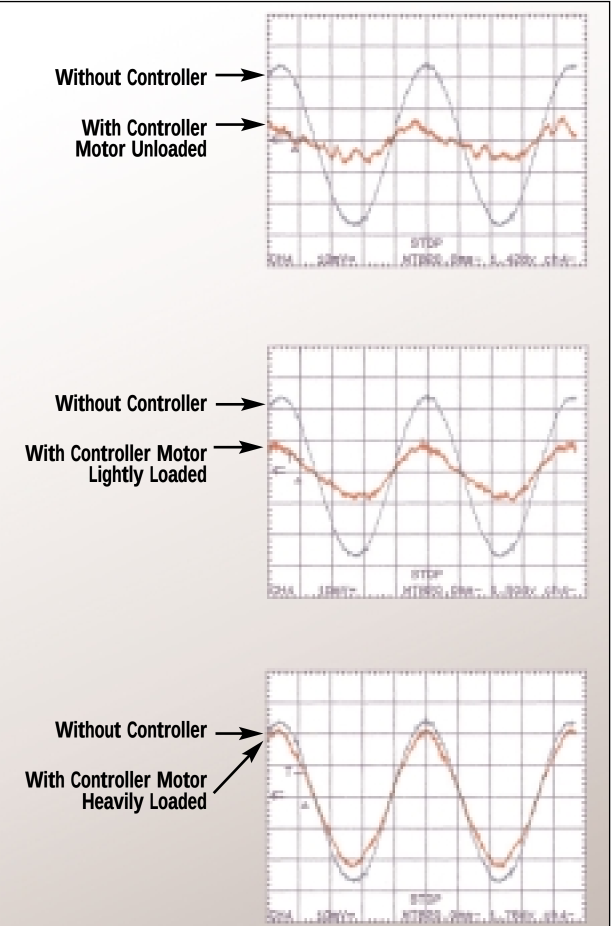
New Power-Efficient
Stepper Motor Control



Comparison of sine-driven stepper currents at 5 amps/division

Developed at NASA Marshall Space Flight Center (MSFC), this innovative stepper motor control method provides a solution to problems typically associated with stepper motors. This highly adaptable control method dramatically reduces the power necessary for operation, enabling energy savings.

Benefits

- Reduces resonance better than conventional sine-driven step motors
- Allows motor downsizing
- Reduces power consumption on lightly loaded stepper motors
- Increases motor efficiency over conventional sine-driven stepper motors
- Provides power proportional to the required load
- Offers nearly instantaneous motor response to loading
- Functions fully with various types of position sensors, including inexpensive Hall-effect sensors

Commercial Opportunities

This stepper motor control method is part of the NASA technology transfer program. The program seeks to stimulate commercial use of NASA-developed technologies. The stepper motor control method has been patented (U.S. Patent 6,013,999), and NASA invites U.S. companies to consider licensing this method for use in commercial applications. NASA is flexible in its agreements, and opportunities exist for exclusive, nonexclusive, and exclusive field-of-use licensing.

Commercial Applications

- Lightly loaded stepper motors (e.g., cranes, industrial machinery)
- Robotic systems
- Translation control for microgravity research (e.g., crystal growth furnaces)

National Aeronautics and Space Administration

The Technology

Stepper motors often are cost-effective solutions in digital control systems. However, they typically have four undesirable features: (1) a finite and usually low number of steps per revolution, (2) a high ripple torque (typically 100 percent), (3) a high constant internal power dissipation (I^2R) regardless of load, and (4) a high mechanical resonance at certain speeds. The first problem can be addressed with a sine wave drive. However, resonance has been a difficult problem to solve when using stepper motors in applications that require smooth, quiet motion. NASA Marshall's stepper motor control method eliminates all four undesirable features.

The novel aspect of NASA Marshall's method is its ability to vary the current to the motor proportional to the load without degrading the motor's response time to load changes. This offers power savings with a nearly instantaneous motor response. In addition, this control method can be coupled with a variety of position sensors, including the following:

- Embedded Hall-effect sensors
- Sine wave quadrature encoders
- Digital encoders
- Resolvers with sine/revolution sensing

NASA Marshall's stepper motor control method compares a sine wave representing the motor drive with a position feedback sine wave to produce current proportional to the load-induced lag, or position error. If a digital position sensor is used, a sine wave must be generated from the digital signals to input to the NASA circuitry. Position sensors with sine wave output are a more direct approach. The most economical solution is to embed Hall-effect sensors within the motor.

The reduction of current in the motor windings afforded by NASA Marshall's method increases motor damping, which eases the jerky, ratcheting response due to a stepper motor moving at a low speed or to resonance at higher speeds. This results in more accurate positioning and quieter operation. This can be particularly helpful in fast, precise robotic systems. In addition, the reduction of current in the motor windings enable the downsizing of motors in many applications.

For More Information

If you would like more information about this technology or about NASA's technology transfer program, please contact:

Paul Hicks
NASA Technology Applications Team
Research Triangle Institute
Phone: (919) 541-7202
Fax: (919) 541-6221
E-mail: phicks@rti.org

Sammy Nabors
Technology Commercialization Lead
NASA Marshall Space Flight Center
Phone: (256) 544-5226
Fax: (256) 544-8110
E-mail: Sammy.Nabors@msfc.nasa.gov

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More information about working with MSFC's Technology Transfer Department is available online.

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