500 kg High-Load Hexapod

HIGH-PRECISION AND REPEATABLE POSITIONING

H-850KMLD

- Min. incremental motion 1 µm (X, Y), 0.5 µm (Z)
- Travel ranges to 100 mm / 60°
- Optionally with absolute encoders

Reference-class 6-axis positioning system
Parallel-kinematic design for six degrees of freedom making it significantly more compact and stiff than serial-kinematic systems, higher dynamic range, no moved cables: Higher reliability, reduced friction. Large clear aperture

Optional feature: Absolute position measurement
Optionally, the position is measured using absolute encoders. The exact position of the axes is determined after the Hexapod has been switched on. A reference move is not necessary

Powerful digital controller, open software architecture
6D vector motion controller for Hexapods, plus two additional servo axes. Arbitrary, stable pivot point, software-selectable. Positions commanded in Cartesian coordinates. Macro command language. Open-source LabVIEW driver and libraries. Determination of the workspace. Virtual machine for Hexapod emulation. Optional: Software for avoiding collisions in restricted workspace

Fields of application
Research and industry. For astronomy, aviation and aerospace

Related products
H-850 6-Axis Hexapod
H-845 High-Load Hexapod

M-850 Hexapod 6-Axis Positioner, High Load, High Precison

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


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 ±1 µm**
- **Encoder Resolution to 0.005 µm**
- **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. It can withstand loads of 200 kg vertically, and at least 50 kg in any direction. In addition to positioning all axes with resolutions in the submicron and arc-second 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 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 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).

Ordering Information

M-850.11
Hexapod Microrobot with Controller, DC-Motor w/ Gearhead

M-850.V11
Hexapod Microrobot with Controller, DC-Motor w/ Gearhead, Vacuum Compatible to 10^{-6} hPa

M-850.50
Hexapod Microrobot with Controller, Direct Drive

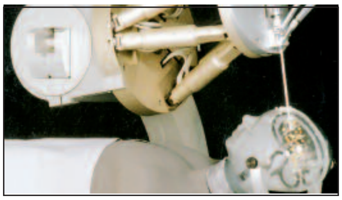
M-850.V50
Hexapod Microrobot with Controller, Direct Drive, Vacuum Compatible to 10^{-6} hPa

Optional Photometers

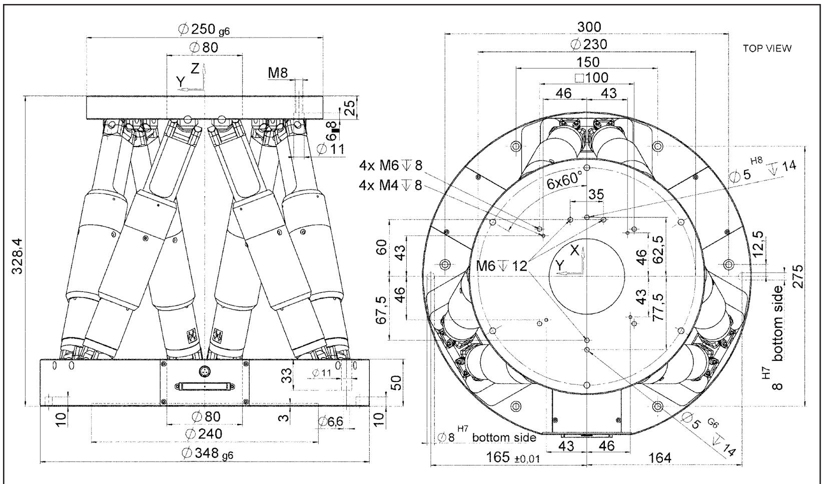
F-206.iiU
Photometer Card, IR Range, 2 Channels

F-206.VVU
Photometer Card, Visual Range, 2 Channels


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



Custom Hexapod designed for neurosurgery Photo: IPA



M-850 Hexapod. Dimensions in mm

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

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	
Actuator stroke	±25	±25	mm
Integrated sensor	Rotary encoder	Rotary encoder	
Sensor resolution	2048	2048	
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)	200 / 50	200 / 50	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.

Custom water-resistant Hexapod

HexControl™ software showing scan of a fiber optics component

*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 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

PI

M-840 HexaLight 6-Axis Parallel Positioning System, 30 kg

High-Speed Parallel-Kinematics Micropositioner with Controller, to 50 mm/s

M-840 HexaLight 6D-Micropositioning System

- **Six Degrees of Freedom, Travel Ranges to 100 mm/ 60°**
- **Rapid Response**
- **No Moving Cables for Improved Reliability and Precision**
- **Self-Locking Version M-840.DG3: Load Capacity up to 30 kg**
- **Direct-Drive Version M-840.5PD: Velocity up to 50 mm/s**
- **Repeatability up to ±2 µm**
- **Encoder Resolution up to 0.016 µm**
- **Significantly Smaller and Stiffer than Serial-Kinematics Systems, Better Dynamics**
- **Vacuum-Compatible Versions Available**
- **Virtual Pivot Point**
- **Sophisticated Controller Using Vector Algorithms**
- **MTBF 20,000 h**

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

The M-840 is the ideal micropositioning system for all complex positioning tasks which rely on high accuracy and speed 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.

Application Examples

- Biotechnology
- Semiconductor technology
- Micromachining
- Micromanipulation
- X-ray diffraction measurements
- Tool control

Fast Positioning in All Six Axes

Two models of the M-840 Hexapod are available. The M-840.5PD Hexapod, which features a higher speed and direct-drive actuators, positions loads of up to 10 kg in horizontal and up to 3 kg in random orientation at up to 50 mm/s and 600 mrad/s with micron accuracy. The DC-motor-version, M-840.DG3, is basically self-locking. It positions loads of up to 30 kg in horizontal and up to 10 kg in random orientation, and offers smallest sub-micron step sizes.

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-840.5PD
Hexapod Microrobot with Controller, Direct Drive, 10 kg Load

M-840.DG3
Hexapod Microrobot with Controller, DC Motor Gearhead, 30 kg Load

Optional Photometer

F-206.iiU
Photometer Card, IR Range, 2 Channels

F-206.VVU
Photometer Card, Visible Range, 2 Channels

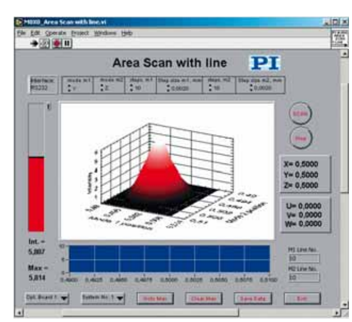
F-361.10
Absolute-Measuring Optical Power Meter, 1000 bis 1600 nm Wavelength

More Hexapod-Models:

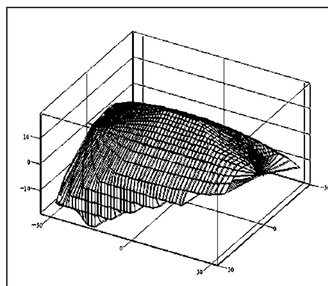
M-850 High-Load Hexapod s. p. 4-6

M-824 Vacuum Compatible Hexapod s. p. 4-10

F-206 Micropositioning System for Maximum Accuracy s. p. 4-12



HexControl software showing scan of a fiber optics component

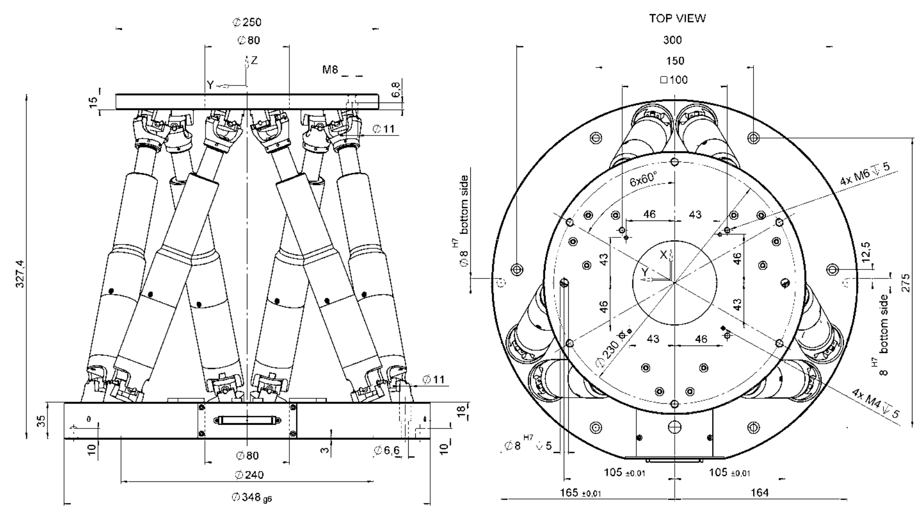


The X, Y, Z working space of the M-840 with θX = θY = θZ = 5°

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 about the photometers see www.pi.ws.



M-840 dimensions in mm, 3 m cable included

Technical Data

Model	M-840.5PD	M-840.DG3	Units
Active axes	X, Y, Z, θX, θY, θZ	X, Y, Z, θX, θY, θZ	
Motion and positioning			
*Travel range X, Y	±50	±50	mm
*Travel range Z	±25	±25	mm
*Travel range θX, θY	±15	±15	°
*Travel Range θZ	±30	±30	°
Actuator drive	DC-motor	DC-motor	
Actuator stroke	±25	±25	mm
Integrated sensor	Rotary encoder	Rotary encoder	
Sensor resolution	2048	2048	
Actuator design resolution	0.5	0.017	µm
**Min. incremental motion X, Y	3	1	µm
**Min. incremental motion Z	1	0.5	µm
**Min. incremental motion θX, θY, θZ	5	5	µrad
Repeatability X, Y	±2	±2	µm
Repeatability Z	±1	±1	µm
Repeatability θX, θY, θZ	±20	±20	µrad
Max. velocity X, Y, Z	50	2.5	mm/s
Max. velocity θX, θY, θZ	600	30	mrad/s
Typ. velocity X, Y, Z	30	2	mm/s
Typ. velocity θX, θY, θZ	300	20	mrad/s
Mechanical properties			
Max. load (baseplate horizontal / any orientation)	10 / 3	30 / 10	kg
Max. holding force (baseplate horizontal / any orientation)	15 / 5	100 / 25	N
Resonant frequency*** FX, FY	100	100	Hz
Resonant frequency*** FZ	300	300	Hz
Miscellaneous			
Operating temperature range	-10 to +50	-10 to +50	°C
Material	Aluminum	Aluminum	
Mass	12	12	kg
Controllers			
Delivered controller	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, θX, θY, θZ) 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).

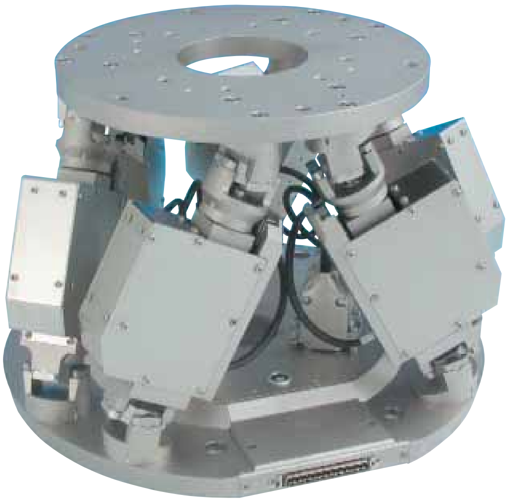
*** Horizontal mounted baseplate without load.

High-speed F-361 Optical Power Meter

PI

M-824 Compact 6-Axis Vacuum Positioning System

Precision Parallel-Kinematics Micropositioner with Controller, Vacuum Versions



M-824.3DG compact vacuum Hexapod

- **Extremely Compact**
- **Travel Ranges to 45 mm (linear), 25° (rotation)**
- **Load Capacity to 10 kg, Self Locking Version**
- **Resolution to 7 nm**
- **Min. Incremental Motion to 300 nm**
- **Repeatability ±0.5 µm**
- **Velocity to 25 mm/sec**
- **Vacuum-Compatible Versions Available**

The M-824 is the ideal micropositioning system for all complex positioning tasks which depend on high speed and accuracy in six independent axes. In addition to positioning all axes, it allows the user to define a center of rotation (pivot point) anywhere inside or outside the system envelope by one simple software command.

Application Examples

- Biotechnology
- Semiconductor technology
- Micromachining
- Micromanipulation
- X-ray diffraction measurements
- Tool control

Extremely Compact, Two Motor Versions

The M-824 uses a very compact drive with motor and spindle mounted side-by-side and, with a height of 188 mm, has a considerably lower profile than either the M-850, page 4-6, or M-840, page 4-8 Hexapods. Two versions featuring different drives are offered: the self-locking M-824.3DG with DC motor and gearhead can position loads of up to 5 kg in any orientation (10 kg with baseplate horizontal) with sub-micron precision. The M-824.3PD with integrated ActiveDrive™ system provides a significantly higher velocity of up to 25 mm/sec with loads up to 5 kg.

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.

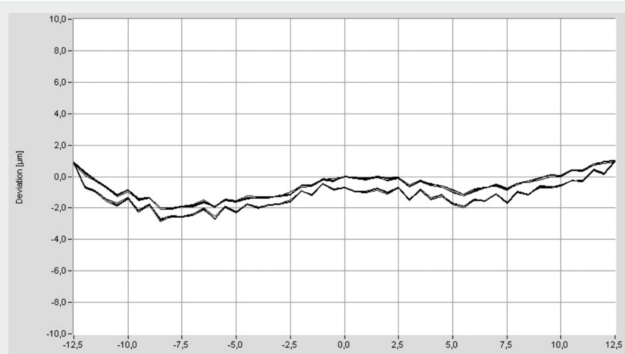
Vacuum Versions

Both models are available as vacuum versions that enable use in applications such as X-ray diffraction microscopy with ambient pressures down to 10^{-6} hPa.

Ordering Information

M-824.3VP
Compact Hexapod Microrobot with Controller, Direct Drive, Vacuum Compatible to 10^{-6} hPa

M-824.3VG
Compact Hexapod Microrobot with Controller, DC Motor Gearhead, Vacuum Compatible to 10^{-6} hPa

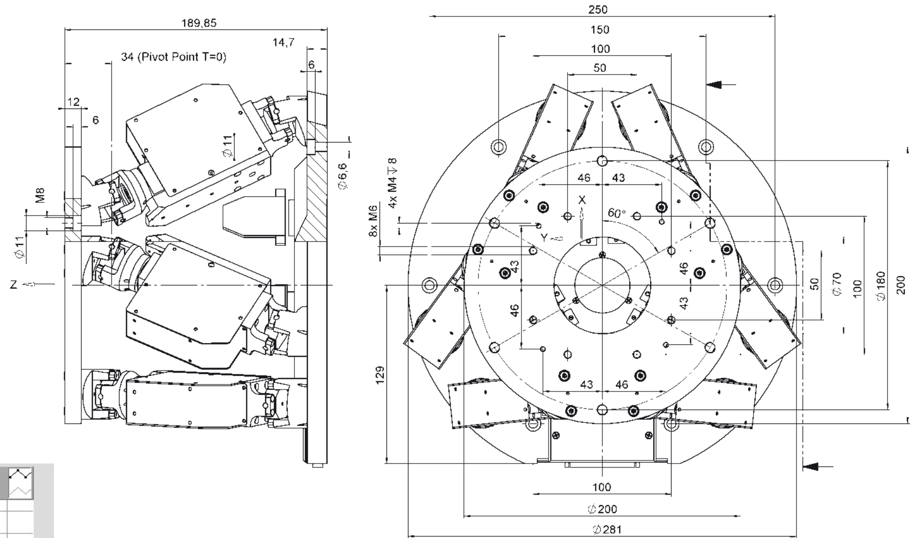


The interferometer test shows the Z axis accuracy over the entire travel range of 25 mm and the extremely high repeatability of ±0.046 µm

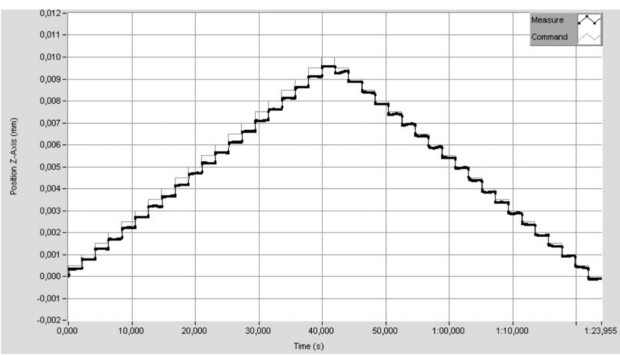
The M-824 comes with a powerful 6D controller and sophisticated, user-friendly positioning and alignment sofware. Keypad and display are optional

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 macro language for programming and storing command sequences.



M-824 dimensions in mm, 3 m cable included



Interferometer tests show the high repeatability, here with 500 nm steps

Technical Data

Model	M-824.3DG	M-824.3PD	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	±22.5	±22.5	mm
*Travel range Z	±12.5	±12.5	mm
*Travel range θ_X, θ_Y	±7.5	±7.5	°
*Travel range θ_Z	±12.5	±12.5	°
Single-actuator drive	DC-motor, gearhead	ActiveDrive™ DC Motor	
Actuator stroke	±12.5	±12.5	mm
Single-actuator design resolution	0.007	0.5	µm
Integrated sensor	Rotary encoder	Rotary encoder	
Sensor resolution	2048	2048	cts./rev.
**Min. incremental motion X, Y, Z	0.3	1	µm
**Min. incremental motion θ_X, θ_Y, θ_Z	3.5	12	µrad
Repeatability X, Y, Z	±0.5	±0.5	µm
Repeatability θ_X, θ_Y, θ_Z	±6	±6	µrad
Max. velocity X, Y, Z	1	25	mm/s
Max. velocity θ_X, θ_Y, θ_Z	11	270	mrad/s
Typ. velocity X, Y, Z	0.5	10	mm/s
Typ. velocity θ_X, θ_Y, θ_Z	5.5	55	mrad/s
Mechanical properties			
*Stiffness X, Y	1.7	1.7	N/µm
Stiffness Z	7	7	N/µm
Load capacity (baseplate horizontal/any orientation)	10/5***	5/2.5	kg
Miscellaneous			
Operating temperature range	-10 to +50	-10 to +50	°C
Material	Aluminum	Aluminum	
Mass	8	8	kg
Controller			
Controller included	M-850.502	M-850.502	
Operating voltage	100–240 VAC, 50/60 Hz	100–240 VAC, 50/60 Hz	

*The travel ranges of the individual coordinates (X, Y, Z, θ_X, θ_Y, θ_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

**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

***Self Locking

Technical data are specified at 20 ±3 °C.
Data for vacuum versions may differ.

More Hexapods: http://www.hexapods.net

Program Overview

- Piezo Ceramic Actuators & Motors
- Piezo Nanopositioning Systems and Scanners
- Active Optics / Tip-Tilt Platforms
- Capacitive Nanometrology Sensors
- Piezo Electronics: Amplifiers and Controllers
- Hexapod 6-Axis Positioners / Robots
- Micropositioning Stages & Actuators
- Photonics Alignment Systems, Solutions for Telecommunications
- Motor Controllers
- Ultrasonic Linear Motors

Request or download the complete PI Nanopositioning & Piezo Actuator Catalog

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