THz Receivers for Thermospheric Science

A. Maestrini, J. Siles, C. Lee, R. Lin, D. Hayton, and I. Mehdi
Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, 91125 USA

***Abstract*—Driven by the JUpiter ICy moon Explorer mission, considerable progress has recently been demonstrated for room temperature Schottky based heterodyne receivers to 1200 GHz. However, pushing operating frequencies of high-spectral resolution receivers to above 2 THz is still considerably challenging due to parasitics associated with traditional planar Schottky diodes and the difficulty to generate the local oscillator signal with sufficient power for optimum operations. This paper will present the on-going work at JPL to demonstrate room-temperature receivers in the 2-5THz band for thermospheric science.**

CRITICAL global measurements of lower thermospheric neutral winds, temperature and density measurements from a low-earth orbit platform are needed to better understand underlying mechanisms of the upper atmospheric composition/dynamics/temperature variability and the role of neutral dynamics on the ionospheric variability. Currently, no reliable satellite remote sensing technique can provide neutral wind measurements in the critical 100-150 km altitude region with complete local time coverage and desired spatial resolution, precision and accuracy. To address this short coming we propose to develop Schottky based receivers to measure the ionized oxygen line at 2.06 and 4.75 THz.

The configuration adopted for the 2.06 THz receiver is shown in Fig. 1. A bias-able subharmonic mixer architecture is used with a local oscillator source at 1.03 THz. The mixer, IF LNA and 1.03THz frequency tripler can be cooled to 120K for improved sensitivity, while the rest of the receiver will be operated at room temperature. The LO chain is predicated on being able to use a high-power amplifier at 114GHz, which are now available. In this configuration, 1.5mW at 1027GHz was recently measured, which is expected to be sufficient to pump the bias-able mixer. An alternate approach relies on a high power G-band PA. The mixer chips have been designed using both the configurations proposed in [2] and in [3]. Respective advantages of these two approaches will be discussed along with recent receiver results.

For the 4.7 THz channel a number of mixer topologies were investigated. The first approach would be to build a fundamental mixer, which would require around 0.5 mW of LO power at 4.7 THz. This is currently not possible with multiplied sources. An alternative to multiplied sources would be to use a QCL. However, QCLs would need cooling to 77K making system design and instrument build more complicated. A second traditional approach investigated was a sub-harmonically pumped mixer such as the one for the 2.06 THz channel. Such a mixer would require LO at 2.35 THz with an output power around 1 mW, which is more than an order of

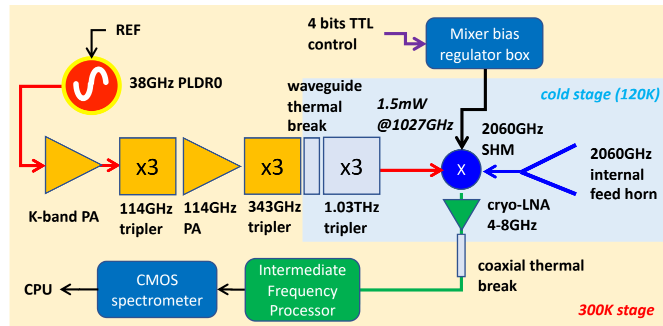

Fig. 1. Top: Receiver architecture designed for the 2.06 THz receiver. The measured LO power at 1027GHz is 1.5mW. This power is sufficient to pump the subharmonic mixer. Bottom: Measured output power from an alternate LO chain featuring two power-combined 114GHz triplers at room temperature [1].

magnitude higher than the state-of-the-art. After detailed consideration we opted to design and build a novel 3rd harmonic mixer for this task. We have designed a novel 3rd harmonic mixer as a practical solution for the 4.7 THz channel.

This novel third-harmonic Schottky mixer which will require around 1 mW at 1.58THz. Given the amount of LO power at 1.58THz that was demonstrated in [1], a single-anode unbalanced third harmonic mixer at 4.75THz is preferred rather than a balanced third-harmonic mixer that would require two diodes on the same circuit.

References

[1] J. Siles, et. al., “A New Generation of Room-Temperature Frequency Multiplied Sources with up to 10x Higher Output Power in the 160 GHz-1.6 THz Range”, Proc. of the IEEE Transactions of Space Terahertz Communications, Nov. 2018

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[3] A. Maestrini *et al*., "The 1200GHz Receiver Frontend of the Submillimetre Wave Instrument of ESA JUpiter ICy moons Explorer," *2018 43rd International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz)*, 2018, pp. 1-2, doi: 10.1109/IRMMW-THz.2018.8509935.