Performance verification of a dual sensor stage

A.Yacoot[1], J. Mountford[1], M. Tedaldi[1], B. Reid[2], S. Levy[2]

[1]National Physical Laboratory, Teddington, Middlesex TW11 0LW UK
[2]Queensgate Instruments, Woodland Road, Torquay, Devon, TQ2 7AY, UK

andrew.yacoot @npl.co.uk

National Physical Laboratory

Abstract

The current trend for nanopositioning with increased speed has led to the development by Queensgate of a dual sensor system for servo control of single axis displacement stages. The stage and control system is currently being evaluated using optical interferometry developed at the National Physical Laboratory. Preliminary results show the performance of the optical interferometer and the stage.


Figure 1

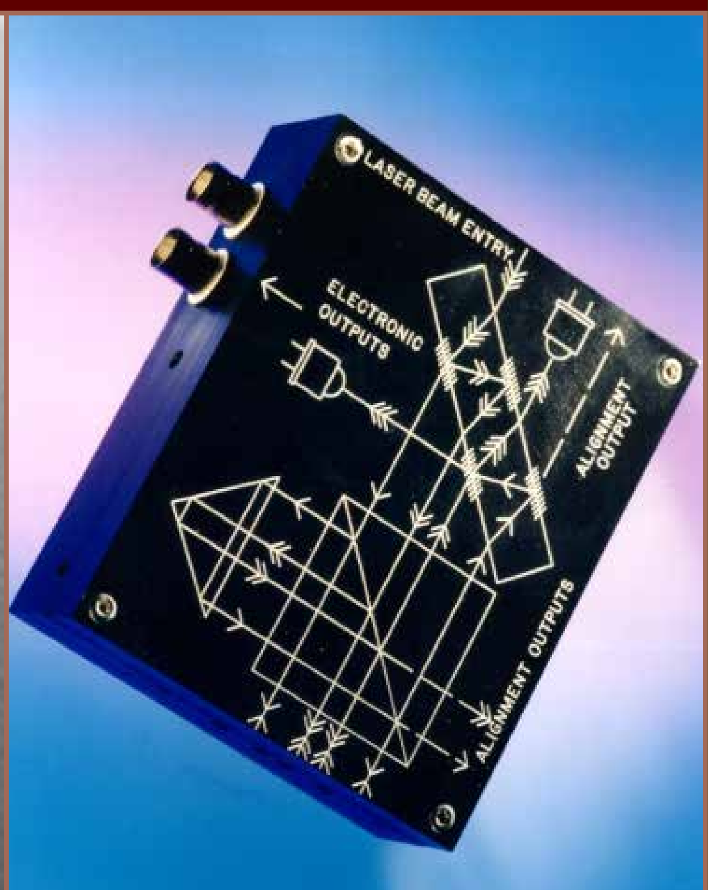


Figure 2

1. Stage development

A Queensgate NPS X-15A single axis displacement piezo driven flexure stage [1] has been fitted with a second sensor in addition to the usual capacitance sensor feedback. This offers the advantages of a 60 % reduction in settling time and a 50 % reduction of the load dependency of the stage which in turn increases the versatility of the stage.

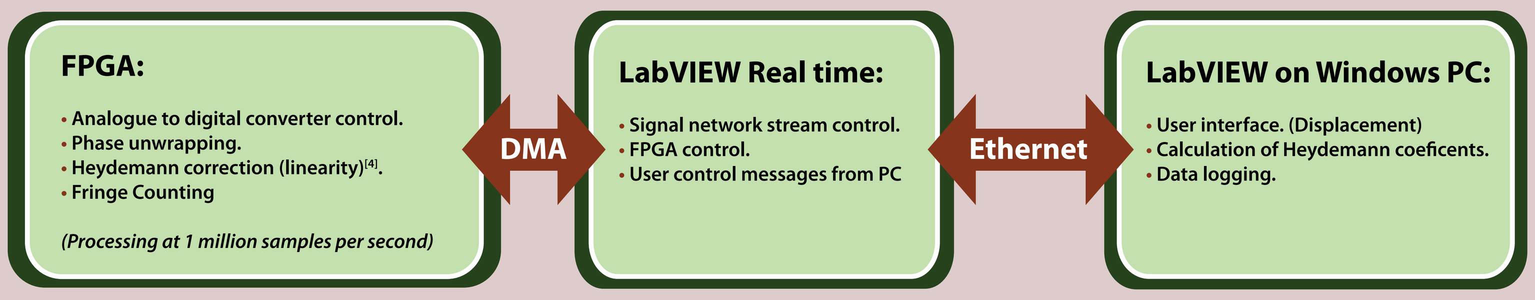


Figure 3: Block diagram of fringe counting system

2. Interferometer development

The NPL plane mirror differential optical interferometer ***figure 2*** [2] has been upgraded with new fringe counting electronics based on a National Instruments Single Board Real Time Input/Output (NIsbRIO) card with an integrated field programmable Gate array (FPGA) and microprocessor running LabVIEW real-time software. Signal collection from the interferometer is achieved using 1.0 MHz 16 bit analogue to digital converters fitted. A block diagram of the complete system is shown in ***figure 3***.

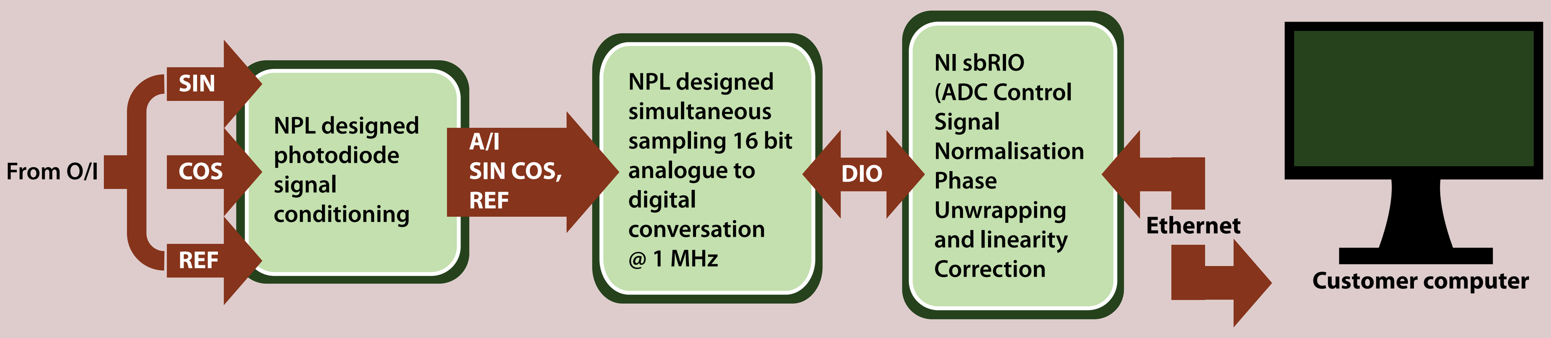


Figure 4: Block diagram showing tasks performed by the software

The x-ray interferometer is an ideal tool for characterising optical interferometers [3] and can be regarded as a ruler or translation stage whose length scale is based on the lattice spacing of silicon. ***Figure 5*** shows the stability of the optical interferometer when referenced against the x-ray interferometer. Over sixteen hours the drift was ~ 150 pm.

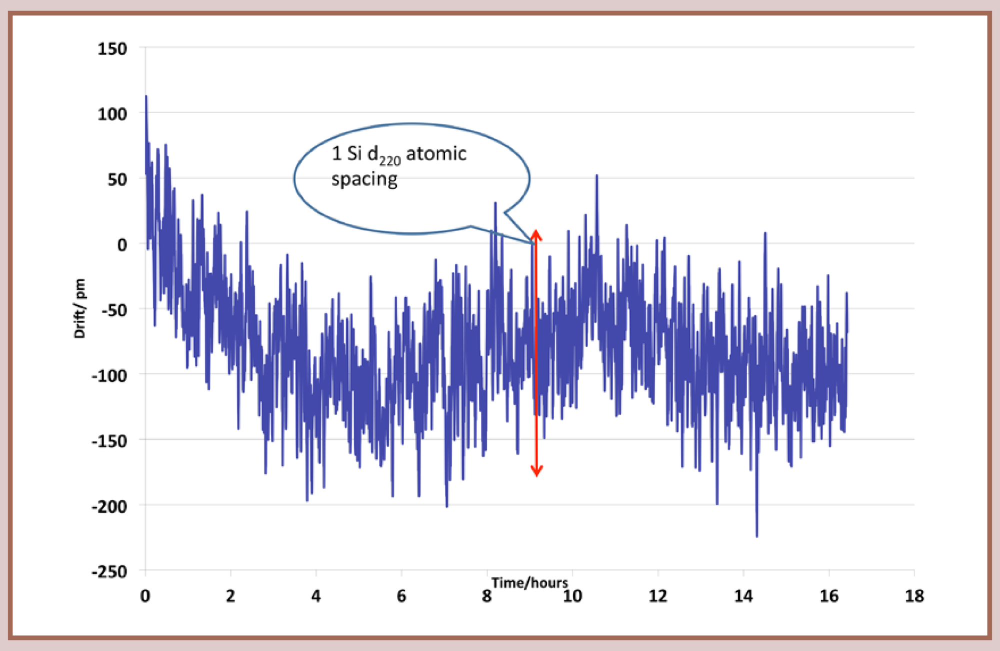


Figure 5: Drift in the optical interferometer

A power spectrum of the interferometer noise is shown in ***figure 6***; it shows noise to be at the 1× 10^{-6} $(\text{nmRMS})^2$ level.

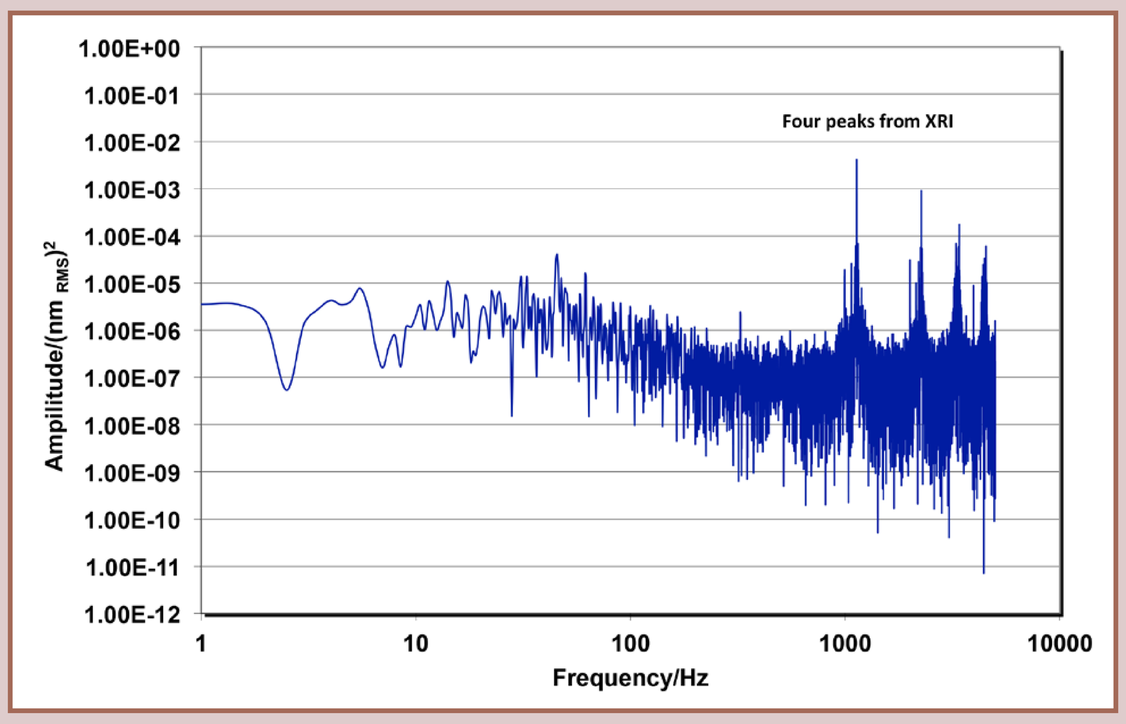


Figure 6: Power spectrum of interferometer noise

3. Stage performance

Figure 7 shows the position noise of the stage measured using the optical interferometer at a sampling rate of 10 kHz; the RMS noise is 0.14 nm.

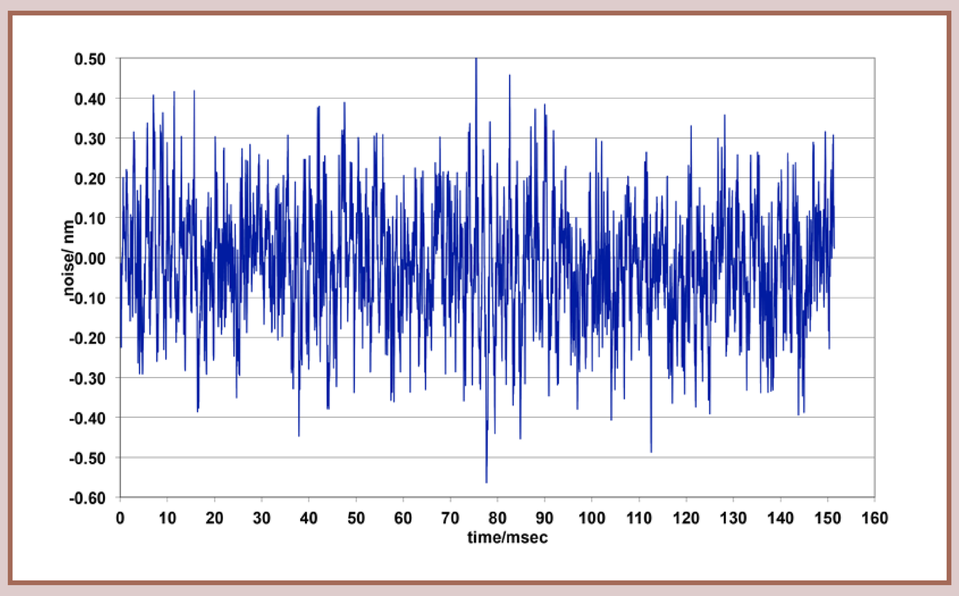
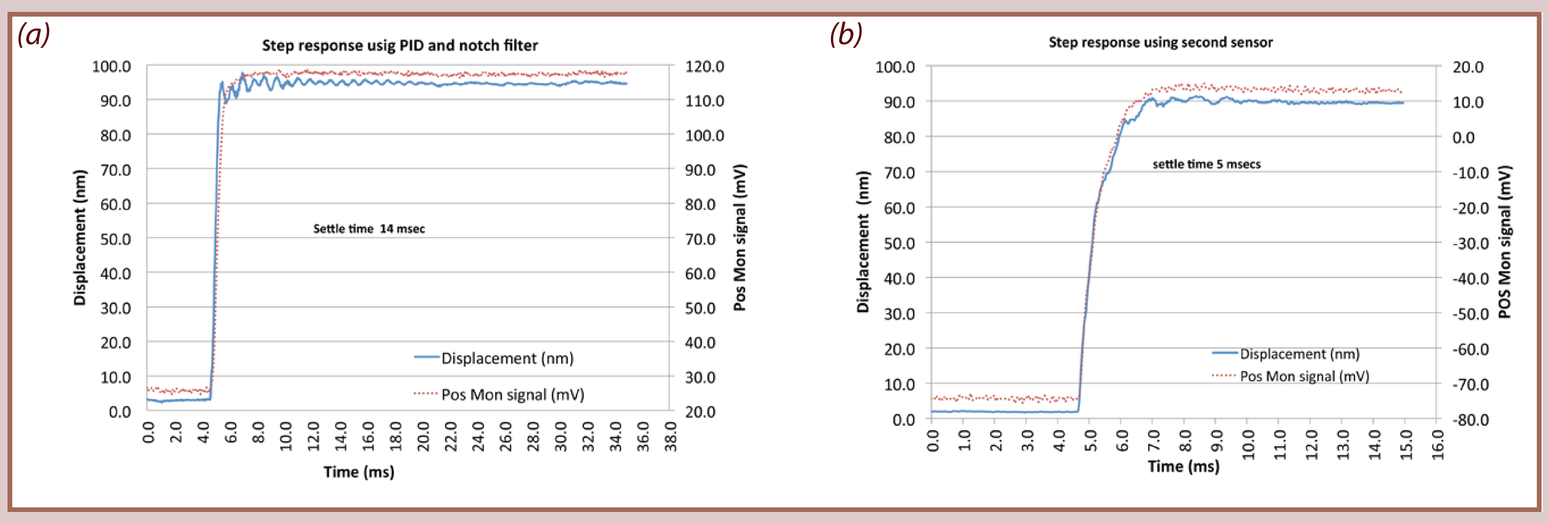


Figure 7: noise measurement of stage

Figure 8 shows the response of the stage to a 100 nm step captured by the interferometer. The blue (solid line) shows the interferometer signal and the red (dotted) shows the response of the second sensor (Pos Mon) in the stage. The response time of the stage to reach a steady state with second sensor is ~4.85 ms compared to ~14 ms without.



Figures 8a and 8b: Step response of stage with second sensor and without second sensor measured using optical interferometry

Future work will complete the characterization of the stage and interferometer.

National Measurement System

queensgate
a brand of Elektron Technology

Acknowledgements

Both Queensgate Instruments and NPL would like to thank the Technology Strategy Board for the funding of this work.
NPL would like to thank the BIS NMS Engineering Measurement Programme for co-funding this work.

References:

[1] http://www.nanopositioning.com/products/nanomechanisms/nps-x-15

[2] Yacoot A and Downs M J 2000 The use of x-ray interferometry to investigate the linearity of the NPL differential plane mirror optical interferometer *Meas. Sci. Technol.* **11** 1126-30

[3] Pisani *et al.* 2012 Comparison of the performance of the next generation of optical interferometers *Metrologia* **49** 455-467

[4] Heydemann P L M 1981 Determination and correction of quadrature fringe measurement errors in interferometers *Appl. Opt.* **20** 3382-4

www.npl.co.uk