

AC Servos Get Faster—And Smarter

Technology advances boost positioning accuracy and stability at high speeds, while simplifying set up.



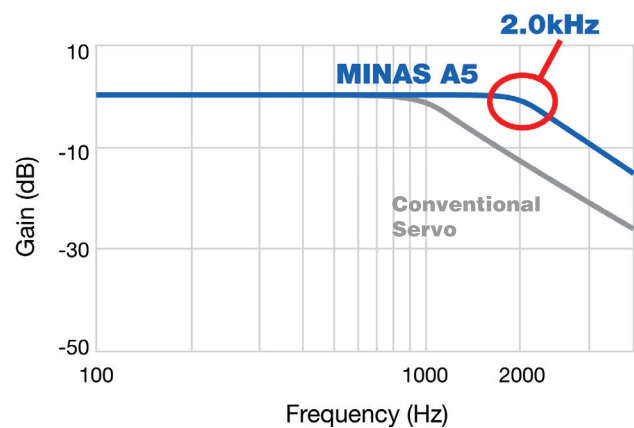
AC servo systems have long been the workhorses of industrial automation, but it's time to start thinking of them as thoroughbreds. Thanks to ongoing advances in control algorithms and processing power, the best AC servo drives can now exert degrees of control that would not have been possible even a year ago.

Not every AC servo drive, however, has what it takes to qualify as the best, making it difficult to bring about significant improvements in line speeds, positioning accuracy, vibration control and other important automation objectives.

In this paper, we'll examine the features you should look for in advanced AC servo drives and provide an overview of the applications these features target.

BOOST FREQUENCY RESPONSE

The top speed of a motion system and its ability to respond quickly to positioning commands obviously depend, at least in part, on the servo drive's frequency response. AC servos can vary widely in their frequency responses. The fastest systems today can achieve a frequency response of 2.3 kHz, while more typical response value would be on the order of 1.0 kHz (See Figure 1).



This extra speed can come in handy in any application that benefits from enhanced positioning accuracy and repeatability, such as semiconductor processing equipment. Speedy motion systems can also improve the productivity of fast-moving processes. Packaging lines are a prime example.

Beyond speed and positioning advantages, a fast frequency response also tends to reduce vibration, which can be important in just about any moving machine application.

MINAS A5 Key Features

- 2.0 kHz frequency response
- Real-time auto-gain tuning
- 20 bits/revolution, 1.04 million pulses.
- Low cogging torque.
- Manual/Auto Notch and Damping Filters
- IP67 enclosure rating for increased environmental resistance.
- In applications where positioning accuracy is paramount, these servos also support pulse train commands operating at 4 Mpps. That's double the 2 Mpps offered by previous models.

MAXIMIZE RESOLUTION

Thanks to breakthroughs in signal processing, the resolution available from incremental encoders has recently improved exponentially.

Our new MINAS A5 AC digital servo drives, to take a leading example, use proprietary signal processing methods and a dedicated serial communications bus to get 1.04 million pulses

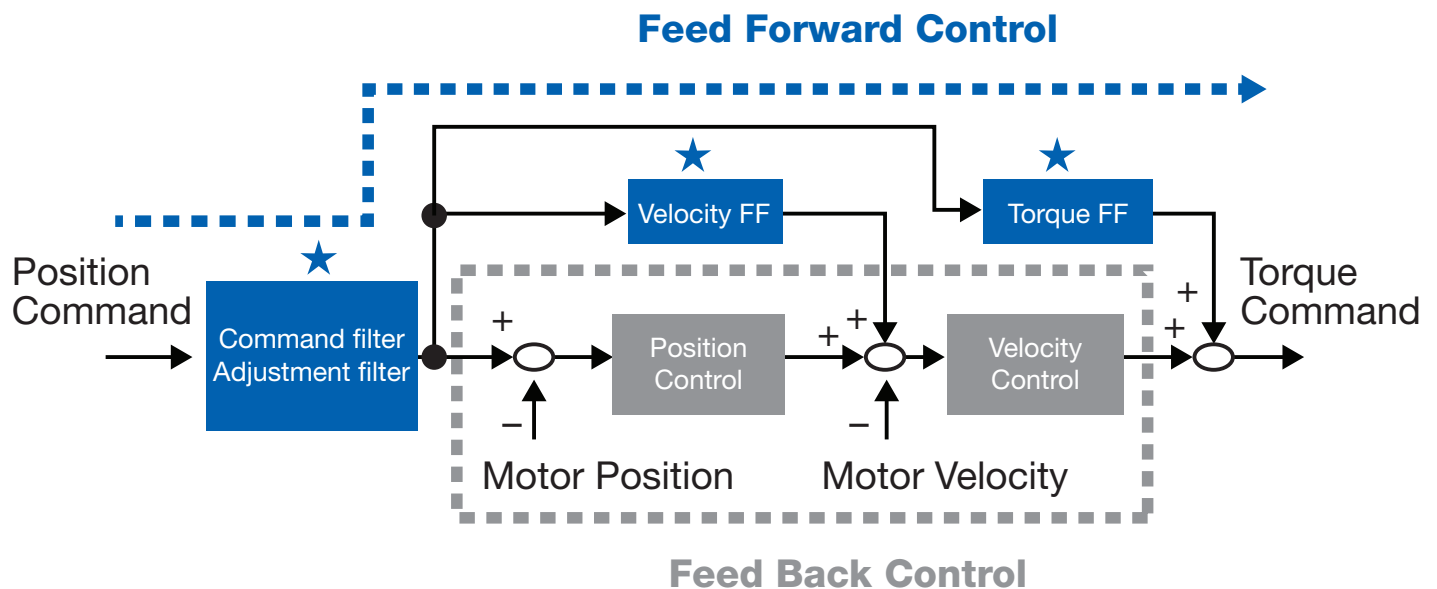
per revolution from a 20-bit encoder. Compare that ultra-high resolution to the 2,500 pulses per revolution that a conventional AC servo drive would get from the same encoder.

This support for high encoder resolutions translates directly to smooth, vibration-free motion and ultimately helps increase positioning accuracy. Machine tools, textile machines and semiconductor equipment can all get a significant performance boost from the additional resolution.

SIMPLIFY SET UP WITH ADVANCED AUTO-TUNING

One often overlooked, but increasingly important, differentiator among AC servo drives is ease of use. While some controls engineers have the knowledge and time to tune PID loops manually for each and every application, more advanced drives have supplemented manual tuning with automated tuning capabilities that make servo drives easier and less costly to set up. Equally important, auto-tuning can also improve servo performance by eliminating tuning errors and achieving a level of control not easily reached by manual tuning.

Consider the auto-gain tuning in our MINAS A5 servo systems, for instance. Based on changes in stiffness alone, it can calculate the relevant inertia ratios, resonance frequency, oscillation and gains. To set up and operate the system, users



Beyond Optimization

With its Real Time Auto Tuning (RTAT) functionality, the Minas A5II can continually fine-tune servo systems that have already been optimized with an initial auto-tuning. Oftentimes, RTAT will enable reductions in the stiffness setting for improvements in positioning. In this example, a belt load with an 60:1 inertia ratio is first auto-tuned and then fine-tuned with RTAT. The results:

	Initial Auto Tuning	After RTAT
Stiffness setting	15	13
Positioning	39.7 msec	5.3 msec
Resolution	±10 pulses, 350-pulse deviation	±10 pulses, 230-pulse deviation

simply single tuning parameter that corresponds to a specific operating goal—including positioning, vertical axes, high-friction axes.

Variants of auto-tuning have become commonly available from many automation vendors, though you will notice differences in how well and how quickly different auto-tuning algorithms will work.

A couple of advanced control features also set MINAS A5 apart from other auto-tuned drives. For one, MINAS A5 drives make use of an adaptive filter that suppresses vibration by automatically setting notch filters to remove resonance component from the torque command.

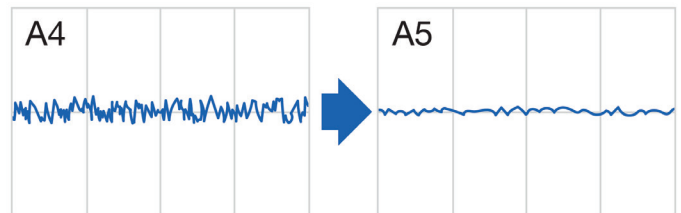
For another, some MINAS A5 models now offer two degree-of-freedom (2DOF) control that supports the simultaneous adjustment of feedforward and feedback control. Put differently, the 2DOF control algorithm allows separate adjustments to a given command's approach and settling reactions for reductions in vibration and response times.

From an applications standpoint, the new 2DOF control algorithm has been shown to improve cycle times on electronics assembly machines, surface finishes in machining operations and the speed and smoothness of industrial robots.

REDUCE COGGING TORQUE

Even the most advanced control algorithms do not adequately compensate for cogging torque, which leads to uncontrolled vibration and positioning errors. The right type of motor, however, can go a long way in reducing cogging torque.

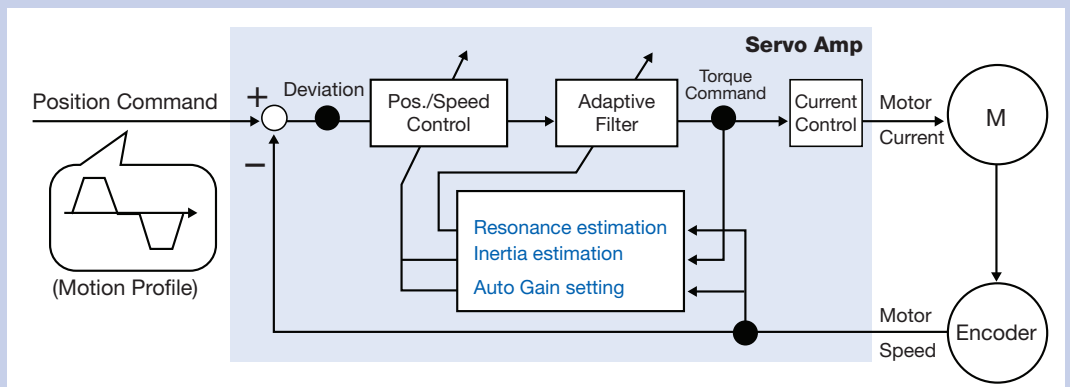
MINAS A5, for example, uses a brand new motor that has been optimized for low cogging torque. With a 10-pole design informed by sophisticated magnetic field analysis techniques, the motor has 37% less cogging torque than previous motors for an eightfold reduction in vibration (See Figure 2).



Vibration reduced by **88%**

Settling Time Reduction

Whether used with ball screws or belt drives, the MINAS A5 II offers significant settling time reductions.



INCREASE HIGH-PERFORMANCE FILTERS

Most moving machines will benefit from a reduction in noise and vibration, both for the longevity of the machine components and also for the machine to operate at its top speed. Notch and damping filters are two of the key control strategies for reducing vibration.

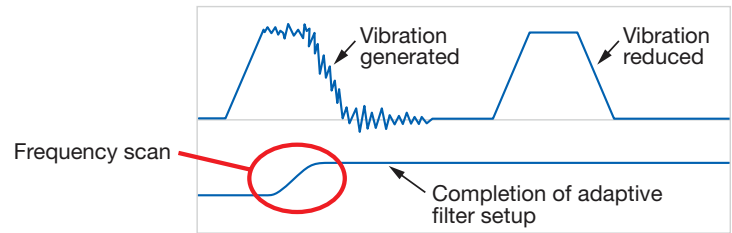
Notch filters reduce the noise and vibration caused by resonant frequencies. MINAS A5, for the first time, has four adaptive notch filters covering a frequency range from 50 to 5,000 Hz. Available in both auto- and manual-tuning modes, the filters can reduce noise and vibration due to resonance in applications such as semiconductor or packaging machines.

Advanced servo systems should also include damping filters, which remove the natural vibration frequency from the command signal. The result is drastically reduced vibration, particularly when a motion axis comes to a stop or settles on a position (See Figure 3). Available in auto- or manual-tuning modes, MINAS A5's four adaptive damping filters cover a frequency range from 1 to 200 Hz.

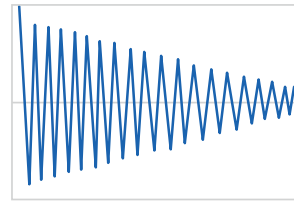
Not all AC servo drives are created equal. But if you select one with the right combination of combination of speed and smarts, you can make all kinds of industrial machines run faster, smoother and better.

For more information on the latest MINAS A5 servo drive and motor packages, visit <http://na.industrial.panasonic.com/products/industrial-automation/motion-control/ac-servo-motors>

Notch Filter Characteristics



Without Damping Filter



With Damping Filter

