Schottky Diode 4th-Harmonic Mixer Characterization at 440 GHz

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***Abstract*— This paper presents the measurements of a 4th-harmonic Schottky diode mixer working at sub-millimeter frequencies, in particular at an RF frequency of 440 GHz. Measured DSB noise temperature of 7900 K and conversion loss of 14 dB have been obtained. This configuration offers an alternative solution which simplifies the LO signal generation. It can find an application in imaging systems, where arrays of detectors need to be simultaneously fed by the same LO.**

I. INTRODUCTION

USUALLY, sub-millimeter-wave mixer designs are based on sub-harmonic architectures, in which the RF frequency is double the LO frequency. The current technology available at the sub-millimeter wave range does not provide in most cases with enough power to feed the available components due to the high operational frequencies. This can result in an important problem when arrays of sub-harmonic mixers need to be pumped at these frequencies. For this reason an alternative approach based on the use of a fourth-harmonic mixer configuration in which the RF frequency is four times the LO frequency can become an attractive solution [1]-[2]. This configuration can resolve the aforementioned problems by working with an LO source operating at much lower frequency where higher power is available.

A fourth harmonic mixer is measured at the WR2 band in this paper. The proposed configuration is conceptually similar to a sub-harmonic architecture, which, by appropriate filtering, selects the fourth mixing product of the LO frequency and the RF frequency.

II. MIXER DESIGN

The 4th-harmonic mixer schematic is depicted in

Fig. 1. It consists of an antiparallel pair of flip-chip Schottky diodes (VDI SC1T2-D20) and two microstrip filters which allow adjusting the diode embedding impedance. In addition, two waveguide to microstrip transitions are used to couple the LO and RF signals to the microstrip channel. The diode parameters are as follows: Is = 0.2 fA, Rs = 13 Ω, n = 1.3, Cjo = 1.3 fF and Vj = 0.73 V.

An LO frequency of 110 GHz has been selected, so that, if the IF signal ranges between 1 and 6 GHz, the RF frequency will be around 440 GHz, satisfying $f_{IF} = 4f_{LO} - f_{RF}$. For these frequencies the RF and LO input ports of the mixer correspond to standard metallic rectangular waveguides, WR2 for the RF frequency and WR8 for the LO frequency. The microstrip circuit is placed in a 0.240 x 0.200 µm channel. The microstrip substrate is 4 mils thick cyclic olefin copolymer (COC), TOPAS 6015F 04 [3]. The dielectric constant of this material has been experimentally obtained as $\varepsilon_r = 2.34$ and tan $\delta = 0.2 \cdot 10^{-4}$ [6].

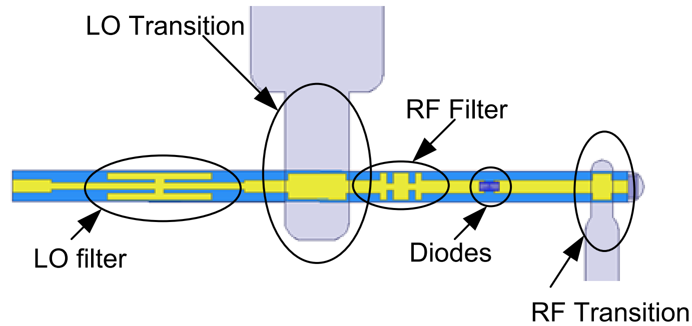


Fig. 1. Longitudinal section of the 4th -harmonic mixer showing its different parts and components.

The LO filter, which isolates the IF and LO ports and directs the LO power towards the diodes, corresponds to a Hammerhead configuration. This reject band filter constitutes a more compact solution than a stepped impedance low pass filter, given the large number of sections required to obtain the same level of isolation.

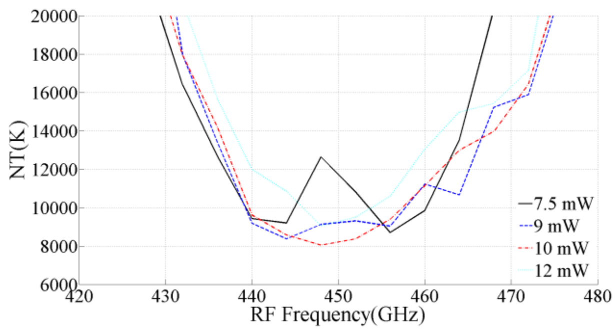
Conversely, the RF filter is a stepped-impedance LPF with cut-off frequency 360 GHz, which isolates the RF port from the LO and IF ports but lets the LO frequency pass towards the diodes.

The distances from the filters to the diodes were optimized using Agilent Advance Design System (ADS) in order to adjust the diodes embedding impedance.

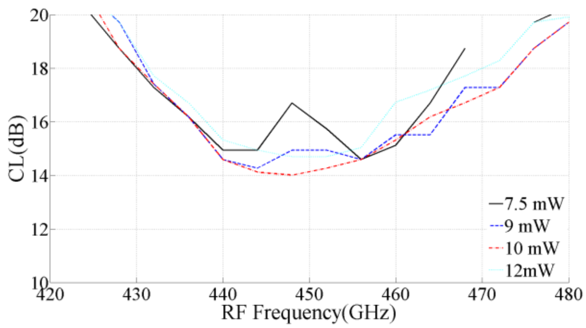
III. CHARACTERIZATION RESULTS

The 4th-harmonic mixer was manufactured assembled and characterized. The performance of the mixer in terms of Double Side Band Noise Temperature, NT, and Conversion Loss, CL, were extracted from these measurements using the Y-Factor and the Gain Method [5],[6] using room temperature and liquid nitrogen cooled absorbing material as hot and cold loads respectively.

This process was carried out for different LO frequencies and powers, see Fig. 2. The mixer performance presents slight differences when the input LO power varies, giving similar performance from 7.5 mW to 12 mW. For this range of LO powers, the NT remains between 8000 – 10000 K between 440 and 460 GHz, whereas the CL values range from 14 to 15 dB. The best results were obtained for an LO power of 10 mW at 448 GHz, where the NT is 7900K and CL is 14 dB.



(a)



(b)

Fig. 2 Measured DSB Noise Temperature, NT (a) and Conversion Loss, CL (b) of the mixer for different values of LO power.

IV. SUMMARY

This paper has performed the characterization of a 4th-harmonic mixer working at an RF frequency of 440 GHz. Minimum noise temperature and conversion loss values of 7900 K and 14 dB respectively were obtained for a LO power of 10 mW, although similar results were achieved for input LO powers from 7.5 mW to 12 mW. Even though this performance is far from being comparable with that of sub-harmonic mixers, they offer a good alternative when LO power at high frequencies results an issue.

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