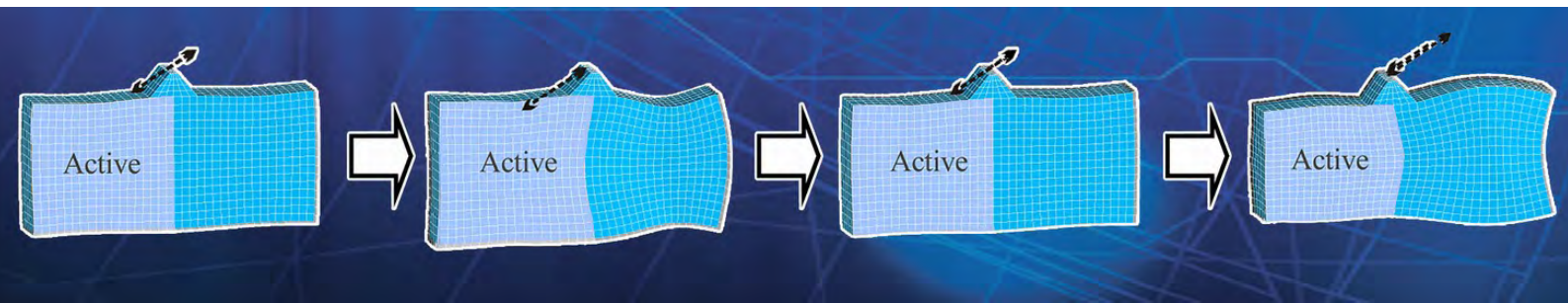


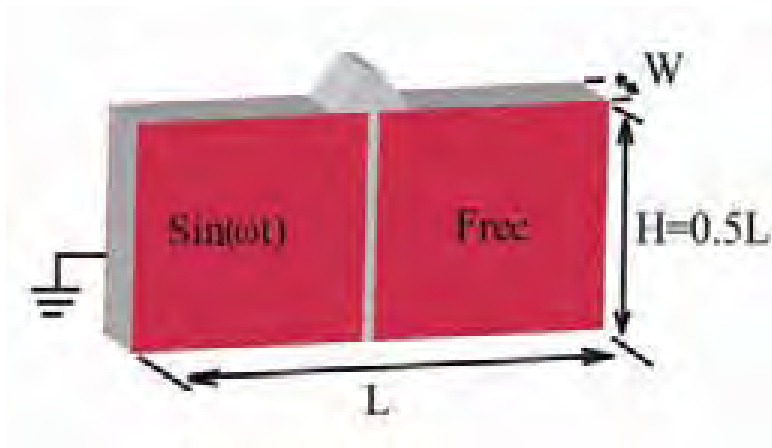
## Ultrasonic Motors for Fast and Precise Positioning



Latest Catalogs:  
[www.pi.ws](http://www.pi.ws)



# 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

## 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 micro-impulses 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.

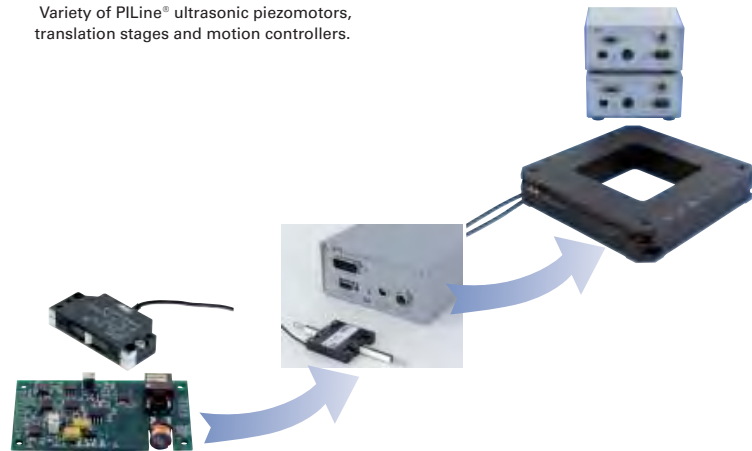
#### PILine® Levels of Integration

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.



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

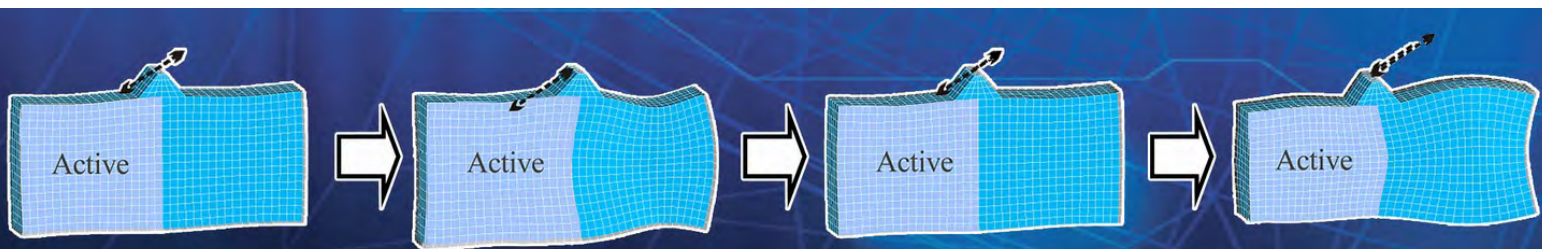


PILine® levels of integration: OEM motor, RodDrive, linear positioning stage.

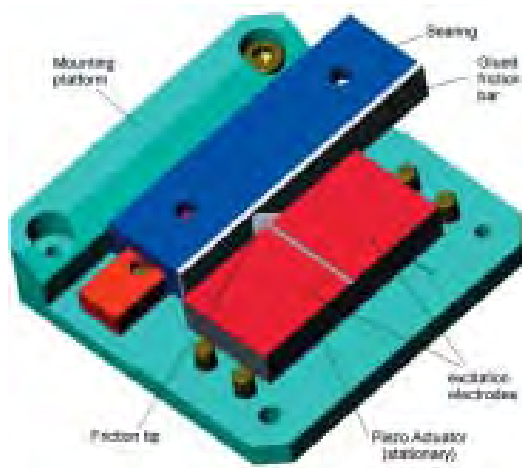
- Linear positioning stages represent the highest level of manufacturer integration. The piezomotor is integrated completely in a high-quality mechanical setup including if necessary the servo-loop with direct-metrology linear encoders.



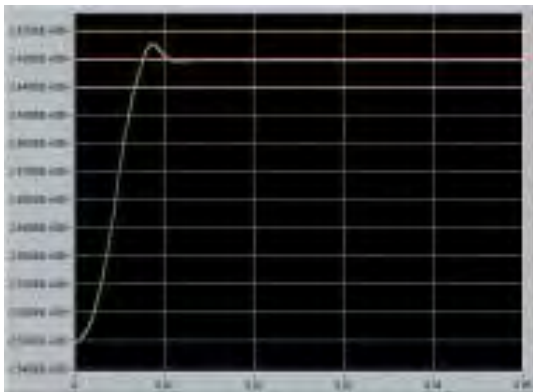
PILine® ultrasonic motors are based on a simple construction allowing for the design of low-cost drive units and extremely compact, high-speed micro-positioning stages smaller than a matchbox.



## Ultrasonic Motor Principle



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



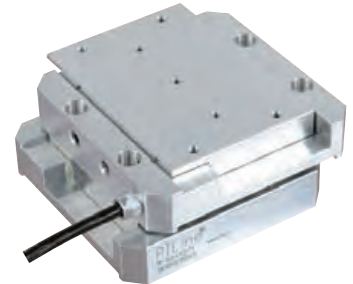
Settling behavior of a PILINE® M-663 linear stage, 100 µm step. A stable position to within 0.1 µm can be reached in only 10 ms.

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 sub-micron 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 nano-positioning 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.



Watch Video at  
<http://www.youtube.com/watch?v=w9FOJemtqvQ>



Cost-effective combination:  
 M-272 closed-loop linear pusher and C-867.OE controller card

## Technical Data (Preliminary Data)

Latest Specs: [www.pi.ws](http://www.pi.ws)

Model	M-272	Tolerance
Active axes	X	
<b>Motion and positioning</b>		
Travel range	50 mm	
Integrated sensor	Linearencoder	
Sensor resolution	5 $\mu\text{m}$	
Design resolution	5 $\mu\text{m}$	typ.
Min. incremental motion	10 $\mu\text{m}$	typ.
Backlash	5 $\mu\text{m}$	typ.
Unidirectional repeatability	10 $\mu\text{m}$	typ.
Velocity	200 mm/s	max.
<b>Mechanical properties</b>		
Guiding	Ball bearings	
Push/pull force	8 N	max.
Holding force	8 N	max.
Lateral force	5 N	max.
<b>Drive properties</b>		
Motor type	U-164 PILine® ultrasonic piezomotor	
Current	800 mA	
Reference switch	Hall-effect	
<b>Miscellaneous</b>		
Operating temperature range	-20 to +50 °C	
Material	Aluminum	
<b>Dimensions</b>		
Mass	0.5 kg	$\pm 5\%$
Cable length	0.5 m	$\pm 10 \text{ mm}$
Connector	MDR, 14-pin	

Recommended controller/driver: C-867.OE

\* Power for the motor is supplied by the drive electronics, which requires 12 VDC.

\*\* For drive electronics

## Ultrasonic Motor OEM Controller

### Affordable OEM Piezo Motor Controller with CAN Interface



Controller C-867.OE for piezo linear drives

#### Ordering Information

**C-867.OE**  
OEM Driver / Controller Card  
for PLine® Ultrasonic Motors,  
1 Channel

**Ask about custom designs!**

- **Optimized for all PLine® Ultrasonic Piezo Linear Motors with Single or Double Drive**
- **PID Servo-Control with Dynamic Parameter Switching**
- **Integrated Piezo Motor Power Driver with Frequency Control**
- **CAN, RS-232, and Analog Interfaces (e.g. for Joystick)**
- **Data Recorder**
- **Powerful Macro Command Language, e.g. for Standalone Operation**
- **Extensive Software Support, LabVIEW, DLL, ...**

The C-867 OEM card is a cost-effective motion controller for closed-loop positioning systems equipped with PLine® ultrasonic piezo motors. The controller card integrates both

the servo controller / communication hardware and the driver electronics for the ultrasonic piezo motors.

For seamless integration in industrial automation environments, the controller can be operated via RS-232 and CAN interfaces. In addition, an analog (joystick) interface and non-volatile macro command memory make stand-alone operation possible.

#### Highly Specialized PID Servo-Controller

The C-867 is based on a highly specialized DSP (Digital Signal Processor) that handles the PID servo-control algorithm as well as other system functions. Because of the motion properties

typical for ultrasonic piezomotors, the controller has a number of advanced features, including dynamic control parameter adaption. By automatically switching between gainsets for dynamic and static operation an optimized settling behavior within a couple of 10 milliseconds is achieved. The broadband encoder input (50 MHz) allows high-resolution encoders to be used with the outstandingly high accelerations and velocities that PLine® drives deliver.

#### Highest Stability and Reliability with Automatic Frequency Control

The integrated piezomotor drive electronics supports all types of PLine® ultrasonic piezomotors currently available.

Variations in the resonant frequency of the motor caused by temperature or load changes are automatically compensated for by a frequency-control loop which adjusts the operating frequency of the driving voltage. This leads to higher stability of the motor output force and velocity and to higher position accuracy.

#### Software / Programming

In addition to the user software for setup, system optimization and operation, comprehensive LabVIEW and DLL libraries are provided.

The PIMikroMove user software provides the PI Tuning Tool for optimizing system performance. Graphic displays show the system's behaviour and facilitate parameter setting.

#### Application Examples

- Biotechnology
- Microscopy
- Fiber positioning
- Automation
- Photonics / integrated optics
- Quality assurance testing
- Testing equipment



Cost-effective combination:  
M-272 closed-loop linear pusher and C-867.OE controller card

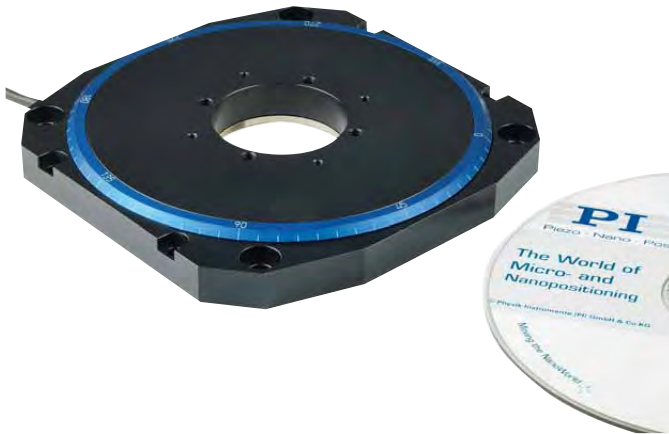
## Technical Data

Latest Specs: [www.pi.ws](http://www.pi.ws)

<b>Model</b>	<b>C-867.OE</b>
Function	Controller and drive electronics for PILine® piezomotors/systems
Drive type	PILine® motors, single and dual drives with P-661, P-664, U-161, U-164 and U-264
Channels	1
<b>Motion and control</b>	
Servo characteristics	Programmable PID V-ff filter, parameter changes on-the-fly
Trajectory profile modes	Trapezoidal
Encoder input	A/B differential signals, 50 MHz
Stall detection	Servo off, triggered by programmable position error
Limit switches	2 TTL (programmable)
Reference switches	1 TTL (active high/low, programmable)
<b>Electrical properties</b>	
Max. output power	15 W
Max. output voltage	200 V <sub>pp</sub>
<b>Interfaces and operation</b>	
Communication interfaces	RS-232, CAN, input / output 32-pin (male) on rear panel (DIN 41612/D)
Motor connector	MDR14
Command set	PI General Command Set (GCS)
User software	PIMikroMove
Software drivers	GCS-DLL, LabVIEW drivers
Supported functionality	Start-up macro, macro, data recorder for recording parameters as motor input voltage, velocity, position or position error
<b>Miscellaneous</b>	
Operating voltage	24 VDC from external power supply (not included)
Current	150 mA + motor current (2 A max.)
Operating temperature range	+5 °C to +40 °C
Mass	420 g
Dimensions	175 x 100 x 38 mm (connectors included)

## Ultrasonic Motor Rotation Stage

### Fast Positioning, Ultra-Low Profile



The M-660 PLine® rotation stage allows high positioning speeds of up to 2 full turns/sec. The 36 mm Ø clear aperture offers flexible usage

- **Unlimited Travel Range**
  - **Max. Velocity 720 °/s**
  - **Low Profile: Only 14 mm in Height**
  - **Self-Locking Ceramic Direct Drive: Energy Saving & High Position Stability**
  - **Direct Metrology Linear Encoder, 34 µrad Resolution**
  - **PILine® Direct Drive: Non-Magnetic and Vacuum-Compatible**
- Working Principle**
- **Compact Combinations with Linear Stages**

M-660 precision rotation stages use PILine® ultrasonic piezo

#### Application Examples

- Biotechnology
- Micromanipulation
- Microscopy
- Quality assurance testing
- Metrology
- Mass storage device testing
- R&D
- Photonics packaging

motors that act on a ceramic friction ring to drive the platform. This direct drive principle allows for the compact design and low profile of the stage. An integrated incremental encoder offers precision position control with up to 34 µrad resolution. The integrated U-164 PLine® linear motors provide a maximum torque of 0.3 Nm, independent from the direction of motion, and a maximum velocity of up to 720 °/sec. The maximum load is 2 kg.

M-660s can be built in different sizes or with other specifica-

tions, and they are available upon request as vacuum-compatible versions.

#### Advantages of PLine® Micropositioning Systems

Positioning systems equipped with ceramic ultrasonic drives of the PLine® series provide several advantages over positioners that apply classic drive technology:

- Smaller dimensions
- Higher holding force when powered down; no holding current
- Increased acceleration of up to 5 g
- Increased velocity of up to 500 mm/s or 720 °/s, resp.
- No leadscrews, gears or other mechanical components, no wear or maintenance
- No lubricants
- Non-magnetic and vacuum-compatible operating principle

#### Optimized Controller and Drive Electronics

For optimum performance, the highly specialized C-867 motion controller (s. p. 4-116) is recommended. This dedicated piezo motor controller also integrates the drive electronics which PLine® motors require to generate the ultrasonic oscillations on the piezoceramic element.

Furthermore, the controller has a number of special characteristics to address the requirements of ultrasonic motors, such as continuous automatic drive frequency adjustment, dynamic parameter switching for optimized high-speed motion and settling behavior. The broad-band encoder input (50 MHz) supports the outstanding high accelerations and

#### Ordering Information

**M-660.55**  
PLine® Rotation Stage, Ø 108 mm, 360°, 34 µrad Resolution

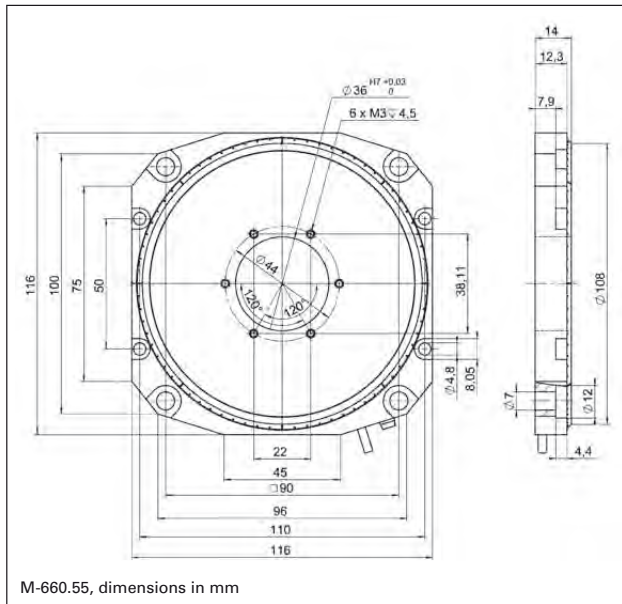
Ask about custom designs!

velocities of PLine® drives at high resolutions.

Optionally, the C-185 analog drive electronics (stand-alone unit) (s. p. 1-36) is available for use with third party servo controllers. It accepts an analog ±10 V signal to control the motor velocity. For optimum performance, the driver must be tuned together with the mechanics and should be ordered at the same time as the motor / stage.

#### Patented Technology

The products described in this document are in part protected by the following patents:  
US Pat. No. 6,765,335  
German Patent No. 10154526



Watch Video at  
<http://www.youtube.com/watch?v=loAhRLFFPNk&NR=1>

Latest Specs: [www.pi.ws](http://www.pi.ws)

## Technical Data

Model	M-660.55	Units	Tolerance
Active axes	Theta Z		
<b>Motion and positioning</b>			
Rotation range	No limit	°	
Integrated sensor	Incremental encoder		
Design resolution	34	μrad	typ.
Min. incremental motion	34	μrad	typ.
Bidirectional repeatability	34	μrad	
Max. velocity	720	°/s	
<b>Mechanical properties</b>			
Load capacity / axial force	20	N	max.
Holding force	0.3	Nm	max.
Max. torque cw/ccw (θ Z)	0.3	Nm	max.
<b>Drive properties</b>			
Motor type	2 x U-164 PILine® ultrasonic piezo drive		
Operating voltage	60 (RMS)*	V	
Electrical power	0.2	W	nominal
Current consumption**	0.3 (2 max.)	A	
Reference switch	optical		
<b>Miscellaneous</b>			
Operating temperature range	-20 to +50	°C	
Material	Al (black anodized)		
Mass	0.4	kg	±5%
Cable length	1.3	m	±10 mm
Connector	MDR, 14-pin		
Recommended controller / driver	C-867 single-axis controller / driver		

\* The operating voltage is supplied by the drive electronics

\*\* For drive electronics

# Ultrasonic Mini Linear Motor

## Fast, Compact OEM Ultrasonic Linear Motor



PILine® P-661 OEM piezo linear motor

- Patented Principle Features with High Forces in Small Space
- Max. Velocity 500 mm/s
- Acceleration to 5 g
- Min. Incremental Motion to 0.05 µm
- Self-Locking to 1.5 N
- No Electro-Magnetic Fields
- MTBF 20,000 h
- Integrated Actuators & Positioning Systems Also Available

### PILine® Linear Motors – Small, Fast, Highly Effective

Despite their small size, PILine® linear motors generate high driving and holding forces.

#### Application Examples

- Biotechnology
- R&D
- Semiconductor testing
- Mass storage device testing
- Metrology
- Micromanipulation
- Microscopy
- Photonics packaging
- Quality assurance testing

PILine® motors have a new, patented, ultrasonic drive developed by PI. The core piece of the system is a piezoceramic plate, which is excited to produce high-frequency eigenmode oscillations. A friction tip attached to the plate moves along an inclined linear path at the eigenmode frequency. Through its contact with the friction bar, the moving part of the mechanics drives 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.

### High Speed and Acceleration

PILine® piezomotor drives can provide accelerations of up to 5 g and speeds of up to 500 mm/s, together with high resolution and high holding

force. Because the ceramic stator is pressed against the slider, holding forces are generated when the motor is powered down. The result is very high position stability without the heat dissipation common in conventional linear motors.

### Accessories for Easy Integration

PILine® piezomotors require a special drive electronics to generate the ultrasonic oscillations for the piezoceramic element. The drive electronics is available as OEM board, stand-alone device or integrated controller and therefore not included in the delivery. PI offers friction bars with different lengths.

### Long Lifetime

PI has over 30 years experience with piezo technology and nanopositioning. PILine® drives offer high precision and reliability, with over 20,000 hours MTBF. This is because PILine® piezo linear motor drives have no mechanical components such as shafts and gears which can cause failures in conventional motors.

### Ordering Information

#### P-661.P01

PILine® Miniature Linear Piezomotor, 2 N

#### Accessories:

#### P-661.B01

Friction Bar for P-661 PILine® Miniature Linear Piezomotor, 15 mm

#### P-661.B02

Friction Bar for P-661 PILine® Miniature Linear Piezomotor, 25 mm

#### P-661.B05

Friction Bar for P-661 PILine® Miniature Linear Piezomotor, 55 mm

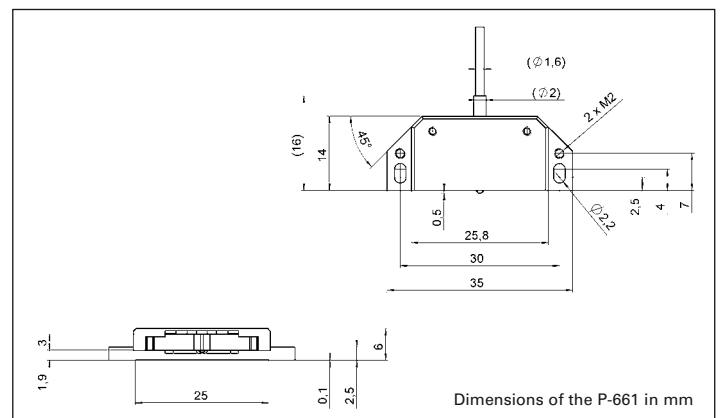
#### C-184.161

Analog OEM Driver Board for PILine® P-661 Motors

#### C-185.161

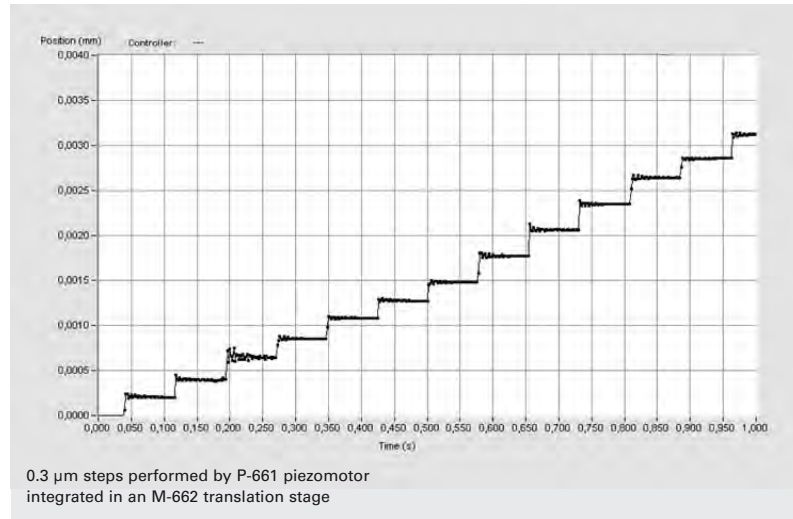
Analog Stand-Alone Drive Electronics with Power Supply for PILine® P-661 Motors

Controller for closed-loop operation are available as C-867 s. p. 4-116.



## Note

The products described in this document are in part protected by the following patents:  
 US Pat. No. 6,765,335  
 German Patent No. 10154526



Latest Specs: [www.pi.ws](http://www.pi.ws)

Model	P-661.P01	Units	Tolerance
<b>Motion and positioning</b>			
Travel range	No limit*	mm	
Minimum incremental motion, open-loop	0.05**	μm	typ.
Max. velocity	500	mm/s <sup>2</sup>	
<b>Mechanical properties</b>			
Stiffness when powered down	0.7	N/μm	±10 %
Holding force when powered down	1.5	N	max.
Push / pull force	2	N	max.
Preload on friction bar	9	N	±10 %
<b>Drive properties</b>			
Resonant frequency	210	kHz	typ.
Motor voltage range	120 (peak-peak) 42 (RMS)	V	
Operating voltage drive electronics	12	V	
Electrical power drive electronics	5	W	
<b>Miscellaneous</b>			
Operating temperature range	-20 to +50	°C	
Body material	Al (black anodized)		
Mass	0.01	kg	±5 %
Cable length	1.6	m	±10 mm
Connector	Open leads		
Recommended controller/driver	C-184.161 OEM board C-185.161 in box		
Dimensions	14 x 35 x 6	mm	
MTBF	>20,000	h	

\* The travel range of piezo linear motors is virtually unlimited and depends on the length of the friction bar, which is available separately.

\*\* The minimum incremental motion is a typical value that can be achieved in the open-loop mode of a piezomotor stage. To reach the specs it is important to follow the mounting guidelines of the OEM-motors.

## Ultrasonic Linear Motor

### Fast, Compact OEM Ultrasonic Linear Motor



OEM ultrasonic piezo linear motor  
U-164.01

- Patented Principle Features with High Forces in Small Space
- Easy Mounting
- Max. Velocity 500 mm/s
- Acceleration up to 5 g
- Min. Incremental Motion to 0,05 µm
- Self Locking, Push-/Pull Forces to 4 N
- No Electro-Magnetic Fields
- Integrated Actuators & Positioning Systems Also Available

#### PILine® Linear Motors—Small, Fast, Highly Effective

Despite their small size, PILINE® linear motors generate high driving and holding forces. PILINE® piezo motors have a new, patented, ultrasonic drive

developed by PI. The core piece of the system is a piezoceramic plate, which is excited with high-frequency eigenmode oscillations. A friction tip attached to the plate moves along an inclined linear path at the eigenmode frequency. Through its contact with the friction bar, the moving part of the mechanics drives 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.

#### High Speed and Acceleration

PILINE® piezomotor drives can provide accelerations of up to 5 g and speeds of up to 500 mm/s, together with high resolution and high holding force. Because the ceramic

stator is pressed against the slider, holding forces are generated when the motor is powered down. The result is very high position stability without the heat dissipation common in conventional linear motors.

#### Accessories for Easy Integration

The PILINE® motors require a special drive electronics to generate the ultrasonic oscillations for the piezoceramic element. The drive electronics is available as OEM board, stand-alone device or integrated inside a controller and therefore not included in the delivery. PI offers friction bars with different lengths.

#### Long Lifetime

PI has over 30 years experience with piezo technology and nanopositioning. PILINE® drives offer high precision and reliability. This is because PILINE® piezo linear motor drives have no mechanical components such as shafts and gears which can cause failures in conventional motors.

#### Ordering Information

**U-164.01**  
PILINE® Piezo Linear Motor, 4 N

#### Accessories:

**P-664.B01**  
Friction Bar for PILINE® Miniature Linear Piezomotor, 15 mm

**P-664.B02**  
Friction Bar for PILINE® Miniature Linear Piezomotor, 25 mm

**P-664.B05**  
Friction Bar for PILINE® Miniature Linear Piezomotor, 55 mm

**C-184.164**  
Analog OEM Driver Board for PILINE® Motors

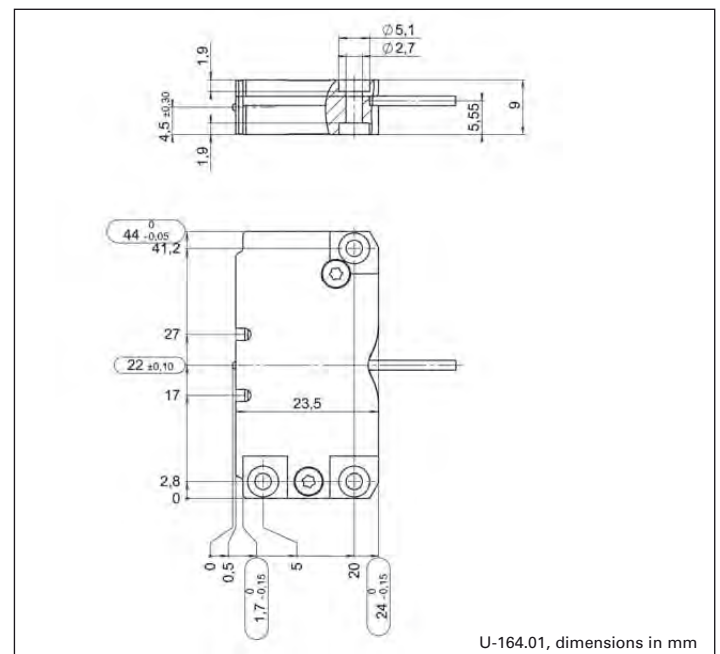
**C-185.164**  
Analog Stand-Alone Drive Electronics with Power Supply for PILINE® Motors

Controllers for closed-loop operation are available as C-867 (see p. 4-116).

**Ask about custom designs!**

#### Patent Information

The products described in this document are in part protected by the following patents:  
US Pat. No. 6,765,335  
German Patent No. 10154526



U-164.01, dimensions in mm

#### Application Examples

- Biotechnology
- R&D
- Semiconductor testing
- Mass storage device testing
- Metrology
- Micromanipulation
- Microscopy
- Photonics packaging
- Quality assurance testing

## M-674K Ultrasonic Z Drive

### Ceramic PLine® 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 PLine® 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 PLine® 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 PLine® 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

- Integrated Non-Magnetic PLine® 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



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

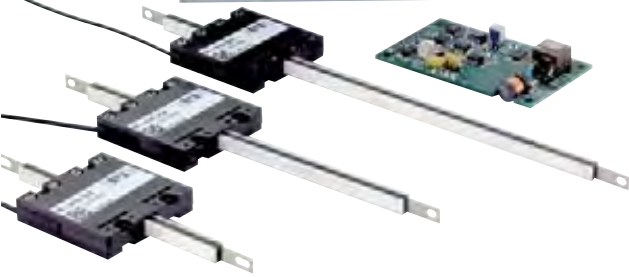
Model	Travel	Load capacity	Max. push/pull force	Dimensions
M-682KNMS PLine® Positioner	50 mm	50 N	6 N	110 x 110 x 20 mm

# Ultrasonic Motor Pusher

## Integrated Fast Ultrasonic Piezo Drives



PILine® RodDrive, shown with C-184 OEM and C-185 bench-top driver electronics, provides 7 N pushing force and travel ranges of 50, 100 and 150 mm



- **Drive-Component for Integration into Micropositioning Systems**
- **Travel Ranges to 150 mm**
- **Push/Pull Forces to 7 N**
- **Min. Incremental Motion to 0.05 µm**
- **Velocity to 450 mm/s**
- **Self-Locking at Rest**

PILine® RodDrives represent a level of integration between P-Line® OEM piezo linear motors such as P-664 (see p. 1-28) and guided micropositioning systems such as the M-682 (see p. 4-32) series stages.

RodDrives may replace classical drive elements like rotary motor/leadscrew assemblies, or magnetic linear drives integrated into a micropositioner.

### Application Examples

- System integration for micropositioning products
- Automation
- Handling
- Micromanipulation
- Biotechnology
- Metrology

They consist of a rod which is preloaded by piezo linear motors from two sides. Depending on the way of integration, either the rod or the motor block is coupled to the moving platform.

### Advantages of P-Line® Micropositioning Systems

The ultrasonic piezoceramic drives used in P-Line® micropositioners have a number of advantages over classical drives:

- Higher Accelerations, up to 5 g
- Speeds up to 500 mm/s
- Small Form Factor
- Self-Locking When Powered Down
- No Shafts, Gears or Other Rotating Parts
- Non-Magnetic and Vacuum Compatible Drive Principle

### Working Principle

RodDrives employ a patented ultrasonic drive developed by PI. The highly compact, integrated P-664 piezomotors can provide velocities of 450 mm/s, together with high resolution and holding force. The maximum travel is determined by the length of the rod and is basically unlimited. Customized adaptations in terms of operating and holding force are feasible by varying type and number of motors used. Because the integrated ceramic motors are preloaded against the rod, RodDrives resist motion with an intrinsic holding force when at rest. The result is very high position stability without the heat dissipation common with conventional linear motors. Furthermore, there are no gears, leadscrews or other mechanical components to contribute play or backlash.

### Variety of Drivers / Controllers

P-Line® piezomotors require a drive electronics for exciting the ultrasonic oscillations. The drive electronics is available as OEM board, stand-alone device or integrated inside a closed-loop motion controller and therefore not included in the delivery.

### Closed-Loop Operation: Optimized for High Velocity and Rapid Step/Settling

Together with a position sensor, RodDrives can be operated in closed-loop with the C-867.D64 (see p. 4-116) piezo motor controller. This specialized servo-controller also integrates the motor drive electronics and enables highly constant speeds up to 350 mm/s with very short settling times (tens of milliseconds). RodDrives can also be operated with conventional servo-controllers. In this case, the C-185 (see p. 1-36) (to be ordered separately) external drive electronics is required which accepts a ±10 V analog signal from the controller.

### Note

The products described in this document are in part protected by the following patents:  
 US-Pat. No. 6,765,335  
 German Patent No. 10154526

Latest Specs: [www.pi.ws](http://www.pi.ws)

## Ultrasonic Linear Piezo Motor Stage



M-662 and M-661 Ultrasonic Motor stages are the smallest piezo-motor-driven translation stages

- **Smallest Translation Stages with Linear Motor Drive**
- **Travel Ranges to 20 mm**
- **Max. Velocity 500 mm/s**
- **Acceleration to 5 g**
- **Incremental Motion to 50 nm**
- **Self Locking at Rest**
- **XY-Combination Possible**
- **MTBF 20.000 h**
- **Vacuum Versions to 10<sup>-7</sup> hPa**

M-661 and M-662 P-Line® translation stages offer accelerations to 5 g with millisecond response and velocities to 500 mm/sec in an extremely compact package. Providing travel ranges to 20 mm, they

are among the smallest motorized translation stages currently on the market. Both models are designed for open-loop operation (a similar closed-loop stage with linear encoder is available as model M-663). The M-662, with its square footprint, is also suitable for use in XY configurations. For applications where the smallest dimensions are essential, the P-652 micro stage is offered.

### Working Principle

P-Line® piezo motors use a new, patented, ultrasonic drive developed by PI. At the heart of the system is a piezo ceramic plate, which is excited with high-frequency eigenmode oscillations. A friction tip attached to the plate moves

along an inclined linear path at the eigenmode frequency. Through its contact with the friction bar, the moving part of the mechanics drives forward or backwards. With each oscillatory cycle, the mechanics execute a step of a few nanometers; the macroscopic result is smooth motion with a virtually unlimited travel range.

### Advantages of P-Line® Micropositioning Systems

The ultrasonic piezoceramic drives used in P-Line® micropositioners have a number of advantages over classical drives:

- Higher Accelerations, up to 5 g
- Speeds up to 500 mm/s
- Small Form Factor
- Self-Locking When Powered Down
- No Shafts, Gears or Other Rotating Parts
- Non-Magnetic and Vacuum-Compatible Drive Principle

### Choice of Drive Electronics

Special driver electronics are required to create the ultrasonic oscillations for P-Line® piezo-

### Ordering Information

**M-661.370**  
P-Line® Translation Stage, 18 mm, Open-Loop

**M-662.470**  
P-Line® Translation Stage, 20 mm, Open-Loop, XY Mountable

#### Accessories:

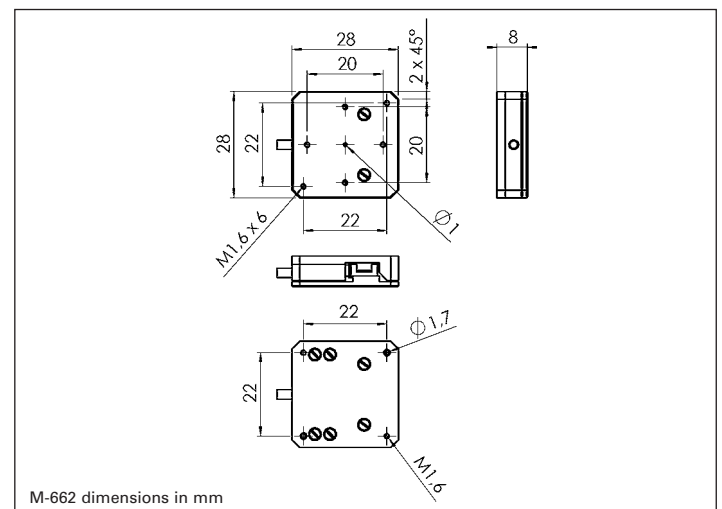
**C-184.161**  
Analog OEM Driver Board for P-Line® P-661 Motors

**C-185.161**  
Analog Stand-Alone Drive Electronics with Power Supply for P-Line® P-661 Motors

motors. The driver controls the motor speed as a function of an analog  $\pm 10$  V signal. The driver is not included, as it is available in different versions, from the low-priced C-184.161 OEM-board to the C-185.161 bench-top unit. The stage and the driver electronics, however, must be ordered together, so that they can be tuned to one-another for optimum performance.

### Notes

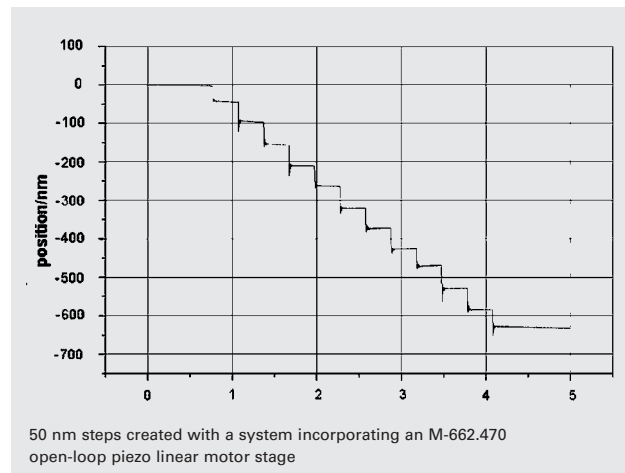
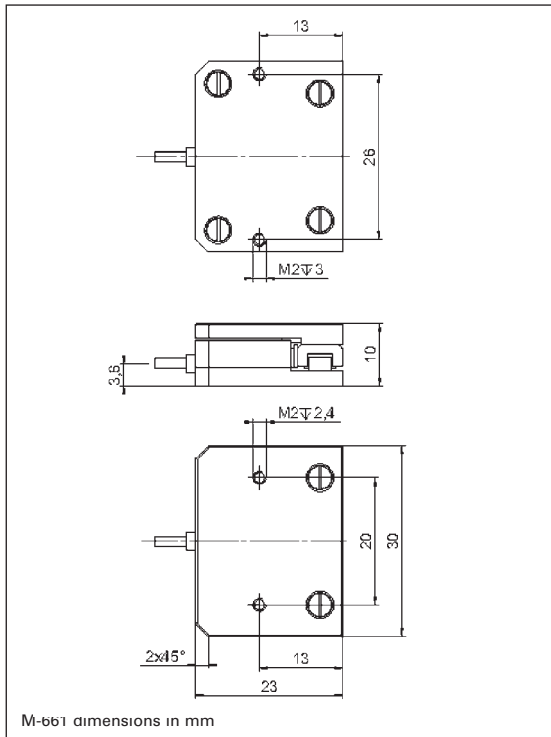
The products described in this document are in part protected by the following patents: US Pat. No. 6,765,335  
German Patent No. 10154526



M-662 dimensions in mm

### Application Examples

- Biotechnology
- Micromanipulation
- Microscopy
- Quality assurance testing
- Semiconductor testing
- Metrology
- Mass storage device testing
- R&D
- Photonics packaging



## Technical Data

Latest Specs: [www.pi.ws](http://www.pi.ws)

Model	M-661.370	M-662.470	Units	Tolerance
<b>Motion and positioning</b>				
Travel range	18	20	mm	
Min. incremental motion	0.05*	0.05*	µm	typ.
Max. velocity	500	500	mm/s	
<b>Mechanical properties</b>				
Max. load	5	5	N	
Max. push/pull force	1	1	N	
Max. holding force	2	2	N	
<b>Drive properties</b>				
Motor type	P-661 PLine® ultrasonic piezomotor drive	P-661 PLine® ultrasonic piezomotor drive		
Operating voltage	120 (Peak-Peak)** 42 (RMS)**	120 (Peak-Peak)** 42 (RMS)**	V	
Electrical power	5***	5***	W	nominal
Current	400***	400***	mA	
<b>Miscellaneous</b>				
Operating temperature range	-20 to +50	-20 to +50	°C	
Material	Al (black anodized)	Al (black anodized)		
Dimensions	30 x 23 x 10	28 x 28 x 8		
Mass	0.03	0.03	kg	±5 %
Cable length	1.5	1.5	m	±10 mm
Connector	LEMO connector	LEMO connector		
Recommended controller/driver	C-184.161 OEM board C-185.161 Bench-top	C-184.161 OEM board C-185.161 Bench-top (p. 1-36)		

\*The minimum incremental motion is a typical value that can be achieved in the open-loop mode of a piezomotor stage.

To obtain it, it is important to follow the mounting guidelines in the motor documentation.

\*\*The stage supply power is drawn from the drive electronics, which runs on 12 VDC.

\*\*\*For drive electronics.

## Ultrasonic Motor Closed Loop Linear Piezo Motor Stage Compact, Fast, with Ultrasonic Piezo Linear Drives, Direct Position Measurement



Ultrasonic Motor stage with integrated linear encoder

- **Smallest Translation Stage with Closed-Loop Linear Motor and Encoder**
- **Travel Range 19 mm**
- **Max. Velocity 400 mm/s**
- **Acceleration up to 10 g**
- **Direct Metrology Linear Encoder**
- **0.1 μm Resolution**
- **XY Combination Possible**
- **Vacuum-Compatible Versions Available**

PILine® M-663 micropositioning systems offer high velocities of up to 400 mm/s and travel ranges of 19 mm in a compact package. The M-663 is the smallest closed-loop trans-

lation stage with piezomotor drives currently on the market. Its square footprint makes it suitable for use in compact XY configurations.

### Working Principle

PILine® motors have a new, patented, ultrasonic drive developed by PI. The core piece of the system is a piezoceramic plate, which is excited to produce high-frequency eigenmode oscillations. A friction tip attached to the plate moves along an inclined linear path at the eigenmode frequency. Through its contact with the friction bar, the moving part of the mechanics drives 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.

### Advantages of PILINE® Micropositioning Systems

The ultrasonic piezoceramic drives used in PILINE® micropositioners have a number of advantages over classical drives:

- Higher Accelerations, up to 5 g
- Speeds up to 500 mm/s
- Small Form Factor
- Self-Locking When Powered Down
- No Shafts, Gears or Other Rotating Parts
- Non-Magnetic and Vacuum-Compatible Drive Principle

### Optimized Controller and Drive Electronics

PILine® motors require a special drive electronics to generate the ultrasonic oscillations for piezoceramic element. For optimum performance the highly specialized C-867 (see p. 4-116) motion controller is recommended. This sophisticated controller also integrates the drive electronics. Furthermore, the controller has a number of special features, including dynamic parameter switching for an optimized high-speed motion and settling behavior to take into account the motion characteristics typical of piezomotors. The broad-band encoder input (50 MHz) supports the outstanding high accelerations and velocities of PILINE® drives at high resolutions.

Optionally, for use with third party servo controllers, the C-185 analog drive electronics (stand-alone unit) is available. It controls the motor speed by an analog ±10 V signal. For

### Ordering Information

**M-663.465**  
PILine® Translation Stage, 19 mm, Linear Encoder, 0.1 μm Resolution

**M-663.Y65**  
PILine® Translation Stage, 19 mm, Linear Encoder, 0.1 μm Resolution, turned cable outlet, XY mountable

**M-663.46V**  
PILine® Translation Stage, 19 mm, Linear Encoder, 0.1 μm Resolution, Vacuum Compatible to 10-6 hPa

### Accessories:

**C-867.161**  
Piezomotor Controller with Drive Electronics, 1 Channel, for PILINE® Systems with P-661 Motors

Driver for use with separate controller:

**C-185.161**  
Analog Stand-Alone Drive Electronics with Power Supply for PILINE® P-661 Motors

optimum performance the driver must be tuned together with the mechanics and should be ordered at the same time as the motor/stage.

### Note

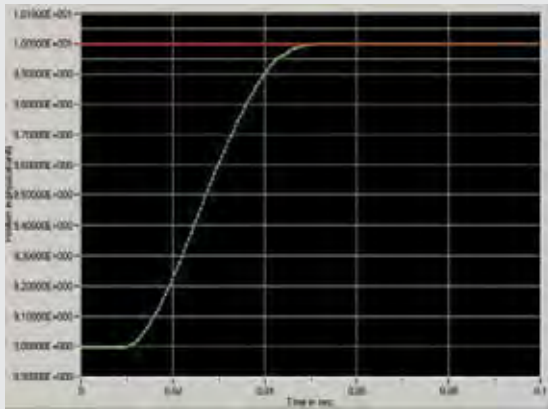
The products described in this document are in part protected by the following patents:  
US Pat. No. 6,765,335  
German Patent No. 10154526

### Application Examples

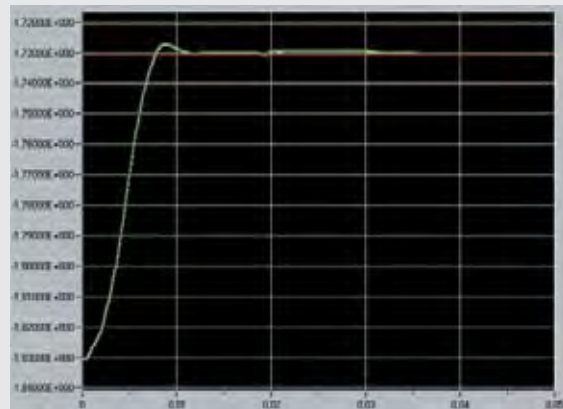
- Biotechnology
- Micromanipulation
- Microscopy
- Quality assurance testing
- Metrology
- Mass storage device testing
- R&D
- Photonics packaging



XY combination of two M-663s; CD for size comparison



A 1 mm step performed by an M-663 stage with 300 g load controlled by a C-867 controller/driver reaches the end position in less than 40 ms

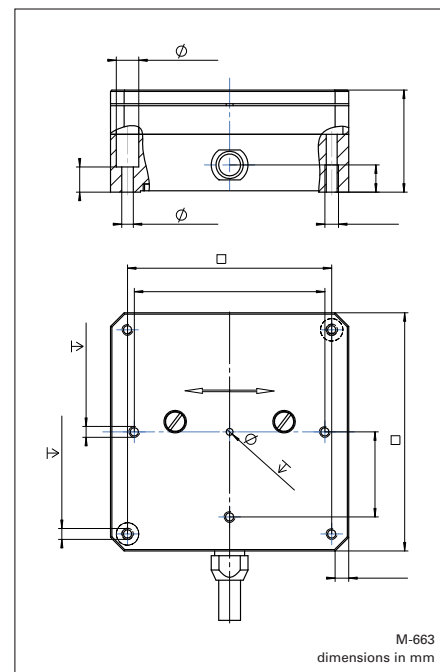


An M-663 with 100 g load settles to 0.1  $\mu\text{m}$  accuracy in 10 ms after a 100  $\mu\text{m}$  step, measured with C-867 controller/driver

## Technical Data

Latest Specs: [www.pi.ws](http://www.pi.ws)

Model	M-663.465	Units	Tolerance
Active axes	X		
<b>Motion and positioning</b>			
Travel range	19	mm	
Integrated sensor	Linear encoder		
Sensor resolution	0.1	$\mu\text{m}$	
Min. incremental motion	0.1	$\mu\text{m}$	typ.
Bidirectional repeatability	$\pm 0.3$	$\mu\text{m}$	typ.
Unidirectional repeatability	0.2	$\mu\text{m}$	typ.
Pitch	300	$\mu\text{rad}$	typ.
Yaw	300	$\mu\text{rad}$	typ.
Max. velocity	400	mm/s	
Reference switch repeatability	1	$\mu\text{m}$	typ.
<b>Mechanical properties</b>			
Max. load	5	N	
Max. push/pull force	2	N	
Max. holding force	2	N	
<b>Drive properties</b>			
Motor type	P-661 PLine® ultrasonic piezomotor		
Motor voltage range	120 (peak-peak)* 42 (RMS)*	V	
Electrical power	5**	W	nominal
Current	400**	mA	
Reference switch	Hall-effect		
<b>Miscellaneous</b>			
Operating temperature range	-20 to +50	$^{\circ}\text{C}$	
Material	Al (black anodized)		
Dimensions	35 x 35 x 15	mm	
Mass	40	g	$\pm 5\%$
Cable length	1.5	m	$\pm 10\text{ mm}$
Connector	MDR, 14-pin		
Recommended controller/driver	C-867.161 Single-axis controller/driver (p. 4-116) C-185.161 Drive electronics (p. 1-36)		



\*Power is supplied by the drive electronics which runs on 12 V DC  
\*\*For drive electronics

## Ultrasonic Motor Linear Piezo Stage

### Low-Profile High-Speed with Ultrasonic Piezo Linear Drives & Direct Position Measurement



Fast and compact M-664 Ultrasonic Motor stage with linear encoder

- Travel Range 25 mm
- Max. Velocity 400 mm/s
- Ultra-Low Profile, 15 mm
- Direct Metrology Linear Encoder with 0.1  $\mu\text{m}$  Resolution
- High Guiding Accuracy with Crossed Roller Bearings
- Compact XY Combinations
- Piezo Linear Motor with 4 N Drive Force
- Self Locking at Rest

M-664 micropositioning systems are low-profile, high-accuracy translation stages with linear encoders. The M-664 stage is next-larger in the series of piezomotor-driven stages of which the M-663 (see p. 4-28) is the smallest. For

improved guiding accuracy, the M-664 uses two crossed roller bearings mounted on ground aluminum profiles. The integrated P-664 PLine<sup>®</sup> linear motor can generate forces up to 4 N and maximum closed-loop velocities to 400 mm/s over a 25 mm travel range.

#### Application Examples

- Biotechnology
- Micromanipulation
- Microscopy
- Quality assurance testing
- Metrology
- Mass storage device testing
- R&D
- Photonics packaging

#### Advantages of PLine<sup>®</sup> Micropositioning Systems

The ultrasonic piezoceramic drives used in PLine<sup>®</sup> micropositioners have a number of advantages over classical drives:

- Higher Accelerations, up to 5 g
- Speeds up to 500 mm/s
- Small Form Factor
- Self-Locking When Powered Down
- No Shafts, Gears or Other Rotating Parts

- Non-Magnetic and Vacuum-Compatible Drive Principle

#### Optimized Controller and Drive Electronics

PLine<sup>®</sup> motors require a special drive electronics to generate the ultrasonic oscillations for the piezoceramic element. For optimum performance the highly specialized C-867 motion controller (see p. 4-116) is recommended. This sophisticated controller also integrates the drive electronics. Furthermore, the controller has a number of special features, including dynamic parameter switching for an optimized high-speed motion and settling behavior to take into account the motion characteristics typical of piezomotors. The broadband encoder input (50 MHz) supports the outstanding high accelerations and velocities of PLine<sup>®</sup> drives at high resolutions.

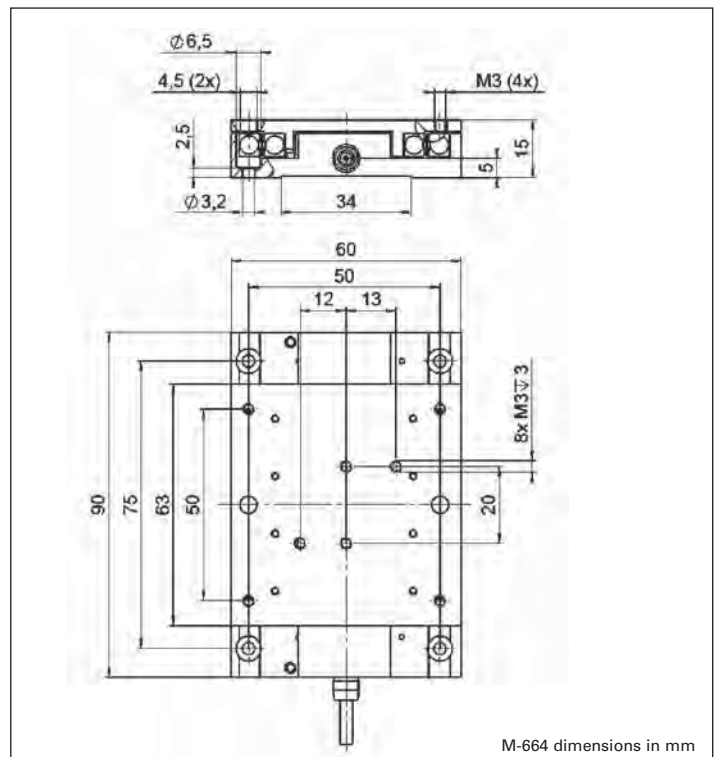
#### Ordering Information

**M-664.164**  
PLine<sup>®</sup> Micro Positioning Stage with P-664 Piezo Linear Motor, 25 mm, 4 N  
**Ask about custom designs!**

Optionally, for use with third party servo controllers, the C-185 analog drive electronics (stand-alone unit, see p. 1-36) is available. It controls the motor speed by an analog  $\pm 10$  V signal. For optimum performance this driver must be tuned together with the stage and should be ordered at the same time as the motor/stage.

#### Notes

The products described in this document are in part protected by the following patents:  
US Pat. No. 6,765,335  
German Patent No. 10154526



M-664 dimensions in mm



Ultrasonic Motor stages: M-682, M-664 and M-663 (from left)

## Technical Data

Latest Specs: [www.pi.ws](http://www.pi.ws)

Model	M-664.164	Tolerance
Active axes	X	
<b>Motion and positioning</b>		
Travel range	25 mm	
Integrated sensor	Linear encoder	
Sensor resolution	0.1 $\mu\text{m}$	
Min. incremental motion	0.3 $\mu\text{m}$	typ.
Bidirectional repeatability	0.2 $\mu\text{m}$	typ.
Unidirectional repeatability	0.2 $\mu\text{m}$	typ.
Pitch	$\pm 50 \mu\text{rad}$	typ.
Yaw	$\pm 50 \mu\text{rad}$	typ.
Max. velocity	400 mm/s	
Reference switch repeatability	1 $\mu\text{m}$	typ.
<b>Mechanical properties</b>		
Max. load	25 N	
Max. push/pull force	4 N	
Max. holding force	3 N	
<b>Drive properties</b>		
Motor type	P-664 PLine® ultrasonic piezo drive	
Operating voltage	168 V (peak-to-peak) * 60 V (RMS) *	
Electrical power	10 W **	nominal
Current	800 mA **	
Limit and reference switches	Hall-effect	
<b>Miscellaneous</b>		
Operating temperature range	-20 to +50 °C	
Material	Al (black anodized)	
Dimensions	90 x 60 x 15 mm	
Mass	0.190 kg	$\pm 5\%$
Cable length	1.5 m	$\pm 10$ mm
Connector	MDR, 14-pin	
Recommended controller/driver	C-867.164 single-axis controller/driver C-185.164 drive electronics	

\*The stage supply power is drawn from the drive electronics, which runs on 12 V.

\*\*For drive electronics

# Ultrasonic Motor Translation Stage

## Low-Profile & High-Speed with Ultrasonic Piezomotor, Direct Position Metrology



M-683.2U4 (50 mm) low-profile translation stage with integrated high-speed ultrasonic motors

- Max. Velocity 350 mm/s
- Low Profile: Only 21 mm Height
- Compact XY Combination Possible
- Up to 6 N Force Generation
- Direct Metrology Linear Encoder, 0.1  $\mu\text{m}$  Resolution
- Travel Range 50 mm
- Excellent Guiding Accuracy Through Crossed Roller Bearings
- PLine®: Non-Magnetic and Vacuum-Compatible Working Principle
- Self Locking at Rest

M-683 precision micropositioning stages make use of PLine® ultrasonic piezo linear motors enabling a compact design and low profile. An integrated linear encoder enables closed-loop control with 0.1  $\mu\text{m}$  resolution. The M-683 translation stages use paired crossed-roller bearings mount-

ed on ground-aluminum profiles for better guiding accuracy. Integrated U-164 PLine® linear motors provide push forces to 6 N and a maximum velocity of up to 350 mm/s. The stages can be arranged to form compact XY systems. If an additional Z-axis is required, the M-110 micro-stage series (see page 4-22) is recommended due to its higher holding force. The M-683 design is scalable and can be extended to provide longer travel ranges to 300 mm. Vacuum-compatible versions are also available on request.

### Limit and Reference Switches

For the protection of your equipment, non-contact limit and reference switches are installed. The reference switch supports advanced automation applications with high precision.

### Advantages of PLine® Micro Positioning Systems

PLine® ultrasonic ceramic drives provide several advantages over classical motors and drivers:

- Higher Accelerations, up to 5 g
- Speeds up to 500 mm/s
- Small Form Factor
- Self-Locking when Powered Down
- No Shafts, Gears or Other Rotating Parts
- No Lubricants
- Non-Magnetic and Vacuum Compatible Operating Principle

### Optimized Controller and Drive Electronics

For optimum performance the highly specialized C-867 motion controller (see page 4-116) is recommended. This dedicated piezo motor controller also integrates the drive electronics which PLine® motors require to generate the ultrasonic oscillations for the piezo-ceramic element.

Furthermore, the controller has a number of special characteristics, including continuous automatic drive frequency adjustment, dynamic parameter switching for optimized high-speed motion and settling behavior and some other features to address the requirements of ultrasonic motors. The broad-band encoder input (50 MHz) supports the outstanding high accelerations and velocities of PLine® drives at high resolutions.

Optionally, for use with third party servo controllers, the C-185 analog drive electronics (stand-alone unit) (see page 1-36) is available. It accepts an analog  $\pm 10$  V signal to control the motor velocity. For optimum performance the driver must be tuned together with

### Ordering Information

**M-683.2U4**  
PLine® High-Speed Linear Stage, 50 mm, 6 N

#### Accessories:

**M-110.05**  
Adapter bracket for vertical mount of M-110 stages on M-683 stages

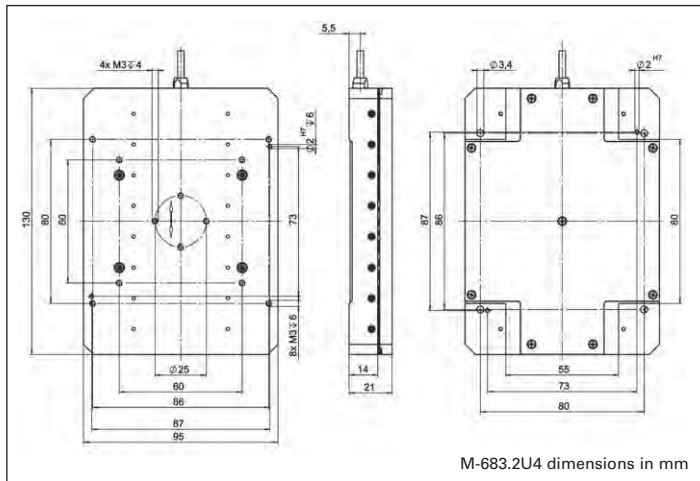
the mechanics and should be ordered at the same time as the motor/stage.

### Patent Protection

The products described in this document are in part protected by the following patents:  
US Pat. No. 6,765,335  
German Patent No. 10154526

### Application Examples

- Biotechnology
- Micromanipulation
- Microscopy
- Quality assurance testing
- Metrology
- Semiconductor testing
- Mass storage device testing
- R&D
- Photonics packaging



Latest Specs: [www.pi.ws](http://www.pi.ws)

Model	M-683.2U4	Tolerance
Active axes	X	
<b>Motion and positioning</b>		
Travel range	50 mm	
Integrated sensor	Linear encoder	
Sensor resolution	0.1 $\mu\text{m}$	
Min. incremental motion	0.3 $\mu\text{m}$	typ.
Bidirectional repeatability	$\pm 1 \mu\text{m}$	typ.
Unidirectional repeatability	0.2 $\mu\text{m}$	typ.
Pitch	$\pm 150 \mu\text{rad}$	typ.
Yaw	$\pm 50 \mu\text{rad}$	typ.
Max. velocity	350 mm/s	
Reference switch repeatability	1 $\mu\text{m}$	typ.
<b>Mechanical properties</b>		
Max. load capacity	50 N	
Max. push / pull force	6 N	
Max. holding force	6 N	
<b>Drive properties</b>		
Motor type	2 x U-164 PLine® ultrasonic piezo drive	
Operating Voltage	60 V <sub>rms</sub> *	
Electrical power	15 W**	nominal
Power consumption	1.5 A**	
Reference Switch	optical	
Limit Switches	Hall-effect	
<b>Miscellaneous</b>		
Operating temperature range	0 to +50 °C	
Material	Al (black anodized)	
Dimensions	130 x 95 x 21 mm	
Mass	0.65 kg	$\pm 5 \%$
Cable length	1.5 m	$\pm 10 \text{ mm}$
Connector	MDR, 14-pin	
Recommended controller / driver	C-867.160 single-axis controller / driver C-185.D64 drive electronics	

\*Power to the motor is supplied by the drive electronics, which runs on 12 V DC, or by the controller (24 V).

\*\*For drive electronics

## Ultrasonic Motor XY Stage

Fast, Low Profile and Large Aperture with Direct Position Measurement



The M-686.D64 open-frame stage with closed-loop piezo motors provides 25 x 25 mm travel range

- **Integrated Closed-Loop Piezomotor Drives Provide High Speed to 100 mm/s**
- **Travel Ranges 25 x 25 mm**
- **Integrated Linear Encoders with 0.1 µm Resolution**
- **Compact Design:**
  - 32 mm Profile Height, 170 x 170 mm Footprint
- **Clear Aperture 78 x 78 mm, 66 x 66 mm in Extreme Position**
- **Self-Locking at Rest**
- **Compatible with PI Piezo Nanopositioning / Scanning Stages**

M-686 open-frame piezomotor stages are mainly designed for automated positioning applications in microscopy. The optimized form factor with a low profile height of only 32 mm and the standardized mounting pattern allows the combination with many PI standard nanopositioning systems.

### Space Saving Piezomotors

Compared to conventional motorized translation stages, the M-686 provides a lower profile and smaller footprint. The compact PLine® piezoelectric linear motors and high-resolution linear encoders make both, the lead screw duct and the flanged, bulky stepper motor employed in traditional stages obsolete. In addition, the piezomotors are self-locking at rest and hold the stage in a stable position without heating up.

### Compatibility to PI Nanopositioning and Scanning Stages

A number of standard PI piezo flexure stages (150 x 150 mm footprint) can be mounted directly on the M-686 open-

frame stage. Depending on the application, these highly specialized, ultra-precise nanopositioning systems are available as fast XY scanners (for fluorescence microscopy), as vertical Z positioners (3D imaging), or with up to 6 degrees of freedom.

### Limit and Reference Switches

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

### Advantages of PLine® Micropositioning Systems

The ultrasonic piezoceramic drives used in PLine® micropositioners have a number of advantages over classical drives:

- Higher Accelerations, up to 5 g
- Speeds up to 500 mm/s
- Small Form Factor
- Self-Locking When Powered Down
- No Shafts, Gears or Other Rotating Parts
- Non-Magnetic and Vacuum-Compatible Drive Principle

### Ordering Information

**M-686.D64**  
XY Open-Frame Stage with Closed-Loop PLine® Piezomotor Drives, 25 x 25 mm, 7 N, 0.1 µm Linear Encoder

**Ask about custom designs!**

### Notes

Nanopositioning stages that fit directly on the M-686:

#### P-561 to P-563

PIMars™ XYZ Nanopositioning systems with up to 300 µm travel

#### P-541.2 to P-542.2

Low-profile microscopy XY scanners

#### P-541.Z

Low-profile Z/tip/tilt piezo nanopositioning stages for microscopy



two-channel C-867.260 controller

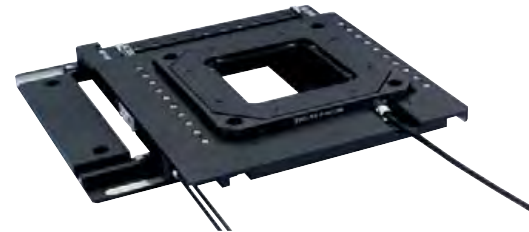
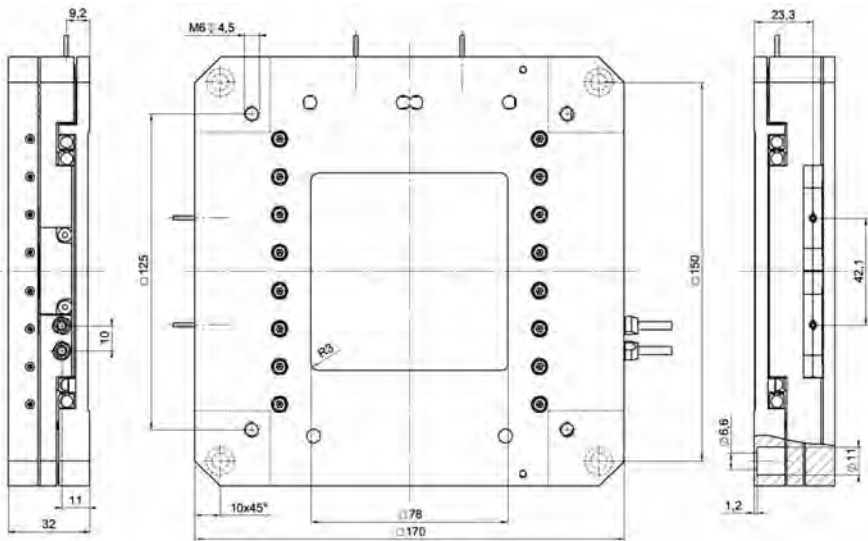


customized M-686 stage for microscopy

### Application Examples

- Biotechnology
- Microscopy
- Scanning microscopy
- Confocal microscopy
- Semiconductor testing
- Handling

M-686.D64, dimensions in mm. The minimum aperture is 66 x 66 mm with both axes at the maximum position



Customized M-686 stage with a bigger footprint, to sink the piezo Z scanner. The system height together with the P-541 piezo scanner is reduced to only 33 mm

## Technical Data

**Latest Specs: [www.pi.ws](http://www.pi.ws)**

<b>Model</b>	<b>M-686.D64</b>
Active axes	XY
<b>Motion and positioning</b>	
Travel range	25 x 25 mm
Integrated sensor	Linear encoder
Sensor resolution	0.1 $\mu\text{m}$
Design resolution	0.1 $\mu\text{m}$
Min. incremental motion	0.3 $\mu\text{m}$
Bidirectional repeatability	0.3 $\mu\text{m}$
Pitch / yaw	$\pm 50 \mu\text{rad}$
Max. velocity	100 mm/s
<b>Mechanical properties</b>	
Load Capacity*	50 N
Max. push/pull force	7 N
Max. lateral force	4 N
<b>Drive properties</b>	
Motor type	2 x PLine® P-664 per axis
Operating voltage	190 V (Peak-Peak)** 67 V (RMS)**
Electrical power	10 W / axis***
<b>Miscellaneous</b>	
Operating temperature range	-20 to +50 °C
Material	Aluminium (black anodized)
Mass	1.2 kg
Cable length	1.5 m
Connector	2 x MDR connector, 14-pin
Recommended controller/driver	2 x C-867.D64 single-axis controller / driver 2 x C-185.D64 single-axis drive electronics for external servo-controllers (p. 4-116, p. 1-36)

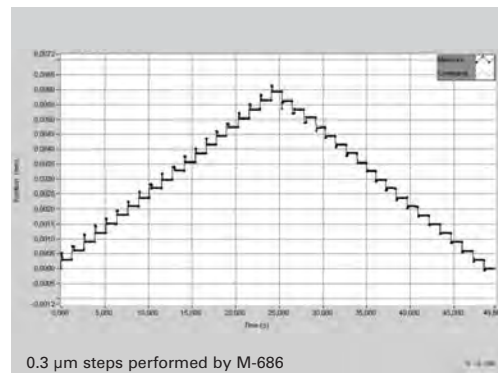
\*10 N for max. velocity

\*\*The operating voltage or the piezomotor is supplied by the drive electronics which requires 12 VDC

\*\*\*For drive electronics



M-686 open-frame stage with P-541.2DD piezo scanner on top, providing a resolution of 0.1 nm and a scanning range of 30 x 30  $\mu\text{m}$ . The system height of the combination with the P-541 XY (or Z) piezo scanner is only 48 mm



## Ultrasonic Motor Controller

### Servo-Controller with Integrated Driver for High-Speed Ultrasonic Piezo Motors



C-867 ultrasonic motor controller with low-profile positioner

- Optimized for PLine® Ultrasonic Piezo Linear Motors
- High-Bandwidth Encoder Inputs Allow High Speed and Resolution
- PID Servo-Control with Dynamic Parameter Switching
- Integrated Piezo Motor Power Driver
- USB, RS-232 and Analog Interfaces (e. g. for Joystick)
- 4 + 4 Programmable TTL-I/Os for Flexible Automation
- Data Recorder
- Daisy-Chain Networking for up to 16 Axes
- Powerful Macro Programming Language, e. g. for Stand-Alone Operation
- Extensive Software Support, LabVIEW, DLL ...

The C-867 controller is especially designed for closed-loop positioning systems equipped with PLine® piezo linear motor drives. A compact case contains both drive electronics for the piezo ceramic motors and components for controlling and communication.

#### Application Examples

- Biotechnology
- Microscopy
- Fiber positioning
- Automation
- Photonics / integrated optics
- Quality assurance testing
- Testing equipment

The controller can be operated from a host PC either via a USB port or an RS-232 interface. Alternatively, a stand-alone operation is possible. Here, stored macro commands can be executed, or manual control by joystick or pushbutton box is possible.

Two models are available: C-867.160 is used to operate single-axis positioning systems, the two-channel C-867.260 is used with XY scanning stages.

#### Highly Specialized PID Servo-Controller

The C-867 is based on a highly specialized DSP (Digital Signal Processor) that handles the PID servo-control algorithm as well as other system functions.

Because of the motion properties typical for ultrasonic piezomotors, the controller has a number of advanced features, including dynamic control parameter adaption. By automatically switching between gainsets for dynamic and static operation an optimized settling behavior within a couple of 10 milliseconds is achieved. The broadband encoder input (50 MHz) allows high resolution encoders to be used with the outstandingly high accelerations and velocities that PLine® drives deliver.

#### Highest Stability by Frequency Control

The integrated piezomotor drive electronics support all PLine® ultrasonic piezomotors used for the M-66x to M-69x positioning stage series.

Drift in the mechanical frequency of the motor caused by temperature or load changes is automatically compensated by a frequency-control loop which adjusts the operating frequency of the driving voltage. This leads to the highest stability in pushing force, velocity and closed-loop control.

#### Software / Programming

In addition to the user software for setup, system optimization and operation, comprehensive LabVIEW and DLL libraries are provided.

The PIMikroMove™ user software provides the PITuningTool for optimizing system performance. Graphic displays show the system's behaviour and facilitate parameter setting.

#### Advantages of PLine® Micropositioning Systems

Positioning systems equipped with ceramic ultrasonic drives of the PLine® series provide

#### Ordering Information

**C-867.160**  
Piezomotor Controller with Drive Electronics, Networkable, for PLine® Systems

**C-867.260**  
Piezomotor Controller with Drive Electronics, 2 Channels, for PLine® Systems

**Accessories:**  
**C-819.20**  
Analog Joystick for 2 axes

**C-819.20Y**  
Y-Cable for Connecting 2 Controllers to C-819.20

**C-170.PB**  
Pushbutton Box, 4 Buttons and 4 LEDs

**Ask about custom designs!**

several advantages over positioners that apply classic drive technology:

- Smaller dimensions
- Higher holding force when powered down; no holding current
- Increased acceleration of up to 5 g
- Increased velocity of up to 500 mm/s or 720°/s
- No leadscrews, gears or other mechanical components, no wear or maintenance
- No lubricants
- Non-magnetic and vacuum-compatible operating principle



The two-channel C-867.260 ultrasonic motor controller operates XY scanning stages, here: a customized M-686 stage for microscopy

## Technical Data

Latest Specs: [www.pi.ws](http://www.pi.ws)

Model	C-867.160	C-867.260
Function	Controller and drive electronics for P-Line® piezomotors / systems	
Drive type	P-Line® motors, single and dual drives with P-661, P-664, U-161 or U-164	
Channels	1	2
<b>Motion and control</b>		
Servo characteristics	Programmable PID V-ff filter, parameter changes on the fly	
Trajectory profile modes	Trapezoidal	
Encoder input	A/B differential signals, 50 x 10° impulses/s	
Stall detection	Servo off, triggered by programmable position error	
Limit switch	2 x TTL per channel (programmable)	
Reference switch	1 x TTL per channel (active high / low, programmable)	
<b>Electrical properties</b>		
Max. output power / channel	15 W	
Max. output voltage / channel	200 V <sub>pp</sub>	
<b>Interfaces and operation</b>		
Communication interfaces	USB, RS-232	
Motor connector	MDR14	2 x MDR14
Controller network	Up to 16 units on single interface	
I/O ports	4 analog/digital in, 4 digital out (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, LabVIEW drivers	
Supported functionality	Start-up macro; macro; data recorder for recording parameters as motor input voltage, velocity, position or position error	
Manual control	Pushbutton box, joystick, Y-cable for control of 2 axes with joystick	Pushbutton box, joystick
<b>Miscellaneous</b>		
Operating voltage	24 VDC from external power supply (included)	
Current consumption	300 mA + motor current (2 A max.)	600 mA + motor current (4 A max.)
Operating temperature range	+5 °C to +40 °C	
Mass	1.0 kg	2.4 kg
Dimensions	206 x 130 x 66 mm (including mounting rails)	320 x 150 x 80.5 mm (including mounting rails)

Products and Technologies
■ Nanopositioning / Scanning Stages
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■ Piezo Actuators
■ Piezo Motors
■ Piezo Controllers
■ Motorized Stages & Actuators
■ Motor Controllers
■ Hexapod 6-Axis Alignment Systems
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