

## Hand-Held Units for Short-Range Wireless Biotelemetry

**These units would power surgically implanted sensors.**

*John H. Glenn Research Center, Cleveland, Ohio*

Special-purpose hand-held radio-transceiver units have been proposed as means of short-range radio powering and interrogation of surgically implanted microelectromechanical sensors and actuators. These units are based partly on the same principles as those of the units described in "Printed Multi-Turn Loop Antennas for RF Biotelemetry" (LEW-17879-1), *NASA Tech Briefs*, Vol. 31, No. 6 (June 2007), page 48. Like the previously reported units, these units would make it unnecessary to have wire connections between the implanted devices and the external equipment used to activate and interrogate them.

Like a unit of the previously reported type, a unit of the type now proposed would include a printed-circuit antenna on a dielectric substrate. The antenna circuitry would include integrated surface-mount inductors for impedance tuning. Circuits for processing the signals transmitted and received by the antenna would be included on the substrate.

During operation, the unit would be positioned near (but not in electrical contact with) a human subject, in proximity to a microelectromechanical sensor or actuator that has been surgically implanted in the subject. It has been

demonstrated that significant electromagnetic coupling with an implanted device could be established at a distance of as much as 4 in. ( $\approx 10$  cm). During operation in the interrogation mode, the antenna of the unit would receive a radio telemetry signal transmitted by the surgically implanted device.

The antenna substrate would have dimensions of approximately 3.25 by 3.75 inches (approximately 8.3 by 9.5 cm). The substrate would have a thickness of the order of 30 mils (of the order of a somewhat less than a millimeter). The substrate would be made of low-radio-frequency-loss dielectric material that could be, for example, fused quartz, alumina, or any of a number of commercially available radio-frequency dielectric composite materials. The antenna conductors would typically be made of copper or a combination of chromium and gold. The choice of metal and the thickness of the metal layer(s) would depend on the choice of substrate material. For example, on a quartz or alumina substrate, one would typically use a layer of chromium 150 Å thick and a layer of gold 2  $\mu\text{m}$  thick.

The proposed units and the implanted devices that they would interrogate or ac-

tivate would be inherently safe to use. They would operate at low radiated-power levels for short interrogation times (typically, milliseconds). Hence, there would be little local heating of tissues surrounding the implanted devices and little absorption of radio energy by such sensitive body parts as the eyes and the brain.

Because the implanted devices would not depend on battery power and would be activated only during short interrogation intervals and would otherwise be in the "off" state most of the time, the useful lifetimes of the implanted devices would be greater than those of comparable battery-powered implanted devices. The compactness of the hand-held transceiver units would facilitate transport and storage and would facilitate self-diagnosis by patients able to handle the units while away from medical facilities.

*This work was done by Félix A. Miranda and Rainee N. Simons of Glenn Research Center. Further information is contained in a TSP (see page 1).*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17483-1.*

## Wearable Wireless Telemetry System for Implantable BioMEMS Sensors

**Physiological monitoring would entail minimal risk, discomfort, or restriction of mobility.**

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Telemetry systems of a type that have been proposed for the monitoring of physiological functions in humans would include the following subsystems:

- Surgically implanted or ingested units that would comprise combinations of microelectromechanical systems (MEMS)-based sensors [bioMEMS sensors] and passive radio-frequency (RF) readout circuits that would include miniature loop antennas.
- Compact radio transceiver units integrated into external garments for wirelessly powering and interrogating the implanted or ingested units.

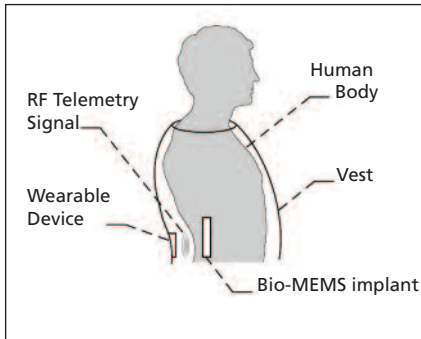
The basic principles of operation of

these systems are the same as those of the bioMEMS-sensor-unit/external-RF-powering-and-interrogating-unit systems described in "Printed Multi-Turn Loop Antennas for Biotelemetry" (LEW-17879-1) *NASA Tech Briefs*, Vol. 31, No. 6 (June 2007), page 48, and in the immediately preceding article, "Hand-Held Units for Short-Range Wireless Biotelemetry" (LEW-17483-1). The differences between what is reported here and what was reported in the cited prior articles lie in proposed design features and a proposed mode of operation.

In a specific system of the type now

proposed, the sensor unit would comprise mainly a capacitive MEMS pressure sensor located in the annular region of a loop antenna (more specifically, a square spiral inductor/antenna), all fabricated as an integral unit on a high-resistivity silicon chip. The capacitor electrodes, the spiral inductor/antenna, and the conductor lines interconnecting them would all be made of gold. The dimensions of the sensor unit have been estimated to be about  $1 \times 1 \times 0.4$  mm.

The external garment-mounted powering/interrogating unit would include a multi-turn loop antenna and signal-pro-



Relative location of the **Bio-MEMS** implantable sensor and the garment integrated wearable device.

cessing circuits. During operation, this external unit would be positioned in proximity to the implanted or ingested unit to provide for near-field, inductive coupling between the loop antennas, which we have as the primary and secondary windings of an electrical transformer.

In the first of two parts of an operational sequence, the loop antenna in the sensor unit would receive a pulse of RF energy transmitted via the loop antenna in the external powering/interrogating unit. This pulse would charge the capacitor in the pressure sensor and thereby

excite decaying oscillations in the resonant circuit constituted by the sensor capacitance and the loop inductance. In the second part of the operational sequence, some of the power of the decaying oscillations would be coupled from the loop in the sensor unit to the loop in the interrogating unit. The frequency of the decaying oscillation would be the resonance frequency, which would vary with the sensor capacitance and, hence, with the sensed pressure. Therefore, the frequency of the signal received by the external unit during the second part of the operational sequence would be measured, and any change in the frequency from a previous value would be taken as an indication of a change in pressure.

The proposed system would offer several advantages over prior invasive physiological-monitoring sensor systems:

- The sensor materials (high-resistivity silicon and gold) would not react with body fluids.
- High-resistivity silicon would cause less attenuation of signals in comparison with other substrate materials.
- The multi-loop antenna in the external unit could be fabricated inexpensively as a printed circuit.

sively as a printed circuit.

- The inductive-powering scheme eliminates the need for a battery in or alongside the sensor unit, thereby reducing the potential for leakage of toxic material into the patient's body.
- Because the sensor circuit would operate only when interrogated by the external unit, power dissipation in the patient and the consequent local heating and discomfort would be minimized and the operational lifetime of the sensor unit would be extended.
- Feed-through wires for power and telemetry, used in some other systems, would be eliminated, thereby greatly enhancing the patient's mobility and reducing the risk of infection.

*This work was done by Rainee N. Simons, Félix A. Miranda, and Jeffrey D. Wilson of Glenn Research Center and Renita E. Simons of John Carroll University. Further information is contained in a TSP (see page 1).*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18222-1.*

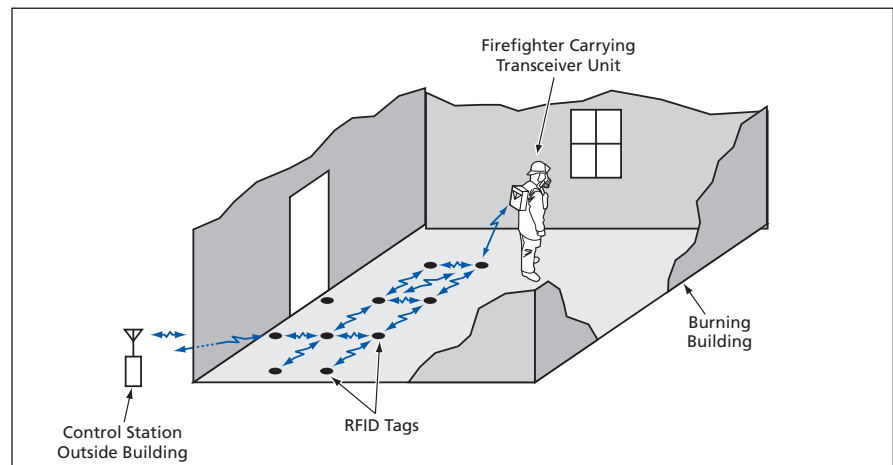
## Electronic Escape Trails for Firefighters

Routes would be traced among RFID tags equipped with sensors showing temperatures.

Ames Research Center, Moffett Field, California

A proposed wireless-communication and data-processing system would exploit recent advances in radio-frequency identification devices (RFIDs) and software to establish information lifelines between firefighters in a burning building and a fire chief at a control station near but outside the building. The system would enable identification of trails that firefighters and others could follow to escape from the building, including identification of new trails should previously established trails become blocked.

The system would include a transceiver unit and a computer at the control station, portable transceiver units carried by the firefighters in the building, and RFID tags that the firefighters would place at multiple locations as they move into and through the building (see figure). Each RFID tag, having a size of the order of a few centimeters, would include at least standard RFID circuitry and possibly sensors for measuring such other relevant environmen-



**RFID Tags** would be dropped by a firefighter at numerous locations while moving through a burning building. The tags would serve as waypoint marks that would be interrogated by an RFID transceiver unit carried by the firefighter. The RFID tags would also relay sensory and position data to the control station outside the building

tal parameters as temperature, levels of light and sound, concentration of oxygen, concentrations of hazardous chemicals in smoke, and/or levels of nuclear

radiation. The RFID tags would be activated and interrogated by the firefighters' and control-station transceivers. Preferably, RFID tags would be config-