

ditions (typically between 1 and 3 V), ions of a metal (silver) are formed at an anode made of that metal and migrate into the solid electrolyte while electrons (typically at a current of the order of microamperes to milliamperes) are injected from an electrochemically inert (nickel) cathode into the solid electrolyte. The injected electrons reduce the metal anions in the solid electrolyte, thereby causing the growth of metal nanowires through the electrolyte from the cathode to the corresponding anode.

Once a nanowire has grown sufficiently to form an electrically conductive path between the electrodes, there is no need to continue to apply electric power to maintain the connection. The process of making the connection can be easily reversed by applying a reverse bias to re-

oxidize the metal atoms in the solid electrolyte to recreate the insulating amorphous layer. Thus, a nanoionics-based switch is a reversible electrochemical switch that can have geometric features as small as nanometers. The process time for making or breaking the connection is about a nanosecond.

Experimental nanoionics based-switches having several different configurations have been built and tested in a continuing effort to gain understanding of the underlying chemical and physical principles and optimize designs. Fabrication of each experimental switch began with deposition of a binary chalcogenide glass on a high-resistivity silicon wafer. Next, a layer of silver was deposited on the glass and exposed to ultraviolet light to induce a photodissolution process in which silver ions mi-

grated into the glass matrix. Then an electrode of silver and an electrode of nickel were deposited on the chalcogenide layer.

The figure shows plots of data from a test of one of the experimental switches. Over the frequency range from 1 to 6 GHz, the insertion loss of the switch in the “on” state was less than 0.5 dB, while the isolation in the “off” state exceeded 30 dB.

*This work was done by James Nessel and Richard Lee 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-18313-1.*

## Lunar Dust-Tolerant Electrical Connector

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

An electrical connector was developed that is tolerant of the presence of lunar dust. Novel features of the connector include the use of a permeable membrane to act both as a dust barrier and as a wiper to limit the amount of dust that makes its way into the internal chamber of the connector. The development focused on the Constellation lunar extravehicular activity (EVA) spacesuit's portable life support system (PLSS) battery recharge connector; however, continued research is applying this technology to other lunar surface systems such as lunar rover subsystems and cryogenic fluid transfer connections for *in-situ* resource utilization (ISRU) applications.

Lunar dust has been identified as a significant and present challenge in fu-

ture exploration missions. In addition to posing contamination and health risks for human explorers, the interlocking, angular nature of lunar dust and its broad grain size distribution make it particularly harmful to mechanisms with which it may come into contact. All Apollo lunar missions experienced some degree of equipment failure because of dust, and it appears that dust accumulation on exposed material is unavoidable and difficult to reverse. Both human EVA and ISRU activities are on the mission horizon and are paramount to the establishment of a permanent human base on the Moon. Reusable and dust-tolerant connection mechanisms are a critical component for mission success.

The need for dust-tolerant solutions is also seen in utility work and repair, mass transit applications, construction, mining, arctic and marine environments, diving (search and rescue), and various operations in deserts, where dust or sand clogging and coating different mechanisms and connections may render them difficult to operate or entirely inoperable.

*This work was done by Jason Herman, Shazad Sadick, and Dustyn Roberts of Honeybee Robotics Spacecraft Mechanisms Corporation for Glenn Research Center.*

*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-18400-1.*

## Compact, Reliable EEPROM Controller

**This controller prevents inadvertent writes in an EEPROM.**

*Goddard Space Flight Center, Greenbelt, Maryland*

A compact, reliable controller for an electrically erasable, programmable read-only memory (EEPROM) has been developed specifically for a space-flight application. The design may be adaptable to other applications in which there are requirements for reliability in general and, in particular, for preven-

tion of inadvertent writing of data in EEPROM cells.

Inadvertent writes pose risks of loss of reliability in the original space-flight application and could pose such risks in other applications. Prior EEPROM controllers are large and complex and do not provide all reasonable protec-

tions (in many cases, few or no protections) against inadvertent writes. In contrast, the present controller provides several layers of protection against inadvertent writes. The controller also incorporates a write-time monitor, enabling determination of trends in the performance of an EEP-

ROM through all phases of testing.

The controller has been designed as an integral subsystem of a system that includes not only the controller and the controlled EEPROM aboard a spacecraft but also computers in a ground control station, relatively simple onboard support circuitry, and an onboard communication subsystem that utilizes the MIL-STD-1553B protocol. (MIL-STD-1553B is a military standard that encompasses a method of communication and electrical-interface re-

quirements for digital electronic subsystems connected to a data bus. MIL-STD-1553B is commonly used in defense and space applications.) The intent was to both maximize reliability while minimizing the size and complexity of onboard circuitry.

In operation, control of the EEPROM is effected via the ground computers, the MIL-STD-1553B communication subsystem, and the onboard support circuitry, all of which, in combination, provide the multiple layers of protection

against inadvertent writes. There is no controller software, unlike in many prior EEPROM controllers; software can be a major contributor to unreliability, particularly in fault situations such as the loss of power or brownouts. Protection is also provided by a power-monitoring circuit.

*This work was done by Richard Katz and Igor Kleyner of Goddard Space Flight Center. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810. GSC-15492-1*

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## Quad-Chip Double-Balanced Frequency Tripler

**This technology has uses such as high-resolution radar and spectroscopic screening.**

*NASA's Jet Propulsion Laboratory, Pasadena, California*

Solid-state frequency multipliers are used to produce tunable broadband sources at millimeter and submillimeter wavelengths. The maximum power produced by a single chip is limited by the electrical breakdown of the semiconductor and by the thermal management properties of the chip. The solution is to split the drive power to a frequency tripler using waveguides to divide the power among four chips, then recombine the output power from the four chips back into a single waveguide.

To achieve this, a waveguide branch-line quadrature hybrid coupler splits a 100-GHz input signal into two paths with a 90° relative phase shift. These two paths are split again by a pair of waveguide Y-junctions. The signals from the

four outputs of the Y-junctions are tripled in frequency using balanced Schottky diode frequency triplers before being recombined with another pair of Y-junctions. A final waveguide branch-line quadrature hybrid coupler completes the combination.

Using four chips instead of one enables using four-times higher power input, and produces a nearly four-fold power output as compared to using a single chip. The phase shifts introduced by the quadrature hybrid couplers provide isolation for the input and output waveguides, effectively eliminating standing waves between it and surrounding components. This is accomplished without introducing the high losses and expense of ferrite isolators.

A practical use of this technology is to drive local oscillators as was demonstrated around 300 GHz for a heterodyne spectrometer operating in the 2–3-THz band. Heterodyne spectroscopy in this frequency band is especially valuable for astrophysics due to the presence of a very large number of molecular spectral lines. Besides high-resolution radar and spectrographic screening applications, this technology could also be useful for laboratory spectroscopy.

*This work was done by Robert H. Lin, John S. Ward, Peter J. Bruneau, and Imran Mehdi of Caltech; Bertrand C. Thomas of Oak Ridge Associated Universities; and Alain Maestrini of the Observatoire de Paris for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-46567*

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## Ka-Band Waveguide Two-Way Hybrid Combiner for MMIC Amplifiers

**This technology is applicable as a power combiner for solid-state power amplifiers (SSPAs) with unequal and arbitrary power output ratios.**

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

The design, simulation, and characterization of a novel Ka-band (32.05±0.25 GHz) rectangular waveguide two-way branch-line hybrid unequal power combiner (with port impedances matched to that of a standard WR-28 waveguide) has been created to combine input signals, which are in phase and with an amplitude ratio of two. The measured return loss and isolation of the branch-line hybrid are better than 22 and 27 dB, respectively. The

measured combining efficiency is 92.9 percent at the center frequency of 32.05 GHz. This circuit is efficacious in combining the unequal output power from two Ka-band GaAs pseudomorphic high electron mobility transistor (pHEMT) monolithic microwave integrated circuit (MMIC) power amplifiers (PAs) with high efficiency.

The component parts include the branch-line hybrid-based power combiner and the MMIC-based PAs. A two-

waybranch-line hybrid is a four-port device with all ports matched; power entering port 1 is divided in phase, and into the ratio 2:1 between ports 3 and 4. No power is coupled to port 2.

MMICs are a type of integrated circuit fabricated on GaAs that operates at microwave frequencies, and performs the function of signal amplification. The power combiner is designed to operate over the frequency band of 31.8 to 32.3