Head assembly for differential measurements

Abstract
The differential sensor head assembly can be used to perform high-precision displacement measurements of a target with respect to a reference surface. Additionally, it is less sensitive to influences due to changes in the refractive index of air.

1. SETUP

The differential sensor head assembly is shown in Figure 1. Unlike in standard **PICO**SCALE sensor heads, the reference mirror is not coated to one of the side surfaces of the beam splitter cube. In contrast, it is guided via a 45° mirror so that it travels parallel to the usual measurement beam. The lateral distance between the two beam is 18 mm (this way, the minimum differential difference between the two arms of the interferometer of 13 mm is guaranteed).

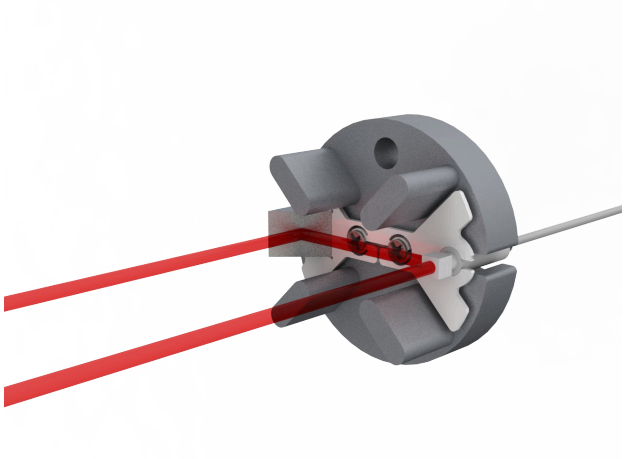

Figure 1. *The differential sensor head assembly. See text for details.*

2. PERFORMANCE MEASUREMENT

The differential sensor head assembly was built into a demonstration setup, shown in Figure 2. One beam (indicated as reference beam) is guided to a mirror that is fixed to the base of the target assembly at a distance of about 40 mm. The other beam (measurement beam) is guided to a mirror that is fixed to the slide of a SmarAct translation stage. Consequently, the **PICO**SCALE will measure the differential movement of the slide with respect to the base, irrespective of any common-mode movement, such as thermal dirft, changes in ambient conditions affecting the refractive index of air, etc.. (Please note: Changes in ambient conditions will only have an effect on the relatively small differential working distance of about 18 mm, given by the lateral offset between the reference and measurement beam.)

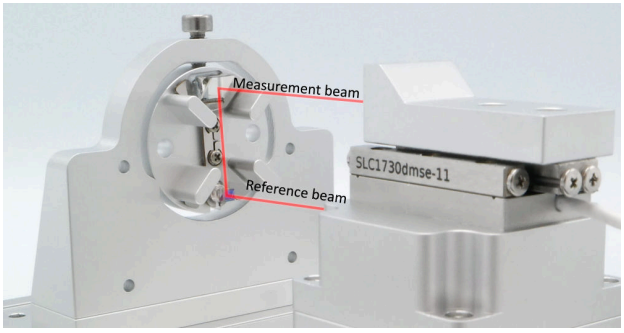

Figure 2. *Setup for the performance measurement. See text for details.*

2.1 Closed-loop measurements

The linear positioner is connected to a SmarAct **MCS**2 controller, which is using sensor data from the **PICO**SCALE. Consequently, the control loop of the positioner is closed using the displacement data measured by the interferometer. In Figure 3, the closed-loop translation is shown, where the position was varied by 1 nm every 5 s.

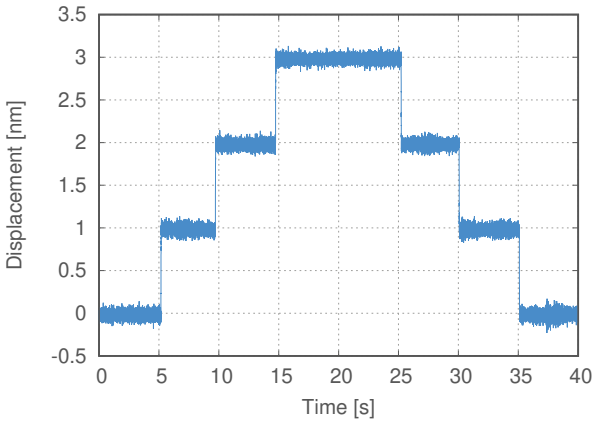

Figure 3. *Closed-loop movements with steps of 1 nm.*

Figure 4 shows a close-up to the first five seconds, demonstrating the very low peak-to-peak noise of 400 pm with a standard deviation of 41 pm.

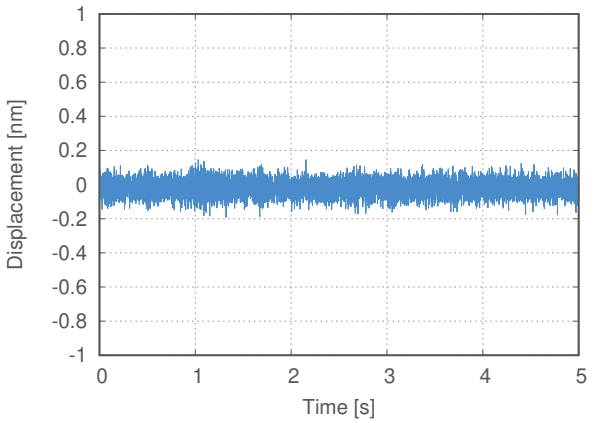

Figure 4. *Time trace of the displacement signal showing a peak-to-peak noise of 400 pm and a standard deviation of 41 pm.*

2.2 Frequency domain measurements

The setup of the previous section was compared to a measurement with a standard sensor head, aligned to a target mirror at a working distance of 40 mm. The amplitude spectral densities of the two displacement data are shown in Figure 5. The differential sensor head shows lower noise, especially at low frequencies, where the standard sensor head suffers disturbances due to acoustic noise as well as influences by changes in the refractive index of air and thermal drifts. The lower noise floor at high frequencies is due to the fact that the *effective* working distance of the differential head assembly is only 18 mm, given by the lateral offset of the two beams. Unavoidable laser phase noise induces a length proportional position noise, which means that lower working distances suffer lower position noise (neglecting additional effects like mechanical vibrations, which typically have stronger influences in larger setups).

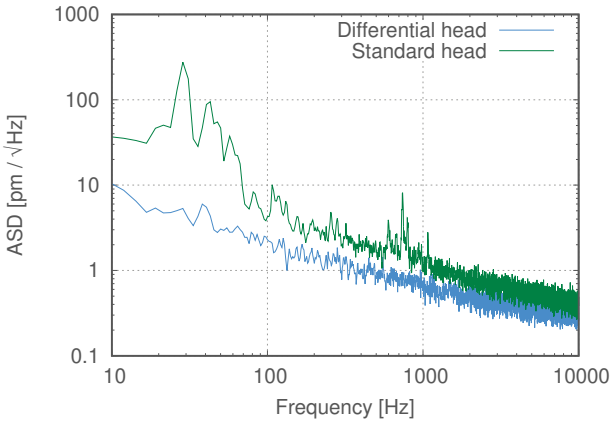

Figure 5. *Comparison of the differential assembly with a standard sensor head at the same working distance. The differential assembly shows lower noise, especially at low frequencies.*

3. MECHANICAL PROPERTIES

The mechanical properties of the differential sensor head assembly are summarized in Table 1.

Table 1. *Summary of mechanical properties of the differential sensor head assembly.*

Property	Value
Diameter of mount	1” (25.4 mm)
Material of mount	Aluminum (others on request)
Material sensor head holder	pre-loaded spring steel
Adjustment screws	M1.6 setscrews (0.7 mm hex key included)

4. ORDER CODE

Please contact SmarAct for advice on the most suitable options of this assembly.

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