Technology Focus: Sensors

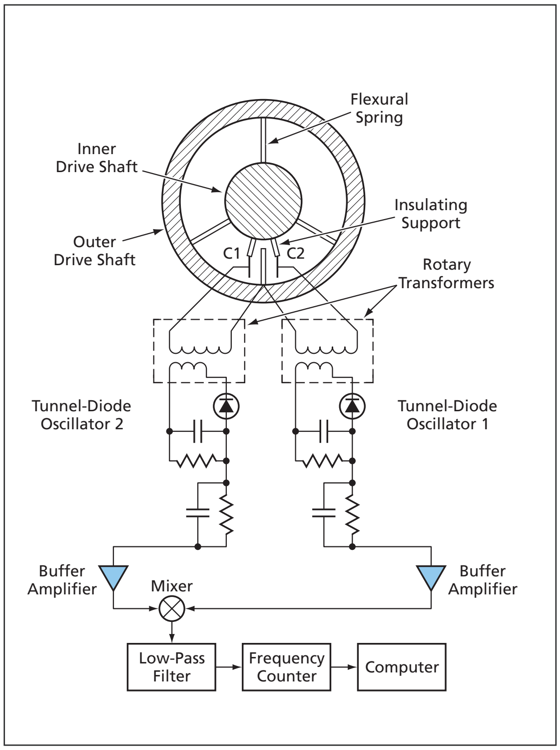
Torque Sensor Based on Tunnel-Diode Oscillator

This sensor would function over a wide temperature range.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed torque sensor would be capable of operating over the temperature range from 1 to 400 K, whereas a typical commercially available torque sensor is limited to the narrower temperature range of 244 to 338 K. The design of this sensor would exploit the wide temperature range and other desirable attributes of differential transducers based on tunnel-diode oscillators as described in "Multiplexing Transducers Based on Tunnel-Diode Oscillators" (NPO-43079), *NASA Tech Briefs*, Vol. 30, No. 9 (September 2006), page 42.

The proposed torque sensor (see figure) would include three flexural springs that would couple torque between a hollow outer drive shaft and a solid inner drive shaft. The torque would be deduced from the torsional relative deflection of the two shafts, which would be sensed via changes in capacitances of two capacitors (C1 and C2) defined by two electrodes attached to the inner shaft and a common middle electrode attached to the outer shaft. Each capacitor would be part of a tunnel-diode oscillator circuit. Each capacitor would be coupled to the rest of its oscillator circuit via a rotary transformer, so that there would be no need for wire connections between the shaft and the stationary part of the affected machine.



Torque Would Bend the Flexural Springs, causing a slight relative rotation of the inner and outer shafts, thereby increasing one of the capacitances and decreasing the other one, thereby further causing a decrease in the frequency of one tunnel-diode oscillator and an increase in the frequency of the other one.

The sensory principle would be mostly the same as that described in the cited prior article. At zero torque, the flexural springs would cause the common middle electrode to lie midway between the C1 and C2 electrodes. The two capacitances, and thus the frequencies of the two oscillators, would vary in opposite directions as torque caused the middle electrode to move away from the midpoint. The outputs of the tunnel-diode oscillators would be mixed and low-pass filtered to obtain a signal at the difference between the frequencies of the two oscillators. The difference frequency would be measured by a frequency counter and converted to torque by a computer.

This work was done by Talso Chui and Joseph Young of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).
NPO-43325

Shaft-Angle Sensor Based on Tunnel-Diode Oscillator

Advantages would include relative simplicity and low-temperature capability.

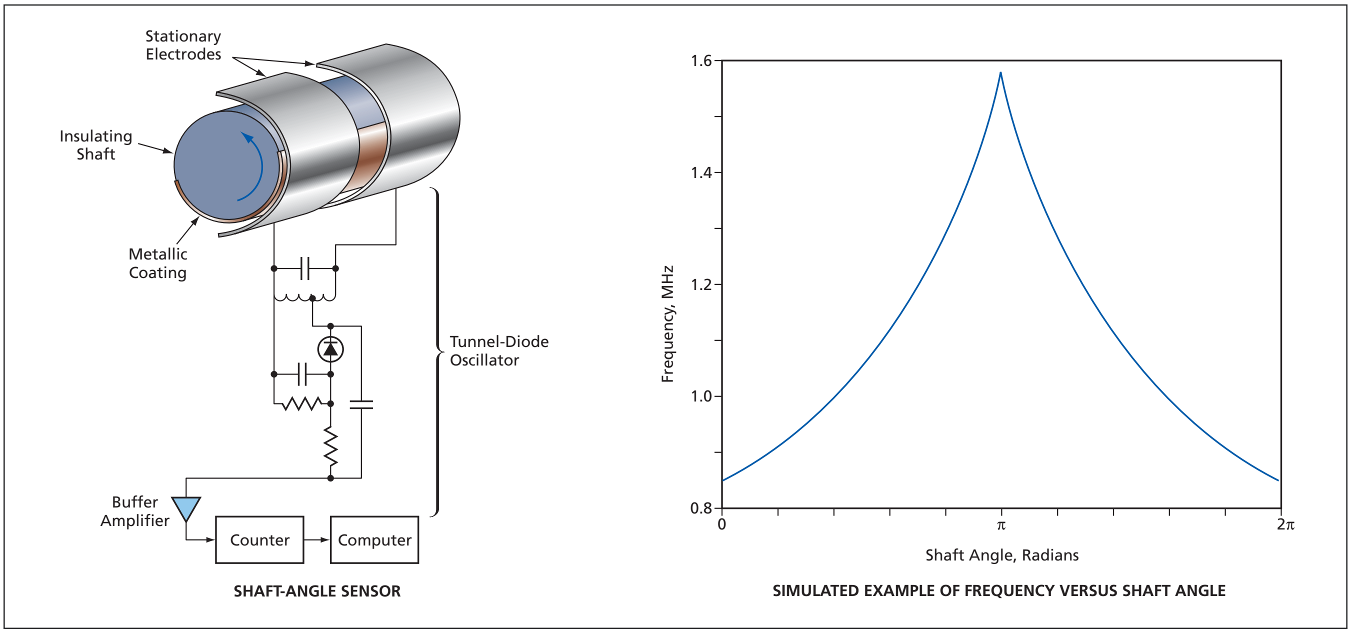
NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed brushless shaft-angle sensor for use in extreme cold would offer significant advantages over prior such sensors:

- It would be capable of operating in extreme cold; and
- Its electronic circuitry would be simpler than that of a permanent-magnet/multiple-Hall-probe shaft-angle sensor that would otherwise ordinarily be used to obtain comparable angular resolution.

As in the case described in the immediately preceding article, the design of this sensor would exploit the wide temperature range and other desirable attributes of differential transducers based on tunnel-diode oscillators as described in "Multiplexing Transducers Based on Tunnel-Diode Oscillators" (NPO-43079), *NASA Tech Briefs*, Vol. 30, No. 9 (September 2006), page 42.

The principle of operation of the proposed shaft-angle sensor requires that the shaft (or at least the portion of the shaft at the sensor location) be electrically insulating. The affected portion of the shaft would be coated with metal around half of its circumference. Two half-circular-cylinder electrodes having a radius slightly larger than that of the shaft would be mounted on the stator, concentric with



The **Series Capacitance** between the stationary electrodes would vary as the shaft turned, causing the frequency of the tunnel-diode oscillator to vary.

the shaft, so that there would be a small radial gap between them and the outer surface of the shaft. Hence, there would be a capacitance between each stationary electrode and the metal coat on the shaft.

The stationary electrodes would be connected into a tunnel-diode oscillator circuit, so that the series combination of the two capacitances would be part of the capacitance that determines the oscillation frequency. As the shaft is rotated, the stationary-electrode/metal-coat overlap area would change, causing the series capacitance and the oscillation frequency to change. The frequency would be measured and used to infer the shaft angle from the known relationships among shaft angle, capacitance, and frequency.

It should be noted that a given frequency could signify either of two distinct shaft angles. If necessary, one could resolve the shaft-angle ambiguity by use of two sensors at different angular positions.

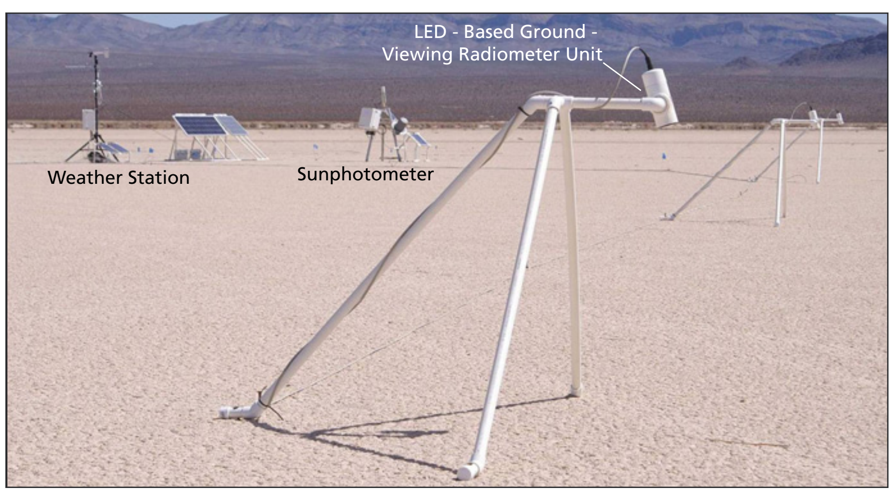
This work was done by Talso Chui of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).
NPO-43328.

Ground Facility for Vicarious Calibration of Skyborne Sensors

This is an automated facility that generates Web-accessible data.

NASA's Jet Propulsion Laboratory, Pasadena, California

An automated ground facility, for vicarious radiometric calibration of airborne and spaceborne sensors of visible and infrared light has been established. In the term "vicarious calibration," "vicarious" is used in the sense of "in place of another," signifying "in place of laboratory calibration." Vicarious calibration involves the use of ground truth in the form of measurements by ground-viewing radiometers, a Sun-viewing photometer, and meteorological instruments positioned in a ground target area. Typically, the target is a dry lakebed or other relatively homogeneous area. (The value of a relatively homogeneous target is that it minimizes effects of errors of registration between the target and the fields of view of sensors.) The



Radiometric and Meteorological Instruments are placed at the target site along with electronic power and communication infrastructure.