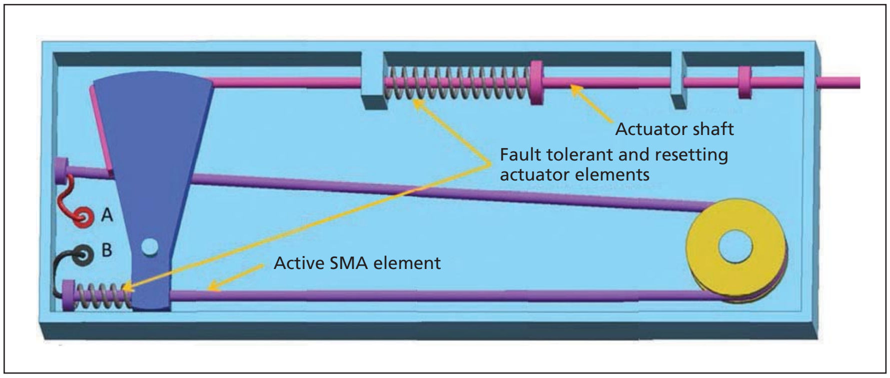

The **Actuator** is driven by shape memory alloy as a primary active element. Electrical connections to points A and B are used to apply electrical power in the resistive NiTi wire, causing a phase change that contracts the wire on the order of 5%.

has an inherent fault tolerance to mechanical resistance. The actuator has the flexibility of being designed for both linear and rotary motion. A specific configuration was designed and analyzed where fault-tolerant features have been implemented. In this configuration, an externally applied force larger than the design force does not damage the active components of the actuator. The actuator housing can be configured and produced using cost-effective methods such as injection molding, or alternatively, its components can be mounted directly on a small circuit board.

The actuator is driven by a SMA -NiTi as a primary active element, and it requires energy on the order of 20 Ws(J) per cycle. Electrical connections to points A and B are used to apply electrical power in the resistive NiTi wire, causing a phase change that contracts the wire on the order of 5%. The actuation period is of the order of a second for generating the stroke, and 4 to 10 seconds for resetting. Thus, this design allows the actuator to work at a frequency of up to 0.1 Hz.

The actuator does not make use of the whole range of motion of the SMA material, allowing for large margins on the mechanical parameters of the design. The efficiency of the actuator is of the order of 10%, including the margins. The average dissipated power while driving at full speed is of the order of 1 W, and can be scaled down linearly if the rate of cycling is reduced. This design produces an extremely quiet actuator; it can generate a force greater than 2 N and a stroke greater than 1 cm. The operational duration of SMA materials is of the order of millions of cycles with some reduced stroke over a wide temperature range up to 150 °C.

This work was done by Mircea Badescu, Stewart Sherrit, and Yoseph Bar-Cohen of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-47991

Ultra-Compact Motor Controller

Applications include industrial robotic arms, industrial machinery, and automobiles.

Lyndon B. Johnson Space Center, Houston, Texas

This invention is an electronically commutated brushless motor controller that incorporates Hall-array sensing in a small, 42-gram package that provides 4096 absolute counts per motor revolution position sensing. The unit is the size of a miniature hockey puck, and is a 44-pin male connector that provides many I/O channels, including CANbus, RS-232 communications, general-purpose analog and digital I/O (GPIO), analog and digital Hall inputs, DC power input (18–90 VDC, 0–10 A), three-phase motor outputs, and a strain gauge amplifier.

This controller replaces air cooling with conduction cooling via a high-thermal-conductivity epoxy casting. A secondary advantage of the relatively good heat conductivity that comes with ultra-small size is that temperature differences within the controller become smaller, so that it is easier to measure the hottest temperature in the controller with fewer temperature sensors, or even one temperature sensor.

Another size-sensitive design feature is in the approach to electrical noise immunity. At a very small size, where conduction paths are much shorter than in conventional designs, the ground becomes essentially isopotential, and so certain (space-consuming) electrical noise control components become unnecessary, which helps make small size possible. One winding-current sensor, applied to all of the windings in fast sequence, is smaller and wastes less power than the two or more sensors conventionally used to sense and control winding currents. An unexpected benefit of using only one current sensor is that it actually improves the precision of current control by using the "same" sensors to read each of the three phases. Folding the encoder directly into the controller electronics eliminates a great deal of redundant electronics, packaging, connectors, and hook-up wiring. The reduction of wires and connectors subtracts substantial bulk and eliminates their role in behaving as EMI (electromagnetic interference) antennas.

A shared knowledge by each motor controller of the state of all the motors in the system at 500 Hz also allows parallel processing of higher-level kinematic matrix calculations.

This work was done by William T. Townsend, Adam Crowell, and Traveler Hauptman of Barrett Technology, Inc.; and Gill Andrews Pratt of Olin College for Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

Barrett Technology, Inc.
625 Mount Auburn Street
Cambridge, MA 02138-4555
Phone No.: (617) 252-9000
Web site: www.barrett.com

Refer to MSC-23930-1, volume and number of this NASA Tech Briefs *issue, and the page number.*