6-Axis Precision Alignment System

IDEAL FOR FIBER ALIGNMENT

H-206

- Flexure based for highest precision
- 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

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. Driven by DC motors

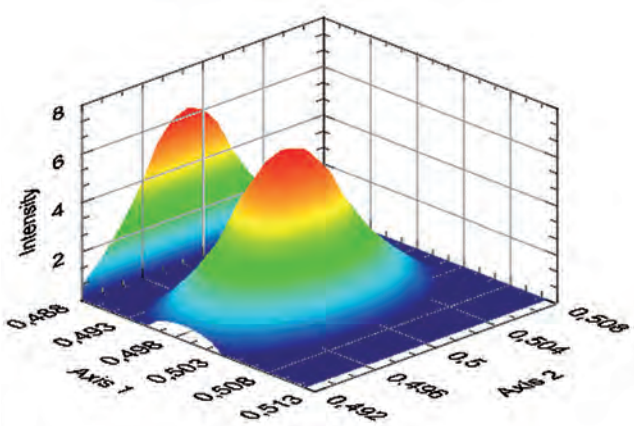
Powerful digital controller, open software architecture

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).

H-206.F11 includes C-887.11, 6D vector motion controller plus 2 additional servo axes. Options:

- 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

H-206.F12 includes C-887.21 compact 6D vector motion controller



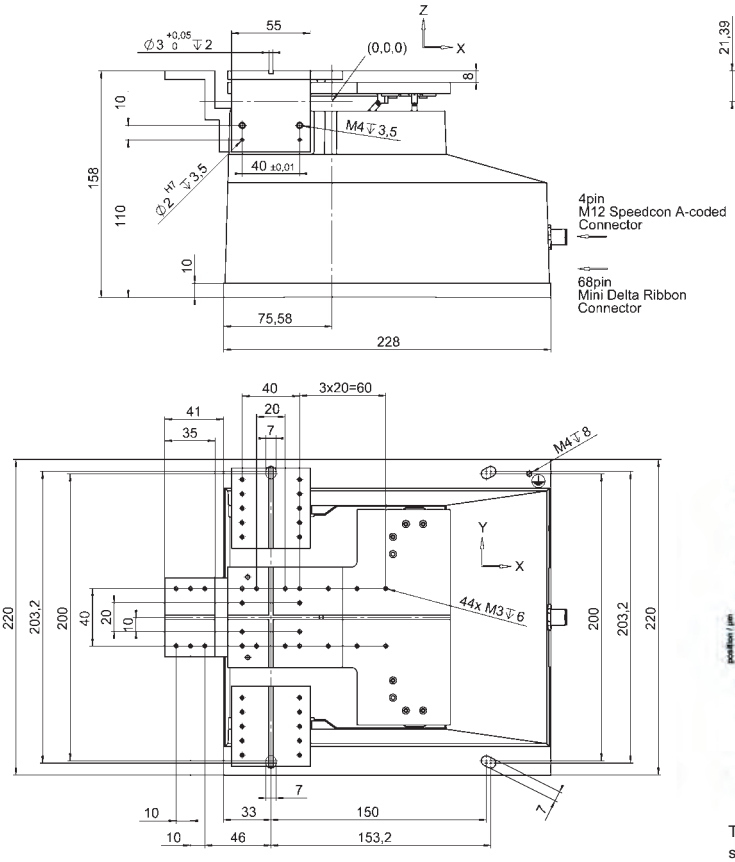
The H-206 includes rapid automatic scan routines for fast multi-axis alignment. The graphic shows 2D optical signal intensity of a fiber optic component. Complete device scan ensures detection of the global peak and prevents locking on to a local maximum

Fields of application

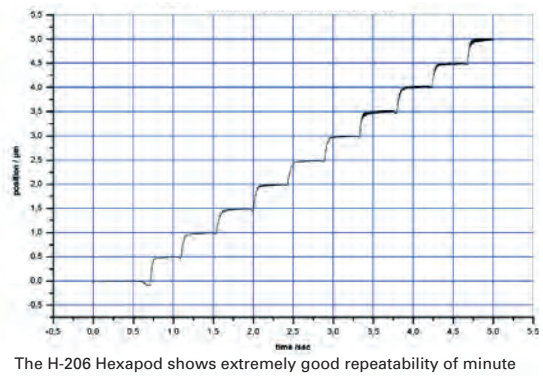
Research and industry. For fiber alignment, micromanipulation systems, optical testing set-ups

	H-206.F1x	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 µrad (0.4")		typ.
Repeatability X, Y, Z	0.3	µm	typ.
Repeatability θ_X, θ_Y, θ_Z	6	µrad	typ.
Max. 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.S, 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

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

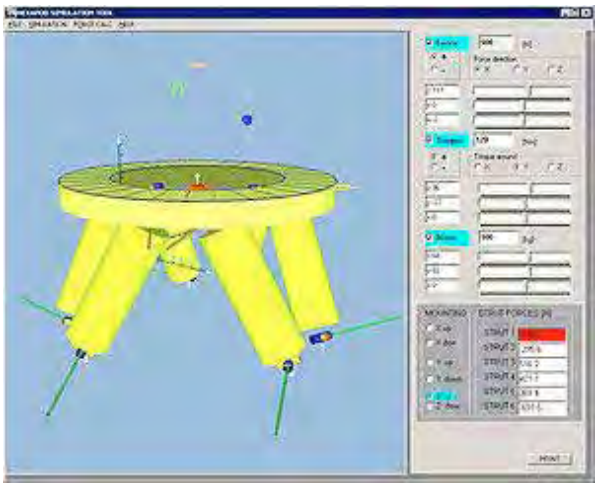
Interfaces

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

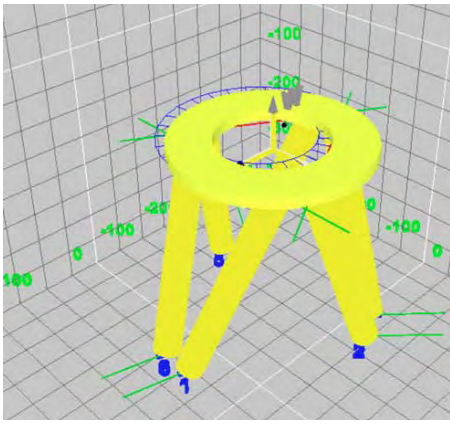
Another proprietary PI simulation software tool enables offline graphical configuration and simulation of the Hexapod motion in the application environment. CAD data of objects can be imported or approximated with simple shapes such as cylinders and cuboids. PIVeriMove then checks restrictions in the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

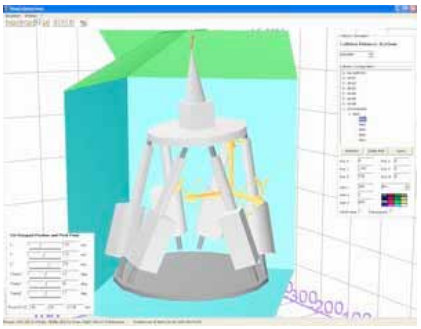
A virtual machine that can be installed on the customer's host PC is available to emulate a complete Hexapod systems (mechanics, controller and even peripherals). Application programs can then be developed and pre-tested, different load scenarios can be simulated and the work space can be determined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



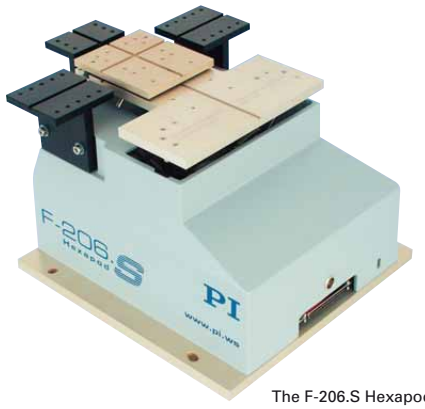
The simulation software graphically displays the position and the available work space of the Hexapod model



The F-206 was replaced by the H-206, see above

F-206.S HexAlign™ 6 Axis-Hexapod

Parallel-Kinematics Precision Alignment System / Manipulator, with Controller



The F-206.S Hexapod comes with a digital 6D controller and comprehensive software

- **Parallel Kinematics with 6 Degrees of Freedom**
- **0.033 µm Actuator Resolution**
- **Repeatability 0.3 µm in Space**
- **No Moving Cables for Improved Reliability, Reduced Friction**
- **Better Dynamics, More Compact than Serial Kinematics Systems**
- **For Scanning and Alignment**
- **Cartesian Coordinate Control with Virtualized Pivot Point**
- **Powerful Digital Controller with Open Source LabVIEW Drivers, DLL Libraries...**
- **Integrated Fiber Alignment Routines**

The F-206.S HexAlign™ Hexapod is a highly accurate micropositioning system for complex multi-axis alignment tasks. It is based on PI's long experience with ultra-high-resolution, parallel kinematics stages. Unlike hexapods with variable-length struts ("legs") the F-206 features constant-length struts and friction-free flexure guides. This gives the F-206 even higher precision than other hexapod designs.

Application Examples

- Micromachining
- Photonics packaging
- Fiber alignment
- Semiconductor handling / test systems
- Micromanipulation (life science)
- Optical device testing
- Collimator and fiber bundle alignment
- MEMS positioning/alignment

Compact, Plug & Play

The F-206.S Hexapod is considerably smaller and more accurate than comparable serial kinematics six-axis systems (stacks of single-axis units).

The parallel kinematics of the F-206 is immune to the cumulative bending and guiding errors of the various axes which, together with the inertia and friction of the moving cables, can limit accuracy in stacked systems. In addition, rotations are not set in hardware, but about a pivot point freely definable in software. A high-performance controller does all necessary coordinate transformation for coordinating the six drives. Because all the actuators are attached directly to the same moving platform, there are none of the servo-tuning problems associated with the loading and inertia differences of the different axes, as are inherent in stacked systems.

Virtualized Pivot Point

It is important to have a fixed pivot point for alignment tasks, especially in photonics packaging. Because the parallel kinematics motion of the F-206 is calculated with complex algorithms in the digital controller, it was easy to allow programming any point in space as center of rotation. Furthermore, the cartesian coordinates of any position and any orientation can be entered directly and the specified target will be reached after travel along a smooth path.

Six Degrees of Freedom, No Moving Cables

In the F-206 parallel kinematics design, all cable terminations are on the stationary base, eliminating unpredictable friction and inertia, improving resolution and repeatability. Further advantages of the system are:

- No cable guides required
- Reduced Size and Inertia
- Improved Dynamic and Settling Behavior
- Identical Modular Actuators for Simplified Servicing

Open Command Set, Simplified Programming

Integration of the F-206 in complex applications is facilitated by the system's open command set and comprehensive tool libraries. The controller can be operated either through a host PC, or directly through a keyboard and monitor. It can also run programs stored in a user-friendly, fully documented macro language.

Automatic Optical Alignment

Optional internal and external photometers are available. Both types are fully integrated with the controller hardware and with routines designed for automatic alignment of collimators, optical fibers and arrays. For more information on the photometers see www.pi.ws.

Ordering Information

F-206.S0
Hexapod 6-Axis Precision Alignment System / Manipulator with 6 DOF Hexapod Controller

F-206.SD
Hexapod 6-Axis Precision Alignment System / Manipulator with 6 DOF Hexapod Controller, Built-in Display and Keypad

Options and Accessories

F-206.AC8
Upgrade for 2 Additional Servo-Motor Control Channels on F-206 Controller

F-206.MHU
Force-Limiting Mounting Platform, (included with F-206.SD)

F-206.NCU
Upgrades: Rapid Nanopositioning Upgrade for F-206.S. Consists of P-611.3SF NanoCube and E-760 Controller Card

F-206.MC6
6D Interactive Manual Control Pad

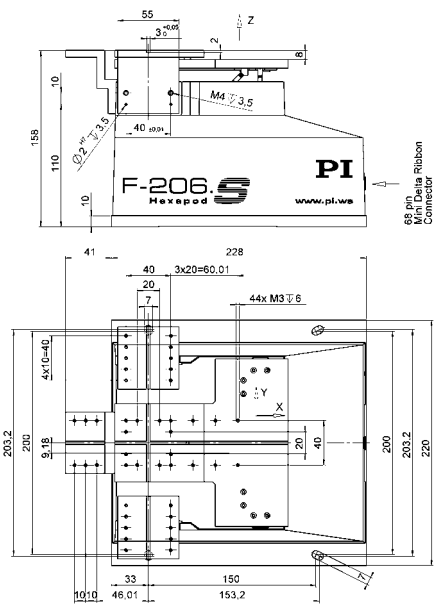
F-206.VVU
2-Channel Photometer Card, (Visual Range)

F-206.iiU
2-Channel Photometer Card (IR Range)

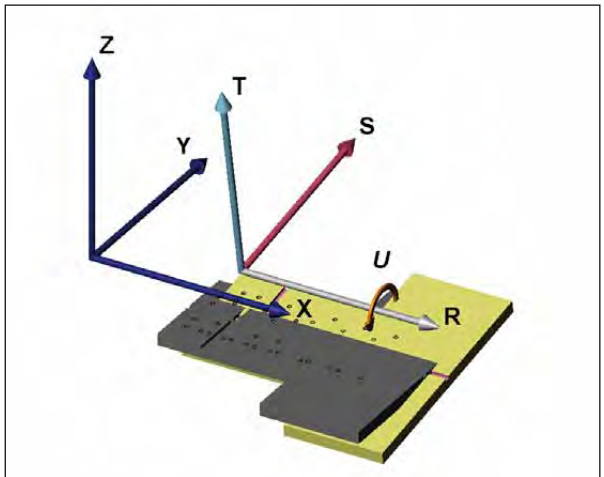
F-361.10
Absolute-Measuring Optical Power Meter, 1000-1600 nm Wavelength

Additional Accessories, see www.pi.ws.

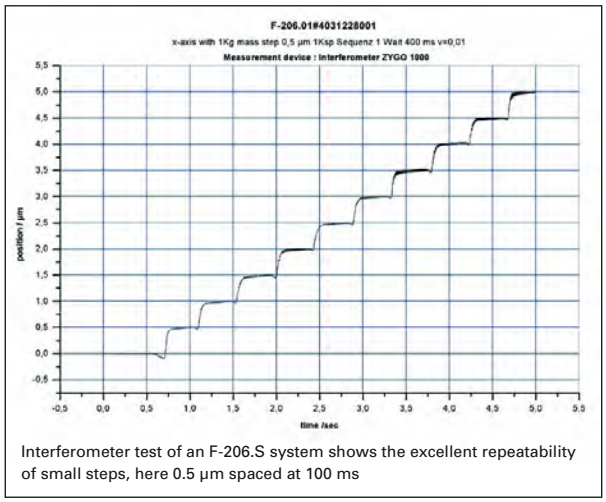
The F-206 was replaced by the H-206, see above



F-206.S. Dimensions in mm



F-206 provides ultra-precise motion in all six degrees of freedom with rotation about any point in space. The pivot point is set by the user with a simple software command



Interferometer test of an F-206.S system shows the excellent repeatability of small steps, here 0.5 µm spaced at 100 ms

Technical Data

Model	F-206.S0 / F-206.SD
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°
Actuator resolution	33 nm
Minimum incremental motion X, Y, Z**	0.1 µm (6-axis move!)
Minimum incremental motion θ_X, θ_Y, θ_Z**	2 µrad (0.4") (6-axis move!)
Bidirectional repeatability X, Y, Z	0.3 µm
Bidirectional repeatability θ_X, θ_Y, θ_Z	3.6 µrad
Speed X, Y, Z	0.01 to 10 mm/s
Maximum load in Z	2 kg (centered on platform)
Mass	5.8 kg
Controller	Digital Hexapod controller with optional photometer card and integrated scan and align routines
Operating voltage	100–240 VAC, 50/60 Hz
Software	LabVIEW drivers, software for alignment of arrays, DLL libraries, scan and align software, terminal software

*Travel ranges in the coordinate directions (X, Y, Z θ_X, θ_Y, θ_Z) are interdependent. The data given shows maximum travel range of the axis in question (i. e. its travel when all other axes are at their zero positions). If this is not the case, the available travel may be less.

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

The F-206 was replaced by the H-206, see above

F-206.MHU Magnetic kinematically clamped force limiting platform

F-206.NCU Rapid NanoAlign Upgrade

For applications where alignment with nanometer-range resolution is required, or where rapid mapping of the entire cross-section of a component in as short a time as possible is desired, the F-206.NCU Rapid NanoAlign upgrade is recommended. It consists of the P-611.3SF XYZ piezo-drive NanoCube® (see p. 2-52) and the E-760 controller board (see p. 2-138), which is installed in the F-206 controller.

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

Ordering Information

F-206.MC6
6D Interactive Manual Control Pad

C-815.MC6
3 m Extension Cable for Manual Control Pad

F-206.iiU
2-Channel Photometer Card (IR Range)

F-206.VVU
2-Channel Photometer Card (Visual Range)

F-206.AC8
Upgrade for 2 Additional Servo-Motor Control Channels on Hexapod Controller

F-311
PIMotion&Vision™ Imaging Processing for Intelligent Automation

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

Upgrades / Options for F-206 Systems

F-206.MHU
Force-Limiting Mounting Platform (included with F-206.Sx)

F-206.TMU
Additional Mounting Platform, for rapid exchange of different setups

F-206.NCU
Rapid Nanopositioning Upgrade for F-206. Consists of P-611.3SF NanoCube® and E-760 Controller Card

M-500.206
Adapter Plate for Mounting F-206 on M-511, M-521 and M-531 Translation Stages

Ask about custom designs!

Hexapod Options & Accessories

Photometer card

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

Optical Metrology Boards

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

F-206.MC6 6D Interactive Control Pad Upgrade

The F-206.MC6 manual control pad facilitates system setup and testing procedures. It consists of a board that plugs into the Hexapod controller and a control pad with six digital "potentiometer" knobs (one for each degree of freedom).

The manual pad works seamlessly with the Hexapod software, and allows programmable step sizes of 1 µm to 500 µm (linear) and 0.001 to 0.5deg (angular) per step. External positioning commands (via the computer interface) can be intermixed with manual positioning input without loss of the true position, because both inputs operate on the same position registers of the Hexapod controller. The control pad comes with a 3 m cable. A 3 m extension cable is available as part number C-815.MC6.

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

Technical Data

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

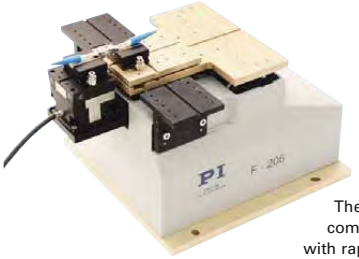
Options for F-206 systems

Force-Limiting Platform

In some applications it may be useful to limit the forces on or from the F-206 platform to protect the mechanics or components mounted on the F-206 from damage:

F-206.MHU

F-206.MHU is a magnetic kinematically clamped, add-on platform which consists of two parts. The upper part, also available separately under order number **F-206.TMU,** releases itself automatically when a certain force or torque is exceeded. With multiple F-206.TMUs, complete setups mounted on different top plates can be interchanged quickly and easily. F-206.MHU is included as standard with F-206.Sx.



The F-206 HexAlign™ 6D alignment system combines high resolution and high accuracy with rapid response, and allows fully automatic alignment of fiber optic components. The optional NanoCube® module (front left) achieves nanometer resolution and, with its rapid-response piezo drive, can scan and characterize the entire cross-section of an optical component in a few seconds (see P-611, p. 2-52)