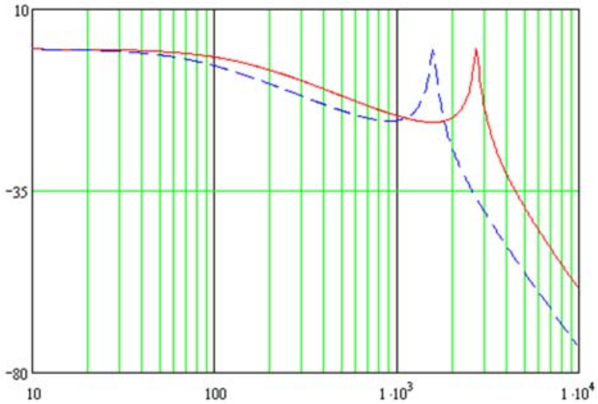
The Significance of Load to Motor Inertia Mismatch

Lee Stephens, Senior Motion Control Engineer
Kollmorgen
540-633-3545
contactus@kollmorgen.com
www.kollmorgen.com

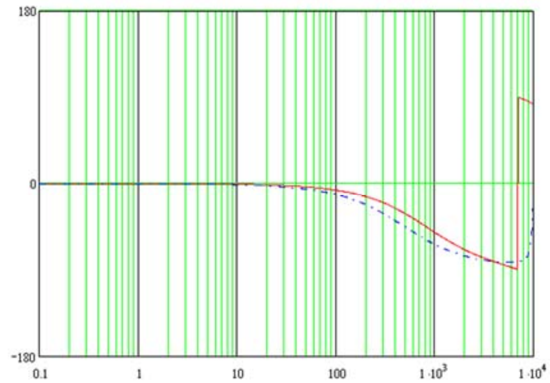
A servo system's inertia ratio is a commonly misunderstood parameter. When dealing with stepper motors, articles and tutorials often instruct the control engineer to select a motor that will match the ratio as close to 1:1 as possible. The reason is that stepper motors are prone to de-synchronization issues and torque losses, and need to be sized to match the load to overcome these challenges. Many incorrectly assume the same ratio is desired when specifying a servomotor, but this rule of thumb will result in a servomotor that is over-sized, unnecessarily expensive, wastes energy and may not perform to specifications.

Where compliant systems have a low frequency bandwidth and allow the load to move while the motor is stationary, a high bandwidth system is "stiff," and is vital for a high-speed precision mechanical system that is free from backlash. In a typical servo system with a "stiff" coupling methodology, a load to motor inertial mismatch of 5:1 is generally accomplished with little or no special techniques, and direct-coupled motors can be successfully tuned to ratios as high as 1600:1.



Magnitude of Load

But how is the bandwidth of the system affected by the motor inertia ratio? As an example, a simple servo system model was constructed where a load transfer function was compared using two servomotors. No motor parameters were changed in order to determine what the inertia ratio of the motor would do to the system.



Phase at Load

The rotor inertia of *Motor 1* (blue) was 0.001 oz·in·sec^2, while the rotor inertia of *Motor 2* (red) was 0.0002 oz·in·sec^2, which equates to a change from a 5:1 ratio to a 1:1 ratio.

With the two transfer functions simultaneously plotted, the frequency response of the system can be seen. The gain of the system is significantly less with the increased inertia. The –3dB point of each system is 133 Hz for *Motor 1*, while *Motor 2* has a –3dB point at 80 Hz. Assuming that system responsive to 100 Hz is necessary, this result would not be possible with *Motor 2* and its 1:1 ratio. As a general rule, at -3dB and 45 degrees phase shift, control has been lost.

KOLLMORGEN

Because Motion Matters™

ABOUT KOLLMORGEN

Kollmorgen is a leading provider of motion systems and components for machine builders around the globe, with over 60 years of motion control design and application expertise.

Through world-class knowledge in motion, industry-leading quality and deep expertise in linking and integrating standard and custom products, Kollmorgen delivers breakthrough solutions unmatched in performance, reliability and ease-of-use, giving machine builders an irrefutable marketplace advantage.

For more information visit www.kollmorgen.com, email contactus@kollmorgen.com or call 1-540-633-3545.