

## Technical Progress with Ultrasonic Piezomotors



they generate high holding forces even when no electrical power is applied, they run extremely quiet and operate at ambient temperatures between  $-20\text{ }^{\circ}\text{C}$  and  $+50\text{ }^{\circ}\text{C}$ .

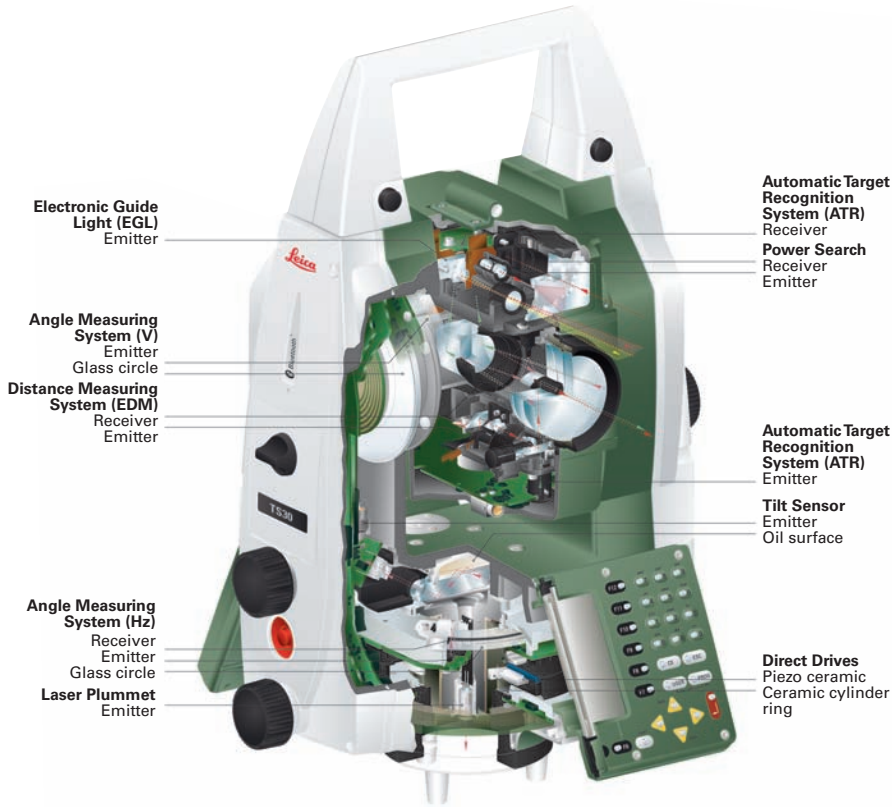
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**Leica Geosystems AG benefits from PLine® ultrasonic motors employed in their newest generation of surveying instruments for geodesy. The requirements for the drive of the new “Leica TS30” total station were, amongst others, higher speeds, shorter positioning times and a very high positioning accuracy when moving the measuring optics.**

These requirements were exceeded by far through the employment of PLine® ultrasonic motors. PI’s U-164 piezomotor was chosen for the vertical as well as the horizontal movement of the measuring optics. Rotations are produced by two such motors which are preloaded against a pivot mounted friction ring doubling as a brake when at rest. In operation, the ceramic piezomotors

oscillate with ultrasonic frequencies. Generating a feed motion of the friction ring. This principle of operation provides unrivalled speeds of  $>180\text{ }^{\circ}/\text{sec}$  and high accelerations of up to  $360\text{ }^{\circ}/\text{s}^2$  and an angular measuring accuracy of  $0.5''$ . The drive also improves starting and stopping behavior and reduces power consumption. The maintenance-free motors are self locking, i.e.

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The cross-section of the total station shows the limited installation space available for the drives  
(Photo: Leica Geosystems AG, Switzerland)

As the above example illustrates, ultrasonic piezomotors continuously expand into new fields of application. Given their great flexibility,

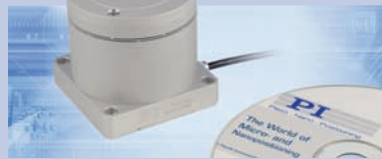
it is hard to predict which application will benefit next from these novel drive systems.

## More Precise than Ever: S-340 Tip/Tilt Mirror Platform with New Sensors

The large S-340 piezo tip/tilt mirror for optics with diameters of up to 100 mm (4 inch) is now equipped with high-resolution strain gauge sensors. The S-340 thus achieves a resolution of 20 nrad at angles of 2 mrad about both orthogonal axes. The resonant frequency for a mirror 50 mm in diameter is 900 Hz.

The S-340 can be operated by the new, low-cost E-616 controller. Together, they form a compact, high-performance solution for

beam control and image stabilization as employed in astronomy, laser machining or optical metrology, for example.



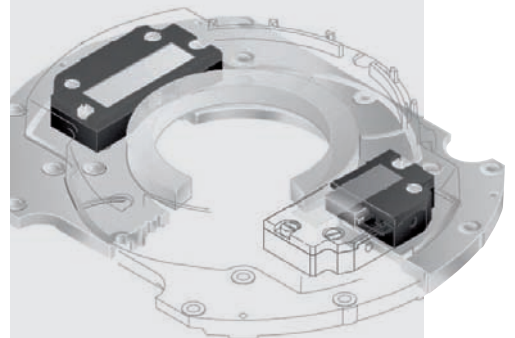
S-340 tip/tilt mirror for optical deflection angles to 4 mrad

## Fast, Compact & Energy Efficient

### OEM Ultrasonic Piezo Motors

U-164 ultrasonic piezo motors are particularly compact, reliable and maintenance-free drives which are self-locking when at rest and intrinsically non-magnetic and vacuum-compatible. In the application, they provide as yet unrivalled speeds and accelerations while offering a high positioning resolution and low power consumption.

With its PLine® series PI offers a broad range of positioning systems with piezo ultrasonic motors: From simple motors to fully integrated custom solutions.



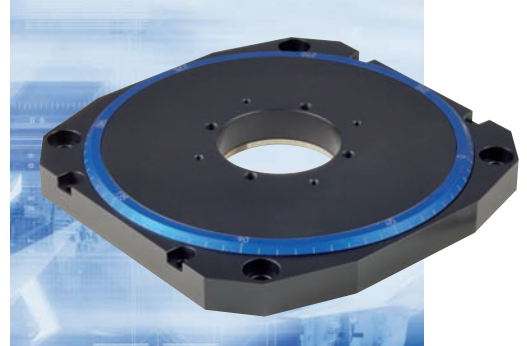
The rotations are produced by two U-164 ultrasonic motors that are preloaded against a friction ring. (Photo: Leica Geosystems AG/ Physik Instrumente (PI))

## Rotation Stage with 720 °/s is only 15 mm High: PLine® Technology Makes it Possible

The M-660 PLine® ultra-low-profile rotation stage opens up new possibilities in fast positioning, from microscopy or biotechnology to test systems of mass storage. The stage achieves a speed of up to 120 RPM. The integrated U-164 PLine® linear motors provide a torque of 0.3 Nm and the stage is designed for a maximum load of 1 kg. These ultra-sonic piezo motors transfer force to a ceramic friction ring mounted on the moving platform and they are self-locking when at rest. An integrated optical encoder provides position feedback with 40 µm resolution.

### M-660 in figures:

- Ultra-low profile, 15 mm high, 35 mm Ø aperture
- Maximum speed 720 °/s, direct Encoder, 40 µrad resolution
- Self-locking: Ceramic direct drive provides significantly higher positional stability than classic motors
- Compact combinations with translation stages possible



## Advanced Piezo Control - New Control Concept for Faster Settling

Digital technology opens up opportunities for improving performance in control engineering which are not available with conventional analog technology. These advantages lie mainly in the improved precision and the dynamic properties, and also the ease of operation of PI's positioning.

In addition to digital controllers based on PID parameters, an alternative control concept is available for the E-712 modular controller for nanopositioning systems: Advanced Piezo Control. The underlying principle is a state controller based on a model of the positioning system. Advanced Piezo Control actively dampens the resonant frequency. This is in contrast to conventional PID controllers with notch filter where the mechanical resonance is cut out of the excitation spectrum. The benefits are faster settling times and lower sensitivity with respect to external disturbances.

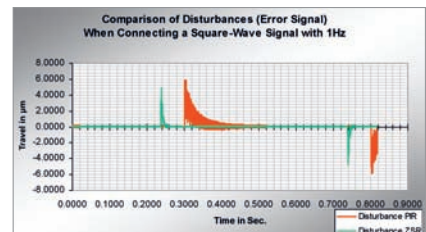
### Order information:

E-712.U1  
Firmware extension Advanced Piezo Control control option

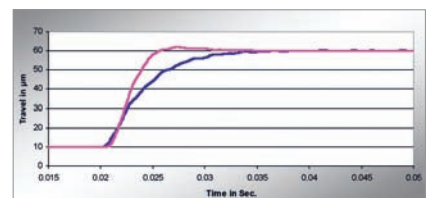
Advanced Piezo Control is also available for the E-753 single-channel controller. Ask your PI sales office.



E-712 modular digital controller for nanopositioning systems with up to 6 axes



Reaction of the closed-loop positioning system to an interference. When Advanced Piezo Control is used (green line) the resonance is not even excited by the external disturbance



Settling behavior of a system with optimized PID parameters (blue) and Advanced Piezo Control (pink)

# PI nano™ Precision Positioning Systems for Microscopy

The new PI nano™ positioning system from PI was specifically designed for applications in optical microscopy.

The core component of the PI nano™ is an XY or XYZ piezo nano-positioning stage with a low profile of only 20 mm and a large central aperture for transmitted-light microscopy. The stage is equipped with long-life PLine® piezo actuators and provides travel ranges of 200 µm with nanometer positioning resolution. It comes with a matched piezo controller featuring a 24-bit interface (USB, Ethernet and RS-232) and a high-bandwidth analog interface. The controller is supported by all major image acquisition software packages.

An optional, manual XY stage for coarse sample positioning can be equipped with stepper motor drives if required. The preloaded XY stage can be mounted directly onto the microscope and it provides the stiffness required to carry a highly dynamic piezo nanopositioning system.



Scanning microscopy methods such as single molecule fluorescence microscopy provide high lateral positioning resolution even below the limitations of the numerical aperture. They require correspondingly precise sample positioning with resolutions in the range of a few nanometers. The PI nano™ system is designed so that its performance data and range of functions correspond exactly to these requirements.

- Piezo-based XY/XYZ nanopositioning system with 200 µm travel for planar scanning and vertical focusing/z-stack acquisition

- Optional 25 x 25 mm coarse-positioning stage with manual or stepper motor drives, preloaded for high stability
- Nanopositioning system with large aperture and 20 mm low profile for easy integration into the microscope
- Mechanical compatibility with inverted microscopes from Zeiss, Nikon, Leica, Olympus
- Accessories and sample holders
- Powerful controller with USB and Ethernet Interface, and extensive software support



Due to their low profile, PI nano™ piezo stages can easily be integrated into existing microscope setups



The P-545 piezo stage provides 200 µm travel per axis with sub-nanometer resolution. PI nano™ features a larger aperture for 1x3" slides.



PI nano™ series comprising E-545 controller, P-545 piezo system and M-545 manual stage

## Increased Data Throughput with Real-Time Operating System Upgrade



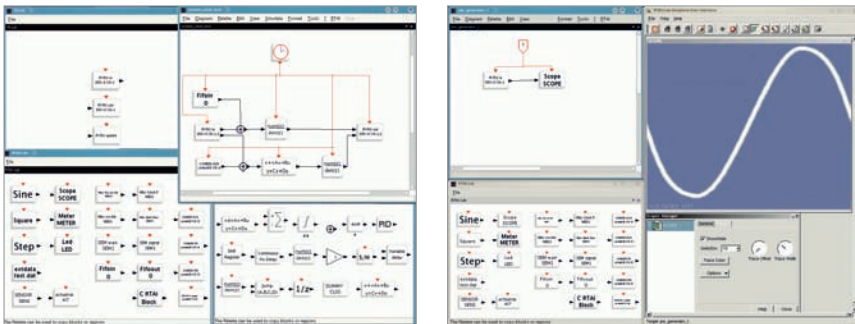
the system to be operated as a black-box via TCP/IP from a Windows computer.

- The system can be installed on a PC or booted directly as a live version from the data carrier.
- A free demo version with restricted functionality is available.

### Order information:

E-712.U3 real-time operating system upgrade for host PC

The upgrade is currently available for the E-712 digital piezo controller with PIO interface.



**The use of real-time operating systems on the host PC eliminates delays in the communication with other system components, e.g. a vision system, providing deterministic temporal behavior at high clock rates.**

PI offers a real-time module as an upgrade for the host PC. The module is based on Knoppix-Linux in conjunction with a pre-configured Linux real-time extension (RTAI). Communication with the real-time system is based on a library which is 100 % compatible with all other PI GCS (General Command Set) libraries. All PI GCS host software available for Linux can be run on this system. The real-time system running in the real-time kernel

can be used to integrate PI control interfaces and additional data acquisition boards. Open functions to implement customer specific control algorithms are provided. Data such as positions and voltages are recorded in real-time and pre-defined data tables are output in real-time.

- User-programmable, real-time functions in C/C++, MATLAB/SIMULINK and SCILAB.
- Included PI GCS server allows

## M-810.0A

### Mini-Hexapod with Larger Aperture and Space-Saving Connection

In addition to the standard M-810.00 miniature hexapod, PI now offers a modified version with cable exit in the direction of the Z-axis. The new model also provides a larger free aperture of 59 mm Ø.



# Medical Engineering News: Driven by Piezo



Piezo elements from PI Ceramic. The broad spectrum of standard products is supplemented by custom engineered products, with the shortest-possible time-to-market

Moreover, the piezo technology reduces the time required to atomize medications by up to 50 % compared to conventional systems increasing the quality of life for patients with chronic diseases.

Piezo ceramics meet the special hygiene requirements in medical engineering; the aerosol generators can be sterilized at high temperatures, even in autoclaves. The ultrasonic operation is soundless for humans, and the low power consumption of the piezo components allows battery operation.

**The continuing miniaturization in medical engineering places ever increasing demands on the components. Piezo drives are the solution for many motion control applications; the piezo effect efficiently generates fast and precise motion while requiring very little space.**

## Efficient Aerosol Generation with Piezo Elements

The treatment of respiratory diseases often involves medications being administered directly with atomizers. One method of atomization is to generate very fine droplets with the aid of ultrasonic piezo ceramics.

Specially shaped piezo disks excite a stainless steel diaphragm with several thousand holes to execute ultrasonic oscillations at more than 100 kilohertz: this produces particularly homogenous aerosols, allowing the medications to be dosed accurately and administered in a more targeted way.

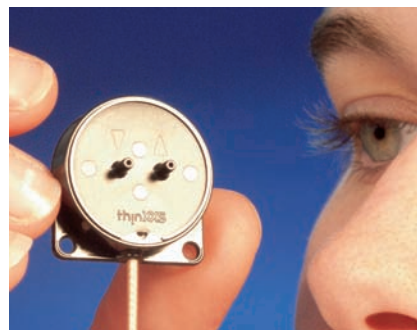
## Piezoelectric Drives in Microfluidics

Piezo-driven microdispensers, i.e. micropumps and microvalves, can dose minute volumes down to the microliter range with very high accuracy. Disk-shaped piezo elements mounted directly onto a metal micro-diaphragm provide the highly dynamic drive for precision miniature liquid or gas pumps. Due to the separation of drive and medium through the diaphragm, interference with the pumped media is completely avoided.

Lab-on-a-chip applications are made possible by the minute dimensions.

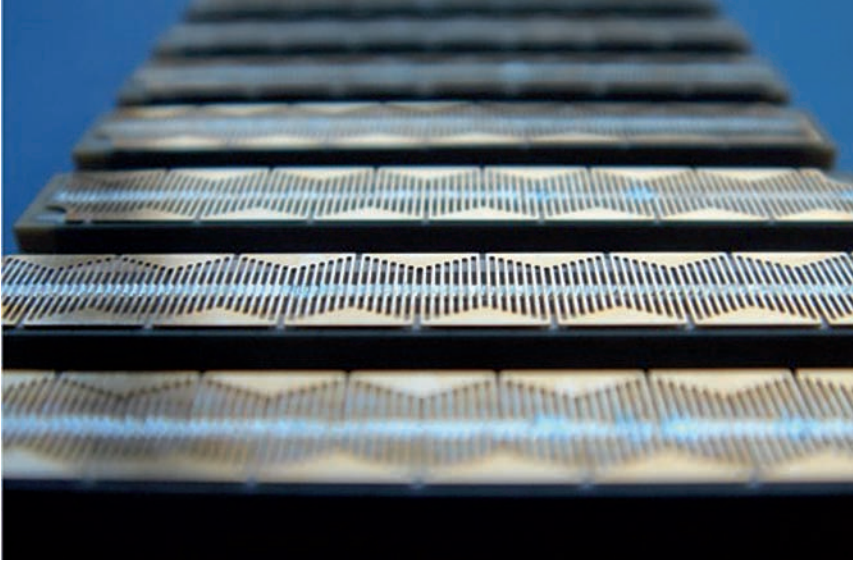


An annular piezo disk serves as an ultrasonic transducer to produce the aerosol in the atomizer head of the eFlow® rapid Electronic Nebulizer series. (source: Pari Pharma GmbH)



Custom piezo disks precisely dose liquids and gases in the ThinXXS micropump. (source: thinXXS Microtechnology AG)

# Faster Switching with New PICMA<sup>®</sup> Actuators and Amplifiers



Piezo actuators are driven with large currents when highly dynamic operation is required in applications where response times as short as 50  $\mu$ s are necessary, such as fast valve switching, microstructure analysis and material testing. For these applications currents up to 20 Amps may be needed and the new PICMA<sup>®</sup> multilayer piezo actuators can handle them with a patented external electrode structure. The new electrodes will be available on the complete PICMA<sup>®</sup> family of actuators in the near future.

## E-618: 3.2 kW Peak Power for New Piezo Amplifier

The E-618 high power amplifier is now available for ultra-high dynamics operation of the new PICMA<sup>®</sup> piezo actuators. It can output and sink a peak current of 20 A in the voltage range between -30 and +130 V. The high bandwidth of >15 kHz makes it possible to exploit the dynamics of the PICMA<sup>®</sup> actuators. This type of performance is required in active vibration cancellation and fast valve actuation applications.

The E-618 comes with a temperature sensor input to shut down the amplifier when the maximum allowed temperature of the piezo ceramics has been exceeded. This is a valuable safety feature given the extremely high power output.

The E-618 is available in several open-loop and closed-loop versions with analog and digital interfaces.

## PICMA<sup>®</sup> Actuators in Extreme Environments

PICMA<sup>®</sup> multilayer piezo actuators are designed for maximum reliability even in adverse conditions (see also new test results on [www.pi.ws/picma](http://www.pi.ws/picma)).

For applications with permanently increased humidity or water spray, additional protection is now available with a stainless steel casing. The casing is hermetically sealed and filled with an inert gas.

The external dimensions for a 5 x 5 x 18 mm piezo ceramic are a mere 22.7 mm in height and 11.2 mm in diameter.

The new, protected actuators can be mounted by clamping or bonding; solder pins are provided at the bottom of the casing for electrical connection.

A white paper on the most recent lifetime testing results of PICMA<sup>®</sup> multilayer piezo actuators is now available in printed form and as PDF at [www.pi.ws/picma](http://www.pi.ws/picma).

## Recently granted PICMA<sup>®</sup> patents:

German patent no. 102005015405

German patent no. 102007011652



E-618.10G High-power piezo amplifier: Single-channel, 9.5" version



Two PICMA<sup>®</sup> piezo actuator versions (5 x 5 x 18 mm ceramic type): Conventional multilayer actuator and actuator with a hermetically sealed stainless steel casing

# Miniature Positioner with NEXACT® Stepping Drive

**20 Nanometer Encoder Resolution over 20 mm Travel Range – All Down to the Drive!**

The extremely compact N-661 stage is entering the race with dream dimensions – a footprint of 50 x 70 mm and a very low profile of only 15 mm. Its travel range is 20 mm, the maximum speed 10 mm/s. The position is controlled by a direct measuring encoder with 20 nanometer resolution.



The N-661 miniature translation stage comprises a PiezoWalk® linear drive in combination with a high-resolution linear encoder

NEXACT® piezo stepping drives replace conventional stepper motors or DC servo-motors.

And not without reason:

- NEXACT® drives securely clamp the stage when the target position has been reached. The drive does not even need to be powered to maintain a position, avoiding heat generation and servo dither / micro-step dither
- NEXACT® is two drives in one: In addition to the variable-size step mode, an analog mode is available to provide high-dynamic, continuous motion with nanometer resolution
- The drive is intrinsically vacuum compatible, non-magnetic and unaffected by magnetic fields

## Tradeshows 2010

<b>Dec, 5 – 9</b>	<b>ASCB Annual Meeting</b>	San Diego (CA), USA	<b>Booth 909</b>
<b>Jan, 23 – 24</b>	<b>Biomedical Optics (BIOS)</b>	San Francisco (CA), USA	
<b>Jan, 26 – 28</b>	<b>Photonics West</b>	San Francisco (CA), USA	<b>Booth 917</b>
<b>Feb, 9 – 11</b>	<b>ATX West (MD&amp;M West)</b>	Anaheim (CA), USA	<b>Booth 4160</b>
<b>Feb, 20 – 24</b>	<b>BioPhysical Society</b>	San Francisco (CA), USA	

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Physik Instrumente (PI) GmbH & Co. KG  
Auf der Römerstrasse 1  
D-76228 Karlsruhe  
Tel. +49 721 4846-0 · Fax +49 721 4846-100  
info@pi.ws

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Editor: Dr. Karl Spanner  
Editorial Staff: Steffen Arnold,  
Stefan Vorndran, Sandra Ebler  
Creation & Design:  
Regelmann Kommunikation, Pforzheim  
Production: Systemedia, Pforzheim

### USA

**PI (Physik Instrumente) L.P.**  
16 Albert St.  
Auburn, MA 01501  
Tel. +1 (508) 832 3456  
Fax +1 (508) 832 0506

5420 Trabuco Rd., Suite 100  
Irvine, CA 92620  
Tel. +1 (949) 679 9191  
Fax +1 (949) 679 9292  
info@pi-usa.us  
www.pi-usa.us

### JAPAN

**PI Japan Co., Ltd.**  
2-38-5 Akebono-cho,  
Tachikawa-shi,  
Tokyo 190-0012 Japan  
Tel. +81 (42) 526 7300  
Fax +81 (42) 526 7301

Hanahara Dai-Ni Bldg. #703  
4-11-27 Nishinakajima,  
Yodogawa-ku, Osaka-shi  
Osaka 532-0011 Japan  
Tel. +81 (6) 6304 5605  
Fax +81 (6) 6304 5606  
info@pi-japan.jp  
www.pi-japan.jp

### UK & IRELAND

**PI (Physik Instrumente) Ltd.**  
Trent House, University Way,  
Cranfield Technology Park,  
Cranfield, Bedford MK43 0AN  
Tel. +44 (1234) 756 360  
Fax +44 (1234) 756 369  
uk@pi.ws  
www.physikinstrumente.co.uk

### ITALY

**Physik Instrumente (PI) S. r. l.**  
Via G. Marconi, 28  
I-20091 Bresso (MI)  
Tel. +39 (02) 665 011 01  
Fax +39 (02) 873 859 16  
info@pionline.it  
www.pionline.it

### FRANCE

**PI France S.A.S.**  
32 rue Delizy  
F-93694 Pantin Cedex  
Tel. +33 (1) 57 14 07 10  
Fax +33 (1) 41 71 18 98  
info@pi-france.fr  
www.pi-france.fr

### CHINA

**Physik Instrumente (PI Shanghai) Co., Ltd.**  
Building No. 7-301  
Longdong Avenue 3000  
201203 Shanghai, China  
Tel. +86 (21) 687 900 08  
Fax +86 (21) 687 900 98  
info@pi-china.cn  
www.pi-china.cn