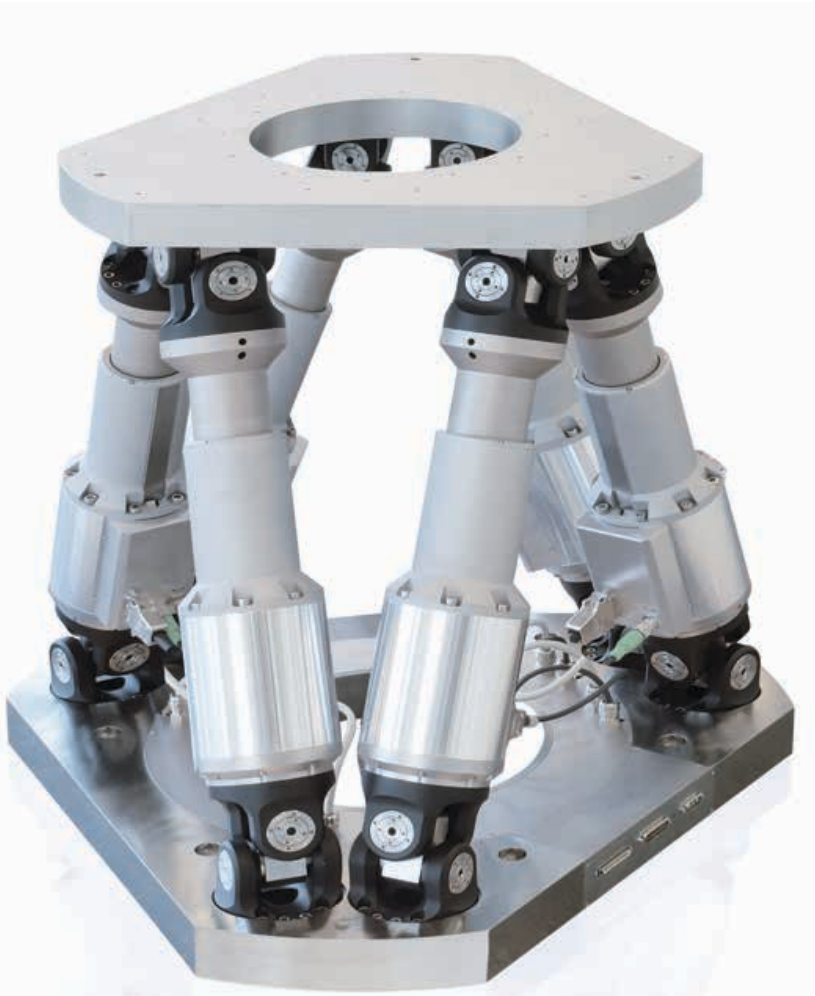
High-Load Hexapod

POSITIONING 1 TON WITH MICROMETER PRECISION



EtherCAT® Option

EtherCAT® is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.

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
- Drive: brushless motors with brake

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 motor/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

Specifications

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.

Order Information

H-845.D11
High- Load Hexapod for 1000 kg Load, Travel Ranges ±110 mm (X, Y), ±50 mm (Z), Max. Velocity 20 mm/ s.
Cable Set 9 m, with 6- D Hexapod Controller, Control of 2 Additional Servo- Motor Axes Included, TCP/ IP and RS-232 Interface

H-845.D21
High- Load Hexapod for 1000 kg Load, Travel Range ±190 mm (X, Y), ±105 mm (Z), Max. Velocity 20 mm/ s.
Cable Set 9 m, with 6- D Hexapod Controller, Control of 2 Additional Servo- Motor Axes Included, TCP/ IP and RS-232 Interface

H-845.D31
High- Load Hexapod for 500 kg Load, Travel Ranges ±110 mm (X, Y), ±50 mm (Z), Max. Velocity 40 mm/ s.
Cable Set 9 m, with 6- D Hexapod Controller, Control of 2 Additional Servo- Motor Axes Included, TCP/ IP and RS-232 Interface

H-845.D41
High- Load Hexapod for 500 kg Load, Travel Ranges ±170 mm (X, Y), ±105 mm (Z), Max. Velocity 40 mm/ s.
Cable Set 9 m, with 6- D Hexapod Controller, Control of 2 Additional Servo- Motor Axes Included, TCP/ IP and RS-232 Interface

H-845.D51
High- Load Hexapod for 400 kg Load, Travel Range ±110 mm (X, Y), ±50 mm (Z), Max. Velocity 50 mm/ s.
Cable Set 9 m, with 6- D Hexapod Controller, Control of 2 Additional Servo- Motor Axes Included, TCP/ IP and RS-232 Interface

H-845.D61
High- Load Hexapod for 1000 kg Load, Travel Ranges ±170 mm (X, Y), ±105 mm (Z), Max. Velocity 50 mm/ s.
Cable Set 9 m, with 6- D Hexapod Controller, Control of 2 Additional Servo- Motor Axes Included, TCP/ IP and RS-232 Interface, 19" Chassis

Ask about custom designs!

Controllers / Drivers / Amplifiers

C-887 Controller for Hexapod Positioning Systems

Related Products

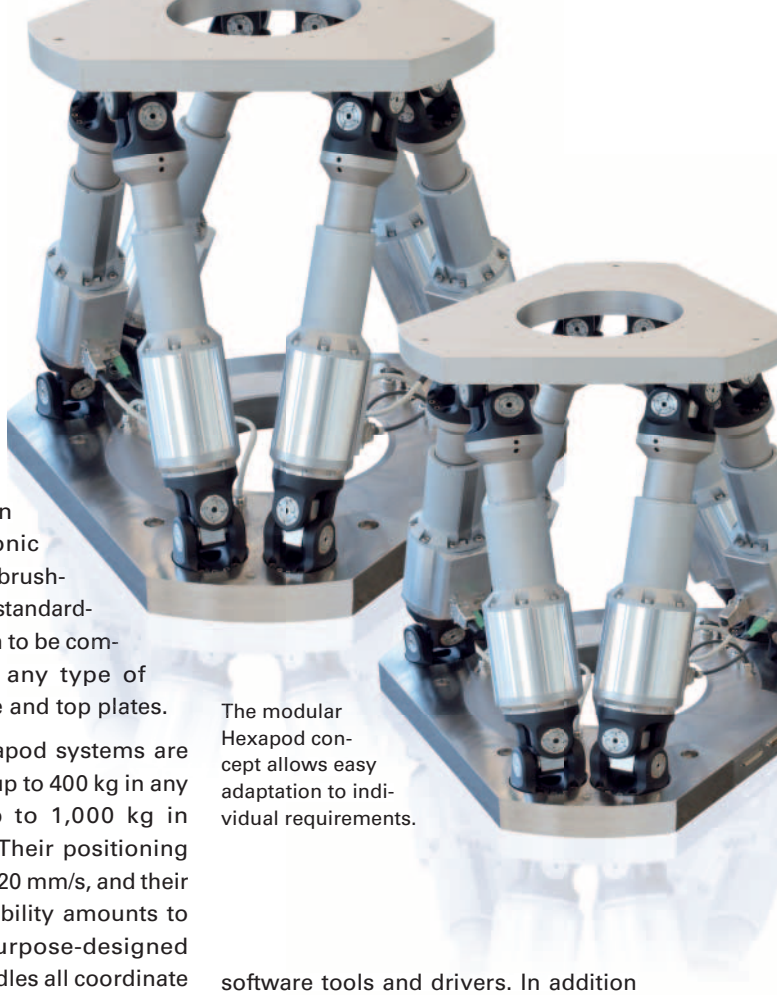
H-850 6- Axis Hexapod
H-850KMLD High- Load Hexapod
H-850KHLC Precision Hexapod for High Loads
M-850KHTH 1000 kg High- Load Hexapod
M-850KHLH Vacuum- Compatible High- Load Hexapod
HP-550 Hexapod
M-850KWAH Weather- Resistant Hexapod for Astronomy

Technology

Hexapods – Parallel- Kinematics Positioning Systems | Hexapod platforms are used for precision positioning and alignment of loads in all six degrees of freedom, three linear axes, and three rotational axes. Learn more ...

Modular, Scalable High-Load Hexapod Concept

Quick & Economical for 6-Axis Positioning Tasks



The modular Hexapod concept allows easy adaptation to individual requirements.

Complex positioning tasks are rarely alike and individual solutions are often required. This is also true of the Hexapod parallel-kinematic systems employed to precisely position heavy loads in six degrees of freedom. A modular concept now ensures that individual requirements can be implemented within a very short period of time and easily integrated into the application.

Hexapods have six actuators, which simultaneously move a common platform, enabling a combination of high precision, stiffness and dynamics not achieved with serial kinematic designs. PI has now developed a modular concept that allows application-specific adjustments within a short period of time.

PI's modular Hexapod struts are designed such that their length can be scaled easily. They include the required electronics for reference point switches, limit switches, position sensors and electronic commutation for the brushless DC motors. Their standardized joints allow them to be combined with almost any type of geometry of the base and top plates.

These modular Hexapod systems are suitable for loads of up to 400 kg in any orientation and up to 1,000 kg in horizontal position. Their positioning velocities reach up to 20 mm/s, and their bidirectional repeatability amounts to about 5 µm. The purpose-designed digital controller handles all coordinate transformations, features vector control, a stable freely programmable pivot point and comes with a solid package of software tools and drivers. In addition to the Hexapod, the controller can handle two more independent motor axes as well.

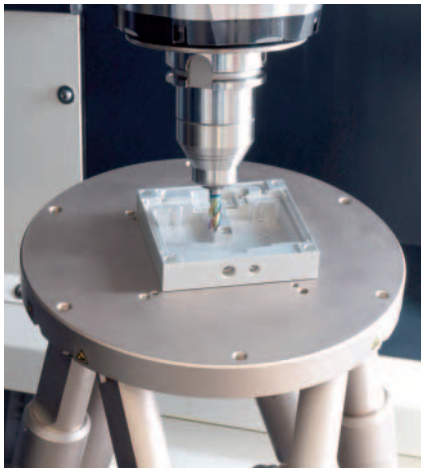
Clock Synchronization for the Entire Automation Line:

Hexapods Communicate via Fieldbus Interfaces

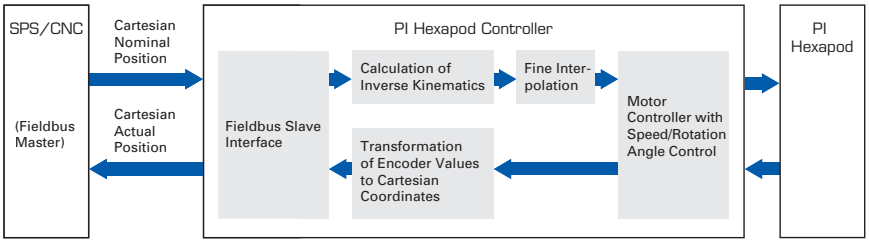
The benefits of parallel-kinematic precision positioning systems can now also be used in automation technology. PI's high performance Hexapods can communicate directly via fieldbus interfaces with a PLC controller.

Fieldbus interfaces are currently available as plug-in modules for Profibus, EtherCAT, Profinet, CANopen and SERCOS. Due to this direct connection, Hexapod systems can be integrated in virtually any automated production line; a clock synchronization with other automated components can easily be achieved, for example, for automated supply systems, machining or other complex adjusting processes.

Here, the PLC defines the target position and trajectories in Cartesian coordinates; in return, it gets the actual positions over the fieldbus interface. All other calculations are handled by the Hexapod controller, i.e. transforming the nominal positions from Cartesian coordinates into the drive commands for the individual drives. The controller acts like an intelligent drive. The cycle times for determining new positions, evaluating signals and synchronizing are between 1 and 3 milliseconds.



Clock synchronization for the entire automation line: Hexapods communicate via fieldbus interfaces.

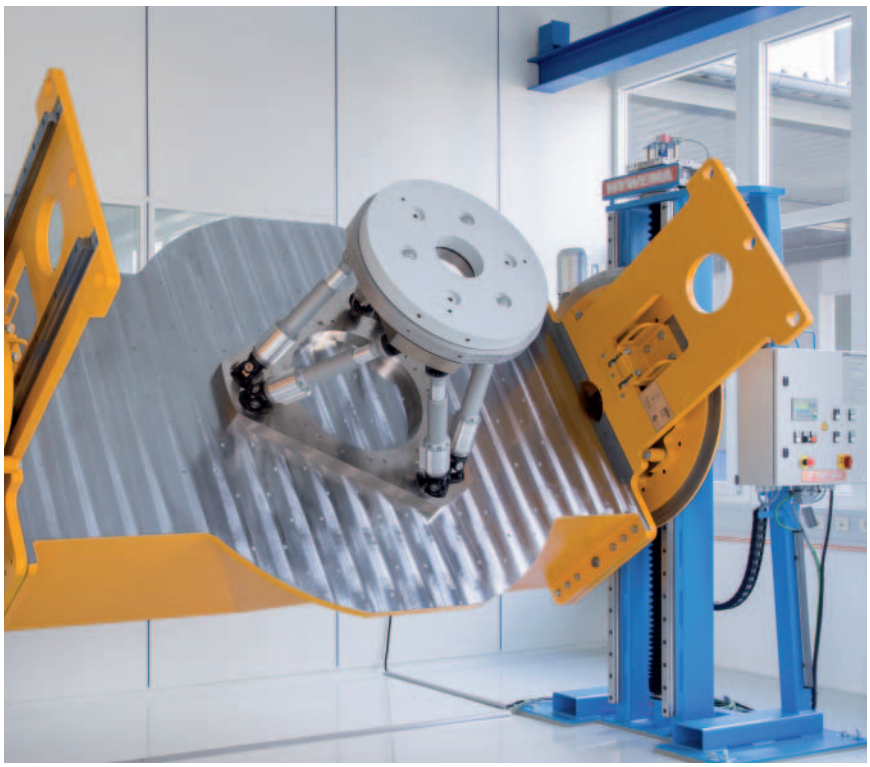


The Hexapod controller acts like an intelligent drive. Due to the exchangeability of the fieldbus interface, communication with numerous types of PLC or CNC controllers is possible.

Vertical Integration and Production Capacity

Automated production of PICMA® multilayer piezo actuators in large quantities

Test laboratories for measuring accuracies down to picometers set standards



Swivel unit, capable of carrying loads to 7 t, for measurements in application situation

The product range from a two-ton Hexapod to a 10-gram nanopositioner requires that PI can both manufacture and qualify these systems.

- Production and mounting at clean room conditions
- Large quantities
- Stable measuring conditions
- Traceable, calibrated measuring instruments
- Monitoring of piezo actuator technology from material composition to final inspection
- In-house production of position sensors

Controller for Hexapod Positioning Systems

6-D VECTOR MOTION CONTROL, COMPREHENSIVE FUNCTIONALITY

C-887

- Sophisticated controller using vector algorithms
- Freely programmable, virtual pivot point
- Data recorder
- Macro program functionality
- Stand-alone operation possible and control through TCP/IP and RS-232 interfaces
- Extensive software support

Digital controller for 6-axis-parallel kinematics

Included in the delivery of all PI standard Hexapod systems

- C-887.11, 19" controller, comprises the control for two additional single axes with servo motors, the functionality can be enhanced with many additional options
- C-887.21 compact bench-top controller for a lower system price

Extensive software support

Functions

Real-time system. Position control using Cartesian coordinates, vectorized motion. Stable, virtual pivot point can be defined freely in the working space. Data recorder for recording operating parameters such as motor control, velocity, position or position error. Macro command language. Stand-alone operation possible with Autostart macro or connection of keyboard and monitor. Optional: Manual control unit

Custom designs

Custom designs are available for use at high altitudes, e.g. for astronomical telescope applications. Processing of absolute sensors. Control of motor brakes. Processing of additional (redundant) position sensors for increased safety requirements, e.g. in medical technology

Software

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

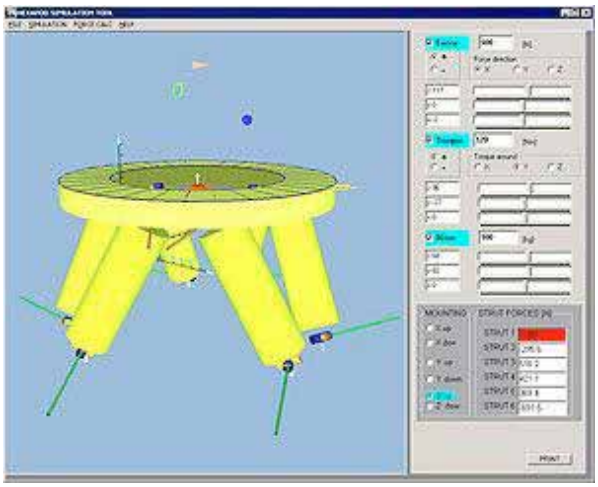
Interfaces

TCP/IP Ethernet can also be used for remote control and service, RS-232. Monitor, mouse and keyboard interface. On request: RS-422 for up to 1.4 km cable length

Possible enhancements for C-887.11

- Analog interfaces/photometer cards for visible light (F-206.VVU) or the infrared light range (F-206.iiU)
- F-206.NCU fast piezo nano-alignment system for alignment with nanometer precision

	C-887.11	C-887.21
Function	6-D controller for Hexapods, 19“, incl. control of two additional single axes, can be enhanced with many options	6-D controller for Hexapods, compact bench-top for a lower system price
Drive type	Servo motors (Hexapod and additional axes) Optional: Piezo drives	Servo motors
Motion and control		
Servo characteristics	32-bit PID filter	
Trajectory profile modes	Trapezoid, linear interpolation	
Processor	CPU: 1.8 GHz, motion control chip with 2.5 kHz servo update rate	
Encoder input	AB (quadrature) differential TTL signal, 5 MHz	
Stall detection	Servo off, triggered by position error	
Reference point switch	TTL signal	
Electrical properties		
Max. output power per channel	10-bit output for PWM drivers, 24 kHz	
Max. output voltage per channel	TTL in PWM operation for SIGN and MAGN	
Interface and operation		
Communication interfaces	TCP/IP, RS-232 VGA (monitor), USB (keyboard, mouse, manual control unit)	
Hexapod connection	MDR, 68-pin for data transmission M12 4-pin. for power supply	
Connection for additional single axes	15-pin sub-D	–
I/O ports	Optional: Analog inputs (photometer cards)	–
Command set	PI General Command Set (GCS)	
User software	PIMikroMove	
Software drivers	LabVIEW driver, shared libraries for Windows and Linux	
Manual control	Optional: C-887.MC control unit for Hexapods	
Miscellaneous		
Operating voltage	100 to 240 VAC, 50 / 60 Hz	
Operating temperature range	5 to 40°C	
Mass	11 kg	5 kg
Dimensions	395 × 483 × 185 mm	255 × 226 × 185 mm



All PI Hexapod systems are delivered with an extensive software package. Included are simulation programs that calculate the working space of the Hexapod and the individual loads on each actuator depending on the Hexapod orientation in space

Highly advanced digital controllers are also available for Hexapods with piezo stepping drives which are suitable for operation in strong magnetic fields or UHV environments

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.

Preventing collisions with PIVeriMove

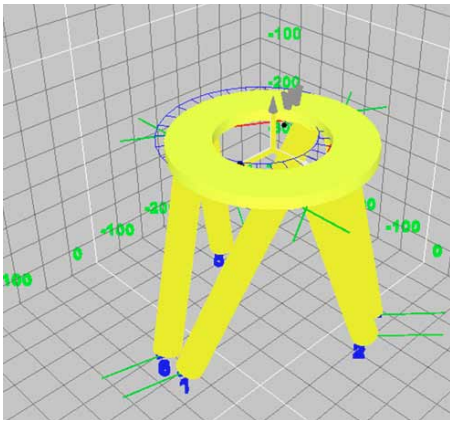
Another proprietary PI simulation software tool enables offline graphical configuration and simulation of the Hexapod motion in the application environment. CAD data of objects can be imported or approximated with simple shapes such as cylinders and cuboids. PIVeriMove then checks restrictions in the 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 simulation software graphically displays the position and the available work space of the Hexapod model