# Tuned Dampers Improve Stepper Performance

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## Introduction

For position-critical equipment driven by stepper motors, performance is gauged by speed and accuracy. In this equipment, a stepper motor is used to move and position a component. In a printer or a plotter, for example, a stepper motor is often used to move the print head or pen carriage laterally.

A certain amount of inaccuracy—or instability—is inherent in such equipment. Because of inertia, theoretical "seek and stop" stepper motor functions are in reality "seek and settle" operations. Unlike most electric motors, which rotate continuously, stepper motors rotate in finite steps, typically with 400 steps possible in one revolution.

When a stepper motor receives a command to move a component to another position, it accelerates, surges through the appropriate number of steps and tries to stop at the correct destination. Inertia, however, causes the component to overshoot the destination slightly. The component cannot perform its appropriate function until motion stops or the oscillation amplitude is within acceptable limits of tolerance for performance.

For these stepper motor applications, optimizing system performance means minimizing the amplitude and duration of the settling oscillations, and thus the settling time, without impeding normal operation.

## The tuned damper

Tuned dampers can provide practical mechanical solutions to these problems of excessive settling time and instability. Adding an optimized tuned damper to a typical system significantly reduces the time required for the complete decay of transient oscillations (Figure 1).

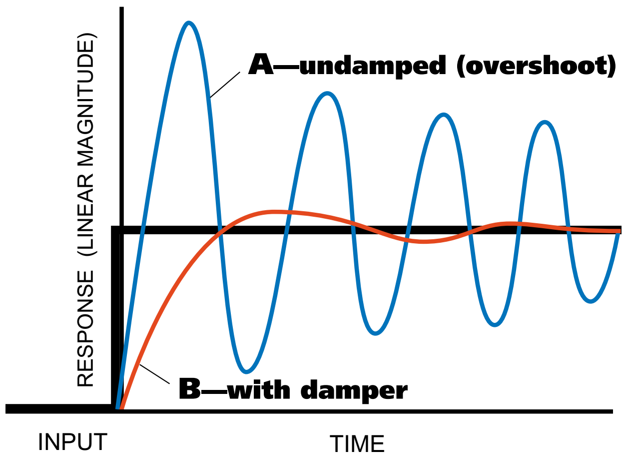


*Figure 1 Comparison of system response, with and without a tuned damper*

An annular shaped damper mass is mounted onto the output shaft of the stepper motor, along with a ring of damped elastomeric material (Figure 2).

Both the mass and the elastomeric ring move with the rotor. The angular momentum of the damper mass, however, causes it to lag slightly behind the rotor motion. This small difference in rotational angle generates shear in the elastomer element and produces the required damping.

The frequency and degree of resonance suppression can be changed by adjusting the damper mass, stiffness and damping properties of the elastomeric material. This adjustment is called tuning.

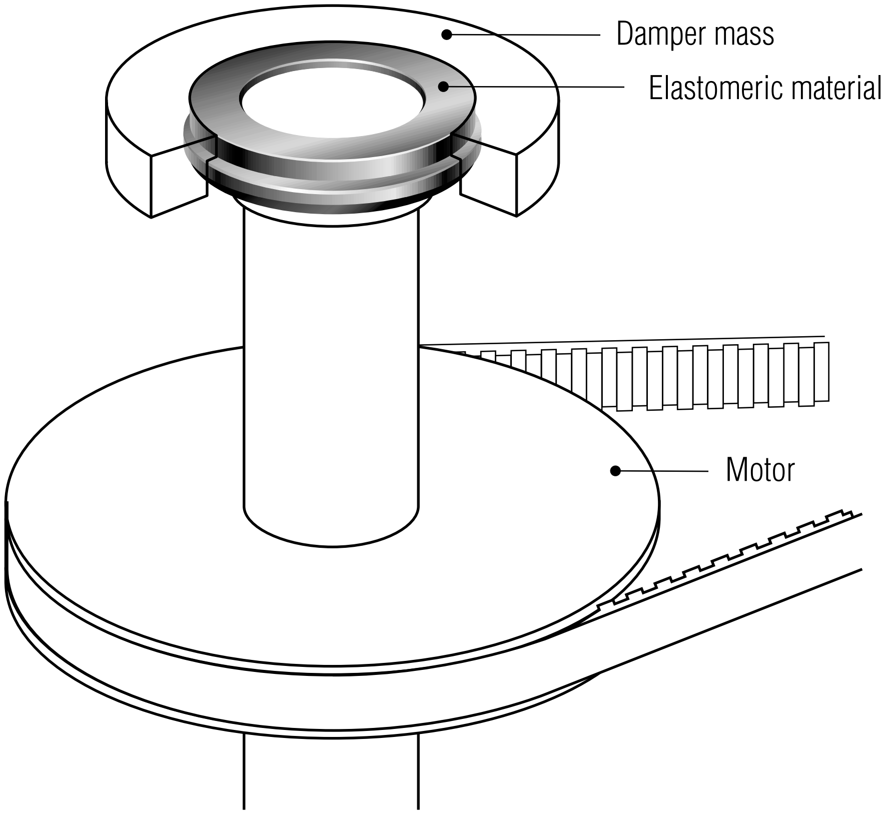


*Figure 2 Tuned damper*

**Optimizing performance**

The effectiveness of a tuned damper lies in the characteristics of the damping elastomer. The ideal material exhibits both high energy-loss characteristics and adequate mechanical stability.

E-A-R Specialty Composites produces proprietary urethane and thermoplastic materials whose high internal damping characteristics make them unusually well-suited for tuned damper applications. These elastomers exhibit high material loss factors, resulting in low amplification at resonance, quick return to equilibrium after vibration or shock input, and operational effectiveness over a broad range of frequencies.

The loss factor of a material represents the ratio of energy it dissipates to the amount it stores, temporarily, for each cycle of vibration. Typical rubber materials dissipate about 3 percent of their stored energy per cycle of vibration. E-A-R's ISOLOSS®, ISODAMP® and VersaDamp™ formulations, however, can eliminate much, if not most, of the stored energy. Further, the materials can be molded into intricate shapes and bonded to standard hardware such as metal washers. And they exhibit none of the contamination problems common with other solutions.

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