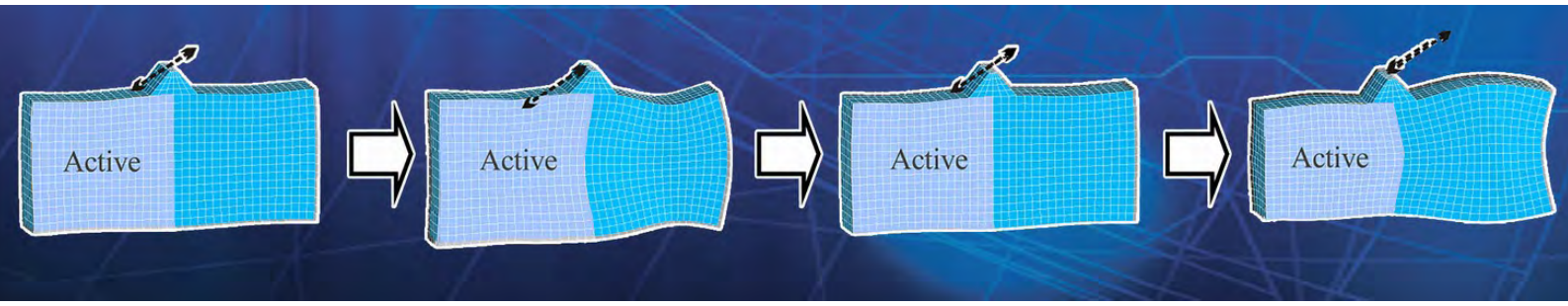
Ultrasonic Motors

for Fast and Precise Positioning



Latest Catalogs:
www.pi.ws

PILine® Linear Positioning Stages

U-521
Compact Linear Stage
Fast PILine® Direct Drive, Incremental Encoder

PILine® Rotation Stages

U-622
Miniature Rotation Stage
20 mm Side Length, Integrated Encoder

U-624
Fast Miniature Rotation Stage
With Ultrasonic Piezomotor

U-628
Fast Rotation Stage with Small Footprint
With Ultrasonic Piezomotor

U-651
Rotation Stage with Low-Profile Design
Fast PILine® Direct Drive

Motion Control

C-877
PILine® Motion Controller
For Ultrasonic Piezomotors, Cost-Efficient and Compact

C-867U
PILine® Motion Controller
For Ultrasonic Piezomotors, 1 and 2 Axes

Ultrasonic Motor Applications

Nanotechnology, Nanofabrication, NanoAutomation®

Precision positioning of components (linear and rotation)
Precision actuation
Microgrippers
Manipulators

Semiconductor Technology

Long-range placement and positioning

Microscopy/Imaging

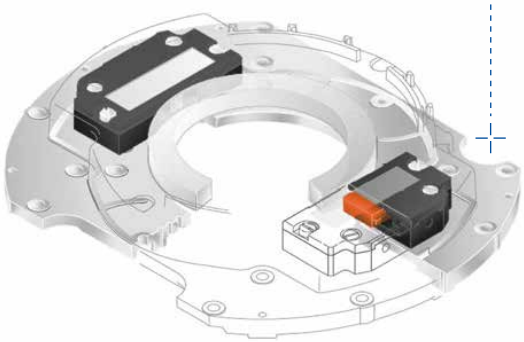
Fast sample positioning
XY-stages
Long range scanning

Biotechnology, Life Science

Microdosing
Dispensing
Nano/microliter pumps
Fast positioning
Bio-handling

Medical Design, Medical Technology

Screening
Fast positioning
Cell penetration, microdosing
Handling
Non-magnetic actuators



PILine® motors act on an annular runner, producing a rapid rotary motion, e.g. for this Leica TS30 total station for automated angle and distance measurement at high accuracy and reliability (Image: Leica Geosystems)

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Cat120E Inspirations2009 08/10.18 / VOR /USM01-11

Ultrasonic Motor Principle

PILine® Ultrasonic Piezomotors

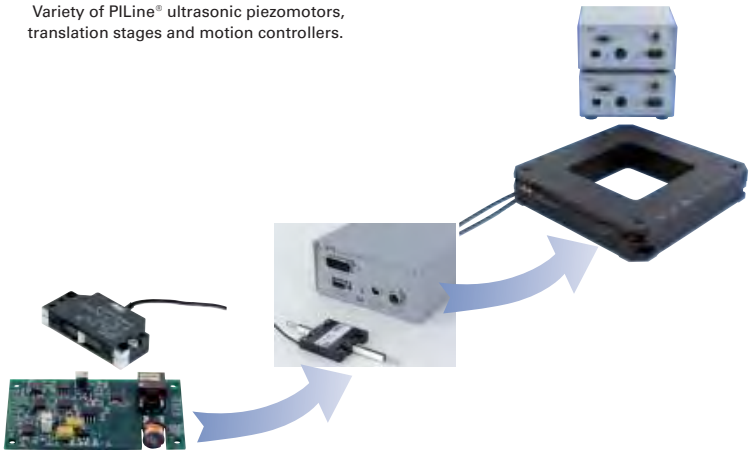
PI Ultrasonic piezomotors are based on a novel, patented ultrasonic drive developed by PI. At the heart of the system is a rectangular monolithic piezoceramic plate (the stator), segmented on one side by two electrodes. Depending on the desired direction of motion, the left or right electrode of the piezoceramic plate is excited to produce high-frequency eigenmode oscillations at tens to hundreds of kilohertz. An alumina friction tip (pusher) attached to the plate moves along an inclined linear path at the eigenmode frequency. Through its contact with the friction bar, it provides microimpulses that drive the moving part of the mechanics (slider, turntable, etc.) forward or backwards. With each oscillatory cycle, the mechanics executes a step of a few nanometers; the macroscopic result is smooth motion with a virtually unlimited travel range. The driving force is taken from the energy in the longitudinal oscillation component. The transverse component serves to increase / decrease the pressure of the friction tip against the friction bar. The transverse oscillation energy determines the maximum frictional force and hence the holding and driving force of the motor. State-of-the-art ultrasonic motors can produce accelerations to 10 g and velocities to 500 mm/s.
Ultrasonic motors cannot provide the unlimited resolution of linear piezo actuators and flexure-guided piezo positioning stages. These motors transfer motion through friction, which is why their repeatability is limited to about 50 nm. Much higher resolution and holding forces can be achieved with PiezoWalk® piezomotors / drives.

PILine® Levels of Integration

PILine® ultrasonic drive products are offered in three different levels of integration. The drive electronics and controller can be chosen accordingly.

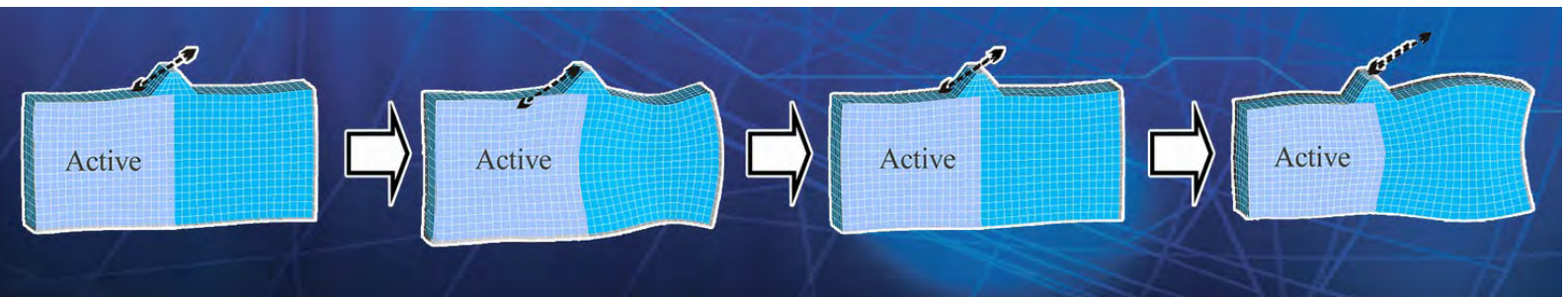
- P-661 and P-664 OEM motors require the greatest amount of care at the customer's site. Motor and friction bar – the length depends on the travel range – have to be integrated into a mechanical setup. Operation requires preload of the motor against the friction bar, guiding and, if necessary, the servo-loop.
- RodDrives can replace classical drive elements like rotary motor / leadscrew assemblies, or magnetic linear drives integrated into a micropositioner or handling device. Integration requires guiding and – if necessary – the servo-loop.
- Linear positioning stages represent the highest level of manufacturer integration. The piezomotor is integrated completely in a high-quality mechanical setup inlcuding if necessary the servo-loop with direct-metrology linear encoders.

Variety of PILine® ultrasonic piezomotors, translation stages and motion controllers.



PILine® levels of integration: OEM motor, RodDrive, linear positioning stage.

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



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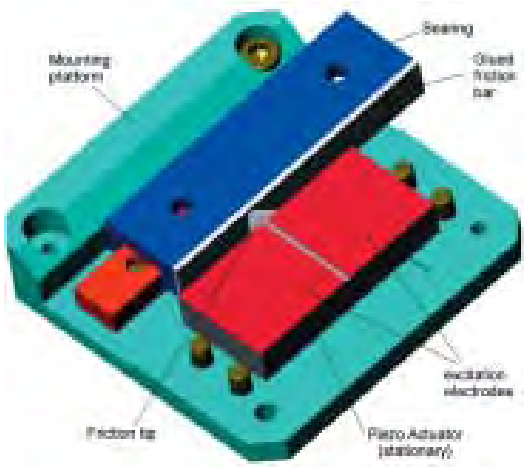
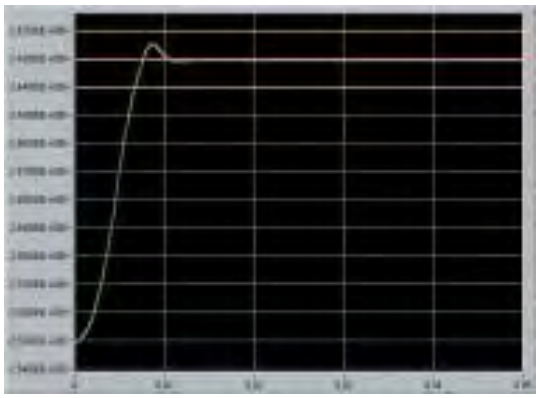
Ultrasonic Motor Principle



Principle .design of a PILine® ultrasonic piezomotor-driven translation stage.

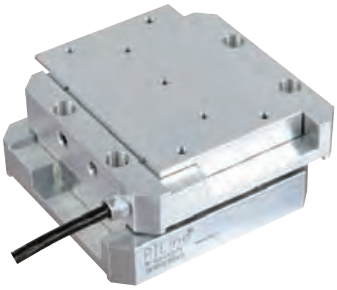


Settling behavior of a PILine® M-663 linear stage, 100 µm step. A stable position to within 0.1 µm can be reached in only 10 ms.

Custom high-force ultrasonic piezo motors can provide forces to 50N.

Features and Advantages of PILine® Ultrasonic Piezomotors

- Compact Size: the direct-drive principle allows the design of ultra-compact translation stages. The M-662, for example, provides 20 mm travel in a 28 x 28 x 8 mm package.
- Low inertia, high acceleration, speed and resolution: PILine® drives achieve velocities to 500 mm/s and accelerations to 10 g. They are also very stiff, a prerequisite for their fast step-and-settle times – on the order of a few milliseconds – and provide resolution to 0.05 µm. The lack of a leadscrew means no lubricant flow or material relaxation to cause submicron creep. There is also no rotational inertia to limit acceleration and deceleration.
- Excellent Power -to-Weight Ratio: PILine® drives are optimized for high performance in a minimum package. No comparable drive can offer the same combination of acceleration, speed and precision.
- Safe: The minimum inertia of the moving platform together with the "slip clutch" effect of the friction drive provide better protection of precision fixtures / devices than leadscrew-driven stages. Despite the high speeds and accelerations, there is a much lower risk of pinching fingers or other injuries than with conventional drives. This means users may not need interlocks, light curtains or other measures to keep them safe.
- Self-Locking Feature: PILine® drives create a braking force when not energized without the position shift common with conventional mechanical brakes. Other benefits of the self-locking are the elimination of servo dither and steady-state heat dissipation.



- Vacuum Compatibility: Vacuum compatible versions of PILine® drives are available.
- Negligible EMI: PILine® drives do not create magnetic fields nor are they influenced by them, a decisive advantage in many applications.
- Custom Solutions / Flexibility for OEMs: PILine® drives are available in open-loop and closed-loop translation stages and as OEM components. PI develops and manufactures all piezo ceramic components in-house. This gives us the flexibility to provide custom motors (size, force, environmental conditions) for OEM and research applications.
- Quality, Lifetime, Experience: Based on PI's 30+ years of experience with piezo nanopositioning technology , PILine® drives offer exceptional precision and reliability with an MTBF of >20,000 hours. Rotating components such as gears, shafts and moving cables that are prone to failure in conventional motion systems, are not part of the PILine® design.

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Compact Linear Stage

FAST PILINE® DIRECT DRIVE, INCREMENTAL ENCODER

U-521

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

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

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

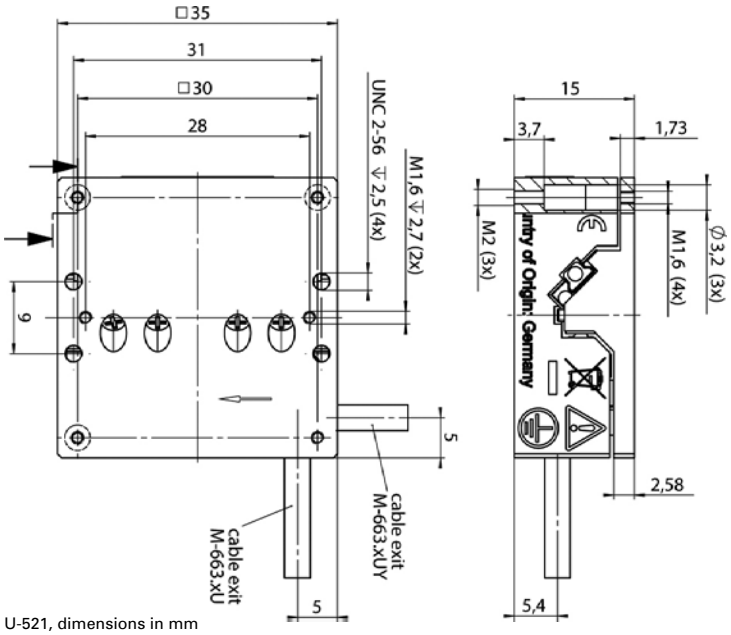
PILine® ultrasonic piezo motor
Oscillating piezoceramic actuators act directly on a linear-guided runner. Self-locking at rest, therefore no heat generation. No drive noises. High velocity up to 200 mm/s. Dynamic start / stop behavior. Holding force 2 N.

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

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

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

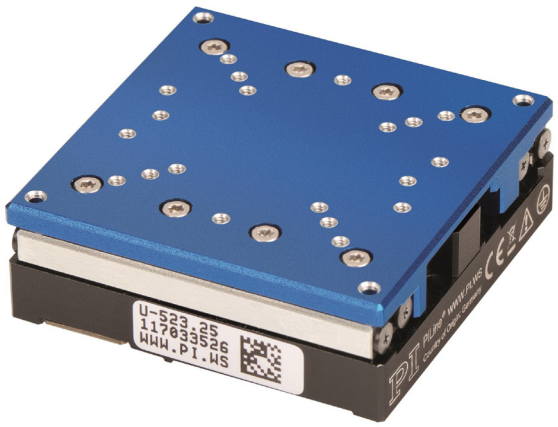
Ask about custom designs!
The U-521 stage series replace the M-663 series



U-521, dimensions in mm

PILine® Linear Stage

Compact Stage with Ultrasonic Piezomotor



U-523

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

Precision-class linear positioning stage

PILine® stages are particularly suitable for applications that require fast precision positioning. When switched off, the self-locking drive holds the position of the stage mechanically stable. Energy consumption and heat generation are therefore considerably reduced. Applications with a low duty cycle that are battery-powered or heat-sensitive benefit from these characteristics. The position of the axis is measured by an encoder and an optical reference switch allows reliable repeatable motion. The piezomotor drive principle and its electrical operation is inexpensive and can be customized.

PILine® ultrasonic piezomotor

An integral part of a PILine® ultrasonic piezomotor is a piezo actuator that is preloaded against a movable, guided runner via a coupling element. The piezoceramic actuator is excited to ultrasonic oscillation by a high-frequency AC voltage between 100 and 200 kHz. Deformation of the actuator leads to periodic diagonal motion of the coupling element relative to the runner. The feed created is a few nanometers per cycle; the high frequencies lead to the high velocities. Preloading the piezoceramic actuator against the runner ensures self-locking of the drive when at rest and switched off.

Direct position measurement with incremental encoder

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

Valid patents

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

Fields of application

Micromanipulation, automation, biotechnology, sample manipulation, sample positioning, applications with limited space, vacuum applications to 10^{-6} hPa (optional).

Specifications

Preliminary data

Moving	U-523.25	Unit	Tolerance
Active axis	x		
Travel range	22	mm	
Velocity	200	mm/s	max.

Mechanical properties	U-523.25	Unit	Tolerance
Load capacity in z	5	N	max.
Mass without cable	70	g	
Linear guiding	Crossed roller bearing with anti-creep system		

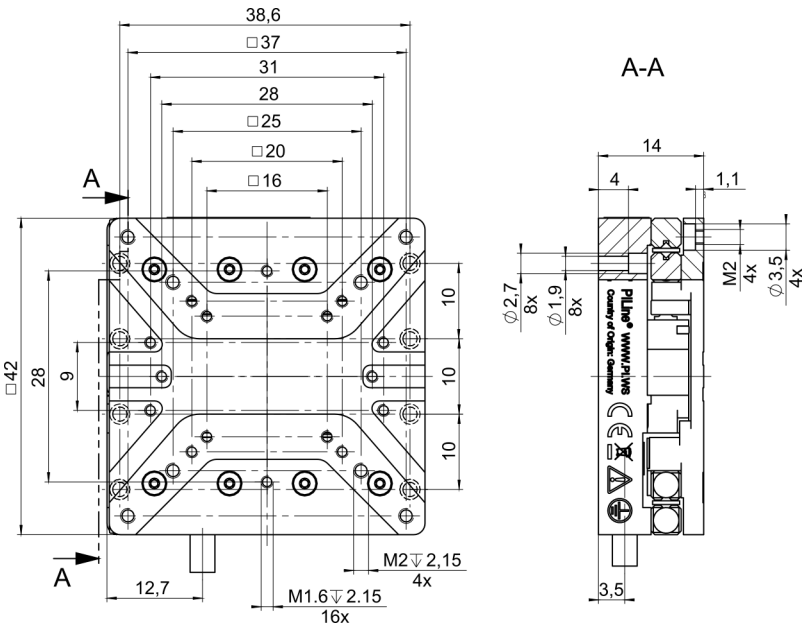
Drive properties	U-523.25	Unit	Tolerance
Drive type	PILine® ultrasonic piezomotor, performance class 1		
Nominal force	2	N	typ.
Holding force	2	N	typ.

Positioning	U-523.25	Unit	Tolerance
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		

Miscellaneous	U-523.25	Unit	Tolerance
Operating temperature range	0 to 40	°C	
Humidity	20 – 90% rel., not condensing		
Material	Aluminum, anodized		
Motor / sensor connection	Sub-D, 15-pin (m)		
Cable length	1.5	m	

Ask about custom designs!
Technical data specified at room temperature (22±3 °C) with C-867.1U.

Drawings and Images



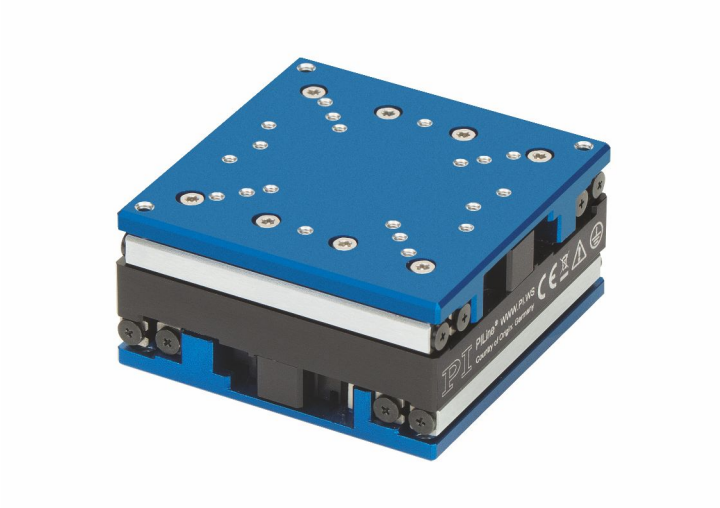
U-523, dimensions in mm

Ordering Information

U-523.25
PILine® Linear Stage, Compact design, 22 mm Travel range, 2 N Drive force, 10 nm Sensor resolution

PILine® XY Stage

Compact XY Stage with Ultrasonic Piezomotors



U-723

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

Precision-class XY stage

PILine® stages are particularly suitable for applications that require fast precision positioning. When switched off, the self-locking drive holds the position of the stage mechanically stable. Energy consumption and heat generation are therefore considerably reduced. Applications with a low duty cycle that are battery-powered or heat-sensitive benefit from these characteristics. The position of the axis is measured by an encoder and an optical reference switch allows reliable repeatable motion. The piezomotor drive principle and its electrical operation is inexpensive and can be customized.

PILine® ultrasonic piezomotors

An integral part of a PILine® ultrasonic piezomotor is a piezo actuator that is preloaded against a movable, guided runner via a coupling element. The piezoceramic actuator is excited to ultrasonic oscillation by a high-frequency AC voltage between 100 and 200 kHz. Deformation of the actuator leads to periodic diagonal motion of the coupling element relative to the runner. The feed created is a few nanometers per cycle; the high frequencies lead to the high velocities. Preloading the piezoceramic actuator against the runner ensures self-locking of the drive when at rest and switched off.

Direct position measurement with incremental encoder

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

Valid patents

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

Fields of application

Micromanipulation, automation, biotechnology, sample manipulation, sample positioning, applications with limited space, vacuum applications to 10^{-6} hPa (optional)

Specifications

Preliminary data

Moving	U-723.25	Unit	Tolerance
Active axes	x, y		
Travel range	22 mm × 22 mm		
Velocity	200	mm/s	max.

Mechanical properties	U-723.25	Unit	Tolerance
Load capacity in z	5	N	max.
Mass without cable	110	g	
Linear guiding	Crossed roller bearing with anti-creep system		

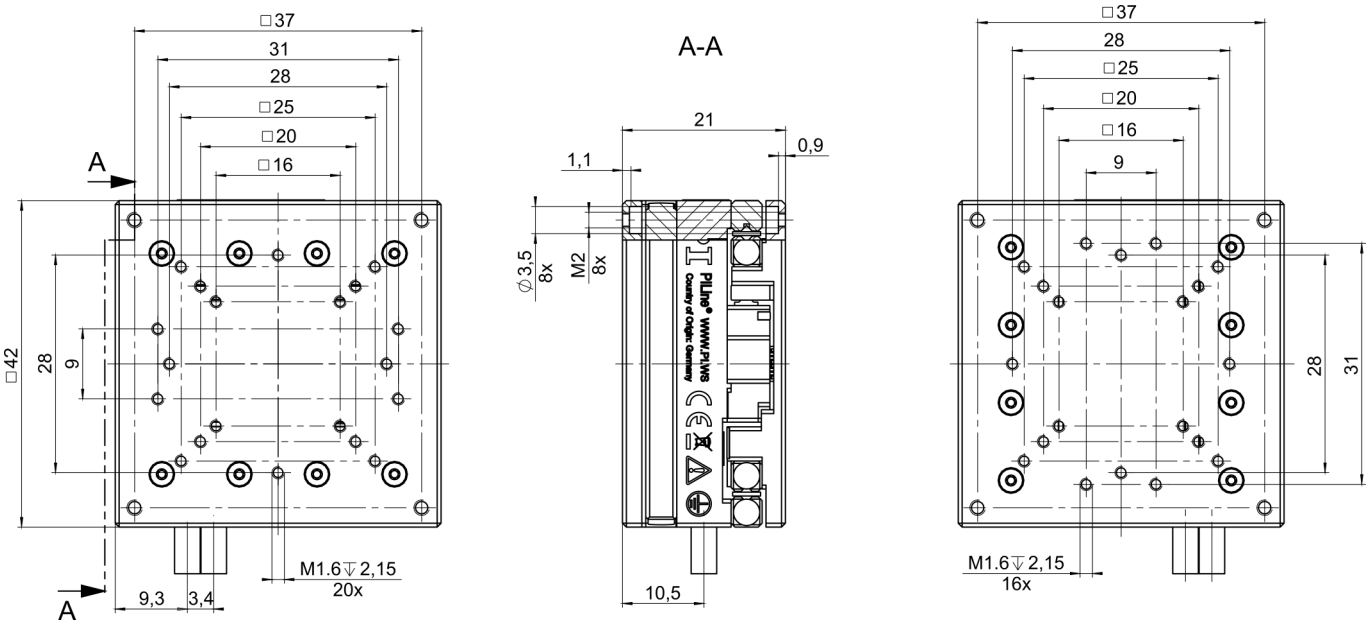
Drive properties	U-723.25	Unit	Tolerance
Drive type	PILine® ultrasonic piezomotor, performance class 1		
Nominal force	2	N	typ.
Holding force	2	N	typ.

Positioning	U-723.25	Unit	Tolerance
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		

Miscellaneous	U-723.25	Unit	Tolerance
Operating temperature range	0 to 40	°C	
Humidity	20 – 90% rel., not condensing		
Material	Aluminum, anodized		
Motor / sensor connection	2 × Sub-D, 15-pin (m)		
Cable length	2 × 1.5 m		

Ask about custom designs!
Technical data specified at room temperature (22±3 °C) with C-867.2U2.

Drawings and Images



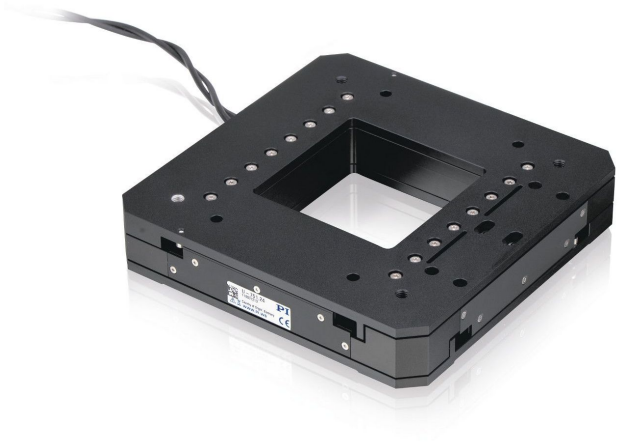
U-723, dimensions in mm

Ordering Information

U-723.25
PILine® XY stage, Compact design, 22 mm × 22 mm Travel range

XY Stage with Piezomotors

Low-profile and Fast, Direct Position Measurement



U-751.24

- 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

Precision-class XY stage

PILine® stages are particularly suitable for applications that require fast precision positioning. When switched off, the self-locking drive holds the position of the stage mechanically stable. Energy consumption and heat generation are therefore considerably reduced. Applications with a low duty cycle that are battery-powered or heat-sensitive benefit from these characteristics. The position of the axis is measured by an encoder and an optical reference switch allows reliable repeatable motion. The piezomotor drive principle and its electrical operation is inexpensive and can be customized.

PILine® ultrasonic piezomotors

An integral part of a PILine® ultrasonic piezomotor is a piezo actuator that is preloaded against a movable, guided runner via a coupling element. The piezoceramic actuator is excited to ultrasonic oscillation by a high-frequency AC voltage between 100 and 200 kHz. Deformation of the actuator leads to periodic diagonal motion of the coupling element relative to the runner. The feed created is a few nanometers per cycle; the high frequencies lead to the high velocities. Preloading the piezoceramic actuator against the runner ensures self-locking of the drive when at rest and switched off.

Direct position measurement with incremental encoder

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

Crossed roller bearings

With crossed roller bearings, the point contact of the balls in ball bearings is replaced by a line contact of the hardened rollers. Consequently, they are considerably stiffer and need less preload, which reduces friction and allows smoother running. Crossed roller bearings are also distinguished by high guiding accuracy and load capacity. Force-guided rolling element cages prevent linear guide creeping.

Valid patents

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

Fields of application

Research and industry. For microscopy, biotechnology, laboratory automation. Special versions for standard light microscopes available on request.

Specifications

Motion	U-751.24	Unit	Tolerance
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.

Mechanical properties	U-751.24	Unit	Tolerance
Load capacity [1]	50	N	max.
Holding force (passive)	6	N	max.

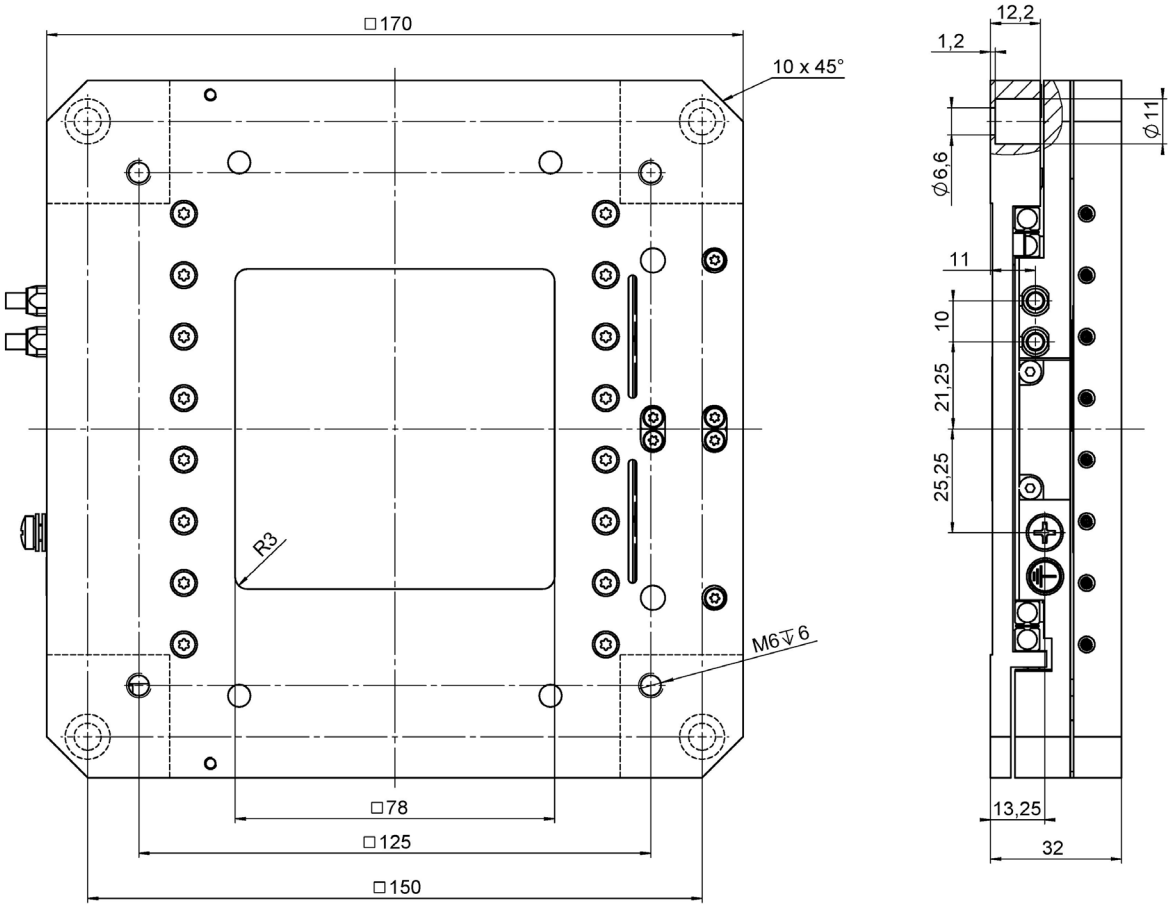
Drive properties	U-751.24	Unit	Tolerance
Motor type	PILine® ultrasonic piezomotor, performance class 2		
Drive force	7	N	max.

Positioning	U-751.24	Unit	Tolerance
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 switches	Optical		
Limit switches	Hall effect		

Miscellaneous	U-751.24	Unit	Tolerance
Operating temperature range	-20 to 50	°C	
Material	Al (black anodized)		
Mass	1.8	kg	±5 %
Motor / sensor connection	2 × Sub-D, 15-pin (m)		
Cable length	1.5	m	±10 mm

[1] At max. velocity 10 N.
Ask about custom designs!

Drawings and Images



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

Ordering Information

U-751.24
XY Stage with PILine® Piezomotors, 25 mm × 25 mm travel range, 7 N drive force, 0.1 µm resolution

Ask about custom designs!

U-780 Datasheet

Date of publication: 10/24/2016

U-780
PILine® XY Stage System with Controller and Joystick

Stable, dynamic, low profile

- High velocity constancy at 10 µm/s
- Velocity to 120 mm/s, resolution 0.1 µm
- Travel range to 135 mm × 85 mm (depending on model type)
- For inverted microscopes, freely revolving nosepiece
- Compact, flat design: Unrestricted access to the sample
- Extensive accessories: Z sample scanners, microscope slide holder and Petri dish and microtiter plate holder

Reference-class microscope XY stage
System with controller and joystick. Large clear aperture 160 mm × 110 mm.
Suitable for the following inverted microscopes:

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

High-resolution PILine® piezo linear drive
Self-locking at rest. Low noise. Highest stability due to low thermal load and no lubricants. Large dynamics range of 10 µm/s to 120 mm/s, ideal for operating with joystick and automated high-content processes.

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Direct position measurement with incremental 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 LabVIEW. Compatible with µManager, MetaMorph, Andor iQ, MATLAB.

Accessories
M-687.AP1 universal holder for microscope slides and Petri dishes.

Fields of application
For inverted microscopes from Nikon, Olympus and Leica, versions for other microscopes available on request. For superresolution microscopy, tiling, automated scanning microscopy.

Compatible products
All M-687 model types:
P-561 • P-562 • P-563 PIMars nanopositioning stage
P-541.2 • P-542.2 XY piezo stage
P-541.Z piezo Z and Z / tip / tilt stages
P-545.xR8S PInano® XY(Z) piezo system
P-737 PIFOC® specimen-focusing Z stage

M-687.UN and M-687.UO:
P-736 PInano® Z microscope scanner for microtiter plates

Related products
M-686 XY stage with piezoceramic linear motors
M-545 open-frame microscope stage

U-780 specifications

	U-780.DNS	U-780.DOS	U-780.DLS	Unit	Tolerance
	System with M-687.UN 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		
Motion and positioning					
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.

	U-780.DNS	U-780.DOS	U-780.DLS	Unit	Tolerance
Velocity	120	120	120	mm/s	max.
Reference point switches	Optical, 1 µm repeatability	Optical, 1 µm repeatability	Optical, 1 µm repeatability		
Limit switches	Hall effect	Hall effect	Hall effect		
Mechanical properties					
Load capacity	25	25	25	N	max.
Drive properties					
Motor type	PILine® ultrasonic piezomotor, performance class 2	PILine® ultrasonic piezomotor, performance class 2	PILine® ultrasonic piezomotor, performance class 2	N	max.
Miscellaneous					
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 %
Piezomotor controller	C-867.2U2 with USB joystick (included in scope of delivery)				
Interface / communication	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				
Command set	PI General Command Set (GCS)				
User software	PIMikroMove				
Software drivers	GCS DLL (with code examples for the most common programming languages such as C++, C#, VB.NET, Python, Delphi), LabVIEW driver, MATLAB library				
Supported functions	Start-up 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)				

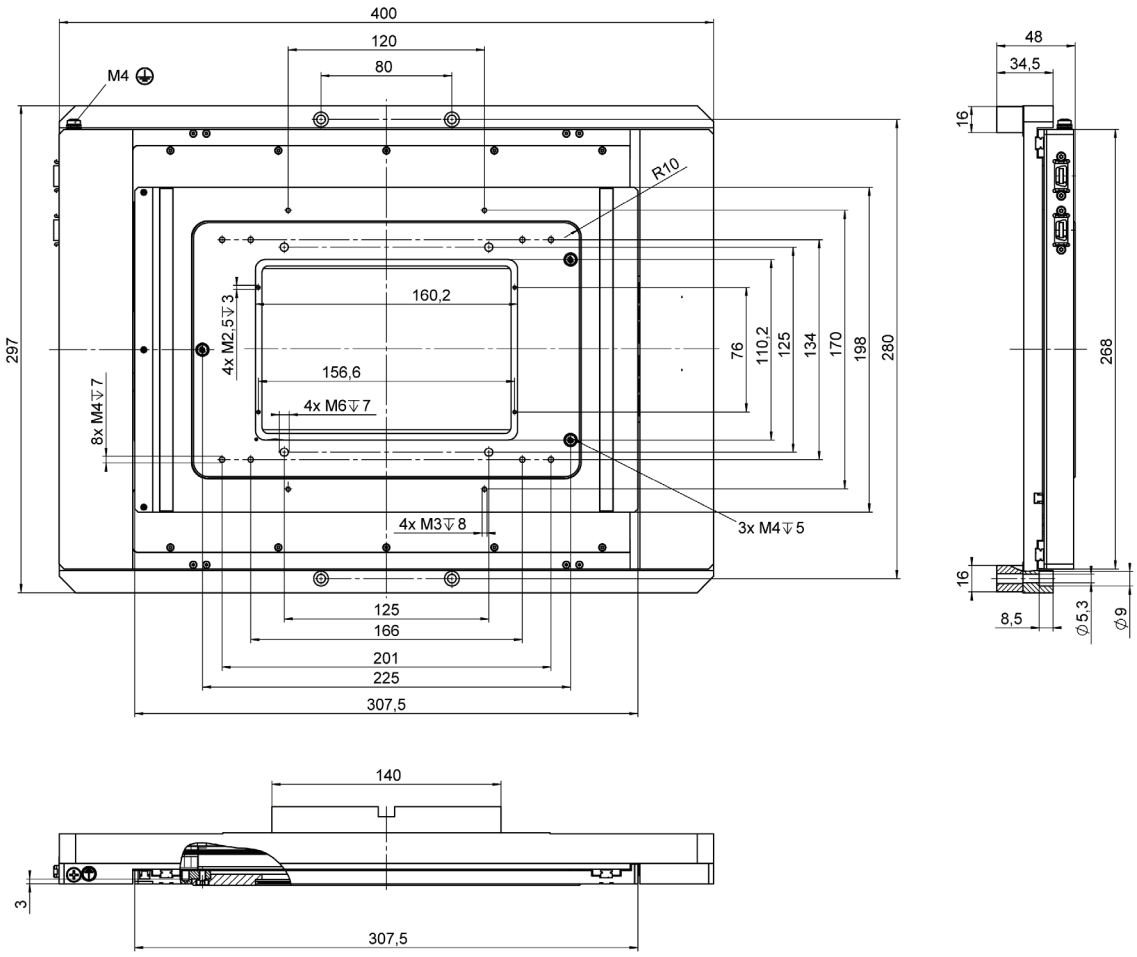


Figure 1: M-687.UN for Nikon microscopes, dimensions in mm

Ordering Information

U-780.DNS
PILine® XY stage system, 135 mm × 85 mm, for inverted microscopes from Nikon, with controller and joystick

U-780.DOS
PILine® XY stage system, 100 mm × 75 mm, for inverted microscopes from Olympus, with controller and joystick

U-780.DLS
PILine® XY stage system, 135 mm × 85 mm, for inverted microscopes from Leica, with controller and joystick

Accessories
M-687.AP1
Universal holder for microscope slides and Petri dishes for PI stages with 160 mm × 110 mm clear aperture

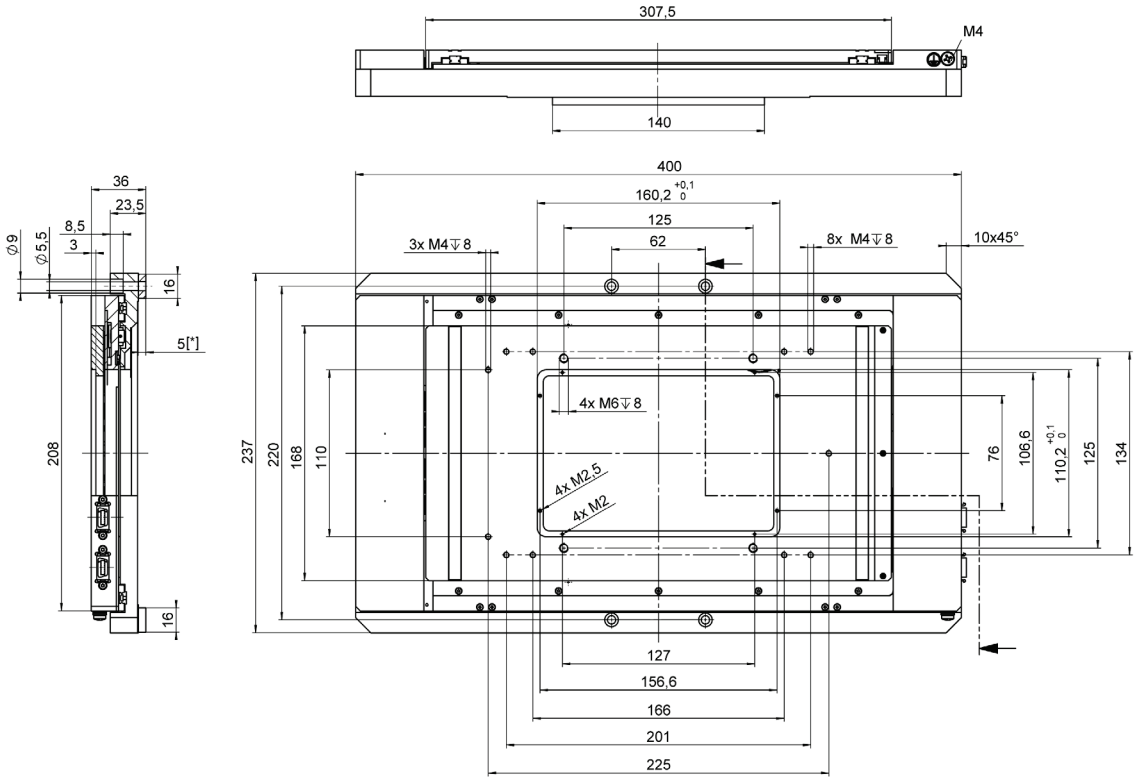


Figure 2: M-687.UO for Olympus microscopes, dimensions in mm

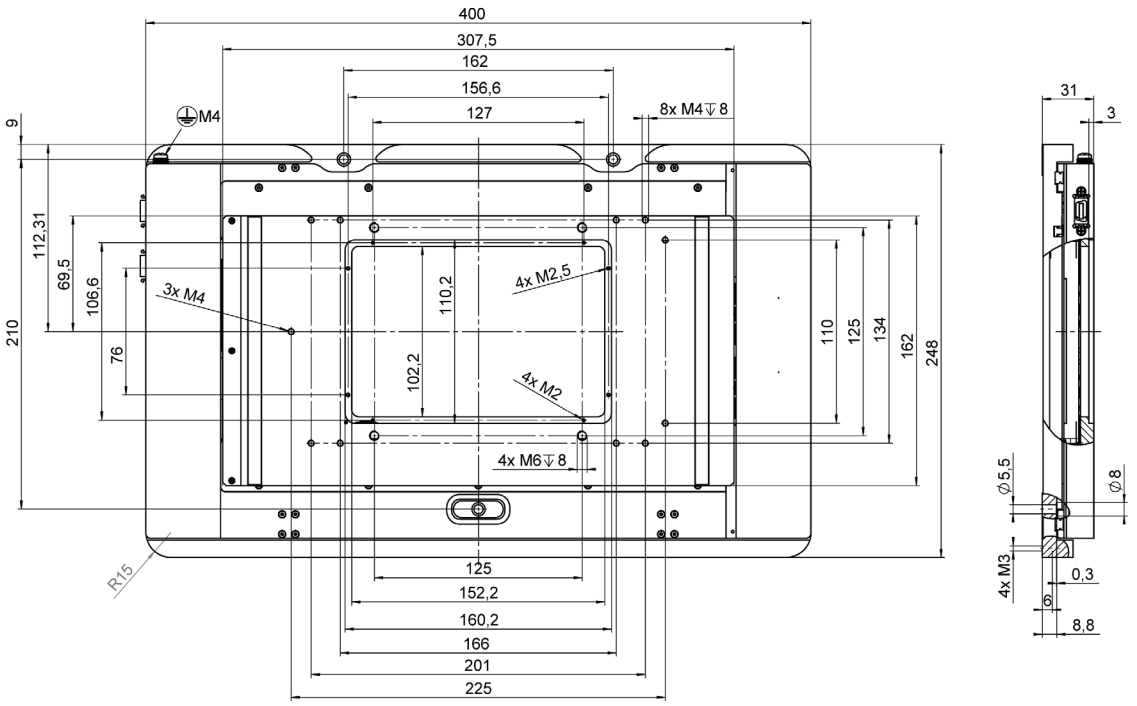


Figure 3: M-687.UL for Leica microscopes, dimensions in mm

Miniaturized Rotation Stage

20 MM SIDE LENGTH, INTEGRATED ENCODER

U-622

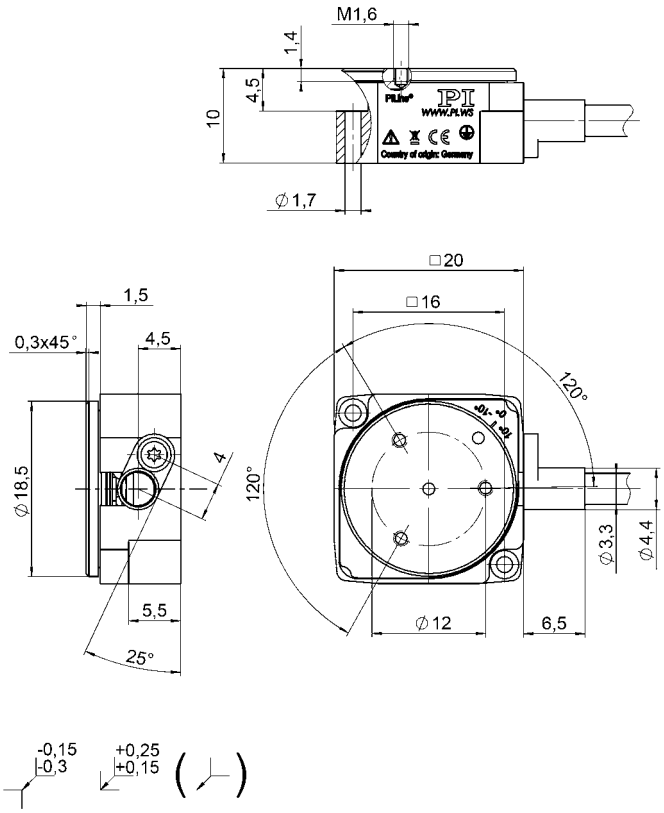
- Only 20 mm edge length, height 10 mm
- Integrated, direct-measuring incremental encoder
- Rotation range >360°
- High velocity 720 °/s
- Drive torque 5 mNm

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

PILine® ultrasonic piezo motor
The piezoceramic ring-shaped motor acts directly on the rotating platform. Self-locking at rest, therefore no heat generation. No drive noises. High velocity to 720 °/s. Holding torque 5 mNm

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

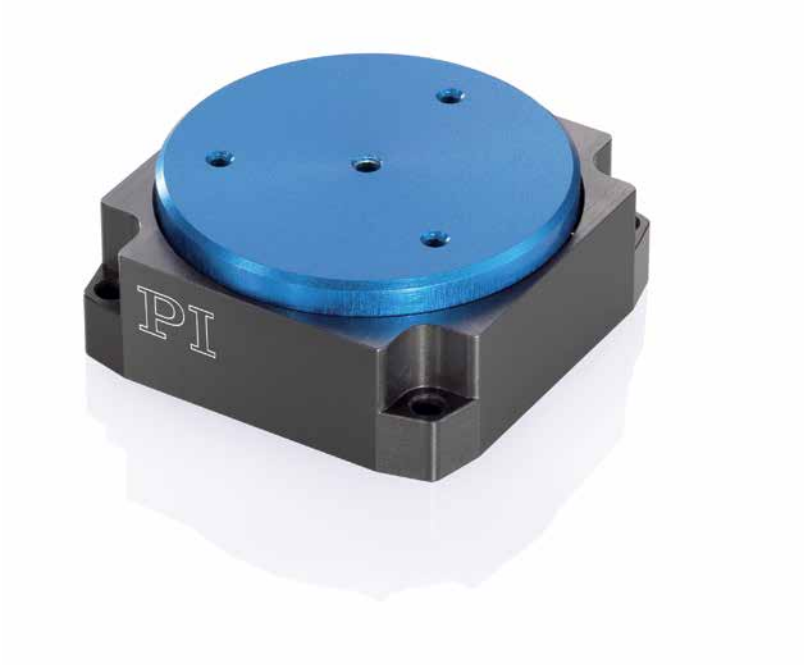
	U-622.03	Unit	Tolerance
Active axes	θ_z		
Motion and Positioning			
Rotation range	>360	°	
Integrated sensor	Incremental encoder		
Design resolution	175	µrad	
Min. incremental motion	525	µrad	typ.
Bidirectional repeatability	±1050	µrad	
Velocity	720	°/s	max.
Mechanical Properties			
Load capacity / axial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



U-622, dimensions in mm

Fast Miniature Rotation Stage

WITH ULTRASONIC PIEZOMOTOR



U-624

- Only 30 mm edge length, height 12 mm
- Integrated, direct-measuring incremental encoder
- Rotation range >360°
- High velocity 720 °/s
- Drive torque 10 mNm

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

PILine® ultrasonic piezo motor
The piezoceramic ring-shaped motor acts directly on the rotating platform. Self-locking at rest, therefore no heat generation. No drive noises. High velocity to 720 °/s. Holding torque 10 mNm

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

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

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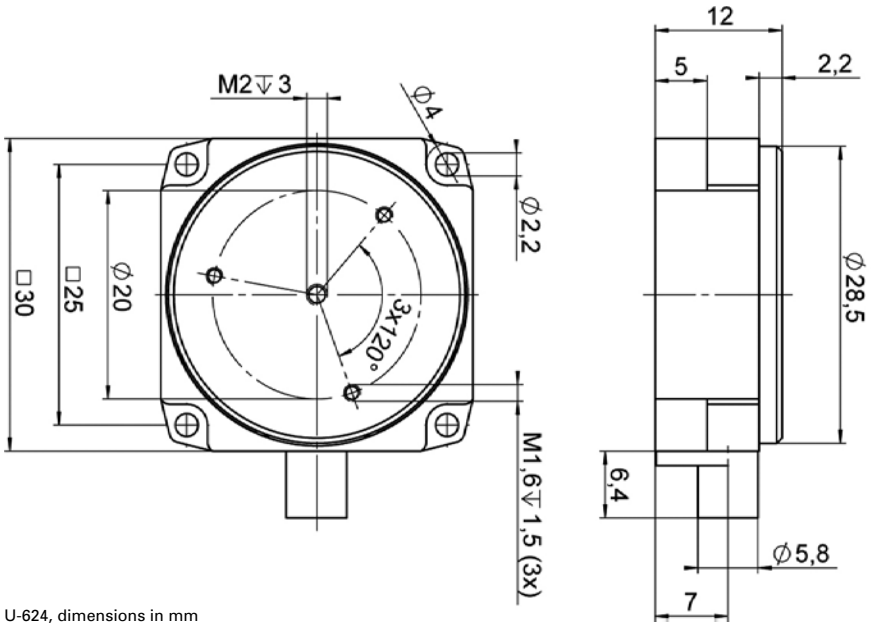


U-624, dimensions in mm

Fast Rotation Stage with Small Footprint

WITH ULTRASONIC PIEZOMOTOR

U-628

- Edge length 50 mm, height 19 mm
- Integrated, direct-measuring incremental encoder
- Rotation range >360°
- High velocity 720 °/s
- Drive torque to 25 mNm, center load to 5 N
- Clear aperture

Precision-class rotation stage

Integrated optical encoder for direct metrology. Rotation range >360°. Optical reference point switch. Central clear aperture with 7 mm diameter

PILine® ultrasonic piezo motor

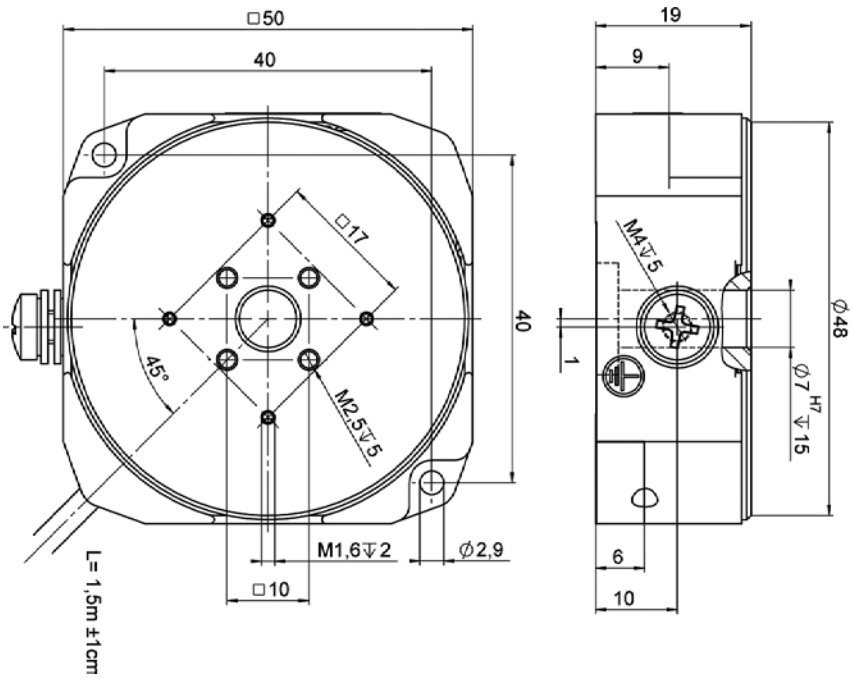
Oscillating piezoceramic actuators act directly on the ring-shaped runner. Self-locking at rest, thus no heat generation. High velocity to 720 °/s. Holding torque 25 mNm

Fields of application

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

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

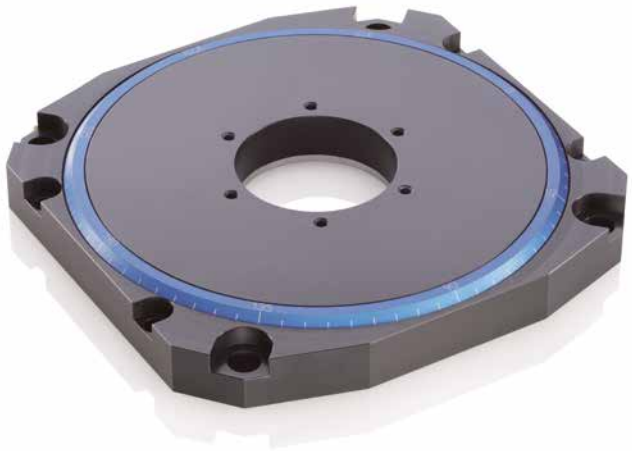
Ask about custom designs!



U-628, dimensions in mm

Rotation Stage with Low-Profile Design

FAST PILINE® DIRECT DRIVE



U-651

- Low profile: Only 14 mm height
- Integrated, direct-measuring incremental encoder with up to 4 µrad resolution
- Rotation range >360°
- High velocity of 720 °/s
- Drive torque to 0.3 Nm in both directions of rotation
- Clear aperture with 36 mm diameter

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

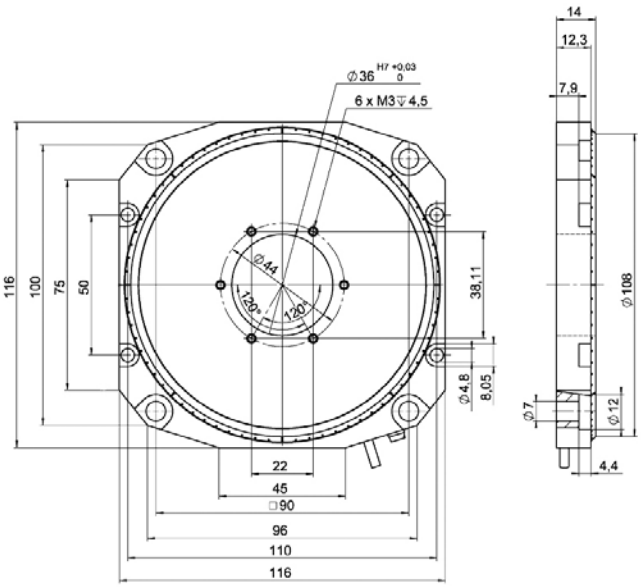
PILine® ultrasonic piezo motor
Oscillating piezoceramic actuators act directly on the ring-shaped runner. Self-locking at rest, therefore no heat generation. No drive noises. High velocity up to 720 °/s. Dynamic start / stop dynamics. Holding torque 0.3 Nm

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

Fields of application
Industry and research. For micromanipulation, automation, optical metrology

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

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



U-651, dimensions in mm

PILine® Motion Controller

FOR ULTRASONIC PIEZOMOTORS, 1 AND 2 AXES

C-867.U

- For PILine® ultrasonic piezo linear motors
- 50 MHz encoder inputs for simultaneous high velocity and resolution
- USB, RS-232, SPI and analog interfaces (e.g., for a joystick)
- ID chip support

Servocontroller and power amplifier
One and two channels, bench-top, special PID controller for ultrasonic piezomotors. Network capable with up to 16 units on a single interface. Power amplifier for PILine® ultrasonic piezomotors and stages with performance class 1, 2, and 3 piezomotors. Dynamic frequency control for optimum operation

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

Digital communication
USB, RS-232, SPI and analog interfaces (e.g., for a joystick). Data recorder. Powerful macro programming language, e.g., for stand-alone operation. ID chip for quick startup, parameter changes on-the-fly. Extensive software support, e.g., LabVIEW, shared libraries for Windows and Linux

The two-channel C-867 controller serves to control XY scanning stages, as in this case a customized M-686 stage for microscopy

	C-867.1U	C-867.2U
	Controller for single-axis positioning or scanning stages	Controller for XY positioning or scanning stages
Drive types	PILine® Performance class 2 motors	PILine® Performance class 2 motors
Channels	1	2
Motion and control		
Servo characteristics	Programmable PID filters, parameter changes on the fly	Programmable PID filters, parameter changes on the fly
Trajectory profile modes	Trapezoidal	Trapezoidal
Encoder input	Sin/cos, A/B, differential, 50 MHz, BiSS interface	Sin/cos, A/B, differential, 50 MHz, BiSS interface
Stall detection	Servo off, triggered by programmable position error or power level	Servo off, triggered by programmable position error or power level
Limit switches	2 programmable TTL lines per channel	2 programmable TTL lines per channel
Reference point switch	1 programmable line per channel (active high / low)	1 programmable line per channel (active high / low)
Electrical properties		
Max. output power per channel	15 W	15 W
Max. output voltage per channel	200 V_{pp}	200 V_{pp}
Interface and operation		
Interface / communication	USB; RS-232, SPI	USB; RS-232, SPI
Motor connector	Sub-D 15-pin (f)	2 x Sub-D pin (f)
Controller network	Up to 16 units on a single interface	Up to 16 units on a single interface
I/O ports	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)
User software	PIMikroMove	PIMikroMove
Software drivers	GCS-DLL (with code examples for the most common programming languages such as C++, C#, VB.NET, Python, Delphi), LabVIEW driver, MATLAB library	GCS-DLL (with code examples for the most common programming languages such as C++, C#, VB.NET, Python, Delphi), LabVIEW driver, MATLAB library
Supported functionality	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
Manual control	Pushbutton box, joystick (for 2 axes), Y-cable for 2-D motion	Pushbutton box, joystick (for 2 axes)
Miscellaneous		
Operating voltage	24 VDC from external power supply (included)	24 VDC from external power supply (included)
Max. operating current	300 mA plus motor current (max. 2 A)	600 mA plus motor current (max. 4 A)
Operating temperature range	5 to 40 °C	5 to 40 °C
Mass	1 kg	2.4 kg
Dimensions	206 mm × 130 mm × 66 mm (incl. mounting rails)	320 mm × 150 mm × 80.5 mm (incl. mounting rails)

Ask about custom designs!

PILine® Motion Controller

FOR ULTRASONIC PIEZOMOTORS, COST-EFFICIENT AND COMPACT

C-877

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

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

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

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

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

Ask about custom designs!

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M-674K Ultrasonic Z Drive

Ceramic PILine® Motor and Linear Encoder for High Speed & Precision

Equipped with two ultrasonic piezo-motors, the slim M-674KCPP offers up to 7 N push and pull force. The 9 mm width is matched to standard multiwell plate sizes, ideally suited to automation tasks in biotechnology

- **High Speed to 100 mm/sec**
- **High Push/Pull Force to 7 N**
- **Extremely Slim Design, Matched with Standard Multiwell Plates**
- **Stackable**
- **Integrated Linear Encoder for Highest Accuracy**
- **Self Locking at Rest**
- **Non-Magnetic and Vacuum-Compatible Working Principle**

Model	Travel	Push/pull force	Velocity	Resolution	Dimensions
M-674KCPP Compact PILine® Positioner	50 mm	7 N	100 mm/s	0.1 µm	120 x 40 x 9 mm

M-664K Ultrasonic Z Array

High-Speed, Compact, Cost-Effective, Stackable PILine® Actuator

Stack of 8 M-664KCEP linear actuators, shown with well plate. The integrated ceramic piezomotor provides high speeds to 100 mm/sec. The low-profile design with only 9 mm width allows stacking for multi-channel dispensing in bio-automation tasks

- **High Speed to 100 mm/sec**
- **Slim Design, Matched with Standard Multiwell Plates**
- **Travel range 50 mm**
- **Cost-Effective Design**
- **Stackable**
- **Non-Magnetic and Vacuum-Compatible Working Principle**
- **Self Locking at Rest**

Model	Travel	Push/pull force	Max. closed-loop velocity	Resolution	Dimensions
M-664KCEP Compact PILine® Positioner	50 mm	5 N	100 mm/s	0.5 µm	120 x 40 x 9 mm

M-682K Non-Magnetic Ultrasonic Motor Stage

Low-Profile, High-Speed with Piezo Ceramic Motor

Custom non-magnetic M-682KNMS linear stage with integrated RodDrive linear motor

- **Integrated Non-Magnetic PILine® RodDrive**
- **Travel Range 50 mm**
- **Integrated Linear Encoders with 0.1 µm Resolution**
- **Up to 6 N Force Generation**
- **Closed-Loop Velocity up to 100 mm/s**
- **Low Profile, Small Footprint**

Model	Travel	Load capacity	Max. push/ pull force	Dimensions
M-682KNMS PILine® Positioner	50 mm	50 N	6 N	110 x 110 x 20 mm

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- Scanning Microscopy Stages
- Steering Mirrors, Mirror Shifters
- Piezo Actuators
- Piezo Motors
- Piezo Controllers
- Motorized Stages & Actuators
- Motor Controllers
- Hexapod 6-Axis Alignment Systems

Fields of Applications

- Biotechnology / Life Sciences
- Semiconductor Technology
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