

## PIFOC® Piezo Nano-Focus Devices **Faster, Smaller, More Travel, now with QuickLock**



P-721, 100  $\mu\text{m}$  Nano-Focus device, exploded view of QuickLock adapter and microscope objective (not included).



P-725, 250  $\mu\text{m}$  Nano-Focus device. Microscope objective (not included).

In addition to the recently introduced P-721.CLO PIFOC® featuring QuickLock, PI now offers the new P-725 series. P-725s are long travel range additions to the PIFOC® family of microscope objective nano-focussing devices. Despite the increased travel ranges (up to 400  $\mu\text{m}$ ) the units are 20% shorter than the P-721 series.

P-725 PIFOCs® are equipped with capacitive direct-motion metrology for highest resolution, accuracy and repeatability. The stiff design allows fast step-and-settle, for example a 250  $\mu\text{m}$  step is completed in only 25 milliseconds.

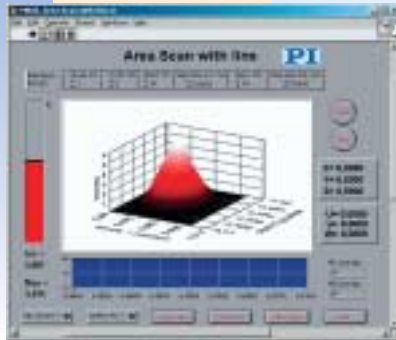
- Scans and Positions Objectives with Sub-nm Resolution
- High Linearity and Stability with Direct-Measuring Capacitive Sensors
- Most-Compact Unit with Direct Metrology
- Enhanced Guiding Precision for Better Focus Stability
- Fast Response & Settling Time
- Compatible with Metamorph™ Imaging Software
- QuickLock Adapter for Easy Attachment

## M-840 Hexapod **6 DOF Motion, now with Automatic Optical Alignment**



M-840 HexaLight Hexapod System

Area scan of an optical device with M-840 Hexapod.



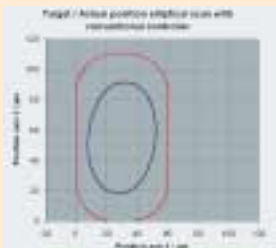
The M-840 HexaLight Hexapod robot provides six degrees of freedom with high resolution and allows the user to define the center of rotation (pivot point) by software.

A recent upgrade to the controller now allows **automated alignment of photonic components** based on an integrated optical power meter and smart search and align algorithms.

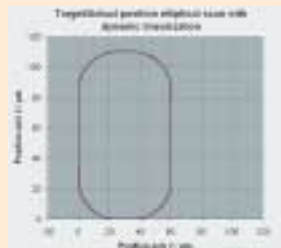
- Six Degrees of Freedom
- Available Built-in Photometer and Optical Alignment Functions
- 6 + 2 Axis Controller
- Fast Step & Settle, Smaller & Stiffer than Stacked Stages
- No Moving Cables for Improved Reliability
- Repeatability to 2  $\mu\text{m}$  (Six-Axis Moves)
- PivotAnywhere™ Virtualized Center of Rotation

## Dynamic Digital Linearization: **Laser Micro Drilling**

### now Faster and More Accurate



Elliptical scan in a laser micro-drilling application with XY piezo scanning stage, conventional controller, 60 msec/rev. The outer curve ellipse describes the target position, the inner ellipse shows the actual motion at the stage.



Same scan as before, with dynamic digital linearization. Target and actual data can hardly be discerned.

The new E-710.SCN Dynamic Digital Linearization option for E-710 digital piezo controllers improves tracking accuracy in one- and two-dimensional scans, such as laser microdrilling (see graphs).

This PI-exclusive technology is a **breakthrough for scanning applications**, reducing phase lag and nonlinearity, common in conventional PID servo-controllers, to indiscernible levels—even with high-frequency dynamic actuation under load. The effect is an improvement in linearity (and usable bandwidth) of up to three orders of magnitude, resulting in significantly increased precision and throughput.

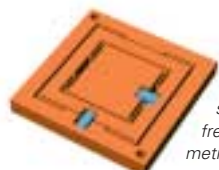


E-710.6CD 6-axis digital piezo controller shown with custom Super Invar 6-DOF piezo flexure NanoPositioning stage.

## Parallel Kinematics/Parallel Metrology **Why?**



Stacked serial-kinematics two-axis nanopositioning stages have significantly higher inertia, higher center of gravity and cannot correct for off-axis errors. Moving cables of the top platform induce friction and cause hysteresis.

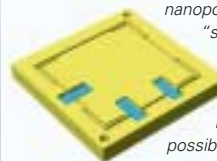


Basic design of a nested serial kinematics nanopositioning stage. Better dynamic performance than stacking, but non-symmetric resonant frequencies and integrated parallel-metrology not feasible.

Nanopositioning equipment users often ask this question. What are the benefits? In a parallel-kinematics multi-axis arrangement, all actuators operate on a central moving platform in parallel. This is the only way to obtain identical resonant frequencies and dynamic behavior in both X and Y. In addition, parallel kinematics allows integrated parallel metrology.

**Parallel metrology can "see" all controlled degrees of freedom simultaneously and compensate** for the slightest off-axis motion in real time. The benefits are reduction of runout and off-axis errors, straighter motion and improved repeatability.

Basic design of a monolithic 3 DOF (X,Y, Theta-Z) parallel-kinematics piezo nanopositioning stage. Integrated parallel metrology can "see" all controlled DOF's simultaneously. Non-contact capacitive position sensors (not shown) directly measure the central moving platform compensating for the slightest off-axis motion in real time (active trajectory control). This is not possible with serial kinematics designs.



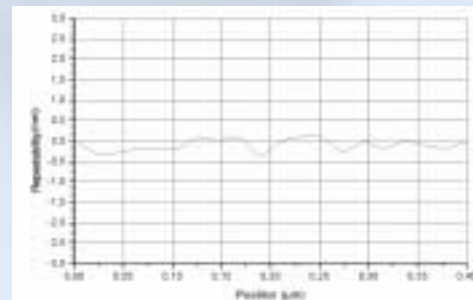
## P-363 PicoCube™ Ultra-Precise & Compact Closed-Loop

### Piezo Scanner for AFM, SPM



The P-363 PicoCube™ XYZ piezo scanning stage is an ultra-high-performance, closed-loop piezoelectric scanning system. Designed for **AFM, SPM and nanomanipulation** applications, it combines an ultra-low-inertia, high-speed XYZ piezo scanner with non-contact, direct-measuring, parallel-metrology capacitive feedback capable of 50 picometers resolution.

- Ultra-High-Performance Closed-Loop Scanner for AFM/ SPM
- Superior Manipulation Tool for Nanotechnology
- Resonant Frequency 10 kHz
- Parallel Metrology/Capacitive Feedback: Highest Linearity & Stability
- Small & Rugged



PicoCube™ Repeatability.

## PICMA™ Piezo Technology **New Additions to PICMA™ Monolithic PZT Actuator Family**



PICMA™ high performance piezo actuators, are currently available in the following cross sections: 2 x 3, 3 x 3, 5 x 5 and 10 x 10 mm<sup>2</sup>.

A few months ago PI introduced the new P-885 PICMA™ Monolithic Multilayer Actuators. Recently a version with higher force capacity (P-888, 10 x 10 mm cross-section) and two more-compact versions (P-882 and P-883, 2 x 3 and 3 x 3 mm cross section) were added for increased versatility.

PICMA™ actuators are ceramic insulated and do not require the humidity-sensitive polymer coating of conventional piezo actuators. They provide high performance and reliability, even in extremely harsh environments.

- Superior Lifetime Even Under Extreme Conditions
- Very Large Operating Temperature Range: up to 150 °C
- High Humidity Resistance
- Excellent Temperature Stability
- UHV Compatible to 10<sup>-9</sup> hPa
- Sub-Nanometer Resolution
- Ideal for Closed-Loop Operation

## SALT Telescope 273 Precision Actuators for the Largest Telescope in the Southern Hemisphere



SALT actuators are based on the heavy duty M-235 ball screw DC motor drives.

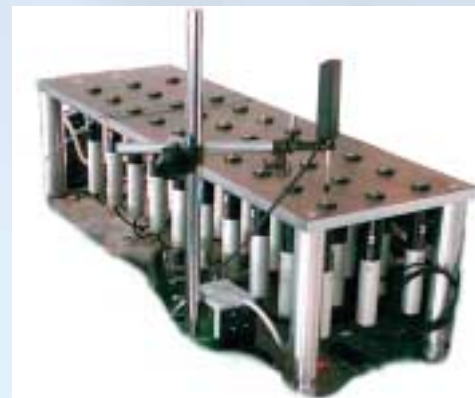


Reliable control of all 273 axes is based on 9 custom PI C-880 multi-axis automation controllers with custom interfacing, firmware and software.

PI is currently delivering custom, high-resolution actuators and controllers for SALT (Southern African Large Telescope). According to officials, SALT is the largest single telescope in the southern hemisphere with a hexagonal mirror array 11 meters across. It "will be able to record distant stars, galaxies and quasars a billion times too faint to be seen with the unaided eye—as faint as a candle flame at the distance of the moon".

The decision to use the PI actuators and controllers was made for the following reasons:

- Superior actuator performance and compliance with strict accuracy requirements even under adverse environmental conditions, as found in comparative testing performed by SALT engineers.
- Reasonable price
- Low risk, because of PI's proven track record.
- PI's ability to meet the tight delivery schedule.



Testbench for one actuator cluster. A total of 9 clusters will control the largest telescope in the southern hemisphere. These custom actuators and controllers are based on PI's 30+ years of nano-motion-control experience.

### Coming Soon (Watch the News on the PI Website):

- **NanoCube 350 C: XYZ NanoAlignment System**
- **P-733.DD with Direct Drive: Faster XYZ Scanning Stages for Microscopy**
- **M-116 Micro-Rotation Stage**
- **M-122 Micro-Translation Stage**

**and more!**

**Micro & NanoAutomation Solutions for Emerging Technologies:**  
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## Smallest Linear Piezo Motor Stages

### Up to 600 mm/s with Ultrasonic Drive

PIline™ M-661, M-662 and M-663 are the smallest piezo-motor-driven translation stages currently available on the market. The lightweight, low-profile ultrasonic piezo drive combines extremely high acceleration (up to 20 g) and velocity up to 600 mm/s with excellent position resolution and high holding forces.

#### Closed-Loop Available

These high-speed translation stages are now also available with integrated optical linear encoders (direct-motion metrology) for closed-loop operation. M-663 closed-loop stages provide high-speed and high-precision positioning at the same time; there are no gears, leadscrews or other mechanical components to contribute play or backlash.

- Smallest Linear-Motor-Driven Translation Stage on the Market
- Velocity to 600 mm/s, Acceleration to 20 g
- Resolution to 0.1  $\mu\text{m}$
- Direct-Motion Metrology Linear Encoders Available
- AutoLock Feature Eliminates Servo Dither
- XY Combinations Available
- > 20,000 h MTBF



M-661, M-662 (open loop) and M-663 closed-loop linear motor stages are the smallest piezo motor driven units available.

## PIHera™ Piezo NanoPositioners

Low-Cost Nano-

### Translation Stage Family Keeps Growing

PIHera™ PZT stages are very cost-effective nanopositioning systems which long combine long travel ranges with high precision motion in a very compact package.

These unique piezo stages were recently launched with 100, 250 and 500  $\mu\text{m}$  travel ranges. Now, a new **extra-small** 50  $\mu\text{m}$  version is available and two additional series of **XY and Z** positioners, combinable to **XYZ configurations**, are being introduced.

- Travel Ranges: 50 to 500  $\mu\text{m}$
- X, XY, Z and XYZ Versions
- Low Cost
- Capacitive Feedback: Resolution < 1 nm
- New Piezo Drive with Extended Lifetime
- 0.01% Position Accuracy
- Vacuum-Compatible Versions



PIHera™ Piezo-NanoPositioning stage family. P-621.1CL, X-stage, P-621.2CL, XY-stage, P-621.ZCL, Z-Stage, and XYZ combination (left to right). PIHera™ stages are available in 50, 100, 250 and 500  $\mu\text{m}$  travel, closed-loop and open-loop versions.