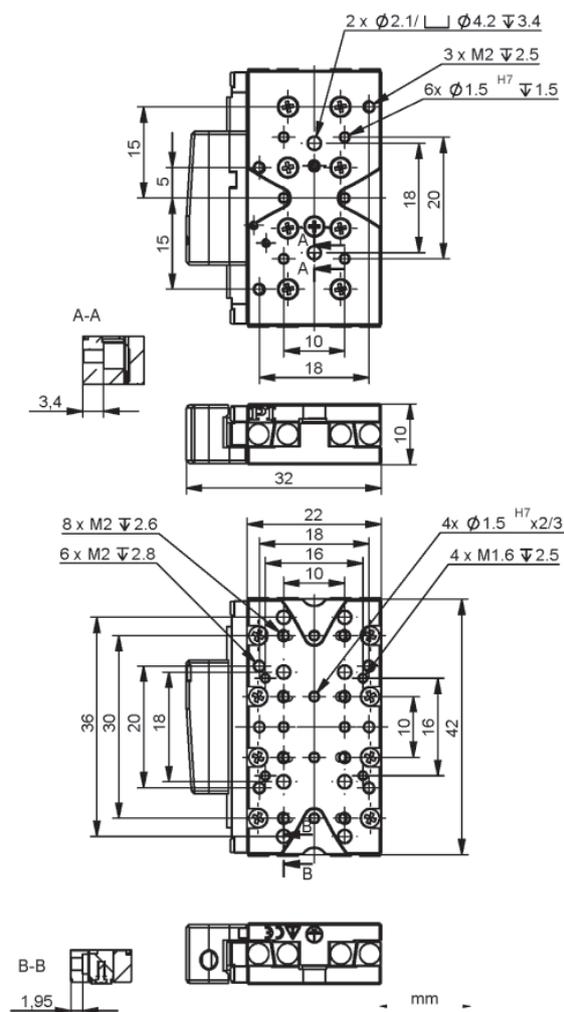
Q-522,140, dimensions in mm



Q-522,200, dimensions in mm



Q-522,240, dimensions in mm



# Q-545 Q-Motion® Precision Linear Stage

High Forces and Small Design Due to Piezo Motors



- Only 45 mm in width
- Push / pull force 8 N
- Incremental sensors with position resolution
- XY combinations without adapter plate possible
- Vacuum-compatible to  $10^{-6}$  hPa (Q-545.xx0)
- Vacuum-compatible to  $10^{-9}$  hPa (Q-545.xxU)

## Piezoelectric inertia drive

Piezo inertia drives are space-saving and affordable piezo-based drives with relatively high holding forces and a virtually unlimited travel range. The inertia drive principle is based on a single piezoelectric actuator that is controlled with a modified sawtooth voltage provided by special driver electronics. The actuator expands slowly and moves the runner. Due to its inertia, the runner is unable to follow the subsequent fast contraction of the actuator and remains at its position. With an operating frequency of up to 20 kHz, the drives acting directly on the runner and achieve velocities of max. 10 mm/s.

## Direct-measuring principle

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

## Vacuum and nonmagnetic environments

All Q-Motion® linear stages are suitable for operation in high vacuum to  $10^{-6}$  hPa. Furthermore, ultrahigh vacuum variants are available for  $10^{-9}$  hPa. Nonmagnetic versions are available on request.



3-axis setup of Q-545 linear stages.

## Applications

- Fine adjustment of the smallest components during assembly
- Photonics / Alignment Applications
- Microscopy
- Beamline systems
- Semiconductor technology
- Test laboratories

- >> Linear Encoder
- >> Q-Motion® Piezoelectric Inertia Drive
- >> Vacuum-Compatible Versions

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	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	13 mm travel range, resolution 1 nm	26 mm travel range, open loop	26 mm travel range, resolution 1 nm		
Active axis	X	X	X	X		
Travel range	13	13	26	26	mm	
Integrated sensor	–	Linear encoder	–	Linear encoder		
Sensor signal	–	Analog, 1 V <sub>pp</sub>	–	Analog, 1 V <sub>pp</sub>		
Sensor resolution	–	1	–	1	nm	
Minimum incremental motion	500 (open loop)	6	500 (open loop)	6	nm	typ.
Unidirectional repeatability	–	0.018	–	0.018	µm	
Bidirectional repeatability	–	±0.018	–	±0.018	µm	
Rotational crosstalk	±50	±50	±80	±80	µrad	
Linear crosstalk	±1	±1	±2	±2	µm	
Maximum velocity, open loop	10	10	10	10	mm/s	min.
Maximum speed, closed loop	–	10	–	10	mm/s	
Reference point switch	–	Optical	–	Optical		
<b>Mechanical properties</b>						
Load capacity	10	10	10	10	N	
Axial stiffness	1.5	1.5	1.5	1.5	N/µm	±10 %
Lateral stiffness	9	9	10	10	N/µm	±10 %
Holding force, power off	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 50	0 to 50	0 to 50	0 to 50	°C	
Material	Aluminum	Aluminum	Aluminum	Aluminum		
Mass, including cabling	216 / 210	216 / 210	245 / 240	245 / 240	g	
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		
Connector	Sub-D 15	Sub-D 15	Sub-D 15	Sub-D 15		
Recommended controller / driver	E-872	E-871, E-873	E-872	E-871, E-873		

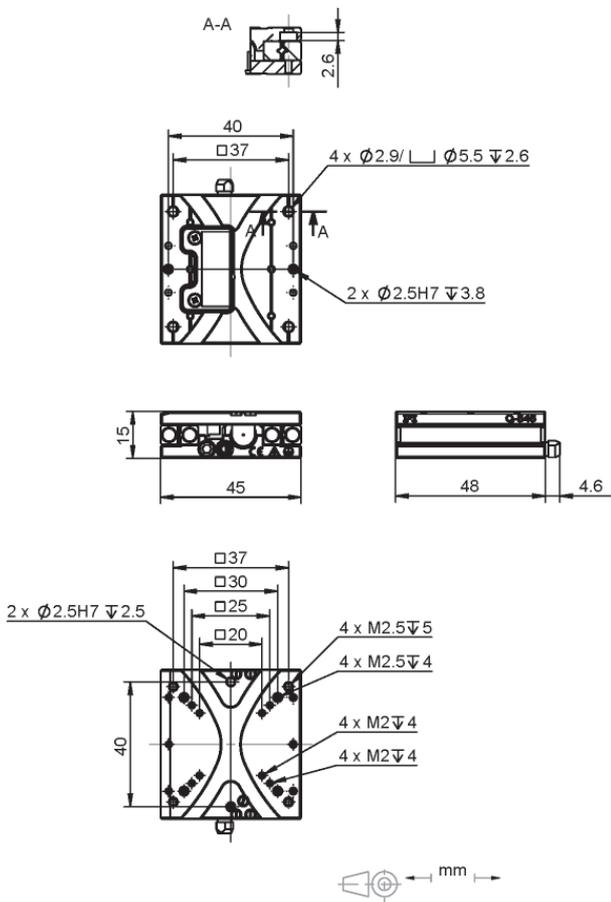
Vacuum versions to 10<sup>-6</sup> hPa are available under the following ordering number: Q-545.xx0.

Vacuum versions to 10<sup>-9</sup> hPa available as Q-545.xxU.

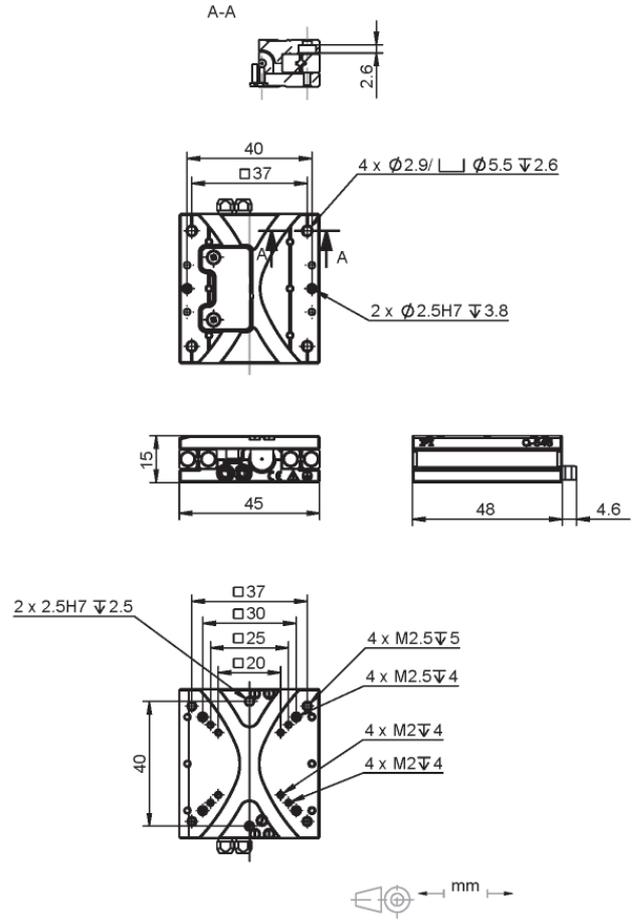
For operation in a vacuum, we recommend a reduced duty cycle of 20 % and a maximum motor push / pull force of 30 % compared to a standard environment. The intrinsic mass of the slider plate must be considered accordingly.

Ask about custom designs!

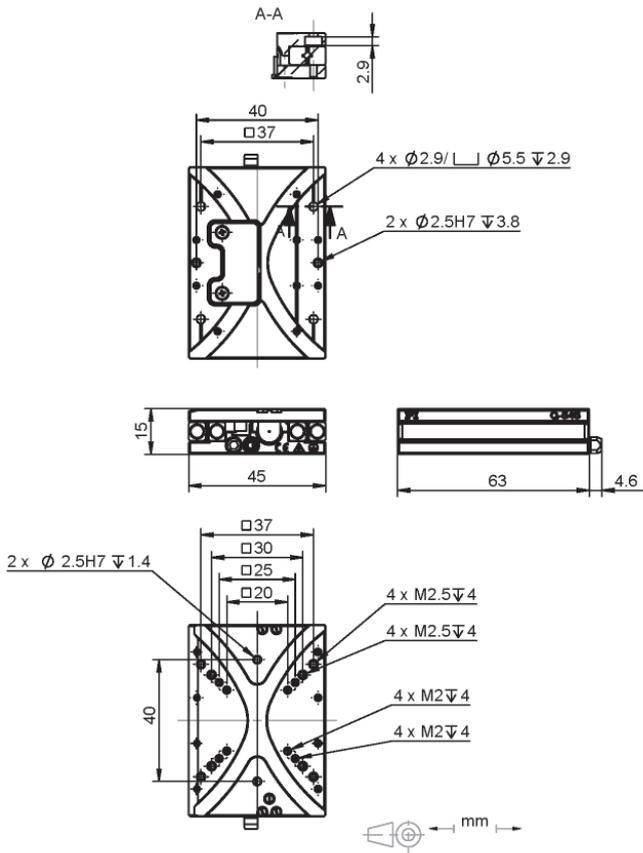
Q-545,100, dimensions in mm



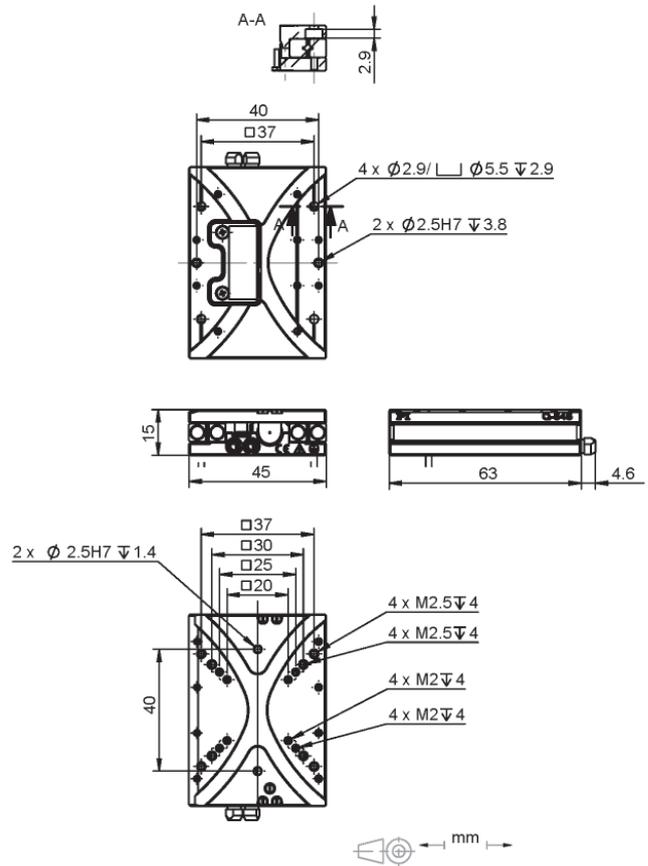
Q-545,140, dimensions in mm



Q-545,200, dimensions in mm



Q-545,240, dimensions in mm





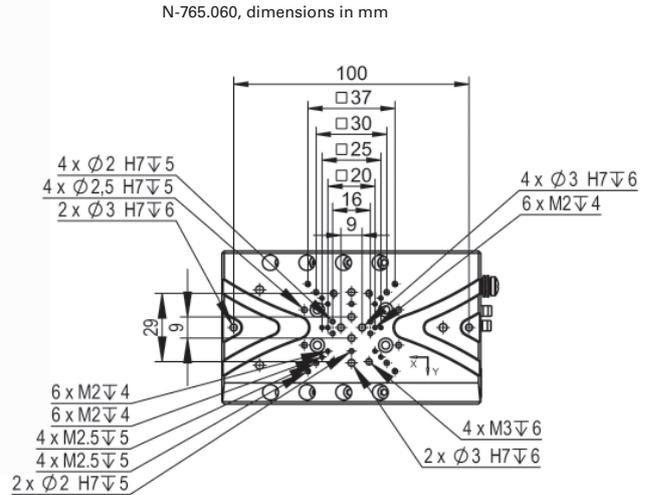
	N-565.160	N-565.260	N-565.360	Unit	Tolerance
<b>Motion</b>					
Active axes	X	X	X		
Travel range	13	26	52	mm	
Velocity, closed loop	10	10	10	mm/s	max.
System resolution	0.5	0.5	0.5	nm	
Bidirectional repeatability	12	12	12	nm	typ.
Unidirectional repeatability	±5	±5	±5	nm	typ.
Straightness / flatness	±1	±1	±1.5	µm	typ.
Pitch	±30	±40	±80	µrad	typ.
Yaw	±30	±30	±30	µrad	typ.
<b>Mechanical properties</b>					
Load capacity in z	20	20	20	N	max.
Overall mass	0.3	0.4	0.6	kg	±5 %

	N-565	Unit	Tolerance
<b>Drive properties</b>			
Drive type	NEXACT® piezo walking drive		
Push / pull force	10	N	max.
Holding force (passive)	10	N	min.

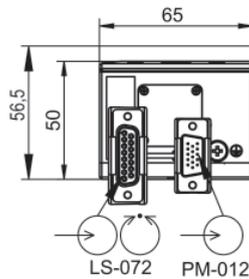
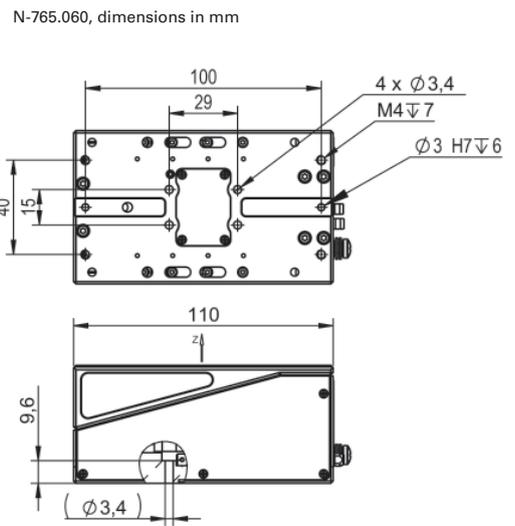
	N-565.x60	Unit	Tolerance
<b>Positioning</b>			
Integrated sensor	PIOne incremental linear encoder		
Measuring principle	Optical		
Measuring method	Direct measuring		
Sensor resolution	0.5	nm	
Minimum incremental motion	2	nm	typ.
Unidirectional repeatability	±5	nm	typ.
Bidirectional repeatability	12	nm	typ.
Reference point switch	Optical		
<b>Miscellaneous</b>			
Operating temperature range	10 to 50	°C	
Operating voltage	-10 to 45	V	
Material	Aluminum, black anodized		
Motor connection	HD Sub-D 15 (m)		
Sensor connection	Sub-D 15 (f)		
Recommended controllers	E-861.1A1, E-712		

# N-765 Precision Z Stage

NEXACT® Piezo Walking Drive with Subnanometer Encoder Resolution



- Direct measurement with PIONe incremental encoder, 0.5 nm resolution
- Min. incremental motion 1 nm
- Travel range 6.5 mm
- Load capacity to 25 N
- Can be mounted directly on an N-565 linear positioner
- Crossed-roller guides, anti-creep



## Applications

- Optical alignment
- Mirror adjustment
- Autofocus

- >> PIONe Linear Encoder
- >> NEXACT® Piezo walking drive

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	N-765.060	Unit	Tolerance
<b>Motion and positioning</b>			
Active axes	Z		
Travel range	6.5	mm	
System resolution	0.5	nm	
Integrated sensor	PIOne linear encoder: Incremental, optical, direct measuring		
Sensor resolution	0.5	nm	
Minimum incremental motion	1	nm	typ.
Velocity, closed loop	2.5	mm/s	max.
Unidirectional repeatability	6	nm	typ.
Bidirectional repeatability	7	nm	typ.
Linear crosstalk on X with motion on Z	1.8	µm	typ.
Linear crosstalk on Y with motion on Z	2	µm	typ.
Rotational crosstalk on $\theta_x$ with motion in Z	25	µrad	typ.
Rotational crosstalk on $\theta_y$ with motion on Z	41	µrad	typ.
Rotational crosstalk on $\theta_z$ with motion on Z	34	µrad	typ.
<b>Mechanical properties</b>			
Load capacity	25	N	max.
<b>Drive properties</b>			
Motor type	NEXACT® piezo walking drive		
Drive force	20	N	max.
Holding force (passive)	25	N	max.
Operating voltage	-10 to 45	V	
<b>Miscellaneous</b>			
Operating temperature range	10 to 50 °C		
Mass	920	g	±5 %
Material	Aluminum, black anodized		
Cable length	3	m	±10 mm
Connection	HD Sub-D 15 (m)		
Sensor connection	Sub-D 15 (f)		
Recommended controllers	E-861.1A1, E-712		

Ask about custom designs!

# XY Stages and Microscopy Solutions



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<b>High-Efficiency PLine® XY Stages</b> .....	<b>52</b>
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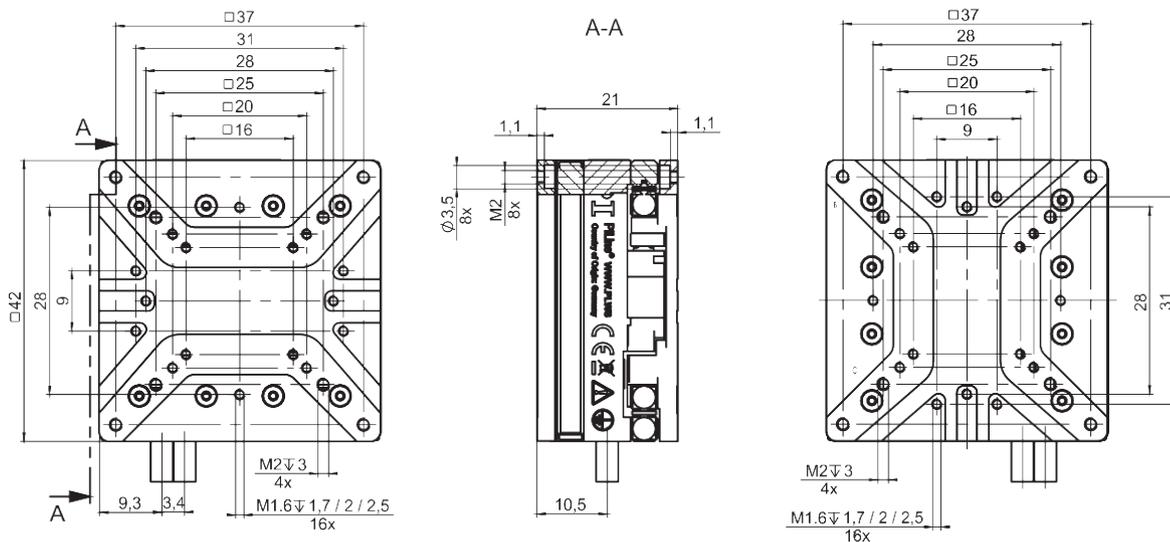
# U-723 PLine® XY Stage

Compact XY Stage with Ultrasonic Piezo Motors



- Fast positioning in 2 axes
- Space-saving and light
- High guiding accuracy
- High sensor resolution of 10 nm
- Self-locking, no heat generation at rest
- Low-noise operation

U-723, dimensions in mm



## Applications

- Micro manipulators
- Sample positioning
- Fieldscan imaging

- >> Incremental Encoder
- >> Linear Encoder
- >> PLine® Ultrasonic Piezomotors
- >> Vacuum-Compatible Versions

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	U-723.25	Unit	Tolerance
<b>Motion</b>			
Active axes	x, y		
Travel range	22 mm × 22 mm		
Velocity	200	mm/s	max.
<b>Mechanical properties</b>			
Load capacity in z	5	N	max.
Mass without cable	110	g	
Linear guide	Crossed roller bearing with anti-creep system		
<b>Drive properties</b>			
Drive type	PILine® ultrasonic piezo motor, performance class 1		
Nominal force	2	N	typ.
Holding force	2	N	typ.
<b>Positioning</b>			
Integrated sensor	Optical, incremental sensor		
Sensor resolution	10	nm	
Minimum incremental motion	0.1	µm	typ.
Reference point switch	Direction-sensing optical reference point switch		
<b>Miscellaneous</b>			
Operating temperature range	0 to 40	°C	
Humidity	20 – 90 % rel., not condensing		
Material	Aluminum, anodized		
Motor / sensor connection	2 × Sub-D 15 (m)		
Cable length	2 × 1.5 m		

Ask about custom designs!

Technical data specified at room temperature (22±3 °C) with C-8672U2.

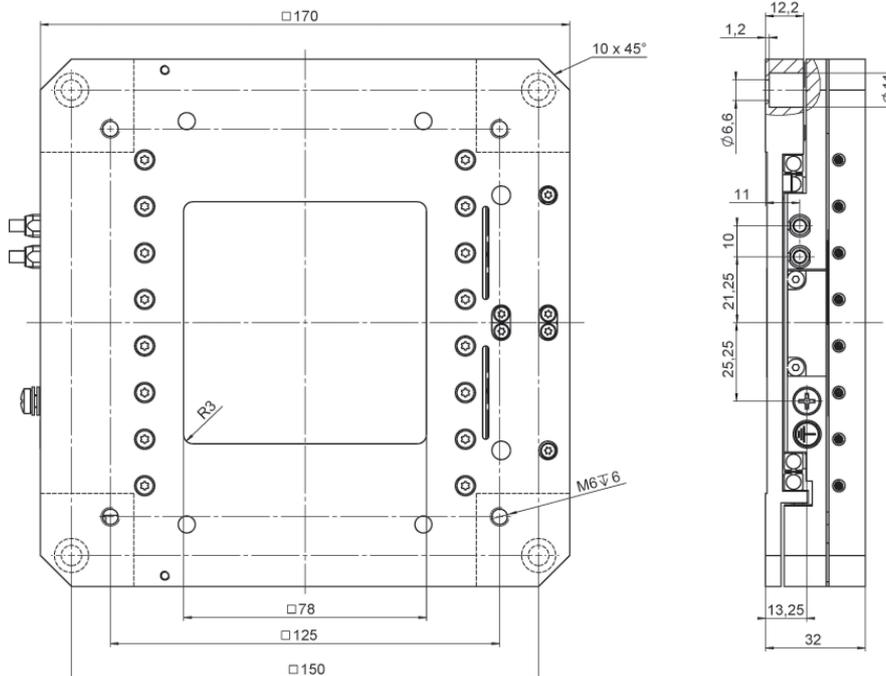
# U-751 XY Stage with Piezomotors

## Low-Profile and Fast, Direct Position Measurement

- Compact design: Only 32 mm in height, no lead screw ducts or flanged motors
- Direct-measuring linear encoder with 100 nm resolution
- Self-locking, no heat generation at rest, no servo jitter
- Clear aperture 78 mm × 78 mm (at maximum displacement 65 mm × 65 mm)
- Noncontact limit and reference point switches



U-751.24, dimensions in mm. Clear aperture 78 mm × 78 mm (at maximum displacement 65 mm × 65 mm).



### Applications

- Micro manipulators
- Sample positioning
- Fieldscan imaging

- >> Incremental Encoder
- >> Linear Encoder
- >> PLine® Ultrasonic Piezomotors
- >> Vacuum-Compatible Versions

Technology Glossary ..... page 148

	U-751.24	Unit	Tolerance
<b>Motion</b>			
Active axes	x, y		
Travel range	25 mm × 25 mm		
Pitch	±50	μrad	typ.
Yaw	±50	μrad	typ.
Velocity, closed loop	100	mm/s	max.
<b>Mechanical properties</b>			
Load capacity <sup>(1)</sup>	50	N	max.
Holding force (passive)	6	N	max.
<b>Drive properties</b>			
Motor type	PILine <sup>®</sup> ultrasonic piezo motor, performance class 2		
Drive force	7	N	max.
<b>Positioning</b>			
Sensor type	Incremental, optical, direct measuring		
Sensor resolution	0.1	μm	typ.
Minimum incremental motion	0.3	μm	typ.
Bidirectional repeatability	±0.3	μm	
Reference point switch	Optical		
Limit switches	Hall effect		
<b>Miscellaneous</b>			
Operating temperature range	-20 to 50	°C	
Material	Al (black anodized)		
Mass	1.8	kg	±5 %
Motor / sensor connection	2 × Sub-D 15 (m)		
Cable length	1.5	m	±10 mm

(1) At max. velocity 10 N.  
Ask about custom designs!

# Microscopy Solutions



Piezo stages are ideal for moving the objective (PIFOC, top) and / or the sample (XYZ sample scanning, middle). The small-stroke piezo stages can be supplemented by low-profile PI Line® Scanning Stages for large travel ranges (bottom)

## Positioning Tasks in Microscopy

Modern microscopic techniques have some similar basic requirements in regard to the positioning elements: compact design and very high accuracy which refers to precision positioning, high repeatability and short settling time. For example, Z-stacks of samples are realized by many individual images in as short a time as possible to avoid damage of the biological cells. Next to that, the observation of dynamic processes is an important application scenario as well – both tasks place great demands on the dynamics of the stage itself.

### Sample or Objective?

Fast focusing in the direction of the optical axis can be done by moving the objective, for example. PIFOC systems with their easily exchangeable PI QuickLock thread inserts, and large apertures, offer up to 2000  $\mu\text{m}$  of travel for the objective or turret. Z stack acquisition, autofocus / focus tracking or drift compensation are typical use cases.

Sample fine positioning can be enhanced by offering additional motion in XY for high-dynamic tracking, e.g. to examine motion of individual molecules. Plnano® tracking stages offer XYZ motion in one compact package.

## Long Range PI Line® XY Scanning Stages

Automated tasks require positioning over larger ranges of approx. 130 mm  $\times$  80 mm with high speed and precision. PI Line® stages are characterized by a low profile, an extremely large dynamic range (10  $\mu\text{m/s}$  to 100 mm/s) and very good velocity constancy, position stability and repeatability. These stages are also very well suited for super resolution microscopy applications such as STORM, PALM, STED or SIM, which place very high demands on the stability.

### System Packages?

Preconfigured packages that include the appropriate controller and software are available for the major product lines. PI controllers come with high resolution digital interfaces (USB, Ethernet, RS-232), high-speed analog interfaces, as well as solid software support for all major image acquisition packages.

## Compatibility of Piezo Scanners with Manual, Motorized and PLine® XY Microscope Stages

	P-545.xR8S P-545.xC8S P-545.3D8S Piano® piezo system	P-736.ZCN2S P-736.ZRN2S Piano® Z piezo scanner system	PD73Z2COW PD73Z2ROW Piano® Z piezo scanner system	P-736.ZR1S P-736.ZR2S Piano® Z piezo slide scanner system	P-733.2xx P-733.3xx Piezo nanopositioning stage	P-541.2xx / P-541.Txx P-541.Zxx / P-542.2xx Piezo nanopositioning stage	P-737.xxx Pifoc specimen-focusing Z stage
<b>U-780.DNS</b> PLine® XY stage system for Nikon microscopes	•	•				•	•
<b>U-780.DOS</b> PLine® XY stage system for Olympus microscopes	•		•			•	•
<b>U-780.DLS</b> PLine® XY stage system for Leica microscopes	•					•	•
<b>U-760.DNOS</b> PLine® XY stage system for Nikon / Olympus microscopes	•			•*	•**	•	
<b>M-545.2MN</b> XY stage for Nikon microscopes TI series	•			•*	•**	•	
<b>M-545.2MO</b> XY stage for Olympus microscopes IX2, IX3	•			•*	•**	•	
<b>M-545.2ML</b> XY stage for Leica microscopes DMI series	•			•*	•**	•	
<b>M-545.2MZ</b> XY stage for Zeiss microscopes Axio Observer	•			•*	•**	•	

\* With P-736.AP1 adapter plate / \*\* With P-733.AP1 adapter plate

## Inserts for PI Sample Stages

	P-545.xR8S P-545.xC8S P-545.3D8S	P-736.ZCN2S P-736.ZRN2S	PD73Z2COW PD73Z2ROW	P-736.ZR1S P-736.ZR2S	P-541.2xx P-541.Txx P-541.Zxx P-542.2xx	P-737.xxx	U-780.DNS	U-780.DOS	U-780.DLS	U-760.DNOS	M-545.2MIN M-545.2MO M-545.2ML M-545.2MZ
Microscope slide holder	P-545.SH3*	P-736.SHN*	P-736.SHO*	P-545.SH3*		P-737.AP1*	P-736.SHN* P-736.SHO*	P-736.SHN* P-736.SHO*	P-736.SHN* P-736.SHO*	P-545.SH3* with M-545.SHP	P-545.SH3* with M-545.SHP
Petri dish holder	P-545.PD3	P-736.PDN	P-736.PDO	P-545.PD3	P-542.PD1	P-737.AP2	P-736.PDN P-736.PDO	P-736.PDN P-736.PDO	P-736.PDN P-736.PDO	P-545.PD3 with M-545.SHP adapter plate	P-545.PD3 with M-545.SHP adapter plate
Microtiter plate holder		P-736.WPN	P-736.WPO		P-542.SH1*		P-736.WPN P-736.WPO	P-736.WPN P-736.WPO	P-736.WPN P-736.WPO		
Universal holder		P-736.UHN*	M-687.AP1*				P-736.UHN* M-687.AP1*	P-736.UHN* M-687.AP1*	P-736.UHN* M-687.AP1*		
Universal holding plate	P-545.PP3			P-545.PP3						P-545.PP3 with M-545.SHP	P-545.PP3 with M-545.SHP

M-545.SHP adapter plate

\* Also available: P-545.C18 Coverslip holder (for 18 mm x 18 mm coverslips), P-545.C22 (for 22 mm x 22 mm coverslips) and P-545.C25 (for 25 mm x 25 mm coverslips)

# U-780 PLine® XY Stage System with Controller and Joystick

Stable, Dynamic, Low Profile



- High velocity constancy at 10  $\mu\text{m/s}$
- Velocity to 120 mm/s, resolution 0.1  $\mu\text{m}$
- Travel ranges to 135 mm  $\times$  85 mm (depending on model type)
- For inverted microscopes, freely revolving nosepiece
- Compact, low-profile design: Unrestricted access to the sample
- Extensive accessories: Z sample scanners, microscope slide holder and holder for Petri dishes and microtiter plates

## Reference-class microscope XY stage

System with controller and joystick. Large clear aperture 160 mm  $\times$  110 mm. Suitable for the following inverted microscopes:

- Nikon Eclipse Ti-E/Ti-U/Ti-S
- Olympus IX2
- Leica DMI

## High-resolution PLine® piezo linear drive

Self-locking at rest. Low noise. Highest stability due to low thermal load and no lubricants. Large dynamics range of 10  $\mu\text{m/s}$  to 120 mm/s, ideal for operating with joystick and automated high-content processes.

## Highly accurate position measuring with incremental linear encoder

Noncontact optical encoders measure the actual position directly at the motion platforms with the greatest accuracy so that nonlinearity, mechanical play or elastic deformation have no influence on position measuring.

## User software

PIMikroMove. PI General Command Set (GCS). Drivers for NI LabVIEW. Compatible with  $\mu$ Manager, MetaMorph, Andor iQ, MATLAB.

### Applications

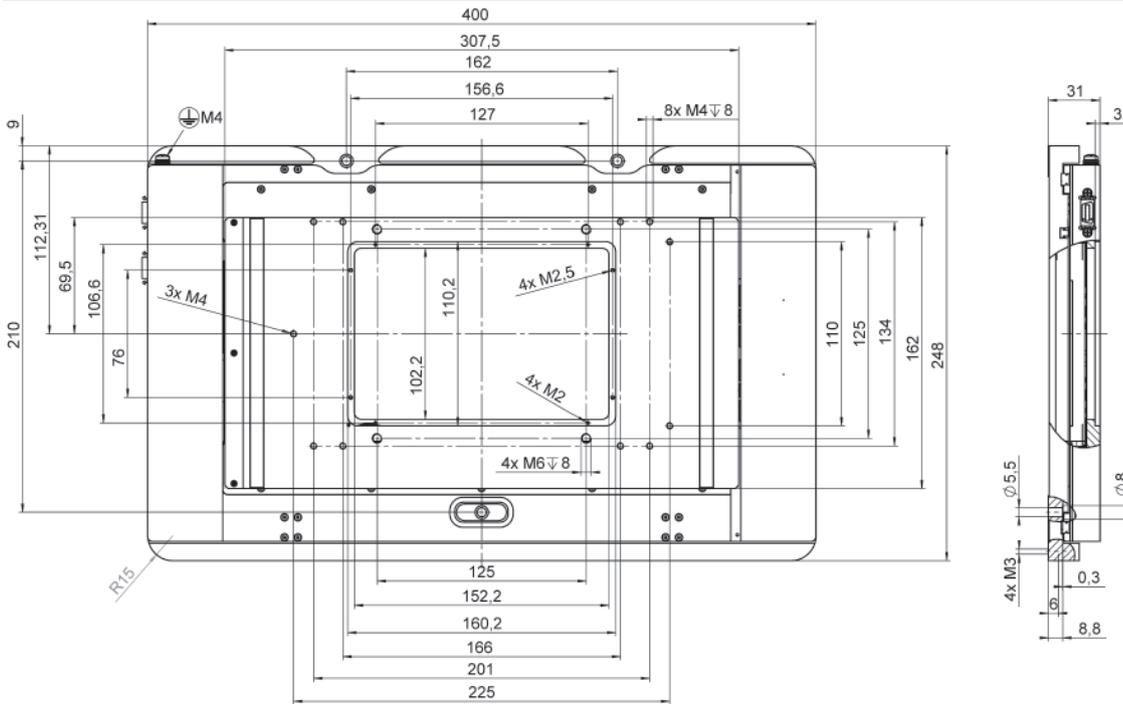
- Scanning microscopy
- Metrology
- Sample positioning
- Biotechnology

- >> Extensive Software Package
- >> Incremental Encoder
- >> Linear Encoder
- >> PLine® Ultrasonic Piezomotors

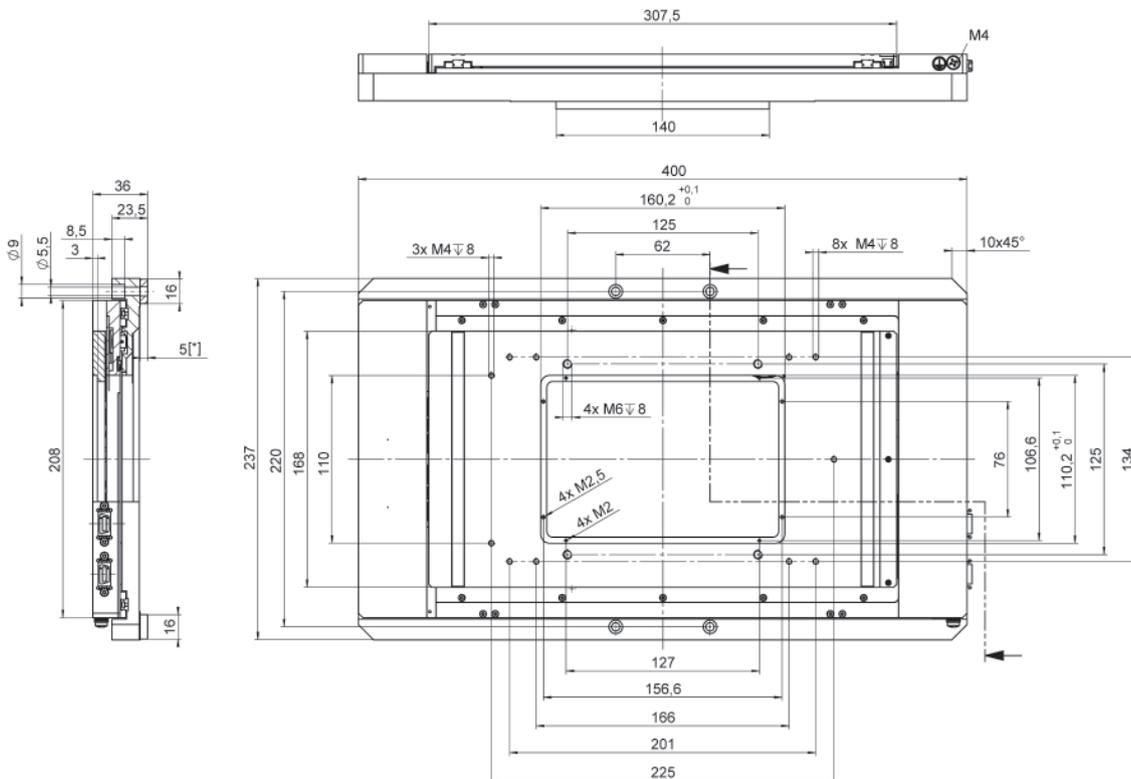
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	U-780.DNS	U-780.DOS	U-780.DLS	Unit	Tolerance
<b>Motion and positioning</b>					
	System with M-687UN for Nikon microscopes	System with M-687.UO for Olympus microscopes	System with M-687.UL for Leica microscopes		
Active axes	X, Y	X, Y	X, Y		
Travel range	135 mm × 85 mm	100 mm × 75 mm	135 mm × 85 mm		
Integrated sensor	Linear encoder	Linear encoder	Linear encoder		
Sensor resolution	0.1	0.1	0.1	µm	
Bidirectional repeatability	±0.3	±0.3	±0.3	µm	
Pitch / yaw	±300	±300	±300	µrad	typ.
Velocity	120	120	120	mm/s	max.
Reference point switch	Optical, 1 µm repeatability	Optical, 1 µm repeatability	Optical, 1 µm repeatability		
Limit switches	Hall effect	Hall effect	Hall effect		
<b>Mechanical properties</b>					
Load capacity	25	25	25	N	max.
<b>Drive properties</b>					
Motor type	PILine® ultrasonic piezo motor, performance class 2	PILine® ultrasonic piezo motor, performance class 2	PILine® ultrasonic piezo motor, performance class 2	N	max.
<b>Miscellaneous</b>					
Operating temperature range	20 to 40	20 to 40	20 to 40	°C	
Material	Al (black anodized)	Al (black anodized)	Al (black anodized)		
Mass of the stage	4.2	3.2	4.2	kg	±5 %
<b>Piezo motor controller</b>					
Interface / communication	USB, RS-232, SPI, Ethernet	USB, RS-232, SPI, Ethernet	USB, RS-232, SPI, Ethernet		
I/O lines	4 analog / digital inputs 4 digital outputs to mini DIN, 9-pin Digital: TTL Analog: 0 to 5 V	4 analog / digital inputs 4 digital outputs to mini DIN, 9-pin Digital: TTL Analog: 0 to 5 V	4 analog / digital inputs 4 digital outputs to mini DIN, 9-pin Digital: TTL Analog: 0 to 5 V		
Command set	PI General Command Set (GCS)	PI General Command Set (GCS)	PI General Command Set (GCS)		
User software	PIMikroMove	PIMikroMove	PIMikroMove		
Software drivers	GCS DLL (with code examples for the most common programming languages such as C++, C#, VB.NET, Python, Delphi), driver for NI LabVIEW, MATLAB library	GCS DLL (with code examples for the most common programming languages such as C++, C#, VB.NET, Python, Delphi), driver for NI LabVIEW, MATLAB library	GCS DLL (with code examples for the most common programming languages such as C++, C#, VB.NET, Python, Delphi), driver for NI LabVIEW, MATLAB library		
Supported functions	Startup macro, macro, data recorder for recording operating data such as motor voltage, velocity, position or position error	Startup macro, macro, data recorder for recording operating data such as motor voltage, velocity, position or position error	Startup macro, macro, data recorder for recording operating data such as motor voltage, velocity, position or position error		
Controller dimensions	312 mm × 153.4 mm × 59.3 mm (incl. mounting rails)	312 mm × 153.4 mm × 59.3 mm (incl. mounting rails)	312 mm × 153.4 mm × 59.3 mm (incl. mounting rails)		

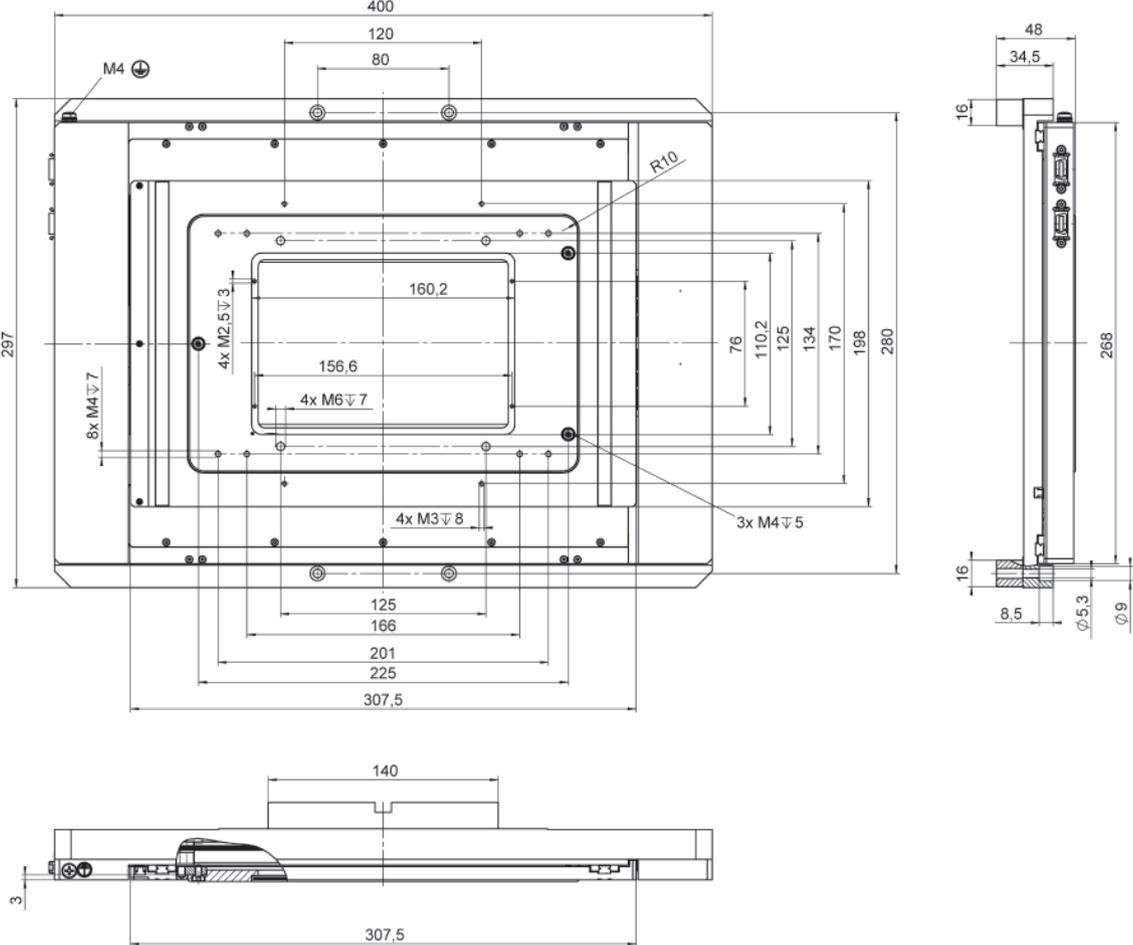
M-687.UL for Leica microscopes, dimensions in mm



M-687.UO for Olympus microscopes, dimensions in mm



M-687.UN for Nikon microscopes, dimensions in mm



# Rotation Stages



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<b>PILine® Rotation Stages with High Dynamical Bandwidth</b> .....	<b>64</b>
U-624 PILine® Rotation Stage .....	<b>64</b>
U-628 PILine® Rotation Stage .....	<b>66</b>
U-651 Rotation Stage with Low-Profile Design .....	<b>68</b>

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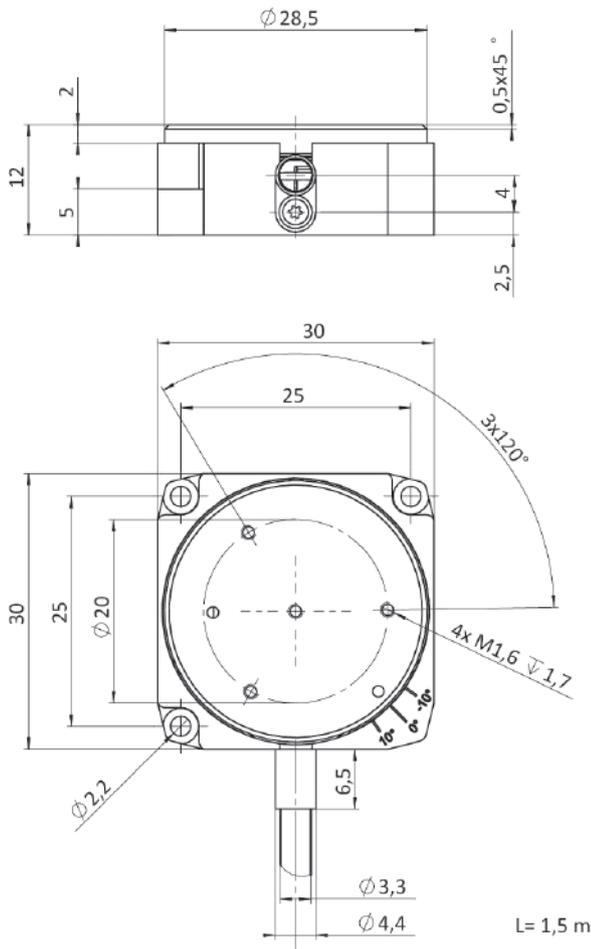
<b>Q-Motion® Stages, UHV-Compatible and Most Compact</b> .....	<b>70</b>
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# U-624 PLine® Rotation Stage

## Miniature Stage with Ultrasonic Piezo Motor

U-624, dimensions in mm



- Extremely space-saving: Edge length only 30 mm, height 12 mm
- Positions small loads quickly and with precision: Velocity to 720 %/s, minimum incremental motion to 105  $\mu$ rad
- Unlimited rotation range >360°
- Drive torque 10 mNm
- Self-locking when switched off: Saves energy and reduces generation of heat
- Light and low noise

### Applications

- Optical filter alignment
- Angular corrections
- Micro manipulators

- >> Incremental Encoder
- >> PLine® Ultrasonic Piezomotors

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	U-624.03	Unit	Tolerance
<b>Motion</b>			
Active axes	$\theta_z$		
Rotation range	>360	°	
Velocity, closed loop	720	°/s	max.
Minimum incremental motion	105	$\mu\text{rad}$	typ.
Bidirectional repeatability	$\pm 210$	$\mu\text{rad}$	
<b>Positioning</b>			
Sensor			
Sensor type	Incremental encoder		
Sensor resolution	35	$\mu\text{rad}$	
<b>Mechanical properties</b>			
Load capacity / axial force	1	N	max.
Holding force	0.01	Nm	max.
<b>Drive properties</b>			
Motor type	PILine® ultrasonic piezo motor, performance class 1		
Drive torque clockwise / counterclockwise ( $\theta_z$ )	0.01	Nm	max.
<b>Connectors</b>			
Motor / sensor	1 × Sub-D 15 (m)		
<b>Miscellaneous</b>			
Reference point switch	Optical		
Operating temperature	0 to 40	°C	
Material	Anodized aluminum		
Mass	130	g	$\pm 5\%$
Cable length	1.5	m	typ.

All specifications based on room temperature (22 °C  $\pm$  3 °C).  
Ask about custom designs!

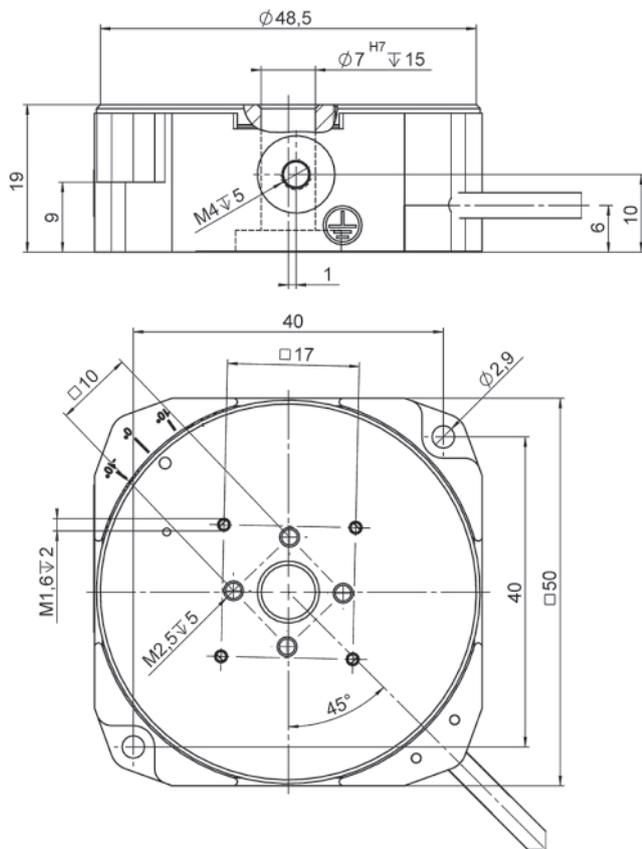


Multi-axis setup consisting of two U-521 linear stages and a U-624 rotation stage, without adapter plate

# U-628 PLine® Rotation Stage

Miniature Stage with Ultrasonic Piezo Motor and Central Opening

U-628, dimensions in mm



- Compact: Edge length 50 mm, height 19 mm
- Positions loads quickly and with precision: Velocity to 720 °/s, minimum incremental motion to 51 μrad
- Unlimited rotation range >360°
- Drive torque 25 mNm
- Self-locking when switched off: Saves energy and reduces generation of heat
- Central aperture for more fields of application

## Applications

- Optical filter alignment
- Angular corrections
- Micro manipulators

- >> Incremental Encoder
- >> PLine® Ultrasonic Piezomotors
- >> Vacuum-Compatible Versions

Technology Glossary ..... page 148

	U-628.03	Unit	Tolerance
<b>Motion</b>			
Active axes	$\theta_z$		
Rotation range	>360	°	
Velocity, closed loop	720	°/s	max.
Minimum incremental motion	51	$\mu\text{rad}$	typ.
Bidirectional repeatability	$\pm 102$	$\mu\text{rad}$	
<b>Positioning</b>			
Sensor type	Incremental encoder		
Sensor resolution	17	$\mu\text{rad}$	
<b>Mechanical properties</b>			
Load capacity / axial force	5	N	max.
Holding force	0.03	Nm	max.
<b>Drive properties</b>			
Motor type	PILine® ultrasonic piezo motor, performance class 1		
Drive torque clockwise / counterclockwise ( $\theta_z$ )	0.025	Nm	max.
<b>Connectors</b>			
Motor / sensor	1 × Sub-D 15 (m)		
<b>Miscellaneous</b>			
Reference point switch	Optical		
Operating temperature	0 to 40	°C	
Material	Anodized aluminum		
Mass	300	g	$\pm 5\%$
Cable length	1.5	m	typ.

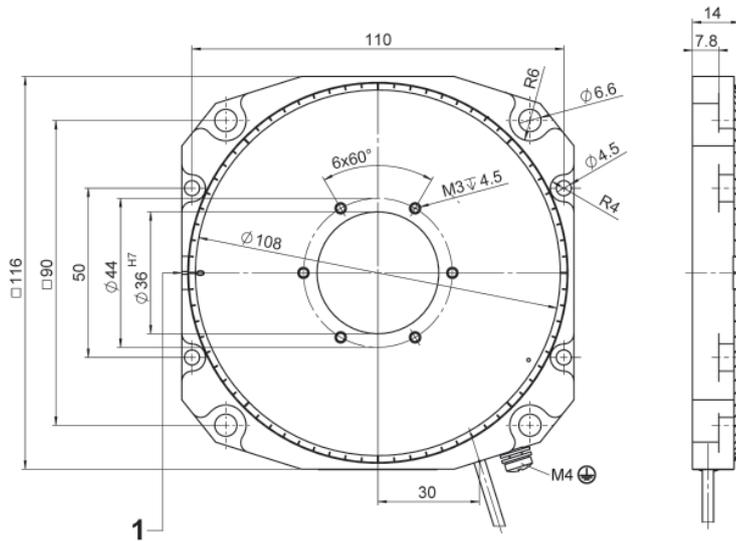
All specifications based on room temperature (22 °C  $\pm$  3 °C).  
 Vacuum versions to 10<sup>-6</sup> hPa available on request. Specifications for vacuum versions can differ.  
 Ask about custom designs!

# U-651 Rotation Stage with Low-Profile Design

Fast PLine® Direct Drive and Central Opening



U-651: Dimensions and position of the 0° mark [1] after the reference point definition. Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.



- Low profile of only 14 mm
- Positions larger loads quickly and with precision
- Unlimited rotation range >360°
- Drive torque to 0.3 Nm in both directions of rotation
- Self-locking when switched off: Saves energy and reduces generation of heat
- Central aperture for more fields of application
- Crossed-roller guides, anti-creep

## Applications

- Optical filter alignment
- Angular corrections
- Micro manipulators

- >> Incremental Encoder
- >> PLine® Ultrasonic Piezomotors
- >> Vacuum-Compatible Versions

Technology Glossary ..... page 148

	U-651.03 / U-651.03V	U-651.04 / U-651.04V	Unit	Tolerance
<b>Motion</b>				
Active axes	$\theta_z$	$\theta_z$		
Rotation range	>360	>360	°	
Velocity, closed loop	540	540	°/s	max.
Minimum incremental motion	27	12	$\mu$ rad	typ.
Bidirectional repeatability	$\pm 54$	$\pm 24$	$\mu$ rad	
Sensor type	Incremental encoder	Incremental encoder		
Sensor resolution	9	4	$\mu$ rad	
<b>Mechanical properties</b>				
Load capacity / axial force	20	20	N	max.
Holding force	0.3	0.3	Nm	max.
<b>Drive properties</b>				
Motor type	PILine® ultrasonic piezo motor, performance class 2	PILine® ultrasonic piezo motor, performance class 2		
Drive torque clockwise / counterclockwise ( $\theta_z$ )	0.3	0.3	Nm	max.
<b>Connectors</b>				
Motor / sensor	1 × Sub-D 15 (m)	1 × Sub-D 15 (m)		
<b>Miscellaneous</b>				
Reference point switch	Optical	Optical		
Operating temperature	0 to 40	0 to 40	°C	
Material	Anodized aluminum	Anodized aluminum		
Mass	500	500	g	$\pm 5$ %
Cable length	1.5 (model .03) 1.0 (model .03V)	1.5 (model .04) 1.0 (model .04V)	m	$\pm 10$ %

All specifications based on room temperature (22 °C  $\pm$ 3 °C).

Vacuum versions to 10<sup>-6</sup> hPa available on request. Specifications for vacuum versions can differ.

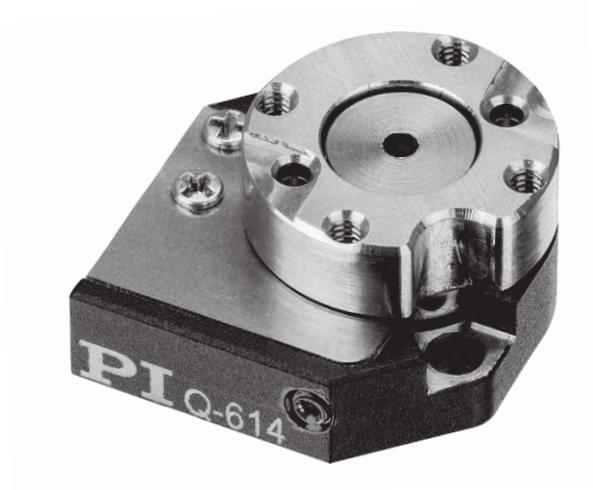
Ask about custom designs!

The U-651 series replaces the M-660 series.

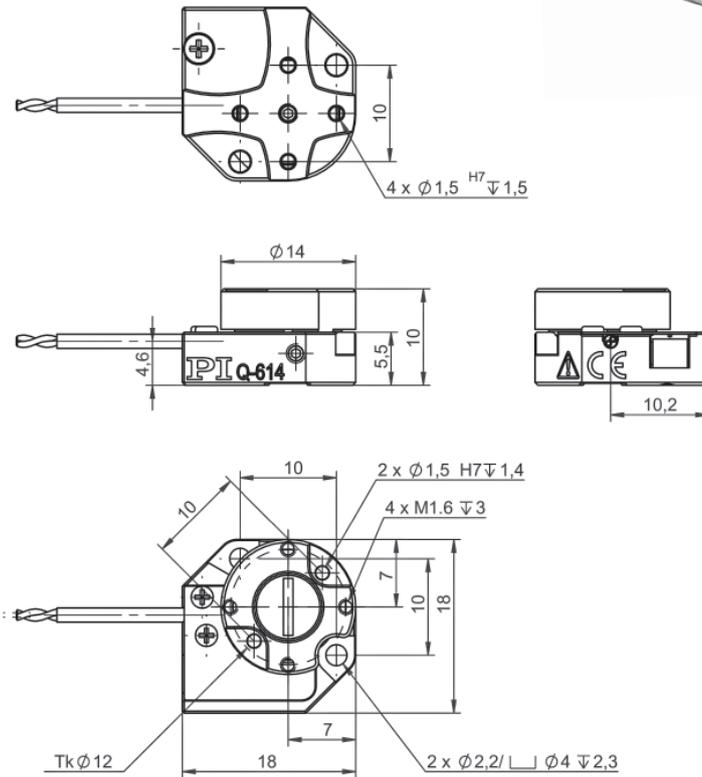
# Q-614 Q-Motion® Miniature Rotation Stage

Minimum Dimensions: 14 mm Turntable Diameter

- Only 18 mm in width and 10 mm in height
- Rotation range >360°
- Velocity 70 °/s
- Drive torque 5 mN·m
- Suitable for vacuum to 10<sup>-6</sup> hPa, versions to 10<sup>-9</sup> hPa available



Q-614, dimensions in mm



## Applications

- Fine adjustment of the smallest components during assembly
- Photonics / Alignment Applications
- Microscopy
- Beamline systems
- Semiconductor technology
- Test laboratories

- >> Q-Motion® Piezoelectric Inertia Drive
- >> Vacuum-Compatible Versions

Technology Glossary ..... page 148

	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 <sup>(1)</sup>	1 <sup>(1)</sup>	μrad	
Minimum incremental motion	100 <sup>(1)</sup>	100 <sup>(1)</sup>	μrad	typ.
Maximum velocity, open-loop	70	70	°/s	
<b>Mechanical properties</b>				
Load capacity	1	1	N	
Holding torque, power off	6	6	mN·m	min.
Torque	5	5	mN·m	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, steel	Aluminum, steel		
Mass without cable	9	9	g	
Cable length	1	1	m	
Connector	Sub-D 15 (m)	Sub-D 15 (f)		
Recommended controller	E-872	E-872		

(1) open loop

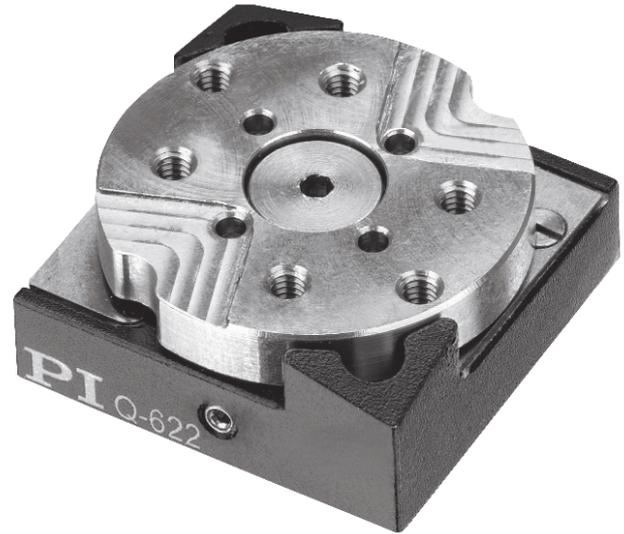
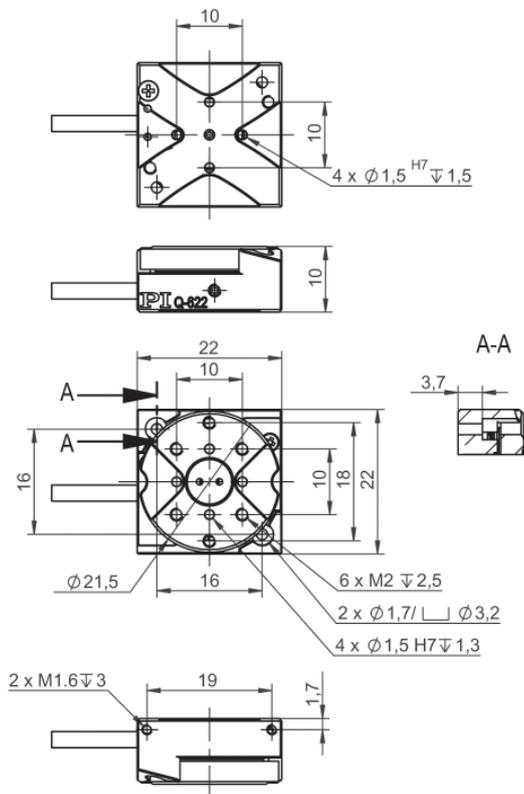
Ask about customized versions!

For operation in a vacuum, we recommend a reduced duty cycle of 20 % and a reduced rotation speed of 50 % compared to a standard environment.

# Q-622 Q-Motion® Miniature Rotation Stage

Minimum Dimensions: 22 mm Turntable Diameter

Q-622, dimensions in mm



- Only 22 mm in width and 10 mm in height
- Direct position measurement with incremental encoder with 0.55  $\mu$ rad resolution
- Up to 2.2  $\mu$ rad minimum incremental motion
- Velocity 70 %/s
- Mountable on the Q-522 linear stage without adapter
- Suitable for vacuum to  $10^{-6}$  hPa, versions to  $10^{-9}$  hPa available

## Applications

- Fine adjustment of the smallest components during assembly
- Photonics / Alignment Applications
- Microscopy
- Beamline systems
- Semiconductor technology
- Test laboratories

- >> Incremental Encoder
- >> Q-Motion® Piezoelectric Inertia Drive
- >> Vacuum-Compatible Versions

Technology Glossary ..... page 148

	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 to 10 <sup>-9</sup> hPa		
Active axis	$\theta_z$	$\theta_z$	$\theta_z$		
Rotation range	>360	>360	>360	°	
Integrated sensor	Incremental encoder	–	–		
Sensor resolution	0.55	–	–	μrad	
Minimum incremental motion	2.2	100 <sup>(1)</sup>	100 <sup>(1)</sup>	μrad	typ.
Unidirectional repeatability	3	–	–		
Maximum velocity, open loop	70	70	70	°/s	
<b>Mechanical properties</b>					
Load capacity	1	1	1	N	
Holding torque, power off	6	6	6	mN·m	min.
Torque	5	5	5	mN·m	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, steel	Aluminum, steel	Aluminum, steel		
Mass without cable	15	12	12	g	
Cable length	1	1	1	m	
Connector	Sub-D 15 (m)	Sub-D 15 (m)	Sub-D 15 (f)		
Recommended controller	E-873	E-872	E-872		

(1) open loop

Ask about customized versions!

For operation in a vacuum, we recommend a reduced duty cycle of 20 % and a reduced rotation speed of 50 % compared to a standard environment.



This 3-axis setup of Q-522 linear and Q-622 rotation stages offers XY and yaw motion on a 22 mm × 22 mm footprint.



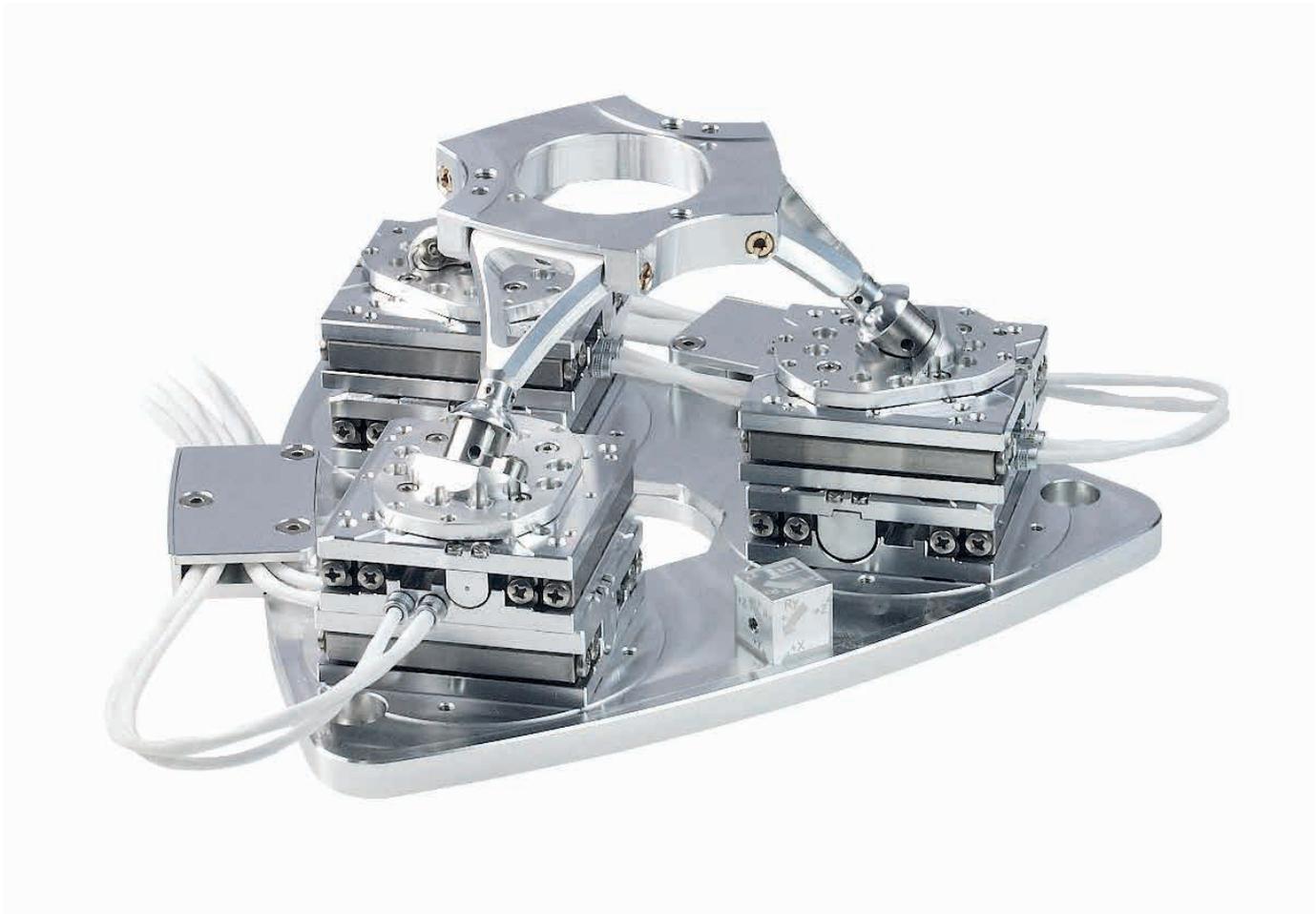
	Q-632.930	Q-632.900	Q-632.90U	Unit	Tolerance
<b>Motion and positioning</b>					
	Rotation stage with position sensor for closed-loop operation	Rotation stage without position sensor	Rotation stage, without position sensor for ultrahigh vacuum to 10 <sup>-9</sup> hPa		
Active axis	θ <sub>z</sub>	θ <sub>z</sub>	θ <sub>z</sub>		
Rotation range	>360	>360	>360	°	
Integrated sensor	Incremental encoder	–	–		
Sensor resolution	0.75	–	–	μrad	
Minimum incremental motion	3	36 <sup>(1)</sup>	36 <sup>(1)</sup>	μrad	typ.
Unidirectional repeatability	6	–	–	μrad	typ.
Maximum velocity, open loop	45	45	45	°/s	
<b>Mechanical properties</b>					
Load capacity	1	1	1	N	
Holding torque, power off	7	7	7	mN·m	min.
Torque	6	6	6	mN·m	typ.
Length	32	32	32	mm	
Width	32	32	32	mm	
Height	8	8	8	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, steel	Aluminum, steel	Aluminum, steel		
Mass without cable	25	21	21	g	
Cable length	1	1	1	m	
Connector	Sub-D	Sub-D	Sub-D		
Recommended controller	E-873	E-872	E-872		

(1) open loop

Ask about customized versions!

For operation in a vacuum, we recommend a reduced duty cycle of 20 % and a reduced rotation speed of 50 % compared to a standard environment.

# Parallel Kinematics / Hexapods



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<b>Parallel-Kinematic Q-Motion® Designs, UHV and Cleanroom Compatible</b> .....	<b>78</b>
Q-845 Q-Motion® SpaceFAB .....	<b>78</b>
Q-821 Q-Motion® Miniature SpaceFAB Robot .....	<b>80</b>

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<b>NEXACT® PiezoWalk® Hexapod for Higher Load Capacity</b> .....	<b>82</b>
N-865 NEXACT® SpaceFAB .....	<b>82</b>

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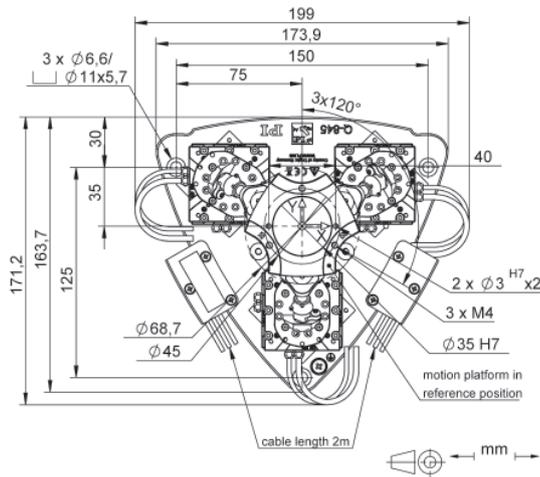
# Q-845 Q-Motion® SpaceFAB

High Precision and High Stiffness

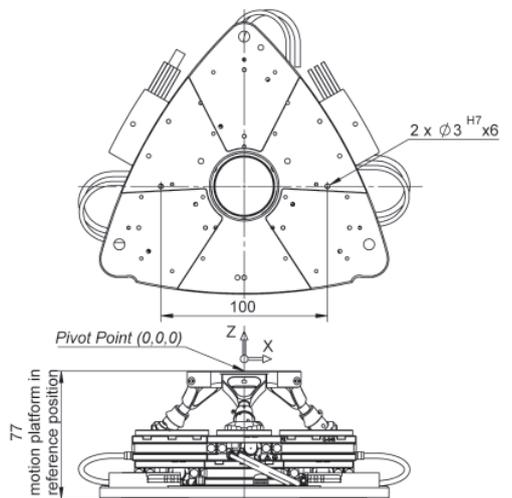


- Six degrees of freedom
- $\pm 7$  mm travel range in X and Y, and  $\pm 5$  mm in Z
- $\pm 7^\circ$  rotation range in  $\theta_x$ ,  $\theta_y$ , and  $\pm 8^\circ$  in  $\theta_z$
- 10 N load capacity, center mounted
- Self-locking, no heat generation at rest
- Crossed roller guides, anti-creep
- Vacuum-compatible to  $10^{-6}$  hPa

Top view of the Q-845.140, dimensions in mm. The reference position corresponds to the center position of all axes



Bottom and side view of the Q-845.140, dimensions in mm. The reference position corresponds to the center position of all axes



## Applications

- Fine adjustment of the smallest components during assembly
- Photonics / Alignment Applications
- Microscopy
- Beamline systems
- Semiconductor technology
- Test laboratories

- >> Parallel Kinematics, Hexapods
- >> Q-Motion® Piezoelectric Inertia Drive
- >> Vacuum-Compatible Versions

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	Q-845.140	Unit	Tolerance
<b>Motion and positioning</b>			
Active axes	X, Y, Z, $\theta_x$ , $\theta_y$ , $\theta_z$		
Integrated sensor	Incremental linear encoder		
Travel range* in X,Y	±7	mm	
Travel range* in Z	±5	mm	
Rotation range* in $\theta_x$ , $\theta_y$	±7	°	
Rotation range* in $\theta_z$	±8	°	
Sensor resolution	1	nm	
Minimum incremental motion in X,Y	6	nm	typ.
Minimum incremental motion in Z	20	nm	typ.
Minimum incremental motion in $\theta_x$ , $\theta_y$ , $\theta_z$	0.9	µrad	typ.
Unidirectional repeatability in X,Y	±30	nm	typ.
Unidirectional repeatability in Z	±35	nm	typ.
Unidirectional repeatability in $\theta_x$	±20	µrad	typ.
Unidirectional repeatability in $\theta_y$	±10	µrad	typ.
Unidirectional repeatability in $\theta_z$	±6	µrad	typ.
Backlash in X, Y	40	nm	typ.
Backlash in Z	60	nm	typ.
Backlash in $\theta_x$ , $\theta_y$	35	µrad	typ.
Backlash in $\theta_z$	20	µrad	typ.
Max. velocity in X, Y, Z	5	mm/s	max.
Max. angular velocity in $\theta_x$ , $\theta_y$ , $\theta_z$	50	mrad/s	max.
<b>Mechanical properties</b>			
Stiffness in X, Y	1	N/µm	
Stiffness in Z	2	N/µm	
Load capacity in X, Y	5	N	max.
Load capacity in Z (base plate horizontal)	10	N	max.
Holding force, power off (base plate horizontal / any orientation)	20 / 10	N	max.
Permissible torque in $\theta_x$ , $\theta_y$ , $\theta_z$	0.5	N·m	max.
Drive type	Piezoelectric Inertia Drive		
<b>Miscellaneous</b>			
Operating temperature range	0 to 40	°C	
Connection	6x Sub-D 15 (m)		
Material	Stainless steel, aluminum		
Mass	1.9	kg	±5 %
Mass without cable and connector	1.2	kg	±5 %
Cable length	2	m	±10 mm

Technical data specified at 20±3 °C.

Ask about custom designs!

\* The travel ranges of the individual coordinates (X, Y, Z,  $\theta_x$ ,  $\theta_y$ ,  $\theta_z$ ) are interdependent.

The data for each axis in this table shows its maximum travel range, where all other axes and the pivot point are at the reference position.

For operation in a vacuum, we recommend a reduced duty cycle of 20 % and a maximum motor push / pull force of 30 % compared to a standard environment. The intrinsic mass of the slider plate must be considered accordingly.

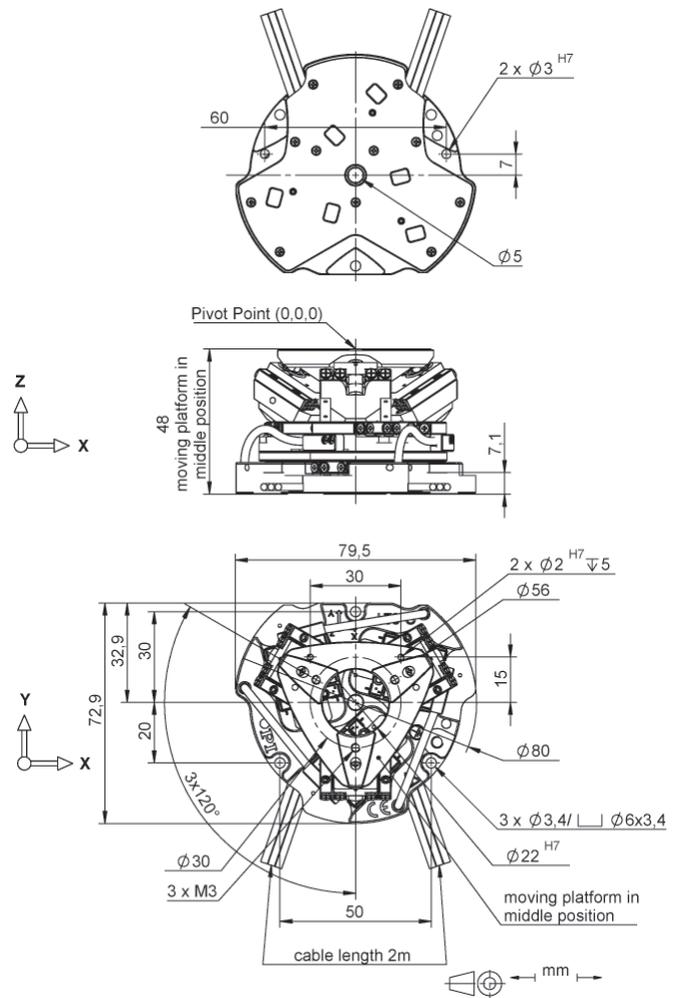
# Q-821 Q-Motion® Miniature SpaceFAB Robot

Piezo-Motorized Inertia Drive, only 80 mm Side Length



- Six-axis microrobotics system
- ±6 mm travel range in X and Y, and ±3 mm in Z
- ±6° rotation range in  $\theta_x$ ,  $\theta_y$ , and ±16.5° in  $\theta_z$
- 1 nm sensor resolution
- Crossed roller guides, anti-creep

Q-821.140, dimensions in mm



## Applications

- Fine adjustment of the smallest components during assembly
- Photonics / Alignment Applications
- Microscopy
- Beamline systems
- Semiconductor technology
- Test laboratories

- >> Parallel Kinematics, Hexapods
- >> Q-Motion® Piezoelectric Inertia Drive

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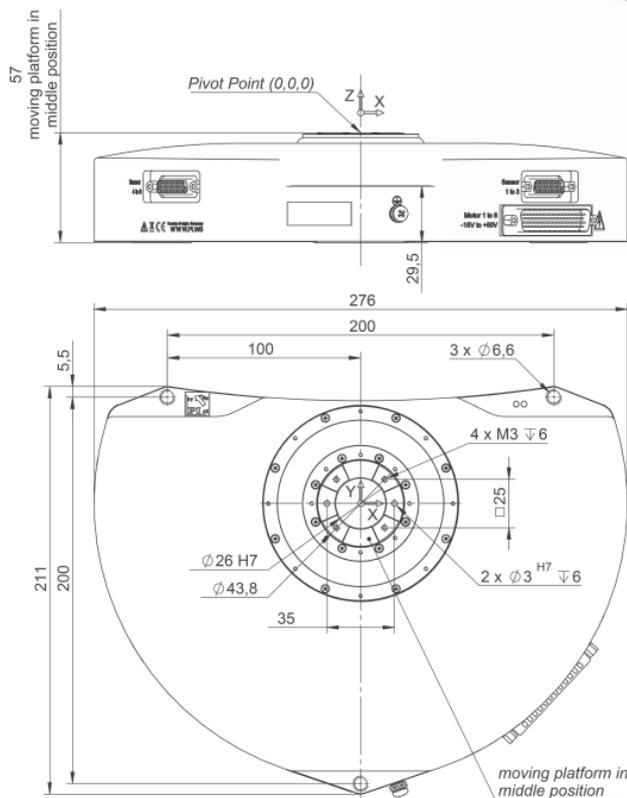
	Q-821.140	Unit	Tolerance
<b>Motion and positioning</b>			
Active axes	X, Y, Z, $\theta_x$ , $\theta_y$ , $\theta_z$		
Integrated sensor	Incremental, optical, direct measuring		
Travel range in X, Y	±6	mm	
Travel range in Z	±3	mm	
Rotation range in $\theta_x$ , $\theta_y$	±6	°	
Rotation range in $\theta_z$	±16.5	°	
Sensor signal	Analog sin / cos, differential, 1 V <sub>pp</sub>		
Sensor resolution	1	nm	
Step size in full step mode	0.4	µm	
Operating frequency in full step mode	10	kHz	
Minimum incremental motion in X, Y	0.01	µm	typ.
Minimum incremental motion in Z	0.02	µm	typ.
Minimum incremental motion in $\theta_x$ , $\theta_y$ , $\theta_z$	0.9	µrad	typ.
Unidirectional repeatability in X	±0.04	µm	typ.
Unidirectional repeatability in Y	±0.07	µm	typ.
Unidirectional repeatability in Z	±0.2	µm	typ.
Backlash in X, Y	0.04	µm	
Backlash in Z	0.08	µm	
Backlash in $\theta_x$ , $\theta_y$	45	µrad	
Backlash in $\theta_z$	25	µrad	
Max. speed in X, Y	5	mm/s	
Max. speed in Z	2	mm/s	
<b>Mechanical properties</b>			
Load capacity in X, Y	1	N	max.
Load capacity in Z (base plate horizontal)	2	N	max.
Holding force in X, Y, Z, passive	3	N	
Drive type	Piezoelectric inertia drive		
Guide type	Crossed roller bearings		
<b>Miscellaneous</b>			
Connection	6x Sub-D 15 (m)		
Material	Stainless steel, aluminum		
Mass without cable and connector	0.3	kg	±5 %
Cable length	2	m	±10 mm
Recommended electronics	C-886.31		

# N-865 NEXACT® SpaceFAB

6 Degrees of Freedom, Highest Precision, Low-Profile Hexapod Design



N-865.160, dimensions in mm



- Six degrees of freedom
- Clear aperture
- Sensor resolution 0.5 nm
- 15 N load capacity
- Self-locking when switched off: Saves energy and reduces generation of heat
- Crossed roller guides, anti-creep

## Applications

- Fine adjustment of the smallest components during assembly
- Photonics / Alignment Applications
- Microscopy
- Beamline systems
- Semiconductor technology
- Test laboratories

- >> NEXACT® Piezo walking drive
- >> Parallel Kinematics, Hexapods
- >> PIOne Linear Encoder
- >> Vacuum-Compatible Versions

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	N-865.160	Unit	Tolerance
<b>Motion and positioning</b>			
Active axes	X, Y, Z, $\theta_x$ , $\theta_y$ , $\theta_z$		
Integrated sensor	Incremental linear encoder PIOne		
Travel range* in X, Y	±6.5	mm	
Travel range* in Z	±5	mm	
Rotation range* in $\theta_x$ , $\theta_y$	±7	°	
Rotation range* in $\theta_z$	±8	°	
Sensor resolution	0.5	nm	
Minimum incremental motion in X, Y	2	nm	typ.
Minimum incremental motion in Z	2	nm	typ.
Minimum incremental motion in $\theta_x$ , $\theta_y$ , $\theta_z$	0.2	μrad	typ.
Unidirectional repeatability in X	±40	nm	typ.
Unidirectional repeatability in Y	±30	nm	typ.
Unidirectional repeatability in Z	±20	nm	typ.
Unidirectional repeatability in $\theta_x$	±5	μrad	typ.
Unidirectional repeatability in $\theta_y$	±7	μrad	typ.
Unidirectional repeatability in $\theta_z$	±7	μrad	typ.
Backlash in X	70	nm	typ.
Backlash in Y	30	nm	typ.
Backlash in Z	20	nm	typ.
Backlash in $\theta_x$	12	μrad	typ.
Backlash in $\theta_y$	9	μrad	typ.
Backlash in $\theta_z$	4	μrad	typ.
<b>Mechanical properties</b>			
Load capacity in X, Y	7.5	N	max.
Load capacity in Z (base plate horizontal)	15	N	max.
Drive type	NEXACT® piezo walking drive		
<b>Miscellaneous</b>			
Connection	HD Sub-D 78 (m)		
Sensor connection	2x HD Sub-D 26 (f)		
Material	Stainless steel, aluminum		
Mass	3.9	kg	±5 %
Operating temperature range	10 to 50	°C	

Technical data specified at 20±3 °C.

Ask about custom designs!

\* The travel ranges of the individual coordinates (X, Y, Z,  $\theta_x$ ,  $\theta_y$ ,  $\theta_z$ ) are interdependent.

The data for each axis in this table shows its maximum travel range, where all other axes and the pivot point are at the reference position.

# Linear Actuators



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<b>PiezoMike Actuators</b> .....	<b>86</b>
N-450 PiezoMike Miniature Linear Actuator .....	<b>86</b>
N-470 PiezoMike Linear Actuator .....	<b>88</b>
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<b>PiezoMike Mirror Mount</b> .....	<b>96</b>
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N-412 Linear Actuator with Q-Motion® Piezo Motor .....	<b>98</b>
N-422 Linear Actuator with Q-Motion® Piezo Motor .....	<b>100</b>

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# N-450 PiezoMike Miniature Linear Actuator

Smallest PiezoMike on the Market for 0.5" Mirror Holders



- 30 % smaller than the N-470
- Feed force 14 N
- Step size 15 nm
- Lifetime >1,000,000,000 steps
- Self-locking, no heat generation at rest
- Nonmagnetic and vacuum-compatible operating principles

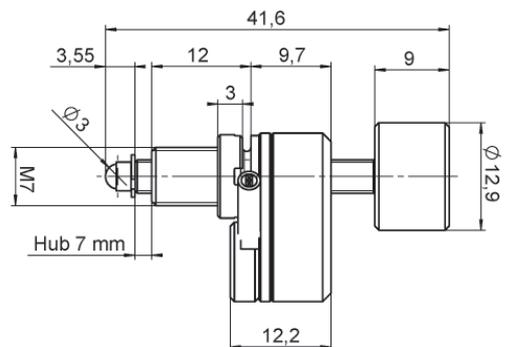
## Linear actuator with piezo inertia drive

The internal piezo actuator slowly expands when an electric voltage is applied. This expansion leads to rotary motion of the claw. Because the claw clamps onto the fine-thread screw, the resulting motion then turns the screw. When the piezo actuator has reached its maximum expansion, it quickly contracts and the claw returns to its initial position. Due to rapid contraction, the claw slides around the screw. Due to its mass inertia, it remains in its initial position.

## Alignment of mechanical and optomechanical components

Stable alignment of optical paths. Long-term positioning stability: High stability at target position, reliable startup even after longer downtimes. Versions to  $10^{-6}$  hPa available.

N-450, dimensions in mm



### Applications

- Optical alignment
- Mirror adjustment
- Autofocus

- >> PiezoMike
- >> Q-Motion® Piezoelectric Inertia Drive
- >> Vacuum-Compatible Versions

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	<b>N-450</b>	<b>Unit</b>	<b>Tolerance</b>
<b>Motion and positioning</b>			
Active axes	X		
Travel range	7	mm	
Step size	15	nm	typ.
Step frequency	2	kHz	
Velocity	2	mm/min	typ.
Feed Force	15	N	typ.
<b>Drive properties</b>			
Drive type	Piezoelectric inertia drive		
Operating voltage	80	V	max.
Power consumption	5	W	max.
<b>Miscellaneous</b>			
Operating temperature range	10 to 40	°C	
Motor connection	LEMO 3-pin		
Cable length	2	m	
Mechanical connection	M7 × 0.75		
Recommended electronics	E-872; E-871.1A1N		

# N-470 PiezoMike Linear Actuator

Minimum Dimensions, High Forces, Stable Positioning



- Holding force >100 N, feed force 22 N
- Step size 20 nm
- Travel range 7.5 mm to 26 mm
- Compact design
- Lifetime >1,000,000,000 steps
- Self-locking, no heat generation at rest

## Linear actuator with piezo motors

Linear screw-type actuator with piezoelectric inertia drive for high-resolution and stable positioning. Open-loop operation in full-step mode.

## Piezo motors

Compact, inexpensive inertia drive (stick-slip). At rest, the drive is self-locking, requires no current, and does not generate any heat. It holds the position with maximum force.

## Alignment of mechanical and optomechanical components

Stable alignment of optical paths. Long-term positioning stability: High stability at target position, reliable startup even after longer downtimes. High holding force and resolution by combining piezo actuators with mechanical thread translation. Vacuum-compatible versions to  $10^{-9}$  hPa available.



PiezoMike linear actuators replace manual micrometer screws in tip / tilt mirror mechanics

## Applications

- Optical alignment
- Mirror adjustment
- Autofocus

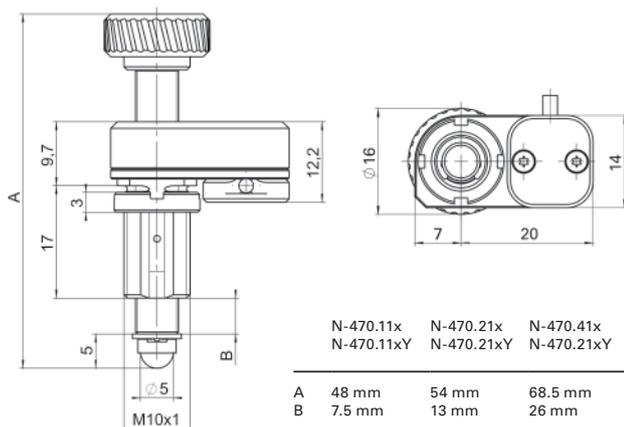
- >> PiezoMike
- >> Q-Motion® Piezoelectric Inertia Drive
- >> Vacuum-Compatible Versions

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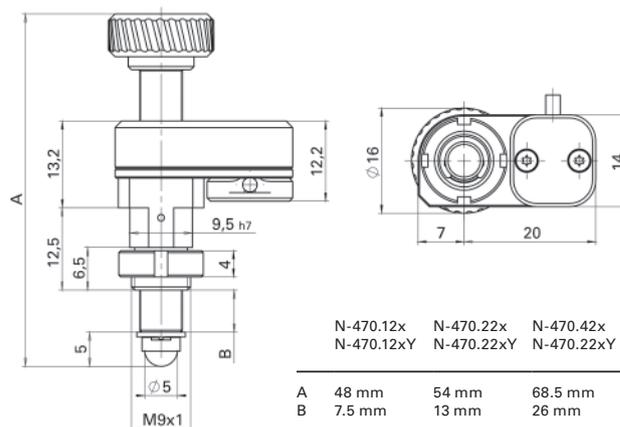
	N-470	Unit
<b>Motion and positioning</b>		
Active axis	X	
Travel range	N-470.1xx: 7.5 N-470.2xx: 13 N-470.4xx: 26	mm
Max. step size in step mode	30	nm
Typ. step size	20	nm
Step frequency	2000	Hz
Max. velocity in full-step mode	3.6	mm/min
Typ. velocity in full-step mode	2.4	mm/min
<b>Mechanical properties</b>		
Mechanical interface	N-470.x1x: Mounting thread M10x1 N-470.x2x: Clamping shank 9.5 mm	
Stiffness in motion direction	15.5	N/μm
Feed force (active)	22	N
Holding force (passive)	>100	N
Permissible lateral force	1	N
<b>Drive properties</b>		
Drive type	Piezoelectric inertia drive	
Max. operating voltage	80	V
Max. power consumption	5	W
<b>Miscellaneous</b>		
Operating temperature range	10 to 40	°C
Material	Screw: Stainless steel Housing: Aluminum	
Dimensions	14 × 28 × 48	mm
Mass	80	g
Cable length	2	m
Cable exit	N-470.xxx: Standard N-470.xxxY: Twisted cable exit	
Connector	Mini DIN 4-pin	
Recommended electronics	E-871.1A1N	

Ask about custom designs!

N-470 with mounting thread, dimensions in mm



N-470 with clamping shank, dimensions in mm



# N-470.V / N-470.U PiezoMike Linear Actuator

Minimum Dimensions, High Forces, Stable Positioning, Vacuum to  $10^{-9}$  hPa

- Holding force >100 N
- Step size 20 nm
- Travel range 7.5 mm to 26 mm
- Compact design
- Feed force 22 N
- Lifetime >1,000,000,000 steps



## Linear actuator with piezo motors

Linear screw-type actuator with piezoelectric inertia drive for high-resolution and stable positioning. Open-loop operation in full-step mode.

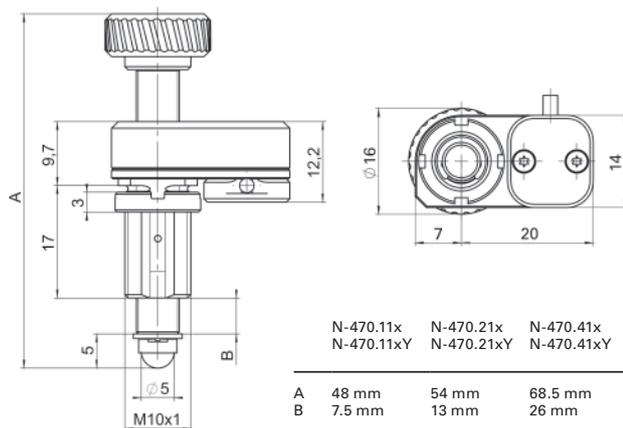
## Piezo motors

Compact, inexpensive inertia drive (stick-slip). At rest, the drive is self-locking, requires no current, and does not generate any heat. It holds the position with maximum force.

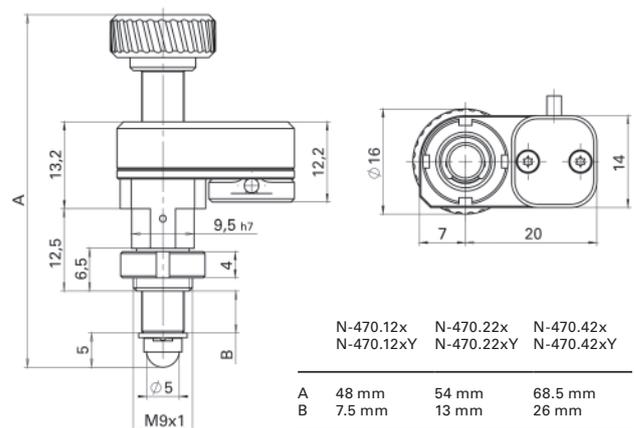
## Alignment of mechanical and optomechanical components

Stable alignment of optical paths. Long-term positioning stability: High stability at target position, reliable startup even after longer downtimes. High holding force and resolution by combining piezo actuators with mechanical thread translation. Vacuum-compatible to  $10^{-9}$  hPa.

N-470 with mounting thread, dimensions in mm



N-470 with clamping shank, dimensions in mm



## Applications

- Optical alignment
- Mirror adjustment
- Autofocus

- >> PiezoMike
- >> Q-Motion® Piezoelectric Inertia Drive
- >> Vacuum-Compatible Versions

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	N-470.x1V N-470.x1VY	N-470.x1U N-470.x1UY	N-470.x2V N-470.x2VY	N-470.x2U N-470.x2UY
Mechanical interface	M10×1 mounting thread	M10×1 mounting thread	9.5 mm clamping shank	9.5 mm clamping shank
Pressure range	10 <sup>-6</sup> hPa	10 <sup>-9</sup> hPa	10 <sup>-6</sup> hPa	10 <sup>-9</sup> hPa

	N-470.11x; N-470.11xx N-470.12x; N-470.12xx	N-470.21x; N-470.21xx N-470.22x; N-470.22xx	N-470.41x; N-470.41xx N-470.42x; N-470.42xx	Unit
<b>Motion and positioning</b>				
Active axis	X	X	X	
Travel range	7.5	13	26	mm
Max. step size in step mode	30	30	30	nm
Typ. step size	20	20	20	nm
Step frequency	2000	2000	2000	Hz
Max. velocity in full-step mode	3.6	3.6	3.6	mm/min
Typ. velocity in full-step mode	2.4	2.4	2.4	mm/min
<b>Mechanical properties</b>				
Stiffness in motion direction	15.5	15.5	15.5	N/μm
Feed force (active)	22	22	22	N
Holding force (passive)	00	>100	>100	N
Permissible lateral force	1	1	1	N
<b>Drive properties</b>				
Drive type	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	
Max. operating voltage	80	80	80	V
Max. power consumption	5	5	5	W
<b>Miscellaneous</b>				
Operating temperature range	10 to 40	10 to 40	10 to 40	°C
Material	Screw: Stainless steel Housing: Stainless steel	Screw: Stainless steel Housing: Stainless steel	Screw: Stainless steel Housing: Stainless steel	
Dimensions	14 × 28 × 48	14 × 28 × 53.5	14 × 28 × 68.5	mm
Mass	80	85	95	g
Cable length / connector	1 m in vacuum chamber, bare stranded wires; 2 m outside of vacuum chamber, exposed wires to Mini DIN 4-pin	1 m in vacuum chamber, bare stranded wires; 2 m outside of vacuum chamber, exposed wires to Mini DIN 4-pin	1 m in vacuum chamber, bare stranded wires; 2 m outside of vacuum chamber, exposed wires to Mini DIN 4-pin	
Recommended electronics	E-871.1A1N	E-871.1A1N	E-871.1A1N	

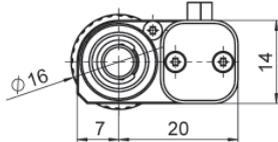
Ask about custom designs!

# N-472 PiezoMike Linear Actuator

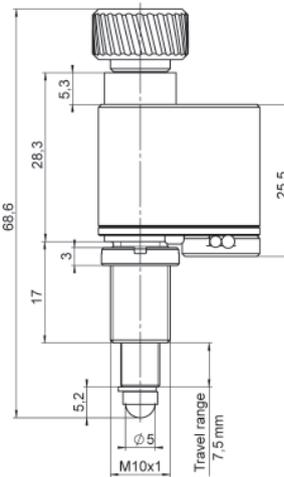
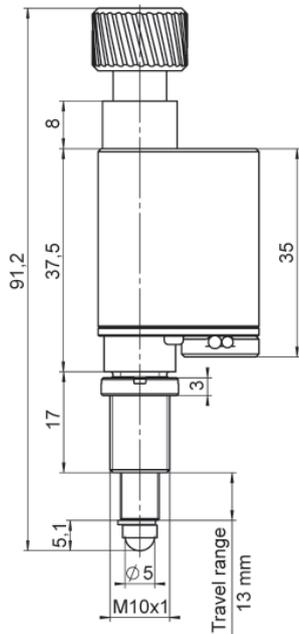
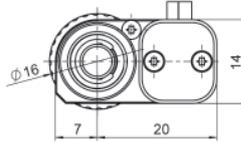
With Position Sensor for Closed-Loop Operation



N-472,210, dimensions in mm



N-472,110, dimensions in mm



- Self-locking at rest even when closed-loop control is switched off
- Compact design with integrated incremental encoder
- High stability at target position
- Reliable startup even after longer downtimes
- Lifetime >1,000,000,000 steps
- Vacuum-compatible versions to  $10^{-6}$  hPa available

## Applications

- Optical alignment
- Mirror adjustment
- Autofocus

- >> PiezoMike
- >> Q-Motion® Piezoelectric Inertia Drive
- >> Vacuum-Compatible Versions

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	N-472.110 N-472.110Y N-472.120 N-472.120Y	N-472.11V N-472.11VY N-472.12V N-472.12VY	N-472.210 N-472.210Y N-472.220 N-472.220Y	N-472.21V N-472.21VY N-472.22V N-472.22VY	Unit
<b>Motion and positioning</b>					
Active axis	X	X	X	X	
Travel range	7.5	7.5	13	13	mm
Integrated sensor	Incremental, optical	Incremental, optical	Incremental, optical	Incremental, optical	
Sensor signal, analog	1	1	1	1	V <sub>pp</sub>
Reference point definition using reference point or limit switch	–	–	–	–	
Design resolution*	0.09	0.09	0.09	0.09	nm
Minimum incremental motion**	50	50	50	50	nm
Unidirectional repeatability**	200	200	200	200	nm
Linearity error***	2	2	2	2	µm
Typical velocity****	2	2	2	2	mm/min
Operating frequency	2000	2000	2000	2000	Hz
Maximum permissible operating frequency during continuous operation	400	200	400	200	Hz
<b>Mechanical properties</b>					
Mechanical interface	M10×1 mounting thread (N 472.110; N 472.110Y) 9.5 mm clamping shank (N 472.120; N 472.120Y)	M10×1 mounting thread (N 472.11V; N 472.11VY) 9.5 mm clamping shank (N 472.12V; N 472.12VY)	M10×1 mounting thread (N 472.210; N 472.210Y) 9.5 mm clamping shank (N 472.220; N 472.220Y)	M10×1 mounting thread (N 472.21V; N 472.21VY) 9.5 mm clamping shank (N 472.22V; N 472.22VY)	
Holding force, power off	>100	>100	>100	>100	N
Feed Force	22	22	22	22	N
<b>Drive properties</b>					
Drive type	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	Piezoelectric inertia drive	
Maximum operating voltage	80	80	80	80	V
<b>Miscellaneous</b>					
Operating temperature range	10 to 40	10 to 40	10 to 40	10 to 40	°C
Vacuum operation	–	To 10 <sup>-6</sup> hPa	–	To 10 <sup>-6</sup> hPa	
Material	Screw: Stainless steel Housing: Aluminum, bronze	Screw: Stainless steel Housing: Stainless steel, bronze	Screw: Stainless steel Housing: Aluminum, bronze	Screw: Stainless steel Housing: Stainless steel, bronze	
Weight	200	250	210	260	g
Cable length	2 m	1 m inside the vacuum, bare stranded wires; 2 m outside the vacuum, bare stranded wires to Sub-D 15	2 m	1 m inside the vacuum, bare stranded wires; 2 m outside the vacuum, bare stranded wires to Sub-D 15	
Motor / sensor connection	Sub-D 15 (m)	Sub-D 15 (m)	Sub-D 15 (m)	Sub-D 15 (m)	
Recommended electronics	E-871.1A1N	E-871.1A1N	E-871.1A1N	E-871.1A1N	

\* With E-871 motion controller

\*\* 20 N preload, measured at 100 µm stroke, compensated for temperature drift

\*\*\* 20 N preload, measured over the entire stroke, compensated for temperature drift

\*\*\*\* Not suitable for continuous operation

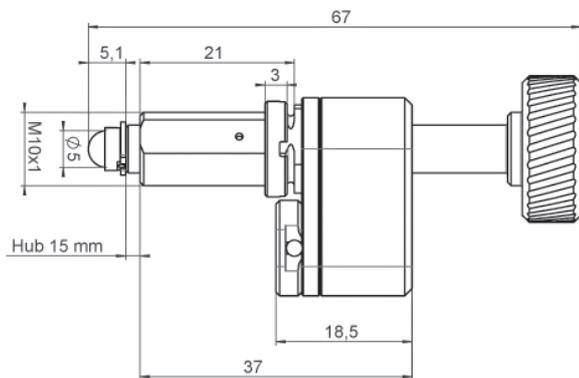
Ask about custom designs!

# N-474 PiezoMike Linear Actuator

Strongest PiezoMike on the Market, Small Dimensions, Stable Positioning



N-474, dimensions in mm



- Feed force 40 N
- Step size 20 nm
- Lifetime >1,000,000,000 steps
- Self-locking, no heat generation at rest
- Nonmagnetic and vacuum-compatible operating principle

## Linear actuator with piezo inertia drive

The internal piezo actuator slowly expands when an electric voltage is applied. This expansion leads to rotary motion of the claw. Because the claw clamps onto the fine-thread screw, the resulting motion then turns the screw. When the piezo actuator has reached its maximum expansion, it quickly contracts and the claw returns to its initial position. Due to rapid contraction, the claw slides around the screw. Due to its mass inertia, it remains in its initial position.

## Alignment of mechanical and optomechanical components

Stable alignment of optical paths. Long-term positioning stability: High stability at target position, reliable startup even after longer downtimes. Versions to  $10^{-6}$  hPa available as N-474.xxVx.

### Applications

- Optical alignment
- Mirror adjustment
- Autofocus

- >> PiezoMike
- >> Q-Motion® Piezoelectric Inertia Drive
- >> Vacuum-Compatible Versions

Technology Glossary ..... page 148

	N-474	Unit	Tolerance
<b>Motion and positioning</b>			
Active axes	X		
Travel range	13	mm	
Step size	20	nm	typ.
Step frequency	2	kHz	
Velocity	2	mm/s	typ.
Feed Force	40	N	typ.
<b>Drive properties</b>			
Drive type	Piezoelectric inertia drive		
Operating voltage	80	V	max.
Power consumption	5	W	max.
<b>Miscellaneous</b>			
Operating temperature range	10 to 40	°C	
Motor connection	LEMO 3-pin		
Cable length	2	m	
Mechanical connection	9.5 mm clamping shank (N-474.x2xx) or M10 mounting thread (N-474.x1xx)		
Recommended electronics	E-871.1A1N		

Technical data specified at 22 ±3 °C with E-872.401.  
Ask about custom designs!

# N-480 PiezoMike Miniature Linear Actuator

## With Kinematic Mirror Mount



- High stability
- For optics with 0.5", 1" or 2" diameter
- Compact design with integrated incremental encoder
- Step size 1  $\mu$ rad
- Lifetime >1.000.000.000 steps
- Vacuum-compatible versions to  $10^{-9}$  hPa available

### Kinematic mirror mounts with piezo motors

Linear screw-type actuator with piezoelectric inertia drive for high-resolution and stable positioning.

### Piezo motors

Compact, inexpensive inertia drive principle (stick-slip). At rest, the drive is self-locking, requires no current, and does not generate any heat. It holds the position with maximum force.

### Alignment of optical components

Stable alignment of optical paths. Long-term positioning stability: High stability at target position, reliable startup even after longer downtimes. High holding force and resolution by combining piezo actuators with mechanical thread translation. Vacuum-compatible versions to  $10^{-9}$  hPa available.



N-480.210L0, PiezoMike mirror holder, right-hand frame



N-480.210R0, PiezoMike mirror holder, left-hand frame



N-480.210RU, PiezoMike mirror holder for ultrahigh vacuum

### Applications

- Optical alignment
- Mirror adjustment

- >> PiezoMike
- >> Q-Motion® Piezoelectric Inertia Drive
- >> Vacuum-Compatible Versions

Technology Glossary ..... page 148

	N-480.205C0; N-480.205CV / N-480.205CU	N-480.210C0; N-480.210CV / N-480.210CU	N-480.210L0; N-480.210LV / N-480.210LU	N-480.210R0; N-480.210RV / N-480.210RU	Unit
<b>Mechanical properties</b>					
Mechanical interface	0,5" optics, closed frame V: Vacuum to 10 <sup>-6</sup> hPa U: Vacuum to 10 <sup>-9</sup> hPa	1" optics, closed frame V: Vacuum to 10 <sup>-6</sup> hPa U: Vacuum to 10 <sup>-9</sup> hPa	1" optics, right-hand V: Vacuum to 10 <sup>-6</sup> hPa U: Vacuum to 10 <sup>-9</sup> hPa	1" optics, left-hand V: Vacuum to 10 <sup>-6</sup> hPa U: Vacuum to 10 <sup>-9</sup> hPa	
Holding force, power off	>100	>100	>100	>100	N
Feed force (active)	22	22	22	22	N

	N-480.x05x, N-480.x10x				Unit
<b>Motion and positioning</b>					
Active axis	$\theta_x, \theta_y$				
Tip / tilt angle	±8				°
Step size	1				μrad

	N-480.220C0; N-480.220CV / N-480.220CU	N-480.220L0; N-480.220LV / N-480.220LU	N-480.220R0; N-480.220RV / N-480.220RU	Unit
<b>Mechanical properties</b>				
Mechanical interface	2" optics, closed frame V: Vacuum to 10 <sup>-6</sup> hPa U: Vacuum to 10 <sup>-9</sup> hPa	2" optics, right-hand V: Vacuum to 10 <sup>-6</sup> hPa U: Vacuum to 10 <sup>-9</sup> hPa	2" optics, left-hand V: Vacuum to 10 <sup>-6</sup> hPa U: Vacuum to 10 <sup>-9</sup> hPa	
Holding force, power off	>100	>100	>100	N
Feed force (active)	22	22	22	N

	N-480.x20x				Unit
<b>Motion and positioning</b>					
Active axis	$\theta_x, \theta_y$				
Tip / tilt angle	±4				°
Step size	0.5				μrad

	N-480				Unit
<b>Drive properties</b>					
Drive type	Piezoelectric inertia drive				
Motor voltage	80				V
<b>Miscellaneous</b>					
Operating temperature	10 to 40				°C
Material	Screw: Stainless steel Holder: Aluminum				
Cable length	2				m
Connector	LEMO type 0S, 3-pin				
Recommended controller	E-872.401				

Ask about custom designs!

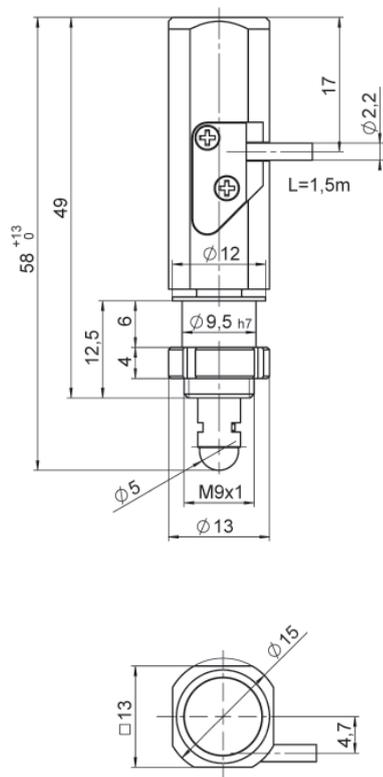
# N-412 Linear Actuator with Q-Motion® Piezo Motor

## Inexpensive and Easy to Integrate OEM Actuator

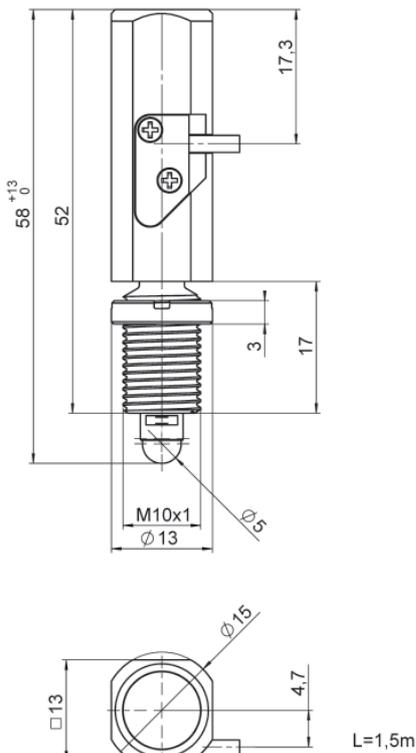
- OEM actuator without position sensor
- Silent: Operating frequency to >20 kHz
- Velocity over 5 mm/s
- Submicron resolution
- Holding force to 10 N
- Low operating voltage to 48 V<sub>pp</sub>
- Self-locking, no heat generation at rest



N-412.50, dimensions in mm



N-412.51, dimensions in mm



### Applications

- Optical alignment
- Mirror adjustment
- Autofocus

- >> Extensive Software Package
- >> Q-Motion® Piezoelectric Inertia Drive

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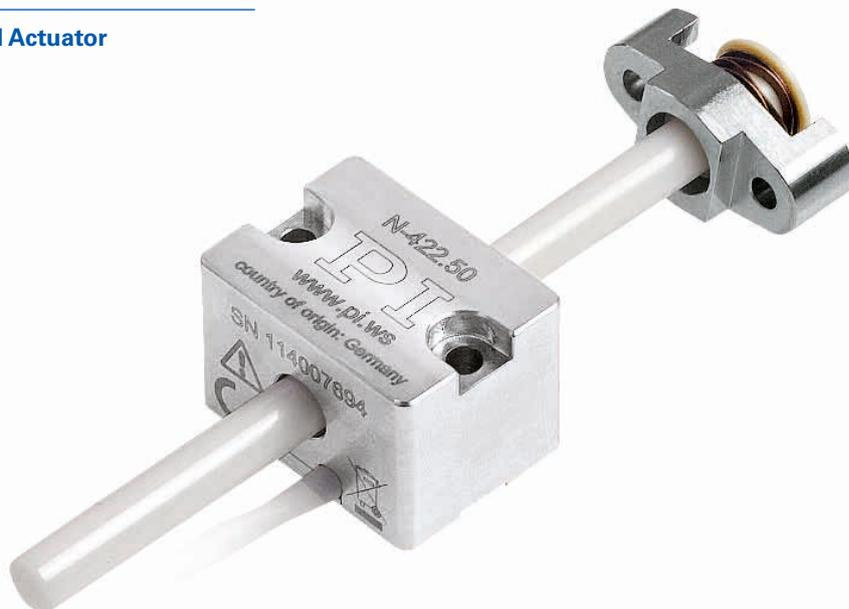
	N-412.50	N-412.51	Unit	Tolerance
<b>Motion</b>				
Active axis	X	X		
Travel range	13	13	mm	
Step size (in step mode)	300	300	nm	typ.
Step frequency*	23	23	kHz	max.
Max. velocity*	5	5	mm/s	min.
<b>Mechanical properties</b>				
Mechanical interface	Linear actuator, 9.5 mm clamping shank	Linear actuator, M10x1 thread		
Stiffness in motion direction	>4	>4	N/μm	±20 %
Push / pull force (active)	7	7	N	max.
Max. holding force (passive)	10	10	N	min.
<b>Drive properties</b>				
Drive type	Piezoelectric inertia drive	Piezoelectric inertia drive		
Operating voltage	48	48	V <sub>pp</sub>	max.
<b>Miscellaneous</b>				
Operating temperature range	0 to 50	0 to 50	°C	
Material**	Stainless steel	Stainless steel		
Dimensions	58 mm length, 15 mm diameter	58 mm length, 15 mm diameter		
Mass	25	25	g	±5 %
Cable length	1.5	1.5	m	±10 mm
Connector	DIN 4-pin	DIN 4-pin		
Recommended electronics	E-871.1A1N	E-871.1A1N		

Ask about custom designs!  
 \* Depending on the driver electronics.  
 \*\* Ceramic rod.

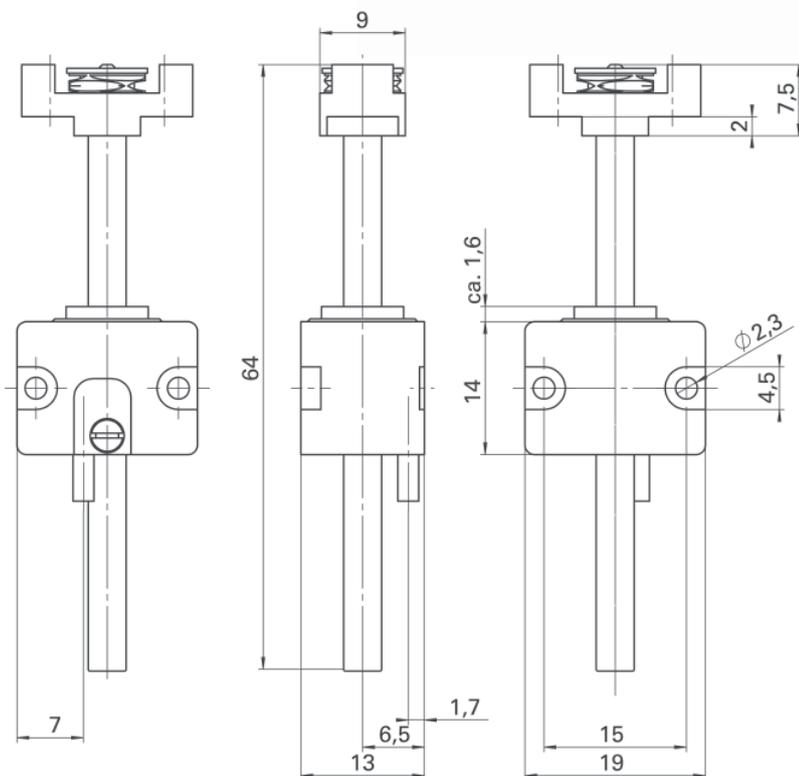
# N-422 Linear Actuator with Q-Motion® Piezo Motor

## Inexpensive and Easy-to-Integrate OEM Actuator

- OEM actuator without position sensor
- Easy integration: Two mounting versions
- Silent: Operating frequency to >20 kHz
- Velocity over 5 mm/s
- Submicron resolution
- Holding force to 10 N



N-422, dimensions in mm



### Applications

- Optical alignment
- Mirror adjustment
- Autofocus

- >> Extensive Software Package
- >> Q-Motion® Piezoelectric Inertia Drive

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	N-422.50	Unit	Tolerance
<b>Motion</b>			
Active axes	X		
Travel range	35	mm	
Step size (in step mode)	300	nm	typ.
Step frequency*	20	kHz	max.
Max. velocity*	5	mm/s	min.
<b>Mechanical properties</b>			
Stiffness in motion direction	>4	N/μm	±20 %
Push / pull force (active)	7	N	max.
Max. holding force (passive)	10	N	min.
<b>Drive properties</b>			
Drive type	Piezo inertia drive		
Operating voltage	48	V <sub>pp</sub>	max.
Power consumption	15 (actuator) 30 (driver input)	W	nominal
<b>Miscellaneous</b>			
Operating temperature range	0 to 50	°C	
Material**	Stainless steel		
Dimensions	21.5 × 18 × 13 + runner	mm	
Mass	25	g	±5 %
Cable length	1.5	m	±10 mm
Connector	DIN 4-pin		
Recommended electronics	E-871.1A1N		

Ask about custom designs!  
 \* Depending on drive electronics.  
 \*\* Ceramic runner.

# Motion Control



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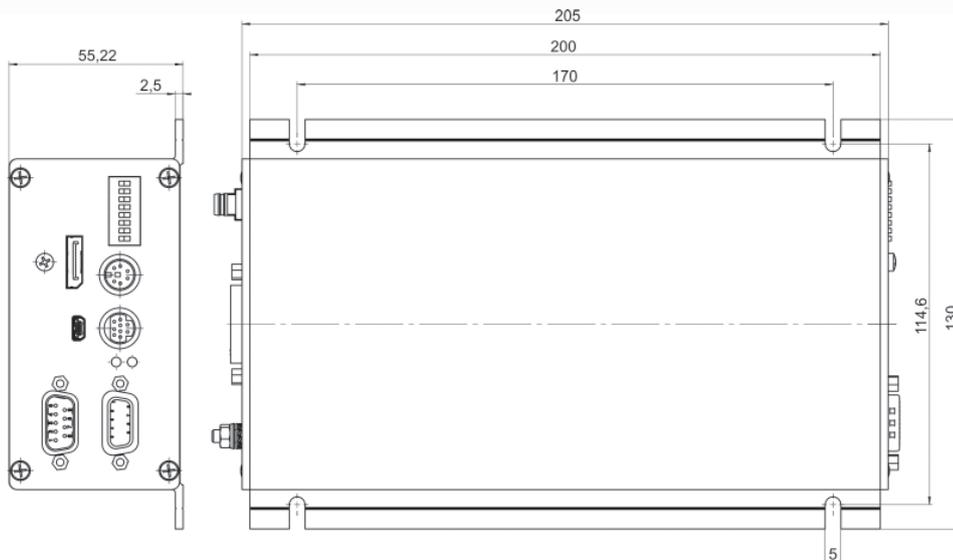
# C-867.1U PLine® Motion Controller

For Single-Axis Positioning Stages with PLine® Ultrasonic Piezo Motor



- Integrated power amplifier with dynamic frequency control
- Multifunctional encoder input: A/B, sin / cos, BiSS
- Macro programmable for stand-alone functionality
- Integrated Interfaces: USB, RS-232, SPI, I/O, joystick
- Daisy chain networking of up to 16 units

C-867.1U, dimensions in mm



>> Extensive Software Package  
 >> PLine® Ultrasonic Piezomotors

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<b>C-867.1U</b>	
Function	Controller for single-axis positioning stages
Drive types	Performance class 1 and 2 PLine® motors
Axes	1
<b>Motion and control</b>	
Controller type	Programmable PID control, parameter changing during operation
Motion profiles	Point-to-point trapeze, user-definable trajectories
Encoder input	Sin / cos (differential), A/B (TTL, differential), BiSS interface
Stall detection	Servo off, triggered by programmable position error or power level
Limit switches	2 programmable TTL lines per axis
Reference point switch	1 programmable TTL line per axis
<b>Electrical properties</b>	
Max. output power per axis	15 W
Max. output voltage per axis	200 V <sub>pp</sub>
<b>Interfaces and operation</b>	
Communication interfaces	USB, RS-232, SPI
Motor connection	Sub-D 15 (f)
Controller network	Up to 16 units on a single interface
I/O lines	4 analog / digital inputs 4 digital outputs to mini DIN, 9-pin Digital: TTL Analog: 0 to 5 V
Command set	PI General Command Set (GCS)
User software	PIMikroMove
Application programming interfaces	API for C / C++ / C# / VB.NET / MATLAB / Python, drivers for NI LabVIEW
Supported functions	Startup macro. Data recorder for recording operating data such as motor voltage, velocity, position or position error. ID chip detection.
Manual control	Pushbutton box, analog joystick
<b>Miscellaneous</b>	
Operating voltage	24 V DC (external power adapter in the scope of delivery)
Max. current consumption	300 mA plus motor current (max. 2 A)
Operating temperature range	5 to 40 °C
Mass	1 kg
Dimensions	205 mm x 130 mm x 55.2 mm (incl. mounting rails)

Ask about custom designs!

### Accessories

- C-862.CN** Network cable for daisy chain network, 30 cm
- C-862.CN1** Network cable for daisy chain network, 1 m
- C-862.CN2** Network cable for daisy chain network, 3 m
- C-170.PB** Pushbutton box with 4 buttons and 4 LEDs
- C-170.IO** I/O cable, 2 m, open end
- C-819.20** Analog joystick for 2 axes
- C-819.20Y** Y cable for connecting 2 controllers to a joystick C-819.20
- C-819.30** Analog joystick for 3 axes
- C-819.JA** Analog joystick for 2 axes, 3 programmable buttons

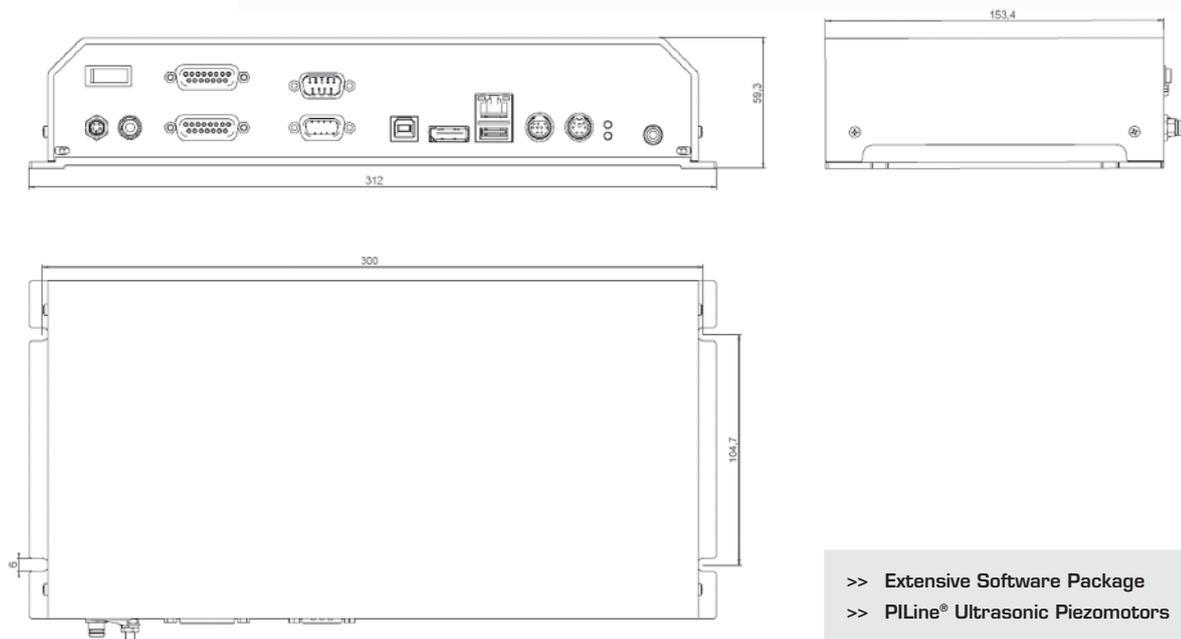
# C-867.2U2 PLine® Motion Controller

For Two-Axis Positioning Stages with PLine® Ultrasonic Piezo Motors

- Integrated power amplifier with dynamic frequency control
- Multifunctional encoder input: A/B, sin / cos, BiSS
- Macro programmable for stand-alone functionality
- Integrated interfaces: USB, RS-232, TCP/IP, SPI, I/O, joystick
- Daisy chain networking of up to 16 units
- Trajectory support for 1- or 2-D motion patterns
- Included in U-780 System for Microscopy



C-867.2U2, dimensions in mm



>> Extensive Software Package  
 >> PLine® Ultrasonic Piezomotors

Technology Glossary ..... page 148

<b>C-867.2U2</b>	
Function	Controller for XY positioning, scanning or microscope stages
Drive types	Performance class 1 and 2 PLine® motors
Axes	2
<b>Motion and control</b>	
Controller type	Programmable PID control, parameter changing during operation
Motion profiles	Point-to-point trapeze, user-definable trajectories
Encoder input	Sin / cos (differential), A/B (TTL, differential), BiSS interface
Stall detection	Servo off, triggered by programmable position error or power level
Limit switches	2 programmable TTL lines per axis
Reference point switch	1 programmable TTL line per axis
<b>Electrical properties</b>	
Max. output power per axis	15 W
Max. output voltage per axis	200 V <sub>pp</sub>
<b>Interfaces and operation</b>	
Communication interfaces	USB, RS-232, TCP/IP, SPI
Motor connection	Sub-D 15 (f)
Controller network	Up to 16 units on a single interface
I/O lines	4 analog / digital inputs 4 digital outputs to mini DIN, 9-pin Digital: TTL Analog: 0 to 5 V
Command set	PI General Command Set (GCS)
User software	PIMikroMove
Application programming interfaces	API for C / C++ / C# / VB.NET / MATLAB / Python, drivers for NI LabVIEW
Supported functions	Startup macro. Data recorder for recording operating data such as motor voltage, velocity, position or position error. ID chip detection.
Manual control	Pushbutton box, analog or digital joystick (for 2 axes)
<b>Miscellaneous</b>	
Operating voltage	24 V DC (external power adapter in the scope of delivery)
Max. current consumption	600 mA plus motor current (max. 4 A)
Operating temperature range	5 to 40 °C
Mass	1.62 kg
Dimensions	312 mm x 153.4 mm x 59.3 mm (incl. mounting rails)

Ask about custom designs!

### Accessories

- C-862.CN** Network cable for daisy chain network, 30 cm
- C-862.CN1** Network cable for daisy chain network, 1 m
- C-862.CN2** Network cable for daisy chain network, 3 m
- C-815.553** Patch cable 1:1, for connecting controller and PC via a TCP/IP network
- C-815.563** Patch cable twisted, for connecting controller and PC directly via TCP/IP
- C-815.34** RS-232 null modem cable, 3 m, 9/9-pin
- C-170.PB** Pushbutton box with 4 buttons and 4 LEDs
- C-170.IO** I/O cable, 2 m, open end
- C-819.20** Analog joystick for 2 axes
- C-819.30** Analog joystick for 3 axes
- C-819.JA** Analog joystick for 2 axes, 3 programmable buttons
- C-819.JD** Digital joystick for 2 axes, 3 programmable buttons

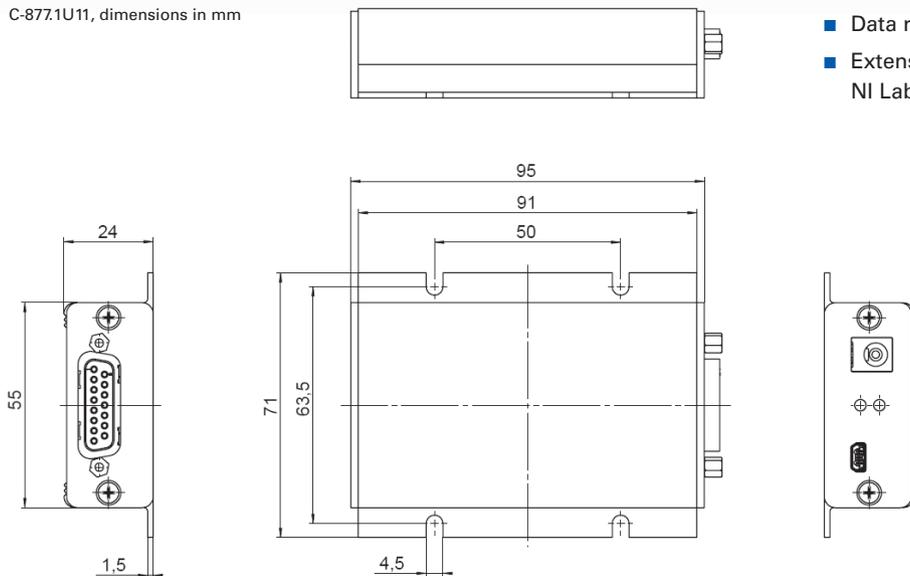
# C-877.1U11 PLine® Motion Controller

For Ultrasonic Piezo Motors, 1 Axis, Inexpensive and Compact



- Integrated power amplifier
- PID servo control with dynamic parameter switching
- Macro programmable for stand-alone functionality
- Data recorder
- Extensive software support, e.g., for NI LabVIEW, C, C++, MATLAB, Python

C-877.1U11, dimensions in mm



- >> Extensive Software Package
- >> PLine® Ultrasonic Piezomotors

Technology Glossary ..... page 148

<b>C-877.1U11</b>	
Function	Controller for positioners or scanning stages with PILINE® class 1 ultrasonic piezo motors
Axes	1
<b>Motion and control</b>	
Controller type	PID controller, parameter changing during operation
Servo cycle time	100 µs
Profile generator	Point-to-point motion. Trapezoidal velocity profile.
Encoder input	A/B quadrature TTL level, differential according to RS-422
Stall detection	Automatic motor stop when a programmable position error is exceeded
Limit switches	2 × TTL (programmable polarity)
Reference point switch	1 × TTL
<b>Electrical properties</b>	
Max. output power per axis	15 W
Max. output voltage per axis	200 V <sub>pp</sub> , 71 V <sub>eff</sub>
<b>Interfaces and operation</b>	
Communication interfaces	USB
Motor / sensor connection	Sub-D 15 (f)
Command set	PI General Command Set (GCS)
User software	PIMikroMove
Application programming interfaces	API for C / C++ / C# / VB.NET / MATLAB / Python, drivers for NI LabVIEW
Supported functions	Startup macro. Data recorder for recording operating data such as motor voltage, velocity, position or position error. Internal safety circuitry: Watchdog timer. ID chip detection
<b>Miscellaneous</b>	
Operating voltage	24 V DC from external power adapter (in the scope of delivery)
Max. current consumption	300 mA plus motor current (max. 0.8 A)
Operating temperature range	5 to 40 °C
Mass	0.13 kg
Dimensions	95 mm × 71 mm × 24 mm (incl. mounting rails)

Ask about custom designs!

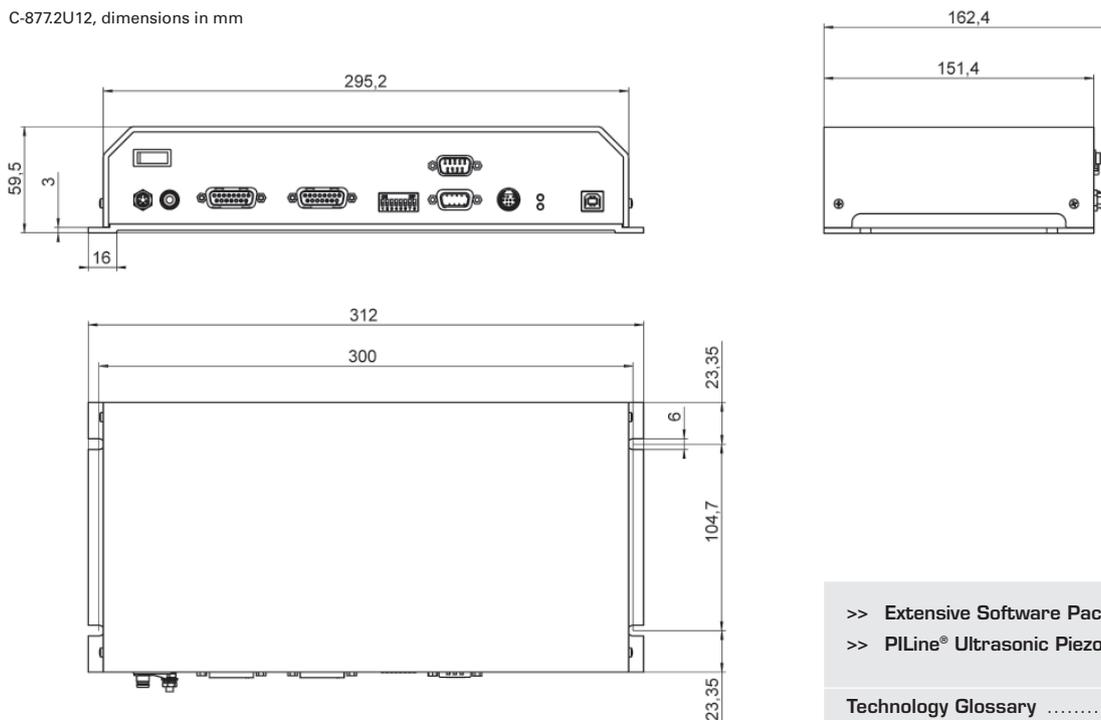
# C-877.2U12 PLine® Motion Controller

For Ultrasonic Piezo Motors, 2 Axes, Inexpensive and Compact



- Integrated power amplifier
- PID servo control with dynamic parameter switching
- Macro programmable for stand-alone functionality
- Data recorder
- Daisy chain networking of up to 16 units
- Extensive software support, e.g., for NI LabVIEW, C, C++, MATLAB, Python

C-877.2U12, dimensions in mm



>> Extensive Software Package  
 >> PLine® Ultrasonic Piezomotors

Technology Glossary ..... page 148

<b>C-8772U12</b>	
Function	Controller for positioning or scanning stages with performance class 1 and 2 PILine® ultrasonic piezo motors
Axes	2
<b>Motion and control</b>	
Controller type	PID controller, parameter changing during operation
Servo cycle time	100 µs
Profile generator	Point-to-point motion. Trapezoidal velocity profile.
Encoder input	A/B quadrature TTL level, differential according to RS-422
Stall detection	Automatic motor stop when a programmable position error is exceeded
Limit switches	2 × TTL (programmable polarity)
Reference point switch	1 × TTL
<b>Electrical properties</b>	
Max. output power per axis	24 W
Max. output voltage per axis	200 V <sub>pp</sub> , 71 V <sub>eff</sub>
<b>Interfaces and operation</b>	
Communication interfaces	USB; RS-232
Motor / sensor connection	2 × Sub-D 15 (f)
Controller network	Up to 16 units on a single interface
I/O lines	4 digital inputs (5 VTTL), 4 digital outputs (5 VTTL)
Command set	PI General Command Set (GCS)
User software	PIMikroMove
Application programming interfaces	API for C / C++ / C# / VB.NET / MATLAB / Python, drivers for NI LabVIEW
Supported functions	Startup macro. Data recorder for recording operating data such as motor voltage, velocity, position or position error. Internal safety circuitry: Watchdog timer. ID chip detection.
<b>Miscellaneous</b>	
Operating voltage	24 V DC from external power adapter (in the scope of delivery)
Max. current consumption	600 mA plus motor current (max. 4 A)
Operating temperature range	5 to 40 °C
Mass	1.62 kg
Dimensions	312 mm × 104.7 mm × 59.5 mm (incl. mounting rails)

Ask about custom designs!

### Accessories

- C-862.CN** Network cable for daisy chain network, 30 cm
- C-862.CN1** Network cable for daisy chain network, 1 m
- C-862.CN2** Network cable for daisy chain network, 3 m
- C-170.PB** Pushbutton box with 4 buttons and 4 LEDs
- C-170.IO** I/O cable, 2 m, open end

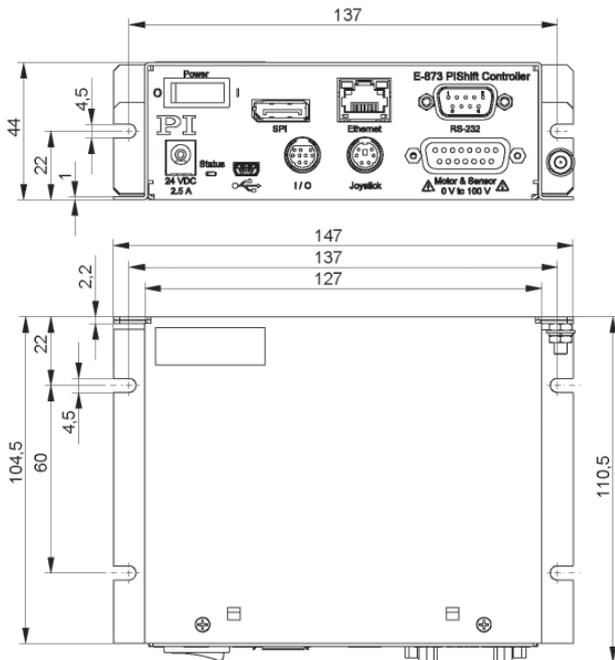
# E-873 Q-Motion® Digital Servo Controller, 1 Axis

For Piezoelectric Inertia Drives, TCP/IP, USB, RS-232 Interfaces

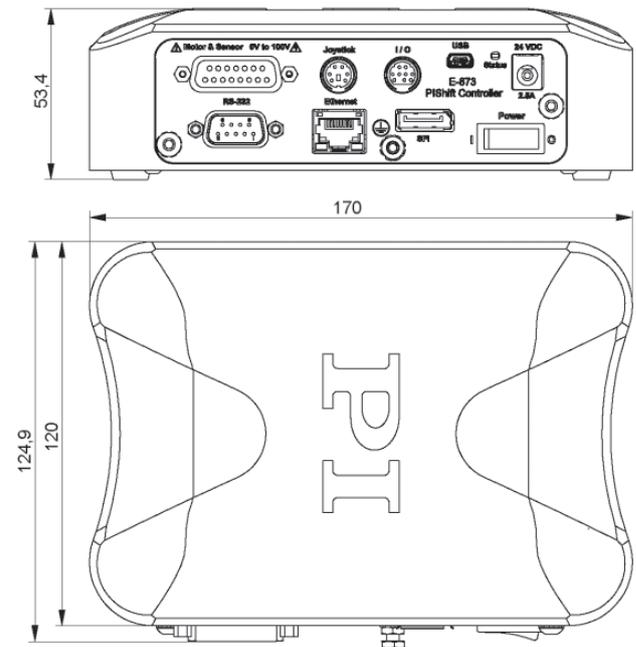


- Actuator mode for nanometer precision positioning at the target position
- Broadband encoder input
- Macro programmable for stand-alone functionality
- Fast startup due to ID chip detection
- Data recorder
- Digital I/O ports (TTL)
- Joystick for manual operation

E-873, dimensions in mm. SPI, TCP/IP, RS-232 only available on E-873.1AT



E-873.1A1, dimensions in mm



- >> Extensive Software Package
- >> Q-Motion® Piezoelectric Inertia Drive

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E-873.1A1 - E-873.1AR - E-873.1AT	
Function	Q-Motion® controller for positioning systems with piezo inertia drives, benchtop device (E-873.1A1) or benchtop device with option for control cabinet mounting (E-873.1AR/E-873.1AT)
Axes	1
Supported functions	Startup macro. Data recorder for recording operating data such as motor voltage, velocity, position or position error. Internal safety circuitry: Watchdog timer. ID chip detection.
<b>Motion and control</b>	
Controller type	PID controller, parameter changing during operation
Servo cycle time	50 µs
Dynamics profile	Trapezoidal velocity profile. Point-to-point motion
Encoder input	Analog encoder inputs sine-cosine, interpolation selectable to 20000; Interpolation electronics preset for differential transmission, 1 V <sub>pp</sub> and 2.5 V encoder offset signal; BiSS interface for absolute encoders
Stall detection	Automatic servo off
Input limit switch	2 × TTL (pull-up / pull-down, programmable)
Input reference point 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
<b>Interfaces and operation</b>	
Communication interfaces	USB E-873.1A1, E-873.1AT additionally: TCP/IP, RS-232
Motor / sensor connection	Sub-D 15 (f)
I/O lines	4 analog / digital inputs, 4 digital outputs
Command set	PI General Command Set (GCS)
User software	PIMikroMove
Application programming interfaces	API for C / C++ / C# / VB.NET / MATLAB / Python, drivers for NI LabVIEW
Manual control (optional)	Joystick
<b>Miscellaneous</b>	
Operating voltage	24 V DC from external power supply (included in the scope of delivery)
Max. current consumption	1.5 A
Operating temperature range	0 to 50 °C
Mass	E-873.1AR: 0.3 kg E-873.1AT: 0.335 kg E-873.1A1: 1.07 kg
Dimensions	E-873.1A1: 120 mm x 170 mm x 53.4 mm E-873.1AR, E-873.1AT: 137 mm x 105 mm x 43.82 mm

Ask about custom designs!

# E-873.3QTU

## Q-Motion® Digital Servo Controller, 3 Axes

For Piezoelectric Inertia Drives, TCP/IP, USB Interfaces



### Digital servo controller for piezo inertia drives

Integrated power amplifier and voltage generator for piezo inertia drives. Point-to-point motion, trapezoidal velocity profile, actuator mode for nanometer precision positioning at the target position. 3 axes.

### Encoder inputs

Differential signal transmission for analog (sin / cos) encoder signals. Input for TTL signals for reference point switches.

### Interfaces

USB and TCP/IP for commanding. I/O lines (digital) for automation. Connection for digital joystick.

### Extensive functions, software support

Powerful macro command language. Nonvolatile macro storage, e.g., for stand-alone operation with autostart macro. Data recorder. ID chip detection for fast startup. PID controller, parameter changing during operation. Extensive software support, e.g., for NI LabVIEW, C, C++, MATLAB, Python. PIMikroMove user software.

- Actuator mode for nanometer precision positioning at the target position
- Broadband encoder input
- Macro programmable for stand-alone functionality
- Fast startup due to ID chip detection
- Data recorder
- Digital I/O ports (TTL)
- Digital joystick for manual operation

>> Extensive Software Package  
>> Q-Motion® Piezoelectric Inertia Drive

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<b>E-873.3QTU</b>	
Function	Q-Motion® controller for positioning systems with piezo inertia drives, benchtop device with option for control cabinet mounting
Axes	3
Supported functions	Point-to-point motion. Startup macro. Data recorder for recording operating data such as motor voltage, position or position error. Internal safety circuitry: Watchdog timer. ID chip detection.
<b>Motion and control</b>	
Controller type	PID controller, parameter changing during operation
Encoder input	Analog encoder inputs sine-cosine, interpolation selectable to 20000; Interpolation electronics preset for differential transmission, 1 V <sub>pp</sub> and 2.5V offset of the encoder signal
Stall detection	Automatic servo off
Input reference point switch	1 × TTL for integrated reference in the encoder
<b>Electrical properties</b>	
Max. output power	30 W per axis
Output voltage	0 to 100 V, drive-dependent selection
<b>Interfaces and operation</b>	
Communication interfaces	TCP/IP, USB
Motor / sensor connection	3 × Sub-D 15 (f)
I/O lines	4 digital inputs, 4 digital outputs
Command set	PI General Command Set (GCS)
User software	PIMikroMove
Application programming interfaces	API for C / C++ / C# / VB.NET / MATLAB / Python, drivers for NI LabVIEW
Manual control (optional)	USB joystick
<b>Miscellaneous</b>	
Operating voltage	24 V from external power supply (included in the scope of delivery)
Max. current consumption	5 A
Operating temperature range	0 to 50 °C
Mass	1.7 kg
Dimensions	312 mm x 153.4 mm x 59.2 mm (incl. mounting rails)

Ask about custom designs!

# C-885 PIMotionMaster

Rack with Processor and Interface Module for Modular Multi-Axis Controller System



- Easy configuration and startup
- Modular design for versatile expansion
- Efficient communication with the controller modules
- Greatly reduced wiring effort
- Saves space and costs

## Easy installation

Plug-and-play installation of the controller modules in the C-885 PIMotionMaster. The processor and interface module communicates with the PIMikroMove software and with the controller modules. It detects the available controller module type automatically. Grouping the controller modules in one housing ensures internal communication and reduces the wiring effort because of the common power supply and external communication via a single USB or Ethernet interface.

## Easy to expand

The system is easily scalable. An additional controller module can be inserted into any free slot and expands the overall system by the corresponding functions. Optional digital inputs and outputs can be installed for every controller module.

## Controller modules

- C-863.20C885 DC Motor Controller Module, 2 Axes
- C-867.1xC885 PILine® Controller Module
- E-861.11C885 NEXACT® Controller Module
- E-873.10C885 Q-Motion® Controller Module
- C-663.12C885 Mercury Step Stepper Motor Controller Module
- C-891.10C885 PIMag® Controller Module

>> Extensive Software Package

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	<b>C-885.R1</b>	<b>C-885.R2</b>	<b>C-885.R3</b>
Function	9.5" chassis for C-885 PIMotionMaster	19" chassis for C-885 PIMotionMaster	19" chassis for C-885 PIMotionMaster
Number of card slots	1 C-885.Mx module (required) 4 controller modules (max.)	1 C-885.Mx module (required) 20 controller modules (max.)	1 C-885.Mx module (required) 19 controller modules (max.)
Dimensions	269.04 mm × 133.14 mm × 349.5 mm (incl. handles)	Without modules: 482.6 mm × 132.55 mm × 265.3 mm With modules: 482.6 mm × 132.55 mm × 278.55 mm	Without modules: 482.6 mm × 132.55 mm × 265.3 mm With modules: 482.6 mm × 132.55 mm × 278.55 mm
Operating voltage	24 V DC from external power supply	24 V DC from external power supply	24 V DC from external power supply also optional: 48 V DC from external power supply
Supply voltage for controller modules	24 V DC	24 V DC	24 V DC / 48 V DC
Current consumption, max.	32 A	32 A	32 A
Mass without modules	3.2 kg	2.9 kg	5.08 kg
Operating temperature range	10 to 40 °C	10 to 40 °C	10 to 40 °C

	<b>C-885.M1</b>	<b>C-885.M2</b>
Function	Digital Processor and Interface Module for C-885 PIMotionMaster	Digital Processor and Interface Module for C-885 PIMotionMaster, supports coupled multi-axis operation
Communication interfaces	Ethernet, USB	Ethernet, USB
Command set	PI General Command Set (GCS)	PI General Command Set (GCS)
User software	PIMikroMove	PIMikroMove
Application programming interfaces	API for C / C++ / C# / VB.NET / MATLAB / Python, drivers for NI LabVIEW	API for C / C++ / C# / VB.NET / MATLAB / Python, drivers for NI LabVIEW
Indicators	LEDs for Power, Error	LEDs for Power, Error
Operating temperature range	10 to 40°C	10 to 40°C
Mass	132 g	270 g
Dimensions	186.42 mm × 128.4 mm (3 RU) × 19.98 mm (4 HP)	186.42 mm × 128.4 mm (3 RU) × 19.98 mm (4 HP)

Ask about custom designs!

# C-867.1xC885 PLine® Controller Module

For C-885 PIMotionMaster Modular Controller System



## Servo controller and power amplifier

Special PID controller for ultrasonic piezo motors. Power amplifier for PLine® ultrasonic piezo motors with performance class 1, 2, and higher. Dynamic frequency control for optimum control.

## Encoder inputs

Differential signal transmission for digital (A/B) encoder signals. BiSS interface support for absolute encoders. TTL inputs for limit and reference point switches.

## Plug-and-play installation in the C-885 PIMotionMaster

Can be inserted in any free slot. Automatic detection and external communication (USB, Ethernet) by the processor and interface module of the C-885. Can be expanded with optional digital inputs and outputs. Power via the power supply of the C-885.

- Integrated power amplifier with dynamic frequency control
- PID servo control with dynamic parameter switching
- 50 MHz encoder inputs for simultaneous high velocity and resolution
- BiSS interface
- Data recorder
- Powerful macro programming language, e.g. for stand-alone operation



C-867.1xC885 Motion controller module for performance class 3 PLine® piezo motor systems

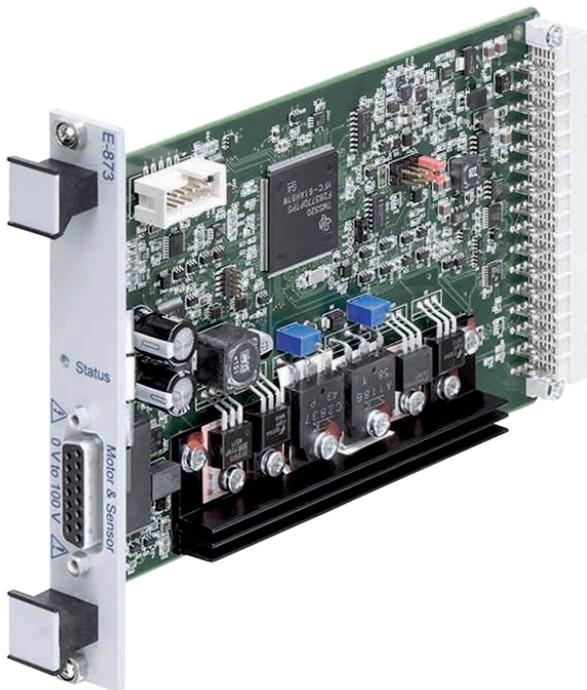
- >> Extensive Software Package
- >> PLine® Ultrasonic Piezomotors

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	C-867.10C885	C-867.11C885
	Controller for single-axis positioning or scanning stages, for C-885 PIMotionMaster modular multi-axis controller system	Controller for single-axis positioning or scanning stages, for C-885 PIMotionMaster modular multi-axis controller system
Drive types	Performance class 1 and 2 PILine® motors	Performance class 3 PILine® motors
Channels	1	1
<b>Motion and control</b>		
Controller type	Programmable PID control, parameter changing during operation	Programmable PID control, parameter changing during operation
Motion profiles	Point-to-point, user-definable trajectories	Point-to-point, user-definable trajectories
Encoder input	Sin / cos (differential), A/B (TTL, differential), BiSS interface	Sin / cos (differential), A/B (TTL, differential), BiSS interface
Stall detection	Servo off, triggered by programmable position error or power level	Servo off, triggered by programmable position error or power level
<b>Electrical properties</b>		
Max. output power	21 W	50 W
Max. output voltage	200 V <sub>pp</sub>	400 V <sub>pp</sub>
<b>Interfaces and operation</b>		
Communication interfaces	USB or Ethernet, via C-885.M1 / C-885.M2 Digital Processor and Interface Module	USB or Ethernet, via C-885.M1 / C-885.M2 Digital Processor and Interface Module
Motor connection	Sub-D 15 (f)	Sub-D 15 (f)
I/O lines	Optional with C-885.iD Digital Interface Module for PIMotionMaster: 4 analog/digital inputs (0 to 5V/TTL), 4 digital outputs (TTL)	Optional with C-885.iD Digital Interface Module for PIMotionMaster: 4 analog/digital inputs (0 to 5V/TTL), 4 digital outputs (TTL)
Command set	PI General Command Set (GCS)	PI General Command Set (GCS)
User software	PIMikroMove	PIMikroMove
Application programming interfaces	API for C / C++ / C# / VB.NET / MATLAB / Python, drivers for NI LabVIEW	API for C / C++ / C# / VB.NET / MATLAB / Python, drivers for NI LabVIEW
Supported functions	Startup macro. Data recorder for recording operating data such as motor voltage, velocity, position or position error.	Startup macro. Data recorder for recording operating data such as motor voltage, velocity, position or position error.
<b>Miscellaneous</b>		
Operating voltage, supply via C-885	24 V DC	24 V DC
Max. current consumption	300 mA plus motor current (max. 2 A)	300 mA plus motor current (max. 4 A)
Operating temperature range	10 to 40 °C	10 to 40 °C
Mass	172 g	227 g
Dimensions	186.42 mm x 128.4 mm (3 RU) x 19.98 mm (4 HP)	186.42 mm x 128.4 mm (3 RU) x 19.98 mm (4 HP)

# E-873.10C885 Q-Motion® Controller Module for C-885 PIMotionMaster

For Piezoelectric Inertia Drives, 1 Axis



- Broadband encoder input
- Macro programmable for stand-alone functionality
- Fast startup due to ID chip detection
- Data recorder
- PID controller, parameter changing during operation

## Digital servo controller for piezo inertia drives

Integrated power amplifier and voltage generator for piezo inertia drives. Point-to-point motion, trapezoidal velocity profile, actuator mode for nanometer precision positioning at the target position. 1 axis.

## Encoder input

Differential signal transmission for digital (A/B) or analog (sin / cos) encoder signals, BiSS interface for absolute encoders.

## Extensive functions, software support

Powerful macro command language. Nonvolatile macro storage, e.g., for stand-alone operation with autostart macro. Data recorder. ID chip detection for fast startup. PID controller, parameter changing during operation. Extensive software support, e.g., for NI LabVIEW, C, C++, MATLAB, Python. PIMikroMove user software.

## Plug-and-play installation in the C-885 PIMotionMaster

Can be inserted in any free slot. Automatic detection and external communication (USB, Ethernet) by the processor and interface module of the C-885. Can be expanded with optional digital inputs and outputs. Power via the power supply of the C-885.

- >> Extensive Software Package
- >> Q-Motion® Piezoelectric Inertia Drive

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<b>E-873.10C885</b>	
Function	Q-Motion® controller module for positioning systems with piezo inertia drives, for C-885 PIMotionMaster modular multi-axis controller system
Axes	1
Supported functions	Point-to-point motion. Startup macro. Data recorder for recording operating data such as motor voltage, velocity, position or position error. Internal safety circuitry: Watchdog timer. ID chip detection.
<b>Motion and control</b>	
Controller type	PID controller, parameter changing during operation
Encoder input	Analog encoder inputs sine-cosine, interpolation selectable to 20000; Interpolation electronics preset for differential transmission, 1 V <sub>pp</sub> and 2.5 V encoder offset signal; BiSS interface for absolute encoders
Stall detection	Automatic servo off
Input limit switch	2 × TTL (pull-up / pull-down, programmable)
Input reference point 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
<b>Interfaces and operation</b>	
Communication interfaces	USB or Ethernet, via C-885.M1 / C-885.M2 Digital Processor and Interface Module
Motor connection/sensor connection	Sub-D, 15 (f)
I/O lines	Optional with C-885.iD Digital Interface Module for PIMotionMaster: 4 analog/digital inputs (0 to 5V/TTL), 4 digital outputs (TTL)
Command set	PI General Command Set (GCS)
User software	PIMikroMove
Application programming interfaces	API for C / C++ / C# / VB.NET / MATLAB / Python, drivers for NI LabVIEW
<b>Miscellaneous</b>	
Operating voltage	24 V DC, supply via C-885 PIMotionMaster
Max. current consumption	1.5 A
Operating temperature range	10 to 40 °C
Mass	200 g
Dimensions	186.42 mm × 128.4 mm (3 RU) × 19.98 mm (4 HP)

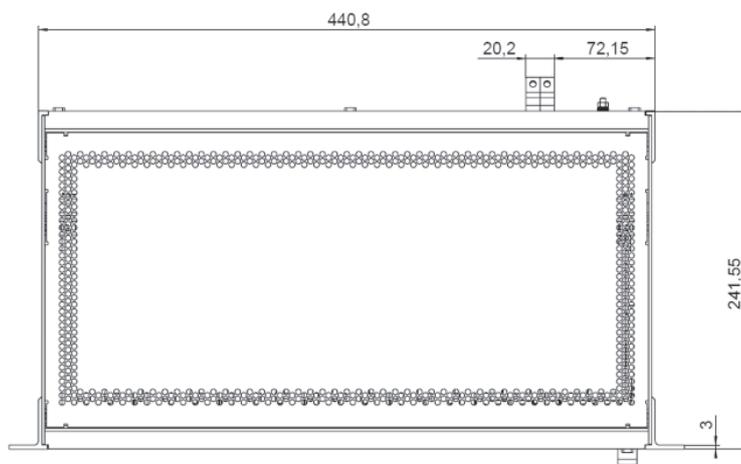
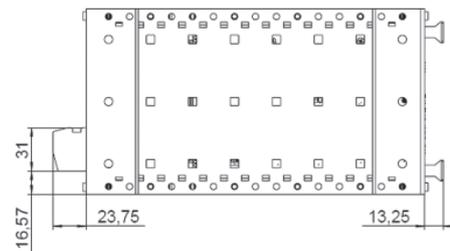
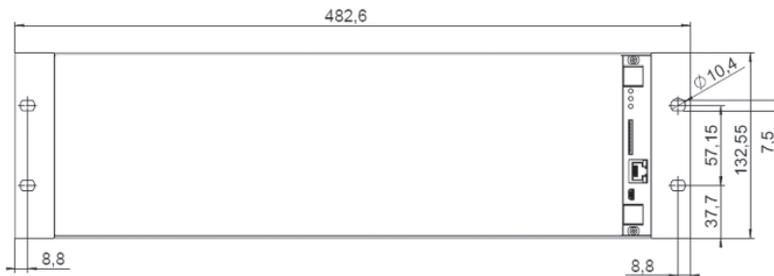
# C-886.31 Parallel Kinematics Controller

For Parallel-Kinematic Positioners with Q-Motion® Piezo Inertia Drive



- Sophisticated controller using vector algorithms
- Commanding in Cartesian coordinates
- Easy customization of coordinate systems by command
- Suitable for Q-Motion® SpaceFAB
- Can be optionally expanded by two single axes
- Extensive software package

C-886, dimensions in mm, here without drive modules



- >> Extensive Software Package
- >> Q-Motion® Piezoelectric Inertia Drive

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<b>C-886.31</b>	
Function	Controller for parallel-kinematic positioners
Axes	6 Optional: 2 additional single axes
<b>Motion and control</b>	
Drive type	Q-Motion® Piezo Inertia Drive Optional single-axis drive type
Motor connection	Sub-D 15 (f)
Controller type	PID controller
Servo cycle time of slave modules	50 µs
Cycle time of the C-886	10 ms
Encoder input	Sin / cos (differential), BiSS interface
Stall detection	Servo off, triggered by position error
Limit switches	2 × TTL per drive (polarity programmable)
Reference point switch	1 × TTL per drive
Characteristics of single axes	Depending on the drive type
<b>Electrical properties</b>	
Output voltage	0 to 48 V
Max. output power	30 W per drive
Characteristics of single axes	Depending on the drive type
<b>Interfaces and operation</b>	
Communication interfaces	TCP/IP: RJ45/Ethernet; USB: Mini-USB type B
Command set	PI General Command Set (GCS)
User software	PIMikroMove
Application programming interfaces	API for C / C++ / C# / VB.NET / MATLAB / Python, drivers for NI LabVIEW
Supported functions	User-defined coordinate system. Startup macro. Data recorder for recording operating data. Wave generator for periodic motion.
<b>Miscellaneous</b>	
Operating voltage	External power adapter 24 V / 10 A in the scope of delivery
Max. current consumption	32 A
Operating temperature range	10 to 40 °C
Mass	4.4 kg without drive modules for single axes
Dimensions	482.6 mm × 132.55 mm × 278.55 mm

# E-871.1A1N PiezoMike – Q-Motion® Controller

For Closed-Loop PiezoMikes, 1 Axis, TCP/IP, USB, RS-232 Interface

- Broadband encoder input
- Macro programmable for stand-alone functionality
- Data recorder
- ID chip support for quick startup
- Interfaces: TCP/IP, USB, RS-232, I/O
- Joystick for manual operation



## 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 precision positioning at the target position. 1 axis. For control of closed-loop PiezoMikes. Also suitable for Q-Motion® positioning systems (in applications which require silent travel (20 kHz)).

## Interfaces

TCP/IP, USB and RS-232 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 lines (analog/digital) for automation. Interface for analog joystick.

## Extensive functions, software support

Powerful macro command language. Nonvolatile macro storage, e.g., for stand-alone operation with autostart macro. Data recorder. ID chip detection for fast startup. PID controller, parameter changing during operation. Extensive software support, e.g., for NI LabVIEW C, C++, MATLAB, Python. PIMikroMove user software.

## Scope of Delivery

Scope of delivery includes wide-range-input power supply with power cord, USB, RS-232 cable, and network cable.

- >> Extensive Software Package
- >> PiezoMike Inertia Drive
- >> Q-Motion® Piezoelectric Inertia Drive

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<b>E-871.1A1N</b>	
Function	Controller for closed-loop PiezoMikes, also suitable for Q-Motion® positioners* Benchtop device with option for cabinet mounting
Drive type	Piezo inertia drive
Axes	1
Supported functions	Point-to-point motion. Startup macro. Data recorder for recording operating data such as motor voltage, position or position error. Internal safety circuitry: Watchdog timer. ID chip detection.
<b>Motion and control</b>	
Controller type	PID controller, parameter changing during operation
Encoder input	Analog encoder inputs sine-cosine, interpolation selectable to 20000; Interpolation electronics preset for differential transmission, 1 V <sub>pp</sub> and 2.5V encoder offset signal; BiSS interface for absolute encoders
Stall detection	Automatic servo off
Input limit switch	2 × TTL (pull-up / pull-down, programmable)
Input reference point 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
<b>Interfaces and operation</b>	
Communication interfaces	TCP/IP: RJ45/Ethernet; USB: Mini-USB type B; RS-232: Sub-D 9 (m)
Motor / sensor connection	Sub-D, 15 (f)
I/O lines	4 analog / digital inputs, 4 digital outputs
Command set	PI General Command Set (GCS)
User software	PIMikroMove
Application programming interfaces	API for C / C++ / C# / VB.NET / MATLAB / Python, drivers for NI LabVIEW
Manual control	Analog joystick
<b>Miscellaneous</b>	
Operating voltage	24 V DC from external power supply (included in the scope of delivery)
Max. current consumption	1.5 A
Operating temperature range	0 to 50 °C
Mass	0.36 kg
Dimensions	147 mm × 104.5 mm × 44 mm (incl. mounting rails)

\* For applications that require/desire silent travel (20 kHz) with point-to-point motion

# E-872.401 Q-Motion® Piezo Motor / PiezoMike Drive Electronics

## Drives up to 4 Linear Actuators, Benchtop Device

- For positioners with Q-Motion® piezo inertia drives and PiezoMike linear actuators
- Inexpensive, scalable multi-channel concept
- Integrated interfaces: TCP/IP, USB, USB for joystick, digital I/O
- Extensive software support



### Drive electronics for 4 piezo mechanics

Drivers for inertia drives (Q-Motion® and PiezoMike) without position sensor (open-loop operation). Drives up to 4 linear actuators: The integrated amplifier drives one axis at a time; switching between the channels is done via commands. Special variant is possible on request for operating up to 64 channels via external module.

### Features

Full-step and linear mode. Interfaces: TCP/IP, USB, USB for joystick, digital I/O.

### Extensive functions, software support

Powerful macro command language. Nonvolatile macro storage, e.g., for stand-alone operation with autostart macro. Data recorder. ID chip detection for fast startup. Extensive software support, e.g., for NI LabVIEW, C, C++, MATLAB, Python. PIMikroMove user software.

- >> Extensive Software Package
- >> PiezoMike Inertia Drive
- >> Q-Motion® Piezoelectric Inertia Drive

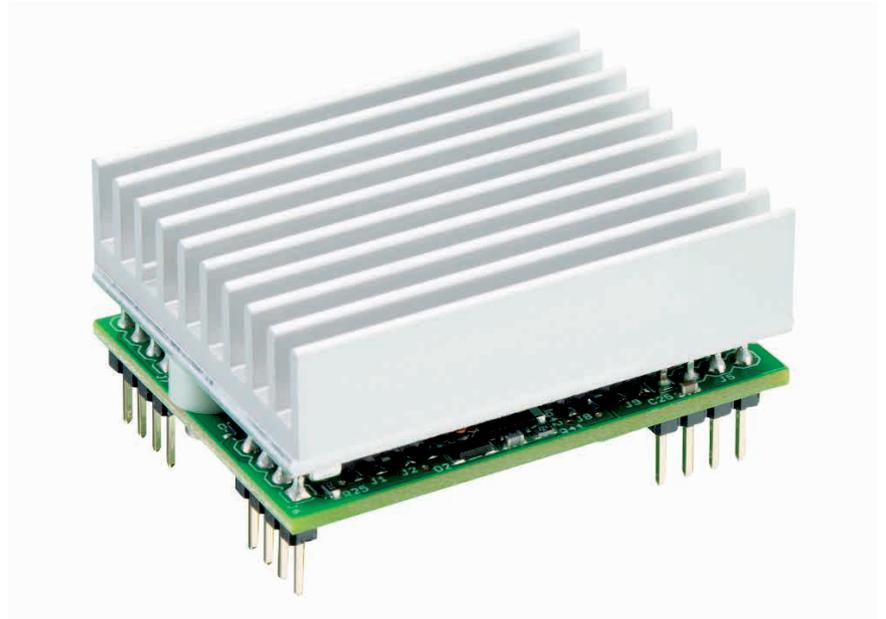
Technology Glossary ..... page 148

<b>E-872.401</b>	
Function	Driver electronics for Q-Motion® positioners and PiezoMike linear actuators; benchtop device
Drive type	Piezo inertia drive
Channels	4 scalable to 64 channels via external module (on request)
Supported functions	Full-step mode, linear mode (analog control)
<b>Amplifier</b>	
Amplifier channels	1 drives one axis at a time, the switching between the drive channels is done via commands
Output voltage	0 to 100 V
Peak power	30 W
Output current / channel (<5 ms)	±650 mA
<b>Interfaces and operation</b>	
Communication interfaces	USB, Ethernet
Actuator connection	4 x LEMO connector, 3-pin
Digital inputs	TTL inputs for commanding and configuration
Digital output	Error status
Command set	PI General Command Set (GCS)
User software	PIMikroMove
Application programming interfaces	API for C / C++ / C# / VB.NET / MATLAB / Python, drivers for NI LabVIEW
Display and indicators	LED indicator for status and operation
Manual control	Joystick via USB
<b>Miscellaneous</b>	
Operating temperature range	0 to 50 °C
Overtemperature protection	Deactivation at 75 °C
Dimensions	147 mm × 125 mm × 40 mm
Mass	0.46 kg
Operating voltage	24 V (power adapter in the scope of delivery)
Max. power consumption	35 W

# E-872 Q-Motion® Piezomotor Driver Electronics, OEM Board

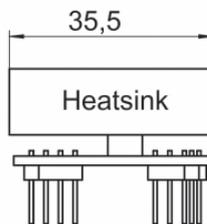
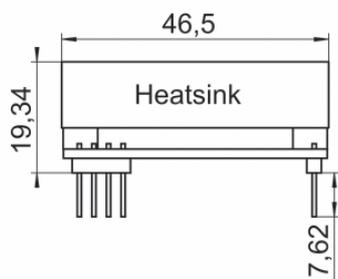
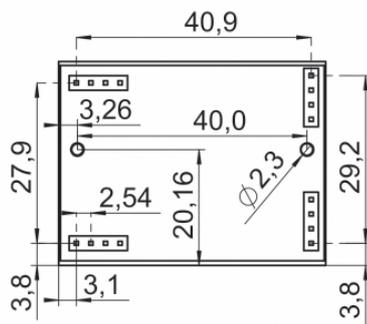
## Easy and Inexpensive Integration into OEM Applications

- Easy to integrate
- Compact design
- Versatile and inexpensive
- Can be used for all Q-Motion® stages



E-872, dimensions in mm

Footprint (Bottom View)



**Compact driver module for piezo inertia drives**  
1 channel. Compatible with all Q-Motion® stages. Easy control via TTL signals for step and direction. 20 kHz step frequency for the highest dynamics.

### Full and microstep variants

Microstep variants with 8-bit resolution for the highest precision or full step variant for particularly easy integration and low voltage drop. External temperature monitoring by integrated sensor via SMBus. Low current consumption at rest.

- >> Extensive Software Package
- >> Q-Motion® Piezoelectric Inertia Drive

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	<b>E-872.01</b>	<b>E-872.02</b>
Function	Driver module for Q-Motion® piezo inertia drives, OEM card with solder pins, for full step operation	Driver module for Q-Motion® piezo inertia drives, OEM card with solder pins, for microstep operation
Drive type	Piezo inertia drive	Piezo inertia drive
Channels	1	1
<b>Amplifier</b>		
Control in	TTL signals for steps and motion direction	TTL signals for steps and motion direction
Maximum full step frequency	20 kHz	20 kHz (corresponds to 5.1 MHz microstep frequency)
Microsteps per full step	–	256
<b>Electrical properties</b>		
Max. output current (<8 ms)	600 mA	600 mA
Current limitation	Short-circuit proof	Short-circuit proof
Output voltage	0 to 48 V	0 to 48 V
<b>Interfaces and operation</b>		
Control connection	Pin header, 4-pin	Pin header, 4-pin
Motor connector	Pin header, 4-pin	Pin header, 4-pin
Temperature sensor connection	Pin header, 4-pin	Pin header, 4-pin
Voltage connection	Pin header, 4-pin	Pin header, 4-pin
Supported functions	Temperature monitoring via SMBus	Temperature monitoring via SMBus
<b>Environment</b>		
Operating voltage	48 V DC	48 V DC
Max. current consumption	0.62 A	0.62 A
Operating temperature range	5 to 50 °C	5 to 50 °C
Mass	39 g	39 g
Dimensions	46.5 mm × 35.5 mm × 24.84 mm (with pin headers)	46.5 mm × 35.5 mm × 24.84 mm (with pin headers)

Ask about custom designs!

# Accessories



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<b>Adapter Plates and Brackets for Multi-Axis Combinations</b> .....	<b>132</b>
Q-122 Adapter Bracket .....	132
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Q-121 Adapter Brackets and Adapter Plate .....	138
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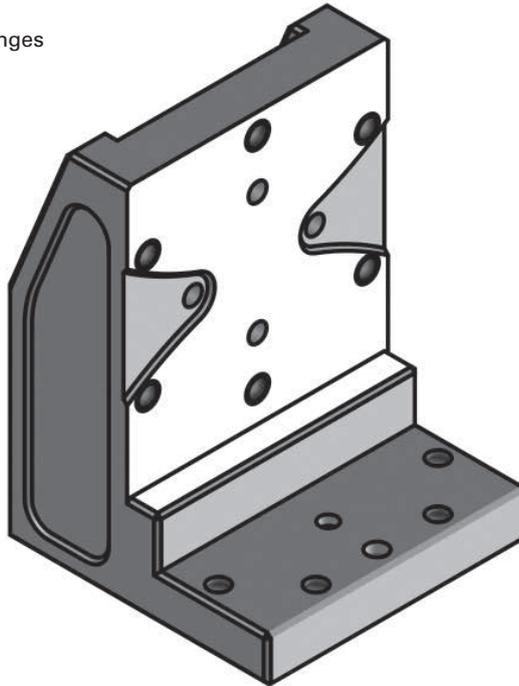
<b>Adapter and Extension Cables</b> .....	<b>147</b>
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# Q-122 Adapter Bracket

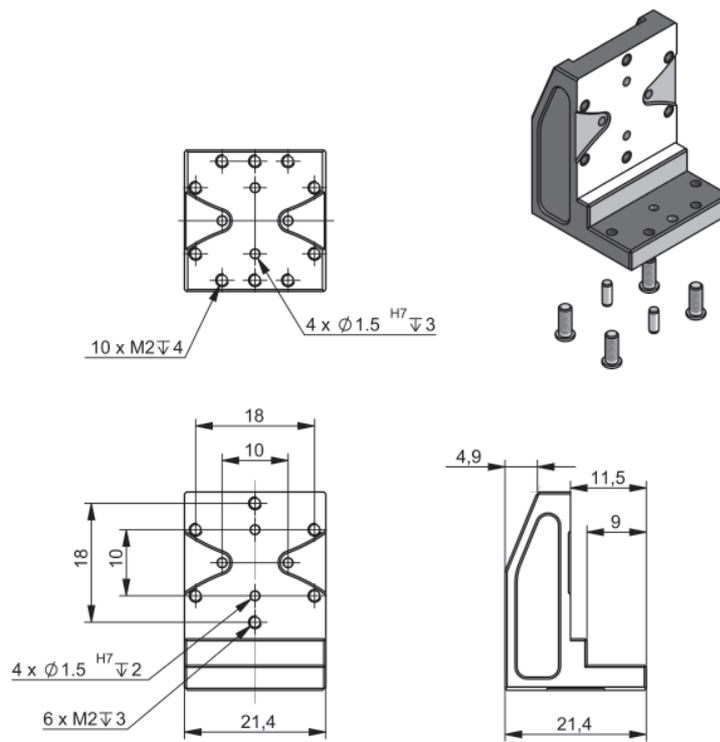
## For Vertical Mounting of Q-522 Miniature Linear Stages

- For vertical mounting
- For axes with 6.5 to 26 mm travel ranges
- UHV version without anodization

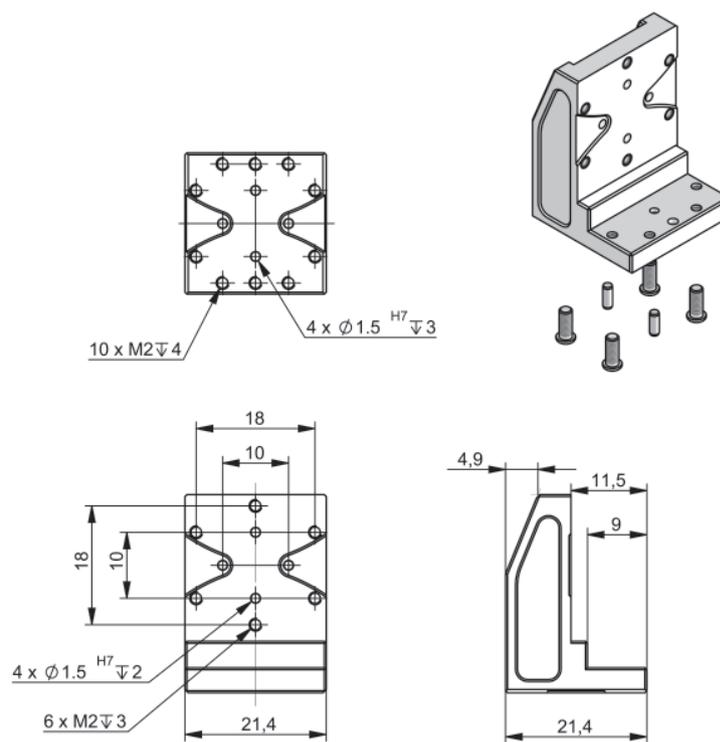


<b>Q-122.000</b>	Adapter bracket for vertical mounting of Q-522 miniature linear stages with 6.5 mm travel range
<b>Q-122.00U</b>	Adapter bracket for vertical mounting of Q-522 miniature linear stages with 6.5 mm travel range, vacuum compatible to $10^{-9}$ hPa
<b>Q-122.100</b>	Adapter bracket for vertical mounting of Q-522 miniature linear stages with 13 mm travel range
<b>Q-122.10U</b>	Adapter bracket for vertical mounting of Q-522 miniature linear stages with 13 mm travel range, vacuum compatible to $10^{-9}$ hPa
<b>Q-122.200</b>	Adapter bracket for vertical mounting of Q-522 miniature linear stages with 26 mm travel range
<b>Q-122.20U</b>	Adapter bracket for vertical mounting of Q-522 miniature linear stages with 26 mm travel range, vacuum compatible to $10^{-9}$ hPa

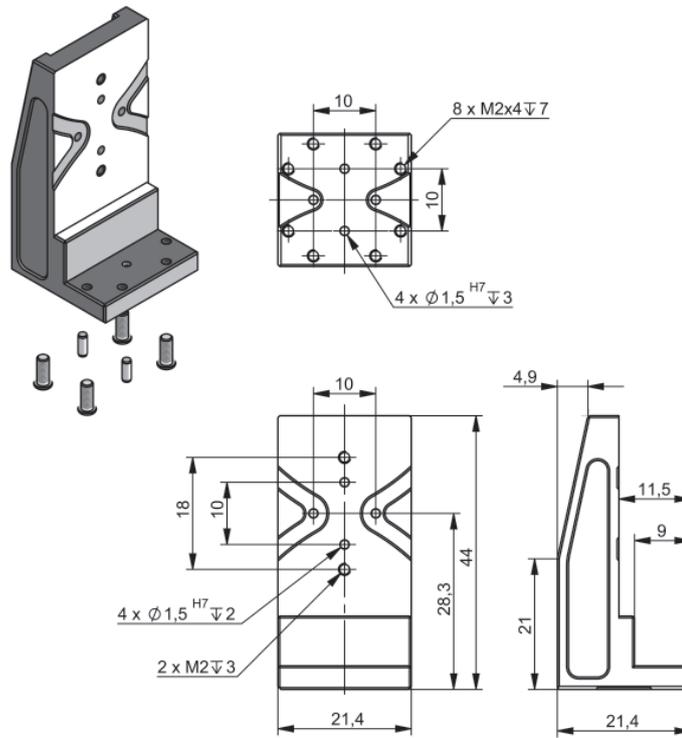
Adapter bracket Q-122.000,  
dimensions in mm



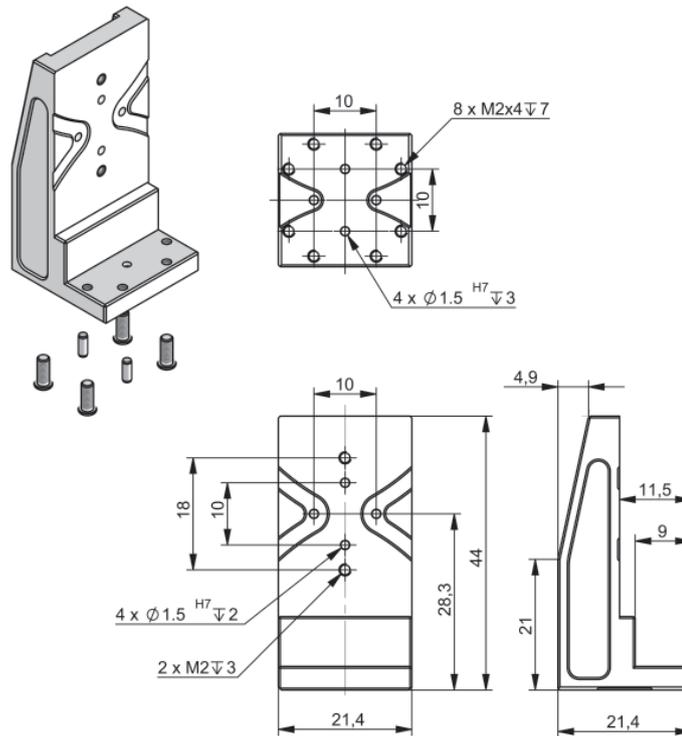
Adapter bracket Q-122.00U,  
dimensions in mm



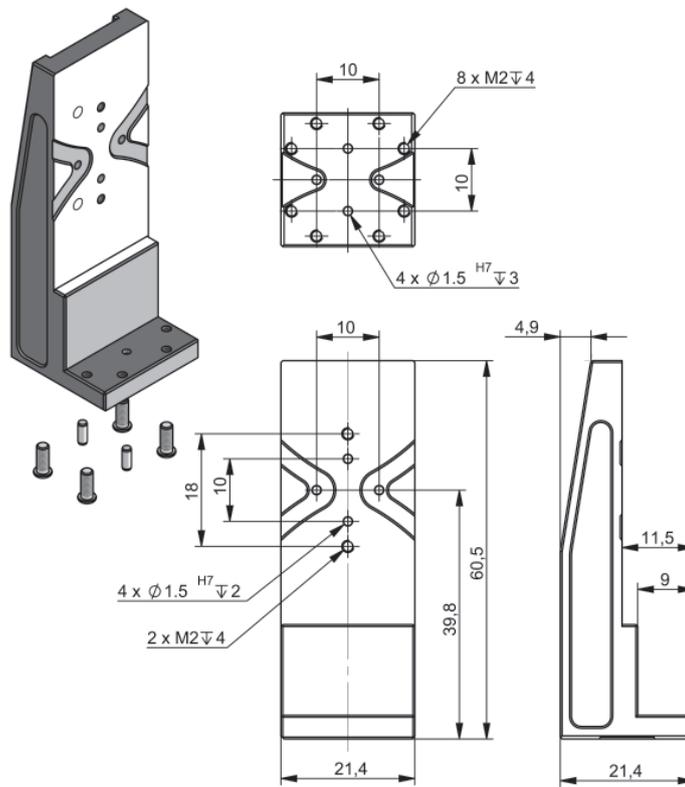
Adapter bracket Q-122.100,  
dimensions in mm



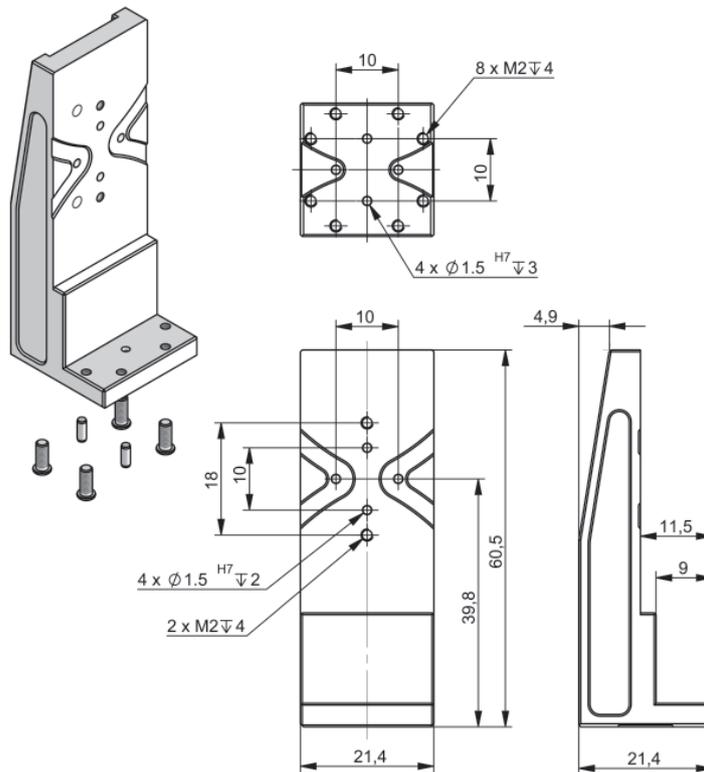
Adapter bracket Q-122.10U,  
dimensions in mm



Adapter bracket Q-122.200,  
dimensions in mm



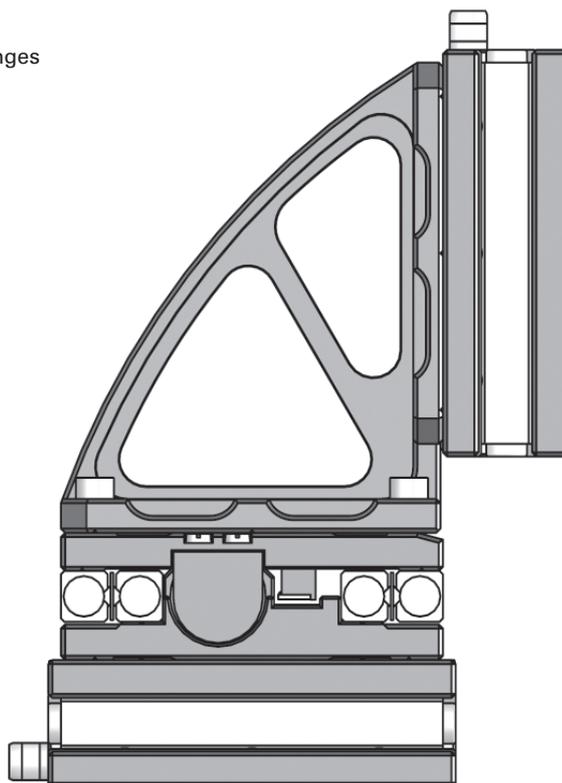
Adapter bracket Q-122.20U,  
dimensions in mm



# Q-145 Adapter Bracket

## For Vertical Mounting of Q-545 Linear Stages

- For vertical mounting
- For axes with 13 to 26 mm travel ranges
- UHV version without anodization

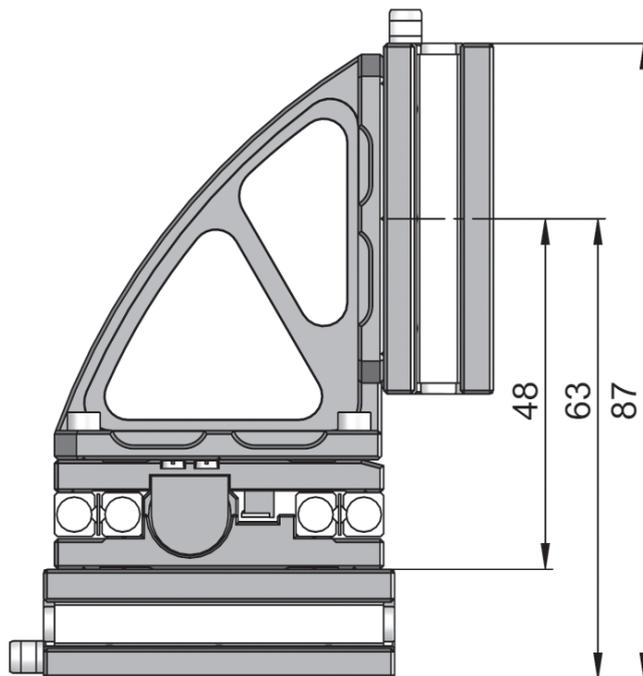


<b>Q-145.1001</b>	Adapter bracket for vertical mounting of Q-545 linear stages with 13 mm travel range
<b>Q-145.10U1</b>	Adapter bracket for vertical mounting of Q-545 linear stages with 13 mm travel range, vacuum compatible to $10^{-9}$ hPa
<b>Q-145.200</b>	Adapter bracket for vertical mounting of Q-545 linear stages with 26 mm travel range
<b>Q-145.20U</b>	Adapter bracket for vertical mounting of Q-545 linear stages with 26 mm travel range, vacuum compatible to $10^{-9}$ hPa

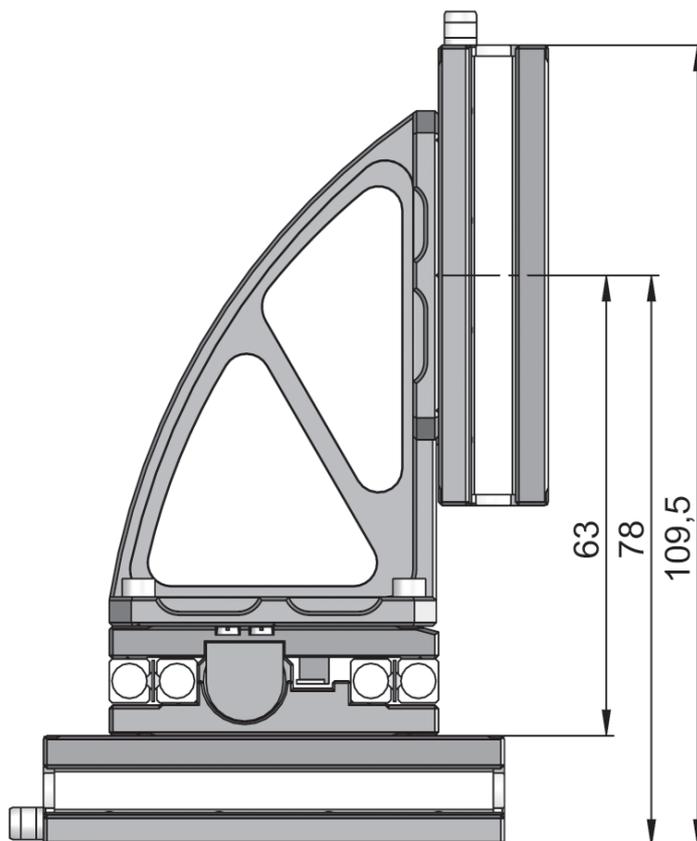
Delivery includes:

- 2 dowel pins A2 2.5 m6 x 4 ISO 2338
- 4 socket head cap screws A2 M2.5x8 ISO 4762

Q-145.1xxx, dimensions in mm



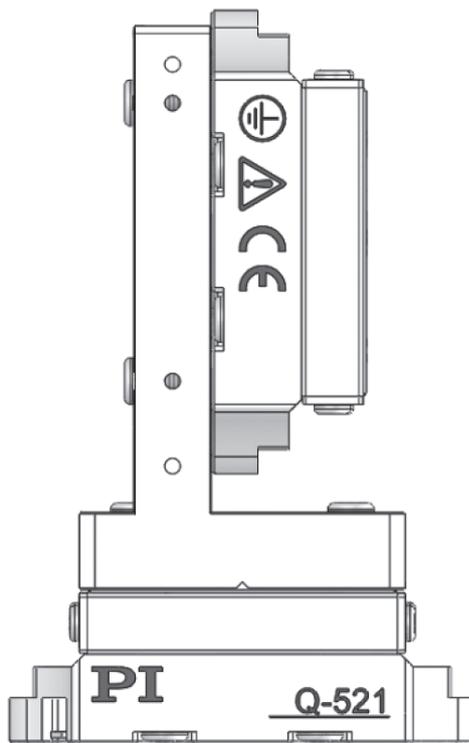
Q-145.2xx, dimensions in mm



# Q-121 Adapter Brackets and Adapter Plate

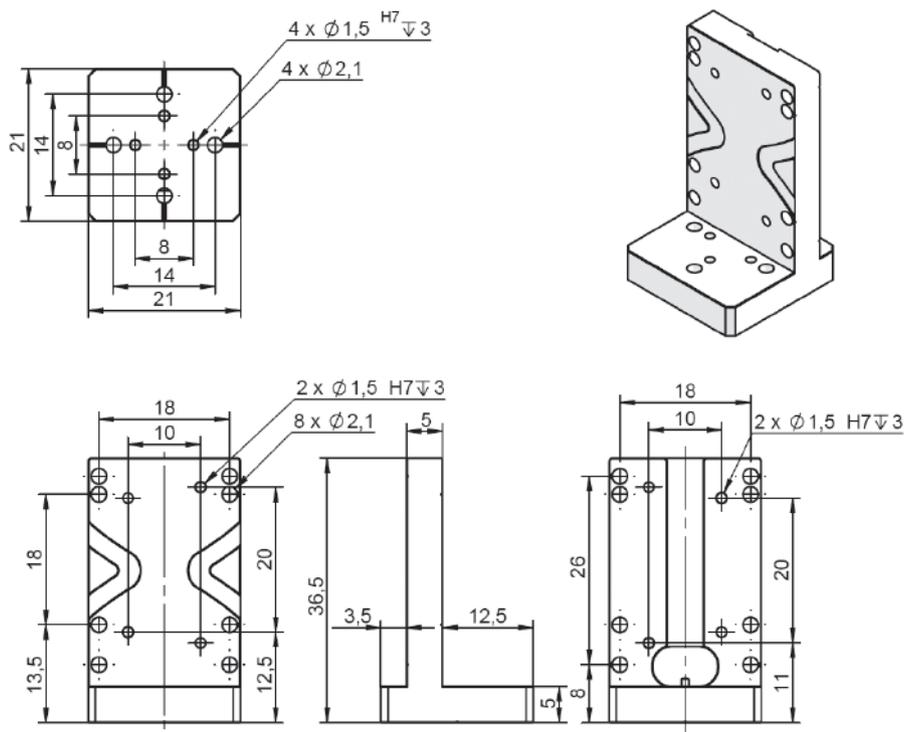
## For Mounting Q-521 Miniature Linear Stages

- For setup of multi-axis systems
- For vertical and XY mounting
- For travel ranges of 12, 22, and 32 mm

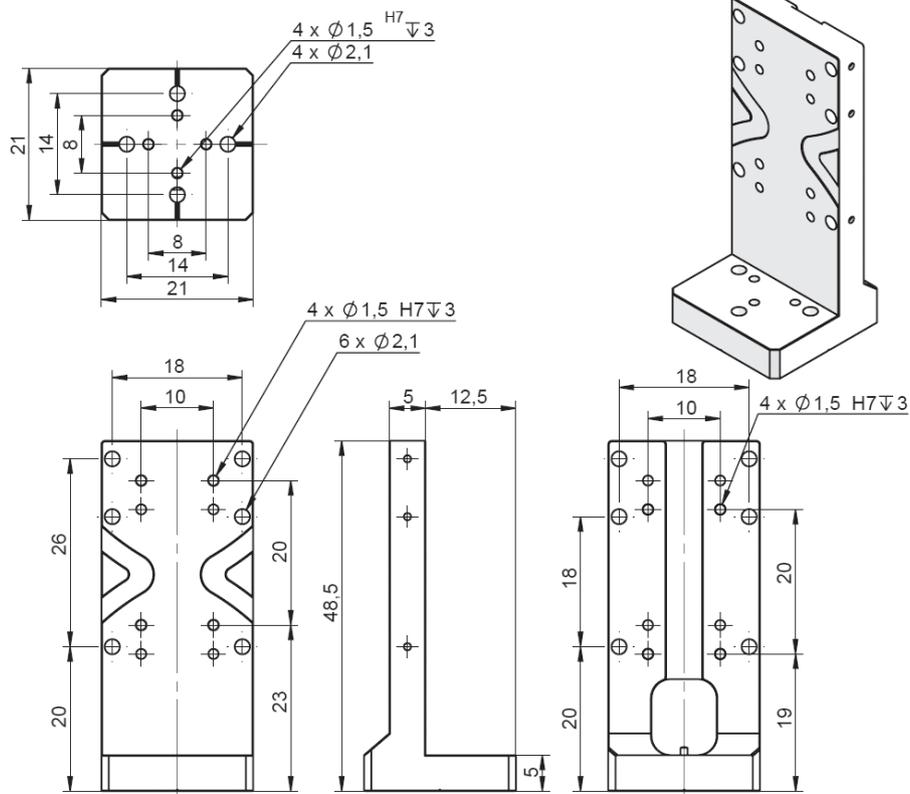


<b>Q-121.10U</b>	Adapter bracket for vertical mounting of Q-521 miniature linear stages with 12 mm travel range, not anodized
<b>Q-121.20U</b>	Adapter bracket for vertical mounting of Q-521 miniature linear stages with 22 mm travel range, not anodized
<b>Q-121.30U</b>	Adapter bracket for vertical mounting of Q-521 miniature linear stages with 32 mm travel range, not anodized
<b>Q-121.80U</b>	Adapter plate for XY mounting of Q-521 miniature linear stages, not anodized

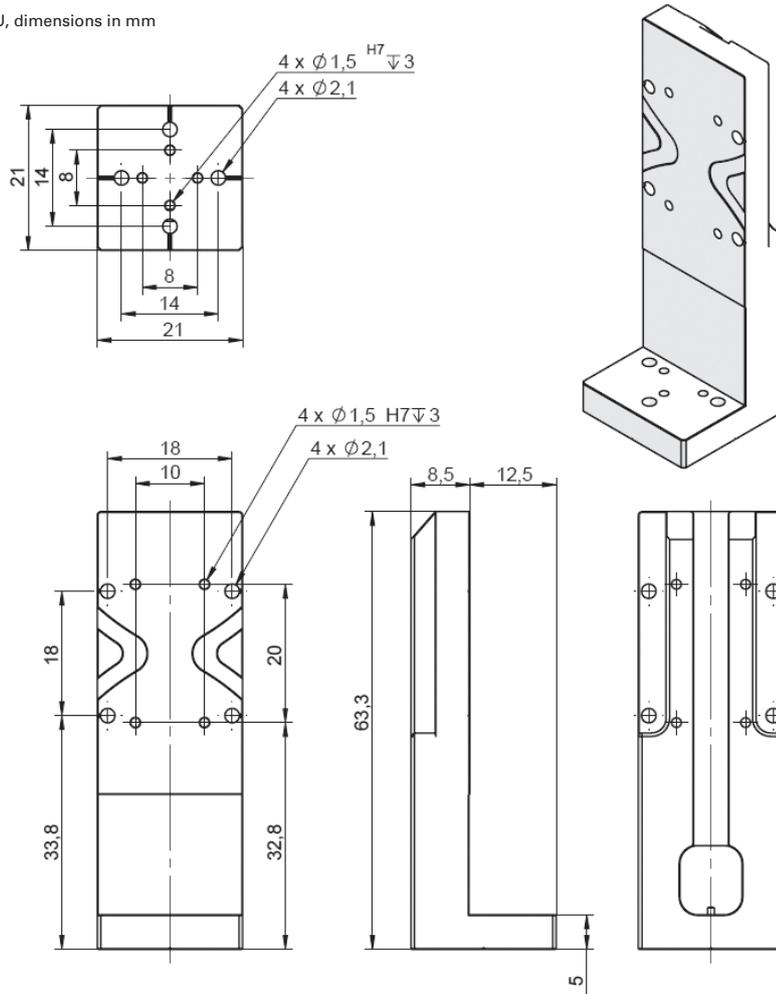
Adapter bracket Q-121.10U, dimensions in mm



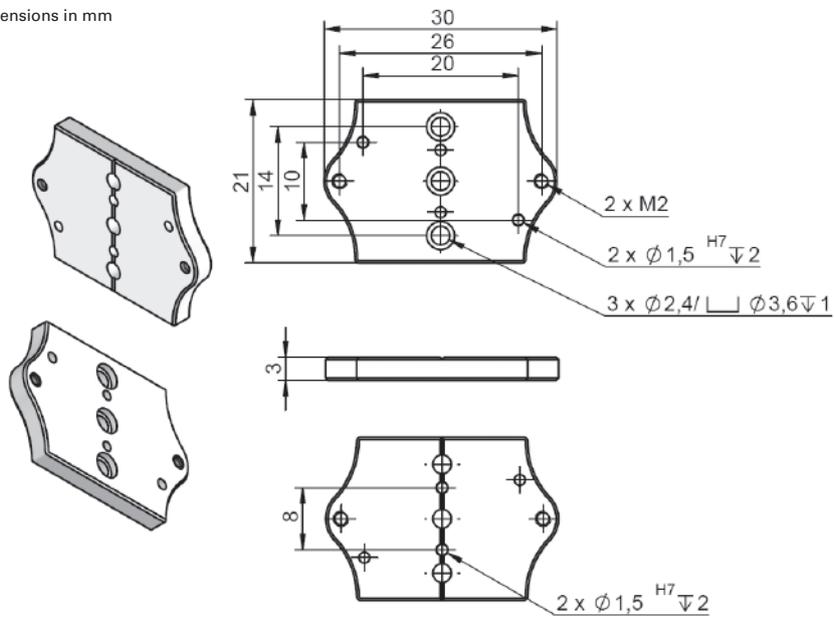
Adapter bracket Q-121.20U, dimensions in mm



Adapter bracket Q-121.30U, dimensions in mm



Adapter plate Q-121.80U, dimensions in mm



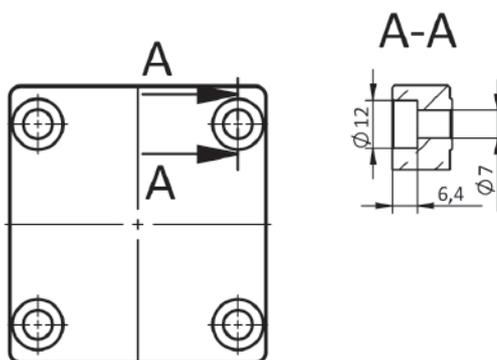
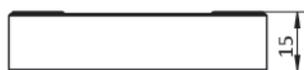
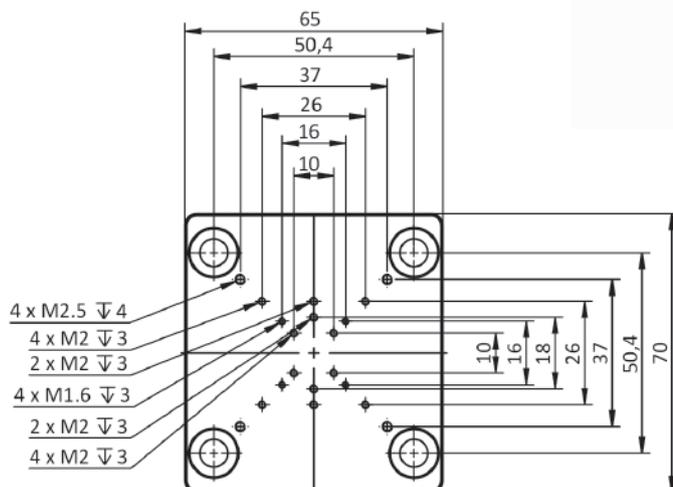
## Q-101.AP1 Adapter Plate

For Q-Motion® Positioners on Plug-in Boards with 25-mm or 1-inch Grid

- Easy mounting of Q-Motion® positioners on plug-in boards
- For plug-in boards with 25-mm or 1-inch grid
- Black anodized



Q-101.AP1 adapter plate, dimensions in mm



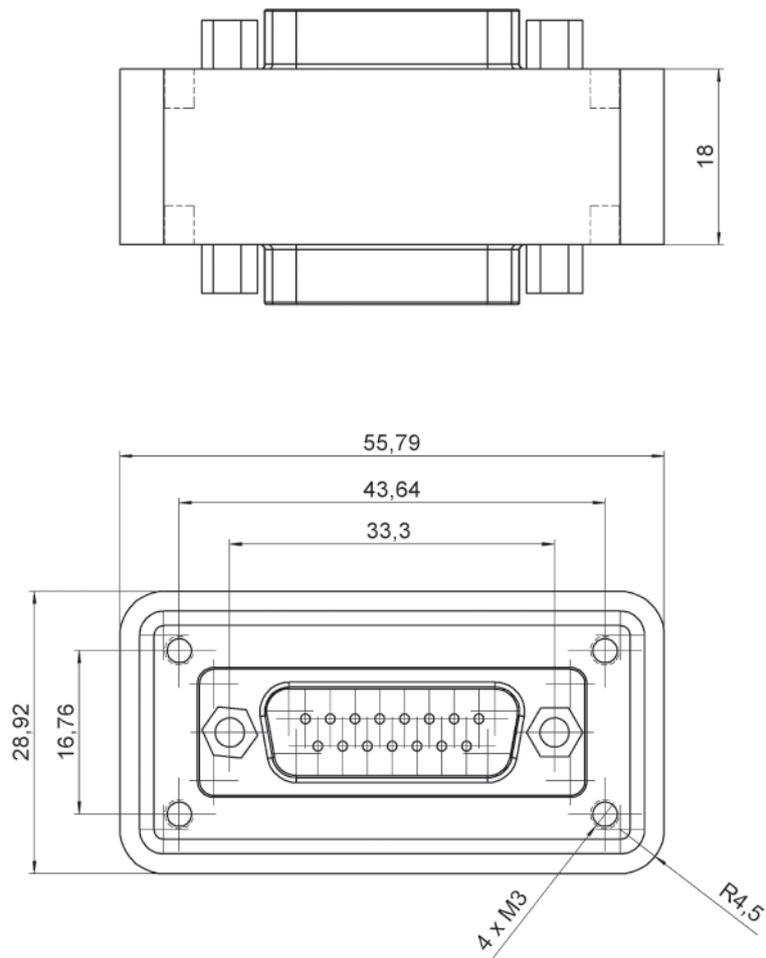
# Vacuum Feedthroughs for $10^{-6}$ hPa

Suitable for Q-Motion® stages and controllers

C-815.VF

Vacuum feedthrough for drive and sensor signals, Sub-D 15 (m/f)

C-815.VF vacuum feedthrough Sub-D 15 (m/f), dimensions in mm.  
Note that the decimal places are separated by a comma in the drawings.



# Vacuum Feedthroughs for $10^{-9}$ hPa

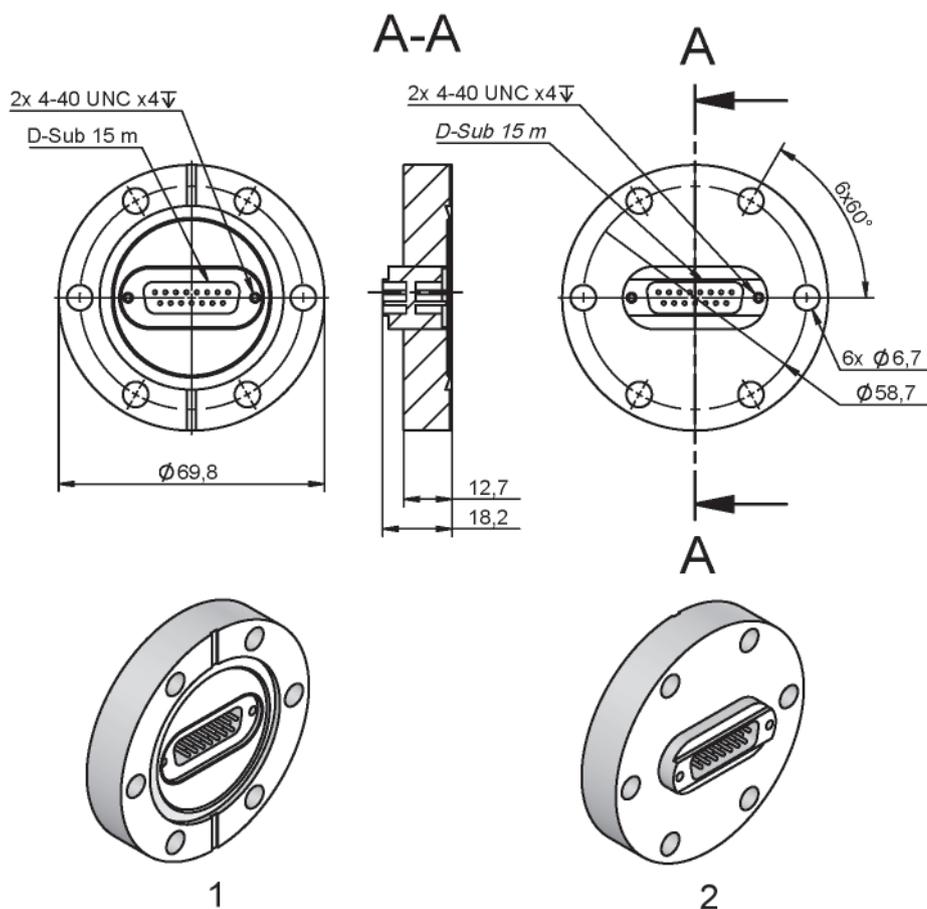
Suitable for Q-Motion® stages and controllers

**C-815.VFU1**

Vacuum feedthrough for drive and sensor signals, Sub-D 15 (m/m), DN40CF

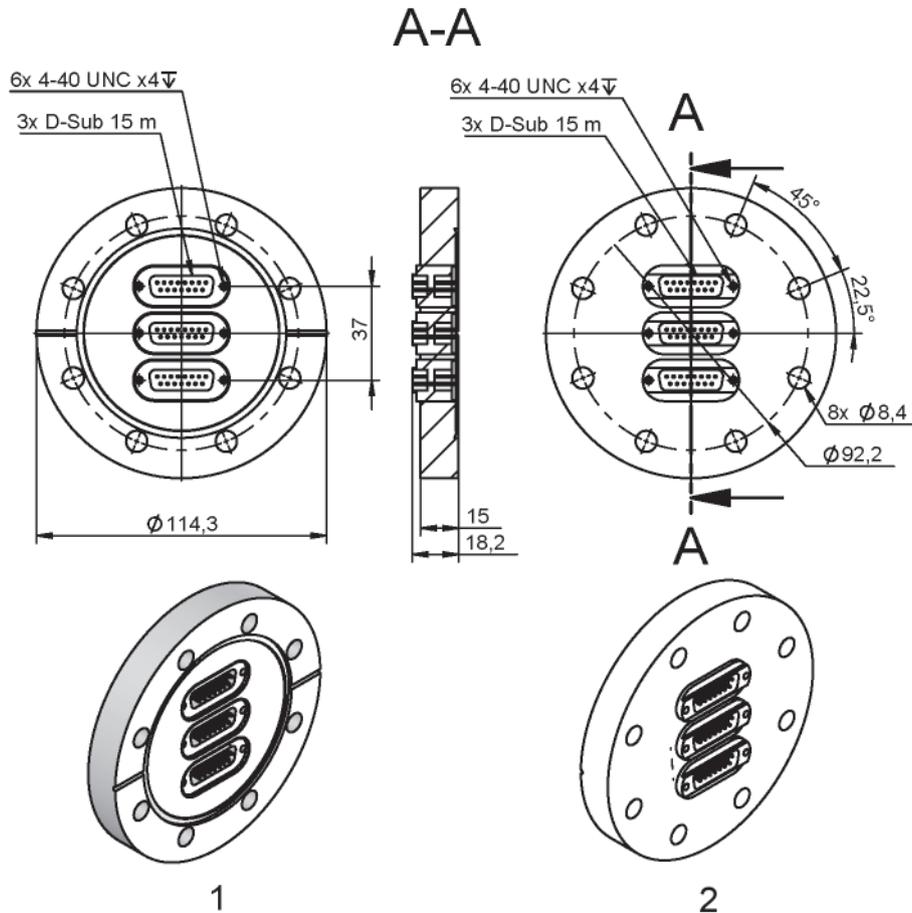
C-815.VFU1 vacuum feedthrough, Sub-D 15 (m/m), dimensions in mm.  
Note that the decimal places are separated by a comma in the drawings.

- 1 Vacuum side
- 2 Air side



C-815.VFU3 vacuum feedthrough, Sub-D 15 (m/m), dimensions in mm.  
Note that the decimal places are separated by a comma in the drawings.

- 1 Vacuum side
- 2 Air side

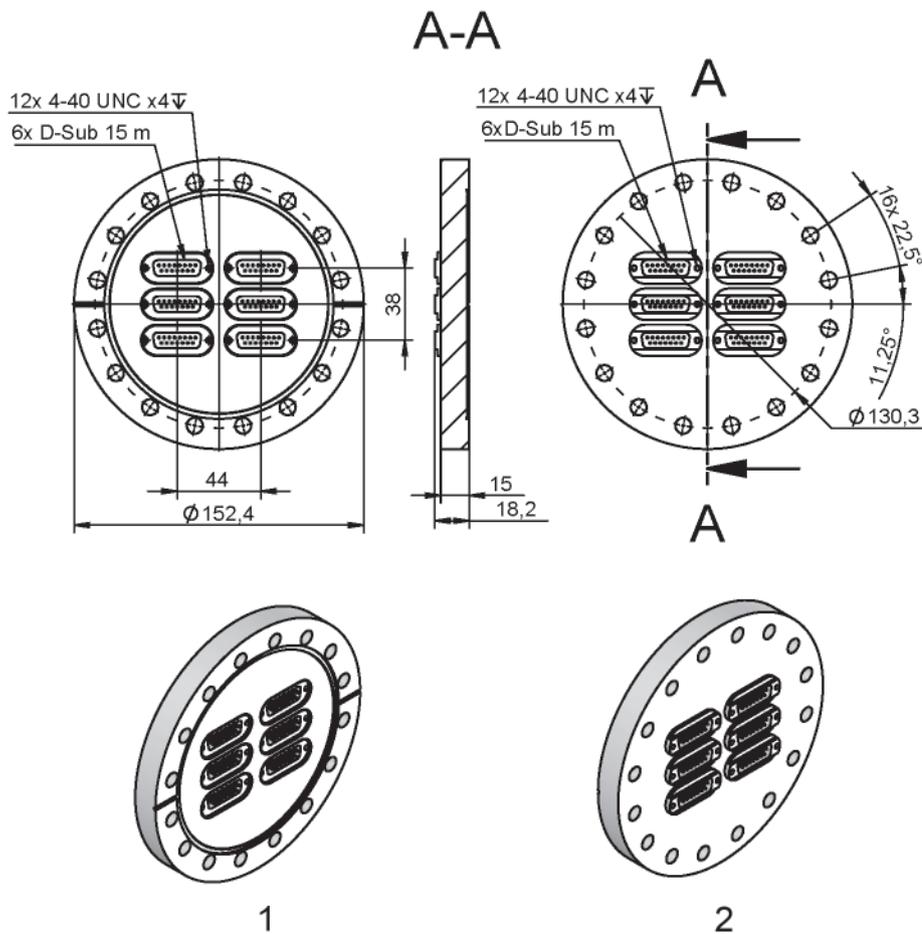


**C-815.VFU6**

Vacuum feedthrough for drive and sensor signals, 6 x Sub-D 15 (m/m), DN100CF

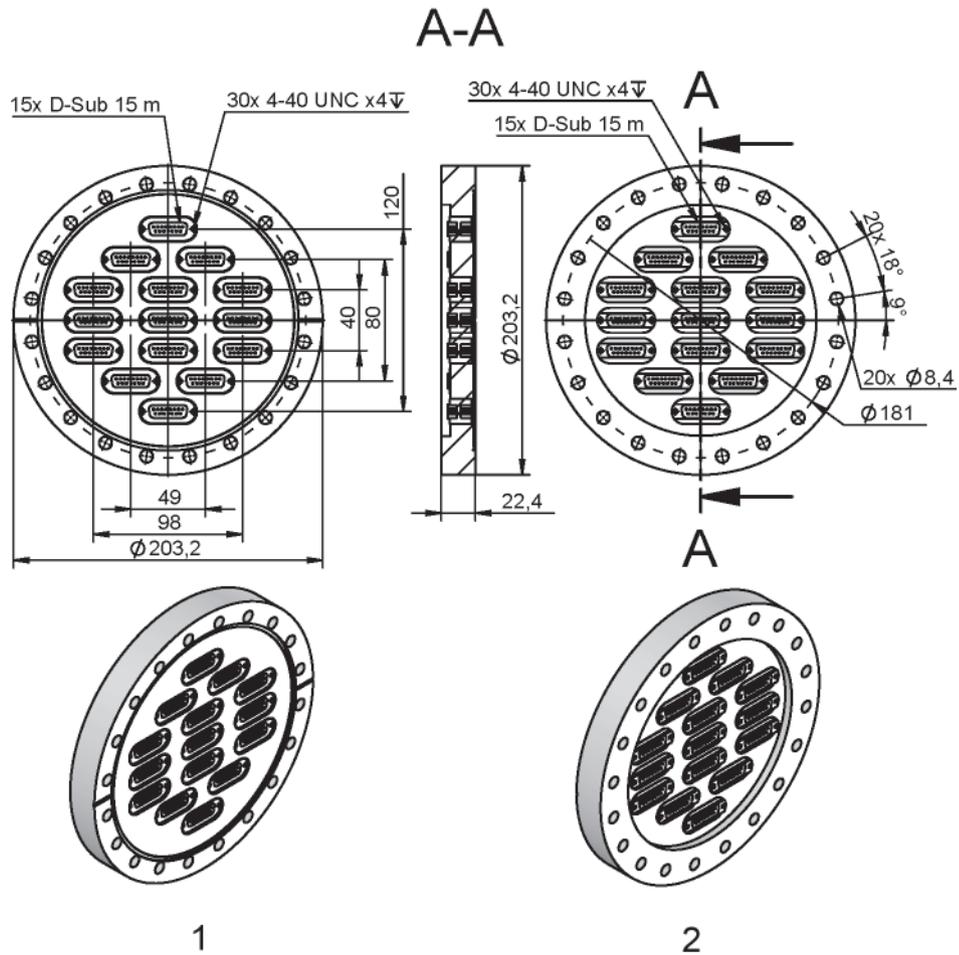
C-815.VFU6 vacuum feedthrough, Sub-D 15 (m/m), dimensions in mm.  
Note that the decimal places are separated by a comma in the drawings.

- 1 Vacuum side
- 2 Air side



C-815.VFU15 vacuum feedthrough, Sub-D 15 (m/m), dimensions in mm.  
Note that the decimal places are separated by a comma in the drawings.

- 1 Vacuum side
- 2 Air side



# Adapters and Extension Cables

<b>For PLine® Stages</b>	
U-600.A01	Extension cable for PLine®, Sub-D 15-pin, 1 m
U-600.A03	Extension cable for PLine®, Sub-D 15-pin, 3 m
U-600.A05	Extension cable for PLine®, Sub-D 15-pin, 5 m
U-600.A08	Extension cable for PLine®, Sub-D 15-pin, 8 m
U-600.A10	Extension cable for PLine®, Sub-D 15-pin, 10 m
U-600.AMD	PLine® adapter cable MDR14 (m) to Sub-D 15 (m) 1.5 m
U-600.ADM	PLine® adapter Sub-D 15 (f) to MDR14
<b>For PiezoMike Actuators</b>	
N-400.A02	Extension cable, LEMO 3-pin to LEMO 3-pin, 2 m
N-400.A05	Extension cable, LEMO 3-pin to LEMO 3-pin, 5 m
N-400.A08	Extension cable, LEMO 3-pin to LEMO 3-pin, 8 m
N-400.A12	Extension cable, LEMO 3-pin to LEMO 3-pin, 12 m
N-400.ALM	Adapter LEMO 3-pin to mini DIN
N-400.AML	Adapter mini DIN to LEMO 3-pin
<b>For Q-Motion® Stages</b>	
E-873.UHV1	Air-side extension cable from vacuum feedthrough or Q-545.xx0 to the adapter cable to the electronics, Sub-D 15 (f) to Sub-D 15 (m), 1 m
E-873.UHV2	Air-side extension cable from vacuum feedthrough or Q-545.xx0 to the adapter cable to the electronics, Sub-D 15 (f) to Sub-D 15 (m), 2 m
E-873.UHV3	Air-side extension cable from vacuum feedthrough or Q-545.xx0 to the adapter cable to the electronics, Sub-D 15 (f) to Sub-D 15 (m), 3 m

# Terms and Technology Glossary

## A

### Absolute encoder

Absolute encoders are used for detecting the position and provide information on the absolute position of a motion platform. For example, this can be realized optically by using an additional Pseudo Random Code (PRC) scale.

## C

### Closed-loop operation

Piezo servo controllers have additional circuitry for position sensing and servo-control that compensates for nonlinearity, hysteresis, and creep. Displacement of the piezo is controlled by an analog signal. Positioning accuracy and repeatability down to the subnanometer range is possible, depending on the piezo mechanics and sensor type. High-resolution position sensors provide optimum positional stability and fast response in the nanometer range. The integrated notch filters (adjustable for each axis) improve stability and allow high bandwidth operation closer to the resonant frequency of the mechanics.

PI piezo drivers for PICMA<sup>®</sup> actuators have an output voltage range of up to -30 to +135 V to provide enough margin for the servo-controller to compensate e.g. for load changes. See "Open-loop operation", "Capacitive sensors", "Strain gauge sensors".

### Crossed roller guide

Crossed roller guides are comparatively stiff and manage with low preload. This results in reduced friction with high load capacity, high guiding accuracy, and smooth running. An additional forced cage control helps to prevent the roller bearing from creeping. Nevertheless, this shortens the possible travel range over the same axis length.

### Crosstalk

Deviation from the ideal motion in axes perpendicular to the direction of motion.

Angular errors are  $rxr = \text{roll}$ ,  $xry = \text{pitch}$ ,  $xrz = \text{yaw}$ . Linear errors are lateral runout such as  $xty = \text{straightness}$ ,  $xtz = \text{flatness}$ . See "Linearity error".

### Current consumption

Current consumption of the system on supply end. It is specified for controller without load. Alternatively, power consumption.

### Current limitation

Short-circuit protection.

## D

### Design resolution

The theoretical minimum movement that can be made. Design resolution must not be confused with minimum incremental motion. In indirect position measurement methods, values for spindle pitch, gear ratio, motor or sensor/encoder resolution, for example, are included in the calculation of the resolution; normally it is considerably below the minimum incremental motion of a mechanical system. Indirect measurement methods, the resolution of the sensor is specified.

### Direct metrology

Position measuring is performed with the highest accuracy directly at the motion platform so that nonlinearity, mechanical play or elastic deformation have no influence on position measuring. This is achieved by noncontact optical linear encoders. Precision positioning systems use different encoder types as position sensor: Incremental encoders with different accuracy levels, absolute-measuring encoders that additionally make referencing unnecessary when a machine is switched on again, and for travel ranges under 2 mm, capacitive sensors.

### Drive type

Defines the types of drive supported by the controller / driver, such as DC motors, piezo stepping drives, piezo actuators.

## E

### Encoder

An encoder is used for determining the position. Basically, a difference is made between linear and rotary encoders, which, depending on the configuration, operate either incrementally or absolutely.

### Encoder input

Maximum bandwidth (-3 dB) of the input signals for the encoder input.

### Extensive software package

To make systems more user friendly, software plays an important role in positioning systems. Customers expect a plug-and-play solution even if several positioning systems are combined or different drive systems need to interact, and that is why PI (Physik Instrumente) provides PIMikroMove<sup>®</sup> host software. You only need to enter your parameters into the application to avoid programming altogether. Also supports a number of text-based

languages, has its own LabVIEW, Python and Matlab drivers, and the software is compatible with Windows, Linux, and OSX. However, not all software tools may be available for all controller versions.

## F

### Flatness

See "Crosstalk".

### Flexure guiding system

Piezo systems from PI (Physik Instrumente) use lever-amplified piezo actuators as the drive, e.g., when adjusting optical lenses. For optimum results regarding dynamics and accuracy, it is necessary to ascertain and optimize the mechanical and piezoelectric properties such as the guiding accuracy, crosstalk or temperature-related drift in the overall system. Friction-free flexure guides that allow hysteresis-free motion steer the motion and retain the stiffness. Very small, but subnanometer precision motion is transferred to the required system motion by using lever amplification.

## I

### ID chip

An ID chip is located in the connector of many piezo stages. When the stage is calibrated at the factory with a digital controller, the calibration data is saved together with specific product information on the ID chip. When switched on, digital electronics read the data from the ID chip of the connected stage. Stages, whose ID chip contains the calibration data, can therefore be connected to any suitable digital electronics without renewed calibration.

### Incremental encoder

When incremental encoders are in motion, they generate impulses that are counted by the controller. However, in contrast to absolute encoders, it is a question of determining a relative position. To determine an absolute position, a limit switch or reference point switch signal must also be referenced.

### Input level

Permissible input level for digital interfaces.

### Integrated feedback sensor

Absolute measuring capacitive, piezo resistive (PRS) or strain gauge (SGS) and optical (absolute and relative) sensors are used to provide position information to the controller.

## L

### Lateral force, max.

Maximum lateral force perpendicular to the operating direction. For piezo systems the lateral force is limited by the piezo actuator and the flexure designs. For XY stages the push / pull force capacity of the other module (in its operating direction) limits the lateral force that can be tolerated.

### Limit switch

Function: Optical, magnetic.

### Linear amplifier / driver

Most piezo drivers use linear amplifiers (class AB) to generate the output voltage. In open-loop (voltage-controlled) piezo operation the amplifier output voltage is determined by an analog input optionally combined with a DC offset.

### Linear ball guiding

Linear ball guides require exact tolerances between the guide and bearing in order to keep the play and friction as low as possible. This limits the load capacity. Due to the simple design, they are only suitable for inexpensive applications with comparatively low requirements.

### Linear encoder

Linear encoders measure the position directly at the motion platform. As a rule, this means that a higher accuracy is achieved compared to rotary encoders, because nonlinearity, mechanical play, and elastic deformation have no influence.

### Linearity error

Deviation in motion direction, of measured position from commanded position (positioning accuracy). Measured with an external, traceable device. The value is given as a percentage of the entire measuring range.

Measurement of the linearity error: The target and measured actual values of the positions are plotted against each other, a line is drawn through the first and last data point, and the maximum absolute deviation is determined. A linearity error of 0.1 % corresponds to an area of  $\pm 0.1$  % around the ideal line. Example: A linearity error of 0.1 % over a measuring range of 100  $\mu\text{m}$  produces a possible maximum error of 0.1  $\mu\text{m}$ .

### Linearization

Digital piezo controllers offer the best positioning accuracy through linearization algorithms with higher-order polynomials. The linearity error with capacitive sensors can be reduced to less than 0.01 %. See "Dynamic digital linearization", "Sensor linearization".

# Terms and Technology Glossary

## Load capacity

Maximum vertical load, when the stage is mounted horizontally. Limited by the flexure designs or the load capacity of the piezo actuators.

## M

### Magnetic bearing

Magnetic levitation allows excellent linear and rotational guiding accuracy on a plane. The passive runner hovers on a magnetic field and is then actively guided by it. Flatness errors are measured and compensated by very accurate noncontact sensors. Contrary to air bearings, which are also very accurate, magnetic bearings can also be used in vacuum.

## N

### NEXACT® Piezo walking drive

Precision piezomotor that creates the walking motion by means of piezo bending elements, in order to move a runner. The drives are very compact and achieve relatively high velocities around 10 mm/s, and forces up to 10 N. A suitable selection of the piezo elements optimizes step size, clamping force, velocity, and stiffness for the respective applications.

### NEXLINE® Piezo walking drive

High-load piezomotor that combines piezo clamping and shear actuators, in order to move a runner. The drives feature particularly high force and stiffness of several 100 N. They are capable of dynamically compensating oscillations in the range of a few micrometers with nanometer resolution. Furthermore the drives are designed for positioning and holding forces of up to 800 N, and work at velocities of about 1 mm/s.

### Noise

For capacitive sensors. In extended measurement ranges, noise is considerably higher than in the nominal measurement range.

### Nonlinearity

See "Linearity error".

## O

### Open-loop operation

The actuator is used without a position sensor. Displacement roughly corresponds to the drive voltage. Creep, nonlinearity

and hysteresis remain uncompensated. Open-loop operation is ideal for applications where fast response and very high resolution with maximum bandwidth are essential. Here, commanding and reading the target position in absolute values is either not important or carried out by external position sensors. Open-loop operation is not possible for electro-magnetic direct drives, such as linear motors and voice-coil drives.

### Operating limits

Values measured at an ambient temperature of 20° C. A sine is used as control signal in open-loop operation. The amplifier works linearly within the operating limits, in particular without thermal limitation.

### Operating temperature range

In any case, the device can be operated safely in the maximum permissible temperature range. To avoid internal overheating however, full load is no longer available above a certain temperature (maximum operating temperature under full load). Nevertheless, recalibration or zero-point-adjustment may be required if the system is operated at different temperatures. Performance specifications are valid for room temperature range. Please refer to individual datasheets and contact PI for more details.

### Operating voltage

Allowed control input voltage range (also input frequency) for the supply of the device.

### Output voltage

The output voltage of piezo controllers show exceptional long-term stability with variations of only a few millivolt.

### Overtemperature protection

Switch-off temperature for voltage output. No automatic restart.

## P

### Patents

PI owns a large variety of patents on piezo and motor technology.

### Parallel kinematics, hexapods

Hexapods are parallel-kinematic systems with six drives that are connected directly to a single platform. This makes it possible for users to position objects automatically in all degrees of freedom, X, Y, Z, and rotatory and, depending on the drive, with an accuracy in the micrometer range or lower. The parallelkinematic system is very stiff, with only a low passive weight to move and, with the corresponding design, can carry loads of up to several

tons. Users are able to arbitrarily choose the reference coordinate system and, today, workers are now working together with hexapods on the production line. The user integrates the system into the automation environment via EtherCAT.

### Peak current

Only available for very short times, typically under a few milliseconds. It is used to estimate the possible dynamics with a certain capacitive load. Note: In this case, the piezo controller / driver does not necessarily work linearly.

### PICA / PICA Power

PICA piezo actuators are specifically designed for high duty cycle applications. PICA Power actuators are additionally optimized for high-temperature working conditions.

All materials used are specifically matched for robustness and lifetime. Endurance tests on PICA actuators prove consistent performance, even after billions (1,000,000,000 ) of cycles. The combination of high displacement and low electrical capacitance provides for excellent dynamic behavior with reduced driving power requirements.

### PICMA® Multilayer piezo actuators

PICMA® actuators take advantage of the indirect piezoelectric effect and achieve high forces with relatively low voltages. They only need a small amount of installation space. At the same time, the PICMA® actuators are very dynamic and can reach a position with a hitherto unattained precision. This is the reason why they are used as micropumps in metering technology. Due to their ceramic insulation, PICMA® actuators exhibit high reliability and climate resistance. PI (Physik Instrumente) also equips PICMA® actuators with individual connections for customer applications.

### PICMAWalk

PICMAWalk drives achieve feed forces up to 50 N and holding forces to 60 N. The maximum velocity is 15 mm/s. PICMAWalk uses the proven PICMA® multilayer piezo actuators. That means lower piezo voltages to 120 V. PICMA® piezo actuators also ensure a long lifetime and the outstanding reliability of the PICMAWalk technology.

### PiezoWalk® walking drive

PiezoWalk® drives take advantage of the piezo walking principle and combine a subnanometer resolution with high forces, a robust design, and a scalable travel range. Industry customers use walking drives for travel ranges greater than 1 mm and to hold a stable position with nanometer precision resolution. PI (Physik Instrumente) offers walking drives with high feed forces as well as positioning and holding forces, but also relatively high velocities, and they also have a long lifetime in a vacuum. See "NEXLINE®", "NEXACT®", and "PICMAWalk".

### PIglide Air Bearing Technology

The PIglide air bearing technology allows friction-free positioning with a high guiding accuracy of up to 5 µrad over 100 mm. The technology improves the position resolution and it is possible to realize constant-velocity scanning. The repeatability is only a few encoder impulses. A similar precision in the nanometer range is also possible with flexure-guided piezo nanopositioners, however, only over considerably shorter travel ranges. The developers at PI (Physik Instrumente) adapt high-precision, air bearing positioning stages and motion control systems according to customer requirements.

### PILine® Ultrasonic Piezomotors

PILine® Ultrasonic piezomotors are precise, dynamic, small, and silent, and replace classical drive technologies, because the drives are also self-locking. As a result, they don't have to be supplied with current when at rest and that, in turn, reduces the energy requirements of the application. For this reason and due to their small size, the drives are very popular for mobile devices in the optical industry and measuring technology.

### PIMag® Magnetic Linear Motors

Magnetic direct drives from PI (Physik Instrumente) provide a direct and stiff connection between the load to be moved and the drive. The industry demand is particularly high when objects need to be positioned with high dynamics and precision. Thanks to the smooth-running precision linear guides with crossed roller bearings, these types of linear motor stages are particularly suitable for applications that require constant-velocity scanning. The drives operate without contact and therefore very reliable. Users can integrate the magnetic direct drives into existing machines and systems quickly and easily via standardized fieldbus systems. See "Linear motor", "Torque motor"

### PIMag® Voice Coil

Thanks to their low weight and friction-free drive principle, voice coil drives are small and particularly suitable for applications that require high dynamics and high velocities over limited travel ranges – for example, in medical technology. Voice coil drives have a greater advantage for the customer when compared to traditional drive screw-based solutions, particularly with respect to wear and dynamics. High scan frequencies and precision positioning are possible with these drives, because they are free of hysteresis effects. See "Voice Coil Drive".

# Terms and Technology Glossary

## **PIOne Linear Encoder**

The high-resolution PIONe encoder allows direct position measuring with a position resolution of much less than one nanometer and a linearity error of less than 1 %. Basic features are the low power consumption, the high signal stability that results in almost no noise, the signal processing optimized for high-precision positioning, and the small size of the sensor head. PIONe was developed by PI which allows for best flexibility for customization and use in OEM stages.

## **PIRest**

Piezo actuator technology for active adjustment of consistently stable gaps of several  $\mu\text{m}$  with subnanometer precision. The PIRest actuator is only powered during the actual positioning sequence and holds its position without power.

## **Pitch**

See "Crosstalk".

## **Power consumption**

Maximum power consumption under full load.

## **Profile generator**

Functionality of motor controllers that allows motion profiles such as linear interpolation, point-to-point, trapezoid, double bends. For several axes: Electronic gearing.

## **Pulse width modulation (PWM)**

PWM-controlled motors allow control of the (motor) performance with a high-frequency-signal. This means that the power signal can be separated from the digital control signal.

PWM control is used for example, with high-performance switching amplifiers for piezo actuators, or for controlling electric motors such linear motors or voice coil drives. The "ActiveDrive Motor" is a special feature from PI, see there.

## **Push / pull force capacity (in operating direction)**

Specifies the maximum forces that can be applied to the system along the active axis. Limited by the piezoelectric material and the flexure design. If larger forces are applied, damage to the piezo actuator, the flexures or the sensor can occur. The force limit must also be considered in dynamic applications.

Example: the dynamic forces generated by sinusoidal operation at 500 Hz, 20  $\mu\text{m}$  peak-to-peak, 1 kg moved mass, are approximately  $\pm 100\text{ N}$ .

## **Q**

### **Q-Motion® Piezoelectric Inertia Drive**

Piezo inertia drives are space-saving and affordable piezo-based drives with relatively high holding forces and a virtually unlimited travel range. With an operating frequency of up to 20 kHz, the drives reach velocities of more than 5 mm/s that act directly on the runner. The Q-Motion® drive operates silently at the maximum operating frequency of 20 kHz. When at rest, the drive is self-locking, requires no current, and does not generate any heat. It holds the position with maximum force. It is therefore suitable for battery-powered, mobile applications with a low number of load cycles.

## **R**

### **Recirculating Ball Bearing**

Due to their design, recirculating ball bearings are already insensitive to creeping. For example, they are suitable for high-precision axes, which are often used for scanning smaller areas. When assembled correctly, they offer a high load capacity and at the same time, long lifetime, no maintenance, and high guiding accuracy.

### **Reference point switch**

Function: Optical, magnetic.

### **Repeatability**

Typical values in closed-loop operation mode (RMS,  $1\sigma$ ). Repeatability is a percentage of the total distance or angle traveled. For small ranges, repeatability may be significantly better.

### **Resolution**

Position resolution relates to the smallest change in displacement that can still be detected by the measuring devices. The resolution in piezo-based positioning systems and piezo actuators is basically unlimited because it is not affected by static or sliding friction. Instead, the equivalent to electronic noise is specified. Values are typical results (RMS,  $1\sigma$ ).

### **Roll**

See "Crosstalk".

### **Rotational runout**

See "Crosstalk".

## S

### Sensor bandwidth

Measured value that specifies the frequency, with which the amplitude decreased by -3 dB.

### Sensor linearization

For capacitive sensors, the signal conditioning electronics demonstrates a notably low noise level. The integrated linearization system (ILS) compensates for the influences of parallelism errors between the capacitor plates.

### Sensor resolution

The smallest calculable increment that can be detected by the measuring system used. Rotary encoder: Number of counts per screw rotation. Linear encoder: Smallest increment still detected by the sensor system used. The sensor can be the critical element in position resolution, for this reason the sensor resolution is specified separately if necessary. See "Design resolution".

### Serial kinematics

Each actuator acts on its own platform. There is a clear relationship between actuators and motion axes. The advantages are the relatively simple assembly and multi-axis control. The dynamic characteristics depend on the individual axis. Guiding errors cumulate and the overall guiding accuracy is poorer if compared to "Parallel kinematics", see there.

### Serial metrology

One sensor is assigned to each moving axis to be servo-controlled. Undesired off-axis motion, guiding error or crosstalk, go unnoticed and uncorrected. See "Parallel metrology".

### Specification

Performance specifications are valid for room temperature ( $22 \pm 3$  °C) and closed-loop systems are calibrated at this temperature (specifications for different operating temperatures on request). Recalibration is recommended for operation at significantly higher or lower temperature. Custom designs for ultralow or ultrahigh temperatures on request.

### Stiffness

Spring constant, nonlinear for piezoelectric materials. Static large signal stiffness of the stage in operating direction at room temperature. Small signal stiffness and dynamic stiffness may differ because of effects caused by the active nature of piezoelectric material or compound effects, for example.

### Straightness

See "Crosstalk".

## T

### Trajectory control

Provisions to prevent deviation from the specified trajectory. Can be passive (e.g., flexure guidance) or active (e.g., using additional active axes and sensors).

## U

### User software and functions

PIMikroMove®, PI General Command Set (GCS). Drivers for LabVIEW, shared libraries for Windows and Linux. Compatible with µManager, MetaMorph, MATLAB. Wave Generator. Linearization. Data recorder. Auto zero. Trigger I/O. Software configurable servo parameters. See "Extensive software package".

## V

### Vacuum-compatible versions

In a large number of industry sectors, production in a vacuum is becoming increasingly more important. Therefore, PI (Physik Instrumente) offers various different drive technologies to its customers that can be operated in a vacuum of  $10^{-7}$  or even  $10^{-10}$  hPa. This includes piezo actuators that work in strong magnetic fields and in a cryogenic environment, piezo systems with travel ranges lower than 1.5 mm and subnanometer precision, piezomotors in a variety of designs with respect to force, dynamics, and travel range, as well as classical motorization with specially designed DC or stepper motors that allow greater travel ranges.

## Y

### Yaw

See "Crosstalk".

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

General Management: Dr. Karl Spanner, Dr. Peter Schittenhelm, Markus Spanner;  
 Commercial Register: Reg.-Gericht Mannheim: HRA 104804; VAT-No.: DE 1431 828 03;  
 WEEE-Reg.-No.: DE 93978928;

General Partner: Physik Instrumente (PI) Verwaltungs GmbH;  
 Commercial Register: Reg.-Gericht Mannheim: HRB 109941;

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## Headquarters

### GERMANY

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

**PI miCos GmbH**  
Freiburger Strasse 30  
79427 Eschbach  
Phone +49 7634 5057-0  
Fax +49 7634 5057-99  
info@pimicos.com  
www.pi.ws

**PI Ceramic GmbH**  
Lindenstrasse  
07589 Lederhose  
Phone +49 36604 882-0  
Fax +49 36604 882-4109  
info@piceramic.com  
www.piceramic.com



## Subsidiaries

### USA (East) & CANADA

**PI (Physik Instrumente) L.P.**  
Auburn, MA 01501  
www.pi-usa.us

### USA (San Francisco Bay Area)

**PI (Physik Instrumente) L.P.**  
Sausalito, CA 94965  
www.pi-usa.us

### ITALY

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www.pikorea.co.kr

### USA (West) & MEXICO

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Irvine, CA 92620  
www.pi-usa.us

### UK & IRELAND

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Taiwan Ltd.**  
Taipei  
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