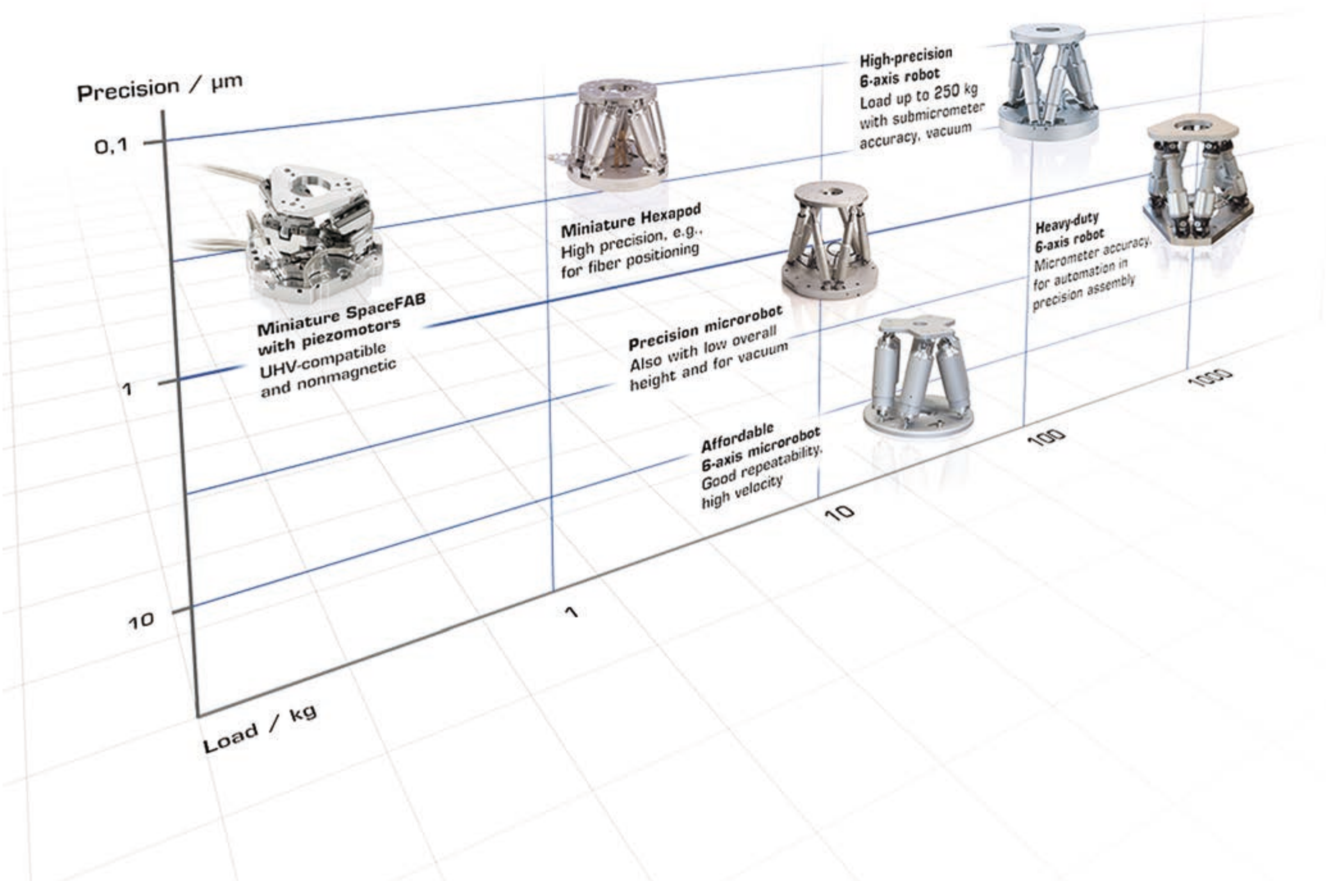
PI

Parallel Kinematics

HEXAPOD SYSTEMS WITH 6 DOF AND NANOMETER RESOLUTION

Contents



Products

HEXAPOD AND SPACEFAB

High-Load Hexapod

POSITIONING 1 TON WITH MICROMETER PRECISION

H-845

- Load capacity to 1000 kg
- Velocity to 50 mm/s
- Repeatability to ±0.5 µm
- Travel ranges to 340 mm / 60°
- Scalable design: Dimensions, travel ranges and loads
- Actuator resolution to 40 nm
- Drive: brushless motors with brake
- Sophisticated controller using vector algorithms, virtual pivot point
- Extensive software support

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. Brushless DC motors with brakes

Rapid implementation of customer requests
The high-load Hexapod has a modular structure and uses a set of different modules for drive unit and joint. The platforms can be adapted to the customer's application. This allows for rapid implementation of special customer requirements

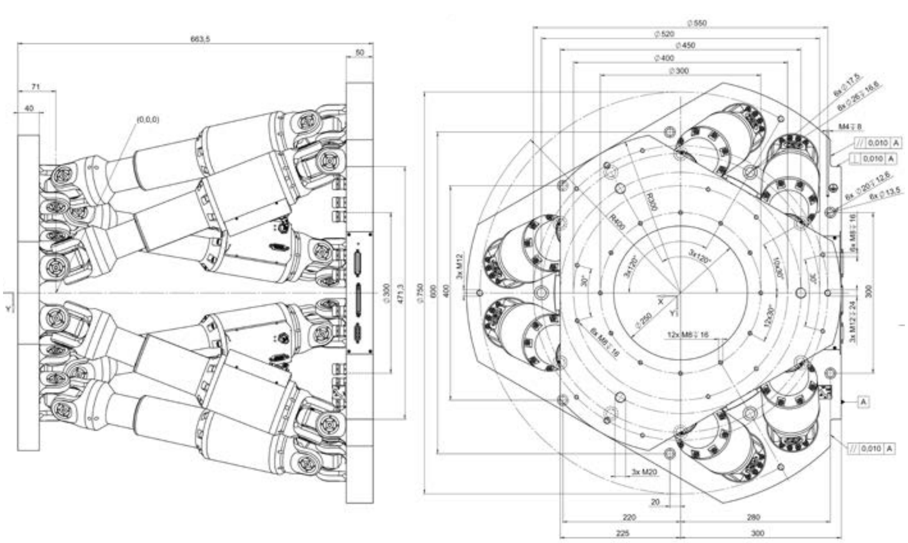
Powerful digital controller, open software architecture
6D vector motion controller for Hexapods, incl. two additional servo axes. Arbitrary, stable pivot point, software-selectable. Positions commanded in Cartesian coordinates. Macro command language. Open-source LabVIEW driver and libraries. Determination 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

Preliminary Data	H-845.D11	H-845.D21	H-845.D31	H-845.D41	H-845.D51	H-845.D61	Unit	Tolerance
Active axes	X, Y, Z, θ_X, θ_Y, θ_Z	X, Y, Z, θ_X, θ_Y, θ_Z	X, Y, Z, θ_X, θ_Y, θ_Z	X, Y, Z, θ_X, θ_Y, θ_Z	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	±110	±170	±110	±170	±110	±170	mm	
Travel range* Z	±50	±105	±50	±105	±50	±105	mm	
Travel range* θ_X, θ_Y	±15	±20	±15	±20	±15	±20	°	
Travel range* θ_Z	±30	±30	±30	±30	±30	±30	°	
Single-actuator design resolution	0.04	0.04	0.08	0.08	0.1	0.1	µm	
Min. incremental motion X, Y	1	1	2	2	2.5	2.5	µm	typ.
Min. incremental motion Z	0.5	0.5	1	1	1	1	µm	typ.
Min. incremental motion θ_X, θ_Y, θ_Z	15	15	30	30	30	30	µrad	typ.
Backlash X, Y	5	5	10	10	10	10	µm	typ.
Backlash Z	1	1	2	2	2	2	µm	typ.
Backlash θ_X, θ_Y	15	15	30	30	30	30	µrad	typ.
Backlash θ_Z	30	30	60	60	60	60	µrad	typ.
Repeatability X, Y	±2	±2	±4	±4	±5	±5	µm	typ.
Repeatability Z	±0.5	±0.5	±1	±1	±2	±2	µm	typ.
Repeatability θ_X, θ_Y, θ_Z	±10	±10	±20	±20	±25	±25	µrad	typ.
Max. velocity X, Y, Z	20	20	40	40	50	50	mm/s	
Max. velocity θ_X, θ_Y, θ_Z	50	50	100	100	120	120	mrad/s	
Typ. Velocity X, Y, Z	10	10	20	20	25	25	mm/s	
Typ. Velocity θ_X, θ_Y, θ_Z	20	20	40	40	50	50	mrad/s	
Mechanical properties								
Load (base plate horizontal / any orientation)	1000 / 300	1000 / 300	500 / 150	500 / 150	400 / 120	400 / 120	kg	max.
Motor type	Brushless DC motor	Brushless DC motor	Brushless DC motor	Brushless DC motor	Brushless DC motor	Brushless DC motor		
Miscellaneous								
Operating temperature range	-10 to 50	-10 to 50	-10 to 50	-10 to 50	-10 to 50	-10 to 50	°C	
Material	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum		
Mass	120	150	120	150	120	150	kg	±5 %
Cable length	9	9	9	9	9	9	m	±10 mm
Controller								
Included in delivery	C-887	C-887	C-887	C-887	C-887	C-887		

Technical data specified at 20 ±3°C. Ask about custom designs!

* 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.



H-845.D11, H-845.D31, H-845.D51 Hexapod, dimensions in mm

High-Load Hexapod

HIGH-PRECISION AND REPEATABLE POSITIONING

H-850KMLD

- Load capacity to 500 kg
- 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

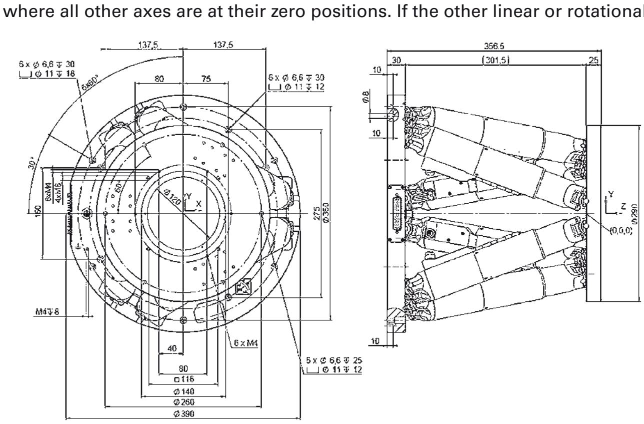
Optional feature: Absolute position measurement
Optionally, the position is measured using absolute encoders. The exact position of the axes is determined after the Hexapod has been switched on. A reference move is not necessary

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

Preliminary Data	H-850KMLD	H-850KMLA	Unit	Tolerance
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	°	
Min. incremental motion X, Y	1	0.5	µm	typ.
Min. incremental motion Z	0.5	0.2	µm	typ.
Min. incremental motion θ_X, θ_Y, θ_Z	5	2.5	µrad	typ.
Backlash X, Y	4	2.5	µm	typ.
Backlash Z	1	0.7	µm	typ.
Backlash θ_X, θ_Y	15	10	µrad	typ.
Backlash θ_Z	30	20	µrad	typ.
Repeatability X, Y	±1	±1	µm	typ.
Repeatability Z	±0.3	±0.3	µm	typ.
Repeatability θ_X, θ_Y	±5	±5	µrad	typ.
Repeatability θ_Z	±9	±9	µrad	typ.
Max. velocity X, Y, Z	0.5	0.5	mm/s	
Max. velocity θ_X, θ_Y, θ_Z	6	6	mrad/s	
Typ. velocity X, Y, Z	0.3	0.3	mm/s	
Typ. velocity θ_X, θ_Y, θ_Z	3	3	mrad/s	
Mechanical properties				
Load (base plate horizontal / any orientation)	500 / 200	500 / 200	kg	max.
Holding force, de-energized (base plate horizontal / any orientation)	4000 / 2000	4000 / 2000	N	max.
Motor type	DC gear motor	DC gear motor		
Miscellaneous				
Operating temperature range	-10 to 50	-10 to 50	°C	
Material	Aluminum	Aluminum		
Dimensions	Base plate Ø 370 Moving platform Ø 280 Clear aperture Ø 100 Hexapod height in center position 350	Base plate Ø 370 Moving platform Ø 280 Clear aperture Ø 100 Hexapod height in center position 350	mm	±10 mm
Mass	20	25	kg	
Cable length	3	3	m	±10 mm

Technical data specified at 20 ±3 °C.
Ask about custom designs!
* 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.



H-850.KMLD, dimensions in mm

6-Axis Hexapod

FOR LOADS OF UP TO 250 KG

H-850

- Load capacity to 250 kg
- Repeatability to ±0.2 µm
- Travel ranges to 100 mm / 60°
- Actuator resolution to 5 nm
- MTBF 20,000 h
- Works in any orientation
- Linear and rotary multi-axis scans
- Vacuum-compatible versions available
- Sophisticated controller using vector algorithms, virtual pivot point
- Comprehensive software package

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. Vacuum-compatible versions to 10^{-6} hPa are available

Drive variants

H-850.Hxx with DC gear motors for heavy loads
H-850.Gxx with powerful DC motors for higher velocity. Heavy-duty, ultra-high-resolution bearings for 24/7 applications

Powerful digital controller, open software architecture

User-defined, stable pivot point, software-selectable. Positions commanded in Cartesian coordinates. Macro programming. Open source LabVIEW driver set. Work space simulation software. Virtual Hexapod machine software. Optional: Collision avoidance software (external obstacles).

Hexapods are by default configured and delivered as a system including a controller

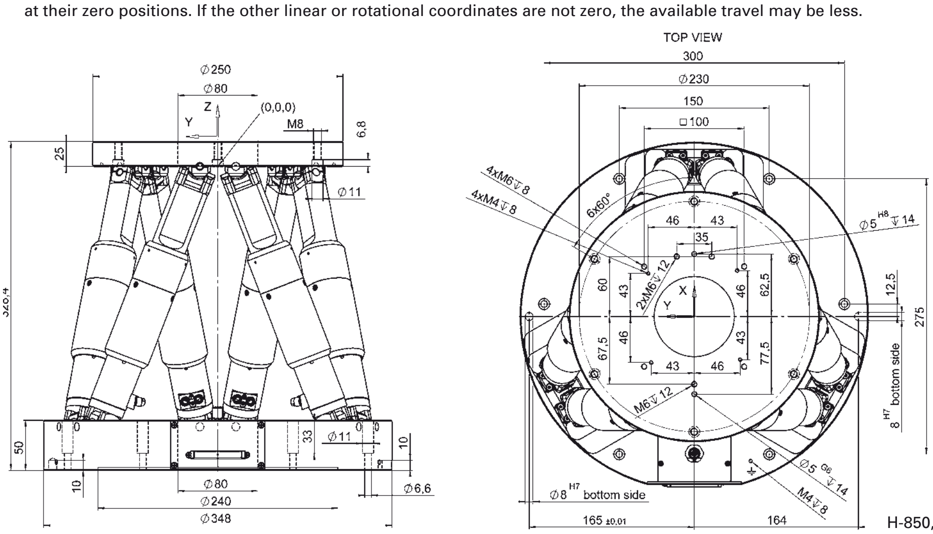
- C-887.52 compact bench-top controller for a lower system price. Digital I/ O interfaces, e.g. for external triggering
- C-887.11 19" controller, comprises the control for two additional single axes with servo motors. Options: Control of piezo axes, photometer cards for visible light or infrared light range

Fields of application

Research and industry, standard and vacuum environments. For astronomy, optics positioning, aviation and aerospace

	H-850.Hxx	H-850.Gxx	Unit	Tolerance
	for higher loads and holding forces	for higher velocity and precision		
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	°	
Single-actuator design resolution	0.005	0.05	µm	
Min. incremental motion X, Y	1	1	µm	typ.
Min. incremental motion Z	0.5	0.5	µm	typ.
Min. incremental motion θ_X, θ_Y, θ_Z	5	5	µrad	typ.
Backlash X, Y	4	5	µm	typ.
Backlash Z	1	1.5	µm	typ.
Backlash θ_X, θ_Y	15	25	µrad	typ.
Backlash θ_Z	30	45	µrad	typ.
Repeatability X, Y	±1	±0.5	µm	typ.
Repeatability Z	±0.3	±0.2	µm	typ.
Repeatability θ_X, θ_Y	±5	±3	µrad	typ.
Repeatability θ_Z	±9	±6	µrad	typ.
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 X, Y	7	7	N/µm	
Stiffness Z	100	100	N/µm	
Load (base plate horizontal / any orientation)	250 / 50	50 / 20	kg	max.
Holding force, de-energized (base plate horizontal / any orientation)	2000 / 500	250 / 85	N	max.
Motor type	DC motor, gearhead	DC motor, gearhead		
Miscellaneous				
Operating temperature range	-10 to 50	-10 to 50	°C	
Material	Aluminum	Aluminum		
Mass	17	17	kg	±5%
Cable length	3	3	m	±10 mm

Vacuum versions to 10^{-6} hPa are available under the following ordering number: H-850.xV. Specifications for vacuum versions can differ.
Technical data specified at 20 ±3°C. Ask about custom designs!
* 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.



H-850, dimensions in mm

6-Axis Hexapod

HIGH VELOCITY, MEDIUM LOAD, AFFORDABLE

H-840

- Load capacity to 30 kg
- Travel ranges to 100 mm / 60°
- Actuator resolution to 16 nm
- Repeatability to ±0.4 µm
- MTBF 20,000 h
- Velocity to 50 mm/s
- Works in any orientation
- Rapid response
- Sophisticated controller using vector algorithms, virtual pivot point
- Comprehensive software package

Precision-class 6-axis 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

Drive variants

H-840.Gxx with DC gear motors

H-840.Dxx with powerful DC motors for higher velocity

Powerful digital controller, open software architecture

User-defined, stable pivot point, software-selectable. Positions commanded in Cartesian coordinates. Macro programming. Open source LabVIEW driver set. Work space simulation software. Virtual Hexapod machine software. Optional: Collision avoidance software (external obstacles).

Hexapods are by default configured and delivered as a system including a controller

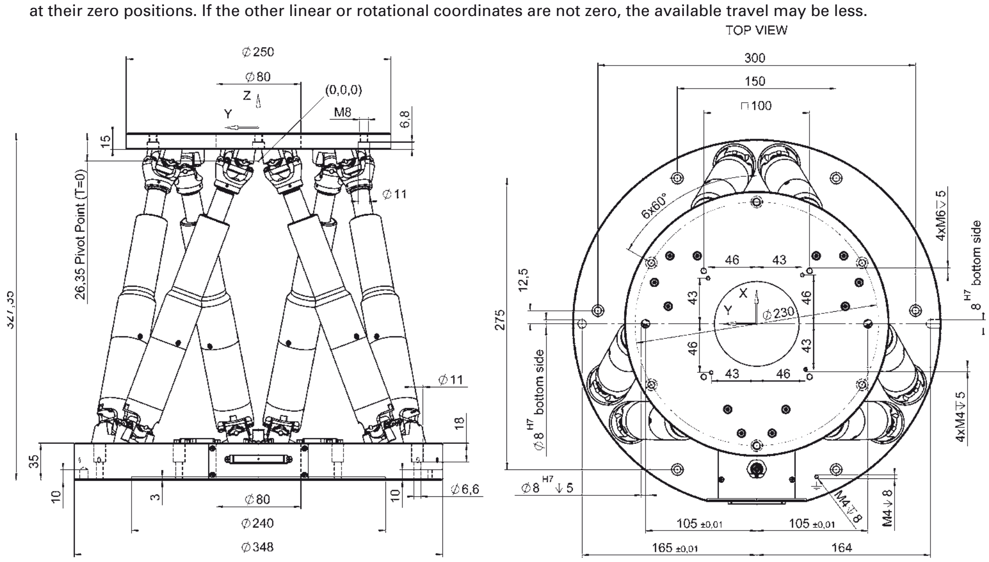
- C-887.52 compact bench-top controller for a lower system price. Digital I/ O interfaces, e.g. for external triggering
- C-887.11 19“ controller, comprises the control for two additional single axes with servo motors. Options: Control of piezo axes, photometer cards for visible light or infrared light range

Fields of application

Research and industry. For tool control, life sciences, micromanufacturing

	H-840.Gxx	H-840.Dxx	Unit	Tolerance
	for higher resolution and load	for higher velocity		
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	°	
Single-actuator design resolution	0.017	0.5	µm	
Min. incremental motion X, Y	1	3	µm	typ.
Min. incremental motion Z	0.5	1	µm	typ.
Min. incremental motion θ_X, θ_Y, θ_Z	5	5	µrad	typ.
Backlash X, Y	3	3	µm	typ.
Backlash Z	0.2	0.2	µm	typ.
Backlash θ_X, θ_Y	20	20	µrad	typ.
Backlash θ_Z	30	30	µrad	typ.
Repeatability X, Y	±0.5	±0.5	µm	typ.
Repeatability Z	±0.4	±0.4	µm	typ.
Repeatability θ_X, θ_Y	±7	±7	µrad	typ.
Repeatability θ_Z	±12	±12	µrad	typ.
Max. velocity X, Y, Z	2.5	50	mm/s	
Max. velocity θ_X, θ_Y, θ_Z	30	600	mrad/s	
Typ. velocity X, Y, Z	2	30	mm/s	
Typ. velocity θ_X, θ_Y, θ_Z	20	300	mrad/s	
Mechanical properties				
Load (base plate horizontal / any orientation)	30 / 10	10 / 3	kg	max.
Holding force, de-energized (base plate horizontal / any orientation)	100 / 25	15 / 5	N	max.
Motor type	DC gear motor	DC motor		
Miscellaneous				
Operating temperature range	-10 to 50	-10 to 50	°C	
Material	Aluminum	Aluminum		
Mass	12	12	kg	±5%
Cable length	3	3	m	±10 mm

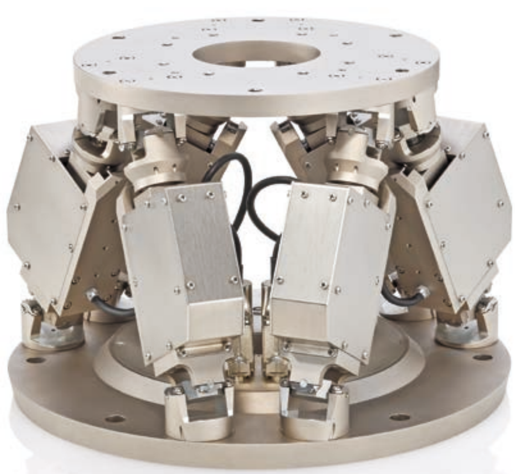
Technical data specified at 20 ±3°C.
Ask about custom designs!
* The travel ranges of the individual coordinates (X, Y, Z, θ_X, θ_Y, θ_Z) are interdependent. The data for each axis in this table shows its maximum travel, where all other axes are at their zero positions. If the other linear or rotational coordinates are not zero, the available travel may be less.



H-840, dimensions in mm

6-Axis Hexapod

LOW-PROFILE, PRECISION PARALLEL-KINEMATIC SYSTEM



H-824

- Load capacity to 10 kg, self-locking version
- Travel ranges to 45 mm / 25°
- Actuator resolution to 7 nm
- Min. incremental motion to 0.3 µm
- Repeatability to ±0.1 µm / ±2.5 µrad
- Velocity up to 25 mm/s
- Vacuum-compatible versions available
- Sophisticated controller using vector algorithms, virtual pivot point
- Comprehensive software package

Precision-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. Vacuum-compatible versions to 10^{-6} hPa are available

Compact due to folded drive design

H-824.Gxx with DC gear motors

H-824.Dxx with powerful DC motors for higher velocity

Powerful digital controller, open software architecture

User-defined, stable pivot point, software-selectable. Positions commanded in Cartesian coordinates. Macro programming. Open source LabVIEW driver set. Work space simulation software. Virtual Hexapod machine software. Optional: Collision avoidance software (external obstacles).

Hexapods are by default configured and delivered as a system including a controller

- C-887.52 compact bench-top controller for a lower system price. Digital I/O interfaces, e.g. for external triggering
- C-887.11 19" controller, comprises the control for two additional single axes with servo motors. Options: Control of piezo axes, photometer cards for visible light or infrared light range

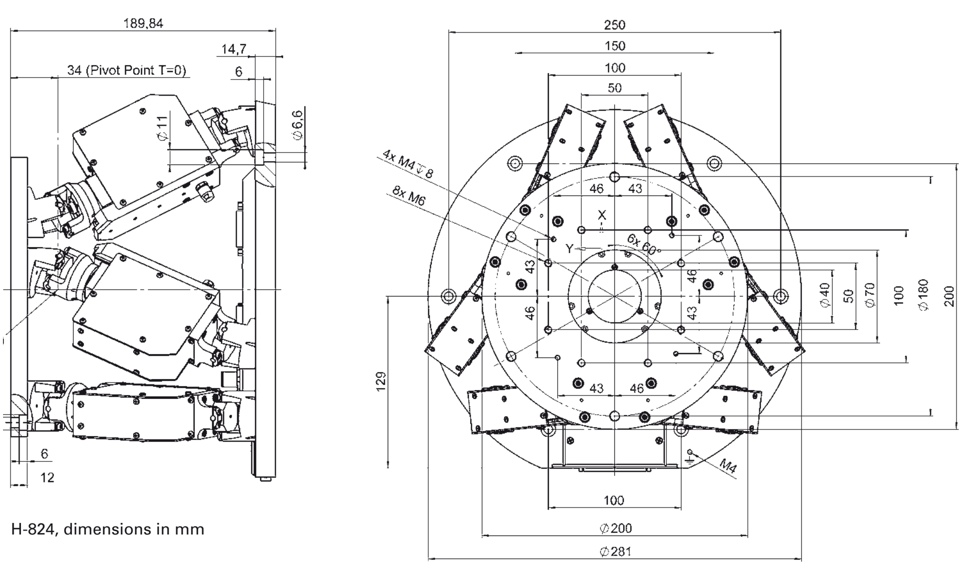
Fields of application

Research and industry, standard and vacuum environments. For micromanipulation, biotechnology, semiconductor manufacturing

	H-824.Gxx	H-824.Dxx	Unit	Tolerance
	for higher resolution and load	for higher velocity		
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 design resolution	0.007	0.5	µm	
Min. incremental motion X, Y, Z	0.3	1	µm	typ.
Min. incremental motion θ_X, θ_Y, θ_Z	3.5	12	µrad	typ.
Backlash X, Y	3	1	µm	typ.
Backlash Z	1	1	µm	typ.
Backlash θ_X, θ_Y	20	15	µrad	typ.
Backlash θ_Z	25	25	µrad	typ.
Repeatability X, Y	±0.5	±0.5	µm	typ.
Repeatability Z	±0.1	±0.1	µm	typ.
Repeatability θ_X, θ_Y	±2	±2	µrad	typ.
Repeatability θ_Z	±2.5	±2.5	µrad	typ.
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 (base plate horizontal / any orientation)	10 / 5	5 / 2.5	kg	max.
Holding force, de-energized (base plate horizontal / any orientation)	100 / 50	15 / 5	N	max.
Motor type	DC gear motor	DC motor		
Miscellaneous				
Operating temperature range	-10 to 50	-10 to 50	°C	
Material	Aluminum	Aluminum		
Mass	8	8	kg	±5%
Cable length	3	3	m	±10 mm

Vacuum versions to 10^{-6} hPa are available under the following ordering number: H-824.xVx. Specifications for vacuum versions can differ. Technical data specified at 20 ±3°C. Ask about custom designs!

* 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.



H-824, dimensions in mm

6-Axis Positioner with Controller

COST-EFFICIENT HEXAPOD

H-820

- Six degrees of freedom, travel ranges to 100 mm / 60°
- Load capacity to 20 kg
- Velocity under full load to 20 mm/s
- Repeatability up to ±1 µm
- MTBF 20,000 h
- Works in any orientation
- Rapid response behavior
- Sophisticated controller using vector algorithms, virtual pivot point
- Comprehensive software package

Standard-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

Direct drive with brushless DC motors (BLDC)

Indirect measuring principle
Rotary encoder on motor shaft

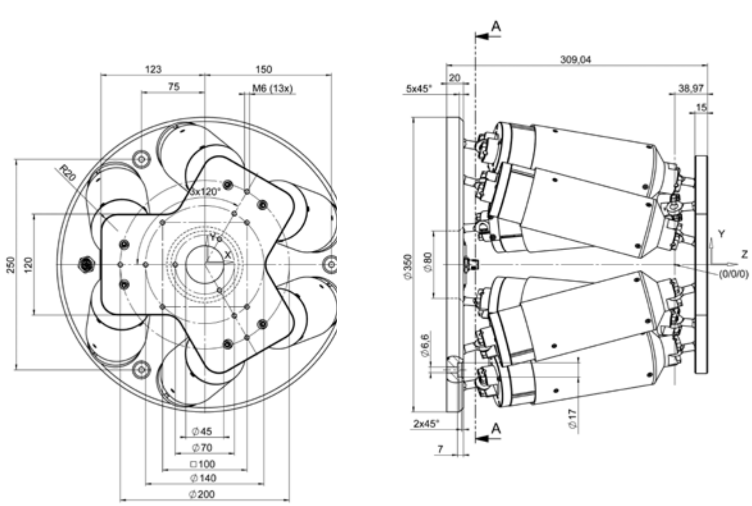
Powerful digital controller, open software architecture
User-defined, stable pivot point, software-selectable. Positions commanded in Cartesian coordinates. Macro programming. Open source LabVIEW driver set. Work space simulation software. Optional interface for PLC control

Fields of application
Research and industry. For life science, biotechnology, automation, micromachining

	H-820.D2	Unit	Tolerance
Active axes	X, Y, Z, θ_X, θ_Y, θ_Z		
Motion and positioning			
Travel range* X, Y	±50	mm	
Travel range* Z	±25	mm	
Travel range* θ_X, θ_Y	±15	°	
Travel range* θ_Z	±30	°	
Actuator drive	Torque motor, brushless (BLDC)		
Single-actuator design resolution	0.2	µm	typ.
Min. incremental motion X, Y, Z	10	µm	typ.
Min. incremental motion θ_X, θ_Y, θ_Z	25	µrad	typ.
Repeatability X, Y	±2	µm	typ.
Repeatability Z	±1	µm	typ.
Repeatability θ_X, θ_Y	±15	µrad	typ.
Repeatability θ_Z	±30	µrad	typ.
Backlash X, Y	30	µm	typ.
Backlash Z	10	µm	typ.
Backlash θ_X, θ_Y	100	µrad	typ.
Backlash θ_Z	300	µrad	typ.
Max. velocity X, Y, Z	20	mm/s	
Max. velocity θ_X, θ_Y, θ_Z	200	mrad/s	
Mechanical properties			
Load (base plate horizontal)	20	kg	max.
Load (base plate in any orientation)	10	kg	max.
Holding force (base plate horizontal)	200	N	max.
Holding force (base plate in any orientation)	100	N	max.
Miscellaneous			
Operating temperature range	0 to +50	°C	
Material	Aluminum		
Mass	15	kg	±5%
Cable length	3	m	±10 mm
Controller	C-887		
Operating voltage	100 to 240 VAC, 50/60 Hz		

Technical data specified at 20 ±3°C. Ask about custom designs!

* 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.



H-820.D2, dimensions in mm

6-Axis Miniature Hexapod

FAST, COMPACT AND HIGHLY PRECISE

H-811.D2

- Travel ranges to 34 mm / 42°
- Load capacity to 5 kg
- Actuator resolution 40 nm
- Min. incremental motion to 0.1 µm
- Repeatability to ±0.06 µm
- Velocity to 10 mm/s
- Vacuum-compatible versions available

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. Vacuum-compatible version to 10^{-6} hPa available. Direct drive with brushless DC motors (BLDC) and long-life ball screws

Fields of application

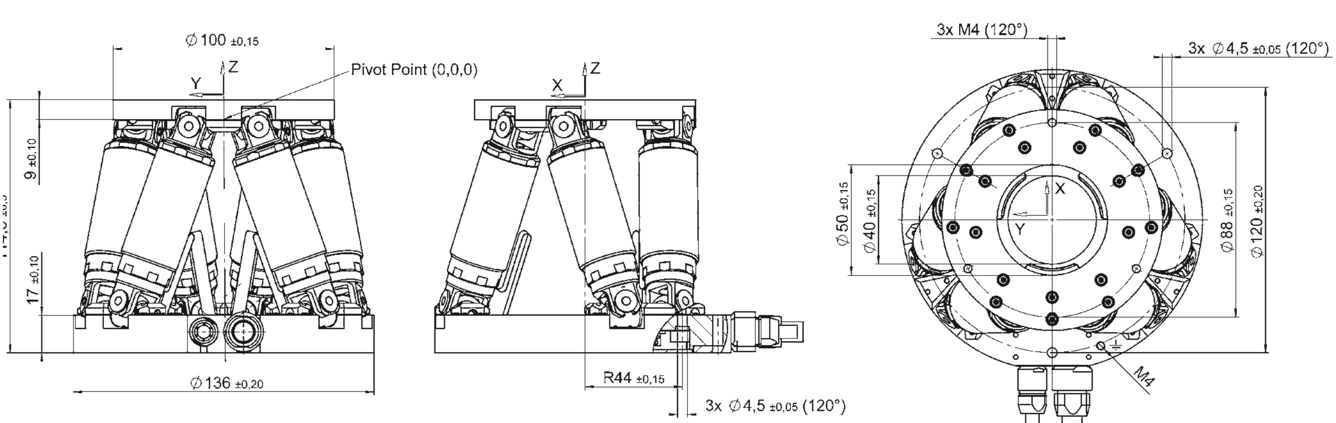
Research and industry, standard and vacuum environments. For micromanufacturing, medical engineering, tool control

	H-811.D2	Unit	Tolerance
Active axes	X, Y, Z, θ_X, θ_Y, θ_Z		
Motion and positioning			
Travel range* X, Y, Z	±17, ±16, ±6.5	mm	
Travel range* θ_X, θ_Y, θ_Z	±10, ±10, ±21	°	
Single-actuator design resolution	40	nm	
Min. incremental motion X, Y	0.25	µm	typ.
Min. incremental motion Z	0.1	µm	typ.
Min. incremental motion θ_X, θ_Y, θ_Z	3	µrad	typ.
Backlash X, Y	0.2	µm	typ.
Backlash Z	0.06	µm	typ.
Backlash θ_X, θ_Y	4	µrad	typ.
Backlash θ_Z	4	µrad	typ.
Repeatability X, Y	±0.15	µm	typ.
Repeatability Z	±0.06	µm	typ.
Repeatability θ_X, θ_Y	±2	µrad	typ.
Repeatability θ_Z	±3	µrad	typ.
Max. velocity X, Y, Z	10	mm/s	
Max. velocity θ_X, θ_Y, θ_Z	250	mrad/s	
Typ. velocity X, Y, Z	5	mm/s	
Typ. velocity θ_X, θ_Y, θ_Z	120	mrad/s	
Mechanical properties			
Stiffness X, Y	0.7	N/µm	
Stiffness Z	8	N/µm	
Load (base plate horizontal / any orientation)	5 / 2.5	kg	max.
Holding force, de-energized (base plate horizontal / any orientation)	15 / 2.5	N	max.
Motor type	Brushless DC motor		
Miscellaneous			
Operating temperature range	0 to 50	°C	
Material	Stainless steel, aluminum		
Mass	2.2	kg	±5%
Cable length	2	m	±10 mm

Specifications for vacuum versions can differ.
Technical data specified at 20 ±3 °C.
Ask about custom designs!

* 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.

Also available:
H-811.S2 Miniature Hexapod Microrobot for High-Dynamics Applications, Direct Drive, 25 mm/s, 1.5 kg Load, 2 m Cable, Sub-D Connector
H-811.F2 Hexapod for 6D-Alignment, 5 kg, 2 m Cable, Sub-D Connector



H-811, dimensions in mm

6-Axis Precision Alignment System

IDEAL FOR FIBER ALIGNMENT

H-206

- Ultra-high precision flexure joints
- Includes integrated scan algorithms for fiber optic alignment
- Actuator resolution 33 nm
- Repeatability 0.3 µm / 6 µrad
- Min. incremental motion 0.1 µm / 2 µrad
- Velocity from 10 µm/s to 10 mm/s
- Sophisticated controller using vector algorithms, virtual pivot point
- Comprehensive software package

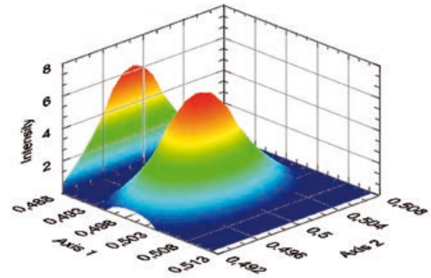
Reference-class 6-axis positioning system
Parallel-kinematic design for six degrees of freedom making it significantly more compact and stiff than serial-kinematic systems, guidance errors of individual axes do not add up. Higher dynamics, higher reliability. H-206.Fxx with DC gear motors

Flexure joints and Hexapod design with passive struts
Positioning with highest precision and repeatability

Powerful digital controller, open software architecture
User-defined, stable pivot point, software-selectable. Positions commanded in Cartesian coordinates. Macro programming. Open source LabVIEW driver set. Work space simulation software. Virtual Hexapod machine software. Optional: Collision avoidance software (external obstacles). Hexapods are by default configured and delivered as a system including a controller

- C-887.52 compact bench-top controller for a lower system price. Digital I/O interfaces, e.g. for external triggering
- C-887.11 19″ controller, comprises the control for two additional single axes with servo motors. Options: Control of piezo axes, photometer cards for visible light or infrared light range

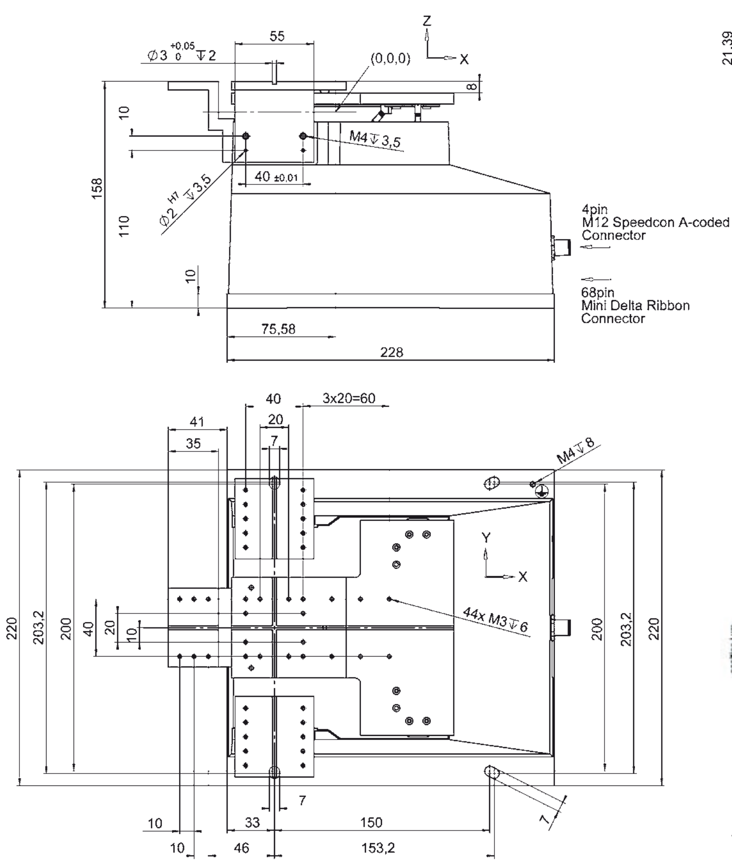
Fields of application
Research and industry. For fiber alignment, micromanipulation systems, optical testing set-ups



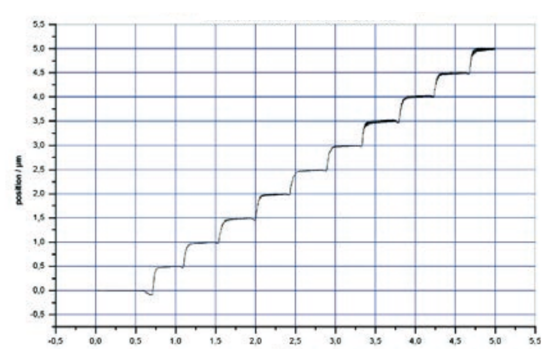
The H-206 includes rapid automatic scan routines for fast multiaxis alignment. The graphic shows 2D optical signal intensity of a fiber optic component. Complete device scan ensures detection of the global peak and prevents locking on to a local maximum

	H-206.Fxx	Unit	Tolerance
Active axes	X, Y, Z, θ_X, θ_Y, θ_Z		
Motion and positioning			
Travel range* X	-8 to 5.7	mm	
Travel range* Y	±5.7	mm	
Travel range* Z	±6.7	mm	
Travel range* θ_X	±5.7	°	
Travel range* θ_Y	±6.6	°	
Travel range* θ_Z	±5.5	°	
Single-actuator design resolution	33	nm	
Min. incremental motion X, Y, Z	0.1	µm	typ.
Min. incremental motion θ_X, θ_Y, θ_Z	2 (0.4")	µrad	typ.
Repeatability X, Y, Z	0.3	µm	typ.
Repeatability θ_X, θ_Y, θ_Z	6	µrad	typ.
Velocity X, Y, Z	10	mm/s	
Load (baseplate horizontal)	1.5	kg	max.
Miscellaneous			
Operating temperature range	5 to 35	°C	
Material	Aluminum		
Mass	5.8	kg	±5%
Cable length	3	m	±10 mm

Technical data specified at 20 ±3°C.
Ask about custom designs!
* 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.



H-206, dimensions in mm



The H-206 Hexapod shows extremely good repeatability of minute steps, in the above graph: 0.5 µm steps with a load of 1 kg in X direction

SpaceFAB

LOW-PROFILE SIX-AXIS MICRO POSITIONING SYSTEM

SF-3000 BS

- Travel ranges linear 50 mm x 100 mm x 12.7 mm
- Travel ranges rotation R_x, R_y, R_z 10°
- Load capacity 3 kg center mounted
- Automatic alignment
- Pivot point can be set by the customer
- User friendly software
- Can be used by any modern programming language
- Including software, controller and amplifiers
- Vacuum Datasheet

Software

- Pivot point can be set by the customer
- Digital display of position and orientation
- Control by macro-language stored in own editor
- Jog mode

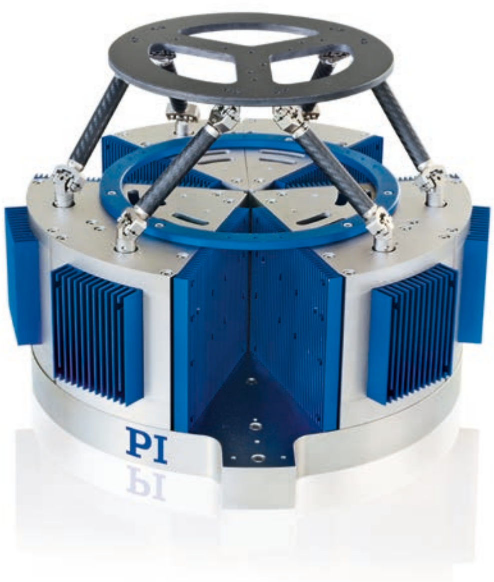
With one SpaceFAB SF-3000 BS all six degrees of freedom can be moved without additional positioning elements. The low weight of the moving platform allows high-dynamic positioning processes.
The non preloaded design can easily carry up to 2 kg center mounted. SpaceFAB SF-3000 BS is operating in closed loop mode. SpaceFAB SF-3000 BS was especially developed for applications in fiber-optic alignment. Furthermore SpaceFAB SF-3000 BS is perfectly designed for auto alignment of optical components, micro-fabrication and bio-genetic. The core software used for the SpaceFAB. SF-3000 BS is the motion server. The motion server includes all the mathematical transformations so that the user can start movements directly by specifying the six coordinates x, y, z, R_x, R_y and R_z. It is also possible to move arbitrary trajectories in a contouring mode.
The motion server can be used as a standalone software or in combination with or selfmade applications. These applications can be written in any modern programming language, the communication is done with TCP/IP. On request: A vacuum-version of the SpaceFAB SF-3000 BS is available in HV and UHV type Ask for: SpaceFAB SF-3000 BS Simulator. A program especially developed for simulation of travel range

SF-3000 BS						
Load Characteristics	Fx (N)	Fy (N)	Fz (N)	Mx (Nm)	My (Nm)	Mz (Nm)
DC-B-034	5	30	5	0.2	0.2	0.2

Travel Range	Linear X, Y, Z (mm)	50 x 100 x 12.7 *
	Rotation R_x, R_y, R_z (°)	10, 10, 10 *
Motor (Pitch 1 mm)		**DC-B-034**
Speed max. X,Y, Z (mm/sec)		30
Speed max. R_x, R_y, R_z (°/sec)		10
Velocity Range (mm/sec)		0.01 .. 30 **
Velocity Range (°/sec)		0.001 .. 10 **
Weight (kg)		24
Bi-directional Repeatability	Linear X, Y, Z (µm)	± 0.5, ± 0.5, ± 0.5
	Rotation R_x, R_y, R_z (°)	± 0.0011
Resolution calc. without load	Linear X, Y, Z (µm)	0.2
	Rotation R_x, R_y, R_z (°)	Depanding on the position of the pivot point
Resolution typical without load	Linear X, Y, Z (µm)	0.2
	Rotation R_x, R_y, R_z (°)	0.0005
Current (A)		2.3
Voltage Range (V)		24
Stiffness, theoretical K_x, K_y, K_z (N/µm)		on request
Material		Stainless steel, Aluminum black anodized

High-Dynamics Hexapod

MAGNETIC DIRECT DRIVE FOR HIGH VELOCITY



H-860KMAG

- Dynamics to 25 Hz over 0.1° travel range
- Integrated wave generator
- Developed for test stations for image stabilization
- Low moved mass
- Velocity > 250 mm/s
- Freely programmable, virtual pivot point

Reference-class 6-axis positioning system

Parallel-kinematic design for six degrees of freedom making it significantly more compact and stiffer than serialkinematic systems, no moved cables.
Precise running of predefined motion profiles with high path accuracy: Sine curves and freely definable trajectories.
Digital I/O interfaces for trigger signal emission

Powerful digital controller, open software architecture

User-defined, stable pivot point, software-selectable. Positions commanded in Cartesian coordinates. Macro programming. Open source LabVIEW driver set. Work space simulation software. Virtual Hexapod machine software. Optional: Collision avoidance software (external obstacles)

PIMag® voice coil magnetic drive for high velocity and high dynamics

Noncontact magnetic drive principle, no frictional or rolling parts for guiding and joints. Zero-backlash positioning, no mechanical noise in the drivetrain. Silent. Low wear and high lifetime. Integrated linear encoder for reliable position control and repeatable accuracy. Fast and precise direction reversal through low moved mass and lightweight design (highly stiff, milled carbon parts)

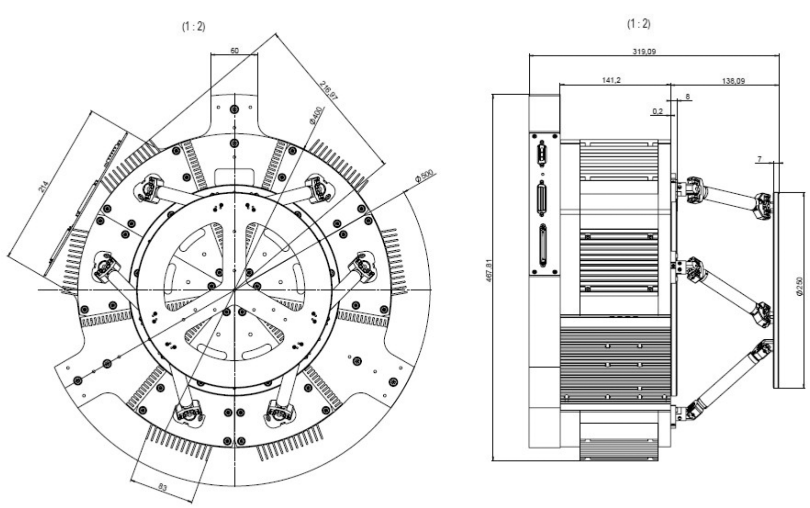
Fields of application

Research and industry, test systems, e.g., for image stabilization in cameras and mobile devices. Equipment for camera test systems and image stabilization software, certification according to CIPA planned. Oscillation simulation, eye tracking, simulation of human and artificial motion

Preliminary Data	H-860KMAG customized solution	Unit	Tolerance
Active axes	X, Y, Z, θ_X, θ_Y, θ_Z		
Motion and positioning			
Travel range X, Y, Z	±7.5	mm	
Travel range θ_X, θ_Y, θ_Z	±4	°	
Integrated sensor	Linear encoder		
Velocity X, Y, Z	250	mm/s	max.
Linear acceleration	4	g	
Load capacity	1	kg	max.
Resonant frequency F_X, F_Y, F_Z	200	Hz	
Drive properties			
Actuator drive / motor type	PIMag® voice coil		
Motion and control			
Servo characteristics	32-bit PID filter		
Trajectory profile modes	Sine, freely definable trajectories		
Cycle time	1		ms
Processor	CPU: ATOM Dual Core (1.8 GHz)		
Electrical properties			
Max. output power	10- bit outputs for PWM drivers, 30 kHz		
Max. output voltage	TTL in PWM operation for SIGN and MAGN		
Operating voltage	230	V	typ.
Power consumption	600	W	max.
Interface and operation			
Communication interfaces	TCP/ IP, RS-232 USB (keyboard, mouse, manual control unit)		
Command set	PI General Command Set (GCS)		
User software	PIMikroMove		
Software drivers	LabVIEW drivers, dynamic libraries for Windows and Linux		
Miscellaneous			
Operating temperature range	+5 to +40	°C	
Hexapod mass	30	kg	±5 %
Cable length	3	m	±10 mm
Controller mass	2.8	kg	±5 %

Technical data specified at 20 ±3 °C.

* 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. Further information on www.pi.ws.



H-860KMAG, dimensions in mm

6-Axis Miniature Hexapod

HIGH PRECISION IN A SMALL PACKAGE

H-810

- Travel ranges to 40 mm / 60°
- Load capacity to 5 kg
- Actuator resolution 40 nm
- Min. incremental motion to 0.5 µm
- Repeatability to ±0.1 µm
- Velocity to 2.5 mm/s
- Works in any orientation
- Sophisticated controller using vector algorithms, virtual pivot point
- Comprehensive software package

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

Direct drive with brushless DC motors (BLDC) and long-life ball screws
High precision, velocity and lifetime

Powerful digital controller, open software architecture
User-defined, stable pivot point, software-selectable. Positions commanded in Cartesian coordinates. Macro programming. Open source LabVIEW driver set. Work space simulation software. Virtual Hexapod machine software. Optional: Collision avoidance software (external obstacles).

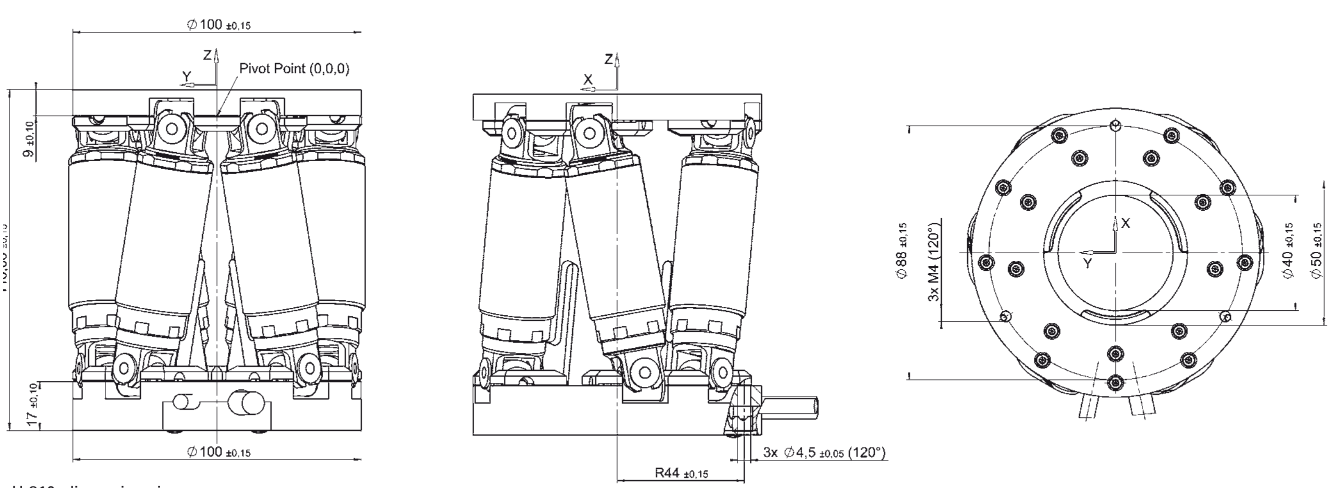
Hexapods are by default configured and delivered as a system including a controller

- C-887.52 compact bench-top controller for a lower system price. Digital I/O interfaces, e.g. for external triggering
- C-887.11 19“ controller, comprises the control for two additional single axes with servo motors. Options: Control of piezo axes, photometer cards for visible light or infrared light range

Fields of application
Research and industry. For micromanipulation, laser and optics alignment, biotechnology, tool control

	H-810.Dxx	Unit	Tolerance
Active axes	X, Y, Z, θ_X, θ_Y, θ_Z		
Motion and positioning			
Travel range* X, Y	±20	mm	
Travel range* Z	±6.5	mm	
Travel range* θ_X, θ_Y	±10	°	
Travel range* θ_Z	±30	°	
Single-actuator design resolution	40	nm	
Min. incremental motion X, Y	1	µm	typ.
Min. incremental motion Z	0.5	µm	typ.
Min. incremental motion θ_X, θ_Y, θ_Z	10	µrad	typ.
Backlash X, Y	3	µm	typ.
Backlash Z	0.5	µm	typ.
Backlash θ_X, θ_Y	15	µrad	typ.
Backlash θ_Z	75	µrad	typ.
Repeatability X, Y	±1	µm	typ.
Repeatability Z	±0.1	µm	typ.
Repeatability θ_X, θ_Y	±3	µrad	typ.
Repeatability θ_Z	±15	µrad	typ.
Max. velocity X, Y, Z	2.5	mm/s	
Max. velocity θ_X, θ_Y, θ_Z	60	mrad/s	
Typ. velocity X, Y, Z	2	mm/s	
Typ. velocity θ_X, θ_Y, θ_Z	30	mrad/s	
Mechanical properties			
Stiffness X, Y	0.1	N/µm	
Stiffness Z	4	N/µm	
Load (base plate horizontal / any orientation)	5 / 2.5	kg	max.
Holding force (base plate horizontal)	15	N	max.
Motor type	Brushless DC motor		
Miscellaneous			
Operating temperature range	0 to 50	°C	
Material	Stainless steel, aluminum		
Mass	1.7	kg	±5%
Cable length	2	m	±10 mm

Technical data specified at 20 ±3°C.
Ask about custom designs!
* 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.



H-810, dimensions in mm

SpaceFAB

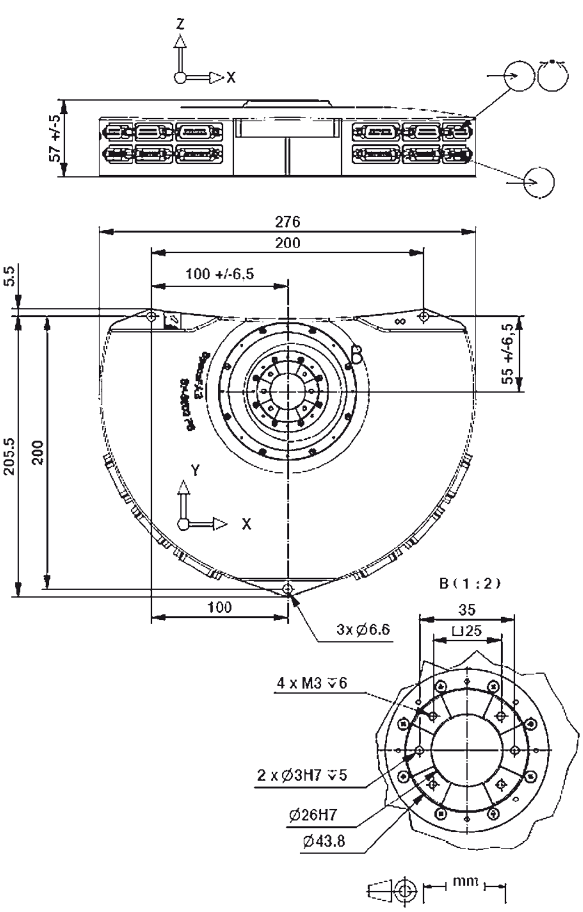
COMPACT, LOW-PROFILE SIX-AXIS MICRO ROBOT

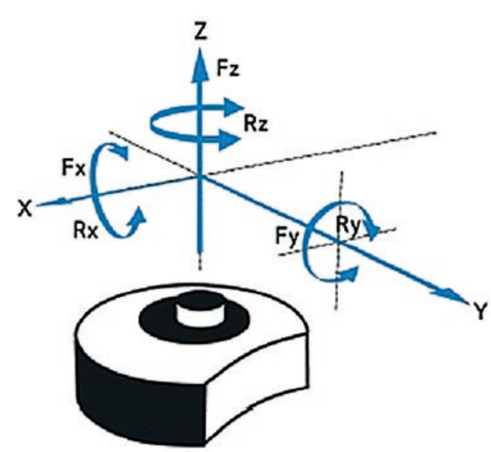
SF-6500 PS

- Linear travel ranges
  13 mm x 13 mm x 10 mm
- Rotatory travel ranges
  12° x 12° x 12°
- Load capacity up to 2 kg
  center mounted
- Pivot point can be set by the user
- User friendly software
- Can be used by any modern programming language
- Including software, controller and amplifiers

	SF-6500 PS
Travel range X, Y, Z (mm)	13 x 13 x 10
Travel range θ_x, θ_y, θ_z (°)	12 x 12 x 12
Speed max. (mm/s)	10
Speed max. (°/s)	5
Velocity range (mm/s)	0.002 ...10
Velocity range (°s)	0.002 ... 5
Bi-directional repeatability X,Y,Z (µm) (without load,center mounted directly on top of the platform)	±0.008
Bi-directional repeatability θ_x, θ_y, θ_z (°) (without load,center mounted directly on top of the platform)	±0.0005
Sensor resolution, without load X,Y,Z (µm) (without load,center mounted directly on top of the platform)	0.005
Sensor resolution θ_x, θ_y, θ_z (°) (without load,center mounted directly on top of the platform)	Depending on the position of the pivot point
Sensor resolution typ., without load X,Y,Z (µm) (without load,center mounted directly on top of the platform)	0.005
Sensor resolution typ., θ_x, θ_y, θ_z (°) (without load,center mounted directly on top of the platform)	Depending on the position of the pivot point

The maximum travel ranges in different coordinates directions (X,Y,Z , θ_x, θ_y, θ_z) are interdependent. The data for each axis in this table shows its maximum travel, wherec all other axes at their zero position. If the other linear or rotational coordinates are not zero, the available travel may be less. For more information, please contact us. The travel range is depending on the position of the pivot point.

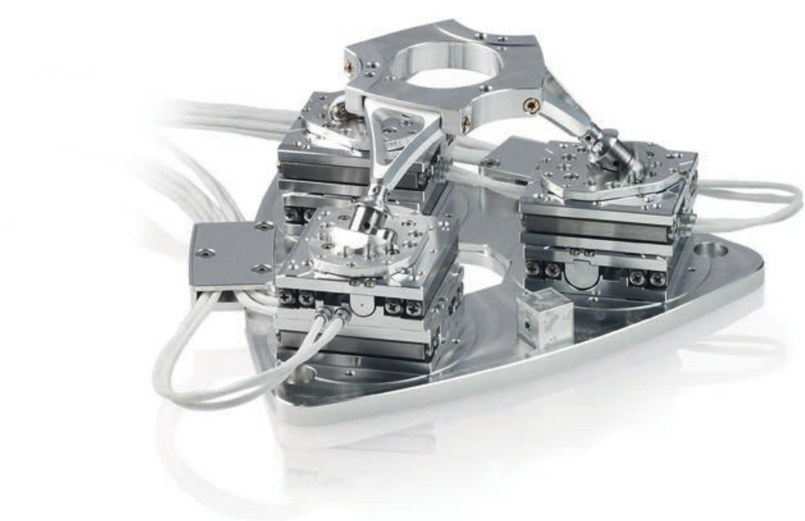




SF-6500 PS, dimensions in mm

Q-Motion SpaceFAB Micro Robot

PIEZO-MOTORIZED INERTIA DRIVE, 1 NM SENSOR RESOLUTION



Q-845

- Six-axis microrobotics system
- Dimensions in reference position 175 mm × 165 mm × 77 mm
- Linear travel ranges to 13 mm x 13 mm x 10 mm
- Rotary travel ranges to 14° x 14° x 14°
- Load capacity up to 5 N, center mounted

Preliminary Data	Q-845	Unit	Tolerance
Active axes	X, Y, Z, θ_X, θ_Y, θ_Z		
Motion and Positioning			
Travel range X, Y, Z	±6.5, ±6.5, ±5	mm	
Travel range θ_X, θ_Y, θ_Z	±7, ±7, ±7	°	
Sensor resolution	1	nm	
Bidirectional repeatability X, Y, Z	±0.25	µm	typ.
Bidirectional trajectory repeatability θ_X, θ_Y, θ_Z	±17.5	µrad	typ.
Max. velocity X, Y, Z	10	mm/s	
Max. velocity θ_X, θ_Y, θ_Z	5	°/s	
Mechanical Properties			
Stiffness X, Y	0.2	N/µm	
Stiffness Z	3.6	N/µm	
Load (base plate horizontal)	5	N	max.
Motor Type	Piezoelectric inertia drive		
Miscellaneous		°C	
Material	Aluminum		
Mass	1.5	kg	±5 %
Cable length	2	m	±10 mm

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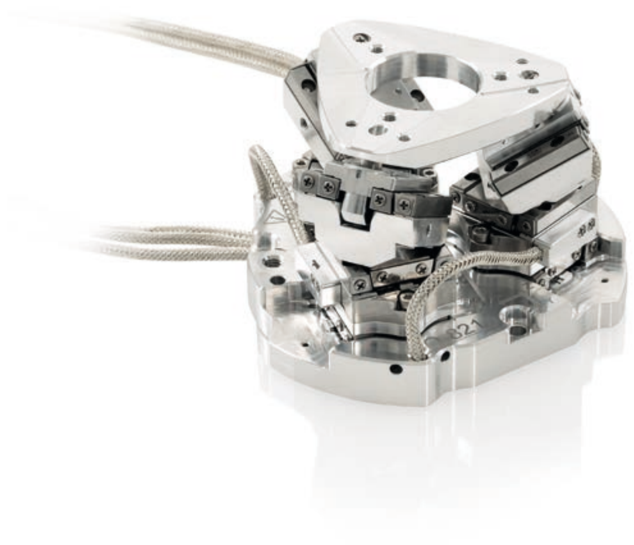
Q-Motion Miniature SpaceFAB Robot

PIEZO-MOTORIZED INERTIA DRIVE, ONLY 80 MM SIDE LENGTH



Q-821

- Six-axis microrobotics system
- Dimensions in reference position 80 mm × 73 mm × 48 mm
- Linear travel ranges to 12 mm x 12 mm x 6 mm
- Rotary travel ranges to 14° x 15° x 40°
- 1 nm sensor resolution

Preliminary Data	Q-821	Unit	Tolerance
Active axes	X, Y, Z, θ_X, θ_Y, θ_Z		
Motion and Positioning			
Travel range X, Y, Z	±6, ±6, ±3	mm	
Travel range θ_X, θ_Y, θ_Z	±7, ±7.5, ±20	°	
Sensor resolution	1	nm	
Max. velocity X, Y, Z	10	mm/s	
Max. velocity θ_X, θ_Y, θ_Z	5	°/s	
Mechanical Properties			
Stiffness X, Y	0.2	N/µm	
Stiffness Z	3.6	N/µm	
Load (base plate horizontal)	2	N	max.
Motor Type	Piezoelectric inertia drive		
Miscellaneous			
Material	Aluminum		
Mass	0.55	kg	±5 %
Cable length	2	m	±10 mm

Fast 6-Axis Hexapod

FOR LOADS TO 60 KG

H-900KSCO

- Low-wear, brushless DC motors
- Travel ranges to 200 mm in X and Y and up to 170 mm in Z
- Tilt and rotation angle to 66°
- High velocities

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.

Powerful digital controller, open software architecture
Optional: Software for avoiding collisions in restricted workspace

Fields of application
Motion simulation: Motion profile compatible according to ISO 20672, ISO 8728, and ISO 16328 Industrial production, tool machines, automotive industry, shipping

Preliminary Data	H-900KSCO customized solution	Unit	Tolerance
Motion and Positioning			
Single-actuator design resolution	0.58	µm	
Travel range* X, Y	200	mm	
Travel range* Z	170	mm	
Travel range* θ_X, θ_Y	66	°	
Min. incremental motion X, Y	5	µm	typ.
Backlash X, Y / Z	20 / 5	µm	typ.
Backlash θ_X, θ_Y / θ_Z	50 / 90	µrad	typ.
Repeatability X, Y / Z	±2 / ±0.5	µm	typ.
Repeatability θ_X, θ_Y / θ_Z	±5 / ±9	µrad	typ.
Max. velocity X, Y Z	80	mm/s	
Max. velocity θ_X, θ_Y θ_Z	520	mrad/s	
Typ. velocity X, Y, Z	20	mm/s	
Typ. velocity θ_X, θ_Y, θ_Z	130	mrad/s	
Mechanical Properties			
Load (base plate horizontal)	635	N	max.
Holding force, de-energized (base plate horizontal)	635	N	max.
Miscellaneous			
Material	Aluminum		
Mass	65.5	g	

Technical data specified at 20 ±3 °C.
Ask about custom designs!
* 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.

UHV-Compatible Miniature Piezo Hexapod

HIGH-PRECISION POSITIONING EVEN IN STRONG MAGNETIC FIELDS

P-911KNMV

- Ultra-compact
- UHV-compatible to 10^{-9} hPa
- Nonmagnetic
- Ultra-high precision flexure joints
- Load capacity to 1.5 kg
- Travel ranges to 1.5 mm, to 2°
- With NEXLINE® piezo stepping drives

The space-saving parallel-kinematic design allows for the low overall height of less than 90 mm and a diameter of only 100 mm. NEXLINE® piezo stepping motor drives and integrated incremental sensors ensure a position resolution down to 0.1 µm in the linear axes

Customized solution	Travel ranges	Max. load	Sensor resolution	Dimensions
P-911KNMV Miniature Hexapod	X, Y, Z: 1.5 mm θ_X, θ_Y, θ_Z: 2°	1.5 kg	0.1 µm	Ø external: 100 mm Height: 90 mm

Weather-Resistant Hexapod for Astronomy

PRECISION 6-AXIS POSITIONER FOR OUTDOOR APPLICATIONS

M-850KWAH

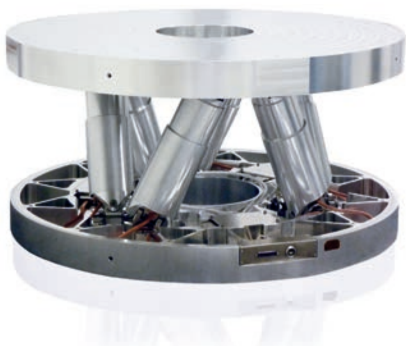
- Unidirectional repeatability 5 µm
- Load capacity to 75 kg
- Clear aperture Ø 420 mm
- Long Lifetime: 2 million cycles
- Drive: brushless motors
- Corresponds to protection class IP 64
- Corrosion protection

The M-850KWAH custom hexapod for astronomy applications is protected by rubber boots and suitable materials. The special mechanical design as well as a non-standard controller make it particularly well-suited for telescope applications in the highlands of Chile, where it is operated outdoors at elevations up to 5,000 m above sea level

Customized solution	Travel ranges	Max. load	Mass	Dimensions
M-850KWAH Weather-Resistant Hexapod for Astronomy	X: ±10 mm Y: ±11 mm Z: ±16 mm	75 kg	46 kg	Ø external: 580 mm height: 357 mm

Precision Hexapod for High Loads

VACUUM-COMPATIBLE, POSITIONING IN 6 AXES WITH MICROMETER ACCURACY



H-850KHLC

- Vacuum-compatible to 10^{-6} hPa
- Six degrees of freedom
- Load capacity to 1500 kg
- Travel ranges to 340 mm / 60°
- Min. incremental motion < 1 µm
- Drive: brushless DC motors with gearhead
- Sophisticated controller using vector algorithms

For positioning high loads in six axes of freedom, special requirements have to be fulfilled by the positioning system. The H-850KHLC Hexapod aligns elements in vacuum environments with highest precision, the mechanical coupling is adapted to the vacuum chamber's characteristics

Customized solution	Travel ranges	Max. load	Repeatability	Dimensions
H-850KHLC high-load Hexapod	X, Y: ±170 mm Z: ±100 mm θ_X, θ_Y: ±20 ° θ_Z: ±30 °	1500 kg	±3 µm	Ø external: 1200 mm height: 600 mm

Piezo Hexapod

FINE ADJUSTMENT AND ACTIVE, DYNAMIC ERROR CORRECTION

P-915KWEF

- Load capacity up to 1500 g
- Min. incremental motion 1 nm / 0.07 µrad
- Travel ranges to 70 µm
- Capacitive sensors for dynamic scanning and precision positioning

Highly dynamic reference-class 6-axis positioning system
Parallel-kinematic design for six degrees of freedom making it significantly more compact and stiff than serialkinematic systems, higher dynamic range, no moved cables: Higher reliability, reduced friction. Piezo actuator direct drives with high stiffness and resonant frequency for dynamic positioning. A powerful real-time digital controller controls the drive axes

Capacitive position sensors
Direct, absolute position measurement with subnanometer accuracy and a high bandwidth and stability

Applications
Dynamic optimization of axial runout, eccentricity and evenness of rotation stages. Vibration insulation, fine adjustment

Customized solution

Accessories

FOR HEXAPOD SYSTEMS

C-887.MC
Hexapod Control Unit, USB Connector, 3 m Cable

- Manual control
- Freely definable step size
- Display for position values

F-206.NCU
Rapid 3-Axis Piezo Nanopositioning System

For use in combination with Hexapod systems

- Consists of P-611.3SF NanoCube® XYZ nanopositioning system, 100 x 100 x 100 µm, strain gauge sensors with integrated fiber adapter interface and E-760.3S0 NanoCube® piezo controller board, ISA bus

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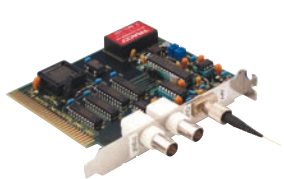


F-206.VVU
Photometer Card, Visible Range, 2 Channels

- Optical inputs in the 480 to 1040 nm range
- Analog inputs 0–10 V

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

- Optical inputs in the 850 to 1680 nm range
- Analog inputs 0–10 V

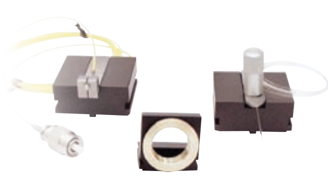
C-887.5Axx Hexapod Cable Sets

- Cable lengths up to 50 m

F-206.TMU
Additional Mounting Platform

Fits H-206 Hexapods

- For quick interchange of complete pre-mounted setups
- magnetic kinematically clamped



F-603
Fiber, Objective and Waveguide Holders

Fits H-206 and P-611 NanoCube®

- Mount on a Variety of PI Alignment Systems
- Precision Machined from High-Strength Aluminum/Brass

For more information, see www.pi.ws

Controller for Hexapod Positioning Systems

COMPACT BENCH-TOP DEVICE FOR CONTROLLING 6-AXIS SYSTEMS

C-887.52x

- Sophisticated controller using vector algorithms
- Commanding in Cartesian coordinates
- Coordinate systems can be switched with one simple command
- Analog interfaces and Motion Stop
- Extensive software support

Digital controller for 6-axis parallel kinematics

High-performance digital controller for Hexapods with DC motors. Additional control for two further single axes with integrated ActiveDrive.

Functions

Position input via Cartesian coordinates, coordinate transformation handled by the controller. To simplify integration of the Hexapod, the coordinate system can be quickly and easily changed. The real-time system prevents jitter and therefore guarantees constantly low response times. Stable, virtual pivot point can be defined freely. Data recorder for recording operating parameters such as motor control, velocity, position or position errors. Macro command language. An autostart macro allows stand-alone operation. The controller supports motor brakes and absolute-measuring sensors with BiSS interface.

Optional:

- Control via manual control unit
- Collision checking for restricted space with PIVeriMove software

Interfaces

Ethernet for remote control and remote maintenance. RS-232. USB connection for external input devices (HID).

Additional interfaces (version-dependent):

- Motion Stop: The supply voltage of the hexapod drive can be switched off using the external switch connected to the controller. The sensor technology remains active so that position information continues to be available and a reference move is not necessary when the drive is reactivated.
- Analog inputs

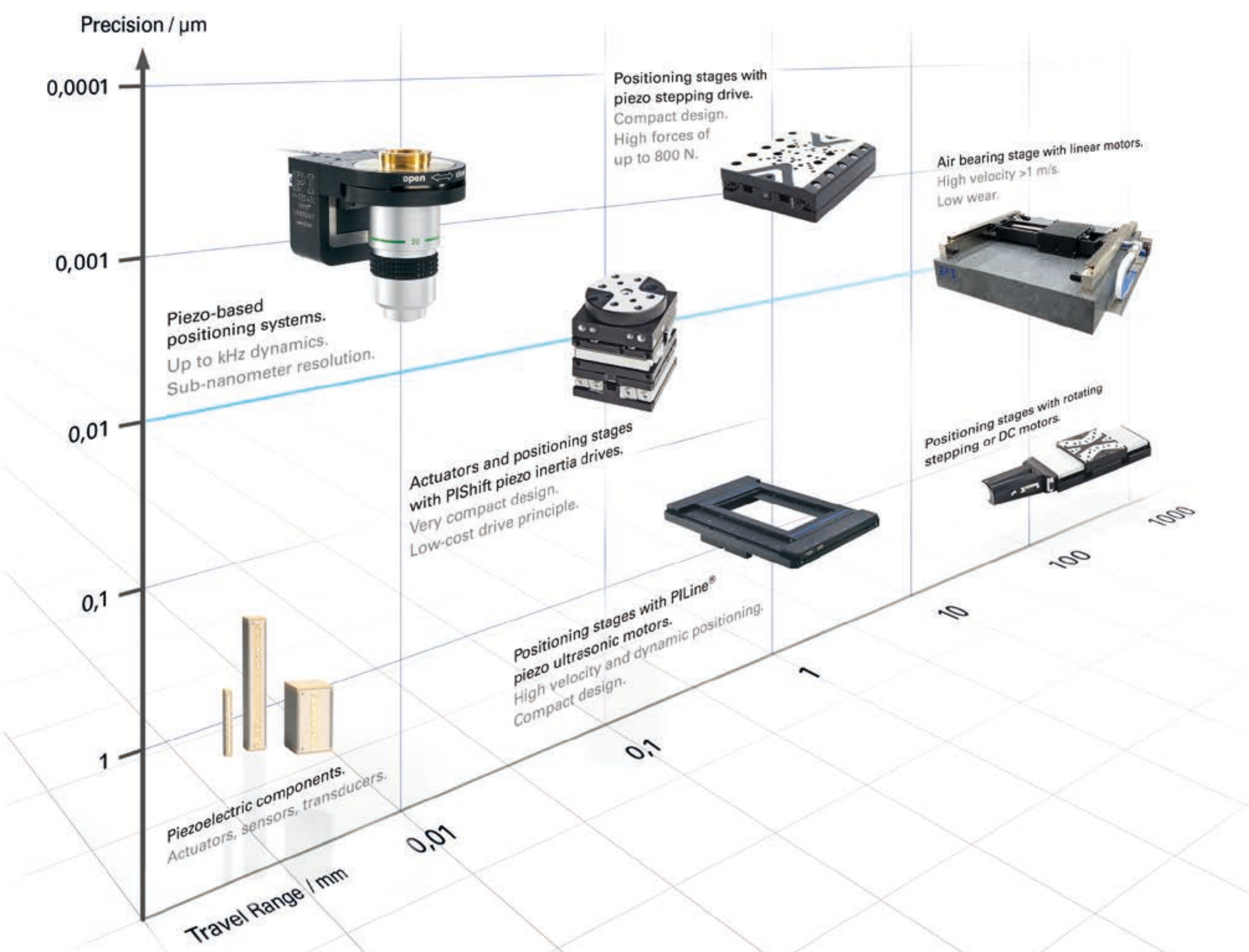
Extensive software

PIMikroMove user software. Common command set for all PI positioning systems. Dynamic libraries for Windows and Linux. Complete set of LabVIEW VI's. Graphical user interfaces, configuration software and graphically displayed scan routines. Optional: PIVeriMove Software for checking a restricted operating space.

Also available:

C-887.53x Hexapod Motion Controller with EtherCAT Fieldbus Interface
Further information on www.pi.ws.

	C-887.52 C-887.521 C-887.522 C-887.523
Function	6-axis controller for Hexapods, incl. control of two additional single axes Compact benchtop Extending the functionality of C-887.52: C-887.521: Additional Analog Inputs C-887.522: Additional Motion Stop C-887.523: Additional Motion Stop and Analog Inputs
Drive type	Servo motors (Hexapod and single axes)
Motion and control	
Servo characteristics	32-bit PID controller
Trajectory profile modes	Jerk-controlled generation of dynamics profile with linear interpolation
Processor	Intel Atom dual core (1.8 GHz)
Servo cycle time	100 µs
Encoder input	AB (quadrature) differential TTL signal, 50 MHz BiSS
Stall detection	Servo off, triggered by position error
Reference point switch	TTL
Electrical properties	
Hexapod control	12-bit PWM signal, TTL, 24 kHz
Hexapod power source	24 V
Maximum output current	7 A
Interfaces and operation	
Interface / communication	TCP/IP, RS-232 USB (HID, manual control unit)
Hexapod connection	HD Sub-D 78-pin (f) for data transfer M12 4-pin power input
Connectors for single axes	Sub-D 15-pin (f)
I/O ports	HD Sub-D 26-pin (f): 4 × analog input (-10 to 10 V, via 12-bit A/D converter) 4 × digital input (TTL) 4 × digital output (TTL)
Analog inputs, only C-887.521, C-887.523	2 x BNC, -5 V to 5 V, via 16-bit A/D converter, 5 kHz bandwidth
Input for Motion Stop, only C-887.521, C-887.523	M12 8-pin (f)
Command set	PI General Command Set (GCS)
User software	PIMikroMove
Software drivers	LabVIEW driver, dynamic libraries for Windows and Linux
Manual operation	Optional: C-887.MC Manual control unit for Hexapods
Miscellaneous	
Operating voltage	24 V external power supply for 100 to 240 VAC, 50 / 60 Hz, in the scope of delivery
Maximum current consumption	8 A
Operating temperature range	5 to 40 °C
Mass	2.8 kg
Dimensions	280 (320) mm × 150 mm × 103 mm Power supply: 170 mm × 85 mm × 42.5 mm



Key Technologies

MOTION CONTROL ON SIX AXES

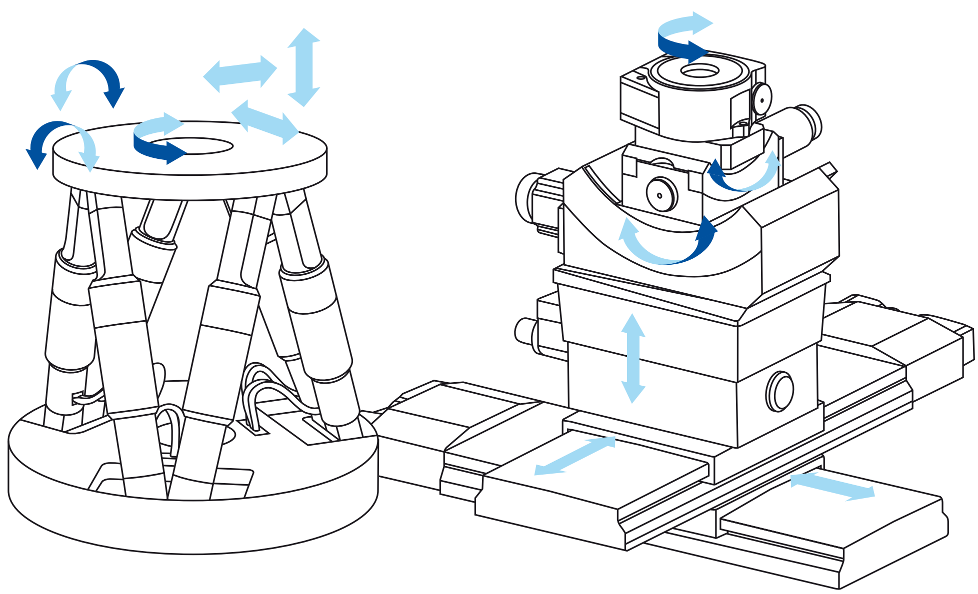
Drive Technology

COMPARISON

Drivetrain	Ideal for ...	Why parallel kinematics with this drive principle?
Piezo stack actuator in multilayer or pressing technology	■ Nanometer-precision positioning with high dynamics ■ Lever-amplified and guided systems ■ Piezo scanners ■ Fine adjustment ■ Force generation ■ Active vibration cancellation ■ Miniaturization: very compact stages	Active vibration cancellation on 6 axes, vacuum and nonmagnetic environments
PiezoWalk® piezo stepping drive	■ Nanometer-precision positioning ■ High holding force ■ Travel ranges up to a few mm ■ Coarse and fine adjustment ■ Force generation ■ Active vibration cancellation ■ Operation with constant low velocity	Compact designs, vacuum and nonmagnetic environments
PILine® ultrasonic piezomotor	■ Positioning with sub-μm-accuracy ■ Fast step-and-settle ■ Scan mode with high velocities ■ Operation with constant low velocity	Compact designs, vacuum and nonmagnetic environments
Piezo inertia drive	■ Nanometer-precision and long-term stable positioning ■ Low to medium holding force ■ Miniaturization: very compact stages ■ Affordable positioning of small loads	Very compact designs, vacuum and nonmagnetic environments, sample positioning e.g., in X-ray tomography
Brushless or brushed DC servo or stepper motor, with and without gearhead	■ Positioning with sub-μm-accuracy ■ Miniaturization: compact stages	6-axis positioning with high accuracy, e.g., sample positioning in laboratories and beamline experiments, fiber alignment, fiber-to-chip alignment, stable test systems, high-precision mounting fixtures motion simulation, precision following of specified trajectories
PIMag® voice coil drive	■ Positioning with sub-μm-accuracy ■ Fast step-and-settle ■ Scan mode with high velocities ■ Miniaturization: very compact stages	Automatic test cycles with high acceleration and high velocity Motion simulation with high frequencies, precision following of specified trajectories
PIMag® linear motor	■ Positioning with sub-μm-accuracy ■ Fast step-and-settle ■ Scan mode with high velocities	Virtually unlimited travel ranges. Automatic test cycles with high acceleration and high velocity Motion simulation with high frequencies, precision following of specified trajectories

Hexapods – Parallel-Kinematics Positioning Systems

HIGH-PRECISION MOTION CONTROL IN UP TO SIX AXES



- Large central aperture
- Three linear axes, three rotational axes
- Low moving mass, low inertia
- Excellent dynamic behavior, fast step-and-settle
- Small installation space
- High stiffness
- Freely definable pivot point
- Minimized axis crosstalk motion
- Very good repeatability

Compact positioning system with 6 degrees of freedom

Hexapod platforms are used for precision positioning and alignment of loads in all six degrees of freedom, three linear axes, and three rotational axes.

Hexapods have a parallel-kinematics structure, i.e., the work piece is actuated simultaneously by multiple actuators, rather than taking a stacked approach. The parallel arrangement of the actuators optimizes the overall system stiffness and allows for a large central aperture.

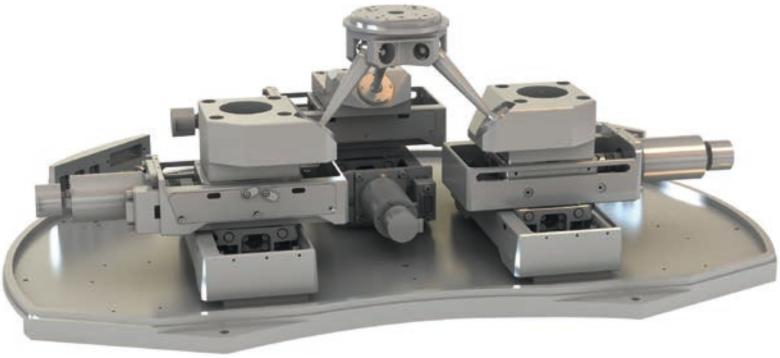
Precise positioning of loads from 2 kg to 2000 kg

Depending on their design, Hexapods can position loads from several kg up to several tons in any spatial orientation, in other words independently of the mounting orientation and with submicrometer precision.

Advantages over serial kinematics design

Hexapods can be designed considerably more compact than serially stacked multi-axis positioning systems and there are no moving cables to increase the footprint. Since only a single lightweight platform is actuated the moving mass is significantly smaller, too. This results in improved dynamics with considerably faster response and reduced step-and-settle times. Furthermore, there are no cable management issues as with serial-kinematics multi-axis positioners. Here friction and torque caused by the cables reduce the positioning accuracy and repeatability.

This principle where the lowest axis not only moves the mass of the payload but also the mass all other positioning mechanics above reduces the stiffness and dynamic performance and results in the accumulation of individual off-axis errors.



If the stiffness requirements of the total system are lower, a 3-strut design can also be used in which additional degrees of freedom are produced because a passive strut can be moved in two or more axes. Example: In the SpaceFAB the individual struts are driven by one XY translation stage each (figure: PI miCos GmbH)

Selection of the mechanical components

A Hexapod is more than the sum of its individual parts. All components have to be carefully selected and designed with the idea of multi-axis motion in mind. This starts with the use of backlash-free mechanical parts and thermally matched materials. The joints also play a very important part because there are 12 of them and all are involved in every move the Hexapod makes. The precision of every strut (actuator) itself is important, too, however it is not enough to equip these actuators with high-resolution sensors and hope the Hexapod system accuracy will be identical to the sensor resolution. On the contrary, there are other more important factors.

Motors and drives

PI Hexapods are based on electromechanical or piezoelectric drives and differ significantly from the hydraulic Hexapods known from flight or driving simulators. Depending on the application, direct-drive designs or gear motors are used, rollerscrews or ballscrews, brushless motors and even linear motors are employed. PI also makes non-magnetic and EUV compatible Hexapods.

Joints

A number of different joint designs is also available to optimize the Hexapods. If high load capacity and overall stiffness are important universal joints with two orthogonally arranged axes, i.e. two degrees of freedom, are the premium choice.

Ball and socket joints offer more degrees of freedom in a relatively simple design. However, the overall stiffness and precision in case of external loads and torque can suffer. A compensating preload is recommended but requires drives with high output forces such as the NEXLINE® piezo walk motors shown in the figure here.

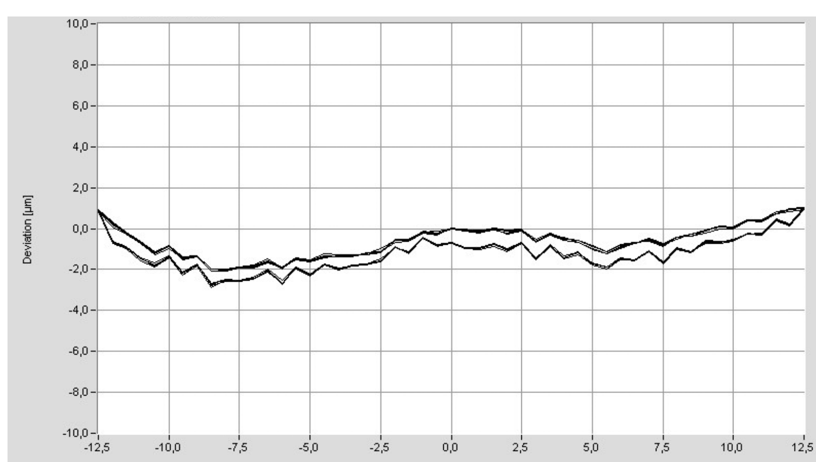
If the highest precision is required, flexure joints are recommended. They exhibit neither friction nor backlash and do not require lubricants. However, they only work over relatively small travel ranges.

The work space

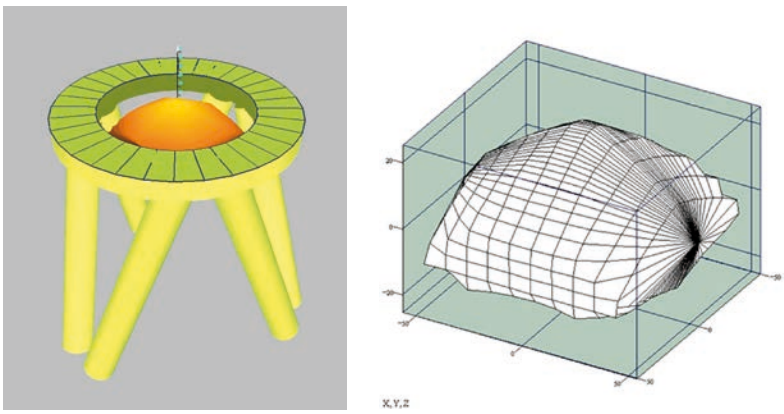
In addition to linear motion, the Hexapod platform can carry out any combination of tilting and rotation around a freely selectable pivot point. Due to the parallel kinematics design, the work space is also not limited by cables movement and cable management systems.

Universal joints of the H-840 Hexapod model

Ball and socket joints



The Z-axis positioning accuracy of an H-824 Hexapod over 25 mm full travel is in the range of a few micrometers only, with the repeatability well below ±0.1 µm



The entirety of all combinations of translations and rotations that a Hexapod can approach from any given position is called the work space; it is given in reference to the origin of the coordinate system used. The work space can be limited by external factors such as obstacles or the position and size of the load

Hexapods with passive struts

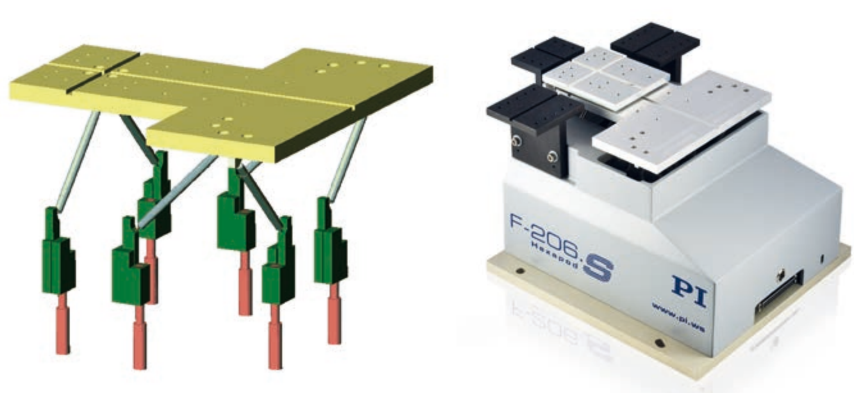
IInstead of variable, active struts, Hexapods can be designed with passive struts that show constant strut length. In this case the coupling points or joints are usually moved along a linear path. This design is advantageous when the drive unit is to be separated from the platform, e.g., outside of vacuum chambers.

Advanced motion control

The individual drives of a Hexapod do not necessarily point in the direction of motion, which is why a powerful controller that can handle the required coordinate transformations in real time is needed.

PI uses advanced digital controllers along with user-friendly software. All motion commands are specified in Cartesian coordinates, and all transformations to the individual actuators take place inside the controller.

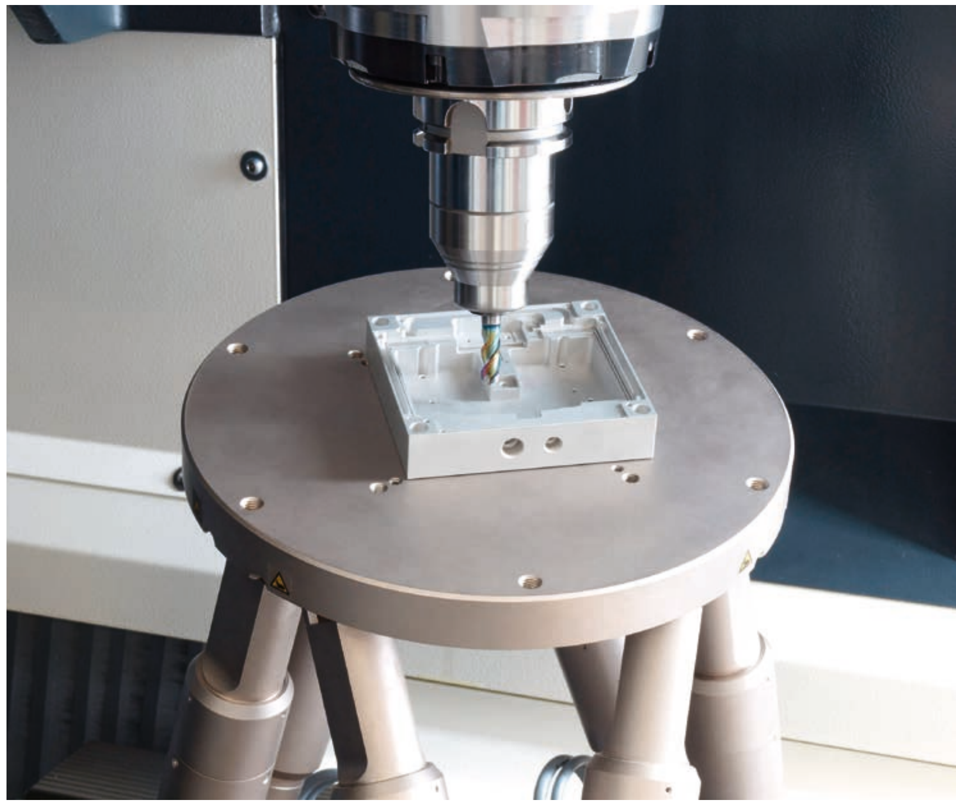
An important Hexapod property is the freely definable pivot point. The possibility to rotate around any point in space opens up new applications from fiber alignment to astronomy.



Constant strut-length Hexapod design. The drive units move the joint position up and down affecting the linear and rotary position of the platform

Hexapods in Automation

CONTROL AND INTERFACES FOR EASY INTEGRATION



Standardized fieldbus interfaces make integration easier: Hexapods in automation technology

Precise trajectory control using G-Code

The Hexapod controller may also control the trajectory based on G-Code according to DIN 66025/ISO 6983. The G-Code command language is directly implemented in the controller.

With G-Code, moving along complex trajectories with defined velocity and acceleration is possible. The Hexapod system can, for example, move a workpiece or tool jerk-controlled and with high precision during machining without the mechanical system starting to vibrate.

User-defined coordinate systems

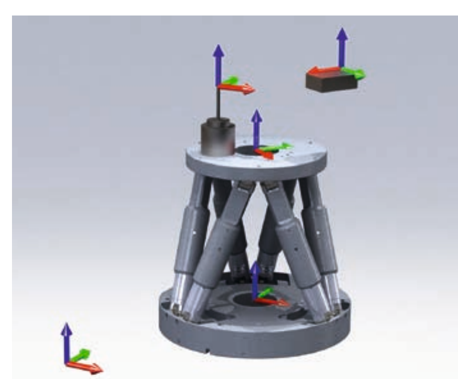
To adapt the trajectory perfectly to the requirements of the application, it is possible to define various coordinate systems which refer, for example, to the position of workpiece or tool. This offers great advantages for applications in industrial automation, but also for fiber alignment.

Standardized automation interfaces

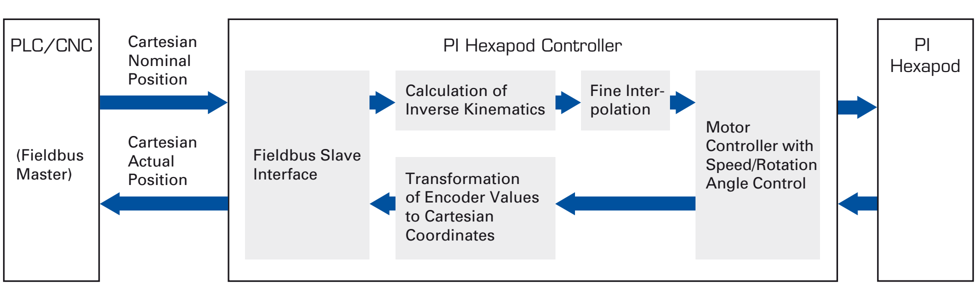
Standardized fieldbus interfaces guarantee an easy connection to parent PLC or CNC controls so that Hexapods can work synchronously with other components in one automation line.

The PLC acts as master and defines the target position in Cartesian coordinates and the trajectories; in return, it gets the actual positions also over the fieldbus interface. All other calculations required to command the parallel-kinematic six-axis system are done by the Hexapod controller, i.e. transforming the nominal positions from Cartesian coordinates into drive commands for the individual drives. In this case, the controller acts just like an intelligent drive.

The cycle times for determining new positions, evaluating signals and synchronizing are between 1 and 3 ms. Fieldbus interfaces are currently available for Profibus, EtherCAT, Profinet, CANopen and SERCOS.



Any coordinate system used as a reference for target values of the Hexapod may be defined



Block diagram: The Hexapod controller acts just like an intelligent drive. The fieldbus interface can be exchanged to allow communication with numerous types of PLC or CNC control

High-Dynamics Hexapod as Motion Simulator

TEST EQUIPMENT WITH SIX MOTION AXES FOR LABORATORY AND INDUSTRIAL USE

- Direct magnetic drives for high accelerations
- High motion repeatability in the submicrometer range
- Running of predefined motion profiles
- Operating frequencies of >100 Hz for small strokes

PI Hexapod in a test setup for CIPA certification (Image: Image Engineering)

Dynamic Motion and Scanning in Six Axes

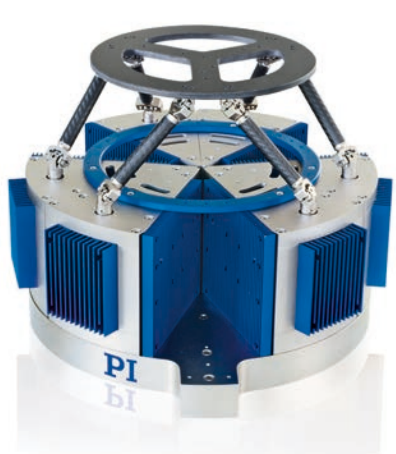
Motion simulators have higher motion dynamics requirements (shakers). They repeatedly perform defined motion cycles, for example for quality assurance and function monitoring of products in mobile use. Motions that are generated, for example, by trembling hands or a moving car, are simulated by means of sine curves and freely definable trajectories.

Six degrees of freedom allow fast motion sequences to be repeated identically in different locations of the workspace.

Applications

Testing of image stabilization algorithms in camera systems, also for mobile devices. In the process, the Camera & Imaging Products Association (CIPA) Standards must be taken into account.

Simulation of oscillations, e.g. eye motion simulation and eye tracking in the medical field.



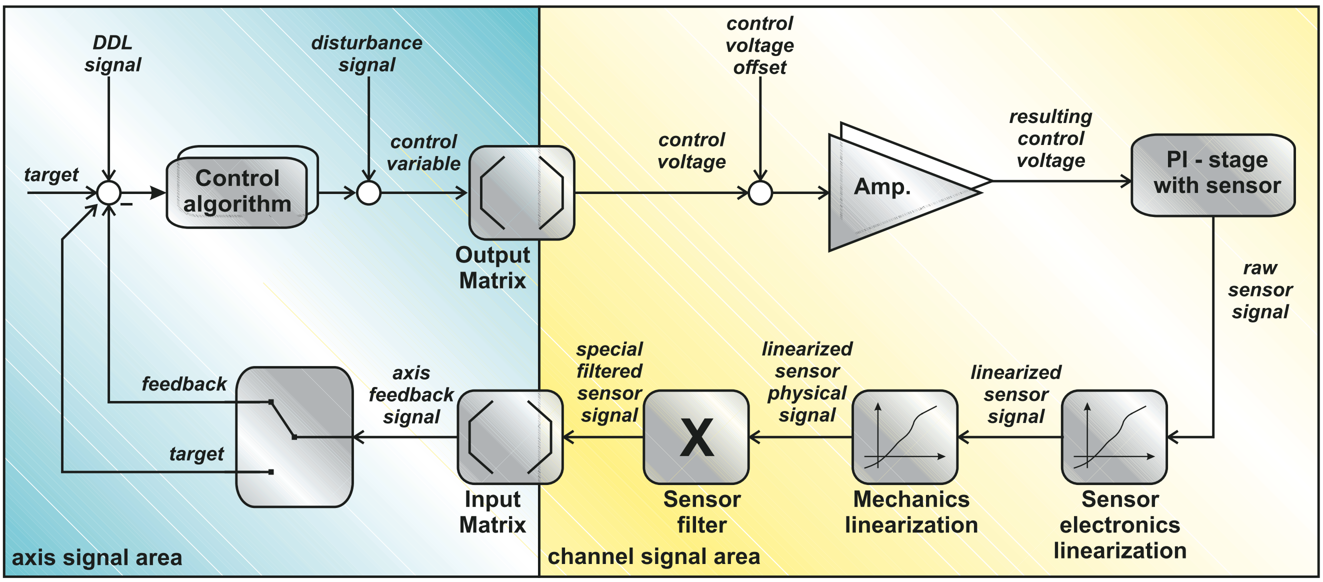
Drive Principles

To generate highly dynamic motions, various drive principles can be used. Hexapods with electromagnetic, brushless torque motors and an appropriate mechanical design of the drive train and sensor system can already provide velocities of up to 25 mm/s and accelerations of up to 2 g.

The best dynamic performance is achieved by Hexapods with magnetic PIMag® direct drives; they offer velocities of several hundred mm/s and accelerations of up to 4 g. The special design which includes flexure joints completely dispenses with rolling or frictional elements, thus allowing a zero-backlash motion without mechanical noise.

Control-Loop Integrates Active Vibration Damping

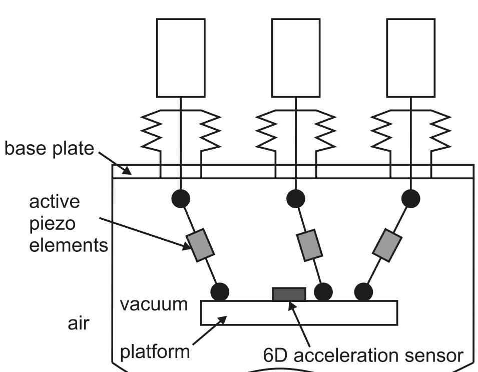
FOR UHV-COMPATIBLE HEXAPOD 6D-POSITIONER



Control design of an E-712 digital controller for active vibration damping

Positioning systems for UHV environments require special mechanical design features.

One particularly elegant solution is the implementation of a parallel-kinematic 6-axis Hexapod with constant leg length, in which only passive parts of the drive system are accommodated inside the vacuum chamber. Electrical and electronic parts, such as motors, sensors, wiring or parts in need of lubrication are situated outside the vacuum chamber. As a result, the space needs within the chamber are very low and the passive hexapod structure inside the chamber is very stiff. Moreover, the vacuum is contaminated as little as possible and no additional cooling of the drives is needed.



The Hexapod design is based on passive, constant-length struts, where the position of the joint is being shifted by external linear actuators. The active and the passive structures are separated by the base plate of the vacuum chamber

Integrated active vibration damping

A crucial factor for the precision is the decoupling of low frequency ambient vibrations that excite resonances in the mechanical system and thus would interfere with the stability and precision of the platform.

For this purpose, the passive struts are equipped with piezo ceramic actuators. A newly developed 6D acceleration sensor feeds vibration back to a closed-loop piezo controller. Digital linearization algorithms for the mechanical and electronic systems and filter functions for the sensor signals further enhance the performance resulting in damping factors in excess of 20 for multidirectional vibrations up to 50 Hz. Linearization algorithms for the mechanical and electronic systems and filter functions for the sensor values then allow undesired vibrations to be dampened completely.

Motion Control Software from PI

EFFECTIVE AND COMFORTABLE SOLUTIONS

Parallel Kinematics

UP TO 6 DEGREES OF FREEDOM

Nanopositioning

SUB-NANOMETER RESOLUTION

GCS

MOTION CONTROL

Drive Technology

DC, STEPPER, PIEZO, MAGNETIC

Micropositioning

LONG TRAVEL RANGES

Supported operating systems

- Windows XP (SP3)
- Windows VISTA
- Windows 7 32/64 bit
- Linux 32/64 bit

All digital controllers made by PI are accompanied by a comprehensive software package. PI supports users as well as programmers with detailed online help and manuals which ease initiation of the inexperienced but still answer the detailed questions of the professional. Updated software and drivers are always available to PI customers free of charge via the Internet.

PI software covers all aspects of the application* from the easy start-up to convenient system operation via a graphical interface and quick and comprehensive integration in customer written application programs.

Universal command set simplifies commissioning and programming

PI's General Command Set (GCS) structure is consistent for all controllers regardless of their complexity and purpose. GCS with its many preprogrammed functions accelerates the orientation phase and the application development process significantly while reducing the chance of errors, because the commands for all supported devices are identical in syntax and function. Further advantages are that different PI controllers can be added and integrated more easily and system upgrades can be introduced with a minimum of programming effort.

* Not every function is available for all controllers. For details, please refer to the corresponding product data sheets.

PIMikroMove software ensures rapid start-up

PIMikroMove is PI's convenient graphical user interface for any type of digital controller and positioning system, regardless of whether piezoelectric, linear motors, or classical electrical motor drives are used and independent of the configuration and number of axes.

All connected controllers and axes are displayed and controlled consistently with the same graphical interface. Two or more independent axes can be controlled by the position pad using a mouse or joystick; Hexapod six-axis positioning systems are also displayed graphically.

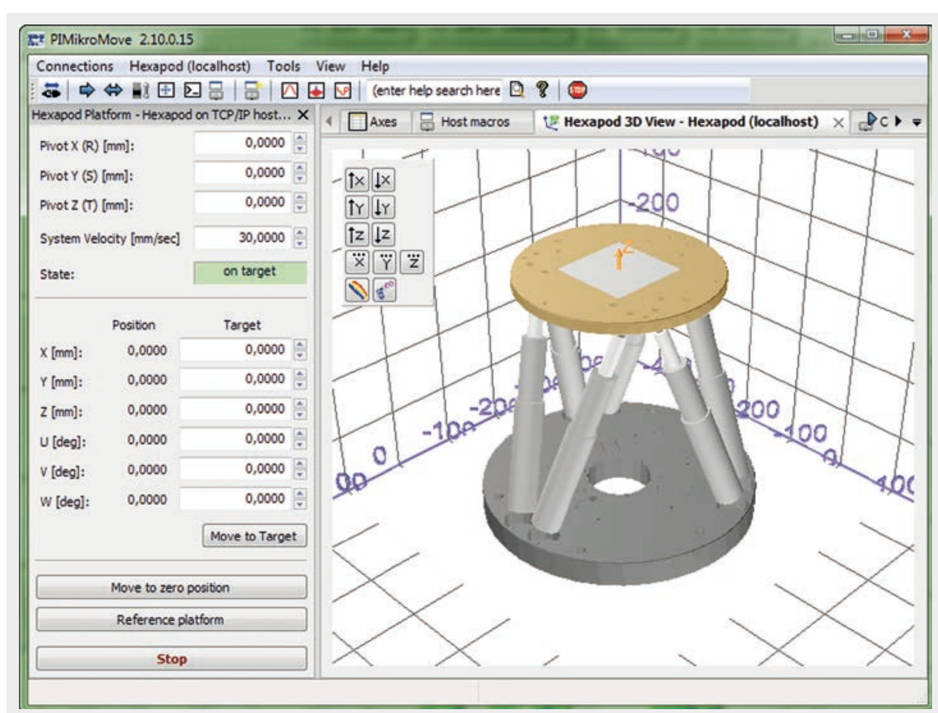
Macro programs simplify repetitive tasks for example in automated processes. The macros are created as GCS command sets that can be executed directly on the controller, e.g., as a start-up macro that allows standalone operation; they can also be processed by the host PC.

Scan and align algorithms can record analog values, e.g., the output of a power meter as a function of position for later evaluation with external software. They can also automatically find the global maximum of, for example, the coupling efficiency of optical devices.

Depending on the specific controller, PIMikroMove supports a number of additional functions. A data recorder can record system parameters and other variables during motion for later analysis.

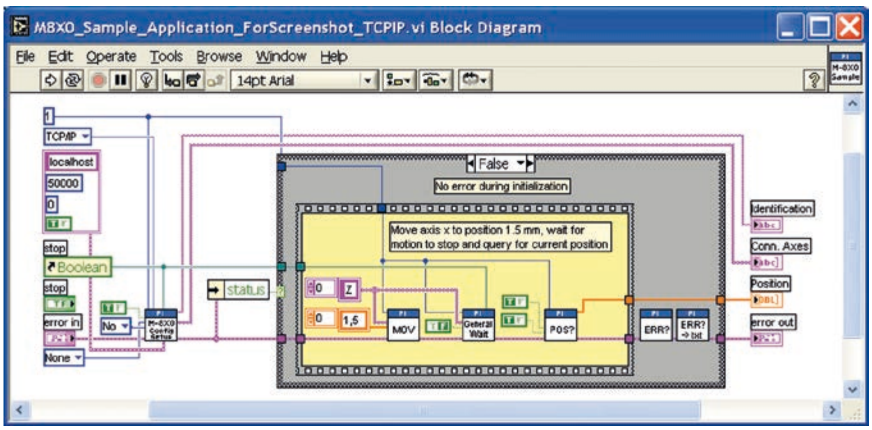
Optimizing system behavior

When the mechanical properties of a positioning system are changed, e.g., by applying a different load, motion control parameters often need to be adapted. PI software provides tools for optimization of the system response and stability. Different parameter sets can be saved for later recall, also accessible from custom application programs.



Programming

RAPID INTEGRATION OF PI POSITIONING SYSTEMS AND CONTROLLERS



In measuring and control technology and automation engineering, many applications are produced in LabVIEW. PI provides complete LabVIEW drivers sets to facilitate programming. A controller-specific Configuration_Setup VI is integrated at the start of the LabVIEW application and includes all system information and initiation steps required for start-up. The application itself is implemented with controller-independent VIs. In case of a controller change or upgrade, it is usually only necessary to exchange the Configuration_Setup VI , whereas the application-specific code remains identical due to the consistent GCS command set structure. The driver set includes many specific exemplary programs, e.g., comprehensive scan and align applications that can be used as template for own programs. Moreover, the open source code of many VIs allows for rapid adaptation to the user needs.

Supported languages and software environments

- C, C++, Python, Visual C++, Visual Basic, Delphi
- LabVIEW, MATLAB, µManager, EPICS, TANGO, MetaMorph
- and all programming environments that support the loading of DLLs

Flexible integration in text-based programming languages

The integration of PI positioning systems in text-based programming languages under Microsoft Windows or Linux is simplified by program libraries and exemplary codes.

These libraries support all common programming languages and all PI positioning systems , allowing the PI GCS command set functions to be integrated seamlessly in external programs.

Third-party software packages

Drivers for the PI GCS commands have now been integrated in many third-party software packages. This allows for the seamless integration of PI positioning systems in software suites such as MetaMorph, µManager, MATLAB, and ScanImage. Moreover, EPICS and TANGO drivers are available for integration into experiments of large-scale research facilities. The drivers for µManager, MATLAB and a large part of the EPICS drivers are being developed and serviced in-house by PI.

Hexapod-Specific Software

Due to their parallel kinematic structure, Hexapods necessitate a particularly complex control system. The position coordinates, for example, are given in virtual Cartesian axes which are then converted into positioning commands for the individual actuators by the controller. PI supplies special software that allow the 6-axes positioners to be more convenient in operation and easier to integrate.

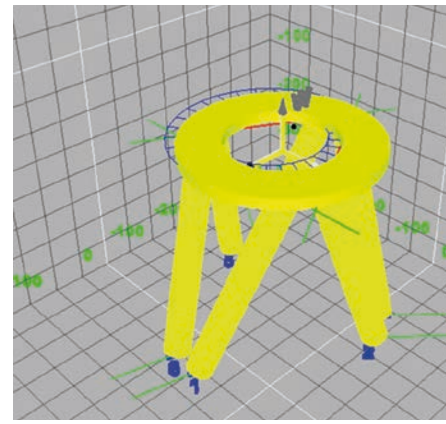
Determining the work space

The limits of the work space vary depending on the current position of the Hexapod (translation and rotation coordinates) and the current coordinates of the pivot point. A special software tool included with each PI Hexapod calculates these limits and displays them graphically.

Checking the permissible load

As with any multiaxis positioning system, the load limit of the Hexapod varies as a function of a number of factors such as orientation of the Hexapod, size and position of the payload, current position (translation and rotation coordinates) of the Hexapod platform, and forces and moments acting on the platform.

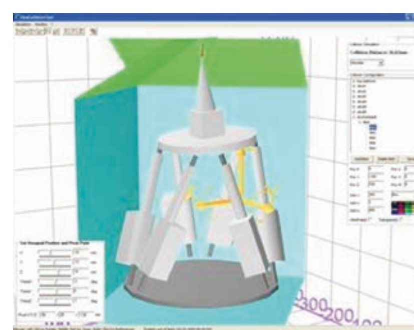
The Hexapod software package includes a PI simulation tool that calculates all forces and moments and compares them individually against the specified load limits of the corresponding Hexapod mechanics.



The simulation software graphically displays the position and the available work space of the Hexapod model

Preventing collisions with PIVeriMove

Another proprietary PI simulation software tool enables offline graphical configuration and simulation of the Hexapod motion in the application environment. CAD data of objects can be imported or approximated with simple shapes such as cylinders and cuboids. PIVeriMove then checks restrictions in the work space. Implemented in the controller firmware or the application software, this prevents the Hexapod from approaching positions where the platform, struts, or the mounted load would collide with the surroundings.



Emulation: The Hexapod system as a virtual machine

A virtual machine that can be installed on the customer's host PC is available to emulate a complete Hexapod systems (mechanics, controller and even peripherals). Application programs can then be developed and pre-tested, different load scenarios can be simulated and the work space can be determined before the system arrives, saving significant cost and development time.

HexaApp: PI Hexapod control via iPhone, iPad or iPod

The Hexapod system can also be controlled wirelessly from mobile Apple iOS devices. A corresponding app enables command control of touchscreen, motion sensors or via a command input window.

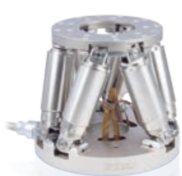
The PI Group Milestones

A SUCCESS STORY

1970
Founding year of PI

1987
New subsidiary in the USA

1991
Market introduction of six-axis parallel-kinematic positioning systems: Hexapods



New subsidiary in Japan

1992


Foundation of PI Ceramic, cornerstone for market leadership in nanopositioning technology

1993
New subsidiaries in Great Britain and France

1994


Market introduction of capacitive position sensors, implementation in piezo-based nanopositioning systems

1998
Market introduction of digital control electronics

2001


Market introduction of PILine® ultrasonic piezomotors

2002

Market introduction of the PICMA® multilayer piezo actuators

New subsidiary in China

2004

Market introduction of the NEXLINE® high-performance piezo linear drives

2007

Market introduction of the DuraAct patch transducers

Market introduction of NEXACT® piezo linear drives

2011

Acquisition of majority shares in miCos GmbH

New subsidiaries in Korea and Singapore

2014

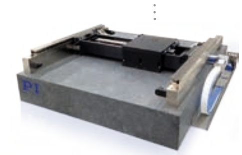
Market introduction of the magnetic PIMag® direct drives

Market introduction of Q-Motion® and PiezoMikes

2015

Introduction of air bearings

Acquisition of Nelson Air Corp., USA



New subsidiaries in Taiwan and the Netherlands

Product Overview

PIEZO ACTUATORS AND COMPONENTS, PRELOADED PIEZO ACTUATORS

Variable Designs, Optionally with Position Measurement, UHV Versions, High Dynamics, Sub-Millisecond Response Time, Picometer Resolution

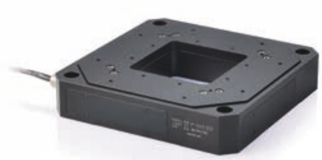
PICMA® multilayer piezo actuators

Piezoelectric components

PIEZO SCANNERS AND POSITIONING STAGES

Nanometer Precision and Millisecond Settling Time

Fast tip/tilt mirrors



Technology for up to six axes:
flexure joints, capacitive sensors,
PICMA® piezo actuators

Piezo scanners and lens focusers:
microscope lens and specimen
fast and precise positioning

PRECISION LINEAR ACTUATORS AND DIRECT DRIVES

Linear actuator with piezomotor for high resolution and drift-free long-term positioning

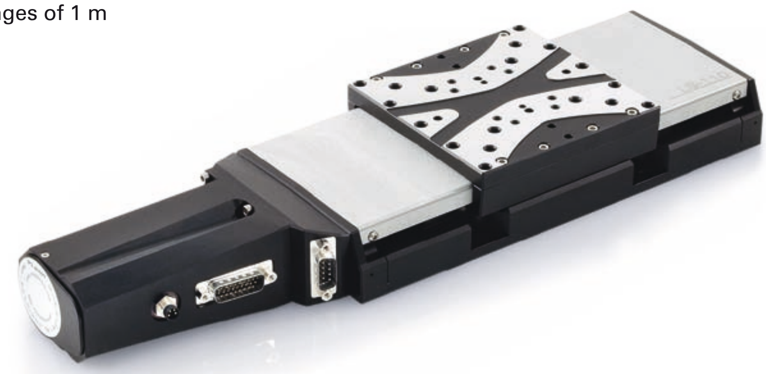
Voice-coil drive for high dynamics, optional force sensor for force-control operation

High load actuators with axial forces up to 400 N for industrial automation

PRECISION LINEAR POSITIONING STAGES

From Miniature Positioning Stages to Travel Ranges of 1 m

Miniature stages with piezomotors



High-precision positioning stages

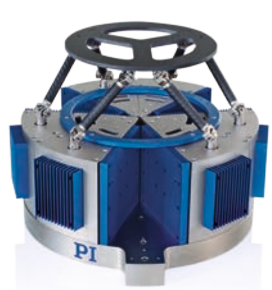
Ultraprecision with air bearings

High velocity and precision
due to magnetic direct drives

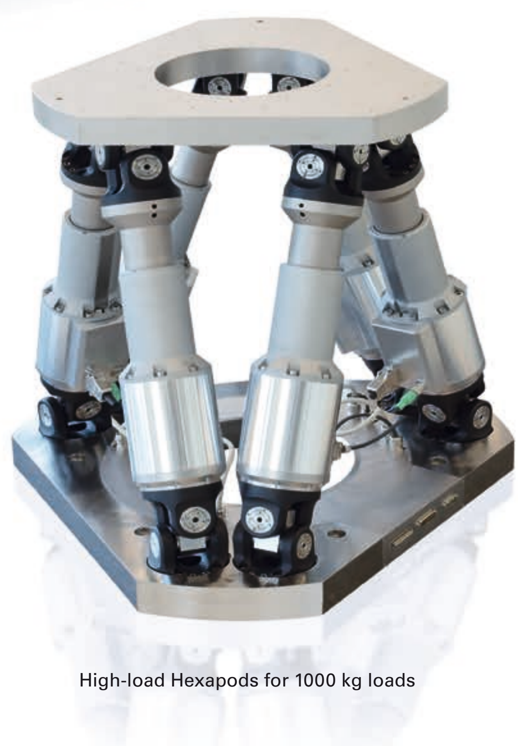
HEXAPOD AND SPACEFAB

Parallel Kinematics for Precise Positioning in Six Axes

Compact design
for microassembly



Dynamic hexapod
for motion simulation



High-load Hexapods for 1000 kg loads

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