Compact Multi-Pixel Frequency Multiplied Local Oscillator Sources for Wideband Array Receivers in the 200-600 GHz & 1.4-2.7 THz Ranges

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Following on the success of high-spectral resolution submillimeter-wave/terahertz receivers recently flown in space, such as MIRO on-board the Rosetta Orbiter and HIFI on-board the Herschel Space Observatory, the next generation of terahertz cameras needs to address the challenge of achieving broadband multi-pixel operation within the strict power budgets of space missions. For planetary science applications, the 200-600 GHz range is key for studying water (and its composition) in comets and ocean worlds, in the search for habitability and the origin of water on Earth. Fast mapping is key in order to be able to avoid the data retrieval issues caused by the fast rotation of comets and to fulfill the science goals during flyby missions to the outer planets and their moons. For Astrophysics, large-band array receivers in the 1.4-2.7 THz are required to capture all key tracers of star formation: [CII], [NII], [OI], CO, HD, etc. Last but not least, dc power consumption is one the main limiting factor for terahertz array receivers. Since the local oscillator (LO) subsystem mostly drives the total power consumption of such receivers, ultra-compact high-efficiency LO systems are required to maximize the number of pixels affordable for future NASA missions involving THz spectroscopy.

Herein, we report in the latest progress towards low dc-power compact multi-pixel Schottky diode-based frequency multiplied local oscillator sources operating at room temperature. For the 200-600 GHz range, progress towards an ultra-broadband 16-pixel 210-600 GHz local oscillator array with >2 mW output power per pixel and ~20 W total power consumption (~1,25 W/pixel), enough to drive Schottky diode-based mixers with healthy margins. For the 1.4-2.7 THz array sources, we will report on the development status of a new 16-pixel 1.9-2.06 THz source with >20 μW/pixel and ~26 W total power consumption (~1.6 W/pixel). This represents one order of magnitude improvement with regards to the JPL 1.9 THz single-pixel LO flown on HIFI (~25 W/pixel) and the state-of-the-art JPL 4-pixel LO flown on STO-2 (20 W/pixel). We will also report on the 1st multi-pixel local oscillator in the 2.5 THz region (see Fig. 1.). This 2.5 THz source produces 15-37 μW/pixel with than 10 W dc power consumption. Currently, the most powerful 2.5 THz LO source flown on GREAT/SOFIA provides ~3-5 μW at 300K. The newest JPL single-pixel source at 2.5 THz produces up to 50 μW and is approximately one-fourth in size than the previous generation. Likewise, the newest 1.6 THz source developed at JPL provides ~0.7 mW (x10 than the previous JPL source in this range). Using phase grating techniques, such a chain could drive at least 64-pixel HEB-based receivers.

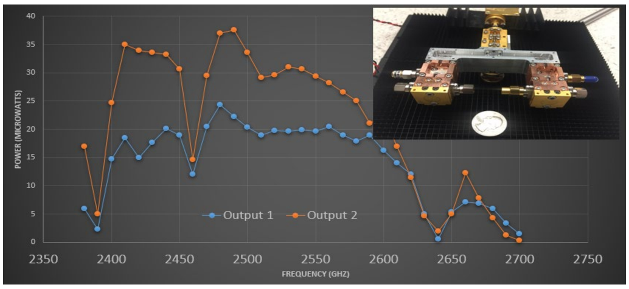

Fig. 1. First ever 2-pixel room-temperature 2.5 THz source.

These improvements in output power and reduction in dc power are mostly due to the JPL patented on-chip power combined topology and thoroughly optimized frequency multipliers [1]. An overview of the latest results will be provided, showing that the efficiency of this new generation of frequency multiplied sources follows now very closely the predictions by accurate physics-based models.

Achieving larger RF bandwidths (up to 50%) for terahertz room-temperature sources is one of the 'unexplored' territories where we are concentrating our efforts on now. For future balloon-borne instruments (e.g. ASTHROS, planned to fly from Antarctica in 2023) and space-borne (e.g. HERO, one of the instruments under study for the Origins Space Telescope concept), this kind of frequency coverage is necessary to maximize science return while minimizing the number of receiver channels to reduce complexity, dc power and cost. Progress towards enhancing the RF bandwidth of these LO sources by a factor of two in the 210-600 GHz and the 1.4-2.7 THz bands will be discussed.

References

[1] J. V. 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", IEEE Transactions on Terahertz Science and Technology, Nov. 2018.

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