A Solid-State, Non-Cryogenic Receiver Operating at 2.5THz

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***Abstract*—A receiver operating at 2.5THz without cryogenics is presented that utilizes an all-solid state local oscillator (LO). A schottky-diode fourth-harmonic mixer is developed to reduce LO power requirements. This mixer has a system temperature of 65,000K at 2.5THz at an optimum LO power of 1.9mW. A highly DC power-efficient 625 GHz source is presented which leverages a G-band power amplifier. This results in a highly compact receiver system that only consumes 7 W.**

Keywords— Remote sensing, radiometers, mixers, amplifiers

I. Introduction

Space-born radiometer and spectrometers systems have long driven towards low-mass and high-power efficiency, but with the rise of the CubeSat platform, there is even greater pressure to deliver high performance instruments with smaller mass, power and size. One such instrument was ICECube, which used a Schottky-diode 2nd harmonic mixer pumped by a highly integrated 400 GHz LO source [1]. This was a 3U CubeSat demonstration that acquired cloud ice data at 833GHz over 15 months.

Schottky-diode based systems have the advantage of not requiring cryogenics and being fully solid-state. Such a receiver cannot complete with an HEB or SIS on sensitivity, but for certain science goals sensitivity can be traded to lower power-consumption and mass. Solar occultation measurements, which uses the sun as the background for the spectral absorption measurement of an atmosphere, do not require the sensitivities of cryogenic detectors to achieve their science goals. One such instrument is SSOLVE which is currently being developed to better understand the water content of the lunar atmosphere [2].

With a relatively high noise temperature being capable of achieving the science goals of the mission, a fourth-harmonic mixer is chosen to reduce the LO power requirements of the receiver system. This work builds upon Bulcha et.al., which used a single-diode fourth-harmonic mixer to achieve a conversion loss of 30 at 2.7 THz [3]. To improve the conversion loss and sensitivity, an anti-parallel diode pair is used.

II. System Design

The receiver is designed in three separate E-plane split housings to allow for testing of each stage of the system, as shown in Fig. 1. Efficiency of the LO amplifier-multiplier chain is radically improved by including an amplifier after 156 GHz tripler. This amplifier, once packaged, produces over 160mW of power at 10% power added efficiency [4]. This reduces the amount of signal power at the lower stages compared to a system that only used multipliers above 50GHz, thus reducing DC-power consumption. Two varactor doublers follow the amplifier to reach 625GHz. These varactors are put into a separate block because the typically require rework to tune the anode size to target the correct frequency. To keep the system compact, a custom flange is used between the low-frequency block and the varactor block. Finally, a fourth-harmonic mixer is attached in another block with a standard waveguide flange. Details of the fourth-harmonic mixer design can be found in [5].

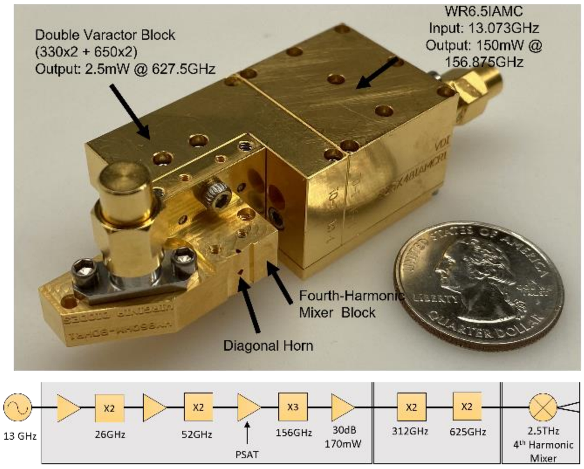

Fig. 1. (Top) The 2.5THz receiver. The size is 6.9x2.5x2cm and it weighs 70g. (Bottom) The system diagram of the receiver.

LO power is adjusted with a voltage applied to the PSAT input of the module, which sets the saturated power of the 52GHz amplifier.

III. Measurements

The power is measured after the 156GHz amplifier and the 625GHz doubler. Fig. 2 (a) shows the powers measured at the amplifier and Fig. 2 (b) is the power at the 625GHz doubler. Bandwidth is limited by the cascaded varactor doublers, which have a fixed bias to simplify the biasing electronics. Over 3 mW is produced at 625 GHz, which is more than sufficient to drive the 2.5THz fourth-harmonic mixer.

Y-factor of the system is measured between room temperature and a liquid nitrogen cooled absorber. Fig. 3 shows the system noise temperature as the LO-driver power is adjusted through the PSAT voltage input. 65,000 K noise temperature is measured across a wide range to PSAT settings, with the mixer turning on at 2.2V, which corresponds to 1.9 mW of LO power.

IV. Conclusion

A compact, low-power 2.5 THz receiver is developed that utilizes a fourth-harmonic Schottky-based mixer. By using a high-frequency, high-efficiency amplifier the amplifier-multiplier chain only consumes 6.8W of DC power. This receiver is currently being integrated at NASA with a 530GHz receiver as part of the SSOLVE instrument.

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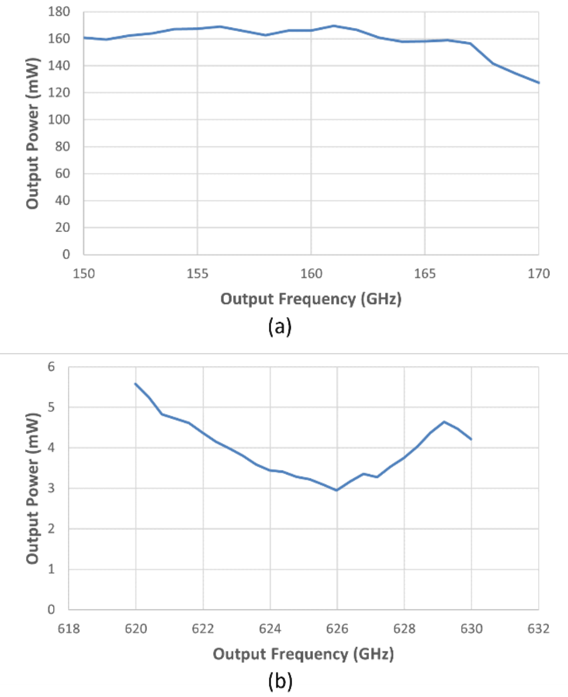

Fig. 2. (a) Output power for the final amplifier in the LO drive chain. (b) The output power after the two varactor multipliers.

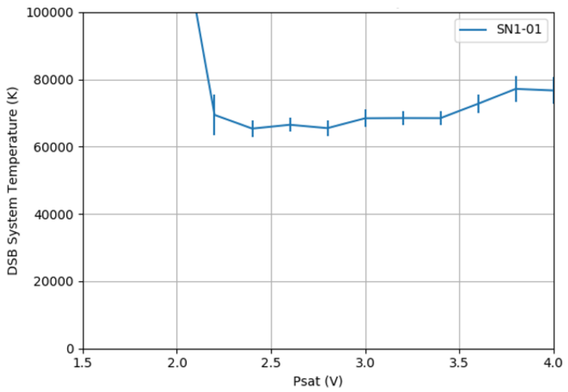

Fig. 3. The system noise temperature of the receiver at 2.5THz as the PSAT voltage is adjusted.

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