

collimates the light into a series of beam splitters. Among the beam splitters are a 99:1 beam splitter for each of the two Raman wavelength bands. In addition to extending the dynamic range of the photon counting system, this arrangement enables better corrections for pulse pile-up saturation effects than

could otherwise be made. The arrangement is such as to make the 387- and 407-mm Raman signals in the large-telescope 1-percent splitter outputs approximately equal in magnitude to the corresponding signals from the smaller telescopes; this makes it possible to use the signals from the small telescopes to

correct for effects of overlap of photon pulses in signals from the large telescope collected from low altitudes.

*This work was done by Thierry Leblanc and I. Stewart McDermid of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-45007*

## Compact Ku-Band T/R Module for High-Resolution Radar Imaging of Cold Land Processes

This module can be used in phased-array antennas for radar or communications.

NASA's Jet Propulsion Laboratory, Pasadena, California

Global measurement of terrestrial snow cover is critical to two of the NASA Earth Science focus areas: (1) climate variability and change and (2) water and energy cycle. For radar backscatter measurements, Ku-band frequencies, scattered mainly within the volume of the snowpack, are most suitable for the SWE (snow-water equivalent) measurements. To isolate the complex effects of different snowpack (density and snow-grain size), and underlying soil properties and to distinctly determine SWE, the space-based synthetic aperture radar (SAR) system will require a dual-frequency (13.4 and 17.2 GHz) and dual-polarization approach.

A transmit/receive (T/R) module was developed operating at Ku-band frequencies to enable the use of active electronic scanning phased-array antenna for wide-swath, high-resolution SAR imaging of terrestrial snow cover. The T/R module has an integrated calibrator, which compensates for all environmental- and time-related changes, and results in very stable power and amplitude characteristics. The module was designed to operate over the full frequency range of 13 to 18 GHz, although only the two frequencies, 13.4 GHz and 17.2 GHz, will be used in this SAR radar application. Each channel of the transmit module produces >4 W (35 dbm) over the operating bandwidth of 20 MHz. The stability requirements of <0.1 dB receive gain accuracy and <0.1 dB transmit power accuracy over a wide temperature range are achieved using a self-correction scheme, which does real-time amplitude calibration so that the module characteristics are continually corrected. All the calibration circuits are within the T/R module.

The timing and calibration sequence is stored in a control FPGA (field-programmable gate array) while an internal 128Kx8bit high-speed RAM (random access memory) stores all the calibration values. The module was designed using advanced components and packaging techniques to achieve integration of the electronics in a 2x6.5x1-in. (5x17x2.5-

cm) package. The module size allows 4 T/R modules to feed the 16x16-element subarray on an antenna panel. The T/R module contains four transmit channels and eight receive channels (horizontal and vertical polarizations). Each channel contains GaAs MMIC (monolithic microwave integrated circuit) amplifiers, a 5-bit phase shifter, and a programmable

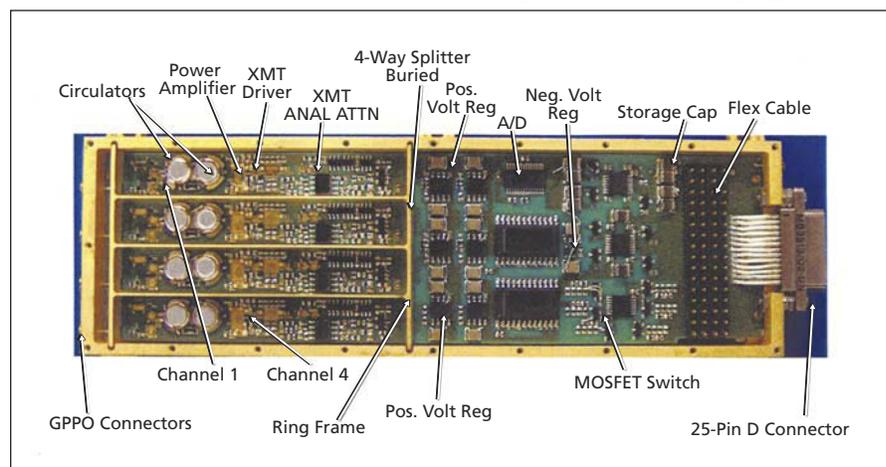


Figure 1 Transmission Side of the T/R Module showing the components.

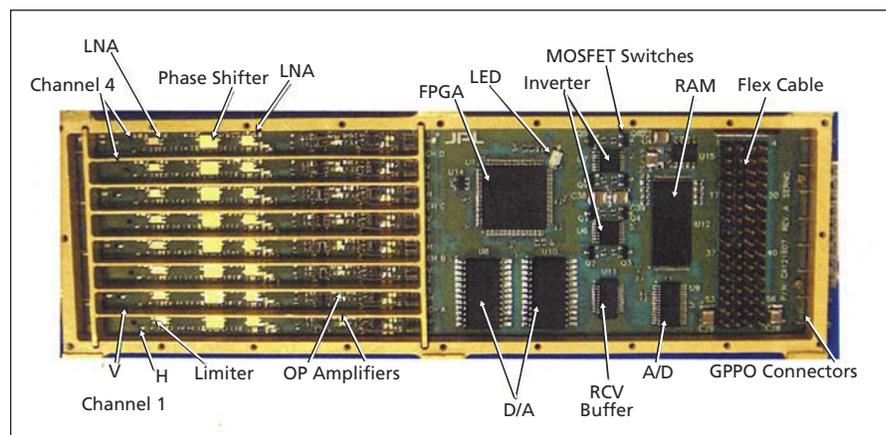


Figure 2. Receiving Side of the T/R Module showing the components.

attenuator. To meet the compact size and maintain isolation between the channels, a two-sided module approach was adapted. The transmit side of the module houses the four transmit channels, the control FPGA, and the power regulators and logic circuitry. It also contains the 4-way stripline power splitter. The 4-dual channel receivers are packaged on

the reverse side of the module along with the horizontal and vertical power combiners, and some logic and power conditioning circuits. The transmit and receive sides of the T/R module with the component identifications are shown in Figures 1 and 2.

The broadband, 4-channel, highly stable self-calibrating T/R module is a use-

ful building block for other radar and communication phased-array systems operating in this band.

*This work was done by Constantine Andricos, Simon H. Yueh, Vladimir A. Krimskiy, of Caltech and Yahya Rahmat-Samii of UCLA for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-46428*

---

## Wide-Field-of-View, High-Resolution, Stereoscopic Imager

*Lyndon B. Johnson Space Center, Houston, Texas*

A device combines video feeds from multiple cameras to provide wide-field-of-view, high-resolution, stereoscopic video to the user. The prototype under development consists of two camera assemblies, one for each eye. One of these assemblies incorporates a mounting structure with multiple cameras attached at offset angles. The video signals from the cameras are fed to a central processing platform where each frame is color processed and mapped into a single contiguous wide-field-of-view image.

Because the resolution of most display devices is typically smaller than the processed map, a cropped portion of the video feed is output to the display device. The positioning of the cropped window will likely be controlled through the use of a head tracking device, allowing the user to turn his or her head side-

to-side or up and down to view different portions of the captured image. There are multiple options for the display of the stereoscopic image. The use of head mounted displays is one likely implementation. However, the use of 3D projection technologies is another potential technology under consideration.

The technology can be adapted in a multitude of ways. The computing platform is scalable, such that the number, resolution, and sensitivity of the cameras can be leveraged to improve image resolution and field of view. Miniaturization efforts can be pursued to shrink the package down for better mobility. Power savings studies can be performed to enable unattended, remote sensing packages. Image compression and transmission technologies can be incorporated to enable an improved telepresence experience.

*This work was done by Eric F. Prechtel of Axis Engineering Technologies, Inc., and Raymond J. Sedwick of the Massachusetts Institute of Technology for Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809.*

*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:*

*Axis Engineering Technologies, Inc.  
One Broadway, 14th Floor  
Cambridge, MA 02142  
Phone No.: (617) 225-4414  
Fax No.: (617) 225-4439  
E-mail: eric@axisetech.com*

*Refer to MSC-23977-1, volume and number of this NASA Tech Briefs issue, and the page number.*

---

## Electrical Capacitance Volume Tomography With High-Contrast Dielectrics

**This nondestructive evaluation tool finds fluid levels in nonconducting composite materials.**

*John F. Kennedy Space Center, Florida*

The Electrical Capacitance Volume Tomography (ECVT) system has been designed to complement the tools created to sense the presence of water in nonconductive spacecraft materials, by helping to not only find the approximate location of moisture but also its quantity and depth.

The ECVT system has been created for use with a new image reconstruction algorithm capable of imaging high-contrast dielectric distributions. Rather than relying solely on mutual capacitance readings as is done in traditional electrical capacitance tomog-

raphy applications, this method reconstructs high-resolution images using only the self-capacitance measurements. The image reconstruction method assumes that the material under inspection consists of a binary dielectric distribution, with either a high relative dielectric value representing the water or a low dielectric value for the background material. By constraining the unknown dielectric material to one of two values, the inverse math problem that must be solved to generate the image is no longer ill-terminated. The image resolution be-

comes limited only by the accuracy and resolution of the measurement circuitry. Images were reconstructed using this method with both synthetic and real data acquired using an aluminum structure inserted at different positions within the sensing region.

The cuboid geometry of the system has two parallel planes of 16 conductors arranged in a 4 × 4 pattern. The electrode geometry consists of parallel planes of copper conductors, connected through custom-built switch electronics, to a commercially available capacitance to digital converter. The figure shows