Electronics/Computers

An All-Solid-State, Room-Temperature, Heterodyne Receiver for Atmospheric Spectroscopy at 1.2 THz

This receiver enables terahertz heterodyne spectroscopy of outer planet atmospheres without cryogenic cooling.

NASA's Jet Propulsion Laboratory, Pasadena, California

Heterodyne receivers at submillimeter wavelengths have played a major role in astrophysics as well as Earth and planetary remote sensing. All-solid-state heterodyne receivers using both MMIC (monolithic microwave integrated circuit) Schottky-diode-based LO (local oscillator) sources and mixers are uniquely suited for long-term planetary missions or Earth climate monitoring missions as they can operate for decades without the need for any active cryogenic cooling. However, the main concern in using Schottky-diode-based mixers at frequencies beyond 1 THz has been the lack of enough LO power to drive the devices because 1 to 3 mW are required to properly pump Schottky diode mixers. Recent progress in HEMT- (high-electron-mobility-transistor) based power amplifier technology, with output power levels in excess of 1 W recently demonstrated at W-band, as well as advances in MMIC Schottky diode circuit technology, have led to measured output powers up to 1.4 mW at 0.9 THz.

Here the first room-temperature tunable, all-planar, Schottky-diode-based receiver is reported that is operating at 1.2 THz over a wide (≈20%) bandwidth. The receiver front-end (see figure) consists of a Schottky-diode-based 540 to 640 GHz multiplied LO chain (featuring a cascade of W-band power amplifiers providing around 120 to 180 mW at W-band), a 200-GHz MMIC frequency doubler, and a 600-GHz MMIC frequency tripler, plus a biasable 1.2-THz MMIC sub-harmonic Schottky-diode mixer. The LO chain has been designed, fabricated, and tested at JPL and provides around 1 to 1.5 mW at 540 to 640 GHz. The sub-harmonic mixer consists of two Schottky diodes on a thin GaAs membrane in an anti-parallel configuration. An integrated metal insulator metal (MIM) capacitor has been included on-chip to allow dc bias for the Schottky diodes. A bias voltage of around 0.5 V/diode is necessary to reduce the LO power required down to the 1 to 1.5 mW available from the LO chain. The epilayer thickness and doping profiles have been specifically optimized to maximize the mixer performance beyond 1 THz.

The measured DSB noise temperatures and conversion losses of the receiver are 2,000 to 3,500 K and 12 to 14 dB, respectively, at 120 K, and 4,000 to 6,000 K and 13 to 15 dB, respectively, at 300 K. These results establish the state-

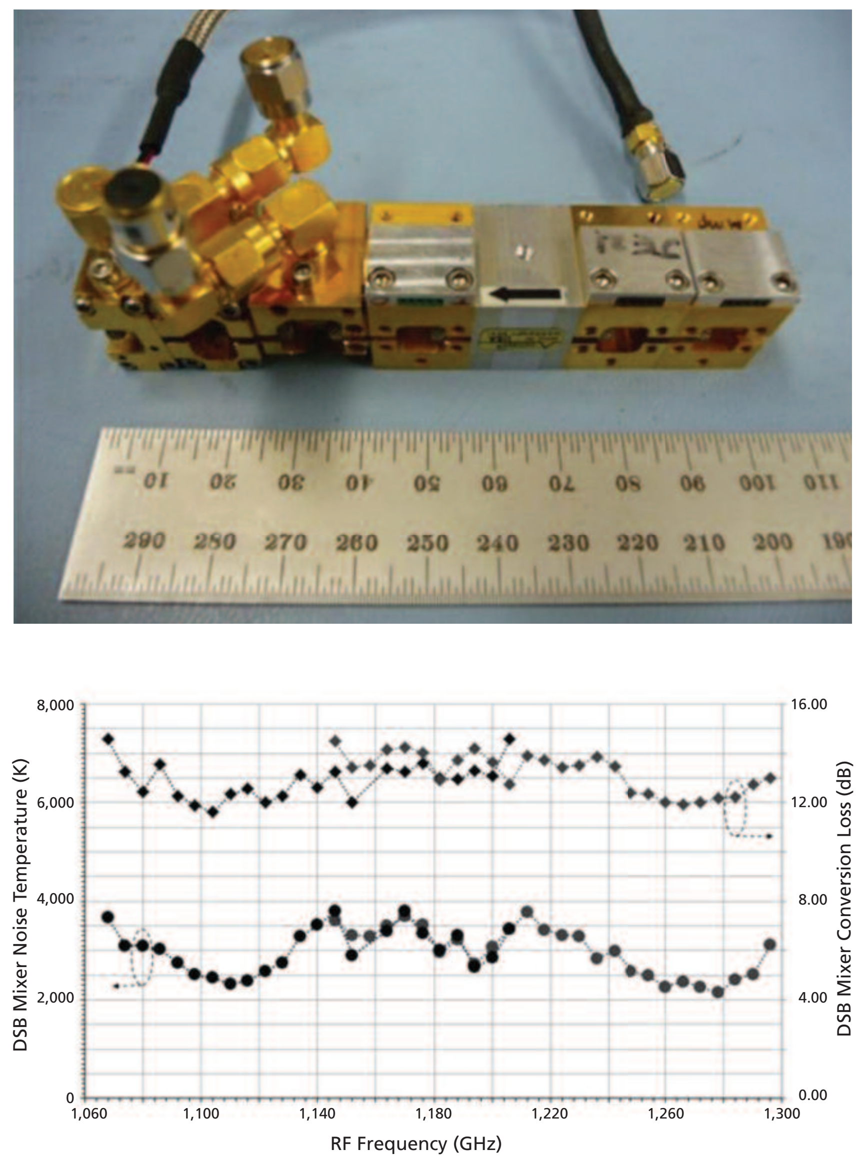

Photo and Performance of the Schottky-diode based 1.2-THz heterodyne receiver.

of-the-art for all-solid-state, all-planar heterodyne receivers at 1.2 THz operating at either room temperature or using passive cooling only. Since no cryogenic cooling is needed, the receiver is eminently suited to atmospheric heterodyne spectroscopy of the outer planets and their moons.

This work was done by Jose V. Siles, Imran Mehdi, Erich T. Schlecht, Samuel Gulkis, Goutam Chattopadhyay, Robert H. Lin, Choonsup Lee, and John J. Gill of Caltech; Bertrand Thomas of Radiometer Physic; and Alain E. Maestrini of Observatoire de Paris for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48896

Stacked Transformer for Driver Gain and Receive Signal Splitting

Lyndon B. Johnson Space Center, Houston, Texas

In a high-speed signal transmission system that uses transformer coupling, there is a need to provide increased transmitted signal strength without adding active components. This invention uses additional transformers to achieve the needed gain. The prior art uses stronger drivers (which require an IC redesign and a higher power supply voltage), or the addition of another active component (which can decrease reliability, increase power consumption, reduce the beneficial effect of serializer/deserializer preemphasis or deemphasis, and/or interfere with fault containment mechanisms), or uses a different transformer winding ratio (which requires redesign of the transformer and may not be feasible with high-speed signals that require a 1:1 winding ratio).

This invention achieves the required gain by connecting the secondaries of multiple transformers in series. The primaries of these transformers are currently either connected in parallel or are connected to multiple drivers. There is also a need to split a receive signal to multiple destinations with minimal signal loss. Additional transformers can achieve the split. The prior art uses impedance-matching series resistors that cause a loss of signal. Instead of causing a loss, most instantiations of this invention would actually provide gain. Multiple transformers are used instead of multiple windings on a single transformer because multiple windings on the same transformer would require a redesign of the transformer, and may not be feasible with high-speed transformers that usually require a bifilar winding with a 1:1 ratio. This invention creates the split by connecting the primaries of multiple transformers in series. The secondary of each transformer is connected to one of the intended destinations without the use of impedance-matching series resistors.

This work was done by Kevin R. Driscoll of Honeywell for Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809.

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act {42 U.S.C. 2457(f)}, to Honeywell. Inquiries concerning licenses for its commercial development should be addressed to:

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Refer to MSC-24854-1/6-1, volume and number of this NASA Tech Briefs *issue, and the page number.*

Wireless Integrated Microelectronic Vacuum Sensor System

This system is applicable to facility monitoring applications, as well as cryogenic fluid manufacture and transport.

Stennis Space Center, Mississippi

NASA Stennis Space Center's (SSC's) large rocket engine test facility requires the use of liquid propellants, including the use of cryogenic fluids like liquid hydrogen as fuel, and liquid oxygen as an oxidizer (gases which have been liquefied at very low temperatures). These fluids require special handling, storage, and transfer technology. The biggest problem associated with transferring cryogenic liquids is product loss due to heat transfer. Vacuum jacketed piping is specifically designed to maintain high thermal efficiency so that cryogenic liquids can be transferred with minimal heat transfer.

A vacuum jacketed pipe is essentially two pipes in one. There is an inner carrier pipe, in which the cryogenic liquid is actually transferred, and an outer jacket pipe that supports and seals the vacuum insulation, forming the "vacuum jacket." The integrity of the vacuum jacketed transmission lines that transfer the cryogenic fluid from delivery barges to the test stand must be maintained prior to and during engine testing. To monitor the vacuum in these vacuum jacketed transmission lines, vacuum gauge readings are used. At SSC, vacuum gauge measurements are done on a manual rotation basis with two technicians, each using a handheld instrument. Manual collection of vacuum data is labor intensive and uses valuable personnel time. Additionally, there are times when personnel cannot collect the data in a timely fashion (i.e., when a leak is detected, measurements must be taken more often). Additionally, distribution of this data to all interested parties can be cumbersome.

To simplify the vacuum-gauge data collection process, automate the data collection, and decrease the labor costs associated with acquiring these measurements, an automated system that monitors the existing gauges was developed by Invocon, Inc. For this project, Invocon developed a Wireless Integrated Microelectronic Vacuum Sensor System (WIMVSS) that provides the ability to gather vacuum-gauge measurements automatically and wirelessly, in near-real