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Air turbulence effects on measurement stability of the RLE10

Introduction

Interferometer systems are used in precision motion control applications for many reasons, including the inherently high resolution available from 'wavelength of light' based systems, and the ability to measure directly in the plane of the worksurface - a feature that enables Abbé offset error to be eliminated.

In non-vacuum environments, atmospheric conditions affect the laser beam and therefore the stability of the measurement. These effects can be the dominant performance limiting factor. To quantify the magnitude of this instability, a series of tests have been undertaken using a Renishaw RLE10 interferometer system with differing optical path lengths and a range of beam protection techniques. These protection techniques varied from beam shrouding within a still air tube, to complete absence of shielding in an open, air conditioned laboratory environment. Results of these tests are summarised in this application note.

Test results - measurement stability (±nm) by path length

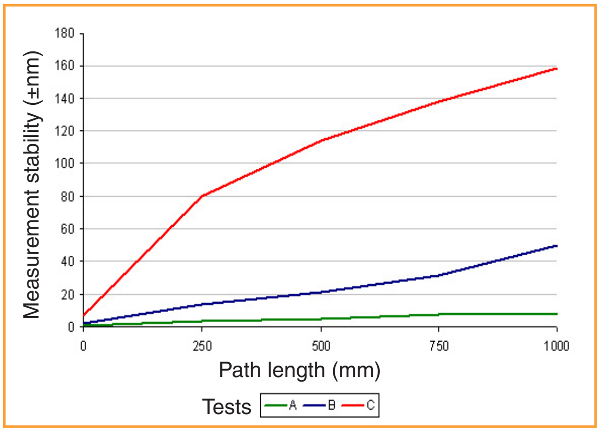
Test*	Path length (mm)				
	0**	250	500	750	1000
A	1.39 nm	3.66 nm	4.92 nm	8.06 nm	8.49 nm
B	2.32 nm	13.90 nm	21.75 nm	31.73 nm	50.02 nm
C	6.98 nm	79.78 nm	114.56 nm	137.72 nm	158.07 nm

Table 1: test results

Notes:

* For test conditions see 'Methodology' right.

** As path length is taken to be the distance between the centre of the beam splitter (within the detector head) and the apex of the retroreflector target optic, a true path length of 0 mm is impossible to achieve even with zero separation between the two components. Stability figures quoted are the average of five, ten minute tests, conducted for each path length under each environmental condition.



Graph 1: test results

Conclusion

Results indicate that measurement stability errors caused by air turbulence increase as path length is extended, and as the level of shielding around the beam is reduced.

Under the most extreme environmental condition tested (Test C), measurement stability errors of up to ±158 nm were experienced.

Measurement stability is improved dramatically simply by switching off the laboratory air conditioning (Test B). Further improvements are achieved by introducing shielding around the beam path (Test A), although in practical applications this may be impossible.

Methodology

Testing was performed using a purpose built Invar test rig (providing a maximum beam path length of 1 metre) and an RLE10 laser interferometer system comprising an RLU10 laser unit, an RLD10 0° detector head and an RLR10 retroreflector optic. (Invar's low coefficient of thermal expansion makes it an ideal material for the production of such a test rig.)

Tests were carried out over five different path lengths ($0^{\ddagger}$, 250, 500, 750 and 1000 mm) and the following environmental conditions:

A: Still air tube surrounding beam path, laboratory air conditioning system switched off

B: Still air tube removed from beam path, laboratory air conditioning system switched off

C: Still air tube removed from beam path, laboratory air conditioning system switched on

‡ See 'Notes' left.

Procedure

The test rig was assembled as shown in Figure 1. The RLD10 0° detector head was attached to one end of the Invar rig and the retroreflector attached to an optical mount, whereby its position could be adjusted to suit the beam path length required.

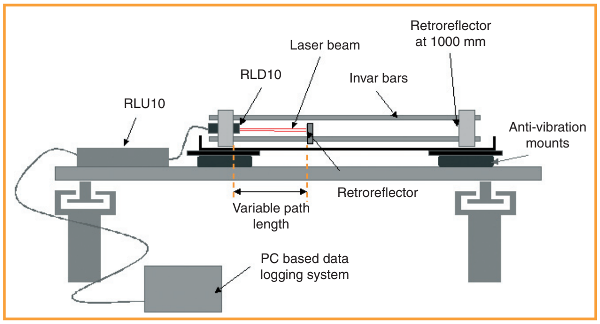


Figure 1: test rig set-up