Wirelessly Interrogated Wear or Temperature Sensors

Such sensors could be embedded in brake pads.

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Sensors for monitoring surface wear and/or temperature without need for wire connections have been developed. Excitation and interrogation of these sensors are accomplished by means of a magnetic-field-response recorder — an apparatus previously reported in “Magnetic-Field-Response Measurement-Acquisition System” (LAR-16908), *NASA Tech Briefs*, Vol. 30, No. 6 (June 2006), page 28. To recapitulate: The magnetic-field-response recorder is placed near, but not touching, the sensor of interest. This apparatus generates an alternating magnetic field that excites oscillations in the resonant circuit, measures the magnetic response of the circuit, and determines the resonance frequency from the response.

These sensors are related to the ones reported in “Wirelessly Interrogated Position or Displacement Sensors” (LAR-16617-1), *NASA Tech Briefs*, Vol. 31, No. 10 (October 2007), page 20. Like the previously reported sensors, these sensors consist mainly of variable capacitors electrically connected in series with fixed inductors. In a sensor of the present type as in the previously reported ones, the capacitance and, thus, the resonance frequency, varies as a known function of the quantity of interest that one seeks to determine. Hence, the resonance frequency is measured and used to calculate the quantity of interest.

The upper part of the figure depicts one of the present sensors, wherein the capacitor consists of multiple interdigitated plate electrodes oriented perpendicular to the wear surface of, and embedded within, a block of material, the wear of which one seeks to monitor. (For example, such a sensor could be embedded in a brake pad.) The embedment is performed during the fabrication of the brake pad or other block of wearing material. The electrodes are made of a metal that becomes worn away more easily than does the material that one seeks to monitor. As the surface wears away, portions of the electrodes are also worn away, reducing the capacitance. The depth of wear can be estimated straightforwardly from the increase in the resonance frequency, using the known relationship between the change in resonance frequency and the reduction in capacitance as a function of the depth of wear.

This wear sensor can be augmented with a temperature-measurement capability by embedding, between two or more of the electrodes, a dielectric material that is temperature-sensitive in the sense that its permittivity exhibits a known variation with temperature. In this case, the capacitance, and thus the resonance frequency, depends on both the depth of wear and the temperature. Hence, if the temperature is known from a measurement by a different sensor, then the depth of wear can be determined from the resonance frequency. Similarly, if the depth of wear has been determined from a prior measurement by a different sensor (or by this sensor at a known temperature)
and there has been no wear since the prior measurement, then the present temperature can be determined from the present resonance frequency.

The lower part of the figure depicts another sensor of the present type, containing multiple sets of interdigitated electrodes embedded parallel to the wearing surface in a configuration such that the number of electrode pairs, and thus the capacitance, decreases with the depth of wear. Optionally, one or more of the sets of interdigitated electrodes can be embedded along with a temperature-sensitive dielectric material to obtain a temperature-measurement capability.

This work was done by Stanley E. Woodard of Langley Research Center and Bryant D. Taylor of Swales Aerospace. Further information is contained in a TSP (see page 1). LAR-16591-1

### Optical Pointing Sensor

The sensor can be used as a digitizer of physical objects to extract shape data.

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The optical pointing sensor provides a means of directly measuring the relative positions of JPL’s Formation Control Testbed (FCT) vehicles without communication. This innovation is a steerable infrared (IR) rangefinder that gives measurements in terms of range and bearing to a passive retroreflector. Due to its reduced range of motion, the range and bearing measurements are on the order of 10 times better than those of the existing sensor system.

The retroreflector is placed on one robot, and the rangefinder and steering optics are on another robot. The measurements are available on the rangefinder-mounted robot, giving it relative position knowledge to the retroreflector.

The system is composed of an HeNe pointing laser, a SICK IR laser rangefinder, a two-axis fast steering mirror, a shear sensor, and a far-field retroreflector (see figure). The pointing laser is injected into the optical path using a beam splitter and bounces off the steering mirror toward the retroreflector. If the retroreflector is hit by the pointing laser, the beam is returned with the exact opposite direction. When the beam impact with the retroreflector is non-central,