Piezo-based active damping and drift correction on a larger hexapod structure

J. Reiser[1], C. Mock[1]

[1]Physik Instrumente (PI) GmbH & Co. KG

j.reiser@pi.de, c.mock@pi.de

Abstract

Ever-challenging requirements for position accuracy, stability and resolution in high-precision mechatronic systems cannot be met anymore by only improving the performance of the systems itself. Minimizing the influence of external disturbances becomes increasingly important as externally introduced vibrations can have a big impact so that the system cannot utilize its full performance being designed for.

In this paper, active damping (resonant eigenmode suppression) and drift correction is investigated on a large hexapod structure with an overall mass of ca. 1 ton by using six active, hybrid hexapod struts with integrated piezoelectric actuators. Inside each strut, the piezoelectric actuators are separated into two segments. One segment is used to actively damp the eigenmodes of the hexapod structure and the second segment is based on PI's patented PIRest technology. It serves as a high-resolution, "remotely-accessible" drift correction unit that doesn't introduce any additional position noise to the system, because its position can be held without any supply voltage.

Capacitive sensors measure the relative motion between the moved plate (the one to be stabilized) and the fixed plate. Both plates are connected via the six hexapod struts. The acceleration of the moved plate is measured by nine high-resolution accelerometers allocated on predefined positions. By using linear coordinate transformation, all single sensor signals and piezo voltages can be coupled to coordinated axis motions, thus, the position, velocity and acceleration of the moved plate can be measured and controlled in six degrees of freedom. By this, each eigenmode can be decoupled according to control and measured value.

An algorithm is developed that minimizes iteratively axis crosstalks caused i.e., by mechanical tolerances, different piezo gains (d_{33}), etc. in the assembled hexapod setup.

To proof the damping performance, several excitations (i.e. external shakers) are tested. The damping results are evaluated in frequency- and time-domain by comparing the open loop and closed loop performance. An overall damping for the first four eigenmodes of a factor of 9 (ca. -19 dB) can be achieved. Some of the resonant peaks are even cancelled out in frequency domain, being barely visible

anymore. The semi-active drift correction unit achieves a minimal incremental motion of down to 1 nrad in rotational axes and 1 nrad in the transversal axes.