attoSENSORICS
Ultra Precision Sensors

Synchronous Data Acquisition for Detecting Vibration Propagation

pioneers of precision

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Synchronous motion tracking in synchrotrons and spallation sources based on the BiSS-C interface

Introduction

Synchrotron is an extremely powerful X-ray source, where the X-rays are produced by highly accelerated electrons, emitting energy at X-ray wavelength when changing directions. These X-ray beams are guided with a beamline to an experimental end-station, where they interact with matter, enabling us to study the properties of different materials. X-ray wavelength are much shorter compared to visible light, which makes is possible to probe much smaller structures (in nanometer-range) compared to traditional microscopes. X-rays, depending on their energies, also have high penetration capabilities, therefore often used in imaging. The beams are highly focused, which makes sample positioning a central issue. Triggering, detection, and feedback of the sample position needs therefore to be well sustained and documented.

BiSS-C is an open source interface that is based on the RS422 protocoll supporting signal transmission of up to 10 MHz [1]. The option for processing external trigger signals, also supported up to 10 MHz, enables the synchronization for several devices. Due to the need of synchronous data communication, attocube provides an IDS3010 with the BiSS-C interface that suits the standards of the Diamond Light Source and Omron/Delta Tau.

In high precision systems for moving object in nanometer ranges, error motions and vibration propagation are crucial information for the motion accuracy. Due to this, synchrotron facilities continue to develop and upgrade different components to keep pace with the latest available technology. The beamline I08 recently upgraded the end-station using attocube interferometers IDS3010 with BiSS-C interface. An experimental setup at the Diamond Light Source is synchronously triggering and tracking the movement of eight different linear axes. These eight axes were controlled by the Delta Tau "GeoBrick" controller, which ensures the accurate timestamped data from all eight axes, i.e. three IDS3010 devices.

Setup

The setup consists of three motion modules as shown in a simplified version in Figure 1: from the bottom one manual positioner, on top of it one stepper motor for more coarse adjustments, and finally on top of that one piezo-based positioner for fine motions. All three modules can move in X-, Y-, and Z-direction, i.e. the complete setup consists of 9 linear movements, and is being tracked by 8-axes consisting of M12/C1.6 high vacuum compatible sensor heads. Since the sample's position is relevant for each movement of the three modules, every motion needs to be tracked. There are two kinds of error motions (parasitic movements) relevant for the sample's position: vibrations caused by moving the positioner that spread to connecting positioners and the sample, as well as uneven motions caused by non-parallel mountings between the positioners.

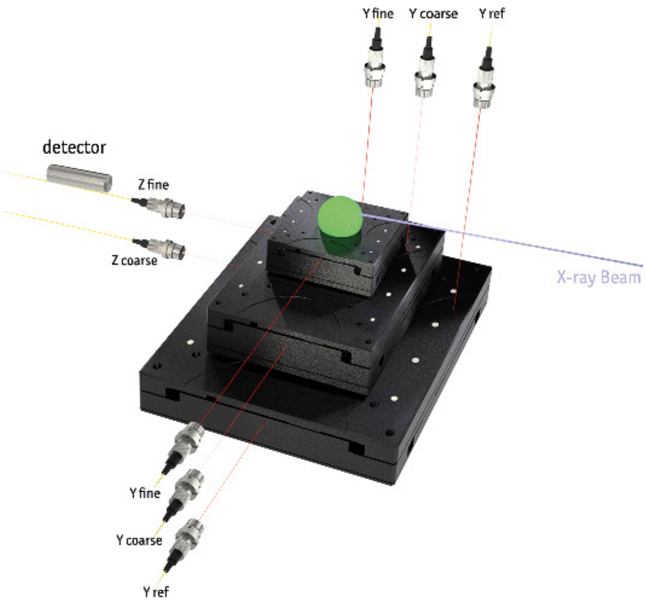

Figure 1: *Rough sketch of the setup. The eight sensor heads M12/C1.6 are shown monitoring the 3 modules, each module consist of 3-dimentional X, Y, and Z movements. The complete setup is in high vacuum.*

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Measurement Results

One measurement example is shown in Figure 2, which only involve the X, Y, and Z piezo-based positioners in the upper module. The two parasitic movements are shown while moving the fine piezo positioner in the X-direction using 5 nm step sizes. The red line (X-axis) shows the positioner moving in one direction, after 10 steps, the positioner is moving back with one 50 nm step. The blue line (the Y-axis) shows the error motions of the fine positioner orthogonal to the motion of the positioner in the horizontal level. The noised oscillations are caused by vibration propagation emerging from the positioner's motions. This line shows a linear offset of 10 pm for every step. This offset originates from the not perfect parallel mounting between the X- and Y- positioners. This non orthogonal mount can be compensated using the information for the other axes. The green line (Z-axis) shows the vertical movements of the fine positioner. Only the last step of 50 nm shows a significant change of the vertical position, presumable due to a rapid vibration.

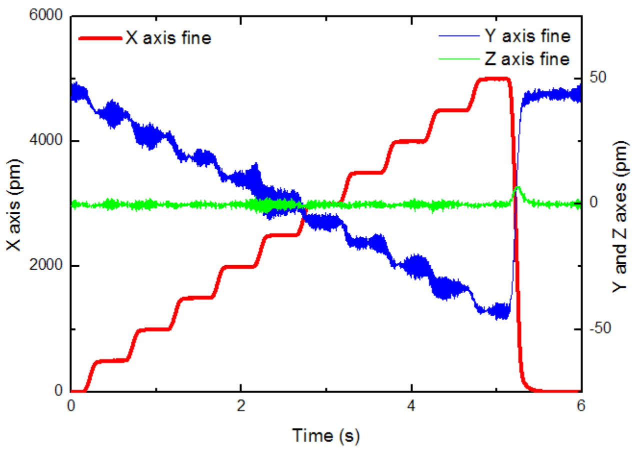

Figure 2: *The blue curve shows the water surface and sensor head movements and the red curve represents the displacements measured on the side of the mirror after hitting the optical table with a hammer.*

Conclusion

In addition to the picometer resolution provided by the IDS3010, this synchronous motion capturing and data acquisition of different measurement axes was realized by the BiSS-C interface. This real-time interface facilitates the simultaneous triggering of multiple measurement axes. In this case, eight axes of three IDS devices were triggered for synchronous data acquisition. With the BiSS-C interface connected with the Master Control on the Delta Tau, one could read the eight incremental encoders from the positioners as well as the 8 interferometer axes. It also gives the absolute positioners without the need to cross any reference axis.

Reference

[1] Official BiSS-C website: http://www.biss-interface.com/

[2]IDS3010 interfaces description http://attocube.com/attosensorics/ids-sensors/ids3010/