Recent Advances in Nano-Precision Motion Technologies Address the Resolution/Speed Tradeoff

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Abstract

Mechanical and controls advancements have long been sought to address the needs for many industrial and optical applications for higher resolution and higher process throughput—or, ideally, both. But traditionally these goals are at cross-purposes, since the time to settle to a given positional tolerance rises exponentially with the inverse of the tolerance, all else being equal. Given the rapidly diminishing dimensional tolerances in a wide spectrum of industrial processes versus the “time is money” truism for any manufacturing or research endeavor, recently marketed advances that address both needs at the same time represent fundamental breakthroughs of keen interest to industrial engineers and researchers. In this session we will present parallel advancements in the fields of flexure-based nanopositioners, multi-axis, low-inertia, parallel-kinematics mechanics designs and high-bandwidth controls engineering with application to nano-scale positioning and active optics:

- Integrated, parallel-kinematics mechanics with up to six degrees of freedom
- Advancements in flexure designs that improve nanometer-scale bidirectional passive trajectory control, often allowing bidirectional processing for the first time
- Multi-axis, high-bandwidth active trajectory control, allowing out-of-plane motions in scanning applications to be controlled to Ångstrom levels
- Cost effective, industrial-class implementations of momentum compensation (also known as Frahm damping) for low-order cancellation of inertial inputs to supporting structures, which is of particular applicability to structures with low natural resonance frequencies such as telescope optics and biotech scanners
- Input Shaping®, a patented controls technique developed at the Massachusetts Institute of Technology, which provides effective cancellation of structural resonances in arbitrary actuation
- Input Preshaping™, a technique realized in both *a priori* and self-learning implementations, which substantially eliminates following errors in repetitive actuation.

The author reviews applications of each of these, alone and together, in a comprehensive overview of state-of-the-art industrial nanopositioning techniques.

Keywords: nano-precision motion control, flexural designs, multi-axis, high-bandwidth, Frahm damping

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