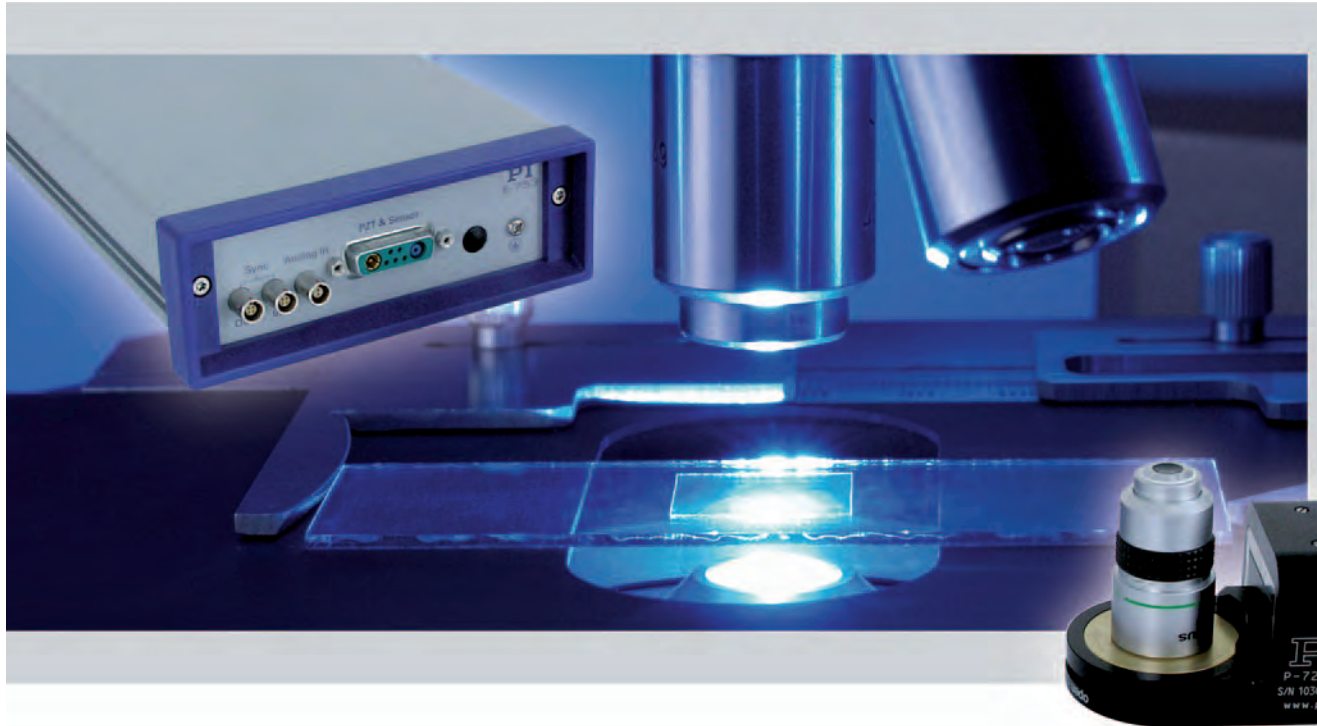




Digital Nanoworlds

E-753 – Next Generation Digital Piezo Controller for Nanopositioning Applications

Piezo controllers are more complex than ordinary motor controllers and require both higher-performance processors and extremely fast and stable A/D and D/A converters. Low-cost components which perform well in audio applications, are often completely unacceptable for the high requirements placed on nanopositioning systems by discerning customers. For this reason, many piezo controllers are still offered today with analog electronics.

Ten Years Ahead

PI has recognized the importance of digital piezo control technology more

than 10 years ago. Since then, it has become an essential ingredient for the highest precision class of nanopositioning systems.

PI is now introducing the next generation of digital controllers: The new E-753 provides a wider range of functionality and, with 24-bit digital/analog converters, offers even higher resolution than the proven E-750 digital controller it replaces.

Digital controllers make possible the implementation of performance-enhancing algorithms involving digital processing of sensor input, position

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target and drive control values, for example:

- Motion linearization based on higher-order polynomials, making possible improved positioning accuracy of up to 0.001% of the full travel range.
- Dynamic Digital Linearization (DDL), which can improve the tracking accuracy by a factor of up to 1000 during rapid, periodic motion.

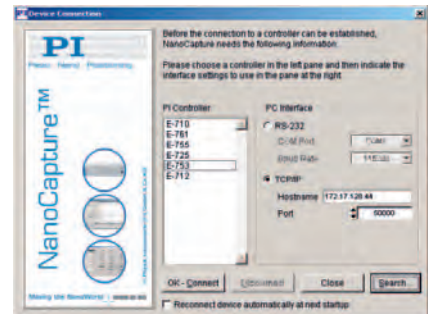
Technical Data Summary

- Single-channel piezo controller for capacitive sensor metrology
- Output voltage -35 to +130 V
- Max. peak output power 7.5 W
- 24-bit D/A converter, 25 kHz sampling rate, 60 MHz DSP, 32-bit floating-point
- 5.6 kHz sensor bandwidth
- Analog input, 2 digital inputs and 1 digital output
- Ethernet and RS-232 interfaces

- Saving of motion profiles and access to standard functions such as sine or triangle waves.
- Freely programmable data recording (offers access to position data, sensor signals, etc), important for later association of events with the saved data e.g. for mapping functions.
- Coordinate transformation for multi-axis, parallel kinematic systems, allowing commanding motion in Cartesian coordinates

Simple programming, digital and analog control

Last but not least, all parameters can be checked and edited via software. System setup and configuration is done with the included NanoCapture™ and PIMikroMove® user-interface software. Interfacing to custom software is facilitated with included LabVIEW™ drivers and DLLs. PI's unique General Command Set allows easy software porting between different controllers. In addition to its digital inputs, the E-753 features a



Easy system setup and configuration with the included NanoCapture® and MicroMove® user-interface software.

broadband analog input, a major advantage for applications with fast, analog control signals.

First of many

The single-channel E-753 is the first of a new generation of digital piezo controllers, of which several are coming soon. The modular E-712 and the new E-725 controller will complement the current E-710, which is available in three-, four- and six-channel versions.

Read more on these new piezo controllers in coming issues of PI News.



The compact M-810 is smaller in diameter than a CD, but offers long travel ranges in six axes with excellent position resolution

Six Degrees of Freedom in a Small Package

New Ultra-Compact Miniature Hexapod

The new M-810 miniature Hexapod combines all advantages of PI's other proven parallel-kinematic systems in the smallest of packages. With a diameter of only 10 cm and a height of 11.8 cm, the M-810 offers travel ranges of up to 40 mm in the XY plane and 13 mm in the Z-direction. Despite of its small size, the hexapod can reliably position loads of up to 5 kg at velocities of 10 mm/s.

The limited space necessitated the usage of new technologies for encoders, motors and limit switches.

Nevertheless, control is 100 % compatible to previous standard PI Hexapods.

As with other parallel-kinematics positioners from PI, the six high-resolution actuators are connected directly to a single moving platform. The user is able to define the center of rotation (pivot point) independent of platform motion with a simple software command.

In contrast to conventional, stacked, multi-axis systems, there is no accumulation of guiding and lever-arm errors.

PIFOC® Revisited: P-737 Piezo-Z Microscopy Specimen Scanning Stage



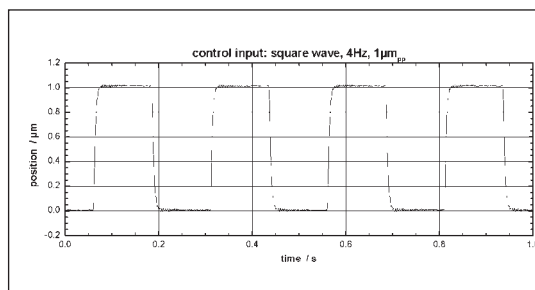
PIFOC® P-737 high-speed vertical positioning systems are designed for integration into motorized XY microscopy stages of leading manufacturers such as Märzhäuser. While the XY stage positions the sample, the piezo flexure-based P-737 moves the sample along the optical axis to adjust the focus quickly and precisely. Vertical stepping with nanometer precision takes only a few milliseconds. The large aperture is designed to accommodate a variety of specimen holders including slides or multiwell plates.

High-speed Z-steps for fast focus control and imaging

The immediate response of the solid-state piezo drives enables rapid Z-steps with typically 10-to-20-times-faster step-and-settle than classical stepper motor drives. This leads to significantly higher image acquisition speed and throughput. The P-737 is available with travel ranges of 100 or 250 μm and offers a choice of feedback sensors between strain gauge or non-contact, capacitive position sensors, depending on the accuracy requirements.

PI is the inventor of high-speed Piezo-Z objective steppers. Today the term PIFOC® is practically synonymous with all high-resolution vertical drives for microscope objectives. Depending on the application, it can be advantageous to adjust the sample instead of the objective. While no sample stage can beat the speed of the fastest PIFOC® objective positioners (due to the stiffer and more compact design), the P-737 stage allows for convenient Z-stack imaging with multiple objectives and very high throughput. In both cases the effect remains the same: the focal plane moves through the sample. This is why the P-737 is also marketed under the PIFOC® trademark.

Settling time is in the 10 ms range – here, 1 μm steps



Analog or Digital Systems

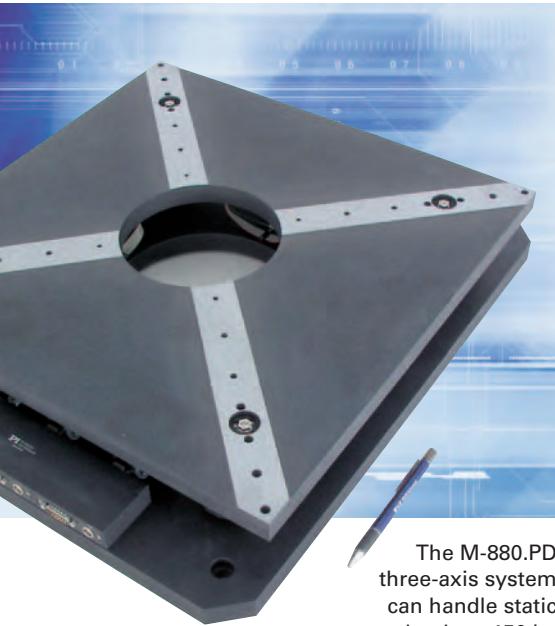
The P-737 together with the E-625 piezo-controller, offers a cost-effective system for high-speed, high-resolution positioning of microscopy specimens. The controller features a choice of a 20-bit digital interface or a broadband analog interface for the target position.

The capacitive-sensor-equipped version can also be operated with the sophisticated E-753 digital servo-controller. The main advantage of this controller is its adaptability to changing load conditions on the piezo stage. No matter what load is applied, the system can always provide an optimum combination of speed, settling time and resolution.



PIFOC® objective positioners and scanners are available with travel ranges of up to 400 μm . QuickLock thread adapters enable fast mounting of the PIFOC® on the microscope and flexible replacement of objective

Low-Profile XY Θ Z Stage for LCD and Semiconductor Inspection



The M-880.PD three-axis system can handle static loads to 150 kg

Parallel kinematics features low profile as well as high load capacity and accuracy

The new M-880.PD micropositioning stage offers three degrees of freedom with all the advantages of a parallel-kinematics multi-axis system for dynamic positioning of loads to 20 kg in a plane. The 500 x 500 mm moving platform with a 160 mm clear aperture is ideal for transmitted-light applications.

The low profile of just 105 mm is possible because all actuators are connected directly to the same moving platform—a principle taken from PI's extensive experience with the design of Hexapod systems.

Three ActiveDrive™ DC motors provide linear velocities up to 20 mm/s. Travel to ± 10 mm from the centerpoint and

rotation around Z to $\pm 4^\circ$ are possible, with a minimum step size of 0.25 μ m.

Precision bearings ensure high stiffness and limit the out-of-plane tilt of the stage to ± 10 arcseconds.

Very high static load capacity

The stage is designed to withstand static loads to 150 kg. This allows, for example, performing manufacturing steps with the stage at rest between inspections without transferring the workpiece to another support.

The system includes the translation stage and a high-performance, PC-based controller which performs coordinate transformation necessary to command the three actuators.

Tip/Tilt Mirror Platforms Feature 20 mrad Deflection, 3 kHz Resonant Frequency

From customer request to standard product: high-dynamics tip/tilt mirror systems with optical deflection angles of up to 20 mrad

In the past, the fast tip/tilt platforms of the S-330 series have been offered with tip/tilt angles of up to 2 mrad.

Over the years, custom systems with higher travel ranges were designed that did not diminish the dynamic performance. The direct drive principle with four differential piezo actuators of the required lengths was retained. The new, standard S-330 versions that have resulted offer tip/tilt angles from 5 to 10 mrad and feature very high resonant frequencies of over 3 kHz.

S-330 versions

S-330.2SL/ S-330.2SD

High-Dynamics Piezo Tip/Tilt Platform, 2 mrad, SGS, LEMO/ Sub-D Connector

S-330.20L

High-Dynamics Piezo Tip/Tilt Platform, 2 mrad, Open-Loop, LEMO Connector

S-330.4SL/ S-330.4SD

High-Dynamics Piezo Tip/Tilt Platform, 5 mrad, SGS, LEMO/ Sub-D Connector

S-330.40L

High-Dynamics Piezo Tip/Tilt Platform, 5 mrad, Open-Loop, LEMO Connector

S-330.8SL/ S-330.8SD

High-Dynamics Piezo Tip/Tilt Platform, 10 mrad, SGS, LEMO/ Sub-D Connector

S-330.80L

High-Dynamics Piezo Tip/Tilt Platform, 10 mrad, Open-Loop, LEMO Connector

S-330 family with tip/tilt angles of 2.4 mrad and 10 mrad tilt angles



Project:

Active Vibration Absorbers to Reduce Wind Turbine Noise Emissions



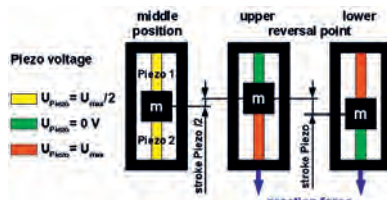
Wind generator plants are contributing increasingly to the energy supply and thus to climate protection and preservation of natural resources. With the increasing number of wind turbines, some in more densely populated areas, the associated noise and its negative impact on people can not be ignored.

Next to the aerodynamic noise like that from the blades, the gear box is a main source. In the gearbox, the meshing of the teeth causes the gears to vibrate.

The problem comes from the resulting structural noise components whose frequencies coincide with resonant frequencies of the drive train and bearing system as a whole. These resonances result in tonal peaks in the noise spectrum. Not even careful design of the drive train and its supports can reliably prevent development of such tonal components. The structure-borne noise propagates to the tower, whose surface area does a very good job of radiating it to the environment. As a result, affected wind plants are often unable to meet the noise-control regulations

in force. The necessary operational limitations lead to substantial reduction of the amount of energy produced by these plants.

The Fraunhofer Institute for Machine Tools and Forming Technology (IWU), in cooperation with ESM GmbH (Mitsch Energy and Vibration Technology), Schirmer Beratende Ingenieure (Schirmer Engineering Consulting) and the Dr. Ziegler engineering office, is developing retrofit active vibration absorbers to suppress these tonal components. The project is supported by the Deutsche Bundesstiftung Umwelt, a foundation promoting innovative and exemplary environmental work.

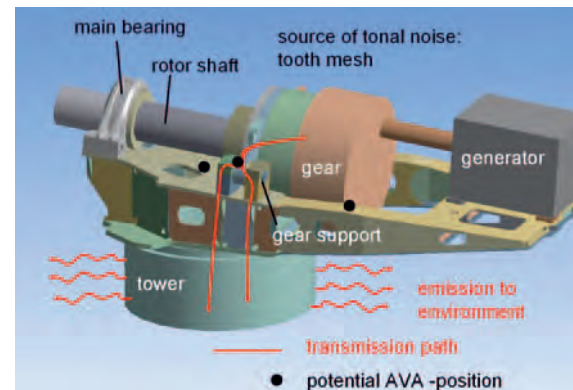


Principle of the active vibration absorber

The active vibration suppressors use high-dynamics, heavy-duty piezoelectric stack actuators from

PI Ceramic and are installed in the transmission path of the tonal components in the wind turbine. The actuators generate carefully controlled forces counteracting the acoustic waves created by the gears in the structure. If the frequency of the targeted tonal components changes, the control circuitry adjusts automatically.

As a result, the radiation of the tonal components to the environment can be minimized, and the legislative limits again be respected. This avoids costly changes of the gearbox or inefficient operation at less than full power for the affected plants.



Transmission path of tonal noise (example)



Active vibration absorber

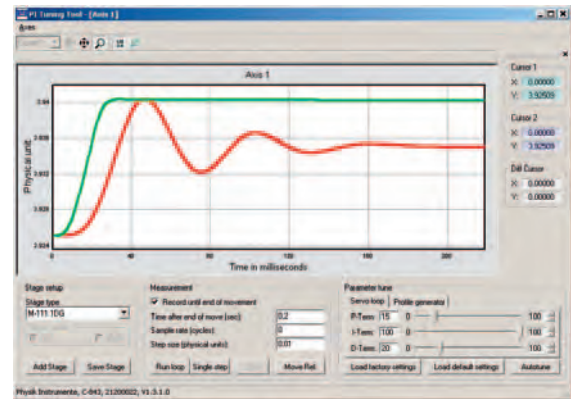
Autotune: Operation under the Best of Conditions

The operation of servo-controlled micro- and nanopositioners requires a well chosen set of dynamic parameters to enable precise and oscillation-free motion. All of PI's motion systems come "preloaded" with servo parameter sets optimized for operation with average loads.

When higher loads, forces or torques are applied to the systems, the dynamic parameters will have to be adjusted. A dialog in the PIMikroMove® host software helps to analyze and optimize servo PID parameters and graphically displays the results.

Autotune

The Autotune option is ideal for users who are not fully versed in the significance of the various control parameters, or who just want to save time. Autotune is based on a sophisticated, fully automatic algorithm that analyzes the system behavior and quickly determines dynamic parameters which will enable oscillation-free operation. The suggested motion parameters can be transferred from non-volatile memory to the user stages database for permanent availability.



Step responses of a closed-loop micropositioner with and without optimized motion parameters

The Autotune option is currently available for the C-843 and C-866 controllers. Integration in further controllers is planned, as the technology allows.

New 3-Channel Electronics Module for Single-Electrode Sensors



PISeca™ Single-Electrode Capacitive Position Sensors—Excellent Precision and Dynamics Now for Multi-Axis Systems

PISeca™ ultra-low-noise electronics is now available in 2 new three-channel plug-in modules for the

E-500/E-501 controller series. These modules can be installed in place of the proven servo-control modules for SGS, LVDT and 2-plate capacitive sensors.

Just like the E-852 stand-alone unit, both the E-509.E3 and the E-509.E03 provide sensor excitation and read-out with a resolution of up to 0.2 nm (<0.001% of the measurement range). Furthermore, the integrated linearization system guarantees excellent linearity of up to 20 nm (<0.1% of the measuring range).

Bandwidth, measuring range and gain are adjusted separately for each channel at the factory to suit the application. This is part of the joint sensor-head and electronics calibration, in which linearity and resolution are optimized.

In addition, the E-509.E3 version includes a full servo-controller for use with PI's piezo nanopositioning systems.

All sensor excitation channels are automatically synchronized with each other, and can therefore be used for different measuring points against the same target, even along different axes.

Single-plate capacitive sensors can perform high-dynamics, non-contact measurements against electrically conductive references. PISeca™ sensor heads are available for three measuring ranges from 20 µm to 500 µm.



Piezo Linear Motors Move Fast and Precise Low-Profile Stages

Low profile and high-quality crossed roller bearings make the new M-664 and M-682 stages giants among the pigmies

- Very Small Footprint and Only 15 mm Profile Height
- High Speed to 400 mm/s for Time-Sensitive Applications
- Linear Encoder and Crossed Roller Bearings for Higher Precision
- Vacuum Compatible & Non-Magnetic Versions

Two new members have been added to PI's family of ultrasonic piezo-motor-driven linear stages. Models M-664 and M-682 provide travel ranges of 25 and 50 mm in a very

compact package. The M-664 provides higher forces than the smallest member, the M-663, but retains the very low profile height of only 15 mm.

The M-682 stage is based on the high performance M-674 PLine® RodDrive, and can also easily be used in XY configurations.

High Accuracy, Speed and Push/Pull Forces

These new translation stages use paired crossed-roller bearings mounted on precision-ground aluminum profiles for better guiding accuracy. Both stages feature a linear encoder with 0.1 μ m resolution, which virtually eliminates backlash and enables a bidirectional repeatability of $\pm 0.2 \mu$ m.

The integrated PLine® linear motors can generate push/pull forces up to 7 N and maximum closed-loop velo-



The M-682, M-664 and the miniature M-663 form a family of fast and space-efficient micropositioning stages based on PLine® piezomotors

cities up to 400 mm/s. Ceramic motors provide high holding forces even when powered off and feature extraordinary position stability without the heat generation characteristic of conventional linear motors.

Applications

These stages are ideal for tasks in the fields of biotechnology, microscopy and photonics packaging. For applications where space is at a premium, the extremely compact M-663 positioner is recommended.



Miniature Servo Motor Linear Stage: Faster and More Accurate

The M-122.2DD with integrated linear encoder, direct-drive DC motor and crossed roller bearings is ideal for industrial applications and satisfies high requirements in precision, repeatability and velocity.

The well-proven miniature translation stages of the M-110 – M-112 series have new company: The M-122 can move loads of up to 5 kg over 25 mm faster and with higher precision.

The M-122 features a space-saving, folded drive train with the servo motor and leadscrew side by side.

Excellent guiding accuracy is ensured through highly precise crossed roller bearings, while a direct-measuring linear encoder enables backlash-free positioning with 0.1 μ m resolution.

The direct drive servomotor enables reliable operation at high velocities to 20 mm/s in industrial applications through a low-friction and maintenance-free recirculating ballscrew design.

Multi-axis stages, choice of controllers

M-122 micropositioners can be easily combined to form XY and XYZ systems. The cost-effective C-863 Mercury™ stand-alone motion controller is the ideal choice for single axis applica-

tions. For multi-axis applications, up to six Mercury™ controllers can be networked. Alternatively, the C-843 PCI-bus card featuring integrated servo amplifiers is available in 2- and 4-axis controller versions.



Measurement results show the high repeatability (here: 0.1 μ m)



Publisher:

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

Editors:
Steffen Arnold,
Stefan Vorndran,
Sandra Ebler
Creation & Design:
Regelmann Kommunikation,
Pforzheim

Production:
Systemedia, Pforzheim

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PI's IMS Certified

PI's Quality Management System has been certified according to ISO 9001 since 1994.

This year, PI and PI Ceramic have in addition implemented an Integrated Management System (IMS) which includes not only Quality Management but also Environmental Protection and Job Safety (according to ISO 14001:2004 and OHSAS 18001:1999).

This system assures legal conformity of all procedures as well as continuous optimization of the processes at all PI locations.

Moreover, the quality of the products and services is a decisive factor for competitiveness and success of PI. Business partners can be sure that PI delivers high-quality products, something which not only certified customers have come to appreciate.

Tradeshows

January

19 – 20	Biomedical Optics (BIOS)	San Jose, CA	Booth #8627
22 – 24	Photonics West	San Jose, CA	Booth #627

February

3 – 5	BioPhysical Society	Long Beach, CA	Booth #519
26 – 28	OFC	San Diego, CA	Booth #1123

March

18 – 20	Defense & Security	Orlando, FL	Booth #832
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May

6 – 8	CLEO	San Jose, CA	Booth #1538
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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.
Akebono-cho 2-38-5
Tachikawa-shi
J-Tokyo 190
Tel. +81 (42) 526 7300
Fax +81 (42) 526 7301

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

GREAT BRITAIN

Lambda Photometrics Ltd.
Lambda House, Batford Mill
GB-Harpending, Hertfordshire
AL5 5BZ
Tel. +44 (1582) 764 334
Fax +44 (1582) 712 084
pi@lambdaphoto.co.uk
www.lambdaphoto.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) 665 014 56
info@pionline.it
www.pionline.it

FRANCE

PI France S.A.S.
32 rue Delizy
F-93694 Pantin Cedex
Tel. +33 (1) 48 10 39 38
Fax +33 (1) 48 10 09 66
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