Amplifier Module for 260-GHz Band Using Quartz Waveguide Transitions

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

Wideband Agile Digital Microwave Radiometer

This technology can be applied to terrestrial science instruments.

NASA’s Jet Propulsion Laboratory, Pasadena, California

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
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.