Mechanics/Machinery

Positive-Buoyancy Rover for Under Ice Mobility

This floating rover operates at the ice/water interface in lakes and seas.

NASA's Jet Propulsion Laboratory, Pasadena, California

A buoyant rover has been developed to traverse the underside of ice-covered lakes and seas. The rover operates at the ice/water interface and permits direct observation and measurement of processes affecting freeze-over and thaw events in lake and marine environments. Operating along the 2-D ice-water interface simplifies many aspects of underwater exploration, especially when compared to submersibles, which have difficulty in station-keeping and precision mobility.

The buoyant rover consists of an all aluminum body with two aluminum saw-tooth wheels. The two independent body segments are sandwiched between four actuators that permit isolation of wheel movement from movement of the central tether spool. For normal operations, the wheels move while the tether spool feeds out line and the cameras on each segment maintain a user-controlled fixed position. Typically one camera targets the ice/water interface and one camera looks down to the lake floor to identify seep sources. Each wheel can be operated independently for precision turning and adjustments. The rover is controlled by a touch- tablet interface and wireless goggles enable real-time viewing of video streamed from the rover cameras.

The buoyant rover was successfully deployed and tested during an October 2012 field campaign to investigate methane trapped in ice in lakes along the North Slope of Alaska.

This work was done by John M. Leichty, Andrew T. Klesh, Daniel F. Berisford, Jaret B. Matthews, and Kevin P. Hand of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48863

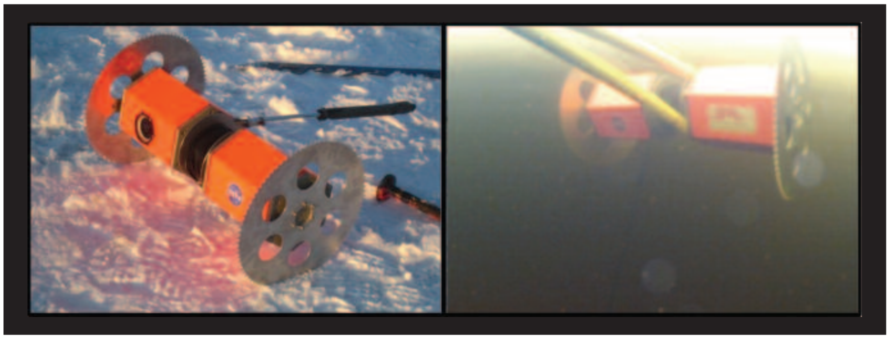

Figure 1. The **JPL Buoyant Under-Ice Rover** shown on the ice (left) and crawling on the underside of the ice (right) during a 2012 field campaign in Alaska. For scale, the rover is 0.54 m wide.

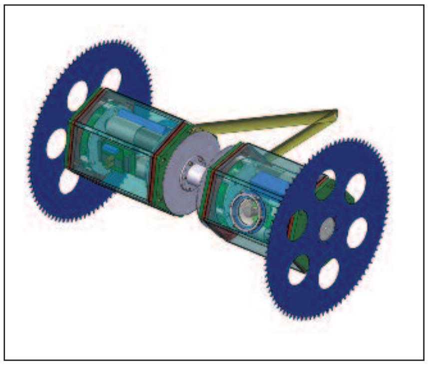

Figure 2. Computer aided design (CAD) model of the **JPL Buoyant Under Ice Rover** showing the two independent chassis regions each with wheel, camera, and instrument capability. The central tether spool can also operate independent of the side chassis.

Electric Machine With Boosted Inductance to Stabilize Current Control

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High-powered motors typically have very low resistance and inductance (R and L) in their windings. This makes the pulse-width modulated (PWM) control of the current very difficult, especially when the bus voltage (V) is high. These R and L values are dictated by the motor size, torque (K_t), and back-emf (K_b) constants. These constants are in turn set by the voltage and the actuation torque-speed requirements. This problem is often addressed by placing inductive chokes within the controller. This approach is undesirable in that space is taken and heat is added to the controller.

By keeping the same motor frame, reducing the wire size, and placing a correspondingly larger number of turns in each slot, the resistance, inductance, torque constant, and back-emf constant are all increased. The increased inductance aids the current control but ruins the K_t and K_b selections. If, however, a fraction of the turns is moved from their "correct slot" to an "incorrect slot," the increased R and L values are retained, but the K_t and K_b values are restored to the desired values. This approach assumes that increased resistance is acceptable to a degree. In effect, the heat allocated to the added inductance has been moved from the controller to the motor body, which in some cases is preferred.

The slew-rate of the current is calculated as V/L and can easily be 250,000 A/s. With a pulse width resolution of 10 μs, for example, the current could slew 2.5 A, which in some cases may exceed the resolution needed for the current control loop. If L is increased, the prob-