NASA SBIR 2020 Phase I Solicitation

S1.03 Technologies for Passive Microwave Remote Sensing

Lead Center: GSFC

Participating Center(s): JPL

Technology Area: TA8 Science Instruments, Observatories & Sensor Systems

Scope Title

Components for addressing gain instability in Low Noise Amplifier (LNA) based radiometers from 100 and 600 GHz

Scope Description

NASA requires low insertion loss solutions to the challenges of developing stable radiometers and spectrometers operating above 100 GHz that employ LNA based receiver front ends. This includes noise diodes with Excess Noise Ratio (ENR) > 10dBm with better than â‰¤ 0.01 dB/Â°C thermal stability, Dicke switches with better than 30 dB isolation, phase modulators, and low loss isolators along with fully integrated state-of-art receiver systems operating at room and cryogenic temperatures.

Expected TRL or TRL range at completion of the project: 4 to 5

Desired Deliverables of Phase II

Prototype, Hardware

Desired Deliverables Description

Hardware to enable low-loss radiometer gain calibration above 100 GHz.

State of the Art and Critical Gaps

Traditional internal microwave radiometer gain instability calibration electronics become prohibitively lossy as the frequency increases above 100 GHz. As such, radiometers at this frequency are most commonly calibrated with external references. These are larger and more massive than internal calibration electronics.

Relevance / Science Traceability

Critical need: Immediate for future earth observing, planetary, and astrophysics missions. The wide range of frequencies in this scope are used for numerous science measurements such as earth science temperature profiling, ice cloud remote sensing, and planetary molecular species detection.

Scope Title
Ultra Compact Radiometer

Scope Description

An ultra-compact radiometer of either a switching or pseudo-correlation architecture with internal calibration sources is needed. Designs with operating frequencies at the conventional passive microwave bands of 36.6 GHz (priority), 18.65 GHz, and 23.8 GHz enabling dual-polarization inputs. Interfaces include waveguide input, control, and digital data output. Ideal design features enable subsystems of multiple (10's of) integrated units to be efficiently realized.

Expected TRL or TRL range at completion of the project: 4 to 5

Desired Deliverables of Phase II

Prototype, Hardware

Desired Deliverables Description

Ultra-compact radiometer prototype.

State of the Art and Critical Gaps

Current microwave radiometers at this frequency are bulky with significant waveguide and coaxial interconnects. Dramatically smaller systems are desired for small SmallSat and CubeSat payloads, or for arrays of radiometer receivers.

Relevance / Science Traceability

This technology, in conjunction with deployable antenna technology, would enable traditional Earth land and ocean radiometry with significantly reduced instrument size, making it suitable for CubeSat or SmallSat platforms.

Scope Title
Correlating radiometer front-ends and low 1/f-noise detectors for 100-700 GHz

Scope Description

Low DC power correlating radiometer front-ends and low 1/f-noise detectors are required for 100-700 GHz. Deliverables should provide improved calibration stability, sensitivity, or 1/f noise performance compared to conventional total-power or Dicke / noise-injection radiometers at these frequencies.

Expected TRL or TRL range at completion of the project: 4 to 5

Desired Deliverables of Phase II

Prototype, Hardware

Desired Deliverables Description

Low DC power correlating radiometer front-ends and low 1/f-noise detectors for 100-700 GHz.

State of the Art and Critical Gaps

The low DC power consumption is critical for small missions, such as CubeSats. Low 1/f-noise of the detectors and correlating radiometers needed for radiometer stability across the scan for measurements at above 100 GHz for atmospheric humidity and cloud measurements as well as atmospheric chemistry.

Relevance / Science Traceability

The wide range of frequencies in this scope are used for numerous science measurements such as earth science temperature profiling, ice cloud remote sensing, and planetary molecular species detection.

Scope Title
Photonic Integrated Circuits for Microwave Remote Sensing

Scope Description

Photonic Integrated Circuits are an emerging technology for passive microwave remote sensing. NASA is looking for photonic integrated circuits for processing microwave signals in spectrometers, beam forming arrays, correlation arrays and other active or passive microwave instruments.

Expected TRL or TRL range at completion of the project: 3 to 5

Desired Deliverables of Phase II

Prototype, Analysis, Hardware, Research

Desired Deliverables Description

PIC designs to enable increased capability in passive microwave remote sensing instruments. This is a low-TRL emerging technology, so vendors are encouraged to identify and propose designs where PIC technology would be most beneficial.

State of the Art and Critical Gaps

Photonic Integrated Circuits (PIC) are an emerging technology not used in current NASA microwave missions, but may enable significant increases in bandwidth.

Relevance / Science Traceability

PICs may enable significantly increased bandwidth of Earth viewing, astrophysics, and planetary science missions. In particular, this may allow for increased bandwidth or resolution receivers, with applications such as hyperspectral radiometry.

Scope Title
Spectrometer back ends for microwave radiometers

Scope Description

Technology for low-power, rad-tolerant broad band spectrometer back ends for microwave radiometers.

Possible Implementations Include:

- Digitizers starting at 20 Gsps, 20 GHz bandwidth, 4 or more bit and simple interface to FPGA;
- ASIC implementations of polyphase spectrometer digital signal processing with ~1 Watt/GHz.
- 5-GHz bandwidth polarimetric-spectrometer with 512 channels. Two simultaneously sampled ADC inputs. Spectrometer filter banks and either polarization combiners or cross correlators for computing all four Stokes parameters (any Stokes vector basis is acceptable: e.g., IQUV, vhUV, vhpmlr). Kurtosis detectors on at least the two principal channels. Rad-hard and minimized power dissipation.

- Combined radar/radiometer receiver with radiometer spectral processing (polyphase filter bank or FFT) synchronized with radar matched filtering and moment processing.

Expected TRL or TRL range at completion of the project: 4 to 5

Desired Deliverables of Phase II

Prototype, Analysis, Hardware

Desired Deliverables Description

The desired deliverable of this Subtopic Scope is a low-power Spectrometer ASIC or other component that can be incorporated into multiple NASA radiometers.

State of the Art and Critical Gaps

Current FPGA based spectrometers require ~10 W/GHz and are not flight qualifiable. High speed digitizers exist but have poorly designed output interfaces. Specifically designed ASICs could reduce this power by a factor of 10.

Relevance / Science Traceability

Broadband spectrometers are required for Earth observing, planetary, and astrophysics missions. Improved digital spectrometer capability is directly applicable to planetary science, and enables Radio Frequency Interference (RFI) mitigation for Earth science.