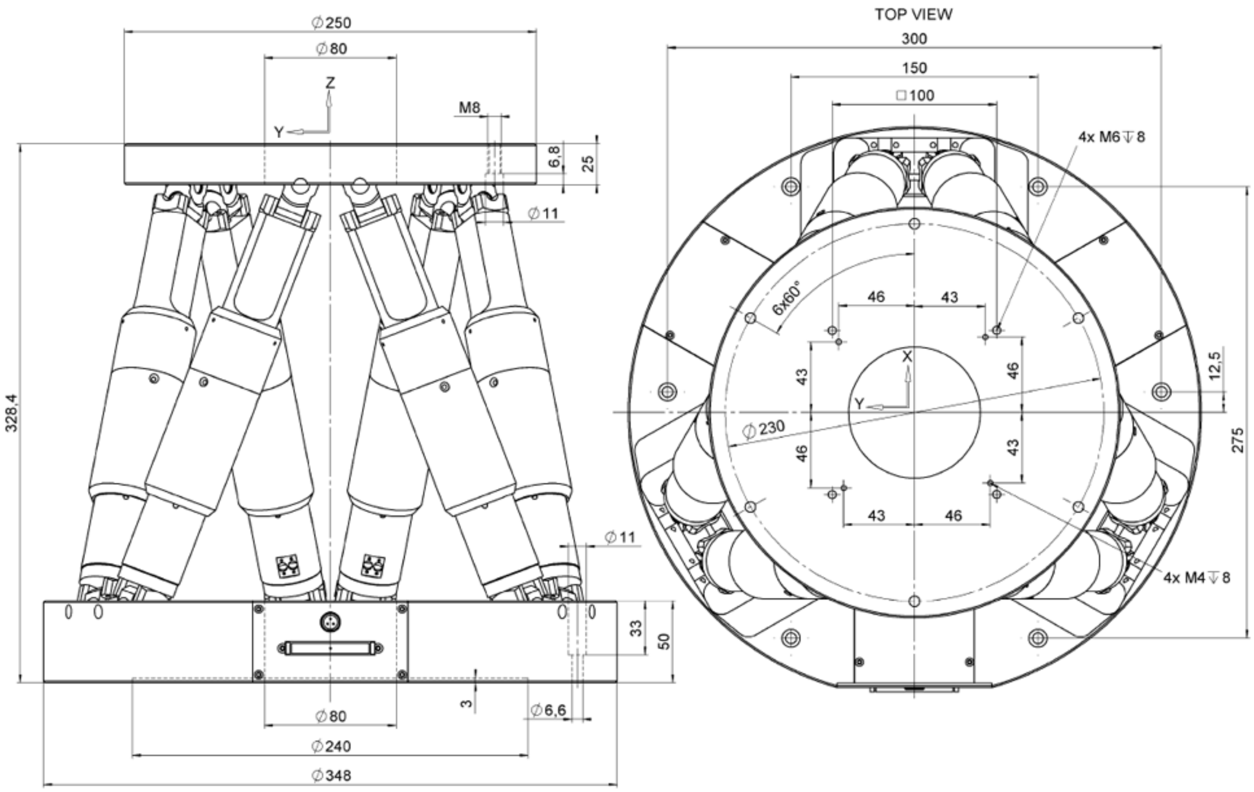
The PI Hexapod at the cSAXS beamline X12SA

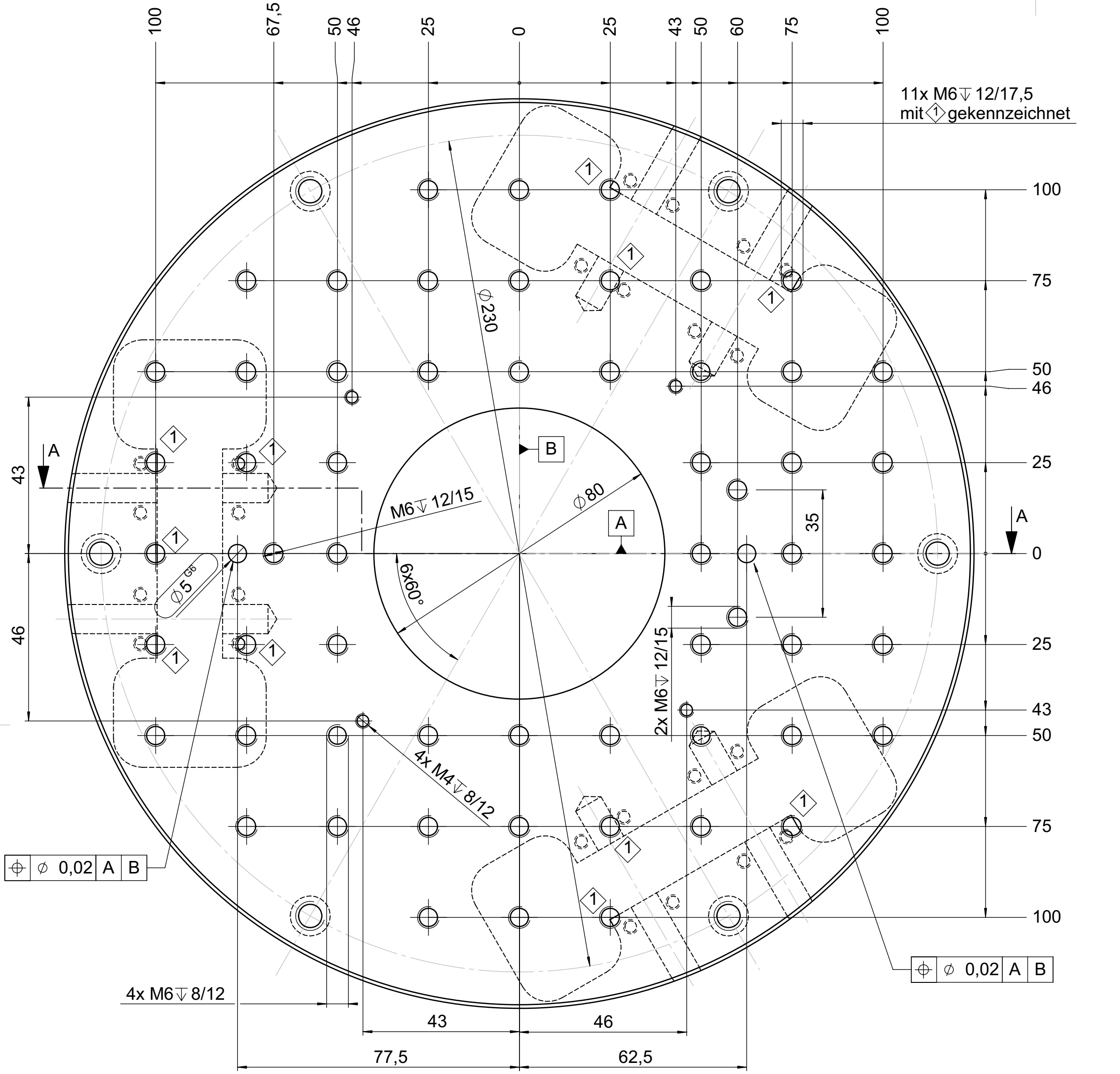
(October 4th, 2007)

The Hexapod model M850.11 allows positioning bulky equipment of up to 200kg with micron position in the beam.
The controller for the six legs of the Hexapod emulates six software motors: Three translations and three rotations. The centre of rotation is software defined. The Hexapod has been integrated in the control program Spec.

Please note: The maximum load is specified for the mounting surface being horizontal. The translation and rotation ranges are correlated. For example moving a translation to its maximum will limit the range of the virtual rotations.

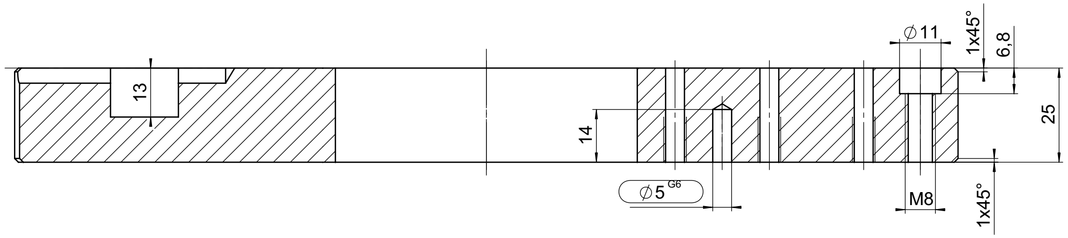
Additionally to the standard whole pattern of the mounting surface shown below the Hexapod has a customized M6 x 25mm pattern shown on the following page. Please note that the M6 pattern of the cSAXS Hexapod is centered on a M6 thread whereas the Hexapod at the MS beamline is centered on the center between four threads.





unbemaßte Gewinde M6 durchgehend (40x)

A-A



-0,15
-0,3

+0,15
+0,25

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FREIMASSTOLERANZ / STANDARD TOLERANCE	DIN ISO 2768 - m - K
MASSTAB / SCALE	1:1
BEHANDLUNG / TREATMENT	chem. vernickelt <10µm
RAUHEIT	Ra1,6
EINHEIT / UNIT	mm
PROJECTION	
WERKSTOFF / MATERIAL	AlMgSi 1 (3.2315)
BEZEICHNUNG/TITLE	NACHARBEIT DECKPLATTE M85050101

	DATUM	NAME
KONSTR.	07.11.2006	RKr
GEZ.	07.11.2006	rkr
GEPR.		

AUS-GABE	ÄNDERUNG	DATUM	NAME
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ARTIKEL-ID / ITEM-NO.	VERSION	GÜLTIG BIS
000015611	00.000	FOREVER

DOKUMENT-ID / DOCUMENT-NO.	VERSION	GÜLTIG BIS
DOC-000024434	00.000	FOREVER

ABGELEITET V. M85050101 NACHFOLGER F.

M-850

Hexapod 6-Axis-Parallel Kinematics Microrobot


M-850 Hexapod Microrobot.

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

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

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

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

Hexapod Working Principle and Advantages

The M-850 Hexapod is driven by six high-resolution actuators (for the M-850.11, 0.005 µm resolution) all connected directly to the same moving platform. The principle is similar to that seen in flight simulators, but considerably more precise. In place of the hydraulic actuators used there, the M-850 uses custom high-load precision screws and servo-motors. It can withstand loads of 200 kg vertically, and at least 50 kg in any direction.

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

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

Virtualized Pivot Point

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

Open Architecture

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

Ordering Information

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

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

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

Optional Photometers

F-206.00U
Photometer Card (visible range)

F-206.iRU
Photometer Card (IR range)

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

Ask about custom designs!

Application Examples

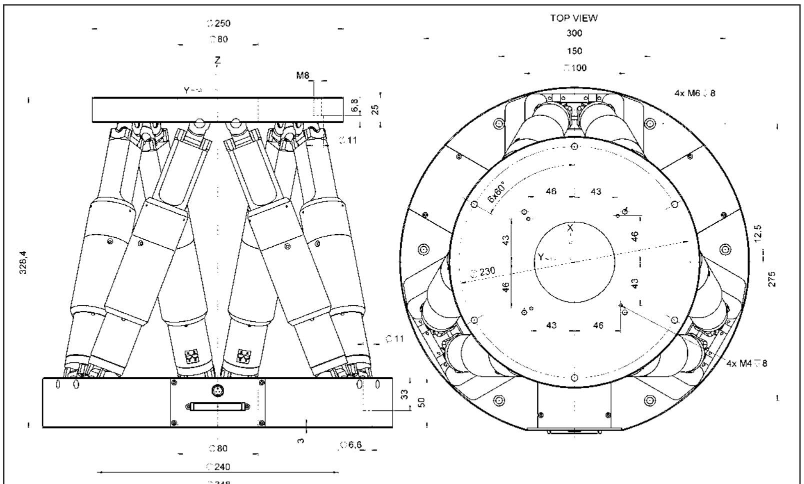
- Alignment and tracking of optics, electron beams, lasers, etc.
- Satellite testing equipment
- Surgical robots
- Micromachining
- Micromanipulation (life sciences)
- X-ray diffraction measurements
- Semiconductor handling systems
- Tool control for precision machining & manufacturing
- Fine positioning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


Custom Hexapod designed for neurosurgery Photo: IPA

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

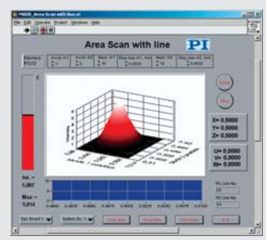
Automatic Optics Alignment

With the internal or external photometer option and the integrated scanning routines, just a few commands are needed to perform an automated alignment of optical components. For more information on photometers / optical power meters, see the F-206.IRU and F-206.00U, p. 8-12 and the F-361, p. 8-14.
A smaller, even-more-precise hexapod, specially developed for alignment of collimators, fiber bundles and I/O chips, is available as the F-206 (see p. 7-18 and p. 8-8)



M-850 Hexapod. Dimensions in mm.


Custom water-resistant Hexapod



HexControl™ software showing scan of a fiber optics component.


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

Technical Data

Models	M-850.11	M-850.50	Units
* Travel range X, Y	±50	±50	mm
* Travel range Z	±25	±25	mm
* Travel range θ_X, θ_Y	±15	±15	°
* Travel range θ_Z	±30	±30	°
Actuator stroke	±25	±25	mm
Actuator design resolution	0.005	0.049	µm
** Minimum incremental motion, X, Y, Z	1 (XY), 0.5 (Z)	1 (XY), 0.5 (Z)	µm
** Minimum incremental motion θ_X, θ_Y, θ_Z	5	5	µrad
Repeatability X, Y	±2	±2	µm
Repeatability Z	±1	±1	µm
Repeatability θ_X, θ_Y, θ_Z	±10	±10	µrad
Speed X, Y, Z (typical)	0.3	5	mm/s
Speed X, Y, Z (max.)	0.5	8	mm/s
Speed θ_X, θ_Y, θ_Z (typical)	3	50	mrad/s
Speed θ_X, θ_Y, θ_Z (max.)	6	100	mrad/s
Stiffness (k_X), (k_Y)	3	3	N/µm
Stiffness (k_Z)	100	100	N/µm
Weight	17	17	kg
Load capacity (vertical / random)	200 / 50	200 / 50	kg
In Z with power off (holding force)	200	25	kg
Resonant frequency	90	90	Hz
Resonant frequency F_Z ***	500	500	Hz

* The maximum travel ranges in the different coordinate directions (X, Y, Z, 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.

Example: The following position is in the workspace:
X: +20 mm θ_X : +10°
Y: +20 mm θ_Y : +10°
Z: +5 mm θ_Z : -2°

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

*** Mounted vertically with 10 kg load

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