It should be noted that any 450-MHz signal passing through the 437.21-MHz band-pass filter would be down-converted along with the 437.21-MHz signal, resulting in cross-talk and loss of dynamic range. It is therefore essential that the 437.21-MHz band-pass filter have extremely high rejection at 450 MHz.

The 12.79-MHz signals in the response and reference channels are converted to a frequency of ≈66 kHz in a tracking down-converter, then detected by a lock-in amplifier that functions as a variable-bandwidth magnitude and phase receiver. The bandwidth and gain are controlled by a laptop computer. The vector DC outputs of the lock-in amplifier are read by an analog data-acquisition card in the computer, wherein these readings are converted to polar format. At maximum detection bandwidth, real-time acquisition speeds of >3,000 points per second are possible.

This work was done by Robert Dengler, Frank Maiwald, and Peter Siegel of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Modular Architecture for the Measurement of Space Radiation

New architecture developed with improved capabilities adds radiation hardness.

Lyndon B. Johnson Space Center, Houston, Texas

A modular architecture has been conceived for the design of radiation-monitoring instruments used aboard spacecraft and in planetary-exploration settings. This architecture reflects lessons learned from experience with prior radiation-monitoring instruments. A prototype instrument that embodies the architecture has been developed as part of the Mars Advanced Radiation Acquisition (MARA) project. The architecture is also applicable on Earth for radiation-monitoring instruments in research of energetic electrically charged particles and instruments monitoring radiation for purposes of safety, military defense, and detection of hidden nuclear devices and materials.

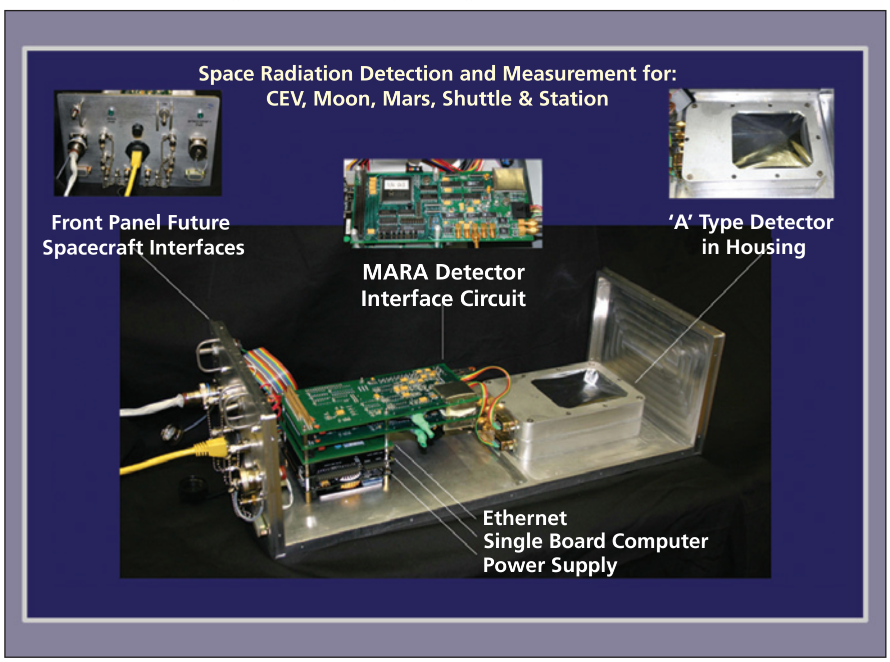
Whereas prior such instruments have contained non-radiation-hardened parts, an instrument according to this architecture is made of radiation-hardened/radiation-tolerant parts, enabling the instrument to resist damage by the radiation that it is intended to measure. One of the building blocks in this modular architecture is a single-channel radiation-detection circuit, which is essentially a detector interface, signal-processing and measurement circuit, dedicated to a single radiation detector that provides radiation-event data to the CPU. The interface between the single-channel radiation-detection circuit and the rest of the instrument is a PC/104 computer-bus interface. [PC/104 is an industry standard for compact, stackable modules that are compatible (in architecture, hardware, and software) with personal-computer data and power-bus circuitry.] Multiple single-channel radiation-detection circuits can be stacked to create a multiple-detector instrument.

The present architecture as embodied in the MARA instrument design offers the following advantages over the architectures and designs of prior radiation-monitoring systems:

The detector interface circuitry in prior instruments included voltage-feedback operational amplifiers, which do not enable accurate tracking of the rising edges of incoming pulses and, as a result, do not enable deterministic discrimination among different levels of radiation events. In contrast, the MARA circuit design provides the capability to more accurately differentiate among different types of energetic charged particles.

Unlike prior designs, the MARA design provides for correlated double sampling, which offers the advantage of subtraction of correlated noise between reset samples and data samples, thereby reducing spurious offsets and the effects of low-frequency noise.

Prior designs do not afford enough dynamic range to enable detection of both low- and high-energy events without adjustment by an operator. The MARA design features 16-bit quantization depth, which provides sufficient dynamic range to en-



MARA Instrument Phase I Prototype is shown in two-detector configuration. (Note: CEV is Crewed Exploration Vehicle.)

able detection of both low- and high-energy events using the same circuit configuration.

The event-detection circuits of prior instruments do not employ hysteresis and, as a result, spurious trigger signals are generated during the rising and falling edges of pulses being detected. The use of hysteresis in the MARA design ensures that only one pulse is produced for each rising edge and for each radiation event.

Prior designs do not employ distributed processing: Instead, they rely on central computers or processors to poll, sample, and store data from multiple boards in the instruments. In contrast, the present architecture provides for distributed processing with local memory, enabling each board to independently sample events and store data pertaining to them. This architecture facilitates prompt reading of time-critical data signals in a consistent operation. Distributed processing with local memory also allows identification of coincident detections by multiple radiation-detection boards through comparison of time stamps attached to data collected by individual boards.

Prior designs employ custom bus interfaces rather than industry-standard ones. Adherence to the PC/104 bus-interface standard in the present architecture (1) makes the architecture more amenable to diverse applications, (2) facilitates customization and reconfiguration of a suite of radiation detectors through stacking of multiple circuit boards, (3) enables incorporation of other interface hardware that also adhere to the PC/104 standard (this saves costs, time and risk), and (4) enables inclusion or exclusion of various communication interfaces through addition or removal of circuit cards of different types.

Prior designs do not provide for in-system reprogrammability of radiation-detection firmware. The MARA design enables remote loading of modifications of firmware and/or replacement of corrupted firmware files with firmware files of known integrity.

Prior designs used a text-based user interface for command and control. MARA employs an easy-to-use graphical user interface, with point-and-click functionality. The control console application also provides several real-time displays, when in the ground mode. Data received from MARA is displayed as detector pulse height spectrum graph, coincident data x–y scatter plot, and historical event count tracking. These displays enable rapid system configuration and calibration.

This work was done by Paul Delaune, Kathryn Turner, and S. Douglas Holland of Johnson Space Center; William R. Carson of Muniz Engineering; and Fadi Riman of Lockheed Martin.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Technology Transfer Office, Johnson Space Center, (281) 483-3089. Refer to MSC-24042/38/41/228.