Spectral Decomposition

A better way to program trajectories when fast tool and standard servos are used in combination

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Introduction

As demands for machine productivity increase steadily, there is growing interest in the use of "fast-tool servos" in motion control applications. These actuators — which include voice-coil motors, piezo crystals, laser galvanometers, and magneto strictive transducers — have very high bandwidths, but limited travel range. Because of this, they are often paired with standard "slow tool" servo actuators that can provide the full range of travel, even though they lack the bandwidth required to execute all high-frequency components of the desired trajectory.

This white paper describes a new method for programming the trajectories of both fast tool and standard servo actuators which involves a "spectral decomposition" of the ideal net trajectory. This technique can be likened to an audio system's split between "woofer" and "tweeter" speaker cones.

Relevant industries:

- Laser
- Sintering
- Cutting/etching
- Machine tooling
- Large-scale mills

Contents

What is the product feature?

When using a combination of fast tool and standard servo actuators, a key question is how to program the trajectories of both actuator types. The traditional method has been to move the standard actuator to the area of interest and have it hold position there. Then the fast tool actuator would operate quickly in this zone. Next, the standard actuator would step to a new position, and the fast tool would operate there. This would repeat until the entire area was covered.

This method has several shortcomings. Throughput is typically low because of the start/stop nature of each actuator's trajectory. If there needs to be continuity in the path between separate stopping locations of the standard servo, this can be difficult to achieve. There are often "stitching errors" at the boundaries of these zones. Finally, it is difficult to program the overall motion, given that detailed knowledge of the different actuator capabilities is required to be embedded in each part program.

A more recently developed strategy is to use a program that commands an idealized mechanism with both the bandwidth and travel range to execute all of the desired trajectory features. Standard CAD/CAM software can often be used to generate these programs. A sophisticated controller then divides this trajectory in real time into separate components that the standard and fast tool actuators execute in coordinated fashion.

Conceptually, the algorithms to do this can usually be quite simple. The ideal net trajectory is passed through a low-pass filter that limits the frequency content of the output to what the standard actuators can reliably execute within their bandwidth. The difference between the net and the low-pass-filtered trajectory – the equivalent of a high-pass-filtered trajectory – is then fed to the fast tool actuators.

This spectral decomposition of the trajectory is analogous to an audio system's split between "woofer" and "tweeter" speaker cones. It can use very standard digital filtering techniques on the digital trajectory values. Of course, care must be taken to keep the actuators fully coordinated.

What technologies support this feature?

Power PMAC provides a variety of tools for implementing hybrid fast-tool/standard servo control. Depending on the system configuration, different tools may be used.

There are two commonly used tools in Power PMAC for separating the frequency content of the overall desired trajectory into high-frequency and low-frequency components for the different actuators. The optimal choice for a particular application depends on the details of the application, particularly the geometry of the mechanism.

Power PMAC provides a programmable trajectory "pre-filter" for each motor as part of the standard firmware. This is a polynomial filter with 4th-order numerator and denominator terms. Simply by setting the coefficients of the filters for both motors and enabling the filters, it is possible to split the commanded trajectory into high-frequency and low-frequency components.

This filter is at the final stage of the processing of the commanded trajectory. It executes under the servo interrupt and provides the same filtering effect regardless of the upstream trajectory processing.

This filtering method is appropriate for the simple geometric case where the standard and fast-tool actuators are moving along the same axis, and there is no need for complex kinematic transformations. It has the advantage of not requiring any user code to implement the filtering; the coefficient values are simply written to the corresponding filter saved setup elements for the motor. Using the built-in filter is more computationally efficient, but less flexible, than a filter written in user code.

Examples of solutions with the feature

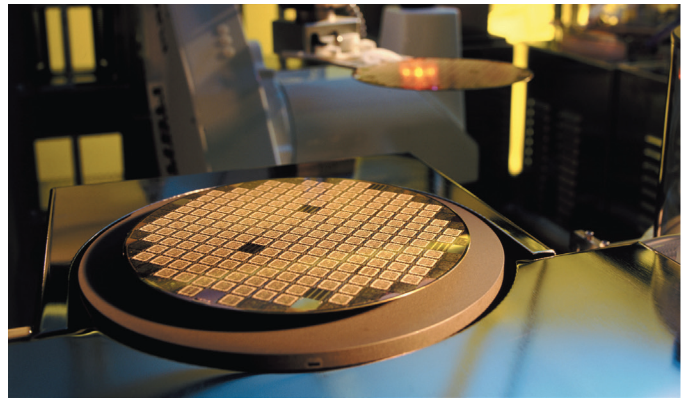
One of the main areas that utilize spectral decomposition is the laser industry. Lasers utilize high-speed actuators like galvanometers and voice coil motors to move the laser. This leaves them a small work area, and frequently a system like a linear motor stage to enlarge the work are to fit the piece that they are working with. By using a PMAC and implement spectral decomposition they can get much better through put while maintaining the accuracies that they are looking to produce with the laser. The PMAC will separate the trajectory into the two trajectories that are needed, one for the Galvo and another of the stage. The result is the tooling (laser) maintaining the highest quality cut while gaining a higher throughput.

PMAC Series – Programmable Multi-Axis Controller

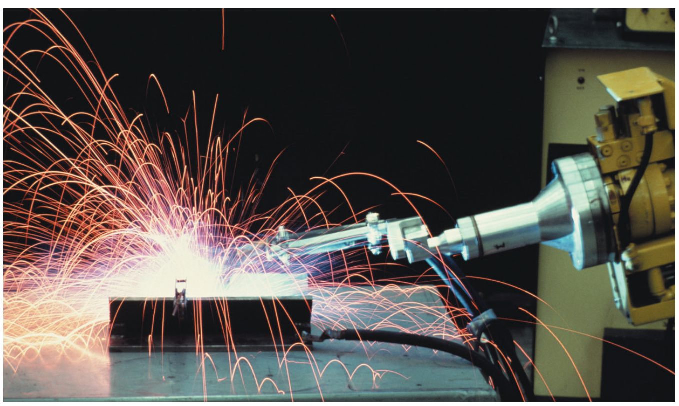
Summary

Fast tool and standard servo actuators are increasingly being combined in various industry applications like sintering, etching, and machine tooling. Although this gives manufacturers the best of both worlds when it comes to bandwidth and travel range, it leads to challenges with programming the trajectories of both actuator types. A new method involving spectral decomposition overcomes the shortcomings of the traditional method for programming these trajectories, and has been shown to improve throughput, minimize stitching errors, and reduce the amount of detailed knowledge required.

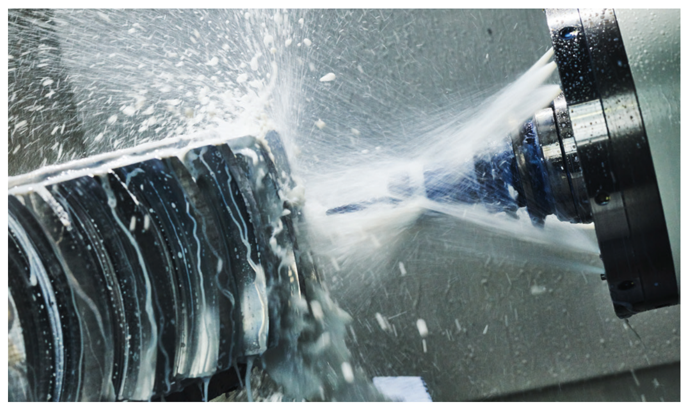
Laser



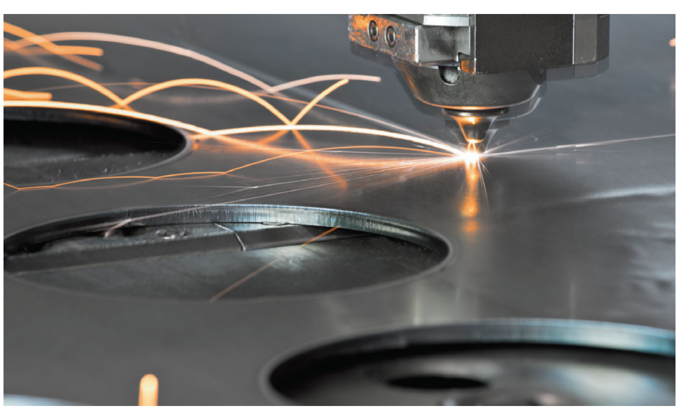
Sintering



Cutting Etching



Machine Tool



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