Fast, High-Precision Readout Circuit for Detector Arrays

NASA's Jet Propulsion Laboratory, Pasadena, California

The GEO-CAPE mission described in NASA's Earth Science and Applications Decadal Survey requires high spatial, temporal, and spectral resolution measurements to monitor and characterize the rapidly changing chemistry of the troposphere over North and South Americas. High-frame-rate focal plane arrays (FPAs) with many pixels are needed to enable such measurements.

A high-throughput digital detector readout integrated circuit (ROIC) that meets the GEO-CAPE FPA needs has been developed, fabricated, and tested. The ROIC is based on an innovative charge integrating, fast, high-precision analog-to-digital circuit that is built into each pixel. The 128×128-pixel ROIC digitizes all 16,384 pixels simultaneously at frame rates up to 16 kHz to provide a completely digital output on a single integrated circuit at an unprecedented rate of 262 million pixels per second. The approach eliminates the need for off focal plane electronics, greatly reducing volume, mass, and power compared to conventional FPA implementations. A focal plane based on this ROIC will require less than 2 W of power on a 1×1-cm integrated circuit.

The ROIC is fabricated of silicon using CMOS technology. It is designed to be indium bump bonded to a variety of detector materials including silicon PIN diodes, indium antimonide (InSb), indium gallium arsenide (InGaAs), and mercury cadmium telluride (HgCdTe) detector arrays to provide coverage over a broad spectral range in the infrared, visible, and ultraviolet spectral ranges.

This work was done by David M. Rider, Bruce R. Hancock, Richard W. Key, Thomas J. Cunningham, Chris J. Wrigley, Suresh Seshadri, Stanley P. Sander, and Jean-Francois L. Blavier of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-47320

Victim Simulator for Victim Detection Radar

This simulator can be placed for long periods of time in environments that would be unsafe for a human subject.

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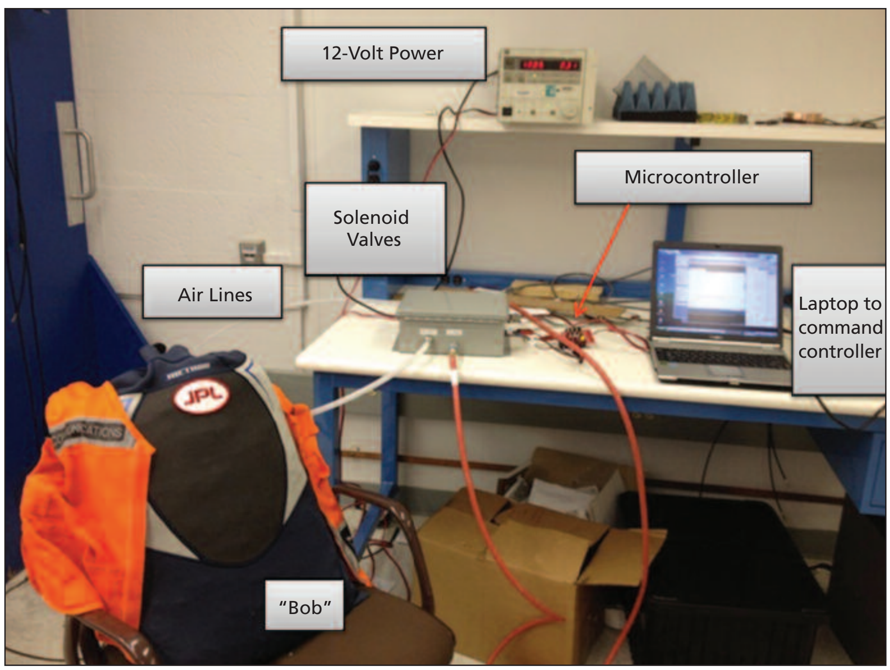
Testing of victim detection radars has traditionally used human subjects who volunteer to be buried in, or climb into a space within, a rubble pile. This is not only uncomfortable, but can be hazardous or impractical when typical disaster scenarios are considered, including fire, mud, or liquid waste. Human subjects are also inconsistent from day to day (i.e., they do not have the same radar properties), so quantitative performance testing is difficult. Finally, testing a multiple-victim scenario is difficult and expensive because of the need for multiple human subjects who must all be coordinated.



The **Victim Simulation System** ("Bob") uses two air-filled bladders sandwiched inside two bags full of a dielectric medium that replicates the properties of humans, within a modified wetsuit to serve as a "skin." An Arduino microcontroller with high-current drivers controls solenoid valves that fill and drain the bladders to simulate human breathing and heartbeat.

The solution is an anthropomorphic dummy with dielectric properties that replicate those of a human, and that has motions comparable to human motions for breathing and heartbeat. Two air-filled bladders filled and drained by solenoid valves provide the underlying motion for vinyl bags filled with a dielectric gel with realistic properties. The entire assembly is contained within a neoprene wetsuit serving as a "skin." The solenoids are controlled by a microcontroller, which can generate a variety of heart and breathing patterns, as well as being reprogrammable for more complex activities.

Previous electromagnetic simulators or RF phantoms have been oriented towards assessing RF safety, e.g., the measurement of specific absorption rate (SAR) from a cell phone signal, or to provide a calibration target for diagnostic techniques (e.g., MRI). They are optimized for precise dielectric performance, and are typically rigid and immovable. This device is movable and "positionable," and has motion that replicates the small-scale motion of humans. It is soft (much as human tissue is) and has programmable motions.

This device provides a way to characterize the performance of victim detecting radars objectively and quantitatively. It dramatically reduces the cost of testing in multiple-victim scenarios. The programmable victim simulator can be used to assess the sensitivity of the radar accurately, and can be placed for long periods of time in environments that would be unsafe for a human subject (e.g., buried for 24 to 48 hours in flowing mud, or within a burning building).

This work was done by James P. Lux and Salman Haque of Caltech; Anthony Vong of Columbus; and James Gill, Anand Gowda, and Susan Milliken of Reel EFX, Inc. for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48793

Hydrometeor Size Distribution Measurements by Imaging the Attenuation of a Laser Spot

Measurement of the DSD's second moment is made by way of the Beer-Lambert law.

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The optical extinction of a laser due to scattering of particles is a well-known phenomenon. In a laboratory environment, this physical principle is known as the Beer-Lambert law, and is often used to measure the concentration of scattering particles in a fluid or gas. This method has been experimentally shown to be a usable means to measure the dust density from a rocket plume interaction with the lunar surface. Using the same principles and experimental arrangement, this technique can be applied to hydrometeor size distributions, and for launch-pad operations, specifically as a passive hail detection and measurement system.

Calibration of a hail monitoring system is a difficult process. In the past, it has required comparison to another means of measuring hydrometeor size and density. Using a technique recently developed for estimating the density of surface dust dispersed during a rocket landing, measuring the extinction of a laser passing through hail (or dust in the rocket case) yields an estimate of the second moment of the particle cloud, and hydrometeor size distribution in the terrestrial meteorological case. With the exception of disdrometers, instruments that measure rain and hail fall make indirect measurements of the drop-size distribution. Instruments that scatter microwaves off of hydrometeors, such as the WSR-88D (Weather Surveillance Radar 88 Doppler), vertical wind profilers, and microwave disdrometers, measure the sixth moment of the drop size distribution (DSD).

By projecting a laser onto a target, changes in brightness of the laser spot against the target background during rain and hail yield a measurement of the DSD's second moment by way of the Beer-Lambert law. In order to detect the laser attenuation within the 8-bit resolution of most camera image arrays, a minimum path length is required. Depending on the intensity of the hail fall rate for moderate to heavy rainfall, a laser path length of 100 m is sufficient to measure variations in optical extinction using a digital camera. For hail fall only, the laser path may be shorter because of greater scattering due to the properties of hailstones versus raindrops. A photodetector may replace the camera in automated installations.

Laser-based rain and hail measurement systems are available, but they are based on measuring the interruption of a thin laser beam, thus counting individual hydrometeors. These systems are true disdrometers since they also measure size and velocity. The method reported here is a simple method, requiring far less processing, but it is not a disdrometer.

This work was done by John Lane of EASI for Kennedy Space Center. Further information is contained in a TSP (see page 1). KSC-13753