

protocol for an environment that requires a very high rate bundle egress data rate. The C&DH (command and data handling) subsystem is also expected to be very constrained so the interaction with the C&DH processor and the temporary storage are minimized.

- Fully pipelined design so that bundle processing database is not required.
- Implements a lookup table-based approach to eliminate multi-pass process-

ing requirement imposed by the Bundle Protocol header's length field structure and the SDNV (self-delimiting numeric value) data field formatting.

- 8-bit parallel datapath to support high data-rate missions.
- Reduced resource utilization implementation for missions that do not require custody transfer features. There was no known implementation of the DTN protocol in a field programmable

gate array (FPGA) device prior to the current implementation.

The combination of energy and performance optimization that embodies this design makes the work novel.

This work was done by Jordan L. Torgerson, Loren P. Clare, and Jackson Pang of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact the JPL Innovative Technology Assets Management Office, 1-818-393-3421, and reference NPO-47344.

Large Ka-Band Slot Array for Digital Beam-Forming Applications

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This work describes the development of a large Ka Band Slot Array for the Glacier and Land Ice Surface Topography Interferometer (GLISTIN), a proposed spaceborne interferometric synthetic aperture radar for topographic mapping of ice sheets and glaciers. GLISTIN will collect ice topography measurement data over a wide swath with sub-seasonal repeat intervals using a Ka-band digitally beam-formed antenna.

For technology demonstration purpose a receive array of size 1×1 m, consisting of 160×160 radiating elements, was developed. The array is divided into 16 sticks, each stick consisting of 160×10 radiating elements, whose outputs are combined to produce 16 digital beams. A transmit array stick was also developed. The antenna arrays were designed using Elliott's design equations with the

use of an infinite-array mutual-coupling model. A Floquet wave model was used to account for external coupling between radiating slots. Because of the use of uniform amplitude and phase distribution, the infinite array model yielded identical values for all radiating elements but for alternating offsets, and identical coupling elements but for alternating positive and negative tilts.

Waveguide-fed slot arrays are finding many applications in radar, remote sensing, and communications applications because of their desirable properties such as low mass, low volume, and ease of design, manufacture, and deployability. Although waveguide-fed slot arrays have been designed, built, and tested in the past, this work represents several advances to the state of the art. The use of the infinite array model for the radiating

slots yielded a simple design process for radiating and coupling slots. Method of moments solution to the integral equations for alternating offset radiating slots in an infinite array environment was developed and validated using the commercial finite element code HFSS. For the analysis purpose, a method of moments code was developed for an infinite array of subarrays.

Overall the 1×1 m array was found to be successful in meeting the objectives of the GLISTIN demonstration antenna, especially with respect to the 0.042°, 1/10th of the beamwidth of each stick, relative beam alignment between sticks.

This work was done by Sembiam Rengaranjan, Mark S. Zawadzki, and Richard E. Hodges of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47416

Development of a 150-GHz MMIC Module Prototype for Large-Scale CMB Radiation

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HEMT-based receiver arrays with excellent noise and scalability are already starting to be manufactured at 100 GHz, but the advances in technology should make it possible to develop receiver modules with even greater operation frequency up to 200 GHz. A prototype heterodyne amplifier module has been developed for operation from 140 to 170 GHz using monolithic millimeter-wave integrated circuit (MMIC) low-noise InP high electron mobility transistor (HEMT) amplifiers.

The compact, scalable module is centered on the 150-GHz atmospheric win-

dow using components known to operate well at these frequencies. Arrays equipped with hundreds of these modules can be optimized for many different astrophysical measurement techniques, including spectroscopy and interferometry.

This module is a heterodyne receiver module that is extremely compact, and makes use of 35-nm InP HEMT technology, and which has been shown to have excellent noise temperatures when cooled cryogenically to 30 K. This reduction in system noise over prior art has been demonstrated in commercial mixers (uncooled) at frequencies of

160–180 GHz. The module is expected to achieve a system noise temperature of 60 K when cooled.

An MMIC amplifier module has been designed to demonstrate the feasibility of expanding heterodyne amplifier technology to the 140 to 170-GHz frequency range for astronomical observations. The miniaturization of many standard components and the refinement of RF interconnect technology have cleared the way to mass-production of heterodyne amplifier receivers, making it a feasible technology for many large-population arrays.