FPS Sensors
Real-Time Interferometric Displacement Analysis
attoSENSORICS: products for nanometer applications

attocube's innovative optical displacement sensors surpass the performance of other presently available devices in terms of precision, speed, and compactness. The patented fiber-based, interferometric measurement principle offers unrivalled accuracy and stability, while the compact design enables strikingly simple adjustment even in spatially confined setups. Fiber-based sensor heads enable the operation in extreme environments, such as ultra high vacuum, cryogenic temperatures, or even hard radiation.

Two product lines have been established and adapted to perfectly meet existing market demands: The FPS Sensor offers integrated measurement and analysis capabilities and is the perfect choice for contactless, ultra-high-precision displacement measurements with immediate data inspection. Typical fields of applications range from quality assurance to R&D. In contrast, the IDS Sensor is ideally suited for machine integration and seamless connection to common industrial networks.

A list of suitable applications for attocube's sensor products can be found to the right.

## Machine Integration

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Device Chassis</strong></td>
<td>Compact case for inline measurements</td>
</tr>
<tr>
<td><strong>Trigger Option</strong></td>
<td>BISS-C interface (optional)</td>
</tr>
<tr>
<td><strong>Analysis Software</strong></td>
<td>WAVE (optional)</td>
</tr>
<tr>
<td><strong>Realtime FFT-Analysis</strong></td>
<td>WAVE (optional)</td>
</tr>
<tr>
<td><strong>Suitable Measurement Setups</strong></td>
<td>Similar measurement setups</td>
</tr>
<tr>
<td><strong>Applicable Number of Axes</strong></td>
<td>High</td>
</tr>
<tr>
<td><strong>Software Features</strong></td>
<td>Zoom in/out for past data, csv-export of measurement data</td>
</tr>
<tr>
<td><strong>Output Interfaces</strong></td>
<td>Ethernet, HSSL, AquadB, Sin/cos, linear analog, BISS-C (optional)</td>
</tr>
</tbody>
</table>

## R&D Setup

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Device Chassis</strong></td>
<td>Tabletop/19” rack-mount for laboratory usage</td>
</tr>
<tr>
<td><strong>Trigger Option</strong></td>
<td>Data marking (optional)</td>
</tr>
<tr>
<td><strong>Analysis Software</strong></td>
<td>Daisy (included)</td>
</tr>
<tr>
<td><strong>Realtime FFT-Analysis</strong></td>
<td>Daisy (included)</td>
</tr>
<tr>
<td><strong>Suitable Measurement Setups</strong></td>
<td>Alternating measurement setups</td>
</tr>
<tr>
<td><strong>Applicable Number of Axes</strong></td>
<td>Low</td>
</tr>
<tr>
<td><strong>Software Features</strong></td>
<td>Angle measurement (pitch/yaw/roll) (optional)</td>
</tr>
<tr>
<td><strong>Output Interfaces</strong></td>
<td>USB, AquadB, HSSL, Ethernet EPICS (optional)</td>
</tr>
</tbody>
</table>
Working Distance
Distance between the front side of the sensor head and the target where a continuous measurement is possible.

Absolute Distance
Distance between the end of the fiber, which is represented by the mechanical stop, and the target.

Focal Length
The focal length $F$ is the distance between the front side of the sensor head and the focal point.

Alignment Tolerance
The angular alignment tolerance represents the target’s tilt range in respect to the laser beam ($\alpha$ in the figure below). The laser beam might not be parallel to the central axis of the sensor head ($\beta$ in the figure below). At retroreflectors, the center of rotation is defined as the center of the retroreflector.

Fabry-Pérot Interferometer
Our FPS and IDS Sensor Systems rely on a low-finesse fiber-based Fabry-Pérot Interferometer. A great advantage of this technology over other displacement sensing techniques is their electronic-free sensor heads. The physical dimension of the sensor head is reduced to the millimeter range. This miniaturization makes the sensor ultra-compact and also compatible with extreme environments such as ultra high vacuum and low temperature.

The fiber-based design allows flexible alignment, thus making multi-axis measurements and large distances of fiber length (even covering kilometer-long distances) an easy task.

Environmental Compensation Unit (ECU)
The ECU provides a fully automated refractive index compensation for contactless interferometric measurements at ambient conditions. Variations in air pressure, temperature, and humidity are recorded and used to automatically compensate for changes in the refractive index.

Focusing Sensor Head
The focusing sensor heads D4/F17 (sensor head diameter of 4 mm with a focal length of 17 mm), M12/F40, and D12/F2.8 are suitable to measure on a wide range of target materials as well as target surface qualities with low, medium, or high surface reflectivity. For example, the focusing sensor heads make it possible to measure on a BK7 glass object with a reflectivity of only 4%.

Collimating Sensor Head
The sensor head M12/C7.6 (sensor head with a M12 metric thread and a beam diameter of 7.6 mm) is suited with a collimating optics type especially designed for the use with retroreflectors. It is optimized to measure longer distances.

Glossary
attoSENSORICS technical terms

Attocube’s interferometers have been tested by the National Metrology Institute of Germany (PTB). The accuracy of the interferometers has been confirmed at various pressure, humidity and temperature conditions over several days, thus also confirming the high performance and reliability of attocube’s ECU (environmental compensation unit).

PTB-Certification for Interferometers
highest accuracy over long distances

The IDS was checked over a working distance of 10 meters. The systematic error of measurement was quantified to 0.0 ppm between a working distance of 0 m and 3 m. The total expanded measurement uncertainty ($\chi = 2$), consisting of the systematic and random measurement errors mostly remains under 0.4 ppm.
The global trend towards miniaturization causes major challenges for advanced metrology: quality standards are increasing, requirements on accuracy and reliability are constantly rising, and failure tolerances in production processes are steadily reduced. Especially in applications such as quality assurance and research & development, instruments need to provide highest precision, while offering versatile implementation options and the immediate availability of data post-processing, analysis, and storage.

With its advanced software automation, the FPS displacement and analysis system is the perfect solution for contactless, ultra-high precision and non-invasive displacement measurement tasks requiring immediate data inspection. Its plug-and-play architecture enables direct integration and versatile operation in a variety of applications within only few minutes.

Accurate
The built-in DFB laser of the FPS is locked to a molecular absorption frequency reference, making the detected displacement traceable to international length standards. All measurements are therefore truly accurate in a metrological sense. (see page 199)

Ultra fast
All FPS sensors measure the position of the target with a bandwidth of 10 MHz and a resolution of 1 pm. At the same time, the sensor is compatible with displacement velocities of up to 1 m/s.

Dedicated software Daisy
FPS sensors are delivered with a dedicated PC-based software, allowing synchronous data visualization, analysis, and storage.

PC & real-time interfaces
Built in USB 2.0 and Ethernet (optional) interfaces enable plug-and-play communication with any personal computer. High-speed real-time interfaces further broaden the application spectrum of the FPS.

Radiation hard
Optional radiation-hard sensor heads and fiber packages are available for the operation in radiation harsh environments. All radiation-hard (‘RAD) components are qualified for radiation doses of up to 10 MGy.

Multi axis operation up to 2 m
The FPS provides three measurement axes, allowing parallel displacement measurements of three targets in real-time. This enables economic measurements in a nanometer range.

Environmental compensation
FPS sensors can be equipped with an optional environmental compensation unit (ECU). The ECU enables the operation of FPS sensors at ambient conditions, while maintaining an accuracy of better ± 1 ppm under a wide range of pressure, temperature, and humidity conditions.

Contactless & miniature
Using small-sized sensor heads, the FPS suits space-limited applications. The technology is based on the Fabry-Perot interferometer that enables contactless measurements and is resistant to outside influences.
The IDS and FPS can be operated with different sensor heads: ultra compact heads for the most confined spaces or alternative designs where priority is given to easy alignment or to the compatibility with various target materials (glass, aluminium, ceramic, etc.).

**Sensor Head Overview**

**IDS & FPS**

- **M12/C7.6:**
  - Ø 14 mm, length 43.9 mm
  - Higher working distances
  - Calibration of machine axes and tools

- **M15.5/F40/FLEX:**
  - Ø 14 mm, length 19.5 mm
  - High angular tolerance
  - Standard for various applications

- **M12/F40:**
  - Ø 14 mm, length 19.5 mm
  - Standard for various applications

- **D4/F17:**
  - Ø 6 mm, length 11.5 mm
  - Small sensor head mounting
  - For space-limited applications

- **D12/F2.8:**
  - Ø 12 mm, length 30.3 mm
  - High angular tolerance
  - For vibrometric and profilometric

**Working Distance up to**

- 0 mm
- 20 mm
- 40 mm
- 60 mm
- 80 mm
- 4900 mm
- 5000 mm

- **Low reflective target**
- **High reflective target**
- **Only compatible with retroreflector**

*FPSH: 0..2000 mm; IDSH: 0..5000 mm

¹ By using special sensor heads, the IDS can realize measurement distances of up to 30 meters.
attocube's FPS1010 is a fully automated interferometric displacement measurement system, compatible with up to three fiber-based sensor heads. The FPS3010/1010 combines state-of-the-art hardware with innovative software concepts, offering real-time data processing and storage, Fast Fourier signal analysis for vibrometry applications, environmental index of refraction compensation (optional), and many other measurement options such as angular measurement software or customized trigger functionality. The flexible, FPGA-based architecture allows firmware upgrades at ease, ensuring that newest features and updates are available to users worldwide. Real-time serial-word and incremental interfaces allow the connection of FPS3010 and FPS1010 devices with other electronics and host controllers.

**Fields of Applications**

- **Metrology**
- **Microscopy**
- **Semiconductor Research**
- **Spectroscopy**
- **Machine & Tool Vibration Analysis**
- **Space Applications**

**CUSTOMER FEEDBACK**

**Prof. Dr. M. Tajmar**

The noise and stability of the attocube FPS interferometer is up to two orders of magnitude better than the second best system on the market. The installation and use of the sensor was so easy that we could obtain high-quality measurements within two weeks after they first arrived at our lab – thanks to the great support from attocube.

(Institute for Aerospace Engineering, Dresden University of Technology, Germany)

**CUSTOMER FEEDBACK**

**Dipl.-Ing. Nanxi Kong**

The motion of a feed unit for micro manufacturing needs to be very precise and accurate. As linear encoders allow only the measurement of the position along one axis, the attocube FPS interferometer can be easily configured to directly measure the position of the tool center point at the feed unit in all directions.

(Institute of Production Engineering, Helmut Schmidt University, Hamburg, Germany)
FPS Sensors are designed for ease of use and simple connectivity. Measured displacement information can be transferred to a personal computer using USB or Ethernet (optional), where the measurement software Daisy allows synchronous data visualization, analysis, and storage.

In addition to these standard interfaces, the FPS includes the high-speed real-time digital interfaces AquadB and HSSL.

HSSL (digital; bandwidth up to 25 MHz and 8-48 bit resolution): attocube’s proprietary serial word protocol provides absolute position information. The HSSL interface consists of two signals (single ended or differential): the clock signal and the data signal that includes the position information.

AquadB (digital; bandwidth up to 25 MHz; resolution freely assignable): The AquadB interface provides incremental displacement information on target displacement. Position resolution and (maximum) clock rate can be user defined using the software interface.

### Interface Specifications

<table>
<thead>
<tr>
<th>Interface</th>
<th>target velocity (pp/s)</th>
<th>resolution USB (abs.)</th>
<th>resolution HSSL (abs.)</th>
<th>resolution AquadB (inc.) at 25 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>0.004</td>
<td>0.004</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

### Daisy: FPS Measurement Software

**Visualization and analysis of measurement data**

The completely new PC-based software of the attocube FPS sensor system not only enables simple data recording. Instead, it offers a ton of features making complex measurements simple - ranging from easy-to-use sensor alignment to synchronous data storage, data marking, and fast-Fourier transformation.

**Synchronous Data Visualization**

The FPS software “Daisy” allows the user to choose a common time base for all axes displayed in order to show displacement data synchronously.

**Synchronous Data Storage**

Position data of all three axes can be saved into one common file with a word length of 64 bits for each axis.

**Dynamic Link Libraries & Virtual Instruments**

With the included DLL and LabVIEW VI’s, all features of the PC software can be accessed through C/C++ and LabView.

**Real-Time FFT Analysis**

The real-time fast-Fourier-Transformation allows a live vibration analysis.

**Data Marking for Triggering Data Acquisition**

The optional feature for data marking includes the function to use external trigger for marking measurement data.

**Improved Initialization Routine**

The software package includes reinitialization of system parameters during ongoing measurements, significantly increasing alignment tolerances of sensor heads.
The blue curve shows the water surface and sensor head movements and the red curve represents the displacements measured on the side of the mirror after hitting the optical table with a hammer.

The shown plot depicts the fast Fourier transform (FFT) analysis between 100 and 400 kHz of a commercial cantilever. The cantilever under investigation has the following dimensions: 225 μm x 38 μm x 7 μm (L x W x T). The resonant frequencies of this cantilever can be seen at 165.6 kHz and the noise floor in the presented frequency range is around 2 pmRMS / sqrt(Hz).

The figure shows the measured positions while the sampling rate of the encoder positions was set to 1 kHz. The position drift observed over the full period of 34 days and a cumulated dose of 3 MGy was only 150 nm with the coated sensor head and 400 nm with the uncoated one.

Measuring Brownian Motion of Commercial Micro-Cantilevers

The resolution capability of the IDS was demonstrated by measuring the Brownian motion of micro cantilevers. Measuring the tiny vibrations of objects excited only by its thermal energy is typically challenging the resolution capabilities of a measurement system. The cantilever was placed on attocube positioners and measured with the focusing sensor head (D12/F2.8). The sensor head has a shot diameter of smaller 2 μm. The figure clearly shows an individual resonance peak at 165.6 kHz excited due to Brownian motion.

Radiation Harsh Environments

The FPS3010 can operate under extreme radiation opening ways to use interferometric systems and subsystems close to synchrotron beams and beamlines, or other environments with high radiation. An experiment conducted under irradiation from a 60Co source (1.17 MeV / 1.33 MeV γ-rays and 0.31 MeV β-rays) shows the stability concerning radiation harsh environments of attocube’s sensor heads. The FPS3010 controller was placed outside the chamber and located in a temperature controlled chamber located in a nonradioactive zone. The temperature stability inside the chamber was better than 1°C during the complete measurement cycle. The total cumulated dose at the end of the measurement was 3.024 MGy in water equivalent. The setup and installation were proven to be robust in terms of mechanical vibration, giving a position uncertainty of less than 10 nm over a measurement period of 34 days. The measured positions were stable within a few 100nm during the whole time.

High Resolution X-Ray Microscopy

When developing an X-Ray microscope capable of nm resolution, careful design is a must. Thermal and mechanical stability of the components and assemblies has to be followed throughout the process. The FPS shows superior performance regarding its outstanding stability and its capability of measuring sub-nm displacements. The sensor has a better than 1.25 nm stability over 40 hours, and a better than 300 pm resolution at 100 Hz bandwidth in a controlled environment. The FPS is therefore the ideal supplement for the mechanical control of all components used in the described X-Ray microscope setup achieving a resolution in the order of 40 nm, while the stability is below 45 nm over the entire time needed for data collection.

Measuring Water Surface Displacements

To measure the displacements of a cup’s water surface compared to the displacements of the table the cup is positioned on, two focused sensor heads were used: one of them focused on the water surface, the other focused on a mirror fixed to the table, while the table was hit by a hammer. The water surface oscillates with a maximum deflection of approximately ± 10 μm and the table with a maximum amplitude of around ± 0.7μm. The zoom highlights that the two measurement areas show similar behaviors in the high frequency range for the first milliseconds after the excitation.

Measuring Water Surface Displacements

To measure the displacements of a cup’s water surface compared to the displacements of the table the cup is positioned on, two focused sensor heads were used: one of them focused on the water surface, the other focused on a mirror fixed to the table, while the table was hit by a hammer. The water surface oscillates with a maximum deflection of approximately ± 10 μm and the table with a maximum amplitude of around ± 0.7μm. The zoom highlights that the two measurement areas show similar behaviors in the high frequency range for the first milliseconds after the excitation.

Measuring Water Surface Displacements

To measure the displacements of a cup’s water surface compared to the displacements of the table the cup is positioned on, two focused sensor heads were used: one of them focused on the water surface, the other focused on a mirror fixed to the table, while the table was hit by a hammer. The water surface oscillates with a maximum deflection of approximately ± 10 μm and the table with a maximum amplitude of around ± 0.7μm. The zoom highlights that the two measurement areas show similar behaviors in the high frequency range for the first milliseconds after the excitation.

Measuring Water Surface Displacements

To measure the displacements of a cup’s water surface compared to the displacements of the table the cup is positioned on, two focused sensor heads were used: one of them focused on the water surface, the other focused on a mirror fixed to the table, while the table was hit by a hammer. The water surface oscillates with a maximum deflection of approximately ± 10 μm and the table with a maximum amplitude of around ± 0.7μm. The zoom highlights that the two measurement areas show similar behaviors in the high frequency range for the first milliseconds after the excitation.

Measuring Water Surface Displacements

To measure the displacements of a cup’s water surface compared to the displacements of the table the cup is positioned on, two focused sensor heads were used: one of them focused on the water surface, the other focused on a mirror fixed to the table, while the table was hit by a hammer. The water surface oscillates with a maximum deflection of approximately ± 10 μm and the table with a maximum amplitude of around ± 0.7μm. The zoom highlights that the two measurement areas show similar behaviors in the high frequency range for the first milliseconds after the excitation.

Measuring Water Surface Displacements

To measure the displacements of a cup’s water surface compared to the displacements of the table the cup is positioned on, two focused sensor heads were used: one of them focused on the water surface, the other focused on a mirror fixed to the table, while the table was hit by a hammer. The water surface oscillates with a maximum deflection of approximately ± 10 μm and the table with a maximum amplitude of around ± 0.7μm. The zoom highlights that the two measurement areas show similar behaviors in the high frequency range for the first milliseconds after the excitation.

Measuring Water Surface Displacements

To measure the displacements of a cup’s water surface compared to the displacements of the table the cup is positioned on, two focused sensor heads were used: one of them focused on the water surface, the other focused on a mirror fixed to the table, while the table was hit by a hammer. The water surface oscillates with a maximum deflection of approximately ± 10 μm and the table with a maximum amplitude of around ± 0.7μm. The zoom highlights that the two measurement areas show similar behaviors in the high frequency range for the first milliseconds after the excitation.

Measuring Water Surface Displacements

To measure the displacements of a cup’s water surface compared to the displacements of the table the cup is positioned on, two focused sensor heads were used: one of them focused on the water surface, the other focused on a mirror fixed to the table, while the table was hit by a hammer. The water surface oscillates with a maximum deflection of approximately ± 10 μm and the table with a maximum amplitude of around ± 0.7μm. The zoom highlights that the two measurement areas show similar behaviors in the high frequency range for the first milliseconds after the excitation.

Measuring Water Surface Displacements

To measure the displacements of a cup’s water surface compared to the displacements of the table the cup is positioned on, two focused sensor heads were used: one of them focused on the water surface, the other focused on a mirror fixed to the table, while the table was hit by a hammer. The water surface oscillates with a maximum deflection of approximately ± 10 μm and the table with a maximum amplitude of around ± 0.7μm. The zoom highlights that the two measurement areas show similar behaviors in the high frequency range for the first milliseconds after the excitation.

Measuring Water Surface Displacements

To measure the displacements of a cup’s water surface compared to the displacements of the table the cup is positioned on, two focused sensor heads were used: one of them focused on the water surface, the other focused on a mirror fixed to the table, while the table was hit by a hammer. The water surface oscillates with a maximum deflection of approximately ± 10 μm and the table with a maximum amplitude of around ± 0.7μm. The zoom highlights that the two measurement areas show similar behaviors in the high frequency range for the first milliseconds after the excitation.
The intrinsic position signal stability of the FPS sensor is unsurpassed, making it challenging to demonstrate the performance of FPS sensors with standard tools and equipment. The measurements shown above were therefore recorded on an evacuated reference cavity with a relative length stability $\Delta l/l$ well below $10^{-8}$. This stability was achieved by temperature stabilizing the titanium cavity within few mK at liquid helium temperature (-269 °C).

Due to the low coefficient of thermal expansion at said temperature, the titanium cavity provides a reference in length approximately 10 times more stable than a corresponding ultra-low-expansion glass (ULE) cavity at ambient conditions. The plot shows position sensing data recorded on a 20 mm long cavity during a 12 hour period of time. The bandwidth of the measurement was 100 Hz.

Long-term FPS signal stability as demonstrated on a 20 mm long Titanium vacuum reference cavity. The cavity is cooled to liquid helium temperature (-269 °C) in order to minimize thermal expansion/contraction. 68% of all position measurement data points lie within 286 pm, as measured at a 100 Hz bandwidth over 12 hrs. Short-term data are recorded at 10 Hz over 10 seconds.

The FPS sensor is not only a very capable real-time displacement sensor but it also serves the user as a powerful vibrometer. With its built-in fast-Fourier algorithm (FFT), the FPS series directly detects the distribution of vibrational modes/amplitudes in frequency space. Frequency and phase information of resonance peaks can be live-viewed on the PC-based FPS application software. The data above demonstrate the suitability of the FPS sensor for this type of application. In this specific case, the low-frequency noise behaviour of the FPS sensor was tested by exciting and measuring the vibration spectrum of a ceramic piezo at low frequency and ultra-low amplitude. As can be seen from the data, the noise floor of the measurement is at $10^{-6}$ microns equivalent to 1 picometer. Stunningly, this noise floor extends to very low frequency, enabling picometer resolution at frequencies as low as 2 Hz. Data are recorded at 100 Hz bandwidth.
## Sensor Head Specifications

<table>
<thead>
<tr>
<th>Sensor Heads</th>
<th>product name</th>
<th>M12/F40</th>
<th>M15.5/F40/FLEX</th>
<th>M12/C7.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>optics type</td>
<td>focusing</td>
<td>focusing</td>
<td>focusing</td>
<td>focusing</td>
</tr>
<tr>
<td>dimensions</td>
<td>Ø 12 mm, length 32.3 mm</td>
<td>Ø 4 mm, length 11.5 mm</td>
<td>Ø 16 mm, length 39.5 mm</td>
<td>Ø 22 mm, length 22.7 mm</td>
</tr>
<tr>
<td>mounting</td>
<td>clamped</td>
<td>clamped</td>
<td>metric M12 x 0.5</td>
<td>metric M15.5 x 0.5</td>
</tr>
<tr>
<td>focal length</td>
<td>2.8 mm</td>
<td>17 mm</td>
<td>40 mm</td>
<td>40 mm</td>
</tr>
<tr>
<td>connector</td>
<td>FC/PC</td>
<td>fiber glued</td>
<td>FC/PC</td>
<td>FC/PC</td>
</tr>
</tbody>
</table>

### Modes of Operation

- **/RT (ambient conditions):** 0 .. 100 °C, 1x10⁻⁴ mbar .. 10 bar
- **/HV (high vacuum):** 0 .. 150 °C, 1x10⁻⁸ mbar .. 10 bar
- **/UHV (ultra high vacuum):** 0 .. 150 °C, 1x10⁻¹⁰ mbar .. 10 bar
- **/LT (low temperature):** mK .. 423 K (150 °C), 1x10⁻⁴ mbar .. 10 bar
- **/RAD (radiation hard):** 0 .. 150 °C, up to 10 MGy radiation dose

### Compatible environments

- **/RT (ambient conditions):** 0 .. 180 °C, 1x10⁻³ mbar .. 1x10⁻¹ mbar
- **/HV (high vacuum):** 0 .. 550 °C, 1x10⁻⁴ mbar .. 1x10⁻¹ mbar
- **/UHV (ultra high vacuum):** 0 .. 350 °C, 1x10⁻³ mbar .. 1x10⁻¹ mbar
- **/RAD (radiation hard):** 0 .. 500 °C, up to 10 MGy radiation dose

### Measurement Specifications

<table>
<thead>
<tr>
<th>benefit</th>
<th>exemplar applications</th>
<th>compatible environments</th>
</tr>
</thead>
<tbody>
<tr>
<td>working range (target: glass)</td>
<td>vibrometric and profilometric of various geometrical shapes</td>
<td>/RT, /UHV, /RAD</td>
</tr>
<tr>
<td>alignment tolerance (target: glass)</td>
<td>deformation monitoring of working pieces during manufacturing</td>
<td>/RT, /UHV, /RAD</td>
</tr>
<tr>
<td>working range (target: mirror)</td>
<td>concentricity tests, detection of imbalance</td>
<td>/RT, /UHV, /RAD, /RAD</td>
</tr>
<tr>
<td>alignment tolerance (target: mirror)</td>
<td>monitoring and diagnostics of machine tools components</td>
<td>/RT, /UHV, /RAD, /RAD</td>
</tr>
<tr>
<td>working range (target: retroreflector)</td>
<td>calibration and synchronization of large-scale machine tools or coordinate measurement machines</td>
<td>/RT, /UHV, /RAD, /RAD, /RAD</td>
</tr>
<tr>
<td>alignment tolerance (target: retroreflector)</td>
<td></td>
<td>/RT, /UHV, /RAD, /RAD, /RAD</td>
</tr>
<tr>
<td>lateral alignment tolerance (target: retroreflector)</td>
<td></td>
<td>/RT, /UHV, /RAD, /RAD, /RAD</td>
</tr>
</tbody>
</table>

### Exemplary Applications

- Vibrometric and profilometric of various geometrical shapes
- Deformation monitoring of working pieces during manufacturing
- Concentricity tests, detection of imbalances
- Monitoring and diagnostics of machine tools components
- Calibration and synchronization of large-scale machine tools or coordinate measurement machines

### IDS & FPS

<table>
<thead>
<tr>
<th>mode</th>
<th>working range (target: glass)</th>
<th>alignment tolerance (target: glass)</th>
<th>working range (target: mirror)</th>
<th>alignment tolerance (target: mirror)</th>
<th>working range (target: retroreflector)</th>
<th>alignment tolerance (target: retroreflector)</th>
<th>lateral alignment tolerance (target: retroreflector)</th>
</tr>
</thead>
<tbody>
<tr>
<td>/RT</td>
<td>2.8 mm ± 4 μm, 14.5...19.5 mm</td>
<td>± 4°, ± 0.15°</td>
<td>50...85 mm, ± 0.35°</td>
<td></td>
<td>± 15°</td>
<td>± 2 mm</td>
<td></td>
</tr>
<tr>
<td>/HV</td>
<td>2.8 mm ± 20 μm, 50...85 mm</td>
<td>± 10°</td>
<td>48...50 mm, ± 0.35°</td>
<td></td>
<td>± 15°</td>
<td>± 2 mm</td>
<td></td>
</tr>
<tr>
<td>/UHV</td>
<td>2.8 mm ± 40 μm, 48...50 mm</td>
<td>± 10°</td>
<td>48...50 mm, ± 0.35°</td>
<td></td>
<td>± 15°</td>
<td>± 2 mm</td>
<td></td>
</tr>
</tbody>
</table>

### Compatible environments

- **/RT (ambient conditions):** 0 .. 180 °C, 1x10⁻³ mbar .. 1x10⁻¹ mbar
- **/HV (high vacuum):** 0 .. 550 °C, 1x10⁻⁴ mbar .. 1x10⁻¹ mbar
- **/UHV (ultra high vacuum):** 0 .. 350 °C, 1x10⁻³ mbar .. 1x10⁻¹ mbar
- **/RAD (radiation hard):** 0 .. 500 °C, up to 10 MGy radiation dose

### Naming Scheme

- F40: focussing head with 40 mm focal length
- C7.6: collimating head with 7.6 mm spot size
- FLEX: flexure structure with integrated (theta, phi) adjustment range
- D12/F2.8: 6 mm mounting diameter
- M12/C7.6: M12 x 0.5 metric thread mounting

### Customized Sensor Heads

Depending on your specific application, modifications concerning the type of optics, focal length, working environment or filter options are possible.

---

**attoscene**

Ultra Precision Sensors
In order to reduce position inaccuracy due to air-induced variations of the index refraction, attocube supplies an environmental compensation unit (ECU). By locally measuring environmental parameters, an accuracy of typically better ±1 ppm can be achieved in air. The ECU is plug-and-play compatible with all IDS models and can be screw- or magnet mounted.

Technical Specifications

<table>
<thead>
<tr>
<th>FPS</th>
<th>IDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>art. no.</td>
<td>1010698</td>
</tr>
<tr>
<td>dimensions</td>
<td>Ø 37 mm, height: 17.4 mm</td>
</tr>
<tr>
<td>weight</td>
<td>36.5 g</td>
</tr>
<tr>
<td>integrated sensors</td>
<td>T, p, rH</td>
</tr>
<tr>
<td>interface</td>
<td>GPIO port RJ12 connector</td>
</tr>
<tr>
<td>sensor mount</td>
<td>magnetic mount, screw mount</td>
</tr>
<tr>
<td>working environment</td>
<td>non condensing</td>
</tr>
<tr>
<td>cable length</td>
<td>2.5 m</td>
</tr>
</tbody>
</table>

Measurement Accuracy (Sensors)

- T-sensor: ±0.1°C (0..50°C)
- p-sensor: ±1 hPa (300..1100 mbar)
- rH-sensor: ±2% (10..90%)

Typ. accuracy setup:

- better ±1 ppm guaranteed
- ±0.5 ppm up to 5 m
- ±0.1 ppm up to 4.2 m

Accessories

A wide variety of customized targets are available (such as unmounted corner cube retroreflectors, mirrors, or glass targets).
Angular measurement software upgrade

With the angular measurement software, the FPS can now also be used to non-invasively measure angular position variations with high resolution. The software is set up to handle three customized sensor heads in parallel, displaying two angular and one linear position information. As with the linear measurement software, the angular software outputs position information via USB, AquadB, and HSSL. Specific sensor head holders for angular measurements are available. This feature requires three customized sensor heads with a collimating optics and a beam diameter of 1.6 mm.

### Technical Specifications

<table>
<thead>
<tr>
<th></th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Angular</strong></td>
<td>±5°</td>
</tr>
<tr>
<td><strong>Linear</strong></td>
<td>0..2000 mm</td>
</tr>
<tr>
<td><strong>Relative Error</strong></td>
<td>±1° typ</td>
</tr>
</tbody>
</table>
| **Sensor Holders**  | M12/F1.6 (customed) d=40 mm, Art. No. 1008993  
M15.5/F1.6/FLEX (customed) d=40 mm, Art. No. 1008994 |

### Cables / Wiring Options

HDMI to SubD adapter cable incl. level adaptation: connecting from HDMI to SubD, supplying both differential AquadB, single-ended AquadB, and single-ended HSSL outputs. One adapter cable is required per axis. Compatible with both FPS1010 and FPS3010, output level complies with TTL/LVDS standards. In addition, we supply a SubD to BNC cable with a length of 2 m to get a direct connection to the single-ended AquadB signal via BNC connectors.

### Cables

<table>
<thead>
<tr>
<th>Length</th>
<th>Art. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5 m</td>
<td>1007329</td>
</tr>
<tr>
<td>10 m</td>
<td>1007332</td>
</tr>
<tr>
<td>BNC 1m</td>
<td>1007330</td>
</tr>
</tbody>
</table>

### Technical Specifications

<table>
<thead>
<tr>
<th></th>
<th>Number of Axes</th>
<th>Max. Sensor Separation</th>
<th>Bandwidth</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Angular</strong></td>
<td>thre alpha, beta, theta</td>
<td>4 x 1500 mm</td>
<td>10 MHz</td>
<td>10 µ° (170 nrad)</td>
</tr>
<tr>
<td><strong>Linear</strong></td>
<td>3 mm</td>
<td></td>
<td></td>
<td>1 pm</td>
</tr>
</tbody>
</table>

### Accessory Kits

There are three different packages available:

- **Basic** (including an alignment laser (635 nm) and a fiber cleaning tool)
- **Pro** (all “Basic” articles as well as additional kinematic mounts for sensor head (type: M12 & M15.5/FLEX) and mirror adjustment)
- **Pro xr** (all “Basic” articles as well as additional kinematic mounts for sensor head (type: D1.2 & D4) and mirror adjustment)

### SYNC package

Ethernet connectivity including EPICS software drivers, TCP/IP commands, and documentation.

<table>
<thead>
<tr>
<th></th>
<th>Art. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SYNC</strong></td>
<td>1007382</td>
</tr>
</tbody>
</table>

### FPS1010 axis upgrade

On-site software upgrade from one to two or one to three axes (no send-in of the unit required). Please inquire at info@attocube.com for upgrade pricing.

<table>
<thead>
<tr>
<th></th>
<th>Art. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Axis upgrade</strong></td>
<td>1007381</td>
</tr>
</tbody>
</table>

### FPS - Optics Kit “Basic”

- FPS - Optics Kit “Basic” 1007370
- FPS - Optics Kit “Pro” 1007371
- FPS - Optics Kit “Pro xr” 1007372