A MIXER UP TO 300 GHz WITH WHISKERLESS SCHOTTKY DIODES FOR SPACEBORNE RADIOMETERS

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Abstract

Millimeter-wave (MMW) mixers employing Schottky diodes as non-linear devices are the only mixers implemented, to-date, for spaceborne missions. Spaceborne missions impose a variety of requirements on such radiometers, which favor particular mixer configurations and Schottky diode structures. This paper reports technical progress at Aerojet regarding the development of subharmonically (x2) pumped mixers up to 300 GHz, with pairs of whiskerless diodes. Such mixers yield particularly desired characteristics for spaceborne missions.

Matching Spaceborne Radiometry Missions with Suitable Receiver Technology

Spaceborne observations of the Earth's atmosphere and its surface with superheterodyne radiometry receivers require sensitivities often achieved with mixers employing Schottky diodes, and operating at "room-temperature" [1]. Such space-to-Earth radiometry missions [2] usually span a period of several years, and typically use unmanned relatively small platforms with tight volume/mass/ power specification for which active cooling requirements pose a burden.
Radiometric systems, mixer components, and Schottky devices encompass a technology field within which numerous and diverse technological implementations have been demonstrated, some of which feature particularly attractive characteristics for spaceborne missions: Whiskerless Schottky diodes yield superior reliability relative to whisker contacted diodes. In addition, they facilitate shorter mixer assembly phases and more repeatable component and system performance. Pairs of whiskerless planar diodes in anti-parallel, series, and anti-series are easily produced as single chips, facilitating the realization of fundamentally and subharmonically pumped [3] balanced mixers. Two diode balanced mixers yield outputs with wider instantaneous bandwidths, reduced LO noise, and RF/LO separation without the need for an external diplexer, in contrast to single-ended mixers. Furthermore, two diode subharmonically pumped mixers facilitate

efficient down-conversion with lower frequency LOs compared to fundamentally pumped mixers. These characteristics establish subharmonically pumped MMW mixers with whiskerless planar Schottky diodes at room-temperature, as particularly suitable for space-to-Earth radiometry missions.

Description of a Wideband Subharmonically (x2) Mixer

Aerojet had developed a subharmonically (x2) mixer to operate in an RF band 150-300 GHz, driven by LOs in the 75-150 GHz frequency range, and with an instantaneous IF bandwidth of 6-18 GHz. This mixer facilitates frequency down conversion throughout the MMW spectrum with readily available solid-state oscillators, without the requirement for frequency multipliers. The mixer consists of a pair of whiskerless planar diodes (produced by UVa), mounted on a printed circuit on 0.003″ thick fused-quartz. The diodes/printed-circuit assembly is housed in a machined waveguide network with RF and LO waveguide inputs, and a coaxial IF output. The Schottky diodes pair is connected to the IF output in parallel as a ~100 Ω impedance, easily matched to standard 50 Ω over a wide frequency output band. The printed circuit bridges the diodes with the IF and LO ports and facilitates efficient coupling of the RF to the diodes.

Measured Mixer Performance

Figure 1 shows receiver noise-figure DSB performance, measured with two different prototype mixers (mixer #1, mixer #2), each one with small design differences sufficient to explain the performance variations. The figure shows receiver noise-figure DSB data for both mixers with a 6-18 GHz wideband IF amplifier, also shown is receiver noise-figure data for mixer #1 with a .4-1.4 GHz narrowband IF amplifier. LOs at frequencies from 75 GHz to 150 GHz drove the mixers and facilitated receiver measurements in the 150-300 GHz MMW band. The broadband characteristics demonstrated in all three mixer ports (RF, LO, and IF), are complemented with efficient coupling between the diodes and the LO as indicated by the relatively low LO power required to drive the mixers (also shown in Figure 1). The noise-temperature and the conversion loss were also measured for mixer #1 (100 GHz LO, and 6-18 GHz IF) and yielded DSB results of 496 K and 6.6 dB respectively.

Figure 2 shows a 200 GHz receiver noise-figure DSB with mixer #1 and a 6-18 GHz IF amplifier, as a function of the 100 GHz LO power drive. Figure 2 indicates the relatively wide range of LO drive (+3.9 dBm to +9.9 dBm) within which receiver noise-figure varies only by about 0.5 dB. This mixer performance characteristic is important for long duration unmanned missions, and is another evidence for the robustness of this developed mixer.

Acknowledgment

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References

[1] Joe W. Waters, "Sub-MMW Heterodyne Spectroscopy and Remote Sensing of the Upper Atmosphere", Proceedings of the IEEE, November 1992.

[2] P.H. Siegel, et al, "Heterodyne Radiometer Development for the Earth Observing System MW Limb Sounder", IR and MMW Engineering, SPIE Vol 1874, 1993.

[3] P.H. Ostdiek, et al, "Integration of an Anti-Parallel Pair of Schottky Barrier Diodes in MMW Mixers", 15th International Conference on IR and MMW, December 1990.

Figure 1: Measured performance of two mixer prototypes

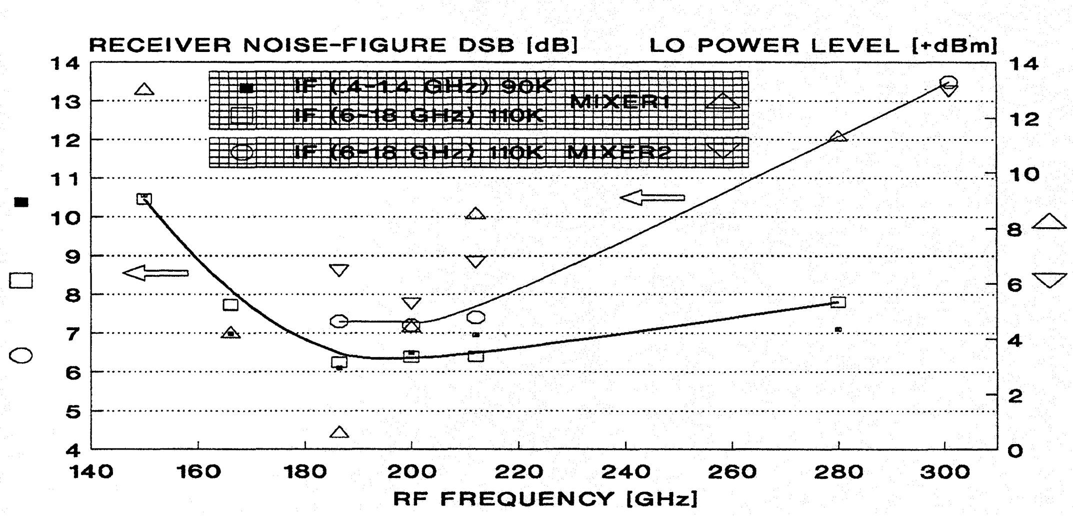

Figure 2: Receiver noise-figure dependence on LO power drive level for mixer #1 with 6-18 GHz IF amplifier