

Precision Hexapods / Parallel Kinematics Featuring Sub-Micrometer Precision



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Hexapod Micropositioning Systems



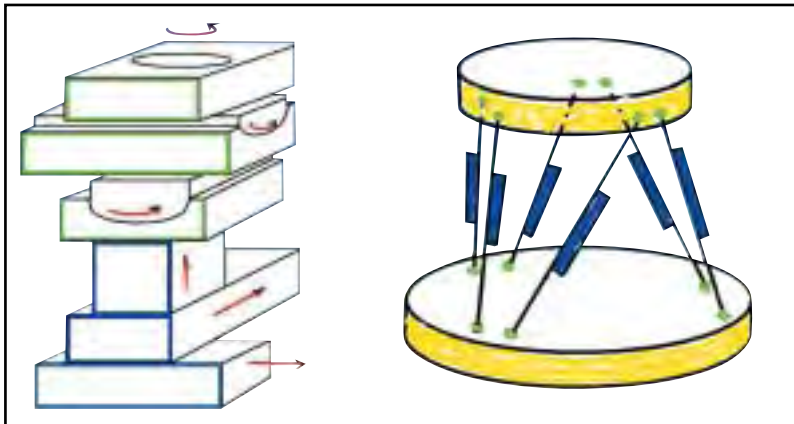
CAD design of a Hexapod 6D micropositioning robot.



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PI is the leading manufacturer of Hexapod micro- and nanopositioning systems. In addition to these parallel kinematics devices, PI offers a wide selection of innovative precision positioning systems

for science and industry. PI's products range from piezoceramic linear motors to actuators to translation and multi-axis stages and include systems with integrated controllers.



Stacked serial kinematics 6D system vs. Hexapod parallel kinematics system designs. Advantages such as compactness and minimized inertia (one platform for all six actuators) are easily seen. The reduced inertial mass makes for significantly faster response than with serial kinematics. Because there are no moving cables to cause friction, repeatability is increased also.



Variety of Hexapod parallel kinematics micropositioning systems.



Large custom Hexapod with a positioning frame measuring some 1.0 x 1.5 meters.

Hexapod Systems, Experience

PI offers a wide selection of innovative precision positioning systems for science and industry.

The following page shows but a few examples of hexapods which PI has developed in recent years.

These systems were designed for special customer applications and are not available off the shelf; many other custom systems are subject to non-disclosure agreements and cannot be shown at all.

Standard hexapods can be found on the following pages.



Custom "6+3" Hexapod with additional struts providing independent position feedback. Translation stage for extended Z-travel.



Custom, high-precision, non-magnetic Hexapod with the award-winning piezo-based NEXLINE® nano drives.



Custom Hexapod for alignment of secondary mirrors in astronomical telescopes.



Custom Hexapod for automatic satellite antenna alignment.



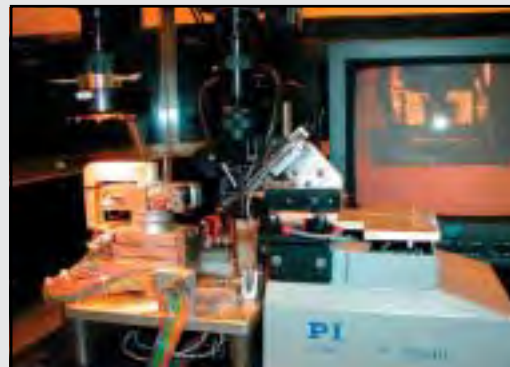
Custom Hexapod with active tip/tilt mirror for the UKIRT infrared telescope on Mauna Kea, Hawaii



Custom Hexapod for brain surgery. Photo courtesy of IPA.



Custom high-load, moisture-protected Hexapod



F-206 Hexapod alignment system at a workstation for automated pigtailed fiber optic devices. Printed with permission from Aries Innovations.

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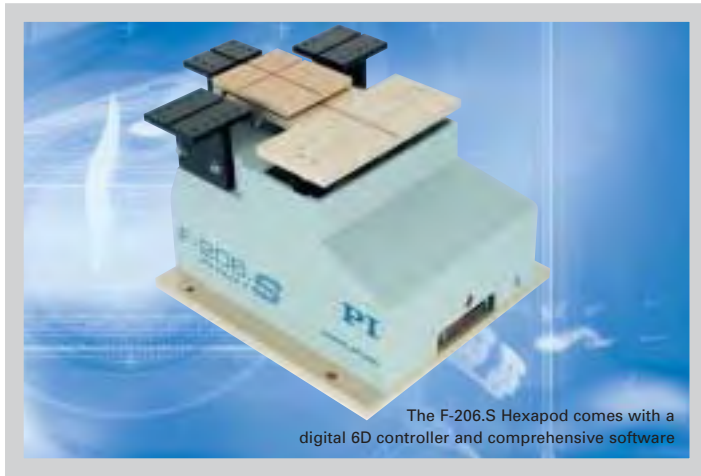
Your Custom System*

* Talk to your local PI office



F-206.S

HexAlign™ 6-Axis Precision Alignment System / Manipulator (Hexapod)



The F-206.S Hexapod comes with a digital 6D controller and comprehensive software

- **Parallel Kinematics with 6 Degrees of Freedom**
- **0.033 μm Actuator Resolution**
- **Repeatability 0.3 μm in Space**
- **No Moving Cables for Improved Reliability, Reduced Friction**
- **Better Dynamics, More Compact than Serial Kinematics Systems**
- **For Scanning and Alignment**
- **Cartesian Coordinate Control with Virtualized Pivot Point**
- **Powerful Digital Controller with Open Source LabView™ Drivers, DLL Libraries...**
- **Integrated Fiber Alignment Routines**

The F-206.S HexAlign™ Hexapod is a highly accurate micro-positioning system for complex multi-axis alignment tasks. It is based on PI's long experience with ultra-high-resolution, parallel kinematics sta-

ges. Unlike hexapods with variable-length struts ("legs") the F-206 features constant-length struts and friction-free flexure guides. This gives the F-206 even higher precision than other hexapod designs.

Application Examples

- Micromachining
- Photonics packaging
- Fiber alignment
- Semiconductor handling / test systems
- Micromanipulation (life science)
- Optical device testing
- Collimator and fiber bundle alignment
- MEMS positioning/alignment

Compact, Plug & Play

The F-206.S Hexapod is considerably smaller and more accurate than comparable serial kinematics six-axis systems (stacks of single-axis units).

The parallel kinematics of the F-206 is immune to the cumulative bending and guiding errors of the various axes which, together with the inertia and friction of the moving cables, can limit accuracy in stacked systems. In addition, rotations are not set in hardware, but about a pivot point freely defin-

able in software. A high-performance controller does all necessary coordinate transformation for coordinating the six drives. Because all the actuators are attached directly to the same moving platform, there are none of the servo-tuning problems associated with the loading and inertia differences of the different axes, as are inherent in stacked systems.

Virtualized Pivot Point

It is important to have a fixed pivot point for alignment tasks, especially in photonics packaging. Because the parallel kinematics motion of the F-206 is calculated with complex algorithms in the digital controller, it was easy to allow programming any point in space as center of rotation. Furthermore, the cartesian coordinates of any position and any orientation can be entered directly and the specified target will be reached after travel along a smooth path.

Six Degrees of Freedom, No Moving Cables

In the F-206 Parallel kinematics design, all cable terminations are on the stationary base, eliminating unpredictable friction and inertia, increasing resolution and repeatability. Further advantages of the system are:

- No cable guides required
- Reduced Size and Inertia
- Improved Dynamic and Settling Behavior
- Identical Modular Actuators for Simplified Servicing

Open Command Set, Simplified Programming

Integration of the F-206 in complex applications is facilitated by the system's open command set and comprehensive

Ordering Information

F-206.S0
Hexapod 6-Axis Precision Alignment System / Manipulator with 6 DOF Hexapod Controller

F-206.SD
Hexapod 6-Axis Precision Alignment System / Manipulator with 6 DOF Hexapod Controller, Built-in Display and Keypad

Options and Accessories

F-206.AC8
Upgrade for 2 Additional Servo-Motor Control Channels on F-206 Controller

F-206.i3E
GPIB/IEEE 488 Interface for F-206 Controller

F-206.MHU
Force-Limiting Mounting Platform, (included with F-206.SD)

F-206.MFU
Mounting Platform with Force Sensors

F-206.NCU
Upgrades: Rapid Nanopositioning Upgrade for F-206.S. Consists of P-611.3SF NanoCube® and E-760 Controller Card

F-206.MC6
6D Interactive Manual Control Pad

F-206.00U
2-Channel Photometer Card, (Visual Range)

F-206.iRU
2-Channel Photometer Card (IR Range)

F-361.10
Absolute-Measuring Optical Power Meter, 1000-1600 nm Wavelength (see p. 8-14)

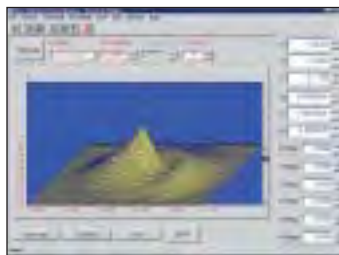
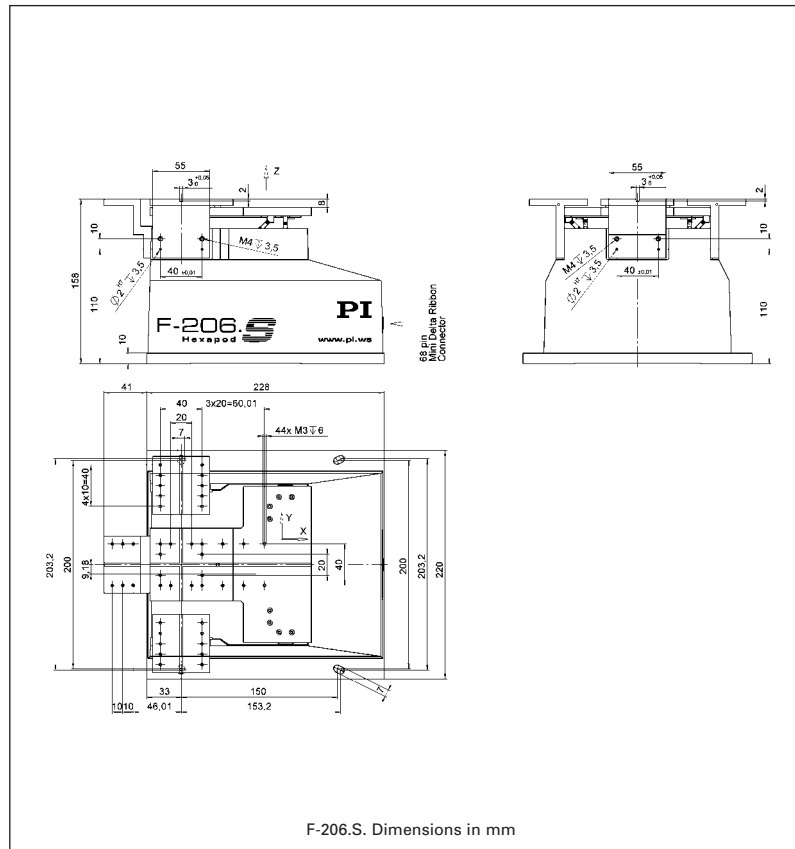
Additional Accessories, see page 8-12 ff.

tool libraries. The controller can be operated either through a host PC, or directly through a keyboard and monitor. It can also run programs stored in a user-friendly, fully documented macro language.

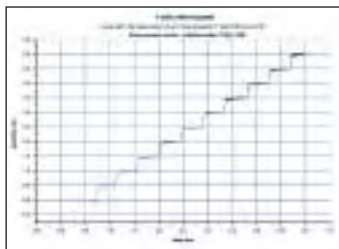
Automatic Optical Alignment

Optional internal and external photometers are available. Both types are fully integrated

with the controller hardware and with routines designed for automatic alignment of collimators, optical fibers and arrays. For more information on the photometers see F-206.IRU and F-206.00U, p. 8-12 and F-361, p. 8-14.



HexControl™ Software displaying scan of photonics component.



Interferometer test of an F-206.S system shows the excellent repeatability of small steps, here 0.5 μm spaced at 100 ms.

Technical Data

Models	F-206.S0 / F-206.SD
Travel range X*	-8 to +5.7 mm
Travel range Y*	± 5.7 mm
Travel range Z*	± 6.7 mm
Travel range θ_x *	$\pm 5.7^\circ$
Travel range θ_y *	$\pm 6.6^\circ$
Travel range θ_z *	$\pm 5.5^\circ$
Actuator resolution	33 nm
Minimum incremental motion X, Y, Z**	0.1 μm (6-axis move!)
Minimum incremental motion $\theta_x, \theta_y, \theta_z$ **	2 μrad (0.400115°) (6-axis move!)
Bidirectional repeatability X, Y, Z	0.3 μm
Bidirectional repeatability $\theta_x, \theta_y, \theta_z$	3.6 μrad
Speed X, Y, Z	0.01 to 10 mm/s
Maximum load in Z	2 kg (centered on platform)
Weight	5.8 kg
Controller	Digital Hexapod controller with optional photometer card and integrated scan and align routines
Operating voltage	100-240 VAC, 50/60 Hz
Software	LabView™ drivers, software for alignment of arrays, DLL libraries, HexControl™, scan and align software, terminal software

* Travel ranges in the coordinate directions (X, Y, Z $\theta_x, \theta_y, \theta_z$) are interdependent. The data given shows maximum travel range of the axis in question (i.e. its travel when all other axes are at their zero positions). If this is not the case, the available travel may be less.

** Six-axis move. No moving cables (unlike serial-kinematic stacked systems) to introduce bending forces, torque and friction which degrade positioning accuracy.

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M-850

Hexapod 6-Axis-Parallel Kinematics Microrobot



M-850 Hexapod Microrobot.

- Six Degrees of Freedom
- Works in Any Orientation
- No Moving Cables for Improved Reliability and Precision
- 200 kg Load Capacity (Vertical)
- Heavy-Duty, Ultra-High-Resolution Bearings for 24/7 Applications
- Repeatability to $\pm 1 \mu\text{m}$
- Actuator Resolution to $0.005 \mu\text{m}$
- Significantly Smaller and Stiffer Package than Conventional Multi-Axis Positioners
- Vacuum-Compatible Versions
- Linear and Rotary Multi-Axis Scans
- Virtualized Center of Rotation (Pivot Point)
- Sophisticated Controller Using Vector Algorithms
- 20,000 h MTBF

The M-850, M-824 and M-840 (see. p. 7-22 ff.) Hexapod systems are the results of PI's many years of experience with high-resolution parallel kinematics (PKM).

The M-850 is the ideal micro-positioning system for all complex positioning tasks which depend upon high load capacity and accuracy in six independent axes. In addition to positioning all axes with resolutions in the submicron and arcsecond ranges, it allows the user to define the center of rotation (pivot point) anywhere inside or outside the system

envelope by one simple software command.

Two models are available: The M-850.50 featuring higher speed and direct-drive actuators, and the M-850.11 with a gear ratio that makes it self-locking even with large loads.

Hexapod Working Principle and Advantages

The M-850 Hexapod is driven by six high-resolution actuators (for the M-850.11, $0.005 \mu\text{m}$ resolution) all connected directly to the same moving platform. The principle is similar to that seen in flight simula-

tors, but considerably more precise. In place of the hydraulic actuators used there, the M-850 uses custom high-load precision screws and servo-motors. It can withstand loads of 200 kg vertically, and at least 50 kg in any direction.

Laser metrology techniques and finite element method (FEM) simulations were used to design and optimize the system.

The low mass of the moving platform and the use of extremely stiff and accurate components results in an unusually high natural frequency of 500 Hz with a 10 kg load. This means that positioning operations can be performed with far lower settling times than with conventional, serial-kinematics multi-axis systems. In such systems, runout, guiding errors, friction and the inertia of moving cables all accumulate to limit accuracy and repeatability—problems which do not affect parallel kinematic systems like the Hexapod. Furthermore, the pivot point is freely definable, independent of the positions of the linear axes.

Virtualized Pivot Point

For optics and other alignment tasks, it is important to be able to define a fixed pivot point. The sophisticated Hexapod controller allows choosing any point in space as the pivot point for the rotation axes. Target positions in 6-space are entered in user-friendly coordinates and reached by smooth vectorized motion.

Open Architecture

Control of the M-850 is facilitated by the controller's open interface architecture, which provides a variety of high-level

Ordering Information

M-850.11
Hexapod 6-Axis Parallel Kinematics Microrobot with Controller, 0.5 mm/s

M-850.50
Hexapod 6-Axis Parallel Kinematics Microrobot with Controller, 8 mm/s

M-850.V50
Vacuum Version of the M-850.50

Optional Photometers

F-206.00U
Photometer Card (visible range)

F-206.iRU
Photometer Card (IR range)

F-361.10
NIST Traceable Optical Power Meter, 1000 to 1600 nm

Ask about custom designs!

Application Examples

- Alignment and tracking of optics, electron beams, lasers, etc.
- Satellite testing equipment
- Surgical robots
- Micromachining
- Micromanipulation (life sciences)
- X-ray diffraction measurements
- Semiconductor handling systems
- Tool control for precision machining & manufacturing
- Fine positioning of active secondary mirror platforms in astronomical telescopes



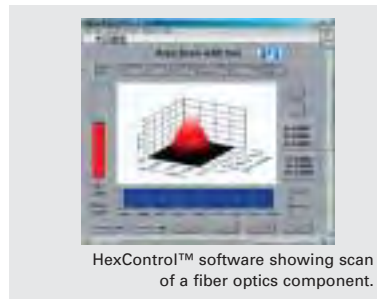
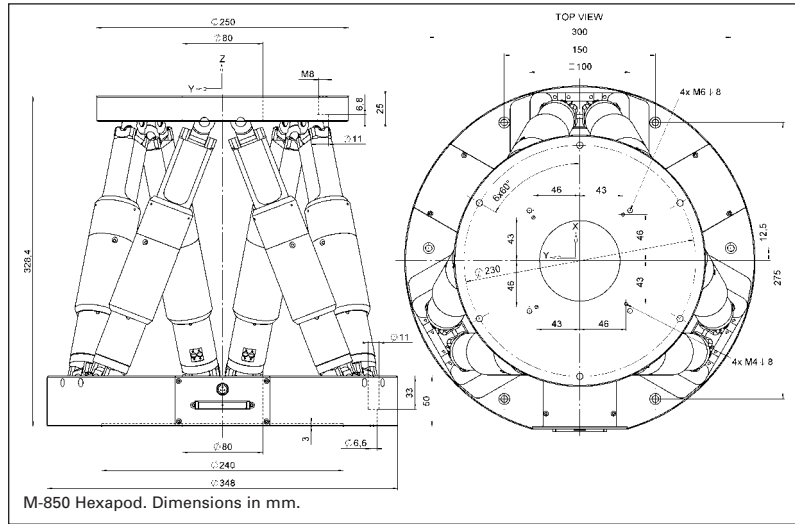
Custom Hexapod designed for neurosurgery Photo: IPA

commands and includes a macro language for programming and storing command sequences.

Automatic Optics Alignment

With the internal or external photometer option and the integrated scanning routines, just a few commands are needed to perform an automated alignment of optical components. For more information on photometers / optical power meters, see the F-206.IRU and F-206.00U, p. 8-12 and the F-361, p. 8-14.

A smaller, even-more-precise hexapod, specially developed for alignment of collimators, fiber bundles and I/O chips, is available as the F-206 (see p. 7-18 and p. 8-8)



Technical Data

Models	M-850.11	M-850.50	Units
* Travel range X, Y	±50	±50	mm
* Travel range Z	±25	±25	mm
* Travel range θ_x, θ_y	±15	±15	°
* Travel range θ_z	±30	±30	°
Actuator stroke	±25	±25	mm
Actuator design resolution	0.005	0.049	µm
** Minimum incremental motion, X, Y, Z	1 (XY), 0.5 (Z)	1 (XY), 0.5 (Z)	µm
** Minimum incremental motion $\theta_x, \theta_y, \theta_z$	5	5	µrad
Repeatability X, Y	±2	±2	µm
Repeatability Z	±1	±1	µm
Repeatability $\theta_x, \theta_y, \theta_z$	±10	±10	µrad
Speed X, Y, Z (typical)	0.3	5	mm/s
Speed X, Y, Z (max.)	0.5	8	mm/s
Speed $\theta_x, \theta_y, \theta_z$ (typical)	3	50	mrad/s
Speed $\theta_x, \theta_y, \theta_z$ (max.)	6	100	mrad/s
Stiffness (k_x, k_y)	3	3	N/µm
Stiffness (k_z)	100	100	N/µm
Weight	17	17	kg
Load capacity (vertical / random)	200 / 50	200 / 50	kg
In Z with power off (holding force)	200	25	kg
Resonant frequency	90	90	Hz
Resonant frequency F_z ***	500	500	Hz



* The maximum travel ranges in the different coordinate directions (X, Y, Z, $\theta_x, \theta_y, \theta_z$) are interdependent. The data for each axis in this table shows its maximum travel, where all other axes are at their zero positions. If the other linear or rotational coordinates are not zero, the available travel may be less.

Example: The following position is in the workspace:
 X: +20 mm θ_x : +10°
 Y: +20 mm θ_y : +10°
 Z: +5 mm θ_z : -2°

** Six-axis move. No moving cables (unlike serial-kinematic stacked systems) to introduce bending forces, torque and friction which degrade positioning accuracy.

*** Mounted vertically with 10 kg load

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M-840

HexaLight™ 6-Axis-Parallel Kinematics Microrobot



M-840 HexaLight™ 6-axis micropositioning system

- Six Degrees of Freedom
- Rapid Response
- No Moving Cables for Improved Reliability and Precision
- 10 kg Load Capacity
- Repeatability to $\pm 2 \mu\text{m}$
- Actuator Resolution to $0.016 \mu\text{m}$
- Significantly Smaller and Stiffer than Serial-Kinematics Systems, Better Dynamics
- Vacuum-Compatible Versions
- Virtualized Pivot Point
- Sophisticated Controller Using Vector Algorithms
- 20,000 h MTBF

The M-840, M-824 and M-850 (see. p. 7-20 ff.) Hexapod systems are the results of PI's many years of experience with high-resolution parallel kinematics (PKM).

The M-840 is the ideal micropositioning system for all com-

plex positioning tasks which depend upon high speed and accuracy in six independent axes. In addition to positioning all axes, it allows the user to define the center of rotation (pivot point) anywhere inside or outside the system envelope by one simple software command.

Two models are available: The M-840.5PD featuring higher speed and direct-drive actuators, and the M-840.5DG with a gear ratio that makes it self-locking.

Hexapod Working Principle and Advantages

The M-840 HexaLight™ is driven by six high-resolution actuators (for the M-840.5DG, $0.016 \mu\text{m}$ resolution) all connected

directly to the same moving platform. The principle is similar to that seen in flight simulators, but considerably more precise. In place of the hydraulic actuators used there, the M-840 uses highly accurate micrometer screws and servomotors.

Laser metrology techniques and finite element method (FEM) simulations were used to design and optimize the system.

Because of the low mass of the moving platform, positioning operations can be performed with far lower settling times than with conventional, stacked multi-axis systems.

In such systems, runout, guiding errors, friction and the inertia of moving cables all accumulate to limit accuracy and repeatability—problems which do not affect parallel kinematic systems like the Hexapod. Furthermore, the pivot point is freely definable, independent of the positions of the linear axes.

Faster Positioning in All Six Axes

In comparison with the M-850 Hexapod (p. 7-20) the M-840 is designed for higher speeds and lighter loads. Loads of up to 10 kg can be positioned at up to 50 mm/s and 600 mrad/s with micron accuracy.

Virtualized Pivot Point

For optics and other alignment tasks, it is important to be able to define a fixed pivot point. The sophisticated Hexapod controller allows choosing any point in space as the pivot point for the rotation axes. Target positions in 6-space are entered in user-friendly coordinates and reached by smooth vectorized motion.

Ordering Information

M-840.5PD
Hexapod 6-Axis Parallel Kinematics Microrobot with Controller, Direct Drive

M-840.5DG
Hexapod 6-Axis Parallel Kinematics Microrobot with Controller, Gearhead Drive

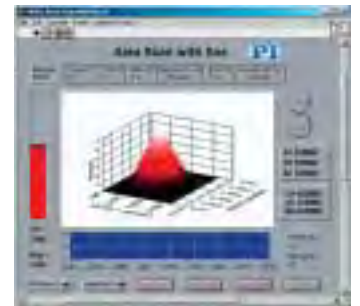
Optional Photometer

F-206.00U
Photometer Card (Visible Range)

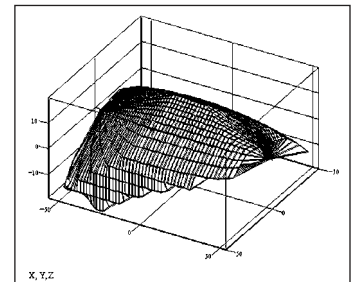
F-206.iRU
Photometer Card (IR Range)

F-361.10
NIST Traceable Optical Power Meter, 1000 to 1600 nm

Ask about custom designs!



HexControl™ software showing scan of a fiber optics component.



x, y, z

The X, Y, Z working space of the M-840 with $\theta_x = \theta_y = \theta_z = 5^\circ$.

Open Architecture

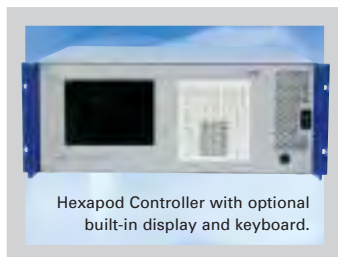
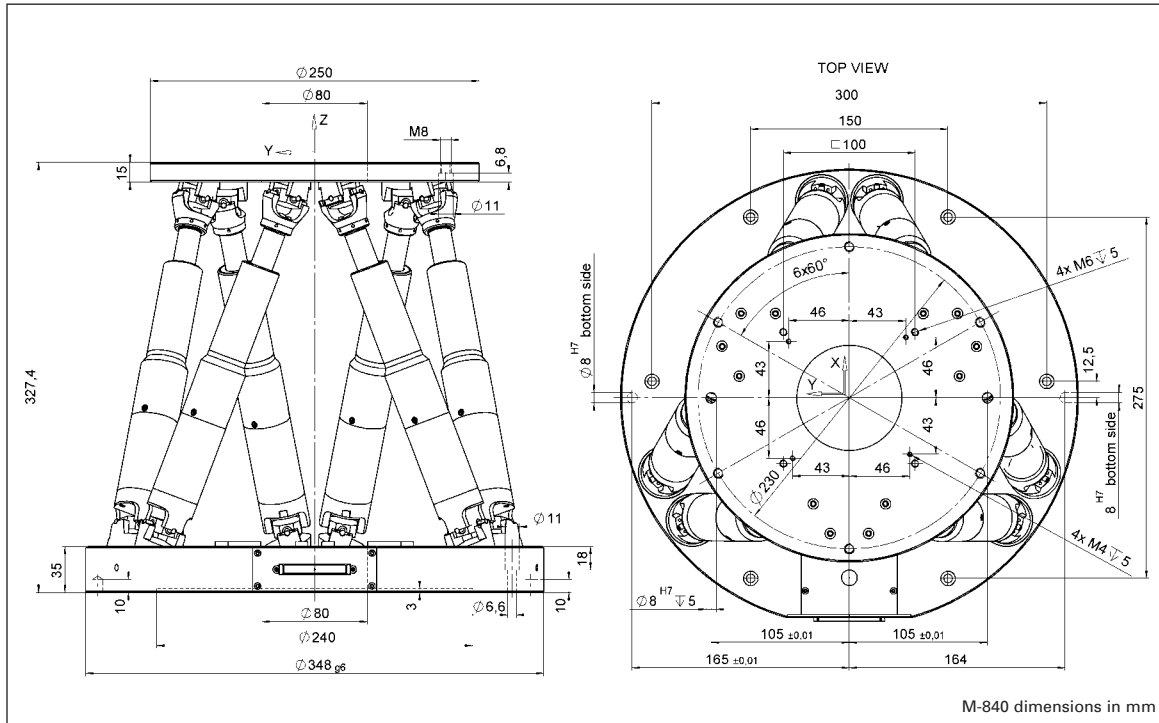
Control of the M-840 is facilitated by the controller's open interface architecture, which provides a variety of high-level commands and includes a macro language for programming and storing command sequences.

Automatic Optics Alignment

With the internal or external photometer option and the integrated scanning routines, just a few commands are needed to perform an automated alignment of optical components. For more information on photometers / optical power

meters, see the F-206.IRU and F-206.00U, p. 8-12 and the F-361, p. 8-14.

A smaller, even-more-precise hexapod, specially developed for alignment of collimators, fiber bundles and I/O chips, is available as the F-206 (see p. 7-18 and p. 8-8).



Technical Data

Models	M-840.5PD	M-840.5DG	Units
* Travel range X, Y	±50	±50	mm
* Travel range Z	±25	±25	mm
* Travel range θ_x, θ_y	±15	±15	°
* Travel range θ_z	±30	±30	°
Actuator stroke	±25	±25	mm
Actuator design resolution	0.5	0.016	µm
** Minimum incremental motion, X, Y	3	1	µm
** Minimum incremental motion, Z	1	0.5	µm
** Minimum incremental motion $\theta_x, \theta_y, \theta_z$	5	5	µrad
Repeatability X, Y	±2	±2	µm
Repeatability Z	±1	±1	µm
Repeatability $\theta_x, \theta_y, \theta_z$	±20	±20	µrad
Typical Speed X, Y, Z	30	2	mm/s
Max. Speed X, Y, Z	50	2.5	mm/s
Typical Speed $\theta_x, \theta_y, \theta_z$	300	20	mrad/s
Max. Speed $\theta_x, \theta_y, \theta_z$	600	30	mrad/s
Load capacity (mounted vertically)	10	10***	kg
Weight	12	12	kg

* The maximum travel ranges in the different coordinate directions (X, Y, Z, $\theta_x, \theta_y, \theta_z$) are interdependent. The data for each axis in this table shows its maximum travel, where all other axes are at their zero positions. If the other linear or rotational coordinates are not zero, the available travel may be less.

** Six-axis move. No moving cables (unlike serial-kinematic stacked systems) to introduce bending forces, torque and friction which degrade positioning accuracy

*** self-locking

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M-824

Compact 6-Axis Parallel Kinematics Microrobot



M-824 Six DOF micropositioning system, vacuum version

- Six Degrees of Freedom
- Vacuum Compatible Versions
- Load Capacity 10 kg
- Travel Ranges to 45 mm (linear), 25° (rotation)
- 7 nm Resolution
- 300 nm Min. Incremental Motion
- Repeatability ±0.5 µm
- Very Compact Design
- Self Locking to 10 kg

The new M-824 is based on PI's experience of more than a decade with parallel kinematics Hexapods like the M-850 / M-840 and F-206 (see catalog). The M-824 is the ideal micropositioning system for all com-

plex positioning tasks which depend upon high accuracy and resolution in six independent axes. In addition to positioning all axes it allows the user to define the center of rotation (pivot point) anywhere inside or outside the system envelope by one simple software command. The vacuum version, the M-824.3VG, enables use in applications such as X-ray diffraction microscopy with ambient pressures down to 10⁻⁶ hPa.

Extremely Compact

The M-824 uses a very compact drive and, with a height of 188 mm, has a considerably lower profile than either the M-850 or M-840 Hexapods. The unit can be mounted in any ori-

entation, and can position loads of up to 10 kg.

Hexapod vs. Serial Kinematics Systems

The M-824 is based on 6 actuators with a high resolution of 0.007 µm, all connected directly to the same moving platform. The principle is similar to that seen in flight simulators, but considerably more precise. In place of the hydraulic actuators used there, the M-824 uses highly accurate micrometer screws and servo-motors.

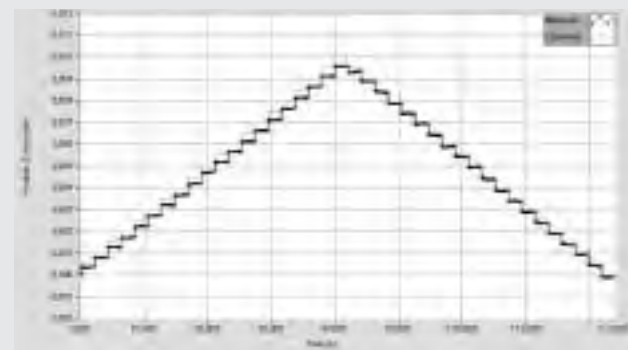
The low mass of the moving platform permits positioning with significantly shorter settling times compared to those obtainable in conventional, stacked, multi-axis systems (serial kinematics).

Ordering Information

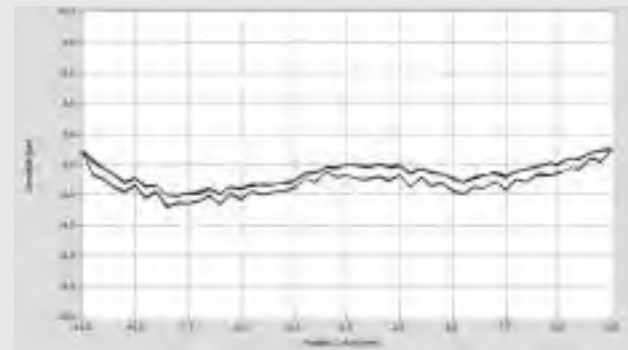
M-824.3DG
Hexapod 6-Axis Parallel Kinematics Robot with Controller.

M-824.3VG
Hexapod 6-Axis Parallel Kinematics Robot with Controller, Vacuum Version down to 10⁻⁶ hPa.

In serial kinematics systems wobble and guiding errors in the bearings of each axis accumulate. Friction and torque caused by moving cables further limit accuracy and repeatability. The parallel kinematics Hexapods are not affected by these ills because all actuators operate directly on the same platform. A further advantage is that the rotation axes do not have their centers of rotation determined by the hardware.



The interferometer test shows the highly repeatable minimum incremental motion of 500 nm.



The interferometer test shows the Z axis accuracy over the entire travel range of 25 mm and the extremely high repeatability of ± 0.046 µm.

Application Examples

- Micromachining
- Micromanipulation
- Life sciences
- X-ray diffraction measurements
- Semiconductor handling systems
- Tool control for precision machining & manufacturing

Plug-and-Play

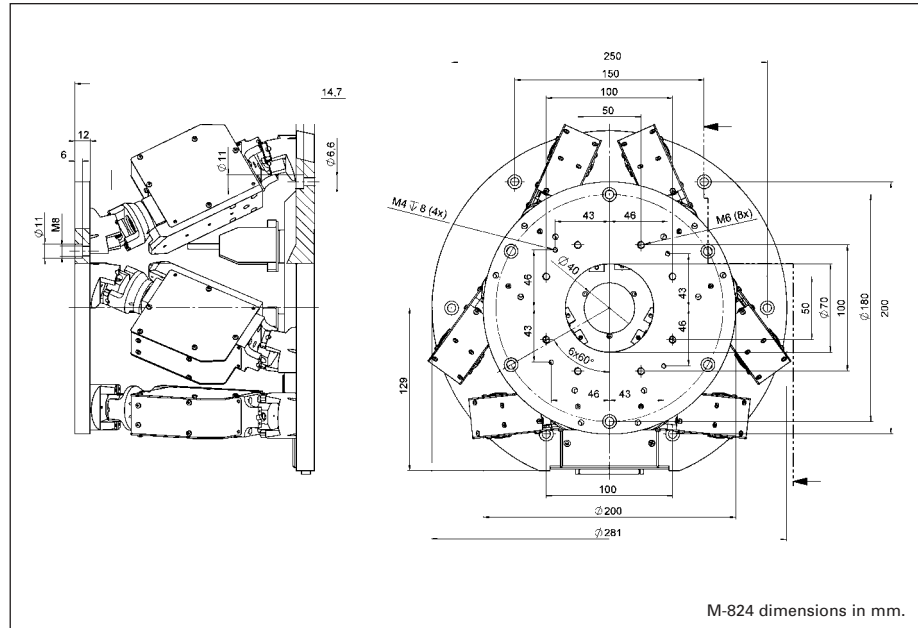
The M-824 is a true plug-and-play system and comes with a powerful 6D controller. Its sophisticated, user-friendly positioning and alignment software can save hundreds of hours of the programming time required to achieve similar functionality with a conventional, stacked, 6-axis system.

Freely Definable Pivot Point

For optics and other alignment tasks, it is important to be able to define a fixed pivot point. The sophisticated Hexapod controller allows choosing any point in space as the pivot point for the rotation axes. Target positions in 6-space are entered in user-friendly coordinates and reached by smooth vectorized motion.

Open Interface Architecture

Control of the M-824 is facilitated by the controller's open interface architecture, which provides a variety of high-level commands and includes a



M-824 dimensions in mm.

macro language for programming and storing command sequences.

Vacuum Version

The M-824.3VG is available in a vacuum-compatible model suitable for operation down to 10^{-6} hPa.

Technical Data

Models	M-824.3DG	Unit
** Travel X, Y	±22.5	mm
** Travel Z	±12.5	mm
** Travel θ_x, θ_y	±7.5	°
** Travel θ_z	±12.5	°
Actuator stroke	±12.5	mm
Actuator design resolution	0.007	µm
* Min. incremental motion X, Y	0.3	µm
* Min. incremental motion Z	0.3	µm
* Min. incremental motion $\theta_x, \theta_y, \theta_z$	3.5	µrad*
Repeatability X, Y	±0.5	µm*
Repeatability Z	±0.5	µm
Repeatability $\theta_x, \theta_y, \theta_z$	±6	µrad
Typ. velocity X, Y, Z	0.5	mm/s
Typ. velocity $\theta_x, \theta_y, \theta_z$	0.35	°/s
Max. velocity X, Y, Z	1	mm/s
Max. velocity $\theta_x, \theta_y, \theta_z$	0.7	°/s
Stiffness (k_x, k_y)	1.7	N/µm
Stiffness (k_z)	7	N/µm
Load capacity (vertical mounting)	10***	kg
Weight	7.8	kg



The M-824 comes with a powerful 6D controller and sophisticated, user-friendly positioning and alignment software. Keypad and display are optional.

* Simultaneous motion of all 6 actuators! No moving cables (as in serial-kinematics stacked systems) to introduce bending sources, torque and friction, which degrade positioning accuracy.

** The travel ranges of the individual coordinates (X, Y, Z, $\theta_x, \theta_y, \theta_z$) are interdependent. The data for each axis in this table shows its maximum travel, where all other axes are at their zero positions. If the other linear or rotational coordinates are not zero, the available travel may be less.

*** Self locking

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PI is present worldwide with eight subsidiaries and total staff of 400+.

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Date: 05/2006

M-850K102 Ultra-High Load Hexapod

PI has designed a unique Hexapod high-load 6-axis positioner for astronomy applications and other alignment tasks. The M-850K102 custom Hexapod combines extremely high precision with a load capacity of up to 1000 kg. It provides minimum incremental motion to 0.8 μm and 1 μrad , respectively. The six individual actuators have a design resolution of 0.08 μm and a stiffness of 40 N/ μm .

- Six Degrees of Freedom
- Works in Any Orientation
- No Moving Cables for Improved Reliability and Precision
- 1000 kg Load Capacity (Vertical)
- Heavy-Duty, Ultra-High-Resolution Bearings for 24/7 Applications
- Repeatability to 0.5 μm
- Actuator Resolution 0.008 μm
- Significantly Smaller and Stiffer Package than Conventional Multi-Axis Positioners
- Vacuum-Compatible Versions
- Linear and Rotary Multi-Axis Scans
- Virtualized Center of Rotation (Pivot Point)
- Sophisticated Controller Using Vector Algorithms



M-850K102, 1000 kg Hexapod shown with M-840 Hexalight.

Hexapod Working Principle and Advantages

The M-850 Hexapod is driven by six high-resolution actuators all connected directly to the same moving platform. The principle is similar to that seen in flight simulators, but considerably more precise. In place of the hydraulic actuators used there, the M-850 uses custom high-load precision screws and servo-motors. It can withstand loads of 1000 kg vertically, and at least 180 kg in any direction.

Technical Specifications:

Number of Axes:	6
Linear travel range XYZ:	24 mm
Rotation range:	8 deg. (rot z) 6 deg. (rot x, y)
Actuator design resolution:	< 0.08 μm
Minimum incremental motion XYZ:	0.8 μm
Minimum incremental motion Rot xyz:	1 μrad
Repeatability X, Y:	1 μm
Repeatability Z:	0.5 μm
Max Linear Velocity XYZ:	0.5 mm/s
Max Rotary Velocity:	6 mrad/s
Actuator Stiffness:	40 N / μm
Load capacity:	up to 1000 kg (depends on orientation)
Weight:	450 kg

Typical Applications

Alignment and tracking of optics, electron beams; fine positioning of active secondary mirror platforms in astronomical telescopes

>> [M-840 Hexapod in Motion Video](#)

>> [Hexapod Selection Guide](#)

>> [NEXLINE Piezo Hexapod \(Non Magnetic\)](#)

>> [M-824 Compact Vacuum Hexapod](#)

>> [M-850, 100 kg Hexapod](#)

>> [F-206, HexAlign Flexure Hexapod](#)

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Date: 04/2005

NEXLINE® Piezo Hexapod - Non Magnetic 6-Axis Precision Positioning System

PI has developed a custom, non-magnetic piezoelectric hexapod based on the [N-215 NEXLINE®](#) ultra-precision piezo motor drives. This Hexapod 6-axis positioning stage can be used in applications with very strong magnetic fields.

Preliminary Specifications:

- 8" Aperture
- Load 50kg
- Low Profile: 140mm
- Translation XYZ: 10mm
- Rotation all axes: 6 °

[>> For further information on the piezo Hexapod, please contact PI.](#)



Custom Non-Magnetic Piezoelectric Hexapod.

A large Z-Tip/Tilt Nanopositioning Platform was also developed:

Preliminary Specifications:

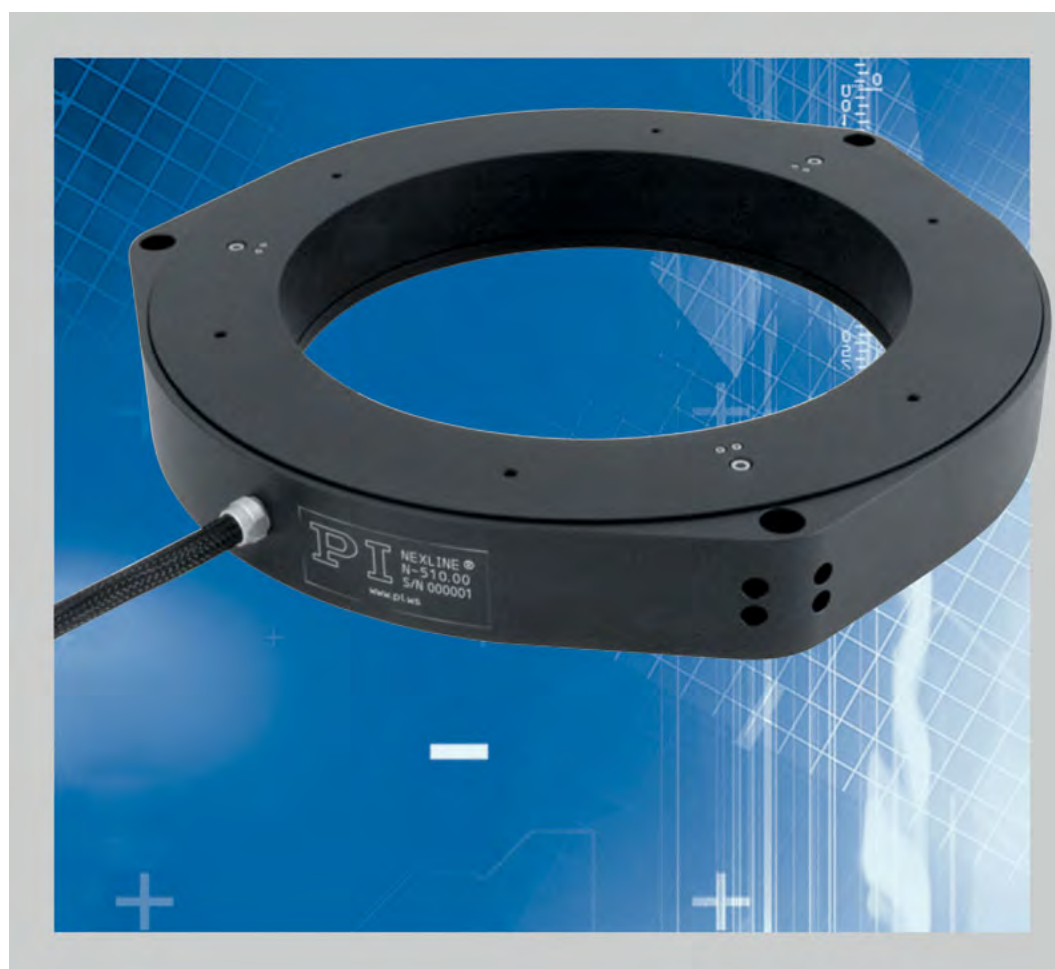
- Z, Tip, Tilt platform with closed-loop NEXLINE® drives and position sensors:
- Diameter: 300 mm (12")
- Load capacity: 200 N
- Travel range: 1.3 mm
- Tilting angle: 10 mrad
- Sensor: High-resolution incremental sensor.

[>> For further information on the large Z-Tip/Tilt Nanopositioning Platform, please contact PI.](#)

[>> More Information on NEXLINE® Motors](#)

[>> Piezo Tip/Tilt Nanopositioning Stages](#)

[>> More on Hexapods](#)



Z-Tip/Tilt Nanopositioning Platform.



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Date: 02/2006

PI Wins Substantial Hexapod Order from General Dynamics Daughter for ALMA Millimeter Radio Telescope

Feb. 2006 - Physik Instrumente (PI) has been awarded a contract by Vertex Antenna Systems, a daughter of General Dynamics C4 Systems, to provide 25 six-axis hexapod alignment systems and motion controllers. These custom high-precision micropositioning systems will be employed to align the secondary reflectors in 25 twelve-meter telescopes - the North American portion of the Atacama Large Millimeter Array Project (ALMA) radio telescope.

ALMA is an international joint effort to build the world's most sensitive radio telescope, in Chile's Atacama Desert, 16,500 feet above sea level. Eventually, an array of up to 64 antennas will work together as one giant virtual telescope and provide a spatial resolution 10 times higher than the Hubble Space Telescope. After its completion in 2011, the telescope will allow scientists to observe galaxies in their formative stages with unmatched clarity.

PI was chosen as a supplier for the secondary alignment systems, because of its long track record with designing and manufacturing astronomical secondary hexapods, actuators and active optics. In the last two decades, PI piezo-driven tip/tilt systems, actuators or hexapods have been employed in a number of astronomical telescopes, for example in: Hawaii, Chile, [South Africa](#) and the Canary Islands.



>> [Additional information on PI Precision Actuators](#)

>> [Additional information on PI Hexapod parallel-kinematics precision positioning systems](#)



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- Capacitive Sensors
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- Hexapods
- Micropositioners
- Positioning Systems for Fiber Optics, Photonics and Telecommunications
- Motor Controllers
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