



Amplifier Module for 260-GHz Band Using Quartz Waveguide Transitions

The development of high-performance, low-noise amplifiers has applications for future earth science and planetary instruments with low power and volume.

NASA's Jet Propulsion Laboratory, Pasadena, California

Packaging of MMIC LNA (monolithic microwave integrated circuit low-noise amplifier) chips at frequencies over 200 GHz has always been problematic due to the high loss in the transition between the MMIC chip and the waveguide medium in which the chip will typically be used. In addition, above 200 GHz, wire-bond inductance between the LNA and the waveguide can severely limit the RF matching and bandwidth of the final waveguide amplifier module.

This work resulted in the development of a low-loss quartz waveguide transition that includes a capacitive transmission line between the MMIC and the waveguide probe element. This capacitive transmission line tunes out the wire-bond inductance (where the wire-bond is required to bond between the MMIC and the probe element). This inductance can severely limit the RF matching and bandwidth of the final waveguide amplifier module.

The amplifier module consists of a quartz E-plane waveguide probe transition, a short capacitive tuning element, a short wire-bond to the MMIC, and the MMIC LNA. The output structure is similar, with a short wire-bond at the output of the MMIC, a quartz E-plane waveguide probe transition, and the output waveguide. The quartz probe element is made of 3-mil quartz, which is the thinnest commercially available material. The waveguide band used is WR4, from 170 to 260 GHz. This new transition and block design is an improvement over prior art because it provides for better RF matching, and will likely yield lower loss and better noise figure.

The development of high-performance, low-noise amplifiers in the 180-to-700-GHz range has applications for future earth science and planetary instruments with low power and volume, and astrophysics array instruments for molecular spectroscopy.

This frequency band, while suitable for homeland security and commercial applications (such as millimeter-wave imaging, hidden weapons detection, crowd scanning, airport security, and communications), also has applications for future NASA missions. The Global Atmospheric Composition Mission (GACM) in the NRC Decadal Survey will need low-noise amplifiers with extremely low noise temperatures, either at room temperature or for cryogenic applications, for atmospheric remote sensing.

This work was done by Sharmila Padmanabhan, King Man Fung, Pekka P. Kangaslahti, Alejandro Peralta, Mary M. Soria, David M. Pukala, Seth Sim, and Lorene A. Samoska of Caltech; and Stephen Sarkozy and Richard Lai of Northrop Grumman Corporation for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48436

Wideband Agile Digital Microwave Radiometer

This technology can be applied to terrestrial science instruments.

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The objectives of this work were to take the initial steps needed to develop a field programmable gate array (FPGA)-based wideband digital radiometer backend (>500 MHz bandwidth) that will enable passive microwave observations with minimal performance degradation in a radio-frequency-interference (RFI)-rich environment. As manmade RF emissions increase over time and fill more of the microwave spectrum, microwave radiometer science applications will be increasingly impacted in a negative way, and the current generation of spaceborne microwave radiometers that use broadband analog back ends

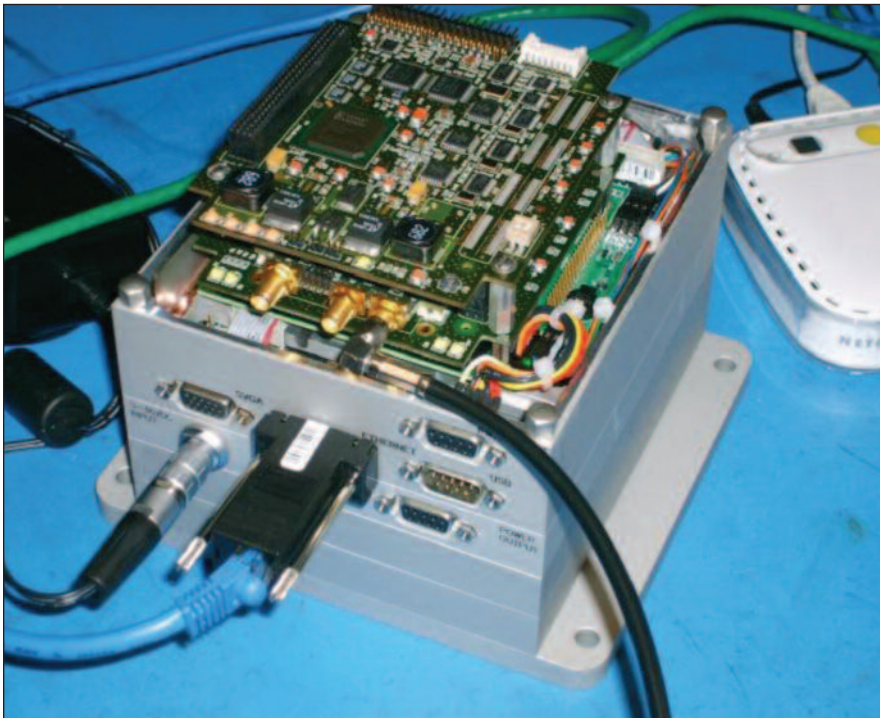
will become severely compromised or unusable over an increasing fraction of time on orbit.

There is a need to develop a digital radiometer back end that, for each observation period, uses digital signal processing (DSP) algorithms to identify the maximum amount of RFI-free spectrum across the radiometer band to preserve bandwidth to minimize radiometer noise (which is inversely related to the bandwidth).

Ultimately, the objective is to incorporate all processing necessary in the back end to take contaminated input spectra and produce a single output value free of manmade signals to minimize data

rates for spaceborne radiometer missions. But, to meet these objectives, several intermediate processing algorithms had to be developed, and their performance characterized relative to typical brightness temperature accuracy requirements for current and future microwave radiometer missions, including those for measuring salinity, soil moisture, and snow pack.

Digital radiometer back ends with similar capabilities currently exist based on older FPGA technology with significantly narrower input bandwidths (10s of MHz). Wider bandwidths are now possible that will allow these back ends to meet the requirements of a much



The FPGA Wideband Digital Radiometer.

broader range of radiometer applications and future missions.

The approach was to design DSP modules for implementation using a commercial FPGA evaluation board with an integrated dual-channel analog-

to-digital converter (ADC), high-speed interfaced FPGA, and high-data-rate embedded computer interface. The board was packaged with a PC104 embedded computer running a real-time O/S for data analysis, packetization,

and storage. The complete system was programmed with appropriate firmware and software to function as an agile digital radiometer back end, capable of spectral sub-banding, kurtosis detection, RFI mitigation, and fully polarimetric complex correlation. It should be noted that this functionality duplicates and exceeds that of the existing Soil Moisture Active Passive brassboard digital back end, but with a factor of ~40 higher bandwidth.

This work advances the state-of-the-art in digital radiometer back ends by improving the system bandwidth by over an order of magnitude compared to other existing systems. It also makes possible the potential to include RFI mitigation onboard, which is critical for wide-bandwidth, multi-channel systems.

(At the time of this reporting, the SMAP mission has not been formally approved by NASA. The decision to proceed with the mission will not occur until the completion of the National Environmental Policy Act (NEPA) process. Material in this document related to SMAP is for information purposes only.)

This work was done by Todd C. Gaier and Shannon T. Brown of Caltech, and Christopher Ruf and Steven Gross of the University of Michigan for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48287