improved the noise temperature substantially. This may be because the mixer was presented with a better impedance match with the use of the isolator.

Cryogenic testing indicates a system noise temperature of 100 K or less at 166 GHz. Prior tests of the MMIC amplifiers alone have resulted in a system noise temperature of 65–70 K in the same frequency range (≈160 GHz) when cooled to an ambient temperature of 20 K. While other detector systems may be slightly more sensitive (such as SIS mixers), they require more cooling (to 4 K ambient) and are not as easily scalable to build a large array, due to the need for large magnets and other equipment.

When cooled to 20 K, this receiver module achieves approximately 100 K system noise temperature, which is slightly higher than single-amplifier module results obtained at JPL (65–70 K when an amplifier is corrected for back-end noise contributions). If this performance can be realized in practice, and a scalable array can be produced, the impact on cosmic microwave background experiments, astronomical and Earth spectroscopy, interferometry, and radio astronomy in general will be dramatic.

Ka-Band, Multi-Gigabit-Per-Second Transceiver

John H. Glenn Research Center, Cleveland, Ohio

A document discusses a multi-Gigabit-per-second, Ka-band transceiver with a software-defined modem (SDM) capable of digitally encoding/decoding data and compensating for linear and nonlinear distortions in the end-to-end system, including the traveling-wave tube amplifier (TWTA). This innovation can increase data rates of space-to-ground communication links, and has potential application to NASA's future space-based Earth observation system.

The SDM incorporates an extended version of the industry-standard DVB-S2, and LDPC rate 9/10 FEC codec. The SDM supports a suite of waveforms, including QPSK, 8-PSK, 16-APSK, 32-APSK, 64-APSK, and 128-QAM. The Ka-band and TWTA deliver an output power on the order of 200 W with efficiency greater than 60%, and a passband of at least 3 GHz. The modem and the TWTA together enable a data rate of 20 Gbps with a low bit error rate (BER).

The payload data rates for spacecraft in NASA's integrated space communications network can be increased by an order of magnitude (>10×) over current state-of-practice. This innovation enhances the data rate by using bandwidth-efficient modulation techniques, which transmit a higher number of bits per Hertz of bandwidth than the currently used quadrature phase shift keying (QPSK) waveforms.

All-Solid-State 2.45-to-2.78-THz Source

Applications include laboratory spectroscopy, THz imaging, and heterodyne instrumentation.

NASA's Jet Propulsion Laboratory, Pasadena, California

Sources in the THz range are required in order for NASA to implement heterodyne instruments in this frequency range. The source that has been demonstrated here will be used for an instrument on the SOFIA platform as well as for upcoming astrophysics missions. There are currently no electronic sources in the 2–3-THz frequency range. An electronically tunable compact source in this frequency range is needed for lab spectroscopy as well as for compact space-deployable heterodyne receivers. This solution for obtaining useful power levels in the 2–3-THz range is based on utilizing power-combined multiplier stages. Utilizing power combining, the input power can be distributed between different multiplier chips and then recombined after the frequency multiplication.

A continuous wave (CW) coherent source covering 2.48–2.75 THz, with greater than 10 percent instantaneous and tuning bandwidth, and having l–14 μW of output power at room temperature, has been demonstrated. This source is based on a 91.8–101.8-GHz synthesizer followed by a power amplifier and three cascaded frequency triplers. It demonstrates that purely electronic solid-state sources can generate a useful amount of power in a region of the electromagnetic spectrum where lasers (solid-state or gas) were previously the only available coherent sources. The bandwidth, agility, and operability of this THz source has enabled wideband, high-resolution spectroscopic measurements of water, methanol, and carbon monoxide with a resolution and signal-to-noise ratio unmatched by other existing systems, providing new insight in the physics of these molecules. Furthermore, the power and optical beam quality are high enough to observe the Lamb-dip effect in water. The source frequency has an absolute accuracy better than 1 part in 10^{12}, and the spectrometer achieves sub-Doppler frequency resolution better than 1 part in 10^8. The harmonic purity is better than 25 dB.

This source can serve as a local oscillator for a variety of heterodyne systems, and can be used as a method for preci-

sion control of more powerful but much less frequency-agile quantum mechanical terahertz sources.

Onboard Interferometric SAR Processor for the Ka-band Radar Interferometer (KaRIn)

NASA's Jet Propulsion Laboratory, Pasadena, California

An interferometric synthetic aperture radar (SAR) onboard processor concept and algorithm has been developed for the Ka-band radar interferometer (KaRIn) instrument on the Surface and Ocean Topography (SWOT) mission. This is a mission-critical subsystem that will perform interferometric SAR processing and multi-look averaging over the oceans to decrease the data rate by three orders of magnitude, and therefore enable the downlink of the radar data to the ground.

The onboard processor performs demodulation, range compression, co-registration, and re-sampling, and forms nine azimuth squinted beams. For each of them, an interferogram is generated, including common-band spectral filtering to improve correlation, followed by averaging to the final 1×1-km ground resolution pixel. The onboard processor has been prototyped on a custom FPGA-based cPCI board, which will be part of the radar's digital subsystem.

The level of complexity of this technology, dictated by the implementation of interferometric SAR processing at high resolution, the extremely tight level of accuracy required, and its implementation on FPGAs are unprecedented at the time of this reporting for an onboard processor for flight applications.