uplink signal. It will also be used in the non-beam-steering case to compensate for phase shift variations through power amplifiers. The digital interface board can be used to set four 5-bit phase shifters and four 5-bit attenuators and monitor their current settings. Additionally, it is useful outside of the closed-loop system for beam-steering alone.

When the VEE program is started, it prompts the user to initialize variables (to zero) or skip initialization. After that, the program enters into a continuous loop waiting for the telemetry period to elapse or a button to be pushed. A telemetry request is sent when the telemetry period is elapsed (every five seconds). Pushing one of the set or reset buttons will send the appropriate command. When a command is sent, the interface status is returned, and the user will be notified by a pop-up window if any error has occurred. The program runs until the End Program button is depressed.

This work was done by Amy E. Smith, Brian M. Cook, Abdur R. Khan, and James P. Lux of Caltech, for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.

This software is available for commercial licensing. Please contact Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-42778.

CoNNeCT Baseband Processor Module

Goddard Space Flight Center, Greenbelt, Maryland

A document describes the CoNNeCT Baseband Processor Module (BPM) based on an updated processor, memory technology, and field-programmable gate arrays (FPGAs). The BPM was developed from a requirement to provide sufficient computing power and memory storage to conduct experiments for a Software Defined Radio (SDR) to be implemented.

The flight SDR uses the AT697 SPARC processor with on-chip data and instruction cache. The non-volatile memory has been increased from a 20-Mbit EEPROM (electrically erasable programmable read only memory) to a 4-Gbit Flash, managed by the RTAX2000 Housekeeper, allowing more programs and FPGA bit-files to be stored. The volatile memory has been increased from a 20-Mbit SRAM (static random access memory) to a 1.25-Gbit SDRAM (synchronous dynamic random access memory), providing additional memory space for more complex operating systems and programs to be executed on the SPARC. All memory is EDAC (error detection and correction) protected, while the SPARC processor implements fault protection via TMR (triple modular redundancy) architecture.

Further capability over prior BPM designs includes the addition of a second FPGA to implement features beyond the resources of a single FPGA. Both FPGAs are implemented with Xilinx Virtex-II and are interconnected by a 96-bit bus to facilitate data exchange. Dedicated 1.25-Gbit SDRAMs are wired to each Xilinx FPGA to accommodate high rate data buffering for SDR applications as well as independent SpaceWire interfaces. The RTAX2000 manages scrub and configuration of each Xilinx.

This work was done by Clifford K. Yamamoto, Thomas C. Jedrey, and Daniel G. Gutrich of Caltech, and Richard L. Goodpasture of Mantech SRS Technologies for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-47773

Cryogenic 160-GHz MMIC Heterodyne Receiver Module

Applications include portable security sensors, hidden weapons detection, airport security, and automotive radar.

NASA's Jet Propulsion Laboratory, Pasadena, California

A cryogenic 160-GHz MMIC heterodyne receiver module has demonstrated a system noise temperature of 100 K or less at 166 GHz. This module builds upon work previously described in "Development of a 150-GHz MMIC Module Prototype for Large-Scale CMB Radiation" (NPO-47664), *NASA Tech Briefs*, Vol. 35, No. 8 (August 2011), p. 27. In the original module, the local oscillator signal was saturating the MMIC low-noise amplifiers (LNAs) with power. In order to suppress the local oscillator signal from reaching the MMIC LNAs, the W-band (75–110 GHz) signal had to be filtered out before reaching 140–170 GHz. A bandpass filter was developed to cover 120–170 GHz, using microstrip parallel-coupled lines to achieve the desired filter bandwidth, and ensure that the unwanted W-band local oscillator signal would be sufficiently suppressed.

With the new bandpass filter, the entire receiver can work over the 140–180-GHz band, with a minimum system noise temperature of 460 K at 166 GHz. The module was tested cryogenically at 20 K ambient temperature, and it was found that the receiver had a noise temperature of 100 K over an 8-GHz bandwidth.

The receiver module now includes a microstrip bandpass filter, which was designed to have a 3-dB bandwidth of approximately 120–170 GHz. The filter was fabricated on a 3-mil-thick alumina substrate. The filter design was based on a W-band filter design made at JPL and used in the QUIET (Q/U Imaging ExperimenT) radiometer modules. The W-band filter was scaled for a new center frequency of 150 GHz, and the microstrip segments were changed accordingly. Also, to decrease the bandwidth of the resulting scaled design, the center gaps between the microstrip lines were increased (by four micrometers in length) compared to the gaps near the edges.

The use of the 150-GHz bandpass filter has enabled the receiver module to function well at room temperature. The system noise temperature was measured to be less than 600 K (at room temperature) from 154 to 168 GHz. Additionally, the use of a W-band isolator between the receiver module and the local oscillator source also 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.

This work was done by Lorene A. Samoska, Mary M. Soria, Heather R. Owen, Douglas E. Dawson, Pekka P. Kangaslahti, and Todd C. Gaier of Caltech, and Patricia Voll, Judy Lau, Matt Sieth, and Sarah Church of Stanford University for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP *(see page 1)**. NPO-47873*

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.

This work was done by Rainee N. Simons and Edwin G. Wintucky of Glenn Research Center; and Francis J. Smith, Johnny M. Harris, David G. Landon, Osama S. Haddadin, William K. McIntire, and June Y. Sun of L-3 Communications Systems–West. Further information is contained in a TSP *(see page 1)**.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18735-1.

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-