

M-850 Hexapod 6-Axis Positioning System

High-Load Parallel-Kinematics Micropositioner with Controller, to 2000 N



- Six Degrees of Freedom
- Works in Any Orientation
- No Moving Cables for Improved Reliability and Precision
- Up to 250 kg Load Capacity (Vertical)
- Heavy-Duty, Ultra-High-Resolution Bearings for 24/7 Applications
- Repeatability to $\pm 1 \mu\text{m}$
- Encoder Resolution to $0.005 \mu\text{m}$
- Significantly Smaller and Stiffer than Serial-Kinematics Systems, Better Dynamics
- Vacuum-Compatible Versions Available
- Linear and Rotary Multi-Axis Scans
- Virtual Pivot Point
- Sophisticated Controller Using Vector Algorithms
- MTBF 20,000 h

Application Examples

- Alignment of secondary mirrors
- Semiconductor technology
- Optics alignment
- Medical technology
- Micromachining
- Micromanipulation
- X-ray diffraction measurements
- Satellite testing equipment
- Tool control

The M-850 is the ideal micropositioning system for all complex positioning tasks which depend upon high load capacity and accuracy in six independent axes. The use of extremely stiff and accurate components for the M-850 Hexapod results in an unusually high natural frequency of 500 Hz with a 10 kg load. 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.

The M-850.50 model can achieve velocities of up to 8 mm/s. In contrast, the M-850.11 model with a higher gear ratio can achieve a load capacity of 250 kg vertically and 50 kg in any orientation.

Hexapod vs. Serial Kinematics Systems

The Hexapod is driven by six high-resolution actuators all connected directly to the same moving platform. This design provides a high system stiffness and a large clear aperture.

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, and the friction and inertia of moving cables all accumulate to limit accuracy and repeatability—problems which do not affect parallel kinematic systems like the Hexapod.

Fixed Virtual 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 by software command. The pivot point remains fixed relative to the platform.

Target positions in 6-space are entered in user-friendly coordinates and reached by smooth vectorized motion.

Open Architecture

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

Ordering Information

- M-850.11**
Hexapod Microrobot with Controller, 0.5 mm/s, 250 kg Load
- M-850.V11**
Hexapod Microrobot with Controller, 0.15 mm/s, 80 kg Load, Vacuum Compatible to 10^{-6} hPa
- M-850.50**
Hexapod Microrobot with Controller, 8 mm/s, 50 kg Load
- M-850.V50**
Hexapod Microrobot with Controller, 2.5 mm/s, 25 kg Load, Vacuum Compatible to 10^{-6} hPa
- Optional Photometers**
- F-206.iiU**
Photometer Card, IR Range, 2 Channels
- F-206.VVU**
Photometer Card, Visual Range, 2 Channels



Custom Hexapod designed for neurosurgery Photo: IPA
macro language for programming and storing command sequences.

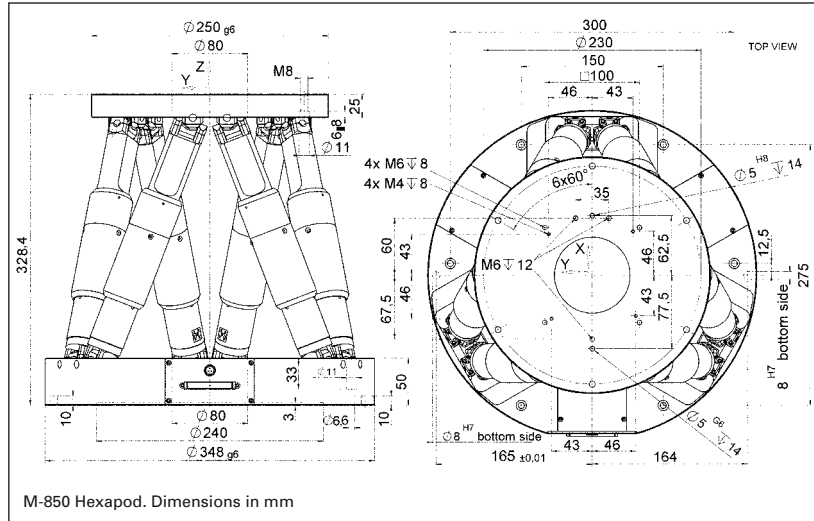
Automatic Optical Alignment

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 www.pi.ws.

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. 4-12).



Custom "6+3" Hexapod with additional struts providing independent position feedback



M-850 Hexapod. Dimensions in mm

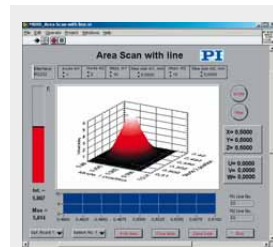
Technical Data

Model	M-850.11	M-850.50	Units
Active axes	X, Y, Z, θ_x , θ_y , θ_z	X, Y, Z, θ_x , θ_y , θ_z	
Motion and positioning			
*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 drive	DC-motor	DC-motor	
Integrated sensor	Rotary encoder	Rotary encoder	
Sensor resolution	2048	2048	cts./rev.
Actuator design resolution	0.005	0.05	µm
**Min. incremental motion X, Y, Z	1 (XY), 0.5 (Z)	1 (XY), 0.5 (Z)	µm (6-axis move!)
**Min. incremental motion θ_x , θ_y , θ_z	5	5	µrad (6-axis move!)
Repeatability X, Y	±2	±2	µm
Repeatability Z	±1	±1	µm
Repeatability θ_x , θ_y , θ_z	±10	±10	µrad
Max. velocity X, Y, Z	0.5	8	mm/s
Max. velocity θ_x , θ_y , θ_z	6	100	mrad/s
Typ. velocity X, Y, Z	0.3	5	mm/s
Typ. velocity θ_x , θ_y , θ_z	3	50	mrad/s
Mechanical properties			
Stiffness (k_x , k_y)	3	3	N/µm
Stiffness (k_z)	100	100	N/µm
Max. load (baseplate horizontal/any orientation)	250 / 50	50 / 20	kg
Max. holding force (baseplate horizontal/any orientation)	2000 / 500	250 / 85	N
Resonant frequency*** F_x, F_y	90	90	Hz
Resonant frequency*** F_z	500	500	Hz
Miscellaneous			
Operating temperature range	-10 to +50	-10 to +50	°C
Material	Aluminum	Aluminum	
Mass	17	17	kg
Controller			
Controller included	M-850.502	M-850.502	
Operating voltage	100–240 VAC, 50/60 Hz	100–240 VAC, 50/60 Hz	

Technical data are specified at 20 ±3 °C. Data for vacuum versions may differ.
 *The max. travel of the several coordinates (X, Y, Z, θ_x , θ_y , θ_z) are interdependent. The data for each axis in this table shows its maximum



Custom water-resistant Hexapod



HexControl™ software showing scan of a fiber optics component

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.
 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°
 ***Baseplate mounted horizontally with 10 kg load

Linear Actuators & Motors

Nanopositioning/Piezoelectrics

Nanometrology

Micropositioning

Hexapod 6-Axis Systems / Parallel Kinematics

Linear Stages

Translation (X)

Vertical (Y)

Multi-Axis

Rotary & Tilt Stages

Accessories

Servo & Stepper Motor Controllers

Single-Channel

Hybrid

Multi-Channel

Micropositioning Fundamentals

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Hexapod Options & Accessories



Photometer card



The F-206.MC6 manual control pad facilitates system setup and testing procedures. It permits independent motion in all degrees of freedom with programmable step size

Optical Metrology Boards

The controllers for the F-206, M-840 and M-850 Hexapod systems can be equipped/retrofitted with the following photometer cards: F-206.VVU (2-channel, visual) and F-206.iiU (2-channel, IR).

F-206.MC6 6D Interactive Control Pad Upgrade

The F-206.MC6 manual control pad facilitates system setup

and testing procedures. It consists of a board that plugs into the Hexapod controller and a control pad with six digital "potentiometer" knobs (one for each degree of freedom).

The manual pad works seamlessly with the Hexapod software, and allows programmable step sizes of 1 μm to 500 μm (linear) and 0.001 to 0.5deg (angular) per step.

External positioning commands (via the computer interface) can be intermixed with manual positioning input without loss of the true position, because both inputs operate on the same position registers of the Hexapod controller. The control pad comes with a 3 m cable. A 3 m extension cable is available as part number C-815.MC6.

More Options see F-311 PIMotion&Vision™ System, F-361 Optical Power Meter and F-603 Fiber, Objective and Waveguide Holders. (www.pi.ws)

Technical Data

Model	F-206.iiU, F-206.VVU Optical Metrology Boards
Optical power range	5 nW – 10 mW
Analog input voltage range	0 – 10 V
A/D resolution	16-bit
Sample rate	10 kHz
Bandwidth	300 Hz (optical input), 10 kHz (electrical input)
Max. sensitivity at:	880 nm (visible, F-206.VVU); 1550 nm (IR range, F-206.iiU)
40% sensitivity at:	480 / 1040 nm (visible, F-206.VVU); 850 / 1680 nm (IR range, F-206.iiU)

F-206.NCU Rapid NanoAlign Upgrade

For applications where alignment with nanometer-range resolution is required, or where rapid mapping of the entire cross-section of a component in as short a time as possible is desired, the F-206.NCU Rapid NanoAlign upgrade is recommended. It consists of

the P-611.3SF XYZ piezo-drive NanoCube® (see p. 2-52) and the E-760 controller board (see p. 2-138), which is installed in the F-206 controller.



F-206.NCU Rapid NanoAlign Upgrade consists of the P-611 NanoCube® piezo nanopositioner and the E-760 controller card