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Feed Forward for servo control

A tuning strategy for achieving better accuracies in production

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Introduction

As manufacturing advances, there is a constant drive to enable higher accuracies in servo control, whether to produce a higher-quality product or to improve machine efficiency by creating less scrap. Tuning is one of the main ways of achieving better accuracies during production.

In highly dynamic applications, the "following error" — which refers to the variance between the commanded position and the actual position of the servo motor — can vary during the rapid acceleration of an axis. The following error is used as feedback to the drive, which then reactively attempts to minimize the following error. A form of tuning known as Feed Forward can help mitigate this effect. One of the possible solutions is to use the servo axis in positional mode together while sending Feed Forward (Velocity and Acceleration) signals from the motion controller to the servo drive.

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Contents

What is Feed Forward?

Feed Forward consists of proactive gains that attempt to predict the velocity and acceleration commands that are needed to achieve zero following error. Even with the use of extremely fast industrial networks (such as EtherCAT), there is a delay in the commands from the controller to the drive due to the cycle of the network. Also, when using Feed Forward, gains in the drive are still reactive, as the drive is getting the profile from the controller over the network.

Feed Forward can improve machine throughput by reducing the settling time of an axis. It also has a very positive effect on coordinated motion and can greatly improve the trajectory of machine tooling by reducing the following error of all coordinated axes.

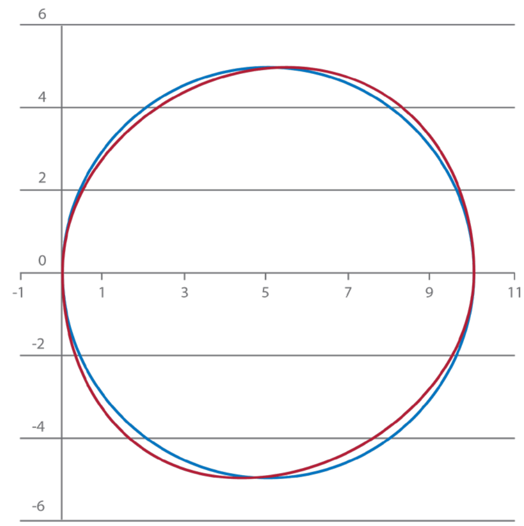

Figure 1

In this coordinated XY table making a circle, the difference between the two colors (the commanded position vs. the actual position) is equivalent to the following error.

Feed Forward in the PMAC controller

In addition to having velocity and acceleration Feed Forward in our servo drives, Omron also has Feed Forward in our PMAC family of advanced motion controllers. This allows the controller to command the Feed Forward based on the upcoming motion profile.

Omron's PMAC controller-based Feed Forward allows for changes in current based on upcoming move profiles rather than waiting for the profile to get to the drive through the fieldbus. By commanding the Feed Forward from the controller, we can achieve a much smaller following error and therefore better accuracies.

By tuning the Feed Forward in the controller, we are using the upcoming motion profile in the Feed Forward parameters. The controller can then compensate by using the following error based on feedback from the drive as well as the upcoming profile for higher accuracy.

With the inclusion of Feed Forward in the PMAC controller, we have seen reduction of more that 90% in systems' following error. This is naturally variant on the motion profile to load to motor.

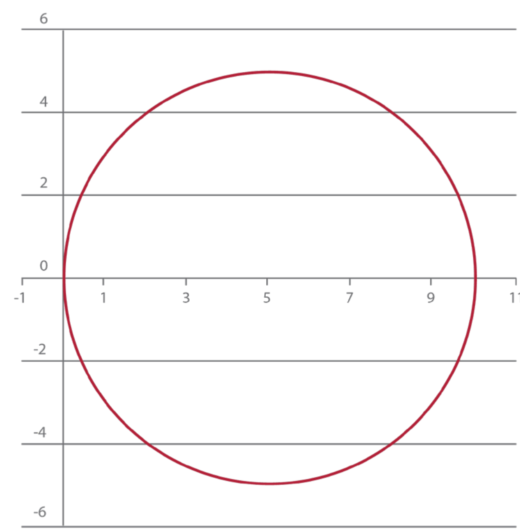

Figure 2

With Feed Forward applied, the same XY table shows that the actual position and commanded position are virtually the same.

How to use Feed Forward

Take an example of a subtractive manufacturing process. All axes of the machine can be accelerating and decelerating at the same time, and this can amplify the effect that following error has on the product. By reducing the following error during this process, it can reduce or even eliminate a secondary process to bring the machining into final tolerances. This is due to the controller being able to compensate the new profile based on response from the motor.

Summary

The Omron skillet lifter conveyor solution cleverly uses the versatile functionality of the F3SG-SR safety light curtain to ensure safety in skillet lifter applications in a way that is both affordable and effective. The light curtain's warning beam and unmonitored blanking functions, along with proper sizing considerations, ensure that any unexpected obstructions between the skillet's two pylons will be reliably detected.

Industries

- Subtractive manufacturing
- Laser, Plasma and Waterjet tables
- CNC
- Lathes

Additive manufacturing

- 3D printing
- Welding

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