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Innovation as a Tradition



Nanopositioning

Micropositioning

Nanometrology

Applications



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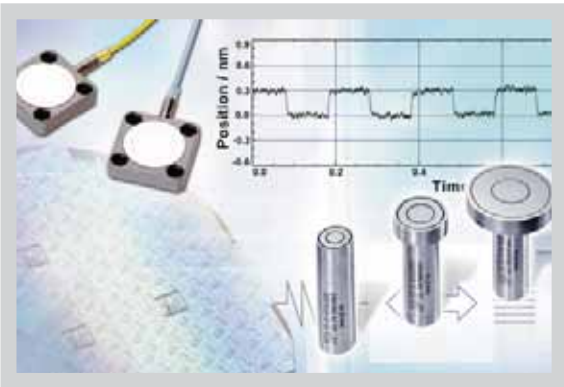
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Thank You!



Dear Customers,

Annual growth rates in double figures, a further expansion of our production capacity and the development of new, globally unique drive technologies: This sums up the last few years at PI.

We owe the success of our business to you.

Your loyalty, your trust, your suggestions and the application problems you have asked us to solve have confirmed PI's role as the leading supplier of piezo-based drives and positioning systems operating with nanometer accuracy.

Our current catalog illustrates some of our products and capabilities. We want to fill you with enthusiasm for our technology. At PI, we not only strive to supply products but also to be your partner in the often difficult quest for technological leadership and commercial success.

Long-term business relationships, reliability, and open and friendly communication with customers and suppliers form an important mainstay for PI—more important than short-term gain.

We are aware of our responsibility towards our customers and take this responsibility very seriously. This is why we continuously invest in the highest quality equipment and qualified personnel. We will continue to extend our leading-edge position as a supplier of high-quality products at the highest technological level.

Find your inspiration—our staff will be delighted to be of service to you.

Kind regards

Kind regards

*Dr. Karl Spanner
President*

About this Catalog

- 200 product families, 30 % of them new
- More than 1,000 products on over 500 pages
- Comprehensive, consistent data-, for a better comparison between products
- More than 1,000 drawings, images, measurement graphs and technical diagrams
- Comprehensive, detailed selection guides and application overviews
- The well-established PI piezo tutorial with background information far exceeding standard product descriptions: a reference work on the basics of piezo technology and precision positioning.

Our "Inspirations 2009" catalog offers all this (and more), and it impressively mirrors the growth that PI has experienced in the recent years.

In detail, the product groups were re-organized into 4 major sections "Linear Drives, Nanopositioning Systems, Nanometrology Sensors and Micropositioning Systems" to reflect the need of our customers.

Additional sub-sections and the use of a colored index system simplify the product search. The product selection guides in each sub-section contain referencing data, scaled down product illustrations, and cross-references to other related sections.

If you cannot find what you are looking for or have any questions, just call or email your local PI representative, or use our extensive online search utility. We will work with you to find the optimum solution – based on catalog product or a custom design optimized for your application.

For up-to-date information on the latest products software updates, user manuals, contact information and a growing list of our world wide subsidiaries and representatives, visit our website at www.pi.ws.

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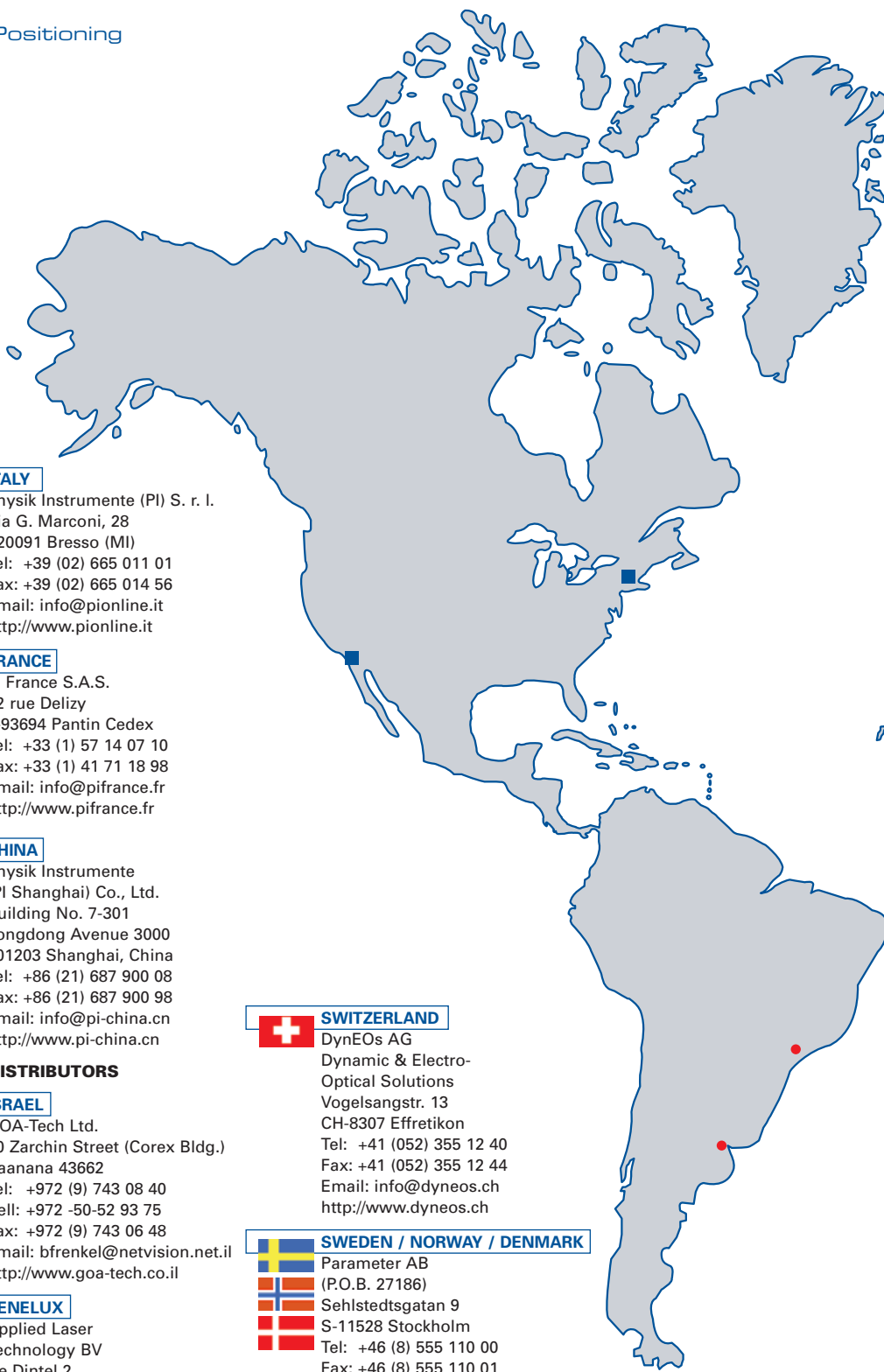
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Moving the Nanoworld

NanoAutomation®: Precision Positioning for Science and Industry



Future Technology Solutions

Today PI delivers micro- and nanopositioning solutions for all important high-tech markets:

- Semiconductor Technology
- Optical Metrology, Microscopy
- Biotechnology and Medical Devices
- Precision Automation and Handling
- Precision Machining
- Data Storage
- Photonics, Fiber Optics, Telecom
- Nano Technology
- Microsystems Technology
- Aerospace Engineering
- Astronomy



PI reception desk:
Our employees look forward to your visit

PI is market and technological leader for precision positioning systems with accuracies well under one nanometer. Nanometer-range motion control is the key to worlds where millions of transistors fit on one square millimeter, where molecules are manipulated, where thousands of “virtual slices” are made in the observation of living cells, or where optical fiber bundles no larger than a human hair are aligned in six degrees of freedom.

Worlds We Call NanoWorlds

Continuous innovation and reinvestment of profits over the decades has allowed PI to attain its present market status. This status is also based on long-term customer relationships and on the freedom to transform ideas into reality.

Over 30 Years Experience

When PI introduced piezo-electric nanopositioning technology more than 30 years ago, typical customers were research labs and universities working on laser cavity tuning, Fabry-Perot interferometers and filters. Few foresaw that

whole industrial sectors like semiconductor manufacturing or biotechnology would become dependent on progress in nanopositioning. Today, not even the precision machining industry can do without nanometer-level positioning systems.

Key Technologies In-House

PI follows a vertical integration strategy designed to develop and maintain all key technologies in-house. We supervise each and every step from design to delivery in the following areas: software, precision mechanics, digital and analog control electronics, sub-nanometer capacitive position sensors, piezo ceramics and piezo actuators. This assures the highest quality and reduces cost.

The PI Group

High Quality and Strong Brands on a Global Scale



PI-USA headquarters in Massachusetts

PI—World Market Player

As a privately run company with a healthy growth rate, over 500 employees and a flexible, vertically integrated organization, PI can meet the most diverse requirements in the area of innovative precision positioning and supply customers anywhere in the world with outstanding products.

International Service and Sales Network

PI has established subsidiaries for sales and service in the most important local markets all over the world and maintains nanometrology test labs on three continents. In addition to PI's main R&D and manufacturing centers in Europe, PI Shanghai and PI USA provide development and manufacturing capabilities to meet the specific demands of local markets faster. In addition to the branch offices, PI has distributors in many other industrial countries. A network of highly qualified personnel around the world assures successful, long-term relationships with customers.

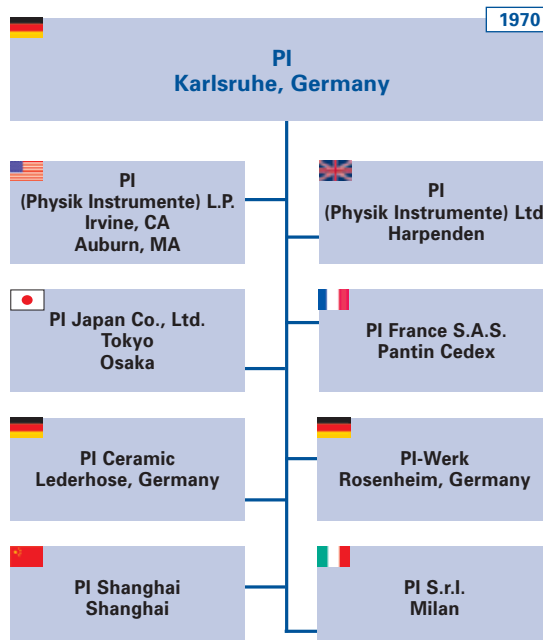
Quality and Brand Policy

We measure the quality and reliability of our products against the strictest of standards. ISO 9001 certification, which also emphasizes points like customer expectations and satisfaction, has been accorded in 1994, making PI the first manufacturer of nanopositioning technology following this standard. PI's Integrated Management System (IMS) includes 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.

PI brands and colors are well known throughout the high-tech world. PIFOC® is almost used as a synonym for objective positioners in general and PICMA® stands for the highest reliability in piezo actuator products.

PI stands for quality and precision – worldwide.



PI Ceramic

Leading in Piezo Technology



PI Ceramic—a PI Subsidiary—is a world-class supplier of high-performance piezoelectric actuator and transducer components and subassemblies.



High-Tech manufacturing: Vacuum coating (sputtering) of piezo ceramics

PI Ceramic also develops and produces all piezo ceramic drive systems employed in PI's precision positioning systems. This makes PI the only supplier of nanopositioning equipment in the world to manufacture its own piezo ceramic drives. This capability allows the flexibility to provide custom engineered piezo ceramic components. It also allows PI to offer the most reliable piezo stages in the world, based upon the award-winning PICMA® actuator technology and to develop innova-

tive drive solutions such as PILine® ultrasonic ceramic motors and NEXLINE® high-force ceramic motors.

In the tradition of the former Keramische Werke Hermsdorf (KWH, until 1990), the PI Ceramic staff embodies knowledge and expertise in the field of piezo and ceramic technology. Since 1992, PI Ceramic has been developing and producing piezo ceramics, worldwide known as PIC: PI piezo Ceramics.

PI Ceramic Strengths

- State-of-the-Art Piezo Assemblies, Transducers and Subsystems
- Design & Manufacture of Key Components for Capital Equipment & Research
- Custom and Standard Solutions
- Short Delivery Through Highly Flexible Processing
- All Key Technologies and Equipment In-House
- ISO 9001-2000, ISO 14001 and OHSAS 18001 Certified



Ceramic high-force piezo motor module

Experience and Innovation

Product Development for Faster Time-To-Market



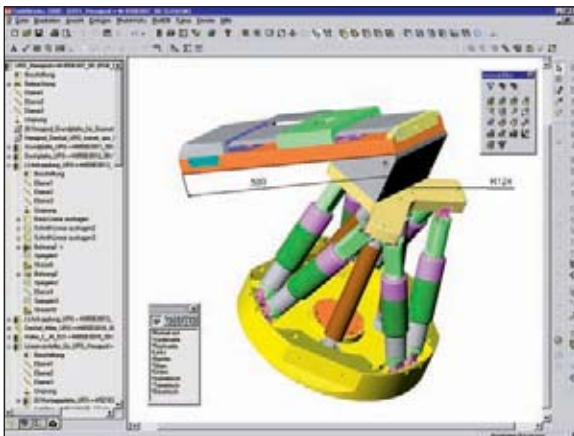
Wall of Fame: More than 100 patented and patent pending technologies related to nanopositioning, motion control and piezoelectric drive systems.

The heart of PI is the R&D department, where physicists and engineers work on technologies which will fulfill tomorrow's stringent requirements for our customers.

With a large percentage of PI's OEM business based on custom-designed products, the wide ranging know-how, long experience and initiative of the developers is crucial to success. Another important factor

is time-to-market, the fast availability of prototypes for evaluation, which are close to the serial product.

PI R&D engineers employ state-of-the-art FEA (finite element analysis) simulation tools and CAD software to develop new electronics and mechanics systems. This assures functionality, precision and performance before the first prototype is ever built.



CAD Software (custom 6-DOF Hexapod shown on screen)



FEA stress simulation showing wire-EDM-cut flexure joint of a tip/tilt mirror system for astronomical telescopes

Production under Control Manufacturing Fractals for high Efficiency and Quality



Flexibility Through Modern Organization: Fractals, Kanban, Demand Flow Technology

The PI Production Department is divided into several autarkic fractals. Each fractal is virtually a company within the company, responsible for all procedures from procurement and production planning to quality testing. Parts replenishment is, to a large extent, handled by Kanban, a parts movement system making heavy use of visual signals in place of documents. Small parts are no longer ordered or tracked internally at all, but rather supplied by an outside service provider (outsourced C-part management). All other aspects of production and procurement are subject to a Demand Flow Technology system.

Environmental Protection and Quality

The Integrated Management System (IMS) of PI and PI Ceramic includes not only the ISO 9001 Quality Management but also Environmental Protection and Job Safety (according to ISO 14001 and OHSAS

18001). 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.

Good is Not Good Enough

We want our customers to be excited about the quality of our products and services. An important tool in this quest is Kaizen, a Japanese philosophy of involving the entire enterprise in a strategy of analysis and continuous improvement of all procedures.

Periodic workshops bring the Kaizen ethos to all PI employees, helping with goals like making production more efficient, eliminating unnecessary processing loops, or instituting "just in time" parts management. In this way the company can assimilate new developments more rapidly and make

important resources available where needed. Delivery times and costs are reduced and quality improved.

Advantages for OEM Customers

With a wide range of sophisticated test and manufacturing equipment, PI can react quickly to product and development demands, including those of highly complex custom systems and subassemblies. PI's high level of vertical integration means that all development and production process-

Measurement technologies and equipment employed by PI:

- Nanometrology labs with multiple thermal, acoustic and seismic isolation for reproducible measurements in the sub-nanometer range
- Laser interferometers with a large variety of special optics for 1-D to 6-D measurements
- Laser scanning vibrometers for vibration measurements
- Capacitive position measuring systems with sub-nanometer resolution
- Surface analysis interferometers for sub-nanometer flatness measurement
- Electronic autocollimators
- Computer-controlled environmental chambers
- Spectrum analyzers
- Coordinate measurement machines (CMM)
- Special microscopes

es, from conception to the final product, are within the reach of the comprehensive quality management program.



Consulting and Customer Service

From Customer to Partner



Working together to find solutions creates bonds that withstand the test of time. And finding solutions is utmost in the minds at PI, where customer service begins with the first exploratory talks and continues well after delivery of the products.

Sales Engineers Worthy of the Name

When our customers want to solve complex problems, they need detailed technical advice. Often the process involves visits at the site of your application and at PI's research, testing and manufacturing facility, where you and our Sales Engineers can take the time necessary to fully clarify all the issues involved. All of PI's Sales Engineers have degrees in physics or engineering and up to 20 years experience in optics, micro- and nanopositioning technology. If necessary, R&D or Applications Engineers can be brought in—even in the first phase of the discussions—to help define a course of action leading to a comprehensive solution.

After-Sale Service

The Sales Engineers are also available after the sale is made. They can advise you when the system is to be expanded, answer technical questions, and help with recalibration or refurbishment.

International Support

PI branch offices and distributors assure global support from many countries in the world. This fact can also be used to advantage by companies which themselves operate worldwide.



Service, sales, and application support team at PI's HQ in Karlsruhe

Thinking in Systems

All in One Hand—All from One Hand



Drive, sensors, mechanics and control electronics with software—components of PI's positioning systems

To assure that the subassemblies used satisfy PI's quality requirements, PI fabricates all components itself, develops the ultra-high-resolution sensors and controllers, and programs both control algorithms and operating software. In Lederhose (Thuringia) at PI Ceramic, piezoelectric drives are developed, optimized and manufactured. With PIC, PI is the only positioning system manufacturer worldwide which develops its own piezoelectric actuators to meet market requirements. The resulting flexibility is an important reason for the technological leadership enjoyed by PI and its customers.

Capacitive Sensors for Nanometrology

Special sensors can fulfill the requirements of many applications for dynamics, linearity and stability better than that provided by standard strain gauges. Non-contact capacitive sensors measure position without drift and provide

linearity to 0,01% of the measurement range. The high resolution of up to 0.0005% allows detection and compensation of the smallest position errors. PI uses capacitive sensors developed in-house, making it possible to adapt the sensor geometries to the space available. Placing the sensors as close as possible to the moving platform, PI provides direct metrology systems—systems in which motion is detected where it is used. PI capacitive sensors are also offered as stand-alone products for nanometrology applications.

Control of Positioning Systems

The characteristics of drives and sensors are made usable by the drive and control electronics. PI has designed all electronics to match the mechanics optimally. Electronic amplifiers for piezoelectric actuators must provide low noise and drift. Fast rise times make possible sub-millisecond

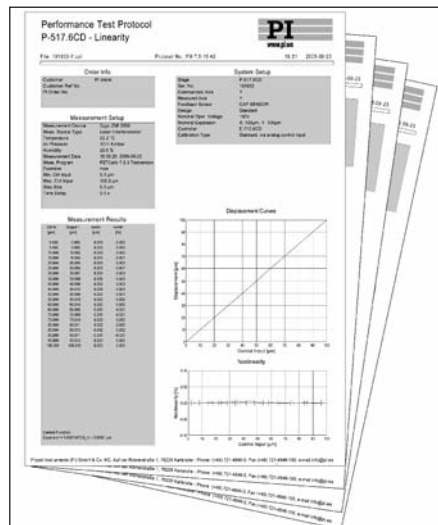
response times and optimized control algorithms minimize settling times. Digital controllers include advanced algorithms to improve the system performance: coordinate transformation matrices matched to the mechanical geometries allow for commanding complex systems in Cartesian coordinates; filters support servo-control by suppressing resonant vibrations; pre-shaping of control signals minimizes trajectory deviation during dynamic scans. All functions are easily accessible through fast and modern interfaces and comprehensive user software and software drivers.

Flexibility Through Competent Partners

High quality requires qualified partners. Over the years PI has thus qualified a number of highly specialized suppliers with whom we now work as partners—partners whose conception of quality is every bit as high as our own.



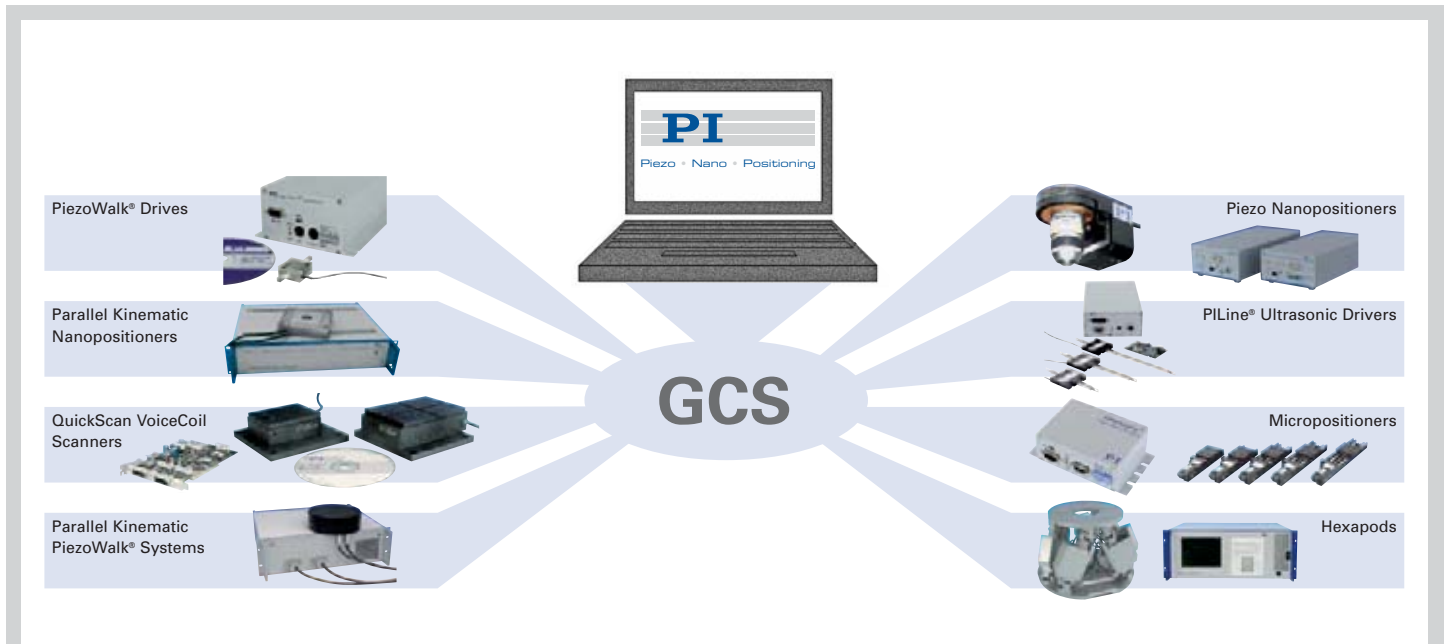
E-710 6-axis Digital Piezo Controller with 6-DOF piezo nanopositioning stage



All PI nanopositioning systems come with extensive system performance documentation

PI Software

Operating Positioning Systems Effectively & Conveniently



Communication between PI components is based upon a universal command set (GCS – General Command Set). It decouples hardware and software, and is used for all drive principles.

The high quality of positioning systems is made apparent in daily operation by PI software. Starting with simple commissioning, through convenient operation with a graphical interface, to quick and simple integration in customized programs with high performance, PI software covers all aspects important to an application.

Universal Command Set Simplifies Commissioning and Programming

For uniform operation of nano and micropositioning systems, the universal PI General Command Set (GCS) is used. GCS operation is independent of the controller or drive principle used, so that several positioning systems can be controlled together, or new systems can be introduced with a minimum of programming effort. With GCS the development of custom application programs is simplified and less prone to errors, because the commands for all supported

devices are identical in syntax and function. Through the use of the GCS command set with its convenient functions, the orientation phase and application development process is

significantly accelerated. The GCS commands are available at the controller terminal, in macros and in the form of a universal driver set for LabVIEW (VIs), Windows

dynamic link libraries (DLL) and Linux libraries. This facilitates the development of custom macros, as well as integration with programming languages like LabVIEW, C++ or MATLAB.

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All about software in the internet—a server offers download of manuals and software CD mirrors

Software Updates Online

PI supports users with free updates, detailed online help and well structured manuals which ease initiation of the inexperienced but still answer the detailed questions of the professional.

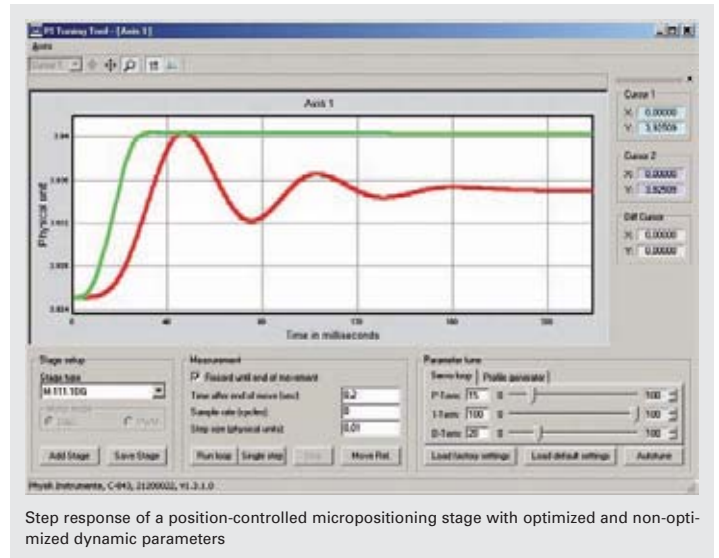
Supported Operating Systems

- Microsoft Windows Vista
- Microsoft Windows XP
- Microsoft Windows 2000
- Linux

Simple Commissioning and Optimization of System Dynamics

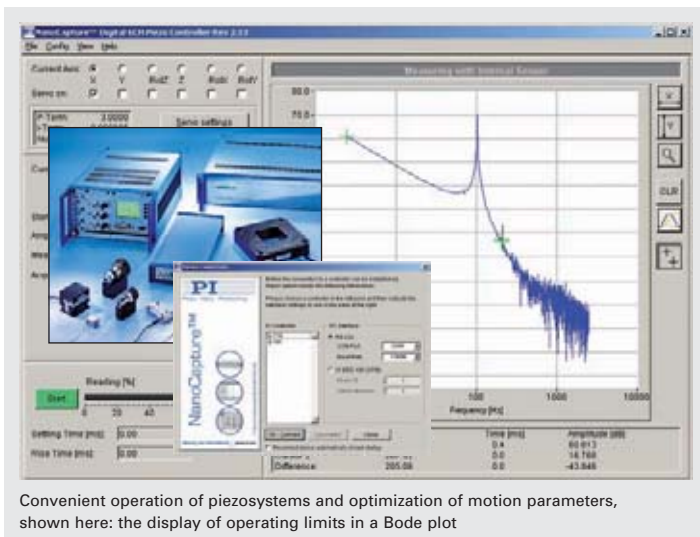
The commissioning of PI positioning systems is quick and easy with the NanoCapture™ and PIMikroMove™ host software. Controller and stages are selected and activated with a few clicks. Then the system can be used directly. Running the system from the NanoCapture™ or PIMikroMove™ host software graphical interface requires no programming knowledge, either for commissioning or direct operation.

Furthermore the system behavior is displayed graphically in easy-to-understand diagrams and allows fast and easy optimization of the operating parameters such as P-I-D terms, notch filter frequencies and slew rate limit.



Step response of a position-controlled micropositioning stage with optimized and non-optimized dynamic parameters

NanoCapture™ Software Optimizing System Performance for Digital Piezo Controllers



Convenient operation of piezosystems and optimization of motion parameters, shown here: the display of operating limits in a Bode plot

- NanoCapture™ Application Software Offers Simple Interface
- Enables Optimization of All Servo Parameters
- Displays Response Behavior & Resonant Frequency, Creates Bode Plots
- Function Generator for Complex Waveforms

NanoCapture™ provides basic and highly advanced functions for operating digital piezo servo-controllers. With its graphical interface, NanoCapture™ enables convenient system optimization and can display settling behavior, resonance frequency, Bode plots, etc. If the nanopositioning system is equipped with directly measuring position sensors, these features are available w/o additional instrumentation.

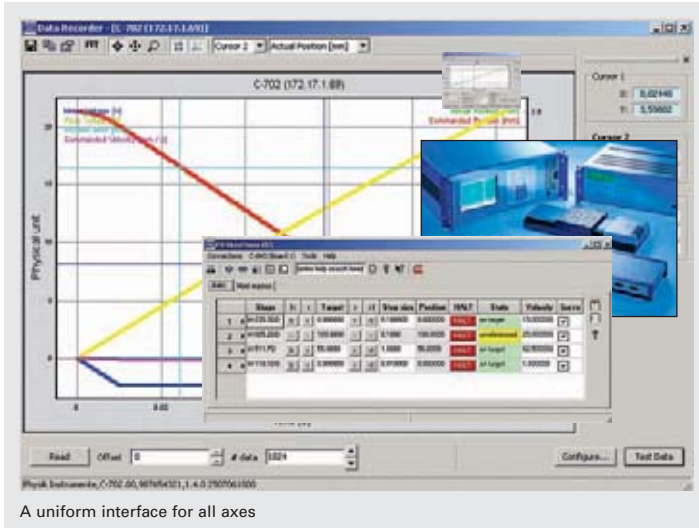
In such a case, the adjustment of parameters like control-loop amplification (P-I parameters), notch filter frequency or the zero-point of the integrated sensors, can optimize response behavior and system stability. In addition, NanoCapture™ supports numerous controller specific properties, like for instance the Wave Generator, which offers synchronized operation of multiple axes with mathematically defined curves, or with arbitrarily customized functions.

Comprehensive System Optimization

The functions described above are especially useful when the mechanical properties of the system calibrated at the factory are changed, e. g. by applying a higher load.

PIMikroMove™ Software

Simple Operation of Positioning Systems



- Operation of PI Motor, Piezo, Piezomotor, Hexapod & Hybrid Controllers
- Optimizing all Servo Parameters
- Macros for Recurring Tasks and Automation
- Profile Generator, Joystick control etc.
- 1D/2D Scan and AutoFind

PI positioning systems can be controlled with PIMikroMove™ in a clear and simple manner; all connected controllers and axes are accessed via the same graphical interface.

PIMikroMove™ supports quick commissioning of controllers and positioners, comprehensive system optimization as well as the programming of macros.

All Axes in One View

With PIMikroMove™ all axes connected can be controlled from one program instance. This, independent of which PI controller is connected to which axis. For example, it is possible to have two axes in an XY application connected to two different controllers, but still command them with PIMikroMove™ from the same window.

Optimal System Behavior

PIMikroMove™ also allows the user to optimize the system behavior through convenient servo tuning. This possibility is especially helpful if the mechanical properties of a system are changed, for example by applying a different load. The system response and stability can then be optimized with the convenient parameter tuning tool. For recurring tasks, different sets of optimized parameters can be saved as stage profiles and then activated as needed in custom-programmed applications.

Macros Ease Recurring Tasks

PIMikroMove™ considerably simplifies the creation of macros for recurring tasks. Execution of a macro, consisting of a previously stored list of GCS commands, can be com-

manded over the interface or, if supported by the controller, run automatically on power-up, with or without a host PC connected.

Controllers without their own macro facility, like the C-843, can be commanded by host macros which PIMikroMove™ edits and stores in the host PC. Host macro execution can be triggered with digital I/O lines and support multiple axes connected to different controllers. With the position pad, two or more independent axes can be moved by a mouse or joystick as an XY stage, also in vector moves.

1D/2D Scan and AutoFind

Scan 1D/2D can measure an input source while moving up to two axes. Moved axes and input source need not be controlled by the same controller. The input source to be measured can be an analog input, an axis position or a raw position sensor value. The measured data is visualized and can be saved to a file on the host PC. AutoFind tries to find the maximum of an intensity signal by

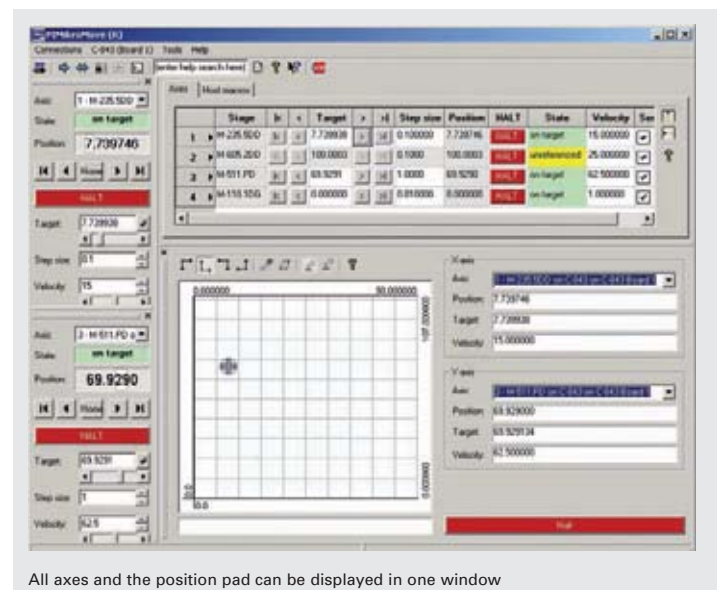
modifying the position of two axes.

FFT, Profile Generator, Data Recorder

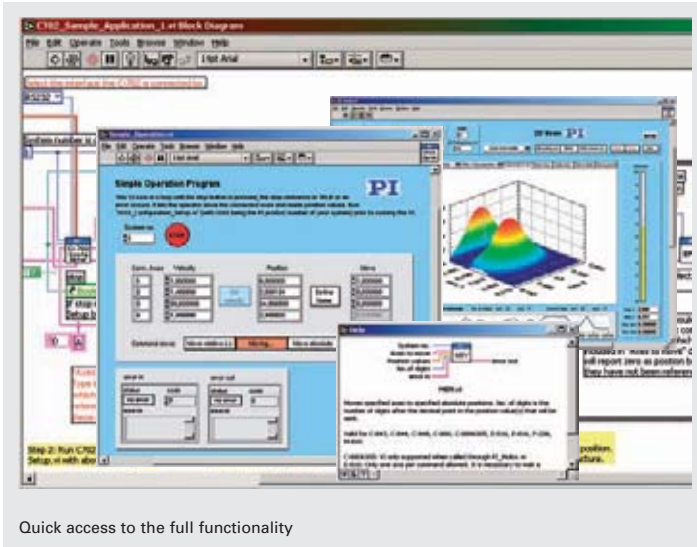
PIMikroMove™ also supports controller-specific features.

Data recorder: record various motion and system parameters, run FFT (fast Fourier transformation) on the data as well as export it to programs like Microsoft Excel (CSV format).

Profile Generator: synchronize motion of several axes along multi-order, mathematically defined curves or customized arbitrary functions.



Programming Quick Integration in LabVIEW



Quick access to the full functionality

The integration and control of PI positioning systems under LabVIEW is greatly simplified by the provision of comprehensive LabVIEW libraries. The LabVIEW drivers support all controllers from PI, independent of the type of connected stage or controller interface. Thus it is possible to operate piezo, DC motor, piezomotor, hybrid and hexapod controllers

with one driver together in one application.

Full Support for NI DAQ Boards

The same LabVIEW programs (virtual instruments, VIs) that are available for PI digital controllers (e.g. set and read voltages and positions, velocity, etc.) can be used in conjunction with a National Instruments

DAQ (data acquisition) board to operate positioning systems based on analog PI controllers. Furthermore, the patented HyperBit™ technology is available under LabVIEW for these systems. HyperBit™ allows attaining position resolution many times better than the resolution of the DAQ board used.

Quick and Easy System Setup

For commissioning a positioning system, the special Configuration Setup VI is executed once. This VI gathers all necessary system information for LabVIEW, including:

- Communication parameters
- Connected controller(s)
- Types & configurations of the connected stages/axes and performs all necessary initialisation steps.

Integrate & Customize Configuration Setup VIs

With its connectors, the Configuration Setup VI can be customized completely to meet the application requirements; it is

implemented as an initialization VI directly in the LabVIEW application. After it has been run, all command VIs and high-level routines of the system can be used. Controller upgrades or changes usually require the exchange of the Configuration Setup VI only. The open source code of many VIs offers additional flexibility in the case of modification needs.

Using Powerful GUI Programs Directly

Beside the command VIs, high-level VIs can be included directly. A comprehensive selection of GUI programs is provided, such as a terminal application, interface selection routine, wave generator samples, 1D and 2D scan and align functions, joystick control, etc.

Flexible Integration in Text-Based Programming Languages

The operation of PI positioning systems from customer applications running under Microsoft Windows or Linux is eased with Dynamic Link Libraries (DLLs) and sample code.

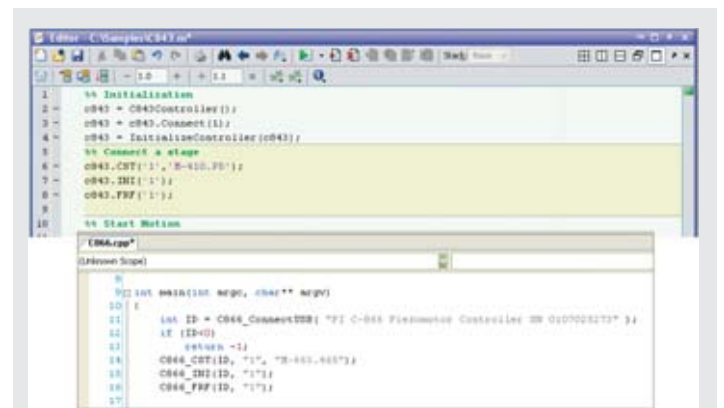
Maximum flexibility

The drivers which are provided support all current programming languages (see inset) and all positioning systems from PI. Since the drivers are based on the uniform PI GCS command set (see p. A-11), GCS functionality can be included directly in external programs. In addition to direct GCS commands, the driver sets also make more

complex functionalities—with their own graphical interfaces—available to external programs. It is thus possible, for example, to use a DLL function call to include the Wave Editor or Profile Generator, complete with operator dialogs, in an external program.

Languages Supported by PI

- MATLAB
- Visual Basic, Delphi
- C, C++, Python
- µManager
- Epics
- MetaMorph
- LabVIEW
- All programming languages that support loading of DLLs



A PI positioning system is initialized with C++ and with Matlab using DLL calls

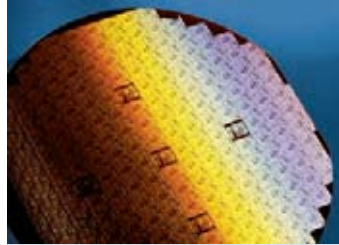
PI—Innovation is a Tradition

70s



- First commercially available piezoelectric translators
- First piezo translators with preloading, for industrial applications

80s



- First commercially available closed-loop piezo actuators
- First nanopositioning systems with flexure guidance and piezo drive
- First fiber positioning systems with hybrid drives
- First preloaded actuators with monolithic low-voltage piezos
- Computer controlled nanopositioning systems
- First closed-loop image-stabilization platforms

90s



- First high-level dynamics nanofocusing system with frictionless guidance
- First two-plate capacitive sensors and controller with integrated linearization for subnanometer accuracy
- First piezo nanopositioning systems with parallel metrology and parallel kinematics
- First piezo-driven tool servo
- PI becomes first nanopositioning systems supplier manufacturing its own piezoceramics
- First Hexapod 6 DOF positioning system with submicron resolution
- First fully automatic fiber alignment system with high-resolution PiezoWalk® linear motor
- First piezo nanopositioning stage with active 6D guidance
- First automated 6D fiber alignment system with fully virtualized center of rotation
- First piezo controller with InputShaping® vibration suppression
- First digital piezo controller with fiber optic interface

2000+



- First multi-layer piezo actuators with ceramic encapsulation for longer lifetime and zero-out-gassing for vacuum operation: PICMA®
- First piezomotor miniature drives in mass production for manipulation of small opto-mechanical components
- Patented PILINE® compact ultrasonic piezomotors and –drives to replace classical motor-spindle configurations
- Patented PiezoWalk® high-resolution, high-load-piezo linear stepping drives: NEXLINE®, NEXACT®
- First digital 6-axis piezo controller with coordinate transformation
- First piezo controller with Dynamic Digital Linearization (improves linearity by up to 1000 times)
- First high-level dynamics, two-axis scanning mirror with closed-loop piezo drive and 100 mrad beam deflection range
- Fastest closed-loop XY nanopositioning stages with large aperture for scanning microscopy
- Scanning stages with <1 nm guiding accuracy in multiple axes

In the course of the last four decades, PI has become the leading manufacturer of nanopositioning technology.

In the 70s, as space exploration and laser technology stimulated optics research, PI introduced piezo actuators which gave scientists the highest positioning precision then available.

In the 80s, as the development of the microcomputer led to the first semi-conductor boom and ongoing miniaturization of electronic structures, PI introduced nanopositioning systems tailor-made for the tasks involved.

The fall of the Berlin Wall marked the end of the Cold War and made the 90s the opening of a new era of bound-

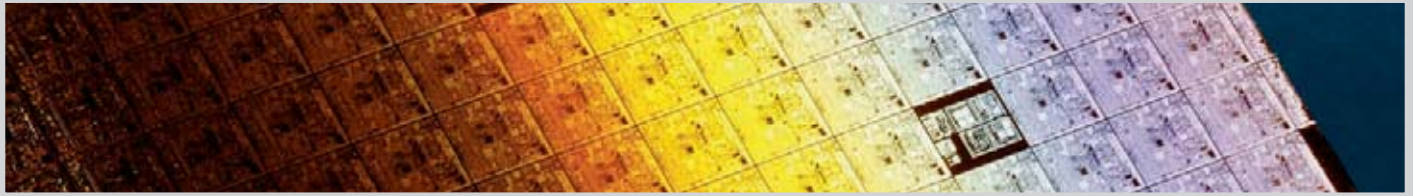
less communications. For PI also, this meant the opening of new horizons with the founding of the PI Ceramic subsidiary in the former East Germany. A main focus in technology was Photonics, where precision positioning of optical fibers and fiber-arrays boomed.

The turn of the century brought global progress in nanotechnology, which finds its first commercialisation in semiconductor manufacturing and inspection, and biotechnology—all fields where “smaller” and “more precise” are keys to success.

PI also offers the appropriate solutions for tasks in these areas with ever faster and more precise nanometer positioning, stabilization and automation.

Applications

Semiconductor Technology



Moore's Law keeps compressing IC line widths and feature-sizes. In order to keep up, nanopositioning mechanisms and precision motion control systems embedded in front-end production and metrology tools must provide 10 to 1000x higher precision than feature size. Vibrations, position errors and drift need to be controlled

to <0.1 nm (atom diameter). Conventional positioning systems do not provide the required stability and precision.

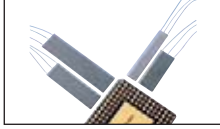
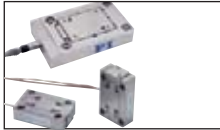
PI offers a wide variety of piezo based solutions from long-life PZT ceramics for vibration cancellation to the ultra-high-performance NEXLINE® long-

travel nanopositioning piezo motors.

Other precision motion products include piezo tilt platforms for fast beam stabilization / correction, piezo flexure stages for nanometrology applications, nanoalignment systems for mask alignment, and the new hybrid long-travel

nanopositioning translation stages for linear and vertical positioning.

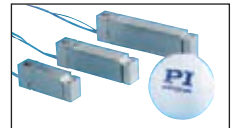
PI's capacitive nanometrology sensors measure motion down to the sub-nanometer range with very high bandwidth.



Application	PI Solution	Typical PI Products*
Nanoimprint CD Testing Mask and Wafer Alignment Objective Precision Positioning Lithography	Piezo Linear Motors, Multiaxis-Piezo Nanopositioning Stages Piezo Actuators PIFOC® Nanofocusing Devices	N-214 N-215 NEXLINE® Linear Motor / Actuator, p. 1-10 P-587 6-Axis Precision Piezo Stage, p. 2-76 P-561-PIMars™ XYZ Piezo System, p. 2-72 P-721 PIFOC® Objective Piezo Nanopositioner, p. 2-26
Wafer Inspection Nanometrology	See Examples on p. A-22	
Interferometry	Closed-Loop Piezo Actuators and Flexure-Guided Systems	P-725 PIFOC® Long-Travel Objective Scanner, p. 2-28 P-753 LISA Linear Actuator & Stage, p. 2-16 P-752 High Precision Nanopositioner, p. 2-18 P-620.1 – P-629.1 PIHera® Piezo Linear Stage, p. 2-22
Wire Bonding	Piezo Bender Actuators	PL112 · PL140 PICMA® Bender Actuators, p. 1-94
Sub-nm Measurements (Nanometrology)	Single and Dual Probe Capacitive Position Sensors	D-015 · D-050 · D-100 Capacitive Sensors, p. 3-14 D-510 PISeca™ Single Probe Capacitive Sensors, p. 3-8
Optics Testing / 6-Axis Alignment	Hexapod 6D Parallel-Kinematics Micropositioning Systems	M-824 Compact 6-Axis-Positioning System, p. 4-10 M-850 Hexapod 6-Axis Positioning System, p. 4-6 F-206.S HexAlign™ 6 Axis-Hexapod, p. 4-12 N-515 Non Magnetic Piezo Hexapod, p. 1-17

*Other standard or custom solutions from PI could be even more suitable for your application. Talk to a PI Applications Engineer or visit www.pi.ws.

Application	PI Solution	Typical PI Products*
Nanoalignment Systems with Long Travel Ranges	Lever-Amplified Piezo Actuators Piezo Flexure Stages with up to 6 Axes PiezoWalk® Linear Motors/Actuators	P-620.1 · P-629.1 PIHera® Piezo Linear Stage, p. 2-22 P-601 PiezoMove™ Z-Actuator, p. 1-68 P-587 6-Axis Precision Piezo Stage, p. 2-76 N-214 NEXLINE® Piezo Motor Actuator, p. 1-10 P-225, P-235 PICA™ Ultra-High-Force Piezo Stack Actuators, p. 1-80
Beam Scanning and Stabilization Optical Path Correction	Fast Piezo Steering Mirror Systems	S-334 Miniature Piezo Tip/Tilt-Mirror, p. 2-90 S-330 High-Dynamics Piezo Tip/Tilt-Mirror, p. 2-88
Active Vibration Cancellation	Piezo Stack Actuators and Ceramics	P-225, P-235 PICA™ Power Piezo Actuators, p. 1-80 P-010.xxP · P-056.xxP PICA™ Power Actuator, p. 1-88 P-876 DuraAct Patch Transducers, p. 1-96
High-Resolution Microscopy	See Examples p. A-18	
Vertical Wafer Positioning	Piezo Z-Tip/Tilt Stages Custom Tripod Stages with Piezo Linear Motors PiezoWalk® Drives and Actuators	M-714 Nanometer-Precision Linear Stage, p. 4-62 P-541.Z Piezo Z and Z/Tip/Tilt Stages, p. 2-44 P-518, P-528, P-558 Piezo Z/Tip/Tilt Stage, p. 2-46 P-587 6-Axis Precision Piezo Stage, p. 2-76 N-510 NEXLINE® Z/Tip/Tilt Stages, p. 1-17
Long-Range Placement and Positioning	Motorized Translation Stages Motorized Rotation Stages PILine® Ultrasonic Motors NEXLINE® PiezoWalk® Motors	N-214 N-215 NEXLINE® Linear Motor / Actuator, p. 1-10 M-674 PILine® RodDrive Piezo Linear Drive, p. 1-30 M-511 Heavy-Duty Micropositioning Stage, p. 4-44 M-038 Precision Rotation Stage, p. 4-80 M-060 Precision Rotation Stage, p. 4-76



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Applications Microscopy/Imaging



Piezo positioning & scanning stages are fundamental tools for high-resolution microscopy. The rapid response and sub-atomic resolution allow scientists to create higher-quality images faster.

PI provides a large variety of fast objective lens positioners

(Z-motors), as well as sample scanners for deconvolution and 3D imaging (Z-stack acquisition) and fast focusing stages.

PIFOC® piezo-actuated Z-scanners typically achieve 10 times higher focusing speed & precision than motorized drives.

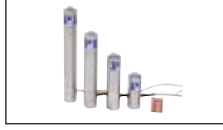
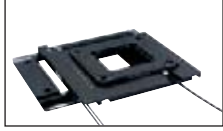
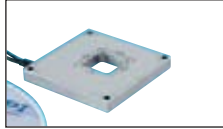
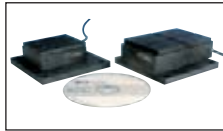
Controllers come with a high-bandwidth analog interface for extremely fast response and compatibility with all major image acquisition packages.

Optical trapping experiments rely on the high resolution and stability of closed-loop piezo flexure stages and steering

mirrors. The latest generation of digital controllers can provide significant advantages in tracking applications.



Application	PI Solution	Typical PI Products*
Confocal Microscopy, Focusing Z-Stack Image Acquisition	Piezo Specimen Z-Stages & Piezo Objective Scanners	P-737 Piezo Z-Stage, p. 2-34 P-721 PIFOC® Nanofocussing Z-Drive, p. 2-26 P-725 PIFOC® Long Travel Nanofocussing Z-Drive, p. 2-28 P-541.Z Piezo Z-Stage, p. 2-44
Scanning Microscopy, Optical Trapping (Tweezers), SNOM, AFM, E-Beam	Fast XYZ Nanopositioning Systems Piezo Nanopositioning Stages Shear Actuators PicoCube® Scanner Scanner Tubes Piezo Beam Steering Mirrors	P-517 · P-527 Multi-Axis Piezo Scanner, p. 2-70 P-111 · P-151 PICA™ Shear Actuators, p. 1-98 PT-120 PT Piezo Tube Actuators, p. 1-100 P-363 PicoCube™ XY(Z) Piezo Scanner, p. 2-66 S-323 High-Resolution, High Dynamics Mirror with Capacitive Sensors, p. 2-96
Screening Long Range Scanning	Voice-Coil Scanning Stages/Positioners Stages with Linear Piezomotors	V-106 QuickScan™ High-Dynamics Scanner, p. 4-48 M-686 PLine® XY-Linear Motor Stage, p. 4-64 M-664 PLine® Linear Motor Stage, p. 4-30
Image Processing Resolution Enhancement, CCD Dithering Pixel Sub-Stepping / Multiplication Biometry	Fast and Cost-Effective scanners	P-713 XY Piezo Scanner, p. 2-56 PL112 Benders, p. 1-94 S-325 Piezo Z / Tip/Tilt Platform, p. 2-92 S-330 High-Resolution, High Dynamics Mirror, p. 2-88
Laser Beam Steering, Stabilization	Tip/Tilt Mirrors (Active Optics)	S-330 High-Resolution, High Dynamics Mirror, p. 2-88 S-323 High-Resolution, High Dynamics Mirror with Capacitive Sensors, p. 2-96 S-334, Long Range Steering Mirror, p. 2-90
Sample Positioning XY-Stages	Stages with Linear Piezomotors or DC Motors	M-686 PLine® XY-Linear Motor Stage, p. 4-64 M-663 PLine® Linear Motor Stage, p. 4-28 M-014 Linear Slide with Aperture, p. 4-54 M-501 Precision Vertical Stage, p. 4-60
Sample Positioning (Very High Resolution)	Piezo Actuators	P-840 · P-841 Preloaded Piezo Actuators, p. 1-74
Digital Controllers for High Speed Tracking	Digital Controllers with Optional InputShaping® Technology	E-712 Modular Digital Piezo Controller, p. 2-140 E-753 Digital Piezo Controller, p. 2-108



*Other standard or custom solutions from PI could be even more suitable for your application. Talk to a PI Applications Engineer or visit www.pi.ws.

Applications

Biotechnology, Life Science



Recent advances in biotechnology and related sciences have increased the need for high-speed, high-precision positioning systems. Please read on for a few examples.

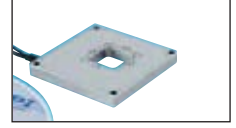
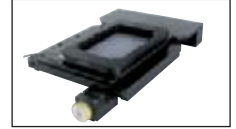
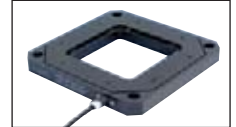
PI piezo actuators can be used to precisely focus a microscope objective in milliseconds, and they can also help to sort cells rapidly. Drug screening applications demand nanoliter dispensing capabilities,

yet another application where the speed and precision and extreme lifetime of PI piezo actuators excel.

The scanning optical microscope—one of the cutting-edge

tools for DNA research—is not feasible without piezo positioning systems. PI's hexapod 6-axis robots provide the precision and flexibility to support surgeons in their craft.

Application	PI Solution	Typical PI Products*
Flow Cytometry Cell Sorting Electrophysiology, Patch Clamp Intra-Cell Metrology	Micro-Translation Stages Linear Actuators Micromanipulators Fast Piezo Actuators	M-110 Compact Micro-Translation Stage, p. 4-22 M-230 Precision Linear Actuator, p. 1-46 F-130 Compact XYZ Fiber Aligner, p. 4-66 P-882 PICMA® Multilayer Piezo Stack Actuators, p. 1-82
Optical Trapping Cell Tracking Optical Tweezers Molecular Stretching	Piezo Nanopositioning and Scanning Stages	P-541 Piezo XY-Stage, p. 2-44 P-527 Multi-Axis Piezo Scanner, p. 2-70 P-733 XY(Z) Piezo-Nanopositioning Stage, p. 2-62 P-363 PicoCube™ XY(Z) Piezo Scanner, p. 2-66
Confocal Microscopy Focusing Z-Stack Image Acquisition	Z-Stages Piezo Specimen Z-Stages & Piezo Objective Scanners	P-541.Z Piezo Z and Z/Tip/Tilt Stages, p. 2-44 P-721, P-725, P-726 PIFOC® Piezo Flexure Objective Scanners, p. 2-26 ff P-737 PIFOC® Specimen-Focusing Z Stage, p. 2-34
Laser Beam Steering, Stabilization	Tip/Tilt Mirrors (Active Optics)	S-334 Miniature Piezo Tip/Tilt-Mirror, p. 2-90 S-330 High-Dynamics Piezo Tip/Tilt-Mirror, p. 2-88
Cell Penetration	PiezoWalk® Linear Motor Actuators Nanopositioners Piezo Linear Scanners	P-601 PiezoMove™ Z-Actuator, p. 1-68 PT120 PT Piezo Tube Actuators, p. 1-100 P-611 Piezo Nanopositioner, p. 2-50 M-674K High-Precision Z Actuator p. 1-35 N-380 NEXACT® Linear Actuator, Piezo Stepper, p. 1-14
Microdosing Dispensing Nano/Microliter Pumps	Piezo Linear Motor Actuators & Stages Piezo Actuators Piezoelectric Components	M-674 PLine® RodDrive Piezo Linear Drive, p. 1-30 P-653 PLine® Miniature Linear Motor / Slide, p. 1-32 P-601 PiezoMove™ Z-Actuator, p. 1-68 PL112 PICMA® Bender Actuators, p. 1-94 See www.piceramic.com
Screening Fast Positioning Bio-Handling	Voice-Coil Scanners Micropositioning Stages Piezo Linear Motors Hexapod 6D Micropositioning System	V-106 QuickScan™ High-Dynamics Scanner, p. 4-48 P-725 PIFOC® Piezo Flexure Objective Scanner, p. 2-28 M-674 PLine® RodDrive Piezo Linear Drive, p. 1-30 M-824 Compact 6-Axis-Positioning System, p. 4-10 M-511 Heavy-Duty Micropositioning Stage, p. 4-46
Image Processing Resolution Enhancement, CCD Dithering Pixel Multiplication, Biometry	Fast and Cost-Effective scanners	P-713 XY Piezo Scanner, p. 2-56 PL112 PICMA® Bender Actuators, p. 1-94 S-325 Piezo Z / Tip/Tilt Platform, p. 2-92 S-330 High-Dynamics Piezo Tip/Tilt-Mirror, p. 2-88



*Other standard or custom solutions from PI could be even more suitable for your application. Talk to a PI Applications Engineer or visit www.pi.ws.

Applications

Medical Design, Medical Technology



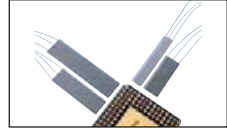
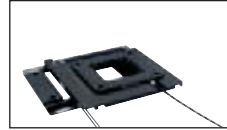
Recent advances in medical design and related life sciences have increased the need for high-speed, high precision positioning systems. Please read on for a few examples.

PI piezo actuators are high-speed, non-magnetic devices

great advantages in MRI & OCT applications. They can also help to sort cells rapidly. Drug screening applications demand nanoliter dispensing capabilities, yet another application where the speed, precision and extreme lifetime of PI piezo actuators excel. Piezo beam

steering systems can be used to direct laser beams extremely fast and precisely. The scanning optical microscope — one of the cutting-edge tools for DNA research — is not feasible without piezo positioning systems. PI's Hexapod 6-axis robots provide the precision

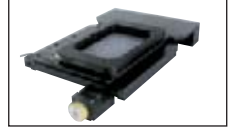
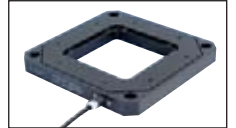
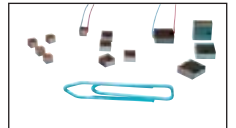
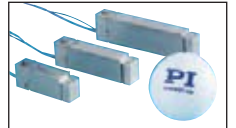
and flexibility to support surgeons in their craft.



Application	PI Solution	Typical PI Products*
Ophthalmology Dermatology Laser Beam Steering, Stabilization	Beam Steering Tip/Tilt Mirrors (Active Optics)	S-334 Long Range Piezo Tip/Tilt-Mirror, p. 2-90 S-330 High Dynamics Steering Mirror, p. 2-88
Flow Cytometry Cell Sorting Electrophysiology, Patch Clamp Intra-Cell Metrology	Micro-Translation Stages Linear Actuators Micromanipulators Fast Piezo Actuators PiezoWalk® Drives and Actuators	M-110 Compact Micro-Translation Stage, p. 4-22 M-230 Servo Motor Actuator, p. 1-46 F-130 Compact XYZ Fiber Aligner, p. 4-66 P-882 PICMA® Multilayer Piezo Stack Actuators, p. 1-82 N-310 NEXACT® OEM Miniature Linear Motor/Actuator, p. 1-12
Cell Penetration Microdosing	Nanopositioners Piezo Scanners PiezoWalk® Drives and Actuators	P-601 PiezoMove™ Z-Actuator, p. 1-68 P-611 Piezo Nanopositioner, p. 2-50 ff M-674 PLIne® RodDrive Piezo Linear Drive, p. 1-30 N-310 NEXACT® OEM Miniature Linear Motor/Actuator, p. 1-12 N-380 PiezoWalk® Nanopositioning Linear Motor Actuator, p. 1-14
Screening Fast Positioning	Voice-Coil Scanners Micropositioning Stages Piezo Linear Stages	V-106 QuickScan™ High-Dynamics Scanner, p. 4-48 P-725 PIFOC® Piezo Flexure Objective Scanners, p. 2-28 M-686 PLIne® XY-Linear Motor Stage, p. 4-64 M-664 PLIne® Linear Motor Stage, p. 4-30
Microscopy	See Examples p. A-18	
Surgical Robots Adjustment of examination tables for treatment	Hexapod 6D Micropositioning Systems Translation Stages	M-824 Compact 6-Axis-Positioning System, p. 4-10 M-850 Hexapod 6-Axis Positioning System, p. 4-6 M-850K 6-Axis Positioning System for Large Loads, p. 4-15 M-511 Heavy-Duty Micropositioning Stage, p. 4-44
Image Processing Resolution Enhancement OCT	Fast X and XY-Scanners Piezo Actuators Tip/Tilt Mirrors	P-713 XY Piezo Scanner, p. 2-56 PL112 · PL140 PICMA® Bender Actuators, p. 1-94 P-882 PICMA® Multilayer Piezo Stack Actuators, p. p. 1-82 S-334 Miniature Piezo Tip/Tilt-Mirror, p. 2-90

*Other standard or custom solutions from PI could be even more suitable for your application. Talk to a PI Applications Engineer or visit www.pi.ws.

Application	PI Solution	Typical PI Products*
Handling Compact Drive Units Non-Magnetic Actuators	Piezo Linear Drives PiezoWalk® Piezo Actuators	P-653 Sub-Miniature Linear Motor, p. 1-32 M-664 PLine® Linear Motor Stage, p. 4-30 N-310 NEXACT® OEM Linear Motor, p. 1-12
Nanodosing Ultrasonic Oscillations Nanoliter Pumps	Piezoceramic Components, Flexure-Guided Actuators	P-601 PiezoMove™ Z-Actuator, p. 1-68 See p. 1-94 ff. and www.piceramic.com
Force and Motion Sensors	Piezoceramic Components	See p. 1-94 ff and www.piceramic.com
OCT, WLI Diagnostics, Dermatology Ophthalmology	Piezo Actuators Piezo Linear Motor Drives PiezoWalk® Drives and Actuators	P-601 PiezoMove™ Z-Actuator, p. 1-68 P-611 Piezo Nanopositioner, p. 2-50 ff P-725 PIFOC® Piezo Flexure Objective Scanners, p. 2-28 ff N-310 NEXACT® OEM Miniature Linear Motor, p. 1-12 N-380 PiezoWalk® Nanopositioning Linear Actuator, p. 1-14
Grating Rotation	Rotation Stages	M-037 Compact Precision Rotation Stage, p. 4-78 M-038 Precision Rotation Stage, p. 4-80 M-060 Precision Rotation Stage, p. 4-76
Optical Trapping Cell Tracking Optical Tweezers Molecular Stretching	Piezo Nanopositioning and Scanning Stages	P-541 Piezo XY-Stage, p. 2-60 P-527 Multi-Axis Piezo Scanner, p. 2-70 P-733 XY(Z) Piezo-Nanopositioning Stage, p. 2-62 P-363 PicoCube™ XY(Z) Piezo Scanner, p. 2-66
Confocal Microscopy Focusing Z-Stack Image Acquisition	Z-Stages Objective Z-Scanners	P-541.Z Piezo Z and Z/Tip/Tilt Stages, p. 2-44 P-721, P-725, P-726 PIFOC® Piezo Flexure Objective Scanners, p. 2-26 ff P-737 PIFOC® Specimen-Focusing Z Stage, p. 2-34



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Applications

Metrology / Laser Systems / Optical Inspection / Tribology



PI precision positioning stages and actuators have been used in many noncontacting optical inspection and contacting nanometrology applications. They provide sub-nanometer precision and extremely uni-

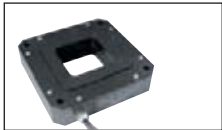
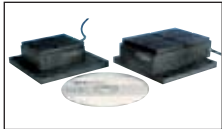
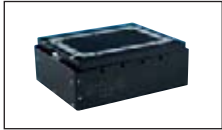
form motion with flatness and straightness in the nanometer and sub-nanometer range for the latest technology breakthroughs. Sophisticated digital control algorithms can improve scanning linearity by

several orders of magnitude while reducing runout errors to subatomic tolerances. PI's capacitive nanometrology sensors measure motion down to the sub-nanometer range with very high bandwidth.

PI piezo-driven actuators and nanopositioning sensors are also ideal components for the design of nano-indentation / micro-indentation mechanisms and nanotribology / nanofriction experiments



Application	PI Solution	Typical PI Products*
Scanning Interferometry White-Light Interferometry	PIFOC® Objective Nanofocusing Systems Piezo Scanning Stages Z-Axis Piezo Phase Shifters	P-721 PIFOC® Piezo Flexure Objective Scanner, p. 2-26 P-587 6-Axis Precision Piezo Stage, p. 2-76 P-734 Low Bow XY Scanning Stage, p. 2-64 S-303 Piezo Phase Shifter, p. 2-96 P-622.Z PIHera® Precision Z-Stage, p. 2-40
Precision Linear Positioning Stages for Surface Analysis, Optical Inspection, Laser Positioning Systems	Microscopy Stages with Piezo Option Hybrid Long-Range Nanopositioning Stages Long Travel Piezo Flexure Stages	M-714 Nanometer-Precision Hybrid Linear Stage, p. 4-62 M-511 Heavy-Duty Micropositioning Stage, p. 4-44 M-014 Linear Slide with Aperture, p. 4-54 P-629 Flexure Stage with 1.8 mm Travel, p. 2-22
Long Range Surface Scanning	Voice-Coil Scanning Stages/Positioners	V-106 QuickScan™ High-Dynamics Scanner, p. 4-48
Nanomaterials Testing Nanotribology Nanothickness Measurements Nanoindentation Contacting Surface Profilometer	Piezo Actuators X, XY and XYZ Piezo Stages Capacitive Sensors Piezo Motor Stages	D-015 · D-050 · D-100 Capacitive Sensors, p. 3-14 P-840 Preloaded Piezo Actuators, p. 1-74 P-734 XY Piezo Scanner, p. 2-64 P-753 LISA Linear Actuator & Stage, p. 2-16 M-663 Ultrasonic Piezo Linear Motor Stage, p. 4-28



*Other standard or custom solutions from PI could be even more suitable for your application. Talk to a PI Applications Engineer or visit www.pi.ws.

Applications

Nanotechnology, Nanofabrication, NanoAutomation®



Piezo positioning systems are fundamental tools for nanotechnology applications. Their extreme precision and speed makes them vital components in applications such as nanoimprint, nanoassembly, ultra-

high density data storage and nanofabrication.

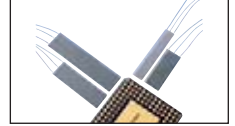
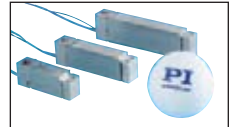
In addition to extremely fast mechanics, PI also designs advanced digital piezo controllers that provide very high

bandwidth and eliminate dynamic nonlinearity for vastly improved tracking accuracy. Active trajectory control eliminates off-axis errors and InputShaping® cancels self-generated vibration, for the

fastest possible settling speeds.

The combination of advanced mechanical design and high-throughput control technology is called NanoAutomation®.

Application	PI Solution	Typical PI Products*
Nanoimprint, Nanoassembly Nanofabrication, Nanojoining Nanomechanics Nanomaterials Testing	Multi-Axis Nanopositioning Systems PIHera® Stages Scanner Preloaded Piezo Actuators PiezoWalk® Nanopositioning Drives	P-733.3DD XY(Z) Piezo-Nanopositioning Stage, p. 2-62 P-587 6-Axis Precision Piezo Stage, p. 2-76 P-620.1 - P-629.1 PIHera® Piezo Linear Stage, p. 2-22 P-840 Preloaded Piezo Actuators, p. 1-74 N-380 PiezoWalk® Nanopositioning Linear Motor Actuator, p. 1-14
Ultra-Precision Linear Motors & Actuators	Motorized Precision Linear Actuators PiezoWalk® Linear Motor Actuators, Ultrasonic Ceramic High-Speed Motors	N-310 NEXACT® OEM Miniature Linear Motor/Actuator, p. 1-12 P-653 Sub-Miniature Piezo Ceramic Linear Motor p. 1-32 M-674 PILine® RodDrive Piezo Linear Drive, p. 1-30 M-230 Servo Motor Actuator, p. 1-46 P-661 Ultrasonic Linear Motor for OEMs, p. 1-28
Nanodosing Microdispensing Nanoliter Control Fast Valve Control	Tube Actuators Disk Actuators Lever Amplified Actuators Bender Actuators Piezoelectric Components	PT120 Piezo Tubes, p. 1-100 P-601 PiezoMove™ Z-Actuator, p. 1-68 PL112 · PL140 PICMA® Bender Actuators, p. 1-94 See www.piceramic.com
Microassembly and Handling Systems	Hexapod 6D Micropositioning Robots	M-840 HexaLight™ 6-Axis Positioning System, p. 4-8 M-824 Compact 6-Axis-Positioning System, p. 4-10 M-850 Hexapod 6-Axis Positioning System, p. 4-6 F-206.S HexAlign™ 6 Axis-Hexapod, p. 4-12
Precision Positioning of Components (Linear and Rotation)	Miniature Stages Rotation Stages	M-110 Compact Micro-Translation Stage, p. 4-22 M-663 PILine® Linear Motor Stage, p. 4-28 M-511.HD Hybrid Ultra-Precision, Micropositioning Stage, p. 4-46 M-060 · M-061 · M-062 Precision Rotation Stage, p. 4-76
Precision Actuation	Motorized Precision Linear Actuators PiezoWalk® Linear Motor Drives and Actuators	N-380 PiezoWalk® Nanopositioning Linear Motor Actuator, p. 1-14 M-230 Precision Linear Actuator, p. 1-46 M-235 Heavy-Duty Precision Linear Actuator, p. 1-50 P-661 PILine® Piezo Linear Drive, p. 1-28 M-674 PILine® RodDrive Piezo Linear Drive, p. 1-30
Microgrippers Manipulators	Piezo Bender Actuators PiezoWalk® Drives PILine® Drives	PL112 · PL140 PICMA® Bender Actuators, p. 1-94 P-885 PICMA® Multilayer Piezo Stack Actuators, p. 1-82 P-653 PILine® Miniature Linear Motor / Slide, p. 1-32 N-310 NEXACT® OEM Miniature Linear Motor/Actuator, p. 1-12
Microembossing	Heavy-Duty Piezo Translators	P-225 PICA™ Power Piezo Stack Actuators, p. 1-80 P-007 PICA™ Stack Actuator p. 1-86



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Applications

Photonics, Telecommunications, Integrated Optics



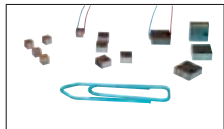
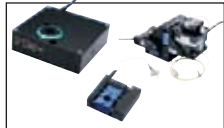
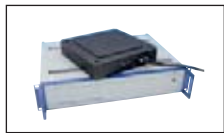
PI offers a great variety of innovative solutions for testing and fabrication of MEMS and photonics devices. Products range from automated 6D alignment systems for industrial automation to simple devices

for laboratory test setups. Piezo drives make possible rapid scanning with sub-millisecond response.

Applications include automated photonic alignment of collimat-

ed fibers or arrays, test systems for MEMS and multi-channel waveguides. Miniature piezo linear motors provide high speed with very low power consumption, ideal in cell phone autofocussing applications.

The following table includes but a few examples of the system solutions that PI has developed for the photonics market.



Application	PI Solution	Typical PI Products*
Autofocusing	PIFOC® Piezo Z-Scanners High Speed Piezo Ceramic Linear Motors	P-653 Sub-Miniature Piezo Ceramic Linear Motor for Micro Lens Positioning / Cell Phone Autofocus & Zoom p. 1-32 P-725 PIFOC® Piezo Nanofocussing Device, p. 2-28 P-661 High Speed Piezo Ceramic Linear Motor for OEMs, p. 1-28
Nanophotonics Laser Deposition Quantum Computing	Multi-Axis Nanopositioning Systems Hexapod 6D Systems	P-587 6-Axis Precision Piezo Stage, p. 2-76 P-563 PIMars™ XYZ Piezo System, p. 2-72 P-615 NanoCube® XYZ Piezo System, p. 2-68 M-824 Compact 6-Axis-Positioning System, p. 4-10
Photonic Packaging MEMS Positioning/Alignment Fiber Alignment Fiber Optic Test Systems	6D Hexapod Alignment Systems, Ultra-Compact, X, XY and / XYZ Translation Stages with Piezo Option 3D Piezo-Driven Nanopositioning Systems Fast Voice-Coil Scanners/Positioners	F-206.S HexAlign™ 6 Axis-Hexapod, p. 4-12 M-110 Compact Micro-Translation Stage, p. 4-22 M-105.3P Linear Slide, p. 4-50 F-130 Compact XYZ Fiber Aligner, p. 4-66 P-611 Piezo Nanopositioner, p. 2-20 V-106 QuickScan™ High-Dynamics Scanner, p. 4-48
Fiber Splicer, Fiber Alignment, Fiber Optic Switches	Piezo Bender Actuators Piezo Actuators for Positioning Tasks Miniature PZT Actuators	P-810 Piezo Actuators, p. 4-14 PL112 · PL140 PICMA® Bender Actuators, p. 1-94
Fiber Stretching/Modulation	Tube Actuators for Fiber Stretching, Compressing, Modulating	PT120 PT Piezo Tube Actuators, p. 1-100
Fiber Optic Alignment	Translation Stages Rotation Stages	F-130 Miniature XYZ Alignment System, p. 4-66 M-122 High Precision Miniature Translation Stage , p. 4-24 M-037 Compact Precision Rotation Stage, p. 4-78 M-126 High-Resolution Translation Stage, p. 4-38 M-235 Heavy-Duty Precision Linear Actuator, p. 1-50
Laser Beam Switching Optical Switches Free Space Communications	Fast Tip/Tilt Mirrors for Optical Beam Switching	S-334 Miniature Piezo Tip/Tilt-Mirror, p. 2-90 S-330 Piezo Tip/Tilt-Platform, p. 2-88
Fabry-Perot Filters Laser Tuning	Optics Nanopositioning Systems Special Piezoceramics Miniature PZT Actuators	PL022 PICMA® Bender Actuators, p. 1-92 S-316 Piezo Z / Tip / Tilt Scanner, p. 2-94 See also www.piceramic.com
Writing Fiber Bragg Gratings	Piezo Nanoscanning Stages Piezo Actuators	P-753 LISA Linear Actuator & Stage, p. 2-16 P-752 High Precision Nanopositioning Stage, p. 2-18 P-885 PICMA® Multilayer Piezo Stack Actuators, p. 1-82

*Other standard or custom solutions from PI could be even more suitable for your application. Talk to a PI Applications Engineer or visit www.pi.ws.

Applications

Precision Machining (Metal, Optics, Laser Cutting, Diamond Turning)



PI introduced the first line of piezoelectric actuators more than 35 years ago. The technology's unique features such as: responsiveness; stiffness; life time and infinite resolution, have opened many markets since then, from semiconductor testing to precision machining. Typical piezoelectric fast tool servos for precision machining are equipped with special waterproof casings

which also provide the mechanical interface to the tooling machine and the tool servo.

Integrated metrology systems feature resolution in the nanometer and sub-nanometer range for closed-loop operation with digital or analog motion controllers. Flexure guiding mechanisms and motion amplifiers provide long

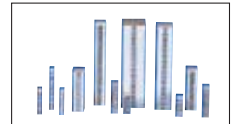
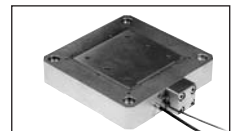
traveling ranges and protect the piezo ceramics from off-axis forces.

PI piezo actuator systems are used throughout the world, often in applications that run 24 hours a day, seven days a week. They improve the manufacturing precision of optics, crank shafts, bearings, cylinders, pistons, etc. in crucial processes such as diamond

turning, milling, grinding, out-of-round boring or wear-compensation of tools.

Custom-manufactured high-performance piezoceramic actuators provide lifetimes of billions of cycles. Power amplifiers with energy recovery and 2000 W peak power are available for high-dynamics applications.

Application	PI Solution	Typical PI Products*
Non-Circular Turning Boring Grinding Polishing of Optics, Bearings, Pistons, Shafts...	Heavy-Duty Piezo Actuators and Amplifiers, Custom Piezoelectric Fast Tool Servos Precision Piezo Stages for Grinding Piezo Actuators for Fast Tool Tip Control	P-225 Preloaded High Force Piezo Actuators, p. 1-78 Fast Piezo Driven Tool Servos, ask PI info@pi.ws
Aspheric Optics Manufacturing (Contact Lenses) Diamond Turning	Piezo Actuators and Amplifiers Piezo Stage Nano-Positioners Custom Piezo Stages	P-212, P-216 PICA™ Power Piezo Stack Actuators, p. 1-78 P-750 Piezo Nanopositioning System, p. 2-24 P-625 PIHera® Piezo Linear Stage, p. 2-22 M-238 High-Load Linear Actuator, p. 1-52
Focus/Beam Control for Laser Welding/Cutting	Piezo Actuators Piezo Steering Mirrors / Optics Custom High-Speed Actuators	S-334 Miniature Piezo Tip/Tilt-Mirror, p. 2-90 S-330 Piezo Tip/Tilt-Platform, p. 2-88 P-842 · P-845 Preloaded Piezo Actuators, p. 1-76 P-885 PICMA® Multilayer Piezo Stack Actuators, p. 1-82
Active Vibration Control	Heavy-Duty Piezo Actuators and ControllerFs Custom Stages	P-885 PICMA® Multilayer Piezo Stack Actuators, p. 1-82 P-056 PICA™ Stack Actuator, p. 1-88 P-212 Preloaded PICA™ Power Piezo Actuators, p. 1-78 P-876 DuraAct™ Piezo Patch Transducers, p. 1-96



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Applications

Data Storage Technology



Piezo positioning systems are fundamental tools for test & metrology systems in ultra-high-density data storage applications, nanoimprint, na-

noassembly, and nanofabrication. Their extreme precision and speed makes them vital components in the quest to follow Moore's law.

PI has taken nanopositioning to the next level by combining advanced mechanical designs and high-throughput control technology to provide nano-

meter precision in milliseconds. This is called NanoAutomation®.



Application	PI Solution	Typical PI Products*
Read/Write Head Testing	High-Level Dynamics Nanopositioning Stages Ultra-Fast Nanoautomation® Controller	P-752 High-Precision Nanopositioning Stage, p. 2-18 P-772 Miniature Nanopositioning System, p. 2-24 P-628 PIHera® Piezo Linear Stage, p. 2-74
High-Speed Tracking Track Following Servos	Digital Controllers with Optional InputShaping® Technology	E-712 Modular Digital Piezo Controller, p. 2-14 E-753 Digital Piezo Controller, p. 2-16
Nanomagnetic Testing Thermal Annealing	Multi-Axis Nanopositioning Systems	P-733.2DD XY(Z) Piezo-Nanopositioning Stage, p. 2-62 P-563 PIMars™ XYZ Piezo System, p. 2-72 P-587 6-Axis Precision Piezo Stage, p. 2-76
Laser Beam Focusing / Alignment Beam Stabilization (DVD Mastering)	PIFOC® Nanofocusing Systems PIHera Nanopositioning Stages Active optics Fast Voice-Coil Drives	P-725 PIFOC® Long-Travel Objective Scanner, p. 2-28 P-628 PIHera® Piezo Linear Stage, p. 2-74 S-334 Long Range Steering Mirror p. 2-90 V-106 QuickScan™ High-Dynamics Scanner, p. 4-48

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Applications

Aeronautics, Image Processing, Cryogenic & Vacuum Environments



PI piezo actuators and piezo motors provide very high forces and require little to no power in quasistatic applications. They can also work in a vacuum and at very low temperatures—condi-

tions found in space applications.

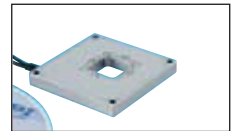
PI hexapods have been used in microwave antenna alignment applications to significantly reduce the alignment time

while improving the antenna performance.

During the last 15 years PI has designed several large-aperture high-speed tip/tilt systems for image stabilization.

Piezoelectrically-driven active mirrors can improve the effective resolution up to 1000% by correcting for these image shifts in real time, especially during long integrations with weak light sources.

Application	PI Solution	Typical PI Products*
Microwave Antenna Precision Alignment	Hexapod 6D Micropositioning Systems	M-824 Compact 6-Axis-Positioning System, p. 4-10 M-850 Hexapod 6-Axis Positioning System, p. 4-6 N-515 Non Magnetic Piezo Hexapod, p. 1-17
Fast Laser Beam Steering/Alignment	Piezo Steering Mirrors	S-334 Miniature Piezo Tip/Tilt-Mirror, p. 2-90 Custom High-Bandwidth Piezo Steering platforms for large mirrors, p. 2-88
Resolution Enhancement Image Stabilization Pixel Multiplication	Piezo Scanning Stages Active Optics	P-713 · P-714 XY Piezo Scanner, p. 2-56 P-733.2 · P-733.3 XY(Z) Piezo-Nanopositioning Stage, p. 2-62 S-325 Piezo Z / Tip/Tilt Platform, p. 2-92 S-334 Miniature Piezo Tip/Tilt-Mirror, p. 2-90
Precision Linear Actuators	DC-Mike & Stepper-Mike NEXLINE® Piezo Linear Motors	N-111, NEXLINE® Miniature Linear Motor / Actuator, p. 1-8 M-238 High Load Servo Motor Actuator, p. 1-52
Beamline Experiments Angular Alignment Sample Positioning	Nonmagnetic NEXLINE® Piezo Linear Motors Hexapod 6D Micropositioning Systems	M-824 Compact 6-Axis-Positioning System, p. 4-10 N-214 NEXLINE® Linear Motor / Actuator, p.1-10 N-515 Non Magnetic Piezo Hexapod, p. 1-17
Cavity Tuning	High Force Piezo Ceramic Actuators	P-235 Preloaded High Force Piezo Stack Actuators, p. 1-78 P-056 PICA™ Stack Actuator Stacks p. 1-88



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Applications

Astronomy, Adaptive Optics



Resolution in large earthbound telescopes is limited by vibrations and atmospheric turbulence. To overcome these limitations, PI has designed and delivered many large-aperture high-speed tip/tilt systems for

active secondary and tertiary mirror stabilization. Piezo-electrically-driven active mirrors can improve the effective resolution up to 1000% by correcting for these image shifts in real time, especially

during long integrations with weak light sources.

PI's hexapod 6-axis micropositioning systems are key components for the precise alignment of active mirrors.

PI precision linear actuators provide superior performance and lifetime and have been successfully employed in large segmented mirror telescopes such as SALT.



Application	PI Solution	Typical PI Products*
High Speed Beam Steering and Stabilization	Piezo Tip/Tilt mirrors	Custom High-Bandwidth Piezo Steering Platforms for Large Mirrors, ask PI (info@pi.ws) S-330, Piezo Steering Mirror, p. 2-88
Low Bandwidth Alignment of Active Mirrors in Astronomical Telescopes	Large Custom Piezo Steering Mirrors for Fast Correction of Turbulence Hexapod 6D Micropositioning Systems	M-850K Weatherproof Hexapod, p. 4-14 M-850 Hexapod 6-Axis Positionie, p. 4-6 M-850K Ultra-High-Load Hexapod p. 4-15
Segmented Mirror Positioning with Linear Actuators	NEXLINE® High-Force, Long Travel Piezo Linear Motor Actuators DC-Mike & Stepper-Mike	N-214, Ultra-High Load Linear Actuator, p. 1-10 N-111, High Load Linear Actuator, p. 1-8 M-235 Heavy Duty Linear Actuator, p. 1-50 M-238 High Load Linear Actuator, p. 1-52
Laser Cavity Tuning/Stabilization	Piezo Actuators, Phase Shifters	S-310 - S-316 Piezo Z / Tip / Tilt Scanner, p. 2-94 S-303 Piezo Phase Shifter, p. 2-96

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Products / Page References to the 2009 Hardbound PI Catalog



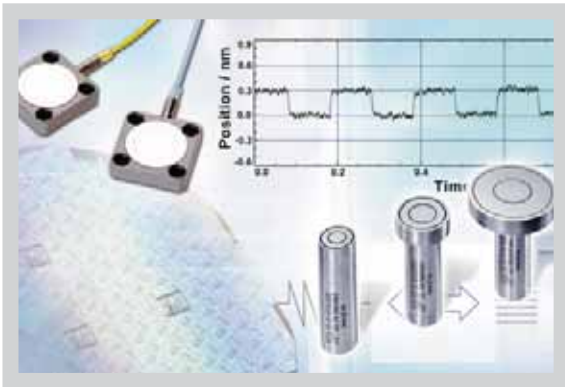
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