An Upgrade to the 1.9THz Local Oscillator for the SOFIA GREAT Instrument

Thomas Crowe[1], Theodore Reck[1], Steven Retzloff[1], and Jeffrey Hesler[1]

***Abstract*—An upgrade to the ~1.9THz channel local oscillator (LO) for SOFIA's GREAT instrument is presented. This LO system produces a minimum of 50uW and up to 120uW with continuous coverage from 1.8 to 2.08THz. A 4-way combined amplifier covering 150-175GHz with over 500mW of power dramatically simplifies the system design by introducing gain at a relatively high frequency in the multiplier chain. In addition, this amplifier reduced the total DC power consumption of each LO chain to 19W. Finally, careful characterization of AM noise was performed to show that the LO source should have minimal impact on the receiver sensitivity.**

Keywords—Local oscillator, Schottky diode, multiplier, amplifier

I. Introduction

The initial LO sources for the ~1.9 THz receivers of the for the German Receiver for Astronomy at Terahertz (GREAT, a facility instrument on NASA's Stratospheric Observatory for Infrared Astronomy (SOFIA) aircraft) were developed by VDI in 2013. These relied on very high-power amplifiers at ~26 GHz, followed by a cascade of three high-power varactor doublers and then two broadband varistor triplers. The resulting power was in the range of 10 – 20 uW for room temperature operation; but this was roughly doubled when the triplers were cryogenically cooled during SOFIA missions. Two such sources were used, with each pumping seven elements of the fourteen-pixel mixer array. The performance of these systems was gradually improved over the years to achieve improved power, tuning bandwidth and AMC [1, 2].

More recently, NASA JPL has demonstrated an LO source using higher frequency, W-Band, amplifiers [3]. This effort successfully demonstrated a highly integrated sixteen-pixel source array, and the per-pixel power of 40uW set a new state-of-the-art for power near 2 THz.

Beginning in 2020, NASA funded a significant upgrade to the LO sources for SOFIA. The specific requirements included a minimum power of 50 uW across the band of 1.80 – 2.08 THz with room temperature operation. The high power and broad tuning range of this upgrade presented a significant challenge requiring a complete revisioning of the system. The key to achieving the bandwidth was to introduce a broadband and high-power G-band amplifier to reduce the number of cascaded varactors to reach 1.9 THz. These amplifiers, fabricated by Teledyne Scientific [4] and packaged at Virginia Diodes, produce over 500mW of power from 150-175 GHz when four-way combined. Finally, a broadband, two-way power-combined 325GHz varactor and a 650 GHz varactor were developed to drive the 1.9 THz varistor tripler.

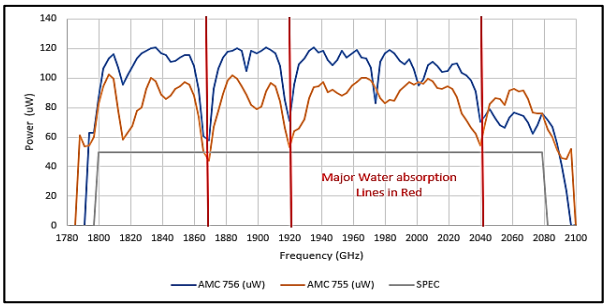

Fig. 1. The output power of the pair of sources, with the water absorbtion lines marked.

II. Results

Figure 1 shows that the 50 uW specification has been exceeded, with one of the two chains delivering as much as 120uW. In total, two pairs of LO chains have now been delivered to NASA, a flight unit and spare. All chains were tested for AM noise, which can contribute significantly to the noise of the single-ended HEB mixers. These measurements were performed at the output of the 650 GHz doublers and yielded AM noise power levels better than -140 dBc/Hz throughout the IF band for all LO frequencies. This result is quite acceptable, especially since the final tripler in the chains is known to be well saturated and thereby further lessens the AM noise at the final output.

The new LO chains have already flown one set of missions on SOFIA and the improved power and LO noise has significantly enhanced the receiver performance. A second set of flights is planned in June 2022.

References

[1] C. Risacher et al., "The upGREAT Dual Frequency Heterodyne Arrays for SOFIA," Journal of Astronomical Instrumentation, Vol. 7, No. 4 (2018).

[2] T.W. Crowe, J.L. Hesler, S.A. Retzloff, D.S. Kurtz, "Higher power multipliers for terahertz sources," 2016 41st Intl. Conf. Infrared, Millimeter, and Terahertz Waves, 2016.

[3] I. Mehdi, J. Siles, C. Lee and R. Lin, "Compact 1.9 THz Multi-Pixel Local Oscillator Chain," 2018 Asia-Pacific Microwave Conference (APMC), 2018, pp. 467-469.

[4] Z. Griffith, M. Urteaga, P. Rowell and L. Tran, "A 150-175-GHz 30-dB S_{21} Power Amplifier With 125-mW Pout and 16.2% PAE Using InP HBT," in IEEE Microwave and Wireless Components Letters.

[1]Virginia Diodes, Charlottesville, VA, USA

NOTES: